Hydraulic Research in the United States

1963

United States Department of Commerce

National Bureau of Standards

Miscellaneous Publication 249

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A complete listing of the Bureau's publications can be found in National Bureau of Standards Circular 460, Publications of the National Bureau of Standards, 1901 to June 1947 ($1.25), and the Supplement to National Bureau of Standards Circular 460, July 1947 to June 1957 ($1.50), and Miscellaneous Publication 240, July 1957 to June 1960 (Includes Titles of Papers Published in Outside Journals 1950 to 1959) ($2.25); available from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402

UNITED STATES DEPARTMENT OF COMMERCE • Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS • A. V. Astin, *Director*

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1963

(Including Contributions from Canadian Laboratories)

Edited by Helen K. Middleton

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FOREWORD

The information contained in this publication was compiled from reports by the various hydraulic and hydrologic laboratories in the United States and Canada. The cooperation of these agencies is greatly appreciated. The National Bureau of Standards cannot assume responsibility for the completeness of this publication. We must depend upon reporting laboratories for the completeness of the coverage of their own programs, as well as upon new laboratories engaged in hydraulics to bring their activities to our attention.

Projects are numbered and the number once assigned is repeated for identification purposes until a project is completed. The numbers 4474 and above refer to projects reported for the first time. All projects are in active state, unless otherwise noted under (f).

The National Bureau of Standards does not maintain a file of reports or detailed information regarding the research projects reported by other organizations. Such information may be obtained from the correspondent listed under (c) or immediately following the title of the organization reporting the work. It is of course understood that any laboratory submitting reports on its work will be willing to supply information to properly qualified inquirers.

A similar bulletin, "Hydraulic Research," compiled and published by the International Association for Hydraulic Research, contains information on hydraulic research being conducted in foreign countries. This bulletin is edited by Professor H. J. Schoemaker, Director of the Hydraulic Laboratory at the Technical University of Delft, Netherlands, and Secretary of the International Association for Hydraulic Research. Copies may be obtained from the Secretary at $6.00 each (postage included).

A. V. Astin, Director

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Key to Projects

(a) Number and title of project
(b) Project conducted for
(c) Correspondent
(d) Nature of project
(e) Description
(f) Present status
(g) Results
(h) Publications

LIST OF CONTRIBUTING LABORATORIES

UNIVERSITY OF ARIZONA.

(4619) A STUDY OF THE MECHANICS OF UNSATURATED FLOW OF WATER IN SOILS.

(b) Agricultural Experiment Station.
(c) Dr. Duwayne M. Anderson, Dept. of Agricultural Chemistry and Soils, Univ. of Arizona, Tuscon, Arizona.
(d) Laboratory Investigation.
(e) An effort is being made to discover all the physical processes occurring during soil water movement.
(g) The movement of a liquid water flow through soils has been shown to consist of no less than five distinct processes: viscous flow of the liquid phase, evaporation of water at the liquid flow, combined diffusion and viscous flow of water vapor ahead of the advancing liquid, sorption of water vapor by the medium, and cyclic heat flow due to thermal gradients and evaporation. A method of distinguishing liquid from vapor movement of water in soils was developed.
(h) "Temperature Fluctuations at a Wetting Front: I. Characteristic Temperature Time Curves," Duwayne M. Anderson and A. Linville. Soil Sci. Soc. Amer. Proc. 26:14-18 (1962).
"Temperature Fluctuations at a wetting front: II. The Effect of Initial Water Content of the Medium on the Magnitude of the Temperature Fluctuations," Duwayne M. Anderson, Garrison Sposito, and A. Linville. Soil Sci. Soc. Amer. Proc. (in press).
"Temperature Fluctuations at a Wetting Front: III. Apparent Activation Energies for Water movement in the Liquid and Vapor Phases," Duwayne M. Anderson, A. Linville, and Garrison Sposito. Soil Sci. Soc. Amer. Proc. (in press).

(4620) EFFECT OF CROP COVER ON EFFICIENCY OF SPRINKLER IRRIGATION UNDER VARYING CLIMATIC AND OPERATING CONDITIONS.

(b) Agricultural Experiment Station.
(c) Mr. Kenneth R. Frost, Department of Agricultural Engineering, Univ. of Arizona, Tuscon, Arizona.
(d) Laboratory for theory and design.
(e) Precise water balance of growing crops under sprinkler application of irrigation water. Crops are grown in a tank of soil 12 feet in diameter and 2 feet deep. Instrumentation permits measurement of loss or gain of 0.005 inches of water on the area of the tank. Measurements permit evaluation of loss or gain of water from dew, rain, irrigation, evaporation, and transpiration on crops at any stage of growth and as functions of ambient atmospheric conditions.
(g) Evapotranspiration during sprinkling is approximately equal to that during non-sprinkling periods since evaporation from wet foliage replaces normal transpiration. Daily evapotranspiration ranges from 6-8 times the one-hour evapotranspiration at the period of peak rates.
Cloud cover reduces evapotranspiration by one-third from that at full-run under the same vapor pressure deficit.
(h) "A Weighing Evapotranspirometer," by K. R. Frost. Agricultural Engineering. 43(3): 160, March 1962.
"Factors Affecting Evapotranspiration Losses During Sprinkling," by K. R. Frost. A.S.A.E. Paper No. 62701 (Mimeo) Presented at 1962 Winter Meeting A.S.A.E.

(4621) SPRINKLER IRRIGATION STUDIES UNDER ARID SOUTHWESTERN CONDITIONS.

(b) Agricultural Experiment Station.
(c) Mr. Kenneth R. Frost, Department of Agricultural Engineering, Univ. of Arizona, Tuscon, Arizona.
(d) Field investigation for design data.
(e) Investigation of the use of sprinkler application of irrigation water in production of Arizona crops. Irrigation efficiencies under sprinkling as compared to efficiencies under surface applications. Irrigation scheduling and system design for sprinkler application of water. Crop yields per unit of land and per unit of water as functions of method of water application, soil type, irrigation schedules, and crop species and variety.
(g) Field tests on citrus, cotton, grains, and legumes indicate increased crop production per unit of water applied when water is applied by sprinklers rather than by surface methods. Results vary with crop and soil texture. On coarse textured soils water savings of 50% have been achieved by sprinkling.
(h) "Sprinkler Evaporation Losses," H. C. Schwalen and K. R. Frost, Progressive Agriculture in Arizona. 4(4): 10-11. 1953.
"Sprinkler Irrigation," H. C. Schwalen, K. R. Frost, W. W. Hins, Ariz. Agr. Exp. Sta. Bull. No. 250, 1954.
"Sprinkler Evaporation Losses," K. R. Frost and H. C. Schwalen, Agricultural Engineering 36(8) 526-527, Aug. 1955.
"Sprinkler Irrigation of Citrus," K. R. Frost. Progressive Agriculture in Arizona. 6(3): 4. 1955.
"Evapotranspiration During Sprinkler Irrigation," K. R. Frost and H. C. Schwalen. Trans. of A.S.A.E. 3(1): 18-20, 24. 1960.
"Citrus Irrigation Experiments on the Yuma Mesa," K. R. Frost and R. Rodney. Progressive Agriculture in Arizona 14(4): 14-15. 1962.
"Twelve Years of Sprinkler Irrigation Research," K. R. Frost. Progressive Agriculture in Arizona 15(1): (in press) 1963.

(4622) GROUND WATER SUPPLIES.

(b) Agricultural Experiment Station, The Univ. of Arizona; City of Tucson; and the Pima County.
(c) Prof. Harold C. Schwalen, Department of Agricultural Engineering, Univ. of Arizona, Tucson, Arizona.
(e) Detailed continuing groundwater inventory of selected basins in Arizona including at present the Santa Cruz from Nogales to Red Rock, Avra, Altar, Little Chino, Reddington Area of the San Pedro. Groundwater contour maps are prepared annually. Specific yields storage coefficients and transmissibilities are determined from well tests. An electric analog of the Tucson groundwater basin is being developed.
(g) Groundwater elevation data has been developed for all areas studied. Volumetric unwatering estimates have been prepared. Water balance estimates have been prepared for the Tucson Metropolitan, sahuarita Districts, and Cortaro Districts. Open files are maintained from which current ground water level data is available for any location in the area studied.
(h) "Water in the Santa Cruz Valley," H. C. Schwalen and R. J. Shaw. Arizona Exp. Sta. Bull. No. 288. October 1957.
"Suspended Sediment and Chemical Analyses of the San Pedro River at Charleston, Arizona," H. C. Schwalen. Arizona Agr. Exp. Sta. Report No. 202, June 1961.
"Progress Report on Study of Water in the Santa Cruz Valley, Arizona," H. C. Schwalen and R. J. Shaw, Arizona Agricultural Exp. Station Report No. 205, November 1961.
"Upper Santa Cruz Valley," H. C. Schwalen, Water Resources Report No. 11, Annual Report on Ground Water in Arizona. Spring 1961 to Spring 1962. pp. 61-66, Arizona State Land

Department 1962.
"Avra-Marana Area," H. C. Schwalen, Water Resources Report No. 11, Annual Report on Ground Water in Arizona. Spring 1961 to Spring 1962. pp. 66-71, Arizona State Land Department 1962.
"Chino Valley," H. C. Schwalen, Water Resources Report No. 11, Annual Report on Ground Water in Arizona. Spring 1961 to Spring 1962. pp. 106-109, Arizona State Land Department 1962.

(4623) CHARACTERISTICS OF SEGMENTAL ORIFICES.

(b) Departmental.
(c) Dr. E. M. Laursen, Department of Civil Engineering, Univ. of Arizona, Tucson, Ariz.
(d) Laboratory investigation for development.
(e) A partial orifice plate such as a segment of a circle may have advantages in some situations as a metering device. The discharge and loss characteristics of such a constriction will be studied.

(4624) HYDROLOGIC CHARACTERISTICS OF A GROUNDWATER BASIN.

(b) City of Tucson and Pima County through a cooperative agreement with the Agricultural Engineering Department, Arizona Agricultural Experiment Station.
(c) Mr. John Ferris, Department of Civil Engrg., Univ. of Arizona, Tucson, Arizona.
(d) Analytical, laboratory, and field investigations for development, operation, design and theory, for Doctoral dissertation.
(e) Attempts are being made to determine the hydrologic characteristics - specific yield and/or storage coefficient and transmissibility -- of the groundwater basin in the Santa Cruz Valley near Tucson, Arizona. Well tests are being made at sites where observation wells are available. Water budget analyses are being used in connection with mathematical models. A passive element electric analog model is being developed.
(g) Well tests made during the past two years indicate that realistic values of specific yield and/or storage coefficient are not obtained from such tests in the Santa Cruz Valley. Values of transmissibility are more consistent and reasonable.

(4625) CRITICAL TRACTIVE FORCE OF UNIFORM SANDS.

(b) Departmental.
(c) Dr. Emmett M. Laursen; Department of Civil Engineering, Univ. of Ariz., Tucson, Arizona.
(d) Analytical and laboratory investigation related to theory.
(e) Analytic and experimental attempts to relate the average boundary shear to the incipient movement of sediment particles composing the boundary. In the laminar regime, the analysis will proceed by approximating the forces on sediment particles in various possible positions among other sediment particles. The turbulent flow regime analysis will also consider the statistical nature of the variations in the flow.
The experimental results will be used to determine any needed constants or functions and to verify the approximate analyses.

(4626) SCOUR AT RELIEF BRIDGES.

(b) Departmental.
(c) Dr. Emmett M. Laursen; Department of Civil Engineering, Univ. of Ariz., Tucson, Ariz.
(d) Laboratory investigation related to theory and design.
(e) To find the effect of sediment size and velocity of flow on the limiting depths of clear-water scour in simple relief-bridge geometries. First, the case of the long contraction will be studied, then the case of the long gradually-contracting channel. The last case to be studied will involve various simple abrupt contractions. Throughout the experiments, examination of the assumptions of the analysis of Dr. E. M. Laursen will be made and also of the time dependency of depth of scour insofar as feasible.
(g) Based on the assumptions that the depth of scour at the obstruction is a multiple of the depth of scour in a comparable long contraction, that the particle shear upstream can be evaluated by Manning's formula and Strickler's relation, and that the shear in the scoured area is the critical tractive force, analytical relationships for the depth of scour have been obtained.
(h) "An Analysis of Relief Bridge Scour," by E. M. Laursen, submitted to Journal of the Hydraulics Division, ASCE.

(4627) A STUDY OF PARTIALLY SATURATED FLOW IN SAND-EPOXY RESIN COLUMNS.

(b) Departmental.
(c) Professor Richard L. Sloane; Department of Civil Engineering, Univ. of Arizona, Tucson, Arizona.
(d) Laboratory investigation related to theory.
(e) The flow of water through soils often takes place under conditions of partially saturated flow. The prediction of fluid distribution and pressure under conditions of partially saturated flow is important to those interested in the problem of recharge to the ground water table from water applied to the surface of the earth.
This study of partially saturated flow will make use of vertical columns made of sand grains cemented together with epoxy resin. The use of this type of sand columns will result in a model for which properties such as void ratio and particle arrangement will remain constant during a series of tests.

(4628) RADIOCARBON AS A TRACER IN WATER SUPPLY PROBLEMS.

(b) Research Corporation unrestricted venture grant and Geochronology Dept. funds.
(c) Dr. Paul E. Damon, project leader; Geochronology Laboratories, Univ. of Arizona, Tucson, Arizona.
(d) Laboratory and field research.
(e) The study of ground water movement through aquifers has been limited by the slow rate of movement of the subsurface waters. Thus, if a tracer is introduced, only limited information is obtainable between the times of spiking and observation. However, radiocarbon (C-14) has been naturally introduced into ground water reservoirs continuously throughout geologic time and, consequently, movement which has taken place during the last 45,000 years may be studied. In additio nuclear technology is now producing radiocarbon at a greater rate than nature and so this artificially produced radiocarbon may also be used to trace recent water movements. Furthermore, it represents a potential hazard to health and therefore it is essential to monitor the increment for the safety of the community.
We propose to monitor the present carbon-14 content of surface water and organic matter in the Southwest and to measure the radiocarbon content of subsurface waters. The source of the carbon in water will be determined by C^{12}/C^{13} measurements. This data will be related to ground water hydrologic problems such as the rate of laminar flow through aquifers, their permeability, the source and rate of recharge, paleoclimatology radioactive contamination in water supplies, and the waste disposal problem.
(g) The C-14 age of a number of water samples has been determined. The results are quite reasonable. For example, flow rates of approximately 10 feet per year have been deduced in the Safford region. The uptake of bomb C-14 in vegetation is also being

monitored.

(h) "Arizona Radiocarbon Dates IV," P. E. Damon, Austin Long, and J. J. Sigalove, American Journal of Science, Radiocarbon, Vol. 5, 1963, in press.

(4629) CURRENT METER DEVELOPMENT.

(b) U.S.G.S. Ground Water Branch and departmental.
(c) Mr. E. H. Cordes, Univ. of Ariz., Tucson, Ariz.
(d) Design and development for field use; master's thesis.
(e) This project will entail the design and operation of a current meter to measure the vertical velocity component in a pumping well. The velocity profile can then be applied to study transmisibility of ground water aquifers.
(f) Work is scheduled to begin July 1, 1963.

(4630) DEVELOPMENT OF HYDRAULIC MODELS ANALOGOUS TO SUBSURFACE GEOLOGIC CONDITIONS FOR STUDYING AND DEMONSTRATING THE CHARACTERISTICS OF GROUND WATER MOVEMENT.

(b) National Science Foundation.
(c) Dr. John W. Harshbarger, Dept. of Geology, University of Arizona, Tucson, Arizona.
(d) Laboratory investigation, design, development and operation.
(e) The purpose of the project is to clarify the characteristics of laminar flow in groundwater movement in a manner which will enable a visual flow net analysis. Hydraulic models are being developed which consist of consolidated media simulating sedimentary rock, enclosed in a water-tight case with a transparent side. Basic geologic structures and lithologies can be synthesized and colored inks can be inserted into the flow system of the model, forming visible flow lines. These flow lines can then be observed and analyzed in order to better understand the pattern of laminar groundwater flow as controlled by geologic factors. A few of the empirical model experiments which are being carried out include: 1) Refraction of flow bands across lithologic interfaces. 2) Continuity of flow around and through highly permeable and impermeable lenses of different lithologies. 3) Flow net systems caused by a single pumping well. 4) Flow-net system of mutual interference of depression cones caused by pumping multiple wells. 5) Artesian aquifer systems. 6) Infiltration phenomenon.
Models are being developed for use in education in science and hydrology at the college and university level.
(g) Models consisting of plexiglass cases containing artificially consolidated porous media which can be arranged in a nearly infinite variety of geologic structures and hydrologic situations have been developed. A wide variety of these models have been constructed and through their use it has become possible for the college student to obtain a clear description and understanding of previously conceived groundwater theories.
(h) "Empirical Studies of Laminar Flow in Porous Consolidated Media," (Abstract) Jay H. Lehr, Geological Society of America Bulletin, Special Paper 68 p. 217, 1961.
"Empirical Studies of Laminar Flow in Porous Consolidated Media," Jay H. Lehr, Doctoral dissertation, Dept. of Hydrology, University of Arizona, June 1962.
"Development of Hydraulic Models Analogous to Subsurface Geologic Conditions for Studying and Demonstrating the Characteristics of Groundwater Movement," Jay H. Lehr, Progress Report to NSF New Laboratory Equipment Program, July 7, 1962.

(4631) GROUND WATER HYDROLOGY OF THE WESTERN DESERT, U.A.R.

(b) In cooperation with General Desert Development Authority, Cairo, U.A.R.
(c) Moh. H. I. Salem, Univ. of Ariz., Tucson, Ariz.
(d) Analytical study of field data; operation and development; for doctoral dissertation.
(e) An electric analog model of the subsurface geologic and hydrologic conditions of the western desert of the U.A.R., Lybia, Sudan and Tehad is being constructed. Presently the area of recharge is in the high regions of Tehad and of Darfur in the Sudan. Ground water is discharged into the Nile and into the Qattera Depression. The distribution of the fundamental differential equations in the system will be determined taking into consideration the boundary conditions. It is hoped that the equations can be solved with the use of the electric analog model. The effects on the Ground Water system due to changed boundary conditions such as the completion of the Aswan High Dam (The Nile is expected to recharge water to the aquifer after the dam is completed) or the initiation of the Qattera depression project, will be included in the general analysis of the western desert.

(4632) ENERGY BALANCE OF DESERT REGIONS.

(b) Departmental project.
(c) Dr. William D. Sellers, Inst. of Atmospheric Physics, Univ. of Arizona, Tucson, Arizona.
(d) Field investigation for testing of new equipment.
(e) Project is to accurately measure all components of the energy balance over various types of desert surfaces. Emphasis is placed on measuring the heat used for evaporation.
(g) Evaporation rates measured in the dry stream channel of Walnut Gulch in S.E. Arizona over an 18-day period in October 1961 were high enough to indicate that natural recharge of the water table is negligible when the watertable is 48 to 90 cm below the surface. For dry soils evaporation rates appear to decrease with increasing wind speed; the reverse is true for wet soils. Practically all the radiative energy incident on short grass is used for evaporation.
(h) "The Energy Balance of Non-Uniform Soil Surfaces," by William D. Sellers and Carl N. Hodges. Journal of the Atmospheric Sciences, 19:6:482-491, November 1962. May be obtained from the Institute of Atmospheric Physics.

(4633) PHYSICS OF CONVECTIVE CLOUDS AND CLOUD MODIFICATION.

(b) National Science Foundation. Also, some assistance by U. S. Weather Bureau and U. S. Forest Service.
(c) Dr. Louis J. Battan, Institute of Atmospheric Physics, Univ. of Arizona, Tucson, Arizona.
(d) Field investigations of the physics of convective clouds and the effects of cloud seeding with silver iodide.
(e) The program involves detailed observations of convective clouds during the summer by means of radar, a pair of high resolution cameras. A network of recording rain gages is employed to measure rainfall. Cloud seeding is conducted with airborne silver-iodide generators. A carefully controlled randomization scheme is employed to decide on which days to seed. The results are analyzed statistically. In addition a physical evaluation is made to uncover information about the fundamental nature of cloud and precipitation formation.
(g) To date the experiments have failed to show that cloud seeding with silver iodide can increase rainfall from the convective clouds commonly observed in the summer in the

vicinity of Tucson. The analyses suggest that the quantity of rainfall does not depend on the ice nuclei properties of the air. This result leads to the inference that seeding with ice nuclei (such as silver iodide particles) is not likely to be successful in increasing rainfall.

(h) "Design of a Program of Randomized Seeding of Orographic Cumuli," L. J. Battan and A. R. Kassander, Jr., J. Meteor., 17, No. 6, 583-590 (1960).
"Some Properties of Convective Clouds," by L. J. Battan, Nubila Verona, Italy, IV, No. 1, 1-12 (1961).
"Evaluation of Effects of Airborne Silver-Iodide Seeding of Convective Clouds," by L. J. Battan and A. R. Kassander, Jr., Sci. Rep. No. 18, Inst. of Atmos. Physics, Univ. Ariz., Tucson, 59 pp. (1962).
"Relationship between Cloud Base and Initial Radar Echo," L. J. Battan, J. Applied Meteor., 2 (1963) (Accepted for publication).

(4634) REDUCTION OF EVAPORATION LOSSES BY USING MONOMOLECULAR FILMS.

(b) U. S. Bureau of Reclamation and Institute.
(c) C. Brent Cluff, Univ. of Ariz., Tucson, Arizona.
(d) Laboratory and field; operation, development and theory.
(e) To develop and verify techniques for determining the effectiveness of various monomolecular films considering film, water and climatic characteristics typical of semi-arid regions.
To develop a simple, effective, inexpensive apparatus for applying and maintaining a monomolecular film at maximum film pressure on ponds and reservoirs.
To screen physical conditioning and spreading agents to be used with the chemicals forming monomolecular films selected under Objective 1.
To develop methods for detecting the presence, extent, and pressure of a monomolecular film.
(g) Initial selection and chemical testing where necessary of the commercial fatty alcohols to be used were accomplished. Calibration of field and laboratory equipment was completed. The laboratory phase of the program is almost completed especially with regard to the determination under controlled conditions of spreading and healing rates with time for varying temperatures and humidities. The evaporation pan testing phase is also providing useful data for application in the pond testing program.
Testing in the field ponds is well underway using chemical in the following physical forms; Solid, flakes, powders, emulsions, and solutions. Considerable attention is being given to the development of dispensers for alcohols in the various physical forms.
(h) Quarterly progress reports prepared to U. S. Bureau of Reclamation. Available from Inst. of Water Utilization.

(4635) INVESTIGATION OF SITES, METHODS, AQUIFER DETERIORATION CONTROL, AND EFFECTS OF ARTIFICIAL GROUND WATER RECHARGE OF ALLUVIAL BASINS TYPICAL OF THE ARID SOUTHWEST UNITED STATES.

(b) Institute.
(c) Dr. L. G. Wilson, University of Arizona, Tucson, Arizona.
(d) Laboratory and field; operation and development.
(e) (1) To test the various methods of ground water recharge and determine the ones best suited to arid lands. (2) To test in laboratory and field and evaluate, also considering costs, various types of flocculants and filters for removal of suspended and colloidal material from recharge water. (3) To determine the effect on the aquifer and ground water of recharging sediment laden flood water. (4) To study the effect on ground water and the aquifer of any bacteria which may be introduced with recharge water; identify and find methods for controlling the growth and spread of these bacteria.
(g) Artificial recharge experiments were conducted on a test pit at Beardsley, Arizona. Constant head and falling head infiltration experiments were performed. Seepage meter tests indicated that water below the pit surface occurred in the unsaturated state. Additional experiments were conducted to determine the effectiveness of grass filters in reducing sediment load in flood water. Coastal Bermuda was the most efficient grass of six grass varieties and one alfalfa variety tested. The investigation conducted to determine the nature of the process of sediment removal by pea gravel filters indicated that removal occurred as a result of adsorption of sediment to an organic film (schmutzdecke).
(h) "Letting Grass Take the Mud out of Water," L. G. Wilson and C. B. Cluff, Progressive Agriculture in Arizona, Vol. XIV, No. 6, p. 12, Nov. - Dec., 1962.

(4636) THE DEVELOPMENT AND TESTING OF METHODS FOR DETERMINING EVAPORATION, TRANSPIRATION AND EVAPOTRANSPIRATION IN PINE STANDS BY SOIL MOISTURE SAMPLINGS.

(b) Dept. of Watershed Management in cooperation with U. S. Bureau of Indian Affairs. White Mt. Apache Tribe and Southwest Forest Industries, McNary, Arizona.
(c) A. L. McComb, Department of Watershed Management, University of Arizona, Tucson, Arizona.
(d) Analytical, field investigation: development and operation.
(e) Study designed to develop and test a method for measuring the evaporation and transpiration components of evapotranspiration in mature ponderosa pine stands in central Arizona. Installation consisted of twelve, 14 x 18 foot trenched plots - 3 with bare soil, 3 with a mature ponderosa pine cover, 3 with a vegetation free soil covered with plastic sheeting, and 3 with mature ponderosa pine and ground covered with plastic sheeting. Soil moisture supplied by natural rainfall, supplemented by irrigation. Soil moisture storage, percolation through the soil, and evaporative losses were determined for each treatment by periodic soil moisture sampling and allied meteorological observations.
(f) Completed.
(g) The individual processes involved in the disposition of precipitation (evaporation, transpiration, soil moisture storage, and percolation through the root zone), and the effects of vegetation on these processes can be evaluated through the use of plastic sheeting, soil moisture sampling and allied climatic measurements. Such information is basic to predicting potential effects of vegetation manipulation on both onsite and offsite water yields.

(4637) EFFECT OF FIRE AND RESIDUAL ASH ON THE VEGETATION, SOIL, WATER RELATIONS IN SELECTED PONDEROSA PINE STANDS.

(b) Dept. of Watershed Management in cooperation with U. S. Bureau of Indian Affairs, White Mt. Apache Tribe.
(c) Dr. A. L. McComb, Department of Watershed Management, Univ. of Arizona, Tucson, Ariz.
(d) Analytical, laboratory and field investigations, theory.
(e) The study will include a series of laboratory and field experiments to evaluate the influences of wild fire and controlled burning on the chemical and physical properties of a forest soil as these may affect the basic processes of surface and soil water movements. Laboratory studies will be carried on to

determine changes in the structure, pore space, and chemical characteristics of the soil due to burning of the ground cover. Field studies employing North Fork type infiltrometers, soil and soil moisture sampling will be carried on to supplement and extend the results of the laboratory studies.

(g) Preliminary studies and literature review indicate conflicting and inclusive evidence of the effects of ash residue on water-soil relations.

(4638) EVAPORATION, TRANSPIRATION AND EVAPOTRANSPIRATION FROM SOILS UNDER VARYING SOIL MOISTURE AND SOLAR RADIATION LEVELS.

(b) Dept. of Watershed Management in cooperation with U.S.D.A., Soil Conservation Service.
(c) Mr. A. L. McComb, Dept. of Watershed Management, Univ. of Arizona, Tucson, Ariz.
(d) Analytical, laboratory, theory.
(e) Effects of different levels of soil moisture and solar radiation on evaporation, transpiration and evapotranspiration were measured by use of 8 groups of fifteen 10-inch plastic pots. Each pot contained a forest soil collected from a mixed stand of ponderosa pine (Pinus ponderosa) and douglas fir (Pseudotsuga taxifolia). Evaporation was studied by using pots containing soil only, transpiration by using pots containing two-year-old Aleppo pine (Pinus halepensis) seedlings with the soil sealed to prevent evaporation, and evapotranspiration by using pots containing tree seedlings with the surface soil exposed.
(f) Completed.
(g) Water losses (transpiration and evapotranspiration) from the potted seedlings were closely correlated with a soil moisture and to a lesser degree with solar radiation. Evaporation from a bare soil surface, on the other hand, was significantly related only to soil moisture. In all cases, the greater the soil moisture, the greater the rate of water loss. This indicates that in the management of vegetation to reduce water loss, emphasis should be placed on methods of reducing the availability of soil water to direct evaporation.

UNIVERSITY OF ARKANSAS, Agricultural Experiment Station.

(2255) GROUND WATER, RESOURCES AND RECHARGE, IN THE RICE GROWING AREA OF ARKANSAS.

(b) Arkansas Agricultural Experiment Station cooperative with U. S. Geological Survey and U. S. Corps of Engineers.
(c) Prof. Kyle Engler, Head of Agricultural Engineering Dept., University of Arkansas, Fayetteville, Arkansas.
(d) Basic and applied research.
(e) The straight 26-inch sand-packed recharge well has been tested for one year and results have not proved completely satisfactory. Main difficulties encountered arise in duplicating test condition under field situations. The sand packed well seemed to filter out plugging material but redevelopment proved more difficult than in the gravel packed well. Separan AP-30 was tried but proved unsatisfactory for conditions as encountered in this test. A slow gravel filter has been constructed and will be tested as a means of clarifying recharge water during the winter and spring of 1960-61.
(g) Project reports are in process of being published.

(4066) HYDRAULICS OF FURROW IRRIGATION.

(b) Arkansas Agricultural Experiment Station.
(c) Prof. Billy B. Bryan, Dept. Agric. Engr., Univ. of Arkansas, Fayetteville, Arkansas.
(d) Experimental, field investigations; basic research.
(e) Investigations of fundamental hydraulic criteria involved in flow of water in irrigated furrows (shallow flow in small, open channels). Object is to develop equations for determining (1) rate of stream advance and recession; (2) depression storage; (3) stream size-storage relationships.
(g) The project has not developed to the point where significant reports may be made.

(4067) SURFACE DRAINAGE IN BOTTOM LAND SOILS AND TOPOGRAPHY.

(b) Arkansas Agricultural Experiment Station.
(c) Asst. Prof. Warren Harris, Dept. Agric. Engr., Univ. of Ark., Fayetteville, Ark.
(d) Experimental and field investigations; applied research.
(e) The purpose of this study is to define the physical requirements for adequate drainage of individual crop rows and of field-sized areas in the bottom land soils and topography of the Miss. River Delta. Shallow surface field ditches are the largest drainage structures considered. Findings are based on the assumption that larger drainage structures must be of a size that will not restrict drainage for undue periods of time.
(g) Depressions and restricted outlets have been found to be the basic causes of inadequate drainage in both individual rows and in shallow surface field ditches. Shallow ditches can be designed and constructed so that with a nominal amount of maintenance, they will form only minor obstructions to mechanized farming operations.
(h) "Surface Field Ditch Studies," by Warren Harris, Paper presented at Southwest Section Meeting of ASAE, Kingston, Okla., Apr. 5-6, 1962.
"Using Computers as a Tool in Land Grading," by Warren Harris, Russell Benedict and John Wait, Arkansas Farm Research, Vol. XI, No. 4, July-August, 1962.
"A Progress Report on a Surface Field Ditch," by Warren Harris, Arkansas Farm Research, Vol. XI, No. 5, September-October, 1962.
Final report on "Row Drainage Studies" in process of publication.

UNIVERSITY OF ARKANSAS, Civil Engineering Dept.

(4068) TURBULENT FLOW IN POROUS MEDIA.

(b) University of Arkansas.
(c) Prof. John C. Ward, Assistant Professor of Civil Engineering, University of Arkansas, Fayetteville, Arkansas.
(d) The project is experimental and theoretical and is classified as basic research with definite practical applications.
(e) Determination of the relationship between permeability of a porous media and its geometric mean size and geometric standard deviation.
(g) The work completed to date on this project consists of deriving and experimentally verifying the following equation for both laminar and turbulent flow in porous media:

$$\frac{dp}{dl} \quad \frac{\mu v}{k} \quad \frac{\rho v^2}{k}, \text{ where}$$

$\frac{dp}{dl}$ is the pressure drop per unit length (dynes/cm /cm),
μ is the absolute viscosity of the fluid (poises),
k is the permeability of the porous media (cm),
v is the macroscopic velocity (cm/sec), and
ρ is the density of the fluid (grams/cc).

Although the units are given in the cgs

system, the equation is dimensionally homogeneous and any consistent set of units (fps, etc.) may be used. At low velocities the equation approximates Darcy's law in that the second term

$$\left(\frac{\rho v^2}{k^{\frac{1}{2}}}\right)$$

becomes numerically insignificant compared with the first term

$$\left(\frac{\mu v}{k}\right).$$

The ratio of the second term to the first term is

$$\frac{vk^{\frac{1}{2}}\rho}{\mu} = R_k, \text{ where}$$

R_K is the Reynolds number for porous media.

(h) Report in preparation.

POLYTECHNIC INSTITUTE OF BROOKLYN

(4071) DIFFUSION OF SUBMERGED JETS.

(b) Laboratory project.
(c) Prof. Matthew W. Stewart, Assoc. Prof. of Civil Engineering, Polytechnic Institute of Brooklyn, 333 Jay St., Brooklyn 1, N. Y.
(d) Experimental, basic research for master's thesis.
(e) To determine the diffusion of a circular water jet discharging vertically upward into a stream of water moving horizontally.
(f) Preliminary study completed.
(g) Colored water was discharged vertically through a 1/2-inch diameter tube into a horizontally moving stream of water. Jet trajectories were determined photographically for various ratios of stream to jet velocity.
(h) Thesis available on loan.

(4484) USE OF RADIOACTIVE TRACERS FOR MODEL STUDIES OF BAFFLED SETTLING BASINS.

(b) Laboratory project, equipment provided by Atomic Energy Commission.
(c) Prof. Paul R. DeCicco, Assoc. Prof. Civil Eng., Polytechnic Institute of Brooklyn, 333 Jay St., Brooklyn 1, N. Y.
(d) Experimental; applied research, teaching facility.

(4485) RADIOLOGICAL TECHNIQUES FOR FLOW MEASUREMENT.

(b) Laboratory project, equipment provided by Atomic Energy Commission.
(c) Prof. Paul R. DeCicco, Assoc. Prof. Civil Eng., Polytechnic Institute of Brooklyn, 333 Jay St., Brooklyn 1, N. Y.
(d) Experimental; applied research, teaching facility.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Engineering Division.

(1548) SPECIAL PROBLEMS IN HYDRODYNAMICS.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. Milton S. Plesset, Calif. Inst. of Tech., Pasadena, California.
(d) Theoretical and experimental; basic research.
(e) Studies of cavitating and noncavitating flow; dynamic behavior of cavitation bubbles; theoretical studies of cavitation damage.
(h) "Experimental Investigations of Three-Dimensional Effects on Cavitating Hydrofoils," by R. W. Kermeen, Jour. of Ship Res., Vol. 5, No. 2, pp. 22-43, Sept. 1961.
"An Analysis of Echoes from a Solid Elastic Sphere in Water," by Robert Hickling, Jour. of Acous. Soc. Vol. 34, No. 10, pp. 1582-1592, Oct. 1962.
"Pulsing Technique for Studying Cavitation Erosion of Metals," by Milton S. Plesset, CORROSION, Vol. 18, No. 5, pp. 181-188, May 1962.
"An Experimental Method for Evaluation of Resistance to Cavitation Erosion," by Milton S. Plesset, Intl. Ass'n. for Hydraulic Res., Inst. for High Speed Mechanics, Tohoku Univ., Sendai, Japan, September 1962.
"Effects of Thermal Conduction in Sonoluminescence," by Robert Hickling, Div. of Eng. and Applied Science, Rep. No. 85-21, Nov. 1962.
"The Pulsation Method for Generating Cavitation Damage," by Milton S. Plesset, Div. of Eng. and Applied Science, Rep. No. 85-22 January 1963.

CALIFORNIA INSTITUTE OF TECHNOLOGY, W. M. Keck Laboratory of Hydraulics and Water Resources.

(2748) RELATION BETWEEN TRANSPORT OF SEDIMENT AND THE HYDRAULIC CHARACTERISTICS OF STREAMS.

(b) Agricultural Research Service, U. S. Dept. of Agriculture.
(c) Prof. V. A. Vanoni and Prof. N. H. Brooks, Calif. Inst. of Tech., Pasadena, Calif.
(f) Experimental work completed January 1961.
(h) "On the Relation between Fall Velocities and Sieve Diameter Distributions of Sand Grains," by John F. Kennedy and Robert C. Y. Koh, Journal of Geophysical Research, Vol. 66, No. 12, pp. 4233-4246, Dec., 1961.

(3669) FLUIDIZATION OF SAND BEDS BY UPWARD FLOW.

(b) U. S. Public Health Service (Research Grant).
(c) Prof. N. H. Brooks, Calif. Inst. of Tech., Pasadena, California.
(d) Experimental thesis project.
(e) When a bed of sand is lifted and expanded by an upward flow (the "quick" condition), it is really not an expanded porous medium, as previously described and analyzed by other investigations, but actually it becomes a thick suspension. The particles move freely, sometimes generating large overturning eddies in the fluid. These phenomena are being investigated in a one-foot square vertical lucite tank, 6-feet high. Studies of large expansions integrate this work with the phenomenon known as hindered settling in dilute suspensions.
(f) Project completed.
(h) "Suspensions of Granular Particles Generated by an Upward Flow," Ph.D. thesis by Francis Clay McMichael, Dec., 1962.

(3670) TURBULENCE AND PARTICLE ENTRAINMENT IN SETTLING TANKS.

(b) U. S. Public Health Service.
(c) Prof. Vito A. Vanoni, Calif. Inst. of Tech., Pasadena, California.
(d) Experimental research.
(e) Flow in a settling tank is simulated by introducing water with a low turbulence level and uniform velocity into a flume 15 feet long with the bed covered by a thin layer of sediment. As the flow proceeds into the flume, a boundary layer develops and becomes progressively thicker. The entrainment of particles is observed visually and the corresponding shear stress is deduced from measured velocity profiles.
(f) Experiments have been completed and the report is being prepared.
(g) Data on critical shear stress for entraining fine sand particles of diameters of 0.1 mm and smaller have been observed.

(3671) EVALUATION OF FORMULAS FOR THE TRANSPORT RATE OF SEDIMENT BY ALLUVIAL STREAMS.

(b) Laboratory project.
(c) Prof. Vito A. Vanoni, Calif. Inst. of Tech., Pasadena, Calif.

(d) Analytical research using published data.
(e) The sediment discharge calculated by several well-known formulas is compared with actual measured sediment discharges in natural streams. The results are presented as graphs of sediment discharge against water discharge.
(f) Project is continuing.

(4074) ENERGY DISSIPATOR FOR SEWAGE FLOWING INTO AN OCEAN OUTFALL.

(b) Holmes and Narver-Montgomery (Consulting Engineers for City of San Diego Sewerage Project).
(c) Prof. N. H. Brooks, Calif. Inst. of Tech., Pasadena, California.
(d) Hydraulic model investigation.
(e) A drop structure for sewage effluent is required between the sewage treatment plant (el. 95 feet above sea level) and ocean outfall. Since discharge goes into a closed ocean outfall pipe 2.3 miles long, air entrainment must be minimized over full range of operation (flow, 60-600 cfs and head drop, 90-10 feet). Recommended solution includes a large vortex with vertical axis.
(f) Project is completed.
(h) Vortex Energy Dissipator for San Diego Ocean Outfall - Laboratory Invesvestigations.

(4075) MECHANICS OF FLOW IN SAND-BED CHANNELS AT VERY LOW RATES OF SEDIMENT TRANSPORT.

(b) National Science Foundation.
(c) Prof. V. A. Vanoni or N. H. Brooks, Calif. Inst. of Tech., Pasadena, California.
(d) Experimental and theoretical research.
(e) Observations are made of the development of dunes with time on a sand bed with flows which produce slow rates of sediment transport and of the resulting changes in flow resistance as the dunes grow.
(f) Project is continuing.

(4076) PRECISION TILTING FLUME.

(b) National Science Foundation.
(c) Prof. Vito A. Vanoni and Prof. Norman H. Brooks, Calif. Inst. of Tech., Pasadena, California.
(d) Development of facilities.
(e) The flume which is to be 130 feet long, 3.5 feet wide, and 1.75 feet deep will be mounted on a rigid supporting structure carried on jacks. Water will be circulated by pumps with variable speed drives for controlling the flow rate. The slope of the flume can be adjusted continuously without interrupting an experiment, up to a maximum of 2 percent. The flume system will be able to produce programmed unsteady flow and will be equipped with convenient recording equipment for observing such flows. It is designed as a general purpose facility for studies of open channel flow problems such as sediment transportation, boundary layers, and wave propagation in shear flow.
(g) The flume is being manufactured and assembled.

(4561) DYNAMICS OF DENSITY-STRATIFIED RESERVOIRS.

(b) U. S. Public Health Service (research grant).
(c) Prof. D. R. F. Harleman and Prof. Norman H. Brooks, Calif. Inst. of Tech., Pasadena, Calif.
(d) Basic research, experimental and theoretical.
(e) The withdrawal of liquid from a reservoir with the density of liquid increasing from surface to bottom is studied experimentally in a tank about 1 foot deep. This problem is also being studied theoretically with the aid of electronic computers.

UNIVERSITY OF CALIFORNIA, Division of Agricultural Sciences, Department of Irrigation and Soil Science.

Inquiries concerning the following projects should be addressed to Professor A. F. Pillsbury, Department of Irrigation and Soil Science, University of California, Los Angeles 24, California.

(27) HYDROLOGY OF WATER SUPPLIES IN CALIFORNIA.

(b) Laboratory project cooperative with Pacific Southwest Forest and Range Experiment Sta., USFS, and with College of Engrg., Univ. of Calif. Los Angeles; coordinated with work of Dept. of Irrigation, Univ. of Calif., Davis, California.
(d) Experimental; applied research.
(e) Work now concerned with: (1) Subsurface movement of moisture; (2) surface treatments affecting infiltration of precipitation; and (3) detention of precipitation by surface litter and effect upon infiltration.
(g) Many watershed soils have been found to be hydrophobic - difficult to wet. Procedures to determine the contact angle between the soil and water have been developed to characterize this property. The effects of contact angle on movement of water and through soil have been evaluated in the laboratory and in the field. Aqueous resinous spray solutions for surface soil stabilization are being developed and evaluated, particularly as regards maintenance of infiltration rates. The relation of dry creep to watershed debris production is being studied. The characteristics of subsurface lateral moisture movement are under investigation. The effect of runoff detention by ground litter is being further evaluated.
(h) "Effects of Vegetation Manipulation on the Disposition of Precipitation on Chaparral-Covered Watersheds," by A. F. Pillsbury, R. E. Pelishek, J. F. Osborn, and T. E. Szuskiewicz. Jour. Geophys. Res. 67: 695-702. 1962.
"New Aqueous Resinous Soil Stabilizers," R. J. Pence, J. Letey, R. E. Pelishek, J. F. Osborn. Calif. Agriculture, March 1962, pp 14, 15.
"Measurement of Liquid-Solid Contact Angles in Soil and Sand," by J. Letey, J. F. Osborn, and R. E. Pelishek. Soil Science 93: 149-153. 1962.
"Effect of Wetting Agents on Irrigation of Water Repellent Soils," by J. Letey, N. C. Welch, R. E. Pelishek, and J. F. Osborn. Calif. Agriculture, Dec. 1962, pp. 12, 13.
"Residual Soil Moisture Below the Root-Zone in Southern California Watersheds," A. F. Pillsbury, J. F. Osborn, and R. E. Pelishek, Jour. Geophys. Res., Jan or Feb., 1963.

(1303) HYDRAULIC CHARACTERISTICS OF IRRIGATION DISTRIBUTION SYSTEMS.

(b) Laboratory project, cooperative with College of Engrg., Univ. of Calif., Los Angeles 24, California.
(d) Basic and applied research.
(e) Work with model low pressure pipe system to study hydraulic transients occurring with automatic controls has been completed.
(f) Work will be completed with filing of Ph.D. Dissertation by graduate student.

(1058) SOIL PHYSICAL CONDITIONS IN RELATION TO IRRIGATION.

(b) Laboratory project, cooperative with College of Engrg., Univ. of Calif., Los Angeles 24, California.
(d) Experimental; applied research.
(e) Present work concerned largely with microscope techniques with use of certain solvents to characterize soil structure as affected by the chemical nature of the irrigation water

applied.
(f) In early stages of work.

(2504) DYNAMICS OF SOIL WATER FLOW TOWARDS AND INTO SUBSURFACE DRAINAGE FACILITIES.

(b) Laboratory project, cooperative with College of Engrg., Univ. of Calif., Los Angeles 24, California.
(d) Experimental; applied research.
(e) Present work concerns (1) Reliability of spot techniques for determination of hydraulic conductivity; (2) relation of water table recession to theory, (3) drainage simulation in shallow soils; relating water table height to drain discharge; (4) drainage simulation in layered soils; and (5) criteria for factors contributing to excessive soil-water.
(h) "Simulation of Drainage in Homogeneous Shallow Soil," (AGU Western Natn'l. Meeting, UCLA, Dec. 27-29, 1961), by J. D. Isherwood.
"Mathematical Models of Flow in Porous Media, II, Simulation of Tile Drainage in a Stratified Soil: (AGU Eastern Nat'l. Meeting, Kansas City, Mo. Nov. 15, 1962), by J. D. Isherwood.
"Comparing Hydraulic Conductivity Values Using the Ponded Water Theory and an Auger Hole Method: by Wm. R. Johnston, John Letey, and A. F. Pillsbury. (ASAE Winter Meeting, Chicago, Dec. 11-14, 1962.).

UNIVERSITY OF CALIFORNIA, College of Engineering, Hydraulic Laboratory.

Inquiries concerning the following projects, except when otherwise indicated, should be addressed to Prof. J. W. Johnson, Dept. of Engineering, Hydraulic Laboratory, Hesse Hall, University of California, Berkeley 4, California.

(529) SAND SOURCES RESEARCH.

(b) Beach Erosion Board, Department of the Army, Washington, D. C.
(d) Experimental and field observations
(e) Purpose of this project is to study origin and movement of sand on beaches in vicinity of San Francisco and north along the coast to the Oregon border. The project consists of periodic measurements of beach profiles, and mechanical, mineralogical and radioactive analyses of samples of sand. The project thus supplies basic data on the regimen of Northern California Beaches and gives information on the pattern of movement of sand on the beaches. Such information is desirable for effective measures for harbor control and beach erosion.
(f) Completed
(h) "Beaches in Northwestern California," by David T. Snow, Univ. of California, Inst. of Engin. Res., Series 14, Issue 25, Aug. 1962.

(1554) SEA WATER CONVERSION RESEARCH.

(b) State of California.
(c) Prof. Everett D. Howe, Coordinator Sea Water Conversion Research, University of Calif., 1301 South 46th Street, Richmond, California.
(d) Experimental, theoretical, field investigation and pilot plant; basic research, applied research, design, and operation.
(e) The purpose of this project is to discover whether there is available any method for the large-scale, low-cost demineralization of sea water. The project includes a number of investigations, of which the following have been active during 1961-62: (1) Multiple effect rotating evaporator; (2) evaporation by immiscible fluid heat transfer; (3) vacuum flash distillation (low temperature difference method); (4) solar distillation; (5) electrodialysis tests; (6) freeze-separation; (7) ion exchange; (8) biological studies; (9) capillary control of vapor transfer gaps; (10) reverse osmosis pilot plant; (11) thermodynamic and economic analysis; (12) experimental heat transfer studies; (13) transport phenomena near a liquid-vapor interface; and (14) fundamental studies of corrosion processes. Investigations are being carried on both at Berkeley and at Los Angeles.
(g) Detailed results may be obtained from the progress reports and publications listed under (h) below. This project has been active since 1951-52 and previous summaries have listed all reports prior to July 1961.
(h) The following reports and publications have been issued during the period since July 1961 and summarize the work to date:
UNIVERSITY OF CALIFORNIA AT LOS ANGELES:*
"Studies of Liquid Film Flow and Evaporation with Reference to Saline Water Distillation," by W. Unterberg, Department of Engineering Report No. 61-26, October 1961.
"Saline Water Research, June 1961, Progress Summary," Department of Engineering Report No. 61-37, September 1961.
"Sea Water Demineralization by means of a semipermeable membrane," by S. Loeb, Dept. of Engineering Report No. 61-42, August 1961.
"Transient Behavior of the Electrical Double-Layer of Stressed Metals in Electrolytes," by K. Nobe, Department of Engineering Report No. 61-56, August 1961.
"Determination of Coefficients for Thermodynamic Equations for Determining the Properties of Sea Water, Particularly Vapor Pressure," by C. Gastaldo, Dept. of Engrg. Report No. 61-80, February 1962.
"Effect of Stress on the Electrode Potential of Silver, Steel, and Brass in Aqueous Solutions," by K. Nobe and Swie-in Tan, Dept. of Engineering Report No. 62-12, March 1962.
"Sea Water Demineralization by means of a Semipermeable Menbrane," by S. Loeb, Dept. of Engineering Report No. 62-26, June 1962.
"Saline Water Research June 1962 Progress Summary," Department of Engineering Report No. 62-33, July 1962.
"Effect of Illumination of the Electrode Potential of Copper and Silver Single Crystals in Aqueous Solutions," by K. Nobe and D. A. Chance, Department of Engineering Report No. 62-35, August 1962.
"Effect of Monochromatic Illumination on the Electrode Potential of Copper and Tin in Aqueous Solutions," by H. A. Arbit and K. Nobe, Department of Engineering Report No. 62-40, August 1962.
"Sea Water Demineralization by Means of a Semipermeable Membrane," by S. Loeb, Dept. of Engineering Report No. 62-41, August 1962.

UNIVERSITY OF CALIFORNIA AT BERKELEY:**
"Condensing Heat Transfer in Steam-Air Mixtures in Turbulent Flow," by P. B. Stewart et al, Institute of Engineering Research Series 75, Issue 25, November 1961.
"Performance of Greenhouse Solar Stills," by L. H. MacLeod, and H. W. McCracken, Inst. of Engineering Research Series 75, Issue 26, November 1961.
"Correlation of the Effects of Temperature, Geometry, and Heat Capacity of the Performance of a Single-Effect Solar Distiller," by L. H. MacLeod, and H. W. McCracken, Inst. of Engineering Research Series 75, Issue 27, November 1961.
"Salt Water Demineralization with a Modified Aquafresh Electrodialytic Stack," by P. M. Rapier et al., Inst. of Engineering Research Series 75, Issue 28, May 1962.
"Saline Water Demineralization by Electrodialysis with Components Manufactured by Ionics, Inc.," by P. M. Rapier et al., Inst. of Engineering Research Series 75, Issue 29, August 1962.
"Berkeley Progress Report for the Year Ending June 30, 1962," Inst. of Engineering Research Series 75, Issue 30, August 1962.
"Condensation Coefficient of Water," by K. Nabavian, and L. A. Bromley, Water Resources

Center Contribution No. 62, October 1962.
"Desalting Water," by E. D. Howe, International Science and Technology, April 1962, pp. 47-52.
"Saline Water Conversion," by E. D. Howe, Proceedings Paris Symposium, UNESCO, Arid Zone Research, Vol. XVIII, pp. 271-97, 1962.
"Fresh Water from Salt Water," by E. D. Howe, New Scientist, Vol. 13, No. 271, June 1962, pp. 196-199.
*Requests for copies should be directed to: Institute of Industrial Cooperation, Dept. of Engineering, Univ. of California, Los Angeles, California.
**Requests for copies should be directed to: Sea Water Conversion Laboratory, Univ. of Calif., 1301 South 46th St., Richmond, Calif.

(1823) THE MECHANICS OF BOTTOM SEDIMENT MOVEMENT WITH OSCILLATORY WAVES.

(b) Beach Erosion Board, U. S. Army, Washington, D. C.
(d) Experimental, basic research.
(e) To obtain experimental information on the criterion for initial and general movement of bottom sediment by wave action. Prototype conditions of the relative motion of water and bed were simulated by use of an oscillating plate in still water.
(g) The experimental velocity distribution law has been used to determine the local lift acting on the grains forming the bed. Because of the turbulent structure of the boundary layer, this lift force has a rapidly varying component which was assumed to have a normal distribution. An expression has been derived which determines the probability of motion of the individual grain. The constants contained in this expression will be evaluated from experimental data which are now being analyzed.

(2261) WAVE REFRACTION RESEARCH.

(b) Beach Erosion Board, Department of Army, Washington, D. C.
(c) Prof. R. L. Wiegel, Assoc. Prof. of Civil Engrg., University of Calif., Berkeley, Calif.
(d) Experimental; basic research.
(e) Laboratory studies are being made of the refraction and some (diffraction and reflection) phenomena of water waves. Special attention is being given to the "Mach stem" phenomenon.
(f) Completed.
(g) In shallow water the velocity of a water gravity wave depends upon the depth of water as well as upon the length of the wave. When it travels in shoaling water it bends. This refraction changes the wave height and direction. Powerful graphical and analytical tools are available for use by the engineers; however, there is an almost complete lack of evidence as to their accuracy. The purpose of this contract has been to perform laboratory experiments to check the validity of the techniques used in practice. The first series of tests were performed in a ripple tank; these showed that the techniques were fairly reliable from a practical standpoint. A series of tests were made in a model basin 150 feet by 64 feet by 2 1/2 feet deep. The results of these tests have been published. Tests have been conducted on the formation of secondary wave crests as periodic waves pass into shoal water, and the results have been found to compare favorably with theory. Studies have been made of the non-reflecting characteristics of waves incident to a steep slope, large plane angle shore, and the results presented in a report. Additional studies have been made of the "Mach stem" phenomenon in the presence of a curved, and a wavy vertical impervious wall, and in the presence of a sloped pervious wall. Studies are being made of the refraction and short-crested wind generated waves in the laboratory.
(h) "Solitary Wave Behavior at Concave Barriers" by Gunnar Sigurdsson and R. L. Wiegel, Univ. of Calif., IER, Tech. Rept. 89-7, Berkeley, Calif., 18 pp., April, 1962.
"Effect of Bottom Slope on Wave Diffraction" by Ismail Mobarek, M. S. Thesis in Civil Engineering, and IER, Tech. Rept. 89-8, Univ. of Calif., Berkeley, Calif., 88 pp., 1962.
"Diffraction of Periodic Waves Along a Vertical Breakwater for Small Angles of Incidence" by Arne Hasle Nielsen, M.S. Thesis in Civil Engineering and IER Tech. Rept. 89-9, Univ. of Calif., Berkeley, Calif., 63 pp., 1962.

(2265) FORCES ON ACCELERATED CYLINDERS.

(b) Laboratory project.
(c) Prof. A. D. K. Laird, 109 Mechanics Bldg., Univ. of California, Berkeley 4, Calif.
(d) Experimental and theoretical, basic research.
(e) Measurement and prediction of drag coefficients and flow configurations about cylinders during accelerated motion in fluids as related to wave forces as cylinders including effects of support flexibility.
(h) "Eddy Forces on Rigid Cylinders," by A.D.K. Laird, Journal Waterways and Harbors Div., Proc. ASCE, Vol. 87, No. WW4, Nov. 1961.
"Water Forces on Flexibile Oscillating Cylinders," by A.D.K. Laird, Journal Waterways and Harbors Div., Proc. ASCE, Vol. 88, No. WW3, Aug. 1962.
"Groups of Vertical Cylinders Oscillating in Water," by A.D.K. Laird and R. P. Warren, Proc. ASCE (in press).

(2505) EFFECT OF SEDIMENT DISTRIBUTION IN STREAM CHANNELS.

(b) University project.
(d) Experimental; basic research.
(e) Alluvial flows in channels with artificially secured banks are studied systematically for their tendency to meander as expressed by the development of alternate bars. It is the aim of this study to develop criteria for stability.
(f) Experimental work concluded.
(g) The important parameters seem to be the Froude's number, the depth-width ratio and the size and uniformity of the bed sediment. The uneven distribution of friction between banks and bed is of prime importance.
(h) "Development of Bed Roughness in Alluvial Channels," by Hsieh W. Shen, Jour. of the Hydraulics Division, Proc. ASCE, Vol. 88, HY3, pp. 45-58, May 1962.

(2753) HYDRAULIC BREAKWATER.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. R. L. Wiegel, Assoc. Prof. of Civil Engrg., Univ. of Calif., Berkeley 4, Calif.
(d) Experimental; applied research.
(e) Determination by model tests of the mechanisms by which hydraulic breakwaters dampen water gravity waves.
(f) Completed.
(g) Three dimensional tests in a model basin show that the effect of wave refraction due to the currents generated by the hydraulic breakwater is of primary importance. For certain conditions the area in the lee of the breakwater can be made to be almost free of waves, while for other conditions the waves behind the breakwater will be higher than if there were no hydraulic breakwater in operation. A series of model sizes have been used and a definite scale effect observed. Tests have been completed in connection with the measurement of the currents generated by the jets and then the effect of the currents on the waves, the purpose being to find out in which portion of the mechanism the scale effect occurs. It was found that the scale effect occurred in the orifice.

The results have been published. Tests have been completed on the effect of hydraulic breakwaters on wind generated waves, and it was found that the short period components of such a wave system were damped, allowing the long period wave components to get past the breakwater.

(h) "Attenuation of Wind Waves by a Hydraulic Breakwater" by John A. Williams and R. L. Wiegel, Proc. Eighth Conf. on Coastal Engrg., Council on Wave Research, The Engineering Foundation, Berkeley, California, 1963.

(3022) FLOATING BREAKWATER.

(b) U. S. Navy Civil Engineering Laboratory.
(c) Prof. R. L. Wiegel, Assoc. Prof. of Civil Engineering, University of California, Berkeley, California.
(d) Analytical and experimental; applied research.
(e) Analytical and experimental studies of new concepts of floating breakwaters.
(f) Completed.
(g) Several new concepts have been investigated. One of these systems consisted of a series of long plastic tubes (slightly buoyant)connected side by side and filled with water. The effectiveness of the system was remarkable for wave lengths of the order of one-half the tube length, or less. Additional work has been done with large plastic bags filled with water with the same results. Small scale laboratory studies have been completed, including the measurement of forces in the mooring lines. Medium scale tests in San Francisco Bay have been completed.
(h) "Hovering Breakwater" by R. L. Wiegel, H. W. Shen, and J. D. Cumming, Journal Waterways and Harbors Div., Proc. ASCE, Vol. 88, No. W W 2, pp. 23-50, May, 1962.

(3384) SAND MOVEMENT BY WIND.

(b) Beach Erosion Board, Dept. of the Army, Washington, D. C.
(d) Experimental.
(e) Laboratory wind tunnel tests were made to develop a relationship for sand transport as a function of wind speed, sand size and sand moisture. Calibration of sand traps for possible field use also was made. Field sampling of the major California dune areas was made to determine the general character of sand being transported under natural conditions.
(h) "Sand Movement by Wind" by Pierre-Yves Belly, Univ. of California Inst. of Engineering Research, Series 72, Issue 7, July 1962.

(3385) ELECTRIC FLOOD MODEL.

(b) U. S. Corps Engineers, Kansas City Dist.
(d) Experimental; design and development.
(e) Using analog model techniques a simulator for the Kansas River and its tributaries is being developed. Purpose is to provide a rapid and convenient means of estimating the effects of reservoir operation and rainfall distribution on flood stages. All pertinent hydraulic variables will be under operator's control, and a flood routing procedure completed each 1/60 second.
(h) "Analog Models for Flood Control Systems," by J. A. Harder, Journal of the Hydraulics Div., Proceedings ASCE, Vol. 88, No. HY2, March 1962.

(3386) SUBSURFACE SALINITY.

(b) Laboratory project.
(d) Analytical and experimental; basic research.
(e) This investigation is concerned with the dynamics of the fresh-salt water interface in flow through porous media. Effects of non-steady flows and dispersion will be considered.
(f) Completed.
(g) Experimental measurements in a parallel plate model are being made for drainage of underlying saline water in irrigated land.
(h) "Seepage of Saline Water in Delta Lowlands," by H. Marcus, D. E. Evenson, and D. K. Todd, Water Resources Center Contribution No. 53, 70 pp., 1962.

(3673) JET PUMP FOR SEDIMENT.

(b) Pacific Coast Engineering Co.
(d) Experimental design.
(e) The use of a jet pump as a booster pump at the end of the ladder of a suction dredge is studied.
(f) Initial design study completed. Investigation continuing on sand erosion effects.
(g) Erosion rates have been substantially reduced by design modifications without sacrificing sand pumping performance.

(3674) INVESTIGATIONS OF BOUNDARY LAYERS ALONG FLUID INTERFACES.

(b) National Science Foundation.
(d) Experimental, basic research.
(e) To investigate the possibility of reducing friction by artificially increasing the stability of the flow.
(g) The literature survey shows that very little work has been done on the study of boundary layers along interfaces as such. Analogy with boundary layers along solid and elastic boundaries suggests that the layer always begins as a laminar flow. This laminar flow finally becomes unstable and the instability may either lead to turbulence or to waves on the interface or to both. It appears that two different characteristics govern the onset of waves and turbulence. The basic problem appears to be the formulation of the two characteristics and of their interaction. It appeared to be impossible to find a general solution for a complicated problem of this type. Instead, work was begun on a number of individual specific problems to gather information which eventually may lead to a more general solution. 1. Analytical solutions are being developed for comparison with measurements of velocity and pressure distributions throughout cylindrical liquid bubbles and surrounding liquids in vertical tubes. The effects of interfacial tension on interfacial boundary layers is included. Preliminary tests have been made of the energy and entropy extremum principles as flow type criteria for vertical laminar annular oil-water flow. 2. A program has been started to measure shear values at the interface between water and other fluids and quasi-fluids. 3. Studies have been made of the flow of air over water, with the water being as much as 25 degrees F cooler and warmer than the air to find the effect of air-water temperature difference and wave formation. Statistical techniques (Tukey's) have been used to study the relationship between the phase of air pressure time history and water surface time history in order to determine the validity of Miles' stability theory. 4. In order to permit the simultaneous measurement of several variables in a form that will facilitate their correlation, a digital data recording system has been developed. It records 8 channels with a precision of 11 bits on magnetic tape in a format compatible with the IBM 7090 and at rates up to 7,500 samples per second.

(3675) CLAY TRANSPORT.

(b) National Science Foundation.
(d) Experimental and theoretical; basic research.
(e) A continuation and generalization of (3382)to various types of clays. The effect of flocculation and concentration

of clay on flows, and the deposition and scour of these sediments are studied systematically.

(g) Viscometer measurements on suspensions of clayey sediment from 5 sources are yielding rheological characteristics of sediment flocs and floc aggregates, including shear strengths. Rheological measurements on consolidating sediments are also in progress. A 1000-ft. channel and circulating system is completed and instrumented to determine friction factors of flowing sediment suspensions in order to study flow-bed interaction during deposition and scour. This work is in progress.

(3676) ARTIFICIAL RECHARGE OF GROUND WATER.

(b) Laboratory project.
(d) Analytical and experimental; basic research.
(e) This investigation is concerned with the unsteady flow of water from recharge areas into homogeneous and non-homogeneous aquifers.
(f) Completed.
(g) Experimental measurements in a translucent model have been made of unsteady flows from recharge areas percolating to impermeable subsurface layers.
(h) "Hydraulics of Artificial Recharge in Non-homogeneous Formations," by K. R. Marmion, Water Resources Center Contribution No. 48, Univ. of California, Berkeley, 88 pp., 1962.

(3677) ANNULAR NOZZLE GROUND EFFECT MACHINE.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. R. L. Wiegel, Dept. of Civil Engrg., Univ. of Calif., Berkeley, California.
(d) Experimental; applied research.
(e) Airborne vehicles supported by annular jets have a lift considerably in excess of that due to the jet momentum when operating in a region close to the ground. The dynamic lift, bending moment, wave resistance, base pressures, and intake pressures are being measured for such a vehicle operating over both calm water and water with surface gravity waves present.
(g) Much information has been obtained on the response of the model vehicle to surface water waves. In regard to wave-making resistance a noticeable nonuniformity of jet momentum has been measured.
(h) "Research on Annular Nozzle Type Ground Effect Machine Operating Over Water: Preliminary Report" by R. L. Wiegel, D. O. Horning, J. Cumming, G. Reichert, G. Sigurdsson, W. M. Linder, and M. Price, Univ. of Calif., IER Tech. Rept. 187-1, Berkeley, Calif., 95 pp., March 1962.
"Research on Annular Nozzle Type Ground Effect Machine Operating Over Water: Pressure Transducer" by D. O. Horning and J. D. Cumming, Univ. of Calif., IER Tech. Rept. 187-2, Berkeley, Calif., 20 pp., March 1962.
"Research on Annular Nozzle Type Ground Effect Machine Operating Over Water: Description of Wake Patterns" by M. Moser, Univ. of Calif., IER Tech. Rept. 187-4, Berkeley, Calif., 26 pp., March 1962.
"Research on Annular Nozzle Type Ground Effect Machine Operating Over Water: Non-uniformity of Jet Momentum" by Gunnar Sigurdsson, Univ. of Calif., IER Tech. Rept. 187-5, Berkeley, Calif., 28 pp., March 1962.

(3678) OCEAN SEWER OUTFALLS.

(b) U. S. Public Health Service.
(d) Basic research.
(e) This study is concerned with the various phenomena involved in the diffusion of sewage at the discharge end of an ocean sewer outfall.
(g) Phases investigated to date have involved mixing resulting from jet action and surface wind waves. The effects of wind and waves on surface dispersion have been studied in a laboratory wind-wave flume. Measurements of the shape of the dispersion plume have been obtained under various wind and wave conditions, and the influence of some of the wave characteristics on the eddy diffusion coefficient has been noted.
(h) "Jet Discharge into a Fluid with a Density Gradient" by W. E. Hart, Jour. Hyd. Div., Proc. ASCE, Vol. 87, No. HY6, pp. 171-200, Nov. 1961.
"Mixing and Dispersive Action of Wind Waves" by Frank D. Masch, Ph.D. Thesis in Civil Engineering (also IER Tech. Rept. 138-6), Univ. of Calif., Berkeley, Calif., 106 pp., Nov. 1961.
"Observations on Vertical Mixing in a Closed Wind Wave System" by Frank D. Masch, Univ. of Calif., IER Tech. Rept. 138-7, 24 pp., Jan. 1962.

(4077) NEARSHORE SEDIMENT MOVEMENT.

(b) National Science Foundation.
(d) Experimental (laboratory and field).
(e) The objective of this investigation is to determine the overall sand balance for selected localities and to explain changes quantitatively. Special consideration is given to sediment conditions at the mouths of large sediment-carrying rivers, submarine canyon heads, and major headlands.
(h) "Transportation of Coastal Sediments" by A. M. Kamel, Ph.D. Thesis, Univ. of Calif., Jan. 1962.
"Littoral Studies near San Francisco using Tracer Techniques," by A. M. Kamel, Beach Erosion Board Tech. Memo. No. 131, 1962.

(4078) BEACH BACKGROUND RADIOACTIVITY.

(b) Atomic Energy Commission, Washington, D. C.
(d) Field observations and theoretical considerations.
(e) Purpose of project is to measure variations in background radioactivity of beaches along the California Coast with the object of determining the normal background, its seasonal variations and variation in radioactivity from place to place at any one time.
(g) The dilution in concentration of naturally radioactive sediments away from a source has proved of value in establishing the predominant direction of littoral drift.
(h) "The Relationship between Watershed Geology and Beach Radioactivity," by J. R. Byerly, M. S. Thesis in Engin., Univ. of California, January 1963.

(4080) FLOW THROUGH ANISOTROPIC POROUS MEDIA.

(b) Laboratory project.
(d) Analytical and experimental; basic research.
(e) This study is concerned with the directional permeabilities in anisotropic porous media. Analytic results are being compared with measurements on an electric analog.
(f) Completed.
(g) Flow directions are evaluated in terms of directional permeabilities and hydraulic gradients.
(h) "Directional Permeability in Anisotropic Porous Media," by H. Marcus and D. E. Evenson, Water Resources Center Contribution No. 31, Univ. of California, Berkeley, 105 pp., 1961.
"The Permeability of a Sample of an Anisotropic Porous Medium," by H. Marcus, Jour. of Geophysical Research (in press).

(4081) RECHARGE OF WASTES IN UNDERGROUND FORMATIONS.

(b) Livermore Radiation Lab., Livermore, Calif.
(d) Experimental; basic and applied research.
(e) This study is designed to evaluate the hydraulics of fluid flow from a surface basin into underlying aquifers. Results are ex-

expected to assist in field studies of disposal of industrial wastes, brines, and radioactive materials.

(h) "Flow from Large Diameter Wells into Unsaturated Confined Aquifers," by D. K. Sunada and D. K. Todd, Hydraulic Laboratory, Univ. of Calif, Berkeley, 78 pp., 1962.

(4082) CAVITATION IN A VENTURI.

(b) Laboratory project.
(c) Prof. H. W. Iversen, Dept. of Mech. Engrg., University of Calif., Berkeley, California.
(d) Experimental and theoretical basic research.
(e) Macroscopic nature of cavitation formation and collapse with inter-relationships of head losses on collapse and with liquids of different vaporization properties.
(g) Tests with water over a 60 degree F - 200 degree F range of temperature are essentially completed.

(4562) ANALYSIS OF NONLINEAR SYSTEMS.

(b) Laboratory project.
(c) Hydraulic Laboratory, Hesse Hall, Univ. of Calif., Berkeley 4, California.
(d) Theoretical; basic research.
(e) Given a sufficiently long record of the input and output of a stationary system that may include nonlinearities, the purpose is to develop a predictor for arbitrary inputs.
(g) Computer program is written that has enabled close prediction of the output of an experimental nonlinear system to a sine wave having an amplitude and frequency well within the limits of the random input used to develop the predictor.
(h) "Nonlinear Analysis of Hydraulic Engineering Systems," by S. L. Jacoby, Ph.D. thesis, Univ. of California, Berkeley, June 1962.

(4563) CLAY-SUSPENSION FILTRATION.

(b) Livermore Radiation Laboratory, Livermore, California.
(d) Experimental; basic and applied research.
(e) Study of the movement of clay suspensions through coarse porous media and through fissured rock.

(4564) FLOW OF SAND-WATER MIXTURES IN PIPES.

(b) University project - thesis project.
(d) Experimental.
(e) To define flow parameters and to design measuring equipment for the two-phase flows.
(g) A piece of experimental equipment has been designed to maintain various sustained flows of water-sand mixtures. Two solutions were investigated for combined flow-rate and concentration meters.
(h) Thesis in preparation.

(4565) MATHEMATICAL MODELS FOR FLOOD ROUTING.

(b) Laboratory project.
(c) Hydraulic Laboratory, Hesse Hall, Univ. of Calif., Berkeley 4, California.
(d) Theoretical; basic research.
(e) Various models are being fitted to experimental floods induced by spillway releases from reservoirs on the Missouri River.

(4566) PROGRESSIVE WAVES AT SPILLWAYS.

(b) Laboratory project.
(c) Hydraulic Laboratory, Hesse Hall, Univ. of Calif., Berkeley 4, California.
(d) Experimental.
(e) Laboratory studies were made of the progressive waves generated downstream from spillways. Spillways studied included the hydraulic pump in both a horizontal and sloping channel and a flip-bucket.
(f) Completed.
(h) "Wave Action at Spillways," by M. M. Abou-Seida, M. S. Thesis in Engineering, Univ. of California, Sept. 1962.

(4567) RAINFALL VARIANCE.

(b) Laboratory project.
(c) Hydraulics Laboratory, Univ. of Calif., Berkeley 4, California.
(d) Theoretical; basic research.
(e) Statistical analysis of long records of hourly rainfall.

(4568) SIGNIFICANCE OF VORTICITY IN TURBULENT FLUID FLOWS.

(b) University project; thesis.
(d) Theoretical.
(e) A basic attempt to define turbulence.
(f) Completed.
(g) Some new characteristics of flows were developed describing the onset and maintenance of turbulence.
(h) "The Significance of Vorticity, Vortex Motion and Dissipation in Turbulent Fluid Flows" by L. F. Mockros, thesis.

(4569) STUDY OF THE PERSISTENT POLYMOLECULAR STRUCTURE OF WATER.

(b) Laboratory project; thesis study.
(d) Basic theoretical and experimental - thesis Ph.D.
(e) The assumption of quasi-permanent structures between the molecules of liquid water is used to explain some of its anomalies.
(f) Completed.
(g) It is shown that several such structure patterns are possible. If one assumes that different patterns exist at different temperatures the anomalies in density, viscosity, etc., can be explained quantitatively.
(h) "A System of Persistent Polymolecular Structures of Liquid Water," by R. B. Krone, 57 pp., May 1962, thesis. Publication in preparation.

UNIVERSITY OF CALIFORNIA, Department of Naval Architecture.

(3026) SHIP RESISTANCE IN UNIFORM WAVES AS A FUNCTION WAVE STEEPNESS.

(b) David Taylor Model Basin, Dept. of the Navy.
(c) Mr. O. J. Sibul, Room 224, Bldg. T-3, Univ. of Calif. Berkeley, California.
(d) Experimental.
(e) A series of experiments were performed to study the effect of width (beam) and the block coefficient of the ship on the added resistance in uniform waves. The following block coefficients were used for Series 60 5-foot models: 0.60; 0.70; 0.80 and a model of DE 1006 with a block coefficient of 0.49. All of the models were towed in waves 3.75; 5.00; 6.25 and 7.50 feet long at seven different wave steepnesses between 0.0146 and 0.0684.

(3029) REPRODUCTION OF RECORDED OCEAN WAVES IN A SHIP MODEL TOWING TANK.

(b) University of California.
(c) Mr. O. J. Sibul, Room 224, Bldg. T-3, University of California, Berkeley, Calif.
(d) Basic and applied research; design.
(e) The work undertaken under this program was the design and construction of a power and control system for the existing wave generator, such that a recorded ocean wave in a desired scale could be reproduced in the towing tank. The system utilizes a magnetic tape input to servomechanism which makes the wave-generator follow a prescribed time-distance curve.
(f) Completed.
(g) A servomechanism controlled wave generator

has been installed. Preliminary testing of the equipment indicates a very satisfactory reproducibility of the wave record from run to run. Some more work will be necessary to achieve a better reproduction of any given wave record in the desired model scale.

(h) "Reproduction of Irregular Long Crested Waves in a Ship Model Towing Tank," by O. J. Sibul; A paper, presented to the 13th Meeting of the American Towing Tank Conference in Ann Arbor, Michigan, September, 1962.

(3685) SHIP SLAMMING LOADS AND HULL RESPONSES.

(b) National Academy of Sciences - National Research Council, Committee on Ship Structural Design.
(c) Prof. H. A. Schade, Room 224, Bldg. T-3, Univ. of California, Berkeley, Calif.
(d) Experimental and theoretical; basic and applied research.
(e) The project involves structural as well as hydrodynamic problems. Only the latter are described here. (1) It will be attempted to determine the virtual mass distribution along the length of a vibrating beam in water (forced vibration as well as impact loading).
(f) Completed.
(g) The beam was fitted into a number of sections(8) of plastic bodies, semi-submerged in horizontal position in water, and forced to vibrate. Vibration frequencies and damping for the first six flectural modes were determined. An impact loading was applied also, to excite the vibrating response.
(h) "Dynamic Response of an Idealized Hull Girdle to Slam-Type Loading," by R. W. Clough and W. M. Maclean. The report will be published by Ship Structures Committee and the National Research Council.

(3686) NON-LINEAR COUPLED SHIP MOTIONS.

(b) David Taylor Model Basin, Department of the Navy.
(c) Prof. John R. Paulling, Jr., Room 224, Bldg. T-3, Univ. of California, Berkeley, California.
(d) Theoretical with some experimental verification.
(e) It has been shown that at certain frequencies of heave or pitch motion of a ship, a rolling motion of large amplitude may arise. This is explained in terms of instabilities of solutions of the equations of motion which include certain non-linear coupling terms.
(g) The relationships between natural frequencies in pitch and roll or heave and roll which lead to unstable rolling motion have been obtained theoretically and verified experimentally. Analog computational techniques have been used in investigating the effect of damping.
(h) "On the Normal Modes of Nonlinear Coupled Ships Motions and their Stability," by W. D. Kinney, University of California IER Series 173, Issue 5, August 1962.

(3687) PRESSURE DISTRIBUTIONS, ADDED-MASS, AND DAMPING COEFFICIENTS FOR CYLINDERS OSCILLATING IN A FREE SURFACE.

(b) Office of Naval Research, Dept. of the Navy.
(c) Professors J. V. Wehausen and J. R. Paulling, Room 224, Bldg. T-3, Univ. of Calif., Berkeley, Calif.
(d) Theoretical and experimental basic research.
(e) A linearized theory is developed for the pressure distributions, added-mass and damping coefficients for horizontal cylinders oscillating vertically with small amplitude while semi-immersed in the free surface of a fluid of uniform depth. Calculated values are compared with values measured in experiments.
(f) Completed.
(g) The measured values and values based on the calculations show similar distinctive behavior.
(h) "Measurement of Pressures, Forces, and Radiating Waves for Cylinders Oscillating in a Free Surface," by J. R. Paulling and R. K. Richardson, University of California, IER Series 82, Issue 23, June 1960.

(4083) DYNAMIC INTERACTION BETWEEN SHIPS.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. J. R. Paulling, Room 224, Bldg. T-3, Univ. of Calif., Berkeley, California.
(d) Theoretical and experimental.
(e) The linearized equations of motion for two ships operating on parallel courses are formulated. Coefficients appearing in these equations are being evaluated by captive model techniques. Analog and digital means of solving the equations are being studied.
(g) Sinusoidal motion generator was used to evaluate velocity and acceleration derivatives for each of the individual models of the ship without the other model being present. Experiments are under way in which interaction forces and moments between two models are measured.
(h) "The Dynamic Problem of Two Ships Operating on Parallel Courses in Close Proximity," by J. R. Paulling and L. Wood, July 18, 1962.

(4084) SHIPS OF MINIMUM RESISTANCE.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. J. V. Wehausen, Room 221, Bldg. T-3, Univ. of Calif., Berkeley, California.
(d) Theoretical applied research.
(e) The usual minimum problem for ship wave resistance fixed the profile and volume and minimizes Michell's Integral among some given class of functions describing the whole ship. Since the theory assumes irrotational flow of an inviscid fluid, it does not take account of the effects of viscosity, e.g., the possibility of a separated boundary layer for certain forms nor of the necessity of fitting a propeller astern. Here one tries to take account of this by fixing the afterbody as one known to be satisfactory, and then allowing only the forebody to vary among a given class of functions.

(4085) EFFECT UPON WAVE RESISTANCE OF THE INITIAL ACCELERATION OF SHIP MODELS.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. J. V. Wehausen, Room 221, Bldg. T-3, University of Calif., Berkeley, Calif.
(d) Theoretical applied research.
(e) An asymptotic expansion for large t is obtained for the wave resistance of a thin ship started from rest and accelerated to a final velocity C_o in a time t . The result indicates an oscillation about the limiting value (Michell's Integral) which is damped like $(t - t_o)^{-\frac{1}{2}}$. The period T is given by $gT/C_o = 8\pi$. A computation is carried through for a simple ship form.

(4570) PRESSURE DISTRIBUTION ON SEMI-SUBMERGED OSCILLATING BODIES.

(b) David Taylor Model Basin, Department of the Navy.
(c) Prof. J. R. Paulling, Room 224, Bldg. T-3, University of California, Berkeley 4, Calif.
(d) Experimental and theoretical.
(e) To determine the response of a floating body in a seaway, it is necessary to know the magnitudes and phases of hydrodynamic forces

and moments acting on this body. In the linearized analysis the total pressure at any point takes the form of two terms: (a) exciting pressure dependent upon the waves only: (b) pressure dependent upon the geometry and motion of the body and independent of the waves. These two terms are being measured on: (1) A prolate spheroid; (2) A ship-like form.
First the models are attached rigidly to the dynamometers, towed in waves and the pressure distribution, total forces and moments measured. Then the models are oscillated sinusoidally in still water and again the pressure distribution, total force and moment measured. The results will be compared with theoretical calculations.

UNIVERSITY OF SOUTHERN CALIFORNIA, Research Foundation for Cross-Connection Control.

Inquiries concerning the following project should be addressed to Dr. K. C. Reynolds, Supervisor, Research Foundation for Cross-Connection Control, University of Southern California, Los Angeles 7, California.

(49) RESEARCH FOUNDATION FOR CROSS-CONNECTION CONTROL.

(b) Laboratory project.
(d) Experimental research and field investigations; basic research.
(e) To determine by proper research the relative value and protection afforded by various backflow prevention devices.
(g) Establishment of standardized laboratory and field test procedures and minimum specification requirements for backflow prevention equipment and continuous evaluation and improvement of such procedures and specifications. Information summarized in "Manual of Cross-Connection Control Recommended Practice."

CARNEGIE INSTITUTE OF TECHNOLOGY, Department of Civil Engineering.

Inquiries concerning the following projects except when otherwise indicated should be addressed to Dr. T. E. Stelson, Dept. of Civil Engineering, Carnegie Institute of Technology, Pittsburgh 13, Pennsylvania.

(2275) FLOW OF LIQUID-SOLID MIXTURES.

(b) Laboratory project.
(d) Analytical and experimental.
(e) Study of the movement of granular material carried in a fluid through closed conduits. Measurements of velocities, energy losses, concentrations and segregated conditions are made.
(h) "Flow Properties of Non-Newtonian Fluids," J. W. Hayden, Ph.D. Thesis, June 1962.

(3203) PRESSURE SURGES IN CLOSED CONDUITS.

(b) Laboratory project - National Science Foundation Fellowship.
(d) Analytical and experimental.
(e) Determination of pipe geometry on the reflection and transmission of pressure surges in closed conduits.
(h) "Generation, Transmission and Reflection of Pressure Surges in Conduits," D. J. Wood, T. E. Stelson, Proceedings of the First Southeastern Conference on Theoretical and Applied Mechanics, 1963.

(3390) MECHANICS OF NON-NEWTONIAN FLOWS.

(b) Laboratory project.
(c) Dr. G. Bugliarello, Dept of Civil Engrg., Carnegie Inst. of Tech., Pittsburgh 13, Pennsylvania.
(d) Analytical and experimental.
(e) Study of energy relationships, velocities and flow structure in non-newtonian flows.
(h) "Derivation of Flow Equations for Sewerage Sludges," by G. Bugliarello. Discussion, J. of the Sanitary Engineering Division, ASCE, Vol. 87, May 1961.
"Non-Newtonian Flows in Hydraulic Engineering," (in Italian with English summary) G. Bugliarello, in: Volume in Honor of Prof. Marzolo, University of Padova, Italy, May 1962.
"Some Considerations on the Analysis and Design of Hydraulic Machinery for Non-Newtonian Fluids," G. Bugliarello, submitted for publication, 1963 Proceedings of the International Association for Hydraulic Research (IAHR).
"On the Similarity between Some Non-Newtonian and Hydromagnetic Flows," M. S. Thesis, R. S. Hyslop, January 1962.

(3689) PHASE SEPARATION EFFECTS IN THE FLOW OF BLOOD.

(b) National Institutes of Health.
(c) Dr. G. Bugliarello, Dept. of Civil Engrg., Carnegie Inst. of Tech., Pittsburgh 13, Pennsylvania.
(d) Analytical and experimental.
(e) Study of the magnitude of the phase separation effect in the flow of blood for vessels of different sizes and configurations, both under steady and pulsating flow conditions.
(h) "High-Speed Microcinematographic Studies of Blood Flow in Vitro," by G. Bugliarello and J. W. Hayden, Science, Vol. 138, No. 3544, Nov. 30, 1962.
"Detailed Characteristics of the Flow of Blood in Vitro," by G. Bugliarello and J. W. Hayden, presented to the 1962 meeting of the Society of Rheology and submitted for publication, Transactions of the Society of Rheology. Abstract in Rheology Bulletin, Vol. 31, No. 2, Fall 1962.
"Phase Separation of a Neutrally Buoyant Rigid-Sphere Suspension in Laminar Flow through a Narrow Rectangular Channel," A. Brandt, M. S. Thesis, January 1962.

(3692) SEPARATION FLOW OF SOLID-LIQUID MIXTURES.

(b) Allegheny County Sanitary Authority.
(d) Experimental and analytical.
(e) In the separation or divergence of flowing liquid-solid mixtures unbalanced concentrations frequently occur in the different channels. Methods are being developed to predict and control the unbalance.
(h) "Grit Unbalance in Sewage Flow Division," Y. Yoshimi and T. E. Stelson, submitted for publication, J. of the Sanitary Engrg. Division, ASCE, December 1962.

(4093) VIBRATORY MOTIONS OF FLOATING BODIES.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental and analytical.
(e) Development of theory for determining wave pattern and virtual mass and damping in the three-dimensional flow field around a shallow ship.
(h) "The Forced Oscillation of Shallow Draft Ships," W. D. Kim, R. C. MacCamy and T. E. Stelson, Report submitted to the Bureau of Ships Fundamental Hydromechanics Research Program, January 1962.

(4094) MOLECULAR DIFFUSION STUDIES BY RANDOM WALK METHODS.

(b) Laboratory project.
(c) Dr. G. Bugliarello, Civil Engineering Dept., Carnegie Inst. of Tech., Pittsburgh 13, Pa.
(d) Analytical.
(e) Development of computer programs for the study of molecular diffusion in a laminar

shear flow using random walk methods.

(h) "A Random Walk Study of Molecular Diffusion in a Convective Flow Field," E. D. Jackson III, M. S. Thesis, March 1962.

(4095) HIGH PRESSURE LIQUID FLOWS.

(b) Laboratory project.
(c) Dr. G. Bugliarello, Dept. of Civil Engrg., Carnegie Inst. of Tech., Pittsburgh 13, Pa.
(d) Experimental.
(e) Study of laminar and turbulent flow of various liquids between concentric cylinders, under pressures up to 15,000 psi.
(h) "Design and Construction of a Concentric Cylinder Apparatus for High Pressure Flow Studies," J. M. Evans III, M. S. Thesis, August 1962.

(4096) FLOW OF SOLID-LIQUID MIXTURES AT BIFURCATIONS.

(b) Laboratory project.
(c) Dr. G. Bugliarello, Dept. of Civil Engrg., Carnegie Inst. of Tech., Pittsburgh 13, Pa.
(d) Experimental.
(e) Study of the effect of bifurcations on the concentration of solid-liquid mixture in the laminar and turbulent flow range in closed conduits.
(h) "The Turbulent Flow of a Neutrally Buoyant Suspension through Bifurcation," G. C. Hsiao, M. S. Thesis, June 1962.

(4571) DESIGN OF A SYNTHETIC COMPUTER LANGUAGE FOR SANITARY ENGINEERING.

(b) U. S. Public Health Service.
(c) Dr. G. Bugliarello, Dept. of Civil Engrg., Carnegie Institute of Tech., Pittsburgh 13, Pa.
(d) Analytical.
(e) Design of a user-oriented computer language leading to a large degree of automation in the area of sanitary engineering and water resources. The first phase of the project is the development of a pilot language for hydrology.
(h) "Toward a Computer Language for Hydraulic Engineering," by G. Bugliarello, Proceedings of the 1961 meeting of the International Association for Hydraulic Research (IAHR). "Electronic Computer Use in Scoping Power Projects," by G. Bugliarello. Discussion, J. of the Power Division, ASCE, Vol. 87, July 1961.

(4572) WATER RESOURCES ENGINEERING.

(b) Laboratory projects.
(c) Dr. G. Bugliarello, Dept. of Civil Engrg., Carnegie Institute of Technology, Pittsburgh 13, Pennsylvania.
(d) Analytical.
(e) Study of various aspects of water resources engineering, with particular emphasis on operational research methods.
(h) "The Water Resources Problem of Haiti," by G. Bugliarello, Carnegie Quarterly, 1961. "Une Revue des Ressources Hydrauliques en Haiti," by H. Jarbath, G. T. Olson and R. D. Silfe, Report, Dept. de l' Agriculture, des Ressources Naturelles et du Developpment Rural. Port-au-Prince, April 1962.

(4573) VIBRATION OF A CIRCULAR CYLINDER IN A FLUID.

(b) Laboratory project.
(c) Mr. J. A. Keane, Dept. of Civil Engineering, Carnegie Institute of Technology, Pittsburgh 13, Pennsylvania.
(d) Theoretical and experimental; basic research for doctoral thesis.
(e) Ascertaining a representation for the functional dependence of the interaction force between vibrating body and the surrounding fluid.

COLORADO STATE UNIVERSITY, Civil Engineering Section.

(55) SNOW COURSE MEASUREMENTS AND FORECAST ANALYSIS.

(b) Soil Conservation Service, Colorado Agric. Experiment Station.
(c) Mr. Jack N. Washichek, Snow Survey Supervisor, Civil Engineering Section.
(d) Field investigations; applied research.
(e) Systematic measurements of depth and water content of snow are being made at high elevations in Colorado and New Mexico mountain areas for the purpose of forecasting the runoff of the principal rivers in the interest of irrigation, power, domestic supplies, and other uses. The use of electrical resistance soil moisture units is being tested to determine a factor of soil moisture deficiency for water supply forecast purposes. Most of the major basins now have two or more soil moisture stations installed. A period of record must follow before any degree of correlation can be accomplished.
(g) Forecasts are now being issued at forty-four gaging stations in Colorado and New Mexico. As forecast procedures improve, additional streams will be forecasted and other areas of potential power and irrigation development will be investigated on the Colorado, San Juan, Animas and Arkansas Rivers.
(h) Colorado Agricultural Experiment Station General Series Papers Nos. 765, 766, 767, and 768 covering monthly snow reports for all of Colorado and New Mexico.
Nine small basin reports and one two-state bulletin covering the South Platte River watershed; Arkansas River watershed; Rio Grande watershed in Colorado; Rio Grande watershed in New Mexico; Dolores River watershed; San Juan and Animas River watershed; Gunnison River watershed; Colorado River watershed; Yampa, White and North Platte River watershed; Lower South Platte River watershed. Supplemental reports are issued January 1, May 15, and June 1.
Summary of all historical data of snow surveys is in the press at the present time. Bulletins on surveys in Colorado after January 1, 1963 will be available.

(821) GROUND WATER FLUCTUATIONS AND THEIR RELATION TO PUMPING.

(b) Colorado Agricultural Experiment Station.
(c) Mr. M. M. Skinner.
(d) Field investigation; applied research.
(e) Semi-annual measurements of the depth to water table in approximately 565 observation wells are presently being obtained. The observation wells are primarily existing irrigation wells in the South Platte and Arkansas River Basins, the High Plains area of eastern Colorado and the San Luis Valley. Electrical Power and Natural Gas Consumption data are compiled and estimates of ground-water pumpage made. The purpose of the project is to detect areas of ground-water depletion and to develop relationships between gross pumpage and respective ground-water reservoir storage volume changes.
(g) Ground-water levels of the spring of 1962 are generally up from the spring of 1961 in the South Platte and Arkansas River Basins and the San Luis Valley. Considerable ground-water pumpage is beginning in the High Plains area of eastern Colorado with some increase in pumping lifts resulting. Reported, electrical-power consumption during 1961 by electrical pumping plants in Colorado amounted to approximately 98,000,000 kilowatt hours for 8765 pumping units.
(h) "Colorado Ground-Water Levels - Spring 1962," by M. M. Skinner, Colorado State University Experiment Station, Civil Engineering Section, Fort Collins, Colorado.
"Operating Characteristics of Ground-Water

Reservoirs Occupying a Trench," by R. E. Glover and M. M. Skinner, Colorado State University, Civil Engineering Section, Fort Collins, Colorado.
"Summary of Electrical Power Used by Irrigation Pumps in Colorado During 1961 as Reported by Power Companies," by M. M. Skinner, Colorado State University, Civil Engineering Section, Fort Collins, Colorado.

(2514) ALLUVIAL CHANNEL HYDRAULICS.

(b) U. S. Geological Survey.
(c) Dr. D. B. Simons, Civil Engineering Section, Colorado State University, Fort Collins, Colorado.
(d) Laboratory investigation; basic research.
(e) A laboratory study of resistance to flow, sediment transport and related problems in alluvial channels.
(g) Five different bed materials ranging in size from 0.19 millimeters to 0.93 millimeters have been studied. The forms of bed roughness which occur and their relation to sediment transport and resistance to flow have been studied and described. The effect of large concentrations of suspended fine sediment (clay), the viscosity of the water and the specific weight and gradation of the bed material on the mechanics of flow and on sediment transport in alluvial channels have also been investigated.
(h) "A Preliminary Study of the Effect of Gradation of Bed Material on Flow Phenomena in Alluvial Channels," by Niwat Daranandana, Ph.D. Dissertation, Colorado State Univ., May 1962.
"Control Structures in Alluvial Channels," by Frederick C. Stepanich, M. S. Thesis, Colorado State University, October 1962.
"An Investigation of Total Sediment Discharge in Alluvial Channels," by Feng-Ming Chang, Ph.D. Dissertation, Colorado State Univ., December 1962.
"Electrokinetic-Probe Response to Vortex-Street Frequency," by Hsing Chuang, paper to be submitted to the Journal of Fluid Mechanics, Colorado State University Civil Engineering Report No. CER62HC55, September 1962.
"Stability of Alluvial Channels," by Francis M. Henderson, Discussion by D. B. Simons, published in the Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, Vol. 88, No. HY4, July 1962.
Closure to "Forms of Bed Roughness in Alluvial Channels," by D. B. Simons and E. V. Richardson, published in the Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, Vol. 88, No. HY4, July 1962.

(2760) METEOROLOGICAL OBSERVATIONS.

(b) Colorado Agricultural Experiment Station and U. S. Weather Bureau.
(c) Mr. Lewis O. Grant, Civil Engineering Section, Colorado State University, Fort Collins, Colo.
(d) Field investigation; basic research.
(e) Meteorological observations are being obtained to establish long-time records of climatological elements and to support current experiment station research which is weather dependent. The elements observed are: Maximum and minimum temperature and wet and dry bulb temperatures every two hours; soil temperatures at 3, 6, 12, 24, 36, and 72 inches; wind direction and velocity at 15 inches and 65 feet above ground; barometric pressure; evaporation from a free water surface; surface water temperature; precipitation; cloud cover; dew and frost.
(g) Complete meteorological observations have been made throughout the year.

(2770) TURBULENCE STUDIES IN LIQUID USING ELECTROKINETIC PHENOMENON.

(b) National Science Foundation.
(c) Dr. J. E. Cermak, Civil Engineering Section, Colorado State University, Fort Collins, Colorado.
(d) Experimental research; basic research, doctoral thesis.
(e) The primary objective of the study is to determine the interaction between velocity fluctuations produced by turbulence in the liquid flow and electrokinetic potential fluctuations generated at a liquid-solid interface. Knowledge gained by this study will be applied to developing techniques for measuring turbulence characteristics in liquids.
(g) Probes constructed with electrode pairs have been used to measure the distribution of turbulence intensities (three components) and the turbulent shear stress across a diameter of a circular pipe. The distribution measured in water agree with those obtained by Laufer in air using a hot-wire anemometer.
(h) "Electrokinetic Potential Fluctuations Produced by Turbulence in Fully Developed Pipe Flow," by H. Chuang, Ph.D. Dissertation, Colorado State University, Fort Collins, Colorado, May 1962.
"Electrokinetic Potential Fluctuations Generated by Jet Impingement at a Solid-Liquid Interface," by L. Duckstein., Ph.D. Dissertation, Colorado State University, May 1962.
"Electrokinetic Probe Response to Vortex-Sheet Frequency," by H. Chuang (submitted to Journal of Fluid Mechanics) Dec. 1962.

(3034) DISTRIBUTION AND CONCENTRATION OF RADIOACTIVE WASTE IN STREAMS BY FLUVIAL SEDIMENT.

(b) U. S. Geological Survey, for Reactor Development Branch of the Atomic Energy Commission.
(c) Mr. D. W. Hubbell, Civil Engineering Section, Colorado State University, Fort Collins, Colorado.
(d) Theoretical, experimental and laboratory research, field investigation; basic research, applied research.
(e) Natural streams provide a convenient and effective medium for the disposal of low-level radioactive wastes. When radio nuclides are introduced in streams, they may become fixed on sediment particles. As a result, waste disposal depends, in part, on the transport and dispersion of the sediment. Project activity includes field and laboratory studies on the application and development of transport and dispersion theory for bed and suspended load. In addition, some phases of the dispersion of liquid contaminants are being studied.
(g) An experiment in which polyethylene particles were released from a point source at the water surface of an 8 foot wide alluvial channel having small dunes was performed to provide data on lateral diffusion. One field experiment and two laboratory flume experiments have been conducted on the dispersion of contaminated bed load particles. In the experiments sand labelled with radioactive isotopes has been released on the channel bottom, then traced with underwater radiation-detection equipment.

(3037) TURBULENT SHEAR FLOW PHENOMENON.

(b) National Science Foundation.
(c) Dr. J. E. Cermak, Civil Engineering Section, Colorado State University, Fort Collins, Colorado.
(d) Experimental research; basic research, doctoral thesis.
(e) Measurements of mean velocities and mean temperatures together with turbulence intensities and correlations have been made.

over a smooth, plane, heated or unheated surface forming the floor of a wind tunnel.

(f) Completed.

(g) Heating of the turbulent boundary layer at low Reynolds numbers has been found to produce the following effects: (1) Increase the coefficient of drag; (2) increase the eddy viscosity; (3) increase the correlation between vertical and horizontal velocity fluctuations. Characteristics of separation flow downstream from a plate set normal to the wind tunnel flow were insensitive to changing plate height relative to local boundary-layer thickness excepting when the plate height was of the order of the laminar "sub-layer" thickness or less.

(3395) FUNDAMENTAL STUDY OF A SUBMERGED THREE-DIMENSIONAL JET IMPINGING UPON A NORMAL PLANE.

(b) National Science Foundation.

(c) Mr. George L. Smith, Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.

(d) Experimental and theoretical; basic research and graduate thesis.

(e) A study was made of an axisymmetrical jet of air impinging normally on a flat smooth plate. The mean velocity, the turbulent intensities and the turbulent shear stress were measured by means of a hot-wire anemometer in order to study the decay of the mean velocity, the growth of the boundary-layer thickness and the turbulent structure. A sensitive floating-element type shearmeter was designed and used. Data on skin friction obtained by direct shear measurements may be used to predict the distribution of the skin friction in similar wall jets. The objective of the program was to investigate systematically the effects on jet flow of the interaction between the free boundary and the solid boundary of varying roughness and configuration.

(f) First phase, case of smooth boundary, completed. Investigation of effect of rough boundary has been initiated.

(g) The characteristics of the whole boundary-layer is dominated by the effect of the free jet, and the wall influences the flow only in a very limited region close to the wall. This results in much higher turbulent intensities and turbulent shear stress which increases the wall shear stress for this flow case as compared to two-dimensional uniform flow over a flat plate and smooth pipe flow. The ratio of turbulent intensities

$$\sqrt{\overline{w'^2}} \Big/ \sqrt{\overline{u'^2}}$$

is in general not a constant across the boundary-layer which indicates non-applicability of Prandtl's assumption $u'\ w'$ for this case.

(h) "Axisymmetric Boundary-Layer of a Jet Impinging on a Smooth Plate," by Yeong-ging Tsuei, Ph.D. Dissertation, Colorado State University, August, 1962.

(3398) TURBULENT DIFFUSION IN SHEAR FLOW.

(b) National Institute of Health, Public Health Service, U. S. Dept. of Health, Education and Welfare, Washington, D. C.

(c) Dr. J. E. Cermak, Civil Engineering Section, Colo. State Univ., Fort Collins, Colorado.

(d) Experimental research; basic research, doctoral thesis.

(e) The objective of this project is to determine the influence of geometrical factors (land surface roughness, topography, structures), and thermal and aerodynamical factors (turbulence intensity and scale) upon atmospheric diffusion of heat and mass. "Laws of modeling" or "similitude parameters" are sought by obtaining detailed data under various conditions in the wind tunnel and by comparing them with similar data now existing for the atmospheric prototype.

(g) Application of a hypothesis of Lagrangian similarity to particle motions in a turbulent shear flow near a solid boundary has yielded similarity parameters and relationships between them which correlate the wind-tunnel diffusion data and available diffusion data obtained in the atmospheric surface layer.

(h) "Diffusion From a Point Source Within a Turbulent Boundary Layer with Unstable Density Stratification," by R. C. Malhotra, Ph.D. Dissertation, Colorado State Univ., June 1962.
"Lagrangian Similarity Hypothesis Applied to Diffusion in Turbulent Shear Flow," by J. E. Cermak. (Submitted to Journal of Fluid Mechanics) July 1962.

(3400) HYDRAULICS OF SUB-CRITICAL FLOW IN SMALL, ROUGH CHANNELS.

(b) Colorado Agricultural Experiment Station and Agricultural Research Service, U. S. Department of Agriculture.

(c) Mr. Norman A. Evans, Agricultural Engrg. Section, Colo. State Univ., Fort Collins, Colorado.

(d) Theoretical, laboratory experiment.

(e) The study was made in a tilting flume with rough channels formed in natural soil and stabilized with chemical spray.

(g) Summary of three years work was prepared showing the character of flow resistance in small, hydraulically rough channels.

(h) "Sub-critical Flow in Small, Rough Channels," by E. G. Kruse, Ph.D. Dissertation, Colo. State University Library, 1962.

(3696) STUDY OF CLOUDS AND SNOWFALL IN THE ROCKY MOUNTAINS, AND CHANGES RESULTING FROM THE ADDITION OF ARTIFICIAL ICE NUCLEI.

(b) National Science Foundation and the Climax Molybdenum Company.

(c) Mr. Lewis O. Grant Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.

(d) Field investigation; basic research, applied research.

(e) Various physical factors important in "Cold Cloud" orographic precipitation processes are being investigated under winter-time conditions in the high mountains of Colorado. This includes observations of airflow over the mountains, the characteristics of the "cold" orographic clouds rising over the nuclei, the characteristics of individual snow particles falling from these clouds, snow water freezing characteristics, snowfall amounts, and the changes in these conditions when artificial ice nuclei are supplied.

(g) Field equipment and procedures for use at high elevations in the Colorado Rockies have been developed. Observations of the daily accumulation of snowfall, atmospheric ice nuclei, and various other cloud and snow characteristics have been made over a large area for seeded and unseeded days during two winter seasons. Significant increases in ice nuclei have occurred in the area of the observation network, on a number of the "seeded" days. The sample size is to be increased before attempting to determine the statistical significance of this apparent increase in snowfall.

(3697) MEASUREMENT OF ATMOSPHERIC OZONE WITH THE DOBSON SPECTROPHOTOMETER.

(b) Air Force Cambridge Research Center, L. G. Hanscom Field, Bedford, Massachusetts.

(c) Mr. Lewis O. Grant, Civil Engineering Section, Colo. State Univ., Fort Collins, Colo.

(d) Basic research.

(e) Measurements of the total amount and the vertical distribution of ozone with height are being made with the Dobson Spectrophotometer. Daily amounts of total ozone are

being related to atmospheric circulation patterns.

(g) Observations of total ozone and the vertical distribution with height have been made on a regular basis for days when sky conditions have been clear.

(h) Obsevational data is being supplied to the U. S. Weather Bureau for publication. Reports are submitted to Air Force Cambridge Research Center.

(3704) DEVELOPMENT AND USE OF COLORADO BENTONITE IN SEALING IRRIGATION CANALS AND RESERVOIRS.

(b) State of Colorado.

(c) R. D. Dirmeyer, Jr., Civil Engineering Sec., Colo. State Univ., Fort Collins, Colorado.

(d) Field investigation; applied research and development.

(e) The work consists of three stages: (1) Inventory of clay deposits in Colorado with emphasis on those potentially usable in sealing canals and reservoirs. (2) Laboratory evaluation of clays from (1) above. (3) Field trials in canals and reservoirs with best clays found in (1) and (2) and evaluation of sealing results (initial and with time.

(g) Inventory and Testing -- In excess of 240 samples of Colorado clays have been collected and tested in the laboratory.
Development of Deposits and Field Trials -- Eight deposits have been developed commercially. Clays from these deposits have been used in about 100 trials in canals and ponds during the past three years.

(h) A final report of the three-year project is being prepared and is scheduled for completion by 7/1/63.
"Progress Report of Clay Sealing Investigations During 1961," by R. D. Dirmeyer, Jr. Colorado State University, Fort Collins, Colorado, CER61RDD8, January 1962.

(3708) INVESTIGATIONS TO DEVELOP WIND TUNNEL TECHNIQUES FOR MEASURING ATMOSPHERIC GASEOUS DIFFUSION IN MODEL VEGETATIVE SURFACES.

(b) Agricultural Research Service, U.S. Dept. of Agriculture.

(c) Dr. J. E. Cermak, Professor of Engineering Mechanics and Civil Engineering; and Mr. E. J. Plate, Assistant Civil Engineer.

(d) Laboratory research; basic research, applied research for thesis (doctoral).

(e) Diffusion of a gas (ammonia) into and out of a model vegetated plane area contributing part of a wind tunnel test section floor is to be studied. Using a test section 80 ft long and 6 x 6 ft in cross-section the turbulent boundary layer in which diffusion occurs will be several times thicker than the vegetation height. Using the basic equations of fluid mechanics, an attempt will be made to establish criterion for application of the model data to prototype conditions. The criterion developed will be checked using field data being obtained at Cornell University by the Agricultural Research Service.

(g) A study of diffusion from a line source into a boundary layer over a flat, smooth plate has been completed. Results show that the diffusion pattern can be separated into different zones, according to distances from the source in which different similarity laws are valid for the diffusion process.

(4098) HIGH LEVEL TURBULENCE.

(b) U. S. Navy Weather Research Facility, Bldg. R-48, Naval Air Station, Norfolk, Va.

(c) Dr. Elmar Reiter, Civil Engineering Section, Colo. State Univ., Fort Collins, Colo.

(d) Field investigation; basic research.

(e) By means of stereo-photography of high-level clouds a study will be made of wavelengths of disturbances in the jet-stream region, which might account for clear-air turbulence.

(g) Cameras have been calibrated and reduction procedures programmed for electronic computer.

(h) "On the Nature of Clear-Air Turbulence (CAT)," by Elmar R. Reiter, and Robert W. Hayman. Scientific Interim Report prepared for the Naval Research Facility Under Contract No. N 189(188) 538-28A. Atmospheric Science Technical Paper No. 28. CER62ERR11.
"A Case Study of Severe Clear-Air Turbulence," by Elmar R. Reiter. Prepared for Navy Weather Research Facility under Contract N 189(185)55120A. AST Paper No. 30. CER62ERR20.
"Die Feinstruktut der Strahlstroeme, I and II," by Von Dr. E. R. Reiter, Associate Professor of Atmospheric Sciences, Colo. State Univ., Fort Collins, Colorado. Die Umschau, Frankfurt A.M., 62(18, 20): 575-577, 628-631; 1962.
"The Atmospheric Micro-Structure and its Bearing on Clear-Air Turbulence (CAT)," by Elmar R. Reiter. Prepared for Navy Weather Research Facility under Contract No. 189(188) 55120A, presented on September 10, 1962 at the 4th Conference on Applied Meteorology, Hampton, Virginia. CER62ERR62.
"Nature and Observation of High-Level Turbulence Especially in Clear Air," by Elmar R. Reiter. Presented at Joint Meeting of IAS and AMS in New York, Jan. 21, 1963. CER62ERR76.

(4099) WAKE CHARACTERISTICS FOR BODIES OF REVOLUTION.

(b) Dept. of Navy, David Taylor Model Basin, Washington 7, D. C.

(c) Dr. J. E. Cermak, Civil Engineering Section, Colo. State Univ., Fort Collins, Colorado.

(d) Experimental research; basic research, doctoral thesis.

(e) A study will be made of the relations between axially symmetrical bodies and the wakes produced by them for varying mean velocities and turbulence levels of the mean flow, both with and without momentum addition by means of a jet directed downstream from the body. Basic data will be obtained for establishing similarity criteria for turbulent and mean flow characteristics at large distances downstream from the body.

(4100) PATTERNS IN SEQUENCE OF ANNUAL RIVER FLOWS.

(b) National Science Foundation.

(c) Dr. V. M. Yevdjevich, Research Hydraulic Engineer.

(d) Theoretical; basic research.

(e) Three large samples, 140 river gaging stations from around the world, 450 river gaging stations from the western United States and western Canada, and several hundred precipitation stations from the western United States and western Canada have been used to study the non-randomness in the fluctuations of wet and dry years of river flows and precipitation.

(g) The majority of the non-randomness of the sequence in wet and dry years of river flows may be explained by the carryover of water in river basins, by evaporation in river basins, by evaporation of the rainfall in the air between the cloud base and the ground (arid regions) and by non-homogeneity and inconsistency in hydrologic data.

(h) "Climatic Fluctuation Studies by Using Annual Flows and Effective Annual Precipitation," by V. M. Yevdjevich, presented at the UNESCO Symposium on Climatic Changes, in Rome, Italy, October 1961.
"Fluctuations of Effective Annual Precipitation," by V. M. Yevdjevich, presented at the Western Snow Conference in Cheyenne, Wyoming, April 17, 1962.

(4101) UNSTEADY FREE SURFACE FLOW IN A LARGE STORM DRAIN.

(b) U. S. Bureau of Public Roads and U. S. Public Health Service.
(c) Dr. V. M. Yevdjevich, Research Hydraulic Engineer.
(d) Experimental and theoretical; basic research.
(e) A 825-ft long, 36-in. diameter conduit, movable on 43 supports on a hillside, is used as the main experimental facility to simulate and record free surface waves in pipes. The same waves are computed by using a digital computer and then a comparison is made. The ultimate purpose is a development of a set of routing methods to suit the desired accuracy and the quality of the initial and boundary data.
(g) The analytical study for directing the research is being completed.
(h) "Unsteady Free Surface Flow in a Storm Drain," by V. M. Yevdjevich, general analytical study, a report to the U.S. Bureau of Public Roads Hydraulic Division, Engineering Research; Colorado State Univ., Fort Collins, Colorado, June 1961.

(4102) WIND FORECASTING TECHNIQUES.

(b) Federal Aviation Agency, Federal Aviation Facilities Center, Atlantic City, New Jersey, Attn: RD-140.
(c) Dr. Elmar Reiter, Associate Professor.
(d) Theoretical, experimental; basic and applied research.
(e) Automatic forecasting techniques for high-level winds which can be used by an automatic air traffic control system shall be devised and tested.
(h) "Wind Forecasting Techniques for Input into an Automatic Air Traffic Control (ATC) System," Dr. E. R. Reiter, Atmospheric Science Technical Paper No. 37, CER62ERR51.
"Note on the Eddy Kinetic Energy Distribution in Relation to the Jet Stream," by Elmar R. Reiter. ATS Paper. Prepared in the course of research on upper-level winds under contract ARDS-450 with Federal Aviation Agency. CER62ERR68. ATSP40.

(4105) HAIL GENESIS AREAS.

(b) Crop Hail Insurance Actuarial Association, Chicago, Illinois.
(c) Dr. Richard A. Schleusener, Associate Research Engineer.
(d) Field investigation, basic and applied research.
(e) Regions of hailstorm genesis were determined by following thunderstorm precipitation areas with a three-centimeter radar set located at New Raymer, Colorado. The climatology of hailstorms and thunderstorms was determined by tracking these precipitation cells during the period 15 May 1962 to 31 July 1962.
(f) The project is being continued.
(g) The direction of hailstorms in the area was normally from the southwest in May, and changed to the northwest by late June or early July. It is noted that there is a concentration of hail genesis in the region just east of the Rocky Mountains, with more thunderstorm areas developing there than in a corresponding region about one hundred miles further east.
(h) "Climatology of Hailstorms in and Near Northeastern Colorado 15 May to 31 July 1962 with Comparative Data for 1961," by Richard A. Schleusener and Thomas J. Henderson, Civil Engineering Report November 1962, Colorado State University. CER62RAS-TJH77.

(4106) GROUND-WATER RESERVOIR MANAGEMENT.

(b) Colorado Agricultural Experiment Station and Colorado Department of Natural Resources.
(c) Mr. M. W. Bittinger, Associate Research Engineer.
(d) Theoretical and field investigation; applied research.
(e) It is the purpose to study the operating characteristics of ground water reservoirs in Colorado. Specific studies include (1) the inter-relationships of ground and surface water in alluvial valleys, (2) natural recharge from ephemeral streams, and (3) artificial recharge possibilities in the High Plains of Colorado.
(g) (1) Statistical analyses of surface and ground water records for a section of the alluvial valley of the Arkansas Valley are being conducted, to determine significant components influencing river gain. (2) Studies in Kiowa Creek have shown influences of stream flows on water table levels. (3) Rainfall and runoff studies are being initiated in the High Plains Area.
(h) "Statistical Techniques for Predicting River Accretion as Applied to the South Platte River," (Henderson-Fort Lupton), by R. A. Longenbaugh. Master of Science Thesis, Colo. State Univ. Library, July 1963. 108 pp.
"Natural Ground-Water Recharge from Kiowa Creek, 1961 Progress Report," by M. W. Bittinger, R. A. Longenbaugh, and E. F. Schulz, Colorado State University Mimeo. March 1962, 10 pp.
"Managing Artificial Recharge Through Public Districts," by S. C. Smith and M. W. Bittenger. Paper presented at 1962 Winter Meeting of the American Society of Agric. Engineers, December 1962, 16 pp.

(4108) WATERSHED HYDROLOGY.

(b) Agricultural Experiment Station, Foothills Campus.
(c) Dr. V. M. Yevdjevich, Research Hydraulic Engineer and Mr. E. F. Schulz, Associate Civil Engineer, Colo. State University, Fort Collins, Colorado.
(d) Theoretical and experimental; basic research.
(e) The research is being initiated in three directions; gathering of the data on several hundred hydrographs and hyetographs for floods from small watersheds; design of a large hydraulic model to investigate rainfall-runoff relationship; and theoretical research for relating variables describing hydrographs, riverbasins, and hyetographs for floods from small watersheds.
(h) "Design Hydrographs for Very Small Watersheds from Rainfall," by B. M. Reich. Ph.D. Dissertation.
"Some Effects of Glaciation on Water Yield," by E. H. Hansen. Master of Science Thesis.
"Normal Monthly and Annual Precipitation for Eastern Colorado," by G. L. Smith and E. F. Schulz. CER62GLS48.
"A Graphical Procedure to Estimate Potential Evapotranspiration by the Penman Method," by E. F. Schulz CER62EFS49.

(4109) METEOROLOGICAL CONDITIONS AFFECTING DENVER AIR POLLUTION.

(b) Yetter Foundation, administered by Denver U. S. National Bank.
(c) Dr. Herbert Riehl, Professor of Atmospheric Science.
(d) Field, applied, basic.
(e) Denver pollution has been steadily growing but has not yet attained extreme proportions. It will be a novel feature of this investigation that the causes and history of pollution periods will be measured and analyzed with view toward providing the basis for a sound city ordinance, before the situation has become very severe.
With instrumentation furnished by the Taft Center of Sanitary Engineering, National Institute of Health, five stations recording detailed wind and temperature fluctuations have been set up in the Denver Area. With collaboration of the U. S. Weather Bureau, the U. S. Air Force, and private industry

six additional stations take records, so that a total of 11 stations are operating during pollution periods. The air sampling is carried out in conjunction with the project by the City of Denver.

(f) Completed.

(h) "A Study of Denver Air Pollution," by Herbert Riehl and Loren W. Crow. A report on research conducted under a Grant by the Helen Dean Yetter Foundation to Colorado State University. June 1962.

(4110) TURBULENT AIR MOTION IN THE HIGH ROCKIES IN RELATION TO THE WATER YIELD OF UPPER WATERSHEDS.

(b) Colorado Agricultural Experiment Station.

(c) Dr. Herbert Riehl, Professor of Atmospheric Science.

(d) Field, basic and applied.

(e) The structure of the turbulent wind eddies, which produce the exchange of momentum between atmosphere and ground in the high mountains, is completely unknown. Yet these eddies have sufficient force for the most part to blow the snow away from the mountain slopes above timberline. This snow in part drifts into high-altitude basins where it accumulates in depth augmenting the summer water supply; in part it drifts on slopes where it readily evaporates. Much interest has been shown in the possibility of channeling the drift so that a substantially higher fraction goes into the basins. Technologically this appears to be feasible. But any construction is dependent on knowledge of the turbulence spectrum, especially on the first day following snowfall. In order to determine this spectrum, a first installation containing electronic wind and temperature measuring instruments is being installed on Quandry Peak (14,250 feet) in the Central Colorado Rockies. It will be maintained there during the 1962-63 winter. Other sites will be chosen in subsequent years. The measurements will yield detailed information on the structure of turbulence, when very fast air currents interact with major topographic features.

(f) Project temporarily postponed while wind equipment is being redesigned.

(4111) THE ROLE OF THE ROCKY MOUNTAINS IN THE GENERAL CIRCULATION OF THE ATMOSPHERE.

(b) U. S. Navy Numerical Weather Prediction Facility, Monterey, California.

(c) Dr. Herbert Riehl, Professor of Atmospheric Science.

(d) Basic.

(e) The Rocky Mountains are a solitary obstacle in the path of the westerly winds which cannot be circumvented like the Himalayas. A large fraction of the exchange of angular momentum between air and ground--estimated as high as 50 percent--takes place in the small mountain region. The processes are direct surface stress from interaction between the high-velocity currents of the upper air and the high mountains, and a torque produced due to the pressure differential between eastern and western mountain slopes. The purpose of the project is (a) to determine the actual atmosphere-ground momentum exchange and its variation in time; (b) to determine the effect of this exchange on weather in and to the lee of the mountains; (c) to determine the importance of the momentum exchange on large-scale weather conditions around the hemisphere; and (d) to find an improved model of the surface stress term for numerical prediction purposes.

(4112) THE DISCHARGE OF MAJOR WESTERN RIVERS IN RELATION TO THE GENERAL CIRCULATION OF THE ATMOSPHERE.

(b) Office of Naval Research, Department of the Navy.

(c) Dr. Herbert Riehl, Professor of Atmospheric Science.

(d) Basic research.

(e) The discharge of major western rivers (Colorado, Columbia, Sacramento, Rio Grande) has fluctuations with the order of magnitude of the mean annual discharge itself. These fluctuations are brought about mainly by variations in winter precipitation yield and by variable evaporation. Heavy precipitation may result from seasonal conditions favorable for the recurrence of cyclones over headwater areas; the occurrence of occasional very heavy storms may also be random. On the other hand, high evaporation, requiring weeks of abnormally dry and warm conditions, must be a manifestation of general circulation anomalies of longer duration. The objective of the study is (1) to separate the "systematic" and "random" components of the precipitation, and (2) to determine the controls for the systematic anomalies of precipitation and evaporation. Such controls may be deviations of air-sea heat exchange from average in the tropical Pacific, deviations of the Asiatic monsoon circulation from the mean, and departures of strength and location of the Siberian winter cold pool from normal.

(h) Publications in progress.

(4113) WEATHER PATTERNS AND CIRCULATION OF THE TROPICS.

(b) U. S. Weather Bureau.

(c) Dr. Herbert Riehl, Professor of Atmospheric Science.

(d) Basic.

(e) Part of the project deals with hurricanes, another part with general characteristics of weather in the tropics. Hurricane investigation is concerned (1) with the energy cycle of the mature storm, especially the role played by air-sea interaction in maintaining the center; (2) with the balance of forces in these storms and the nature and importance of frictional forces in a fully turbulent vortex; (3) with the formative stage of hurricanes; and (4) with the ocean-air heat exchange and recovery of ocean temperatures subsequent to hurricane passage. Other studies are concerned with the variability of radiative emission from the atmosphere as a function of height; with the thermal modification of air passing over the tropical ocean under various types of general weather conditions; and with the interaction between tropical disturbances of less than hurricane intensity with their environment at large using line integral approaches.

(h) "Some Observations of Low-Level Wind Variation in the Vertical in Tropical Cyclones," by Arthur C. Pike. A report on research conducted under contract No. CWB-9918 between the U. S. Weather Bureau and Colorado State University. February 1962. Engineering Report 62-12.
"Estimating the Effect of Cloudiness on Incoming Solar Radiation," by Arthur C. Pike. A report on research conducted under contract No. CWB-9918 between the U. S. Weather Bureau and Colorado State University. May 1962. Engineering Report 62-33.
"Radiation Measurements over the Caribbean During the Autumn of 1960," by Herbert Riehl. Published in Journal of Geophysical Research, Vol. 67, No. 10, pp. 3935-3942. March 1962. Engineering Report 62-13.

(4114) GRAVEL FILTER FOR TILE DRAINS.

(b) Colorado Agricultural Experiment Station.

(c) Mr. Norman A. Evans, Agricultural Engineer.

(d) Applied; experimental.

(e) Gravels classed as "pit-run" have been tested in a sand tank model with very fine sand as the aquifer.

(g) Criteria for selecting very non-uniform gravels as fillers for very fine sand have been established.
(h) "Criteria for Gravel Filter Design," by C. des Bouvrie, Master of Science Thesis, Colo. State Univ. Library, 1962.

(4115) INFLUENCE OF INORGANIC WATERSHED COVERS ON MOISTURE EXCHANGE IN A VERTICAL DIRECTION ACROSS THE SOIL-AIR INTERFACE.

(b) Colorado Agricultural Experiment Station, a contributing project of the Western Regional Research Project W-73.
(c) Dr. A. T. Corey, Professor of Agricultural Engineering.
(d) Applied and basic research.
(e) This project is a study of the effects of inorganic covers (especially gravel mulches) on the hydrologic processes of evaporation and infiltration of moisture across the soil-air interface and the relationship of these processes to water yield.
(g) It has been demonstrated by both laboratory and field experiments that gravel mulches substantially reduce the rate of evaporation from bare soils and promotes an increased accumulation of water in the soil.
(h) "Influence of Inorganic Watershed Covers on Moisture Exchange in a Vertical Direction Across the Soil-Air Interface," by Colorado Contributing Project, W-73, Progress Reports Nos. 1 and 2, Colorado Agricultural Experiment Station, October 1961 and October 1962.

(4606) STRUCTURE OF TURBULENCE IN TURBULENT SHEAR FLOW.

(b) Department of the Army.
(c) Dr. J. E. Cermak, Prof. of Engineering Mechanics and Civil Engineering, and Mr. E. J. Plate, Asst. Professor, Colo. State Univ., Fort Collins, Colorado.
(d) Experimental research; basic research, doctoral theses.
(e) The effects of surface roughness and surface heating or cooling upon the structure of turbulence in boundary layer flow will be determined. The flows investigated will be those existing on the heated or cooled floor of a wind-tunnel test section 6 x 6 ft in cross section and 80 ft long. Space-time correlations, joint probability densities, spectra and intensities of the turbulent velocities and temperatures will be obtained by hot-wire techniques and special analog computers employing magnetic tape input.

(4607) WIND-WAVE RESEARCH FACILITY.

(b) National Science Foundation.
(c) Mr. E. J. Plate, Asst. Professor, Colo. State Univ., Fort Collins, Colorado.
(d) Laboratory development.
(e) The research facility consists of a tilting water channel approximately 35 feet long and 2 feet by 2 feet in cross section with a closed upper space about 2 feet by 2 feet in cross section to permit controlled air flow over the water. Studies of wind-wave generation and growth and interfacial transfer phenomena will be made possible with this water channel-wind tunnel combination.
(g) Construction is in progress.

(4608) TURBULENCE DATA ANALYSIS SYSTEM.

(b) Department of the Army and National Center for Atmospheric Research.
(c) Dr. L. V. Baldwin, Assoc. Professor, Colo. State Univ., Fort Collins, Colorado.
(d) Laboratory development.
(e) The system employing magnetic tape input is designed to yield the following information: (1) spectra (10^{-3} to 10^{4} cycles/second), (2) joint probability densities, (3) root-mean-squares, and (4) space-time correlation.
(g) Installation is near completion.

(4609) MODELING OF AIR-FLOW PATTERNS AT CANDLESTICK BALL PARK.

(b) Metronics Associates Inc., Menlo Park, Calif.
(c) Dr. J. E. Cermak, Prof. of Engineering Mechanics and Civil Engineering; and Mr. E. J. Plate, Asst. Professor, Colo. State University, Fort Collins, Colorado.
(d) Experimental; applied research.
(e) The applied study utilizes a 1:800 scale model of the local topography and the Candlestick Ball Park Stadium placed in a 6 by 6 foot wind tunnel. Verification of the modeling technique is being accomplished as a first phase of the study by comparing model wind patterns with prototype wind patterns obtained by field measurements. The second phase of the model study will consist of modifying both topography and stadium to obtain minimum wind disturbance in the ball park.
(g) The first phase of the study has been completed with the result that model wind patterns have been found to be sufficiently representative of field behavior to permit proceeding to the second phase with confidence.

(4610) PREPARATION AND ANALYSIS OF CLIMATOLOGICAL DATA OF IMPORTANCE TO AGRICULTURE IN COLO.

(b) Colorado Agricultural Experiment Station, a contributing project of the Western Regional Research Project W-48.
(c) Dr. A. T. Corey, Prof. of Agricultural Engineering, Colo. State Univ., Fort Collins, Colorado.
(d) Applied.
(e) This project has as its objectives: (1) To provide climatological data for a representative network of Colorado stations in a form suitable for weather analysis; (2) to obtain summaries of distributions of meteorological parameters pertinent to agriculture; (3) to devise and utilize statistical and computer methods for estimates of the probabilities of significant weather conditions; e.g., weekly rainfall totals and dates of critical spring and fall temperatures.
(g) Work on objective No. 2. has almost been completed.
(h) Colorado Contributing Project, W-48, Progress Report No. 1, Colorado Agricultural Exp. Station, September 1962.

(4611) PERMEABILITY AND CAPILLARY PRESSURE RELATED TO MEDIA PROPERTIES.

(b) National Science Foundation.
(c) Dr. A. T. Corey, Prof. of Agricultural Engineering, Colo. State Univ., Fort Collins, Colo.
(d) Experimental and theoretical basic research.
(e) The study involves an investigation of a tentative theory describing how the functional relationship between relative permeability and relative capillary pressure is related to measurable properties of porous media.
(g) A theory showing how the variables capillary pressure, liquid and gas permeability are related to degree of saturation has been developed. The experimental results to date appear to verify the theory. The most important property of granular porous media in respect to the functional relationship between relative permeability and relative capillary pressure seems to be the presence or absence of secondary porosity (structure).
(h) "Hydraulic Characteristics of Porous Media," by R. H. Brooks and A. T. Corey, Annual Research Report 1960, 1961.

(4612) TRANSPORT OF PARTICLES THROUGH UNSATURATED

SOILS.

(b) Department of Health, Education, and Welfare, Bureau of State Service.
(c) Dr. A. T. Corey, Prof. of Agricultural Engineering, Colo. State Univ., Fort Collins, Colorado.
(d) Applied; experimental.
(e) The objective of this research is to determine to what extent the transport of solid particles by water flowing through soil may be affected by the degree of saturation of soil. The term "soil" is interpreted broadly as including sands and gravels as well as agricultural soils. The solid particles to be considered in this study will be of sizes and shapes corresponding to that of viruses.
(f) Project was only recently funded and is just getting started.

(4613) MORPHOLOGY OF WHITE RIVER, MOUNT RAINIER, WASHINGTON.

(b) U. S. Geological Survey, Water Resources Division, General Hydrology Branch.
(c) Mr. Robert K. Fahnestock, Geologist, U. S. Geological Survey.
(d) Field investigation; basic research.
(e) To determine the processes of valley train formation and the influences of a glacier on the stream form.
(h) "Dynamics of Stream Braiding as Shown by Means of Time Lapse Photography," by R. K. Fahnestock, (Abs) Geol. Soc. America Bull., v. 70, No. 12, Pt. 2, p. 1599, 1959.
"Morphology and Hydrology of a Glacial Stream," by R. K. Fahnestock, Ph.D. Thesis, Cornell University, 1960, (Abs) Geol. Soc. America Bull., v. 71, no. 12, pt. 2 page 1862, (Abs) Dissertation Abstracts, v. 21, No. 6.
"Significance of a Braided Channel Pattern," by R. K. Fahnestock, (Abs) Geol. Soc. America Bull., v. 71, No. 12, pt. 2, p. 1862, 1960.
"Competence of a Glacial Stream," by R. K. Fahnestock, U. S. Geological Survey Professional Paper 424-B, p. B211-213, 1961.
"Morphology and Hydrology of a Glacial Stream, White River Below Emmons Glacier, Mount Rainier, Washington," by R. K. Fahnestock, U. S. Geological Survey Professional Paper 422A, in press.

(4614) SEDIMENT TRANSPORT AND FLUVIAL MORPHOLOGY OF THE RIO GRANDE NEAR EL PASO, TEXAS.

(b) U. S. Geological Survey, Water Resources Division, General Hydrology Branch.
(c) Mr. Robert K. Fahnestock, Geologist, U. S. Geological Survey.
(d) Field investigation; basic research.
(e) A reach of canalized river 100-ft wide and another 200-ft wide have been selected for comparison. Discharges from 100 to 1300 cfs are available in the form of irrigation releases from Caballo Reservoir. Preliminary maps of bed form and bottom velocity have shown marked variations with time, sediment transport, width, water temperature, and discharge. Measurements of variables in these and additional reaches will allow comparison with flume data and provide a better basis for prediction of bed behavior in natural and artificial channels.

(4615) MORPHOLOGY OF STREAMS OF THE OLYMPIC PENINSULA, WASHINGTON.

(b) U. S. Geological Survey, Water Resources Division, General Hydrology Branch.
(c) Mr. Robert K. Fahnestock, Geologist, U. S. Geological Survey.
(d) Field investigation; basic research.
(e) The objectives of the study are to determine the characteristics of streams of the Olympic Peninsula, the processes taking place within the channel and to relate these characteristics and processes to morphology of the stream valley.

(4616) WATER CYCLE (GENERAL HYDRAULIC CHARACTERISTICS OF WESTERN NORTH AMERICA).

(b) Office of Naval Research.
(c) Dr. V. M. Yevdjevich, Research Hydraulic Engineer, Colo. State Univ., Fort Collins, Colo.
(d) Theoretical; basic research.
(e) By using a large sample of 450 homogeneous river gaging stations in western North America and several hundred precipitation stations, the regional correlation of wet and dry years, as well as their simultaneity, is being investigated.
(g) Both large samples are in a final stage of processing with standardized variables of annual flows, effective annual precipitation and annual precipitation obtained.

(4617) MECHANICS OF LOCAL SCOUR.

(b) Department of Commerce, Bureau of Public Roads, Hydraulic Research Division.
(c) Mr. S. S. Karaki, Associate Civil Engineer, Colo. State Univ., Fort Collins, Colorado.
(d) Theoretical and experimental; basic research.
(e) A theoretical study of the mechanics of local scour is under way to develop basic equations for determining local scour. Basic experiments will be undertaken simultaneously to assist theoretical development.

UNIVERSITY OF COLORADO, Department of Civil Engineering.

(4639) WAVE REFLECTION STUDIES.

(b) Laboratory project.
(c) Dr. Warren DeLapp, Department of Civil Engineering, University of Colorado, Boulder, Colorado.
(d) Experimental, basic research, for Master's thesis.
(e) Initial studies were made of artificially generated waves reflected from a beach of variable slope and roughness, and included studies of the effects of the wave steepness ratios. Current studies are being made of reflection and transmission of waves at a submerged barrier.
(g) The reflection coefficient is found to decrease with increasing beach roughness and wave steepness. An empirical equation was developed relating the variables for beach slopes of more than 30 degrees. An unstable transition condition was found for flatter slopes and results were considered inconclusive.
(h) "Effect of Roughness, Wave Steepness, and Beach Slope on the Reflection of Deep Water Waves," by D. K. Lysne, M. S. Thesis available on inter-library loan from University of Colorado Library.

(4640) STUDIES OF TURBULENT SWIRL FLOW IN A PIPE.

(b) National Science Foundation.
(c) Dr. Frank Kreith, Department of Mechanical Engineering, University of Colorado, Boulder, Colorado.
(d) Analytical and experimental; basic research.
(e) A swirling secondary flow is induced in a plastic pipe by a short section of twisted tape inserted in the pipe at the upstream end. The flow is studied downstream of the inducer to determine the rate of decay of the secondary flow and the effective resistance coefficient. Reynold's Numbers of the main flow range from 15,000 to 150,000. Other variables include pipe diameters and the length and pitch of the swirl inducers.
(g) A theoretical analysis of the swirl decay has been made. The experimentally observed values of rate of decay compare favorably

with the theory. Pipe resistance studies are in progress.

(h) "A Theoretical Investigation of the Decay of Turbulent Swirl Flow in a Pipe," by Otto Sonju; M. S. Thesis available on inter-library loan from University of Colorado Library.

CORNELL UNIVERSITY, School of Civil Engineering.

(2285) QUADRANT EDGE ORIFICE STUDIES.

(b) ASME Fluid Meters Committee (in part).
(c) Dr. J. A. Liggett, Hollister Hall, Cornell Univ., Ithaca, New York.
(d) Experimental; applied research for M. S. theses.
(e) This project is a study of the characteristics of the quadrant edge orifice at high and low Reynolds numbers. The effect of such items as the effect of upstream velocity distribution, orifice and boundary roughness, and the beta ratio are being studied.

(4121) TWO-DIMENSIONAL CHANNEL FLOW.

(b) Laboratory project.
(c) Dr. J. A. Liggett, Hollister Hall, Cornell Univ., Ithaca, New York.
(d) Theoretical; basic and applied research for Ph. D. thesis.
(e) The equations of two dimensional free surface flow have been solved numerically using high speed computer.
(g) Results to this point have demonstrated the feasibility of solving the hyperbolic equations of high speed channel flow on a digital computer. Included are such effects as slope and friction. However, the program at this point still has certain limitations which will be the subject of further study.
(h) Ph.D. thesis now being written.

(4531) SECONDARY CURRENTS IN NON-CIRCULAR CONDUITS.

(b) National Science Foundation.
(c) Dr. J. A. Liggett, Hollister Hall, Cornell Univ., Ithaca, New York.
(d) Theoretical and experimental.
(e) Those secondary currents caused by Reynold's stresses in straight, non-circular conduits are being studied. A triangular open channel is being used. Measurements are to be taken by the hot-film anemometer.
(f) Equipment is being constructed.

(4532) THE INFLUENCE OF CHANNEL HYDRAULICS AND WATERSHED GEOMETRY ON THE SHAPE OF THE RUNOFF HYDROGRAPH.

(b) Laboratory project.
(c) Dr. W. H. Brutsaert, Hollister Hall, Cornell Univ., Ithaca, New York.
(d) Experimental; basic research for Ph.D. thesis.
(e) The purpose of this project is to further explore the influence of channel hydraulics and watershed geometry on the geometry of the runoff hydrograph. A model watershed will be constructed in the laboratory which will allow the singular variation of the following: (1) Channel geometry, slope and roughness; (2) the drainage density; and (3) the watershed shape. Information obtained from this physical model will be compared and analyzed with a mathematical model, suitable for solution on a digital computer.
(f) In planning stage.

UNIVERSITY OF DELAWARE, Fluid Mechanics Laboratory Section, Dept. of Civil Engineering.

(4123) STUDIES ON MECHANICS OF FLUID FLOW.

(b) Laboratory project.
(c) Department of Civil Engineering, Dr. K. P. H. Frey, Professor.
(d) Experimental, operation, development for basic and applied research, thesis, educational aid.
(e) Continued efforts to make the versatile flume most useful for the study on mechanics of fluid flow and related problems resulted in (1) installation of two flowmeters recording rates of flow up to 4000 g.p.m., (2) taking of still photographs and short movies of complex flow phenomena, (3) extended studies of submerged flow visualization, (4) internal reports on the facility (description, manual of instructions). Purpose: participation in educational aid, research projects, improved usefulness of facility for interdepartmental interests.
(f) Item (e-1) completed, items (e-2) and (e-3) suspended, item (e-4) three reports completed.
(g) Item (e-1) indispensable, (e-2) basically achieved, (e-3) Meriam fluid of spec. gr. of unity is suitable for generation of submerged spheres (red spheres adjustable to desirable sizes), (e-4) indispensable for efficient work if facility is used by various investigators (see, for example, special listing of Department of Mechanical Engin.).
(h) "Description of Versatile Flume," Dr. K. P. H. Frey, Prof. C. E. Dept., and Dr. B. S. Seidel, Assistant Prof. Mechanical Engin. Dept.
"Manual of Instructions on Versatile Flume, Part I and Part II," by K. P. H. Frey. Available on request, see item (c).

(4557) MICROSCOPIC STUDIES OF VELOCITY PROFILES AT LOW REYNOLDS NUMBERS (0.018 to 1.85).

(b) Laboratory project.
(c) Dr. K. P. H. Frey, Dept. of Civil Engineering, Univ. of Delaware, Newark, Delaware.
(d) Experimental; development of improved techniques, master thesis.
(e) Improvement of photomicrographic techniques to determine accurate velocity profiles near boundaries; water depths 0.08 to 3.2 mm, velocities 0.015 to 1.2 mm.p.second. Particle sizes of less than 0.003 mm (specially prepared suspension of titaniumdioxide), dark field microscope (magnification factor 186 for observation, 62 for photographs), and Xenon arc tube cooled by air flow are found to be suitable means to make use of the depth of field of microscope used (1 mm depth of water can be sectioned into 100 layers by selective focusing). With shutter speeds being known, measurements from photographs of the layers yield velocity profiles. Closest distance from boundary used for evaluation is 0.01 mm. Purpose: originated from gutter flow studies and heat exchange interests, it is believed that improvements of photomicrographic techniques are of basic interest.
(f) Completed at anticipated scope; under review by Dr. J. H. Olson, Ass. Prof. of Chemical Engin. for his interests in microscopic flow studies.
(g) The shown technique of photomicrographic studies is simpler and more conclusive than previously developed techniques. Accurate measurements at 0.01 mm distance from boundary were accomplished. Still photographs and one short film were taken.
(h) "A Dark Field Photomicroscopic Method for Measuring Velocity Profiles," by N. C. Vasuki, C.E. Master Thesis 1962, Memorial Library, U. of Del., Newark, Del.

UNIVERSITY OF DELAWARE, Department of Mechanical Engrg.

(4556) DRAG REDUCTION BY BOUNDARY LAYER GAS INJECTION.

(b) Laboratory project.
(c) Prof. B. Seidel, Prof. J. P. Harnett, Prof. K. Frey, (Civil Engineering) Univ. of Delaware, Newark, Delaware.

(d) Theoretical and experimental; master's thesis.
(e) The possibility of reducing the skin-friction drag of a body moving through a liquid by ejecting air from the body is being investigated. Measurements of the drag on a flat plate are being obtained.

UNIVERSITY OF FLORIDA, The Engineering and Industrial Experiment Station, Coastal Engineering Laboratory.

Inquiries concerning the projects should be addressed to Dr. Per Bruun, Head, Coastal Engineering Lab., University of Florida, Gainesville, Florida.

(3051) BASIC STUDY OF THE RELATION BETWEEN WIND AND WATER BEHAVIOR IN COASTAL WATER.

(b) National Science Foundation.
(d) Field and laboratory study; basic research.
(e) A combined field and laboratory research program analyzing the transfer of energy from wind to water and the effect of sloping offshore profiles. Observations were made on platforms in the Gulf of Mexico and in a laboratory wave tank.
(f) Completed.
(g) Shear stress in the boundary layer above water surface is affected by momentum exchange between wind and water. Water waves play a significant part in the relation between wind speed and the frictional stress at the water surface. For high wind speeds, the roughness parameter of a water wave surface is related to both shear stress and water wave height and steepness. For low wind speeds, however, the actual roughness at the interface is determined by the Reynolds number of the smooth boundary layer.
(h) "Surface Wind Stress Over Water as Related to Wave Action," Coastal Engineering Laboratory, 1962.
"Amplification of Long Waves in Bays," by Dr. R. Dorrestein, Technical Paper No. 213, Florida Engineering and Industrial Experiment Station, University of Florida, 1961.
"On the Deviation of the Average Pressure at a Fixed Point in a Moving Fluid From its Hydrostatic Value," by Dr. R. Dorrestein, Section A, Vol. 10, Applied Scientific Research, 1961.
"Wave Setup on a Beach," by Dr. R. Dorrestein, Coastal Engineering Laboratory, 1962.
"Surface Wind Stress Over Water as Related to Wave Action" to be presented at the International Association of Hydraulic Research Conference, London, 1963.

(3412) FLOOD TIDE STUDY.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) Topography of coastal areas in Florida in relation to potential flooding and statistical analysis of extreme high tides.
(f) Completed.
(h) "Storm Tides in Florida as Related to Coastal Topography," by Per Bruun, T. Y. Chiu, F. Gerritsen, and W. H. Morgan, Bulletin Series No. 109, Vol. XVI, No. 1, Florida Engineering and Industrial Experiment Sta., University of Florida, January 1962.

(3413) INLET STUDIES.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) Study of the stability of coastal inlets.

(3722) HYDRAULIC MODEL STUDY OF SARASOTA BAY.

(b) City of Sarasota and Arvida Realty Corp.
(c) City of Sarasota, Sarasota, Fla.
(d) Experimental; applied research.
(e) To study effect of fills in Sarasota Bay on the stability of New Pass and Big Sarasota Pass.
(f) Completed.
(h) "Sarasota Bay Model Study," Report, Coastal Engineering Laboratory, December 1961.

(3723) EMERALD BEACH PROJECT, PASCO COUNTY.

(b) Trustees of Emerald Beach Project.
(c) Mr. C. C. Edwards, P. O. Box 308, Port Richey Florida.
(d) Field investigation; applied research.
(e) Recommendations for planning of fill projects
(f) Completed.
(h) "Coastal Engineering Study of Emerald Beach Project," Pasco County, Report, Nov. 1960.

(3724) ANALYSIS OF BEACH PROFILES AT JUPITER ISLAND.

(b) Mr. Alton A. Register.
(d) Field investigation; applied research.
(e) Recommendations for the establishment of a sea wall line.
(f) Completed
(h) "Coastal Engineering Investigation at Jupiter Island," Report, Coastal Engineering Lab., November 1960.

(4124) MODEL STUDY OF EAST HORSENECK BEACH INLET.

(b) Duffill Associates, Consulting Engineers, Boston, Mass.
(c) Duffill Associates, Consulting Engineers, Boston, Mass.
(d) Experimental; applied research.
(e) Study of wave action in inlet.
(f) Completed.
(h) "Model Study of Navigation Inlet at East Horseneck Beach, Mass.," Report, Coastal Engineering Laboratory, September 1961.

(4125) HYDRAULIC MODEL STUDY OF SAN NICOLAS HARBOR, ARUBA, N.W.I.

(b) Lago Oil and Transport Co., Ltd., Aruba, N.W.I.
(c) Lago Oil and Transport Co., Ltd., Aruba, N.W.I.
(d) Experimental; applied research.
(e) To investigate wave action and recommend improvements for the harbor and fenders.
(f) Completed.
(h) "Hydraulic Model Study of San Nicolas Harbor, Aruba," Report, Coastal Engineering Laboratory, July 1962.
"Fenders -- Design Criteria for San Nicolas Harbor, Aruba," October 1962.

(4126) COASTAL ENGINEERING STUDY AT MULLET KEY.

(b) Pinellas County Park Board, Clearwater, Fla.
(c) Pinellas County Park Board, Clearwater, Fla.
(d) Field investigation; applied research.
(e) Recommendations for protection from beach erosion.
(f) Completed.
(h) "Coastal Engineering Study at Mullet Key," Report, Coastal Engineering Laboratory, March, 1962.

(4127) FLUORESCENT TRACING OF SEDIMENT IN COASTAL AREAS.

(b) National Institute of Health, Department of Health, Education and Welfare.
(d) Field investigation; basic and applied research.
(e) Tracing of sediment drift on beach and offshore bottoms by means of injected fluorescent material.
(g) Statistical sampling methods, rapid measurement fluorescent tracer concentration by electronic scanners, a new longshore current theory and a statistical approach to littoral transport mechanism are being developed at the laboratory.
(h) "Tracing of Material Movement on Seashores," by Per Bruun, Shore and Beach, April 1962.
"Longshore Currents and Longshore Troughs," by Per Bruun, Geological Society of America (in print).

(4128) FLUX OF WAVE ENERGY PERPENDICULAR TO THE DIRECTION OF WAVE PROPAGATION.

(b) National Science Foundation.
(d) Basic research.
(e) Experiments to determine flux of wave energy perpendicular to the direction of wave propagation.

(4129) INFLUENCE OF SEA LEVEL RISE ON EROSION.

(b) State Government.
(d) Basic field research.
(e) To determine the influence of short-term as well as long-term fluctuation of sea level on erosion and shoreline movements.
(h) "Sea-level Rise as a Cause of Shore Erosion," by Per Bruun, ASCE paper 3065 WW, February 1962.

(4130) EROSION STUDY OF SAND SHORES IN FLORIDA.

(b) State Government.
(d) Applied research.
(e) To check present status of erosion.

(4474) COASTAL ENGINEERING STUDY AT SOUTH LAKE WORTH INLET, FLORIDA.

(b) South Lake Worth Inlet District Commission.
(c) South Lake Worth Inlet District Commission, c/o K. C. Mock and Associates, 2930 Okeechobee Road, West Palm Beach, Florida.
(d) Experimental field and applied research.
(e) To study distribution of inlet currents, improvement of entrance jetties, and navigation channels and measures against beach erosion.

(4475) COASTAL ENGINEERING STUDY AT HILLSBORO INLET, FLORIDA.

(b) Hillsboro Inlet Improvement and Maintenance District, City of Pompano Beach and Trustees of the Internal Improvement Fund.
(c) Director, Trustees, Internal Improvement Fund, Capitol Bldg., Tallahassee, Florida.
(d) Experimental, field and applied research.
(e) To study methods for inlet stabilization, navigation improvement, and sand bypassing across the inlet.

(4476) COASTAL ENGINEERING STUDY OF CURRENT ACTIVITY AT SEBASTIAN INLET.

(b) Florida State Road Department.
(c) Florida State Road Department, Tallahassee.
(d) Field investigation; applied research.
(e) To study the effect of currents on bridge alinement and fender system.
(f) Completed.
(h) "Coastal Engineering Study of Current Activity at Sebastian Inlet," Report, Coastal Engineering Laboratory, November 1962.

(4477) COOPERATIVE STUDY OF SHORE PROTECTION STRUCTURES IN FLORIDA (in cooperation with U. S. Army Corps of Engineers, Jacksonville District).

(b) State and Federal Government.
(d) Field investigation; applied research.
(e) To study effectiveness and structrual durability of various types of shore protection structures existing along Florida coastline by making repetitive surveys of selected shore segments.

(4478) COASTAL ENGINEERING STUDY AT COCOA BEACH, FLA.

(b) City of Cocoa Beach.
(c) City Manager, City of Cocoa Beach, Florida.
(d) Field investigation; applied research.
(e) To study the best locations of bulkhead lines and bay fills and draft ordinances from coastal engineering point of view.

(4479) REVIEW OF BEACH EROSION AND STORM TIDE SITUATION IN FLORIDA.

(b) Engineering and Industrial Experiment Sta., University of Florida.
(d) Field investigation; applied research.
(e) Photographic review of the erosion situation in Florida and preliminary suggestions for remedial measures.
(h) "Review of Beach Erosion and Storm Tide Situation in Florida," Report, Engineering and Industrial Experiment Station (in print).

(4480) ENGINEERING STUDY OF COASTAL PROBLEMS IN FLA.

(b) Trustees of the Internal Improvement Fund, Florida.
(c) Trustees of the Internal Improvement Fund, Florida.
(d) Field investigation; applied research.
(e) The Coastal Engineering Laboratory acts as a consultant to the State Government and submits reports on the basis of field inspection and study of proposed structures, fills, dredging, etc.

(4481) INVESTIGATION OF STABILITY AND MOVEABLE BED MODEL LAWS OF INLETS.

(b) Laboratory project.
(d) Basic and applied research.
(e) With a new basic approach to similitude laws in sediment transport by currents, investigations are underway in the stability analysis of inlets by means of model studies of suitable inlets. A theoretical study of model laws for moveable bed models initiated as introductor to inlet study.

(4482) EXPERIMENTAL STUDY OF MECHANICS OF DUNE BUILDING AT CAPE HATTERAS NATIONAL SEASHORE AREA.

(b) Cape Hatteras National Seashore, National Parks Service, Manteo, North Carolina.
(c) Cape Hatteras National Seashore, National Parks Service, Manteo, North Carolina.
(d) Experimental and field research.
(e) Study of mechanics of dune building by various types of sand fences and other sand catchment devices under controlled conditions is underway in a laboratory wind tunnel to be later correlated with field tests.

(4483) COASTAL ENGINEERING STUDY OF PROPOSED JETTY AT HONEYMOON ISLAND.

(b) Honeymoon Development Corporation, Tampa, Fla.
(c) Southworth Associates, Tampa, Florida.
(d) Field investigation; applied research.
(e) A field study of current patterns during flow and ebb tides was undertaken to find the best alinement for a jetty at the southern tip of Honeymoon Island.
(f) Completed.
(h) "Proposed Jetty at the Southern Tip of Honeymoon Island," Report, Coastal Engineering Laboratory, July 1962.

GEORGIA INSTITUTE OF TECHNOLOGY, Engineering Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. R. E. Stiemke, Director, Engineering Experiment Station, Atlanta 13, Georgia except as otherwise indicated.

(291) FLOW OF WATER OVER HIGHWAY EMBANKMENTS.

(b) Laboratory project.
(c) Prof. C. E. Kindsvater, School of Civil Engineering, Georgia Institute of Technology, Atlanta 13, Georgia.
(d) Experimental; partly sponsored by U. S. Geological Survey.
(e) Experimental data were obtained on the discharge characteristics of an embankment-shaped weir. Emphasis has been placed on free discharge over smooth-surfaced embankments. Data have been obtained on the influence of embankment height and tailwater submergence. Detailed velocity surveys have been made to define the boundary layer

between the upstream edge of the upstream shoulder and the crown. Tests were made on a 1:9-scale model in a 3-foot wide flume.

(f) Completed.

(g) It has been established that the discharge characteristics of an embankment can be related to the theoretical equation of discharge for a broad-crested weir by means of the discharge-displacement boundary-layer thickness. Data and procedures for computing the thickness of the boundary-layer at the control section have been determined as a means of generalizing the discharge equation for various shapes, sizes and roughness of embankments.

(h) "Discharge Characteristics of Embankment-shaped Weirs," Geological Survey Water-Supply Paper, in press.

(1331) THE DIFFUSION OF FOREIGN PARTICLES IN A FLUID.

(b) Laboratory project; sponsored by the National Science Foundation.

(c) Dr. M. R. Carstens, School of Civil Engrg., Georgia Institute of Technology, Atlanta, Georgia.

(d) Experimental; basic research for doctoral dissertation.

(e) Diffusion of macroscopic foreign particles and of dye were measured in agitated water. The water within the diffusion chamber was agitated by pulsating jets which were arranged in geometrically repeating patterns. The amplitude and frequency of the pulsing was controlled. Dye concentration was measured by light transmission and particle concentration by gamma-ray radiation from the ion-exchange resin beads (particles) to which radioactive cesium was attached.

(f) Completed.

(g) The diffusion coefficients were found to be proportional to the one-third power of the rate of energy dissipation. The values of the particle-diffusion coefficient were indicative that the particle boundary layer was turbulent when a laminar boundary layer was expected.

(h) "Investigation of the Relationship Between Fluid-Turbulence Characteristics and the Diffusion of Solid Particles," Richard Cleveland Farmer, Ph.D. Dissertation, Georgia Tech, 1962.

(1584) FLOW OF WATER OVER WEIRS AND SPILLWAYS.

(b) Water Resources Division, Surface Water Branch, U. S. Geological Survey.

(c) Prof. C. E. Kindsvater, School of Civil Engineering, Georgia Institute of Tech., Atlanta 13, Georgia.

(d) Library search, re-analysis and correlation of published data, plus original research as required.

(e) A comprehensive study of the discharge characteristics of practical forms of weirs and spillways, including the preparation of bibliography and the collection and analysis of experimental data from all known sources. Objectives include the publication, in generalized form, of available experimental data.

(f) Inactive.

(2529) UNIFORM FLOW IN OPEN CHANNELS.

(b) Water Resources Division, Surface Water Branch, U. S. Geological Survey.

(c) Mr. H. J. Tracy, U. S. Geological Survey, 162 Peachtree-Seventh Building, Atlanta, Ga.

(d) Reanalysis and correlation of existing data; original experimental research and analysis; theoretical study of turbulence energy transfer and diffusion mechanisms.

(e) A fundamental investigation of the mechanics of uniform flow in open channels, with particular emphasis on the influence of channel shape on velocity distributions and wall shear-stress distributions. Experimental work is being conducted on simple and compound cross sections in a variable slope 90-foot long flume.

(3414) INFLUENCE OF FREE-SURFACE DISTURBANCES ON PIEZOMETRIC MEASUREMENTS.

(b) Laboratory project.

(c) Dr. P. G. Mayer, School of Civil Engineering, Georgia Institute of Technolgy, Atlanta 13, Georgia.

(d) Experimental and theoretical; research for master's thesis; partly supported by U. S. Geological Survey.

(e) Observations on laboratory flume (see proj. 2529) revealed a discrepancy between depth measurements and piezometric-head measurements for flow conditions involving disturbed free surface. The phenomenon appears to be analogous to pressure or density variations in unsteady, compressible-fluid flows.

(f) Completed.

(h) "Piezometric Measurement of Depth in Open Channels," by W. W. Emmett, M. S. thesis, Georgia Institute of Technology, 1961.

(3725) SECONDARY MOTION IN ENCLOSED CONDUITS AND OPEN CHANNELS.

(b) Laboratory project.

(c) Dr. P. G. Mayer, School of Civil Engineering, Georgia Institute of Technology, Atlanta 13 Georgia.

(d) Theoretical and experimental; research for Ph.D. thesis.

(e) A fundamental study of secondary motion in turbulent flows. Secondary motions are often superimposed upon flows in enclosed conduits and open channels. The mode of origin, development and decay is being studied to delineate the influence on the general motion pattern in straight, non-circular conduits and channels. The present phase concerns turbulent flow in a non-circular enclosed conduit.

(4131) FLOW OVER GATED SPILLWAYS.

(b) Laboratory project; Georgia Power Company.

(c) Dr. P. G. Mayer, School of Civil Engineering, Georgia Institute of Technology, Atlanta 13, Georgia.

(d) Experimental, applied research.

(e) Studies are to be made to evaluate discharge characteristics of gated spillways under various operating conditions in a 1:40 scale model.

(f) Completed.

(4574) THE ROLE OF A PERMEABLE BED IN SEDIMENT TRANSPORT.

(b) Bureau of Ships, Department of the Navy.

(c) Dr. M. R. Carstens, School of Civil Engineering, Georgia Inst. of Tech., Atlanta 13, Georgia.

(d) Analytical and experimental; fundamental research for doctoral dissertation.

(e) To determine theoretically the effect of the vertical seepage force, which occurs in porous-media flow, on the effective weight force in terms of an apparent specific weight of sediment. To study experimentally the influence of the seepage force on incipient sediment motion.

(f) Analytical part completed; experimental part in progress.

(g) For porous-media flow in a sand bed induced by progressive gravity waves, the seepage force is shown to render sediment particles lighter under the wave trough and, conversely heavier beneath the wave crest. The apparent specific weight of sediment at the bed can be shown to vary from 0.85 to 1.40 times the real specific weight. The theoretical treatment is effected for both Stokian and cnoidal waves.

(h) "The Influence of a Permeable Bed on Sediment Transport with Special Reference to Gravity

Waves", M R. Carstens and C. S. Martin, Georgia Institute of Technology, Engineering Experiment Station, Technical Report No. 1, Project A-628, 55 pp., November 1962.

(4575) VAPOR-CAVITY FORMATION IN A PIPE AFTER VALVE CLOSURE.

(b) Laboratory project.
(c) Dr. M. R. Carstens, School of Civil Engineering, Georgia Inst. of Tech., Atlanta 13, Ga.
(d) Theoretical and experimental; research for M.S. thesis.
(e) The pressure as a function of time was measured at a downstream valve in a pipe line following rapid closure of the valve. The pipe line was 334 ft of coiled 5/8-in. OD copper tubing. The experimental measurements indicated that a vapor-cavity formed at the valve at the time that the first shock wave, which was reflected from the upstream reservoir, reached the downstream valve. This vapor cavity grew in size and then decreased in size. At the instant of decay of the vapor cavity, another shock wave was generated. The process repeated with decay.
(f) Completed.
(g) The results of graphical shock-wave analysis assuming "lumped" resistance, a single vapor cavity, and vapor pressure within the cavity were in excellent agreement with experimental results.
(h) "Vapor-Cavity Formation in a Pipe after Valve Closure", William E. Heath, M.S. thesis, Georgia Institute of Technology, 1963.

(4576) FLOW CHARACTERISTICS OF A TWO-DIMENSIONAL ORIFICE PLACED UNSYMMETRICALLY IN THE APPROACH CHANNEL.

(b) Laboratory project at Georgia Institute of Technology and at SEATO Graduate School of Engineering, Bangkok, Thailand.
(c) Dr. M. R. Carstens, School of Civil Engineering, Ga. Inst. of Tech., Atlanta 13, Ga.
(d) Experimental and theoretical; research for M.S.theses.
(e) The flow characteristics, coefficient of contraction and angle of jet deflection, were to be determined both analytically and theoretically.
(f) Continuing.
(g) Experimental results have been obtained for opening width-approach channel width ratios of 0.2, 0.4, 0.6, and 0.8, for a range of opening eccentricities. Theoretical results have been evaluated for symmetrical jet and for maximum eccentricity. Numerical integration is being done for intermediate eccentricities.
(h) "Flow and Discharge Characteristics of a Two-Dimensional Orifice (Slot) Placed Unsymmetrically in the Approach Channel", Sumana Chowchuvech, M.S. thesis, SEATO Graduate School of Engineering, Bangkok, Thailand, 1961.
"Theoretical Study of the Flow and Discharge Characteristics of a Two-Dimensional Orifice", Anat Arbhabhirama, M.S. thesis, SEATO Graduate School of Engineering, Bangkok, Thailand.

(4577) CIRCULATION OF CONDENSER WATER, CHATTAHOOCHEE RIVER.

(b) Georgia Power Company, Atlanta, Georgia.
(c) Dr. P. G. Mayer, School of Civil Engrg., Georgia Inst. of Tech., Atlanta 13, Ga.
(d) Experimental.
(e) Study involving flow distribution patterns in a partial river model. Favorable routing of condenser discharge water from two steam power plants in tandem was sought to permit optimum plant efficiencies during low flow periods.
(f) Completed.
(g) Results of the model study suggested engineering solution to problem of short circuiting of hot condenser water between the two power plants.

(4578) INFLUENCES ON PIEZOMETRIC MEASUREMENTS.

(b) Laboratory project.
(c) Dr. P. G. Mayer, School of Civil Engineering, Georgia Institute of Technology, Atlanta 13, Georgia.
(d) Experimental and theoretical; partly supported by U. S. Geological Survey; research for M. S. thesis.
(e) Results of a previous project (see 3414) indicated influences on piezometric measurements other than those reported in W. W. Emmett's thesis. The influence of turbulence intensity, piezometer hole diameter, length of piezometer tubing and channel roughness were investigated.
(f) Completed.
(g) Results indicated that errors, ΔD, in piezometric measurements of depth of flow of smooth, open channels may be expressed by

$$\Delta D = C \frac{V^2}{g}$$

where V is the mean stream velocity, and C an empirical coefficient. C was shown to be a function of turbulence intensity, scale of turbulence, and hole diameter.
(h) "Influence on Piezometric Measurements," by James R. Wallace, M. S. thesis September 1962.

(4579) WHIRLPOOL FORMATION AND VORTEX STRETCHING.

(b) Laboratory project; partly sponsored by the Georgia Power Company, Atlanta, Georgia.
(c) Dr. P. G. Mayer, School of Civil Engineering, Georgia Institute of Technology, Atlanta, Ga.
(d) Experimental and theoretical.
(e) Asymmetric approach condition to the suction bells of centrifugal pumps led to severe whirlpool formation, prerotation, and air entrainment. A model study was conducted to alleviate existing conditions in a condenser-water circulating system. A rotating pot apparatus was built subsequently to study free vortex motion and vortex stretching under controlled conditions.
(g) Laboratory measurements and photographic analysis of vortices permitted a comparison with results predicted by hydrodynamic relationships.

(4580) ISOTROPIC-TURBULENCE WATER TUNNEL.

(b) Laboratory project; sponsored partly by U. S. Geological Survey.
(c) Dr. P. G. Mayer, School of Civil Engineering, Georgia Institute of Technology, Atlanta 13, Georgia.
(d) Experimental and theoretical.
(e) In order to establish response characteristics of turbulence probes, a known field of turbulence is necessary. Isotropic turbulence can be created behind square-mesh grids and results of the decay of isotropic turbulence have been known from wind tunnel studies. The experimental flow system consists of a head tank, a contraction cone, an 8-inch diameter test section and a tailwater bay. The turbulence-generating grid was built into the throat of the contraction cone.
(f) Velocity calibration in progress.

(4581) INFLUENCE OF ROUGHNESSES ON FLOW ESTABLISHMENT AND VELOCITY DISTRIBUTION IN OPEN CHANNEL FLOW.

(b) Laboratory project; partly sponsored by U. S. Geological Survey.
(c) Dr. P. G. Mayer, School of Civil Engineering, Georgia Institute of Technology, Atlanta 13, Georgia.
(d) Experimental; research for M. S. thesis.
(e) Vorticity and secondary motions are created at channel transitions. The longevity of these vortices is to be investigated in a

80-foot-long variable-slope channel. The velocity profiles of the developing flows are to be compared with one another for various channel conditions. The deformation and recovery of velocity profiles downstream from disturbances are to be investigated.

(4582) INVESTIGATION OF THE SPECTRUM OF TURBULENCE IN A RECTANGULAR CLOSED CONDUIT.

(b) Laboratory project.
(c) Dr. P. G. Mayer, School of Civil Engineering, Georgia Institute of Technology, Atlanta 13, Georgia.
(d) Experimental; basic research for doctoral dissertation.
(e) Energy spectra are being investigated in a wind tunnel study. A hot wire anemometer and a wave analyzer are being used to measure spectral components in the stream-wise direction. Various physical changes at the entrance to the wind tunnel create different turbulence conditions in order to shed light on the mechanism of turbulence-energy transfer and the structure of turbulence.

(4583) EXPERIMENTAL INVESTIGATION OF NON-ISOTHERMAL VELOCITY PROFILES.

(b) National Science Foundation.
(c) Prof. C. W. Gorton, School of Mechanical Engineering, Georgia Institute of Tech., Atlanta 13, Georgia.
(d) Experimental and theoretical; research for two master's theses.
(e) Horizontal and vertical velocity profiles were measured for the flow of mineral oil through a one inch steam heated horizontal tube in the Reynolds number range 800 to 1400. The purpose of the research was to better understand the effects of varying viscosity and density on velocity profiles.
(f) Completed.
(g) Horizontal and vertical velocity profiles and temperature profiles were measured for ten different Reynolds numbers in the laminar range.
(h) Partial results have been accepted for publication by the AIChE Journal as a communication to the editor.

(4584) VISCOUS FLUID FLOW UNDER THE INFLUENCE OF A RESONANT ACOUSTIC FIELD.

(b) Aeronautical Research Laboratories, Office of Aerospace Research, United States Air Force.
(c) Prof. T. W. Jackson, School of Mechanical Engineering, Georgia Institute of Technology, Atlanta 13, Georgia.
(d) Experimental and theoretical; research for master's and doctor's theses.
(e) An experimental and theoretical study of the effects of resonant acoustic vibrations on the fluid flow and heat transfer in a 4-inch horizontal tube heated by steam. Air was used as the fluid, resonant frequencies were 220 and 356 cps, and sound pressure levels up to 164 decibels were obtained.
(g) The existence of standing vortices in the tube were confirmed experimentally by a visualization study of the flow. Periodic variations in the heat transfer coefficient were obtained and the period of the variation is a half wave-length of the resonant frequency. The resonant vibrations tended to increase the overall heat transfer for laminar flow and decrease it for turbulent flow conditions.
(h) "The Effects of Resonant Acoustic Vibrations on the Local and Overall Heat Transfer Coefficients for Air Flowing Through an Isothermal Horizontal Tube," by Thomas W. Jackson, Kenneth R. Purdy, Calvin C. Oliver, and Harold L. Johnson, ARL Technical Report 60-322, October 1960.
"The Effects of Resonant Acoustic Vibrations on the Nusselt Numbers for a Constant Temperature Horizontal Tube," by T. W. Jackson, Kenneth R. Purdy, and Calvin C. Oliver, Paper No. 57, 1961 International Heat Transfer Conference, August 28 - Sept. 1, 1961, University of Colorado, Boulder, Colorado, USA, and January 8-12, 1962, Central Hall Lecture Theater, Westminister, London, England.
"Heat Transfer Threshold Values for Resonant Acoustic Vibrations in a Horizontal Isothermal Tube," by Ian Eastwood, Thomas W. Jackson, Calvin C. Oliver, and Kenneth R. Purdy, ARL Technical Report 62-326, April 1962.
"Viscous Fluid Flow Under the Influence of a Resonant Acoustic Field," by Kenneth R. Purdy, Thomas W. Jackson, and C. W. Gorton, paper No. 62-WA-116 presented at the 1962 Annual Meeting of the ASME and to be published in the Heat Transfer Journal.

(4585) THE VISCOSITY OF HIGH PRESSURE STEAM.

(b) National Science Foundation.
(c) Prof. T. W. Jackson, School of Mechanical Engineering, Georgia Institute of Technology, Atlanta 13, Georgia.
(d) Experimental and theoretical; research for master's and doctor's theses.
(e) An experimental and theoretical study of the viscosity of steam to 10,000 psi and 1200 degrees F.
(g) Experimental data have been obtained for the viscosity of steam using an annulus type transpiration viscosimeter. A unique method of measuring small pressure drops at very high static pressures was developed. Experimental and theoretical work are continuing on the project.
(h) "An Investigation of the Viscosity of Steam at High Pressures," Samuel C. Barnett, Ph.D. Thesis.
"The Experimental Determination of Steam Viscosity at Pressures of 5,000 psia and 7,500 psia," Roger Harold Whitesides, Jr., M.S.M.E. Thesis.
"A High Pressure Differential Manometer," by S. C. Barnett, T. W. Jackson, and R. H. Whitesides, Jr., accepted for publication in Journal of Heat Transfer of ASME.

(4586) EXPERIMENTAL AND THEORETICAL STUDIES OF SECONDARY FLOW PHENOMENA INDUCED BY CURVATURE AND VISCOUS SHEAR LAYERS.

(b) National Science Foundation.
(c) Prof. A. W. Marris, School of Mechanical Engineering, Georgia Institute of Tech., Atlanta 13, Georgia.
(d) Experimental and theoretical; master's and doctor's theses.
(e) Basic research on secondary flow development by the action of curvature on non-uniform velocity gradients and viscous shear layers.
(h) "Turbulent Flow of Water in Plane Curved Channels of Finite Depth" by O. G. Brown and A. W. Marris, Paper No. 62-WA-75, 1962 Annual ASME Meeting, (to be published in Journal of Basic Engineering).
"A Review on Vortex Streets, Periodic Wakes and Induced Vibration Phenomena," by A. W. Marris, Paper No. 62-WA-106, 1962 Annual ASME Meeting, (to be published in Journal of Basic Engineering).
"Radial Distributions of Temporal-Mean Peripheral Velocity and Pressure for Fully Developed Turbulent Flow in Curved Channels," by A. W. Marris, ASME Journal of Basic Engineering, Sept. 1960, Vol. 82, Series D, No. 3, p 528-538.

(4587) HEAT TRANSFER IN ANNULI.

(b) Departmental research.
(c) Prof. H. C. Ward, School of Chemical Engineering, Georgia Institute of Tech., Atlanta 13, Georgia.
(d) Experimental; basic research for doctor's thesis.

(e) Investigation of the effect of diameter ratio, Prandtl number, Reynolds number, and unheated entrance length on heat transfer through outer wall of annuli.
(f) Completed.
(g) Heat transfer coefficients to water, ethylene-glycol, and n-butanol were obtained for a one inch O.D. inconel tube (wall thickness 0.049"), 10 feet long with center plugs of 0.037, 0.125, 0.25, 0.407, 0.502, 0.673, and 0.752 inches in diameter.
(h) "Heat Transfer in Annuli: Nusselt Numbers at the Outer Wall as a Function of the System Variables," by John Paul Sanders, Ph.D. thesis, August 1962.

(4588) MASS TRANSFER IN THE ENTRANCE LENGTH OF A PIPE - LAMINAR FLOW.

(b) Departmental research.
(c) Prof. H. C. Ward, School of Chemical Engrg., Georgia Institute of Technology, Atlanta 13, Georgia.
(d) Experimental and theoretical; basic research for doctor's thesis.
(e) The project was established to determine the mass transfer effects in the entrance lengths of tubes.
(g) Local mass-transfer rates were obtained by measuring the thickness decrease of a naphthalene layer as a function of time and position. Theoretical results were calculated using Langhaar's entrance length velocity profiles.
(h) "Mass Transfer in the Entrance Length of a Pipe - Laminar Flow," by R. T. Bosworth and H. C. Ward, paper presented at 55th Annual Meeting of American Institute of Chemical Engineers, Chicago, Illinois, Dec. 2-6, 1962.

(4589) A THEORETICAL STUDY OF NONISOTHERMAL FLOW AND HEAT TRANSFER IN VERTICAL TUBES FOR FLUIDS WITH VARIABLE PHYSICAL PROPERTIES.

(b) Departmental research.
(c) Prof. H. C. Ward, School of Chemical Engrg., Georgia Inst. of Tech., Atlanta 13, Georgia.
(d) Theoretical; basic research for doctor's thesis.
(e) A theoretical study of nonisothermal flow in vertical tubes.
(g) A numerical scheme has been obtained for calculating heat transfer and fluid friction characteristics for laminar flow of fluids with variable physical properties in vertical circular tubes. Correlation parameters were developed for common fluids, taking into account free convection effects, variable viscosity, and variable heat capacity and thermal conductivity. Correlated mean temperatures and friction factors are presented.
(h) "A Theoretical Study of Nonisothermal Flow and Heat Transfer in Vertical Tubes for Fluids with Variable Physical Properties," by W. J. Lee and H. C. Ward, paper presented at 55th Annual Meeting of American Institute of Chemical Engineers, Chicago, Illinois, Dec. 2-6, 1962.

(4590) ADIABATIC, EVAPORATING, TWO-PHASE FLOW OF STEAM AND WATER IN HORIZONTAL PIPES.

(b) Departmental research.
(c) Prof. H. C. Ward, School of Chemical Engrg., Georgia Inst. of Tech., Atlanta 13, Georgia.
(d) Experimental and theoretical; basic research for doctor's thesis.
(e) The adiabatic, evaporating, two-phase flow of steam and water in a horizontal pipe, including the critical flow, was sucessfully described by a system of non-linear differential equations which were solved, using numerical techniques, on a digital computer. Experimental data which were obtained show that the theoretical equations describe the complex flow phenomena to plus or minus 10 percent when radial temperature gradients are small. Design charts based on the numerical solution of the theoretical equations are presented for rapid computation of the flow variables including the critical flow situation.
(h) "Adiabatic, Evaporating, Two-Phase Flow of Steam and Water in Horizontal Pipe," by R. W. Pike and H. C. Ward, paper to be presented at the National Meeting of the American Institute of Chemical Engineers, New Orleans, Louisiana, March 10-14, 1963.

(4591) LAMINAR-FLOW DEVELOPMENT IN AN ACOUSTICALLY RESONANT HORIZONTAL TUBE.

(b) Departmental research.
(c) Prof. H. C. Ward, School of Chemical Engrg., Georgia Inst. of Tech., Atlanta 13, Georgia.
(d) Theoretical; basic research for doctor's thesis.
(e) An analytical study of resonant acoustic vibrations in air flowing through a horizontal tube. Constant density and viscosity are assumed. Also the effects due to gravity are assumed to be negligible. A mathematical model for instantaneous velocity profiles was generated through an adaptation of the equations of motion. The model was solved numerically and the results predicted an instantaneous acoustic vibration effect on the normal boundary layer development which is periodic with respect to axial position in the system.
(f) Completed.
(g) Provides analytical expressions for velocity profiles in a tube in which resonant acoustical vibrations are established. These profiles may be used in analytical expressions for heat or mass transfer rates in similar systems.
(h) "Laminar-Flow Development in an Acoustically Resonant Horizontal Tube," by J. M. Spurlock and H. C. Ward, paper to be presented at National Meeting of American Institute of Chemical Engineers, New Orleans, Louisiana, March 10-14, 1963.

UNIVERSITY OF IDAHO, Engineering Experiment Station.

Inquiries concerning Projects Nos. 1859, 3056, 3057, and 3416 should be addressed to Prof. C. C. Warnick, College of Engineering, and for Projects Nos. 1862, 2786, and 3418 should be addressed to Prof. G. L. Corey, Dept. of Agricultural Engineering, Univ.of of Idaho, Moscow, Idaho.

(1859) INVESTIGATION OF METHODS OF CONTROLLING AND EVALUATING CANAL SEEPAGE.

(b) Laboratory project; in cooperation with U. S. Bureau of Reclamation.
(d) Experimental and field investigation; basic and operational with master's thesis.
(e) Different types of canal linings are being studied and various ways of evaluating performance are being considered, especially ideas for measuring canal seepage from both lined and unlined canals.
(g) New sealants are being investigated in experimental sections of irrigation canals. Techniques for measuring seepage are being compared in simultaneous testing in by-pass sections of canal.
(h) Annual progress report is available on a limited basis.
"A Study of the Measurement of Canal Seepage," D. E. Woodward, M. S. Thesis, University of Idaho, 1962.

(1862) DETERMINATION OF ANNUAL RUNOFF FROM WATERSHED CHARACTERISTICS.

(b) Laboratory project; being carried on under Agricultural Experiment Station.
(d) Experimental; applied research.
(e) A study of the hydrological factors affecting the Moscow Mountain Watershed as it applied to the total water use in the area.

(g) Measurement data on a small watershed is continuing to be collected.

(2786) FARM IRRIGATION EFFICIENCIES.

(b) Laboratory project; cooperative with the Bureau of Reclamation under the Agricultural Experiment Station.
(d) Field investigation; basic and applied research.
(e) To evaluate irrigation efficiencies on actual farms to aid in planning of a water use on irrigation projects. To consider efficiency from aspect of farm operations and not just consumptive use of crops.
(g) Basic field data have been collected for five years. Final results are being prepared for publication.

(3056) TELEMETERING HYDROLOGIC DATA FROM MOUNTAIN LOCATIONS.

(b) Laboratory project; in cooperation with federal agencies and power companies.
(d) Laboratory and field investigation; basic and applied operational research.
(e) A complete system for reporting six or more hydrologic data is being studied and basic parameters of snow melt are being studied for conversion into time delay circuits for transmission by radio.
(g) Prototype unit is being tested on Moscow Mountain; elements of measurement transducers are being studied both in the field and in the laboratory. License for station has been approved.
(h) Annual progress report is available on loan.

(3057) CONSERVATION OF WATER FOR RANGE STOCK.

(b) Laboratory project; in cooperation with Bureau of Land Management and ranchers.
(d) Field investigation; applied operational research.
(e) Experimental stock watering ponds in desert areas will be lined and evaporation control measures supplied to see if extension of such water supply can be developed economically.
(g) Several ponds lined and unlined are being studied and enonomolecular films are being experimented with to find net water savings. The hydrology of small ponds is also being investigated.
(h) "Idaho Reconnaissance Precipitation Gage," by F. R. Collett and C. C. Warnick, Circular No. 1, Engineering Experiment Station, Univ. of Idaho, July 1962.

(3416) STUDY OF METHODS FOR AUTOMATIC MEASUREMENT OF SNOW WATER CONTENT.

(b) Laboratory project; cooperative with Agricultural Research Service, U. S. Dept. of Agriculture.
(d) Field investigation; applied research.
(e) A study is being made of basic methods of measuring snow water content for use in telemetering data from remote mountain locations.
(g) Five different methods are being investigated in field experiments at mountain locations. Data are being obtained manually and correlated with conventional tube snow measurements.
(h) First phase to be completed in December 1962. Two theses are in preparation and a final report will be made in 1963.

(3417) INFILTRATION AS AFFECTED BY FURROW PARAMETERS AND SOIL VARIABILITY.

(b) Laboratory project; under investigation in Agricultural Experiment Station.
(c) Assistant Prof. D. W. Fitzsimmons, Dept. of Agricultural Engineering, Univ. of Idaho, Moscow, Idaho.
(d) Theoretical; basic research.
(e) To determine the effect of various furrow geometric parameters and soil conditions on infiltration patterns by analogy methods.
(g) Flow patterns from square, round and triangular shaped furrows in uniform soils have been investigated.
(h) "Electric Analog Studies of Steady Flow from Irrigation Furrows," by D. W. Fitzsimmons, M. S. Thesis, University of Idaho, 1962.
"A Procedure for Determining Equivalent Conductivities of Soils for Electric Analog Solutions of Steady Flow Problems," by D. W. Fitzsimmons and G. L. Corey, Idaho Agricultural Experiment Station Research Bulletin No. 58.
"Infiltration Patterns from Irrigation Furrows," by G. L. Corey and D. W. Fitzsimmons, Idaho Agricultural Expt. Sta. Research Bulletin No. 59.

(3418) AUTOMATIC CONTROL OF SURFACE IRRIGATION WATER.

(b) Laboratory project; under investigation in Agricultural Experiment Station.
(d) Experimental field investigation; applied research.
(e) To develop sensing elements which will electrically trip automatic headgates after a field has become irrigated.
(g) Several elements have been field tested. No element has been developed thus far that is sufficiently sensitive to high soil moisture levels.

(4533) MEASUREMENT OF TURBULENCE IN LIQUIDS IN PIPE FLOW USING COMPUTER TECHNIQUES.

(b) Laboratory project; National Science Foundation grant.
(c) Assoc. Professor G. Q. Martin, Chemical Engineering Department, University of Idaho, Moscow, Idaho.
(d) Experimental; basic research.
(e) To measure relative intensity and Eulerian integral scale of turbulence from autocorrelation measurements using computer techniques.
(f) Completed.
(g) A correlation has been obtained to predict the relative intensity of turbulence and Eulerian and Legrangian scales of turbulence for flow of fluids through pipes.
(h) "An Investigation into the Turbulence Characteristics of Fluids in Pipe Flow," by G. Q. Martin, Ph.D. Thesis, University of Washington, 1963.

(4534) MEASUREMENT OF TURBULENCE IN LIQUIDS IN PIPE FLOW USING A WAVE ANALYZER.

(b) Laboratory project; National Science Foundation grant, National Defense and Education Act fellowship.
(c) Assoc. Prof. G. Q. Martin, Chemical Engrg. Department, University of Idaho.
(d) Experimental; basic research.
(e) To measure relative intensity and Eulerian integral scales of turbulence using a wave analyzer.
(h) "Measurement of Pipe Turbulence Using a Wave Analyzer," by D. K. Edwards, M. S. Thesis, University of Idaho, 1963.

(4535) CROP COEFFICIENTS FOR CONSUMPTIVE USE IN IDAHO.

(b) Laboratory project.
(c) Department of Agricultural Engineering, Univ. of Idaho, Moscow, Idaho.
(d) Field investigation; applied research for master's thesis.
(e) To determine crop coefficients, using the Blaney-Criddle formula, for such crops as potatoes, beans, and corn for southern Idaho areas. The variation of the crop coefficients for (1) light, medium and heavy applications of water, (2) each month of growing or irrigation season, and (3) the stage of growth of each crop. These coefficients will be compared with the coefficients developed by Blaney-Criddle and other investigators for

other areas.
(g) Data are currently being collected.

ILLINOIS STATE WATER SURVEY DIVISION

A list of publications is available upon request; write to Illinois State Water Survey, Box 232, Urbana, Illinois.

(552) SEDIMENTATION OF ILLINOIS RESERVOIRS.

(b) Laboratory project; cooperative with Agricultural Research Service, Soil Conservation Service, and University of Illinois Agricultural Experiment Station.
(c) Mr. R. L. Corinth, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research.
(e) For design of water-supply reservoirs, measurements of sediment accumulation in lakes in Illinois. Sediment samples are analyzed and complete surveys of watershed soil type, slopes, land use, and conservation practices are made.
(g) Results show correlation between rate of sedimentation and land use on watershed; results show six factors in explaining sediment deposition: age of lake, capacity-inflow ratio, watershed gross erosion, a watershed shape factor, the density of non-incised channels, and a watershed slope factor.
(h) "An Empirical Equation for Reservoir Sedimentation," William C. Ackermann and Roger L. Corinth, State Water Survey Reprint Series 1962-H, extract of publication No. 59, I.A.S.H., Commission of Land Erosion, pp. 359-366.

(555) EVAPORATION IN ILLINOIS.

(b) Laboratory project.
(c) Mr. W. J. Roberts, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research.
(e) Measurements were made of evaporation at four stations in northern, central, and southern Illinois. Evaporimeters constructed and installed adjacent to pans for year-round records.
(f) Measurements discontinued November 1, 1962.
(h) Measurements published in Climatological Data, Illinois Section. "Lake Evaporation in Illinois," State Water Survey Technical Letter No. 5, 1960.

(559) ARTIFICIAL RECHARGE OF GROUND WATER.

(b) Laboratory project.
(c) Mr. Robert H. Harmeson, Peoria Laboratory, Illinois State Water Survey, Box 717, Peoria, Illinois.
(d) Experimental; basic research.
(e) Model studies of different pit types and variations in relationship between groundwater gradients and artificial recharge.
(g) Pilot plant pit operation by Water Survey relinquished; laboratory analysis in progress.

(560) GROUND WATER INVESTIGATION IN PEORIA, ILLINOIS, DISTRICT.

(b) Laboratory project.
(c) Mr. Robert H. Harmeson, Peoria Laboratory, Illinois State Water Survey, Box 717, Peoria, Illinois.
(d) Field investigation; applied research.
(e) Continuing evaluation of ground water resources of the district. Ground water levels and temperatures are monitored in wells in key locations. Effects of artificial recharge are evaluated. Analyses for changes in composition of ground water used to trace movement of ground water and to observe for possible introduction and movement of contaminants as a result of artificial recharge.
(g) Ground-water conditions substantially improved in past ten years and consistently since the use of four recharge pits was initiated in 1956. One pit in North Field is operated the year-round with nearly complete recovery of the recharged water. Second pit in North Field inoperative in 1962. Recharge in Central Field arbitrarily limited to cool surface water seasons. Central Field recharge has been reduced because of improved ground water conditions.
(h) "ABS in the Peoria Domestic Water Supply," Orville W. Vogel and Robert H. Harmeson, State Water Survey Reprint Series 1962-E, Jour. AWWA, 54(7):803-810, July 1962.
"Eleventh Annual Report on Operation of the Cedar Street Recharge Pits," Virginia Schnepper, Peoria Assoc. of Commerce, Peoria, Ill., 1962.

(561) GROUND-WATER INVESTIGATION IN EAST ST. LOUIS AREA.

(b) Laboratory project.
(c) Mr. R. J. Schicht, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research.
(e) Evaluation of potential yield of the sand and gravel deposits beneath the American Bottoms (East St. Louis area). Ground water levels are measured in more than 200 observation wells, 9 of which are equipped with recording gages. Ground water pumpage, Mississippi River stages, rainfall, and quality of ground water data are continuously collected. Maps have been prepared showing the distribution and areal extent of the hydraulic properties, the thickness of the aquifer, and water-table contours. Computations are being made to determine the amount of recharge from precipitation and from induced infiltration of river water, and the amount of subsurface flow from valley walls into the American Bottoms. An electric analog model has been constructed to simulate the complex aquifer system.
(h) "Ground-Water Levels and Pumpage in East St. Louis Area, Illinois, 1890-1961," R. J. Schicht and E. G. Jones, State Water Survey Report of Investigation 44, 1962.

(1335) GROUND WATER INVESTIGATION IN THE CHICAGO AREA.

(b) Laboratory project, in cooperation with Illinois State Geological Survey.
(c) Mr. H. F. Smith, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research.
(e) Study of variations of natural resources. Investigation of artesian well field with wells 1200 to 2200 feet deep, locally heavily pumped. Study of ground water level recession, interferences, transmissibilities, effect of additional demands.
(g) Results show the ground water resources in Chicago region are developed from four water-yielding units: glacial drift aquifers, shallow dolomite aquifers, Cambrian-Ordovician Aquifer, and Mt. Simon Aquifer. The Cambrian-Ordovician has been the most highly developed source of large ground-water supplies. Future ground-water supplies should be taken from the shallow aquifers wherever possible.
(h) "Yields of Deep Sandstone Wells in Northern Illinois," W. C. Walton and Sandor Csallany, State Water Survey Report of Investigation 43, 1962.
State Water Survey annual summaries of water-level decline and pumpage in the Chicago region for 1959, 1960, 1961, given in Circulars. 79, 83, 85, respectively.

(1865) HYDRAULIC DESIGN OF DROP-INLET SPILLWAY STRUCTURES FOR SMALL RESERVOIRS.

(b) Laboratory project, in cooperation with

Agricultural Research Service, Soil Conservation Service, and Illinois Agricultural Experiment Station.
(c) Mr. H. W. Humphreys, Illinois State Water Survey, Box 232, Urbana, Ill.
(d) Experimental; generalized applied research for development and design.
(e) To determine the most desirable proportions and shapes of drop-inlet spillway structures that have unique flow characteristics and to develop anti-vortex devices. To provide the necessary information on flow relations and discharge coefficients so that these structures may be economically designed. Initial phases of study concerned with hydraulics of square risers with free discharge. Effect of lip or crest shape and anti-vortex devices being studied. Second phase to include the complete spillway. Experimental apparatus constructed and tests are being conducted on the complete spillway. Information is being obtained on discharges, vortex effect on discharge, pressures, a flat plate anti-vortex device, and flow conditions.
(g) Hydraulics of various types of flow possible in square risers are well defined as well as some of the effect of non-square crest shape. Model tests were performed on a drop-inlet spillway to determine whether or not a metal grating deck placed above the inlet can control vortices. The results of the tests show that gratings do not prevent or control strong vortices.

(2532) EVAPORATION RETARDATION.

(b) Laboratory project.
(c) Mr. W. J. Roberts, Illinois State Water Survey, Box 232, Urbana, Ill.
(d) Field investigation; applied research, design.
(e) Monomolecular chemical films to retard evaporation from water supply lakes and ponds in Illinois.
(f) Additional summer tests planned.
(g) Results appear favorable and tests will be continued through 1963 summer season with soluble packages.

(2534) DENSE RAIN GAGE NETWORK PROJECTS.

(b) Laboratory project.
(c) Mr. G. E. Stout, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research.
(e) Data from four rain gage networks, consisting of 50 gages in 400 square miles, 10 gages in 100 square miles, 54 gages in 550 square miles, and 11 gages in 10 square miles. Studies include: (1) Rainfall variability, (2) frequency of point and areal mean rainfall, (3) area-depth relations, (4) variation of point rainfall with distance; (5) areal representativeness of point rainfall; and (6) reliability of areal mean rainfall estimates.

(2535) FILTERING THROUGH COARSE MATERIALS.

(b) Laboratory project.
(c) Mr. Robert H. Harmeson, Peoria Laboratory, Illinois State Water Survey, Box 717, Peoria, Illinois.
(d) Experimental; basic research.
(e) Small, coarse media (1/4 - to 3/4-inch) filters are operated at rates comparable to those achieved in field practice. Purpose is to study the effects of coarse media on physical, chemical, and bacteriological properties of recharged water and to evaluate the function of coarse media in protecting aquifer materials.
(g) Results of former field tests of various sizes of materials are reported in State Water Survey Bulletin 48. Program of specially controlled laboratory test runs initiated in 1962 under grant from U. S. Public Health Service.

(2788) METEOROLOGY OF FLOOD-PRODUCING STORMS.

(b) Laboratory project.
(c) Mr. F. A. Huff, Illinois State Water Survey, Box 232, Urbana, Ill.
(d) Applied research.
(e) Investigation of meteorological conditions associated with flood-producing storms in Illinois to obtain basic data for reliable definition of time and space distribution of such storms and for calculation of probable maximum rainfall.
(g) Continuing project; analysis of storm area-depth relations, orientation of storms, seasonal and geographic distribution, synoptic weather types, topographic influences. Development of area-depth frequency relations underway.

(3058) HYDROMETEOROLOGICAL ANALYSIS OF SEVERE RAINSTORMS.

(b) Laboratory project.
(c) Mr. F. A. Huff, Illinois State Water Survey, Box 232, Urbana, Ill.
(d) Field investigation; applied research.
(e) Field surveys and detailed analyses of severe rainstorms in Illinois. Analyses based upon radar, synoptic weather, and field survey data and include area-depth-duration relations, antecedent rainfall evaluation, isohyetal maps for peak periods of storm.
(g) Analyses completed on 16 storms since 1951.
(h) State Water Survey Reports of Investigation Nos. 14, 24, 27, 35, and 42.

(3059) THERMAL LOADINGS AND CHARACTERISTICS OF SURFACE WATERS.

(b) Laboratory project.
(c) Mr. Robert H. Harmeson, Peoria Laboratory, Illinois State Water Survey, Box 717, Peoria, Illinois.
(d) Field investigation; applied research.
(e) A study of heat loads applied to fresh water bodies in Illinois to determine relationships between temperature and/or heat loadings, water usage, stream assets, and stream recovery capabilities.

(3419) PRECIPITATION DROUGHT CHARACTERISTICS.

(b) Laboratory project.
(c) Mr. F. A. Huff, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Applied research.
(e) Investigation of precipitation drought frequency in Illinois, distribution in space and time of dry periods, relative severity of these periods, meteorological conditions favorable for drought in Illinois, correlation of precipitation drought with other meteorological factors such as thunderstorm frequency and atmospheric moisture distribution, and association of precipitation drought with low stream flow.
(h) Report in preparation.

(3420) FREQUENCY AND DURATION OF LOW FLOWS.

(b) Laboratory project.
(c) Mr. John B. Stall, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Theoretical; applied research.
(e) Analysis of the severity, frequency, and duration of low flows in Illinois streams as they affect impounding reservoir yields.
(g) Methodology devised to determine gross and net yield of an impounding reservoir during various recurrence-interval droughts. A non-sequential mass curve analysis gives gross yield. Net lake evaporation is processed on a frequency basis; applied to the reservoir; and net yield is determined. Risks associated with an impounding reservoir have been determined and clarified to allow better understanding of reservoir design and recurrence of events.
(h) "Reservoir Mass Analysis by a Low Flow Series,"

ASCE Sanitary Engineering Division, Sept. 1962. "Calculated Risks of Impounding Reservoir Yield," ASCE Hydraulics Div., January 1963. Final report in progress, to be titled "Low Flows of Illinois Streams for Impounding Reservoir Yield."

(3421) PILOT DRAINAGE BASIN STUDIES IN NAPERVILLE AREA.

(b) Laboratory project.
(c) Mr. W. C. Walton, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research.
(e) All factors of the hydrologic cycle (especially precipitation, temperature, stream flow, soil moisture, changes in surface and subsurface storage, and evaporation) to be measured and examined to obtain quantitative knowledge of the movement and storage of ground water under natural conditions in the 22-square mile basin. The annual rate of recharge to, and evapotranspiration from, the ground-water reservoir to be determined. Stream discharge hydrograph to be separated into its two components, surface runoff and ground-water runoff. Gravity yields of glacial deposits and underlying dolomite aquifer to be estimated.

(3731) HYDROLOGY OF DOLOMITE AQUIFERS.

(b) Laboratory project, in cooperation with Ill. State Geological Survey.
(c) Mr. W. C. Walton, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research.
(e) Evaluation of water yielding potential of dolomite aquifer in Illinois from pumping test and specific capacity data is in progress. Statistical analysis of well production data is being made to determine geological controls on aquifer productivity.
(g) Frequency graphs were used to determine the role of individual units of a dolomite aquifer in DuPage County, Illinois, as contributors of ground water. The practical sustained yield of the dolomite aquifer was estimated based largely on case histories of heavy ground-water development.
(h) "Ground-Water Resources of DuPage County, Illinois," A. J. Zeizel, W. C. Walton, R. T. Sasman, and T. A. Prickett, Illinois State Water Survey and Geological Survey Cooperative Ground-Water Report 2, in press 1962.

(3732) TRANSPIRATION RETARDATION.

(b) Laboratory project.
(c) Mr. W. J. Roberts, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Laboratory and field investigation.
(e) Monomolecular film-forming fatty alcohols are introduced to roots of plants causing the plants to transpire less water than control plants.
(g) Field tests being analyzed.
(h) "Reduction of Transpiration," W. J. Roberts, State Water Survey Reprint Series 1961-E, Jour. Geophys. Res., 66(10):3309-12, Oct. 1961.

(3733) EVALUATING WELLS AND AQUIFERS WITH ANALYTICAL METHODS.

(b) Laboratory project.
(c) Mr. W. C. Walton, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research.
(e) Case histories of ground-water development are being studied to determine if it is possible to evaluate wells and aquifers with analytical expressions by devising approximate methods of analysis based on idealized models of aquifer situations. Geohydrologic boundaries are assumed to be straight-line demarcations and are given mathematical expression by means of the image-well theory. The hydraulic properties of the aquifer and overlying confining beds are considered mathematically by using ground-water formulas. Records of past pumpage and water levels and a digital computer are used to establish the validity of this mechanism to describe the response of aquifers to pumping.
(g) Case histories of ground-water development have been used to evaluate the practical sustained yields of eight aquifers in Illinois.
(h) "Selected Methods for Well and Aquifer Evaluation," W. C. Walton, State Water Survey Bulletin 49, 1962.

(3734) INDUSTRIAL WATER USE IN ILLINOIS.

(b) Laboratory project.
(c) Mr. W. J. Roberts, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research.
(e) Determine withdrawal of water by industries in Illinois, with delineation according to kinds of industry, location by area, and sources of supply.

(4135) CORROSION PREVENTION BY $CaCO_3$.

(b) Laboratory project.
(c) Mr. T. E. Larson or H. W. Humphreys, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Experimental.
(e) To determine chemical requirements and velocity requirements to provide protective coating in water pipes.

(4136) SEVERE STORM SINGULARITY STUDY.

(b) Laboratory project.
(c) Mr. S. A. Changnon, Jr., Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Applied research.
(e) Investigation of the tendency of severe weather events to occur on preferred dates, the causes of observed tendencies, and the application of the results in defining the probability distribution of severe storms. Elements under study include severe rainstorms, thunderstorms, hailstorms, and tornadoes.
(f) Completed.
(h) "Singularities in Severe Weather in Illinois," S. A. Changnon, Jr., paper presented at American Meteorological Society meetings on Climatology, Asheville, N. C., Oct. 1962; to be publishe as research report for Crop-Hail Insurance Actuarial Assoc., January 1963.

(4137) DIURNAL DISTRIBUTION OF PRECIPITATION AND RELATED WEATHER ELEMENTS.

(b) Laboratory project.
(c) Mr. S. A. Changnon, Jr., Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Applied research.
(e) Investigation of the diurnal distribution of various weather elements on a monthly, seasonal, annual, and geographic basis. Elements under study include rainfall, sleet, hail, tornadoes, thunderstorms, freezing rain, and fog.
(f) Suspended.

(4138) EVAPOTRANSPIRATION IN ILLINOIS.

(b) Laboratory project.
(c) Mr. D. M. A. Jones, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Applied research.
(e) Evaluation of methods for calculating evapotranspiration and assessment of evapotranspiration in Illinois.
(h) "Evapotranspiration in Illinois," Report of Investigation in preparation.

(4139) PRECIPITATION PATTERNS OVER AND AROUND LOWER LAKE MICHIGAN.

(b) Laboratory project.
(c) Mr. G. E. Stout, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Applied research.
(e) Radar film records are being studied to de-

termine the influence of Lake Michigan on precipitation processes. A proposal has been submitted to develop a raingage for bouy installation and plans have been prepared for additional radar data collection over lower Lake Michigan.

(h) "Influence of Lake Michigan on Squall Line Rainfall," Proceedings, Fifth Conference on Great Lakes Research, Great Lakes Research Division Publication No. 9, University of Michigan, pp. 111-115, 1962.

(4536) GEOHYDROLOGIC SYSTEM ANALYSIS WITH AN ELECTRIC ANALOG COMPUTER.

(b) Laboratory project.
(c) Mr. William C. Walton, Illinois State Water Survey, Box 232, Urbana, Ill.
(d) Experimental; applied research.
(e) Purpose of project is to apply electric analog computers to ground-water resource evaluation problems in Illinois. Ground-water development schemes are being tested and the relative merits of alternate choices of development are being appraised. The consequences of the utilization of aquifers are being forecast. The electric analog computer in use consists of an analog model and excitation-response apparatus, i.e., waveform generator, pulse generator, and oscilloscope. The analog model is a regular array of resistors and capacitors and is a scaled-down version of an aquifer.
(g) Analog models have been constructed for three idealized aquifer situations to study the accuracy and reliability of the analog computer. Close agreement between analog computer and exact analytical solutions for the three selected aquifer situations has been obtained. A comparison of the analog computer and simplified analytical solutions for a selected complex aquifer situation indicates that resource evaluations based on incomplete data and analog or idealized mathematical models can be meaningful and useful. Analog models for sand and gravel aquifers in the East St. Louis and Champaign-Urbana areas have been constructed. Past records of pumpage and water levels have been used to establish the validity of the analog model for the East St. Louis area.
(h) "Electric Analog Computers for Analyzing Ground-Water Problems," W. C. Walton and T. A. Prickett, has been submitted for publication in the Journal of the Hydraulics Division, ASCE.

(4537) HYDROMETEOROLOGY OF SPECIFIC ILLINOIS BASINS.

(b) Laboratory project.
(c) Mr. F. A. Huff, Illinois State Water Survey, Box 232, Urbana, Ill.
(d) Applied research.
(e) Development of relations defining the distribution of precipitation extremes in major basins. Included are studies of the frequency distribution of excessive point and areal mean rainfall in various regions of basins, the frequency distribution of drought, average slope of area-depth curves, actual depth-duration-area relations in the heaviest storms on record, area-depth frequency relations based upon all major storms of record, seasonal distribution of heavy storms, and the shape characteristics of major storms. Research presently confined to the Kaskaskia basin.

ILLINOIS STATE WATERWAYS DIVISION, Springfield.

(1863) EROSION CONTROL, ILLINOIS SHORE OF LAKE MICHIGAN.

(b) State of Illinois.
(c) Mr. Thomas B. Casey, Chief Waterway Engr., Div. of Waterways, Dept. of Public Works and Buildings, 201 West Monroe Street, Springfield, Illinois.
(d) Field investigation; applied research.
(e) To obtain and correlate basic data on the several forces and factors involved in erosion processes along the Illinois Shore of Lake Michigan to the end that future efforts toward the prevention of erosion might be founded upon a more definite and factual basis with a consequent greater degree of assurance that the works will serve the intended purposes.

UNIVERSITY OF ILLINOIS, Soil and Water Conservation Engineering Lab., Department of Agricultural Engrg.

Inquiries concerning the following projects should be addressed to Prof. B. A. Jones, 100 Agricultural Engineering, University of Illinois, Urbana, Ill.

(2316) RUNOFF FROM SMALL AGRICULTURAL AREAS IN ILLINOIS.

(b) Laboratory project cooperative with ARS, U. S. Department of Agriculture.
(d) Experimental and field investigation; basic research.
(e) To determine frequencies of peak rates and total amounts of runoff from agricultural watersheds of 25 to 1,500 acres; to determine maximum rates of runoff from agricultural watersheds in different soil association areas in Illinois; to compare runoff from agricultural watersheds under accepted soil conservation practices with watersheds cultivated without soil conservation practices. Watersheds of 45.5, 63, 82, and 390 acres near Monticello, Illinois are covered with a rain gage network, and runoff is measured at weirs and spillway structures by water level recorders. Maximum stage recorders are installed at field structures on 8 watersheds in Champaign, Piatt, Vermillion, and Ford Counties on watersheds ranging in size from 45 to 1,400 acres. Model studies and field calibrations are made on the field structures.
(h) Bulletin summarizing twelve years of record being written.

(2789) LABORATORY MODEL STUDIES OF CONSERVATION AND DRAINAGE STRUCTURES.

(b) Laboratory project.
(d) Experimental investigation in the laboratory; applied and basic research.
(e) To investigate the performance of soil and water conservation structures by means of hydraulic model studies, to study water flow patterns into surface drains and to determine the cause of failures and remedial measures of certain conservation structures under flood conditions.
(h) "Filter Materials for Tile Drains in a Medium Sand - A Laboratory Comparison," by D. R. Sisson and B. A. Jones, Jr. Trans. of ASAE: 5-1, 54-58 (1962).
"Discussion: End Depth at a Drop in Trapezoidal Channels" by J. A. Replogle, Proc. ASCE 88-HY2, 161-165. (March 1962).
"A Microdifferential Pressure Transducer," by L. F. Huggins, Agricultural Engineering 43-9, 529, 531. (September 1962)
"Comparison of Theoretical, Laboratory, and Field Discharge Ratings of a Drop Inlet for a Small Farm Pond," by J. A. Replogle, L. F. Huggins and R. D. Black, Trans. of ASAE 5-2, (in press 1962).
"Gully Control Without Structures" by W. S. Harris and R. C. Hay, Trans. of ASAE 5-2 (in press 1962).

(3424) A STUDY OF RAINFALL ENERGY AND SOIL EROSION.

(b) Laboratory project cooperative with ARS, U. S. Dept. of Agriculture.
(d) Experimental; basic research.
(e) Natural rainstorms are photographed with a raindrop camera so that the number of raindrops, their size and size distribution, and

the kinetic energy of a rainstorm may be calculated. Physical measurements will be made of the soil to determine the effect of the kinetic energy of the rainstorm on soil loss. The nature and properties of rainstorms that occur in this area of Illinois will also be studied.

(h) "Modifications to Improve Hydrologic Data from Wheel-Type Samplers" by J. A. Replogle. Paper No. 62-717 presented at the Winter Meeting of the American Society of Agricultural Engineers, December 1962 (available from the Executive Secretary ASAE, St. Joseph, Michigan).

UNIVERSITY OF ILLINOIS, Hydraulics and Water Resources Laboratory, Department of Civil Engrg.

Inquiries concerning all projects should be addressed to Dr. V. T. Chow, Prof. of Hydraulic Engineering, University of Illinois, Urbana, Ill., unless otherwise indicated.

(1591) DETERMINATION OF WATERWAY AREAS.

(b) Laboratory project, cooperative with Illinois Division of Highways and Bureau of Public Roads.
(d) Analytical and field investigation; applied research and design.
(e) To determine the discharge of water which will reach openings of highway drainage structures, such as bridges and culverts and to provide a simple but scientific procedure for use of engineers in establishing the economical and adequate size of opening.
(f) Completed.
(g) A scientific, simple, and practical method is developed for the determination of peak discharges from small drainage basins. For practical applications, a design chart for climatic and physiographic conditions in Illinois is prepared.
(h) "Hydrologic Determination of Waterway Areas for the Design of Drainage Structures in Small Drainage Basins," by Ven Te Chow, University of Illinois, Engineering Experiment Station, Bulletin No. 462, March, 1962.
"Hydrologic Design of Culverts," by Ven Te Chow, Proceedings American Society of Civil Engineering, Paper 3071, Journal of Hydraulics Division, HY2, March, 1962, pp. 39-55; reprinted also as University of Illinois Civil Engineering Series, Hydraulic Engrg. Series No. 5, Illinois Cooperative Highway Research Program, Series No. 5, June, 1962.

(3060) OPERATIONAL CHARACTERISTICS OF FILTER DRAINS.

(b) Association of American Railroads.
(c) Prof. J. C. Guillou, Dept. of Civil Engrg., Univ. of Illinois, Urbana, Illinois.
(d) Experimental; applied research.
(e) Investigation of characteristics of flow through granular filters and several types of drain pipe. Investigations have included tests of coated and uncoated corrugated metal pipe, drain tile, and plastic pipe. Compaction studies have been completed. Current investigation is directed toward study of migration of fines within the filter and the effect of migration upon filter stability.
(f) Completed.
(g) Little sorting of filter material occurs at pipe perforations. Optimum compaction of concrete sand filters appears to be about 15 percent greater than loose fill. Filter stability is caused by binding of fines in the intergranular openings near the pipe openings.
(h) "First Progress Report on Performance of Filter Materials," by J. C. Guillou, Bulletin 556, American Railway Engineering Assoc., February, 1960.
"Second Progress Report on Performance of Filter Materials," by J. C. Guillou and R. F. Lanyon Report ER-12, AAR Research Center, Chicago, Illinois, May, 1961.

(3425) LOCKPORT SLUICEGATE STUDY.

(b) Metropolitan Sanitary District of Greater Chicago.
(c) Prof. J. C. Guillou, Dept. of Civil Engrg., Univ. of Illinois, Urbana, Illinois.
(d) Experimental, applied research.
(e) A 1:20 scale model has been constructed and tested. The subject sluicegates will be used for supplemental control of storm water releases from the Chicago Drainage Canal. Three turbine pits in the existing powerhouse at Lockport have been modified to receive triple sluicegates. The model data have been used to develop operational rating data for the gates under various headwater and tailwater conditions.
(g) Report in preparation.

(3736) NON-LINEAR APPROACH TO THE INSTANTANEOUS UNIT HYDROGRAPH THEORY.

(b) Graduate project, doctoral thesis for K. P. Singh.
(d) Theoretical; basic research.
(e) To study the characteristics of instantaneous unit hydrographs (IUH) on the basis of the concept of non-linearity. Various mathematical models are analyzed by means of digital computers.
(f) Completed
(g) A non-linear theory is developed to account for the variations in IUH derived from different storms over a drainage basin. The transformation of rainfall exesss having a non-uniform areal and time distribution to a direct runoff hydrograph is accomplished by considering the mechanics of overland and channel flow in terms of translation and storage effects.
(h) "Non-linear Approach to the Instantaneous Unit Hydrograph Theory," by K. P. Singh, Doctoral Dissertation, University of Illinois, 1962, Prof. V. T. Chow being the advisor.

(3737) HYDRODYNAMICS OF FREE-SURFACE EFFECT.

(b) Departmental study.
(d) Theoretical; basic research.
(e) To evaluate the free-surface effect of flow in open channels.
(g) A preliminary study is being made to check the variation in roughness coefficient in circular conduits when the flow is partially full. In this study Prandtl's assumption of constant shearing stress is changed to an assumption of variable shearing stress depending on hydraulic radius. The computed variation in roughness coefficient agrees in general with the average observations.

(4140) MODEL STUDY OF HYDROGRAPH CONCEPTS.

(b) Graduate project by W. H. Huang.
(d) Experimental, basic research.
(e) This study involves the construction of a hydraulic apparatus to test the theory involved in the conventional method of hydrograph analysis and to determine the effects on hydrographs due to various factors including slope, roughness, and geometry of the drainage basin and the movement, duration and intensity of simulated rainfalls. The method employed is both experimental and analytical.
(g) A basin model of 4 ft. by 8 ft. has been constructed and preliminary test runs were made for three different durations. The simulated rainfall is produced by six Spraco sprinklers. The runoff discharge is measured by differential volumetric tanks and recorded by successive time exposures of a movie camera.

(4537) BOX CULVERT ENERGY DISSIPATORS.

(b) Laboratory project.

(c) Prof. M. B. McPherson, Dept. of Civil Eng., Univ. of Ill., Urbana, Illinois.
(d) Experimental; applied research; NSF undergraduate research grant problem.
(e) Initially, applicability of U.S.B.R. Basin VI (ASCE Proc., Vol. 83, No. HY5, Paper 1406, Oct., 1957) for highway box culverts under investigation. Study will be extended to development of alternative structures for erosion control.

(4538) WATER DISTRIBUTION SYSTEMS-ANALYSIS CRITERIA.

(b) Laboratory project.
(c) Prof. M. B. McPherson, Dept. of Civil Eng., Univ. of Ill., Urbana, Illinois.
(d) Numerical; development.
(e) General criteria are being sought for determination of minimum initial cost and optimum operating cost of systems comprising pumped input, network and equalizing storage. Consideration will be given to hourly and yearly demand variations.
(g) General network head-loss parameters and pump-network-storage balancing criteria have been developed.
(h) "Generalized Distribution Network Head-Loss Characteristics," by M. B. McPherson, ASCE Trans., Vol. 126 (1961).
"Applications of System Analyzers: A Summary," by M. B. McPherson, Proceedings of Fourth Sanitary Engrg. Conf., Univ. of Illinois, Engrg. Experiment Station Circular No. 75, 1962. (Reprinted in Water and Sewage Works, Reference Volume, 1962).

(4539) NON-UNIFORM SUPPLY OVERLAND FLOW.

(b) Laboratory project; support from University of Illinois Research Board and NSF undergraduate research grant.
(c) Prof. M. B. McPherson, Dept. of Civil Eng., University of Illinois, Urbana, Illinois.
(d) Experimental and theoretical; applied research.
(e) Uniform and linearly varying rainfall supply is simulated with a sprinkling system on a sheet of variable slope and roughness. Limitations of Izzard's relations for a uniform supply are under investigation and relations for non-uniform supply are to be studied.

(4540) CIRCULAR HYDRAULIC JUMP.

(b) Laboratory project; cooperative with Illinois State Water Survey.
(c) Prof. M. B. McPherson, Dept. of Civil Eng., University of Illinois, Urbana, Illinois.
(d) Experimental; development; graduate special problem.
(e) A 60 degree sector of a circular hydraulic jump is being studied to determine feasibility of using a radial-efflux conduit exit transition for more efficient energy dissipation.

(4541) VARIATION OF TRACTIVE FORCE IN SEWERS AND DRAINS.

(b) Laboratory project for J. A. Replogle's doctoral thesis.
(d) To study the distribution of boundary shearing stress, or tractive force in a circular conduit flowing partially full and to determine the relationship between the shearing-stress distribution and the velocity distribution.
(e) A 4 in. smooth copper tube with fully developed open-channel flow is used for a variety of flow depths. The velocity distribution is measured by using a small pitot tube and the "law of the wall" method.

(4542) CRITICAL-FLOW CHANNEL.

(b) Laboratory project for graduate studies.
(e) To construct a critical-flow channel which will be used to verify the theory of critical flow and to examine the behavior of flow in such a channel.
(g) A critical-flow channel was constructed of Plexiglass plates which were shaped to the form of the theoretically computed cross section.

(4543) WATER RESOURCES SYSTEM.

(b) Laboratory project supported by the University's Center for Advanced Study.
(d) Theoretical; basic research.
(e) To study the methods of synthetic hydrology and the use of mathematical models in the planning and development of water resources systems. The approach is analytical and mathematical, including various methods of probability, programming techniques, and operations research.

(4544) ELECTRONIC ANALOG MODEL FOR GROUND WATER.

(b) Laboratory project for graduate studies by P. A. Carr and S. H. Whitaker; cooperative with Illinois State Water Survey.
(d) To construct an electronic analog model to simulate aquifer characteristics.
(e) Part of the electronic analog model to simulate the aquifers in the area of Champaign-Urbana, Illinois, has been completed.

UNIVERSITY OF ILLINOIS, Fluid Mechanics and Hydraulic Laboratory.

Inquiries concerning Project No. 2083 should be addressed to W. M. Lansford, 219 Talbot Laboratory, University of Illinois, Urbana, Illinois, and for Projects Nos. 2320, 2536, 2537 to Professor J. M. Robertson, 125 Talbot Laboratory, University of Ill., Urbana, Illinois.

(2083) VELOCITY DISTRIBUTION IN AN OPEN CHANNEL HAVING A TRIANGULAR CROSS-SECTION.

(b) Laboratory project.
(d) Basic research.
(e) Data being obtained from a channel artificially roughened.
(f) Investigation reactivated, additional data being taken with new improved instruments.

(2536) STUDY OF HOMOLOGOUS TURBULENCE.

(b) Laboratory project, formerly National Science Foundation.
(d) Basic research.
(e) The nature of turbulence (its production and dissipation) is being studied in the simplest possible shear flow. This flow is produced in plane Couette flow where the shear is constant and the turbulence homogeneous but not isotropic. Mean flow studies essentially complete. Transformation of turbulent stress to different orientation of axes currently being studied.
(f) Reactivated.

(3427) STRUCTURE OF TURBULENCE NEAR ROUGH SURFACES.

(b) Bureau of Ships Fundamental Hydromechanics Research Program.
(d) Basic research; experimental.
(e) Information on mean-flow and turbulence structure near roughnesses being studied in an 8-inch "natural roughness" pipe and in 3-inch sand-roughened pipe. Basic question is how roughness produces turbulence. Current emphasis is on spectrum.
(f) Investigation in process.

(4142) TURBULENT BOUNDARY-LAYER FLOW TOWARDS A NORMAL STEP.

(b) Graduate project.
(c) Professor J. M. Robertson, 125 Talbot Lab., University of Illinois, Urbana, Illinois.
(d) Basic Research.
(e) An analytical and experimental study is being

made of upstream separation, i.e., the real fluid behavior (separation, mixing, reattachment) in front of a normal step projecting inward from a plate along which fluid is flowing with a turbulent boundary layer. Air is fluid medium being used.

(f) Investigation in process.

(4143) HEMODYNAMICS SIMILITUDE STUDY OF AN ARTERIAL DISTRIBUTION SYSTEM.

(b) State of Illinois, Department of Public Welfare, Galesburg State Research Hospital, Galesburg, Illinois.
(c) Prof. M. E. Clark, 123 Talbot Laboratory, University of Illinois, Urbana, Illinois.
(d) Basic research; experimental.
(e) The flow of blood in the Circle of Willis--the arterial distribution system for the brain--is to be studied utilizing larger-sized models of both the prototype fluid and conduit system. Present goal is to fabricate a model which will simulate in as many ways as possible the prototype and its flow.
(f) Investigation in process. Fabrication of first-stage model essentially complete. Model-prototype verification studies to be initiated.

(4558) EFFECT OF TURBULENT NORMAL STRESS ON DRAG EVALUATION BY WAKE MOMENTUM METHOD.

(b) Laboratory project.
(d) Basic research.
(e) Conventionally the evaluation of drag of bodies from wake transverses ignores normal stresses in wake. Estimates from scanty data indicate this factor to account for 2 to 10 percent of drag. Experiments are being conducted to obtain a more precise indication of the size of the error and how it varies.
(f) Investigation in initial stages.

(4559) FLOW STABILITY AND HEAD LOSS IN BRANCHED TUBES.

(b) State of Illinois, Department of Public Welfare, Galesburg State Research Hospital, Galesburg, Illinois.
(c) Prof. M. E. Clark, 123 Talbot Laboratory, Univ. of Illinois, Urbana, Illinois.
(d) Basic research; experimental.
(e) In conjunction with a model study of the Circle of Willis--the arterial distribution system for the brain--a need was felt for a better understanding of the stability of viscous flows through certain types of junctions as well as the amount of head loss which occurs. A series of bifurcations and fusions of rigid, circular tubes are being studied to gain this understanding.
(f) Investigation in process.

IOWA INSTITUTE OF HYDRAULIC RESEARCH, State Univ. of Iowa.

(66) HYDROLOGIC STUDIES, RALSTON CREEK WATERSHED.

(b) Cooperative with Department of Agriculture, U. S. Geological Survey.
(c) Prof. J. W. Howe, Department of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa.
(d) Field investigation; applied research, and M. S. theses.
(e) Study being made of relation between rainfall and runoff over a small area. Discharge from a 3-square-mile area measured by U. S. G. S.; rainfall records at five automatic recording stations collected by Agricultural Research Service. Continuous records since 1924 of precipitation, runoff, groundwater levels, and vegetal cover.
(g) Yearly records available for examination at Iowa Institute of Hydraulic Research.
(h) Reports prepared annually since 1924 available in files at the Iowa Institute of Hydraulic Research. Summary of 33-year record published as Bulletin 16 of the Iowa Highway Research Board in 1961; available upon request from Iowa Highway Commission, Ames, Iowa.

(67) COOPERATIVE SURFACE-WATER INVESTIGATIONS IN IOWA.

(b) Cooperative with U. S. Geological Survey.
(c) Mr. V. R. Bennion, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Field investigation; collection of basic stream-flow data.
(e) Stream-flow and sediment measuring stations maintained throughout the State of Iowa cooperatively on a continuous basis. Records collected by standard methods of U. S. G. S.
(g) Records of stream-flow and sediment discharge computed yearly.
(h) Records contained in Water-Supply Papers available through offices of the Geological Survey.

(68) HYDROLOGIC STUDIES, RAPID CREEK WATERSHED.

(b) Cooperative with U. S. Geological Survey.
(c) Mr. V. R. Bennion, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Field investigation; applied research.
(e) Study being made of relation between rainfall and runoff over a small area. Discharge from a 25-square-mile area measured and flood runoff on main subbasins determined by U. S. Geological Survey; rainfall records at four automatic recording stations collected by U. S. Weather Bureau. Continuous records since 1941 of precipitation, runoff, and ground-water levels.
(g) Rainfall records published in Weather Bureau Climatological Bulletins and surface runoff and ground-water levels published in Geological Survey Water-Supply Papers.

(73) MEASUREMENT OF TURBULENCE IN FLOWING WATER.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical; basic and applied research.
(e) Instruments, primarily electrical in operation, are being developed to measure the characteristics of turbulent flow over a wide range of laboratory and field conditions. Both sensing and computing elements are involved.
(g) Commercial pressure transducers have been used with adapters to measure instantaneous values of total and local pressures at a point in a flow field. Modifications using hot-wire elements to measure pressure-velocity correlations are also under study.

(79) CAVITATION.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical; basic research and graduate theses.
(e) Basic information is sought on cavitation for systematically varied boundary conditions. Studies of cavitation in jets and behind disks and plates are being continued.
(h) "Cavitation and Pressure Fluctuation Behind a Bluff Body With and Without a Trailing Splitter Plate," by Arthur D. Newsham, M.S. thesis, State University of Iowa, February 1963. (Available on loan.).

(81) MATHEMATICAL ANALYSIS OF PRESSURE DISTRIBUTION.

(b) Cooperative with Office of Naval Research and David Taylor Model Basin, Department of the Navy.
(c) Dr. Louis Landweber, Iowa Institute of

Hydraulic Research, Iowa City, Iowa.
(d) Applied research.
(e) Pressure and velocity distributions on a series of 30 bodies of revolution, in axial, transverse, and rotational motion are being analyzed.
(f) Phase described in (e) completed.
(g) Computer program for obtaining flow patterns developed. Report near completion.
(h) "Potential Flow About a Family of Bodies of Revolution," by L. Landweber and Matilde Macagno. Final report on Contract N600 (167)55727(x) to the David Taylor Model Basin December 1961.

(1875) CHARACTERISTICS OF STABLE EDDIES.

(b) Laboratory project, partially supported by Office of Naval Research, Department of the Navy and U. S. Army Research Office (Durham).
(c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and analytical; basic research.
(e) Distributions of velocity, pressure, and turbulence are being investigated throughout the vicinity of separation zones produced by abrupt changes in flow section, to the end of establishing the primary eddy characteristics as functions of the boundary geometry.
(g) Studies are being conducted on flow in the wake of a circular disk and in axisymmetric conduit expansions.
(h) "Flow Characteristics at Abrupt Axisymmetric Expansions," by Mahesh C. Chaturvedi, Ph.D. dissertation, State University of Iowa, August 1962. (Available on loan.)

(2091) RESEARCH ON SHIP THEORY.

(b) Cooperative with Office of Naval Research and David Taylor Model Basin, Department of the Navy.
(c) Dr. Louis Landweber, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical; basic research.
(e) To determine the laws governing the forces, moments, and motions of ships in smooth and disturbed seas, in order to furnish design data to the naval architect. Work is under way on the following problems: (1) Wave damping of a series of rolling (Ursell) cylinders, (2) resolution of viscous and wave drag by means of measurements in the wake of a ship, (3) effect of a free surface on separation, (4) treatment of vibration of spheroids and shiplike forms on the basis of a unified theory of hydroelasticity, and (5) image of a source in a prolate spheroid.
(h) "Experimental Investigation of Ursell's Theory of Wavemaking by a Rolling Cylinder," by W. C. McLeod and Tsuying Hsieh, submitted for publication to Schiffstechnik.
"Drag Coefficients of Flat Plates Oscillating Normally to their Planes," by M. Ridjanovic, Schiffstechnik, Bd. 9, Heft 45, 1962.
"Separation of Viscous from Wave Drag of Ship Forms," by Jin Wu, Journal of Ship Research, June 1962.
"The Viscous Drag of Submerged and Floating Bodies," by L. Landweber and Jin Wu, IIHR Report, March 1962.
"Image System in an Ellipse due to an External Source," by Matilde Macagno, IIHR Report, July 1962.

(2324) ANALYSIS OF FLOW PATTERNS FOR SHARP-CRESTED WEIRS.

(b) Laboratory project, partially supported by National Science Foundation.
(c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Analytical; basic research for doctor's degree.
(e) Determination of streamline configuration through use of digital computer for various relative heights of weir.
(h) "Irrotational Flow Over Weirs,"by Theodor S. Strelkoff, Ph.D. dissertation, State Univ. of Iowa, June 1962. (Available on loan.).

(2328) INVESTIGATION OF SURFACE ROUGHNESS.

(b) Cooperative with U. S. Geological Survey, Dept. of the Interior.
(c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental; basic research for doctoral dissertation.
(e) Primary purpose is to determine the effect of different concentrations of roughness elements on open-channel resistance. Tests have been conducted in two flumes, 30 feet and 85 feet, in both the subcritical and supercritical regimes using both a cubical roughness element and a natural sand-grain element varying systematically from minimum to maximum concentration. The correlation between free-surface instability, increased channel resistance, and the presence of roll waves has also been studied. Apparatus is now being devised for measuring drag on individual elements.

(2541) DEVELOPMENT OF INSTRUMENTS FOR USE IN ANALYZING APERIODIC SIGNALS.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental; applied research.
(e) The purpose is to improve the analysis of turbulent velocity and pressure fluctuations, especially where long-period fluctuations are significant.
(g) Such basic computing elements as operational amplifiers, integrators, and function generators are combined to perform all the necessary statistical operations.

(2792) THE DECAY OF TURBULENCE IN A ZERO-MOMENTUM WAKE.

(b) Cooperative with the Office of Naval Research, Department of the Navy.
(c) Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Primarily experimental; basic research.
(e) Powered models of a strut-mounted propeller and a merchant vessel are driven in a towing basin, and the wake is investigated with a Pitot rake and a hot-wire anemometer.
(g) Measurements of turbulent velocities are being made to supplement the mean-velocity data already at hand.

(2795) PREDICTION OF RUNOFF FREQUENCY FROM PRECIPITATION AND INFILTRATION FREQUENCIES.

(b) Laboratory project.
(c) Prof. J. W. Howe, Department of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa.
(d) Statistical.
(e) Exploration of possibility of estimating frequencies of rare floods based on combination of observed frequencies of precipitation and infiltration.
(f) Completed.
(g) Good correlation for small and medium-sized but not for large watershed.
(h) "Prediction of Runoff Frequency Based on Precipitation and Infiltration Frequencies," by Srinivasan Mukundan, M. S. thesis, State University of Iowa, February 1963. (Available on loan.).

(3068) DETERMINATION OF DYNAMIC FORCES ON FLASHBOARDS.

(b) Laboratory project.
(c) Prof. J. W. Howe, Department of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa.
(d) Experimental; for M. S. thesis.
(e) Measurement of dynamic moment exerted by water flowing over flashboard.

(f) First phase completed; investigation continuing.
(g) A parameter involving turning moment on flashboard related to head- and tail-water levels for typical OG spillway crest.
(h) "Overturning Moments on a Flashboard Mounted on a Parabolic Spillway Crest," by Alberto Lizarralde, M.S. thesis, State University of Iowa, February 1962. (Available on loan.).

(3074) WAKE OF ZERO MOMENTUM FLUX.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Eduard Naudascher, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental; basic research.
(e) Distribution of velocity, mean and turbulent, and of pressure is being measured in the field of flow past a bluff, axisymmetric body with a centrally located jet for the particular condition of zero momentum flux.
(h) "Preliminary Studies of the Wake of a Body with Zero Difference of Momentum Flux," by Horacio Alberto Caruso, M.S. thesis, State Univ. of Iowa, August 1962. (Available on loan.).

(3428) MECHANICS OF BANK SEEPAGE IN NATURAL STREAMS DURING FLOOD FLOWS.

(b) Laboratory project.
(c) Prof. J. W. Howe, Dept. of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa.
(d) Field investigation; basic research for Ph. D. thesis.
(e) Observations taken on transverse profile of ground-water levels during rise and recession of hydrographs. Sections on Missouri, Des Moines, Boone, Iowa, and English Rivers, Clear Creek and Rapid Creek. Permeability tests made by pumping wells.
(g) Early results indicate substantial flow into banks during period of rise, thus showing a negative groundwater contribution to the flow in this period.

(3429) JET WITH TRANSVERSE PRESSURE GRADIENT.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical; basic research.
(e) In order to better understand the effect of jet mixing on an annular jet, the diffusion of a two-dimensional jet directed against a flat plate in the presence of a transverse pressure gradient has been studied.
(h) "Patterns of Flow Under a Two-Dimensional Gem," by Ben-Chie Yen, Report to Office of Naval Research, January 1962.

(3431) SEDIMENT SORTING.

(b) Partially supported by National Science Foundation.
(c) Dr. Lucien M. Brush, Jr., Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental; basic research.
(e) To determine the effect of various particle-size distributions with the same means but different standard deviations on (1) total-load and suspended-load transportation, (2) bed configuration, and (3) size distribution of the total load.

(3432) ACCELERATED MOTION OF A SPHERE FALLING IN AN OSCILLATING FLUID.

(b) Laboratory project.
(c) Dr. Lucien M. Brush, Jr., Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and analytical; basic research and Ph. D. dissertation.
(e) To determine accelerated motion of a sphere falling in an oscillating fluid.
(h) Partial results in "A Study of Sediment in Suspension," by Lucien M. Brush, Jr., Hau-Wong Ho, and Surya Rao Singamsetti, Internat. Assoc. of Scientific Hydrology, Symposium of Bari, Pub. No. 59, p. 293-310, 1962.

(3738) SEDIMENT DIFFUSION.

(b) Laboratory project partially supported by a grant from Gulf Research and Development Co.
(c) Dr. Lucien M. Brush, Jr., Iowa Institute of Hydraulic Research, IowaCity, Iowa.
(d) Experimental; Ph. D. dissertation.
(e) To determine the sediment-diffusion characteristics for small concentrations of particles in a submerged jet of water.
(h) "Exploratory Study of Sediment Diffusion," by Lucien M. Brush, Jr., Trans. Amer. Geophys. Union, Vol. 67, No. 4, p. 1421 - 1433, 1962.
"A Study of Sediment in Suspension,"by Lucien M. Brush, Jr., Hau-Wong Ho, and Surya Rao Singamsetti, Internat. Assoc. of Scientific Hydrology, Symposium of Bari, Pub. No. 59, p. 293 - 310, 1962.

(3739) EDUCATIONAL FILMS ON THE MECHANICS OF FLUIDS.

(b) National Science Foundation.
(c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City Iowa.
(e) Six 20-minute sound films in color are planned to cover following material: (1) An introduction to the subject, stressing its great breadth of coverage, the necessarily close tie between theory and experiment, the role of the scale model in engineering analysis and design, and methods of flow measurement in laboratory and field. (2) The source and significance of the fundamental principles of continuity, momentum, and energy, and their application to typical problems in many professional fields. (3) Gravitational phenomena, including jets, nappes, channel transitions, waves, surges, and effects of density stratification. (4) Effects of viscosity, examples of laminar flow, characteristics of fluid turbulence, and problems of surface resistance. (5) Form drag and lift, and their application to propulsion and fluid machinery. (6) Compressibility effects - water hammer, submarine signaling, gravity-wave and sound-wave analogies, and supersonic drag.
(g) First two films of series, "Introduction to the Study of Fluid Motion" and "Fundamental Principles of Flow" now available from Bureau of Audio-Visual Instruction, Extension Div., State Univ. of Iowa, Iowa City, Iowa. Third film, "Flow in a Gravitational Field," in preparation.

(3740) HYDRODYNAMICS OF FLUIDS UNDER CONDITIONS OF RAPID ACCELERATION.

(b) Rock Island Arsenal, U. S. Army.
(c) Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Theoretical and experimental; basic research.
(e) Analytical techniques which are applicable to systems involving rapid acceleration of fluids through constructions or of solids through fluids. Results will be expressed as lumped-constant parameters similar to those used for steady-flow phenomena.
(g) A complete description of the behavior of an orifice in unsteady flow requires terms representing convective acceleration, virtual mass, and a residual which is as yet unexplained.
(h) "An Approximation for the Motion of a Compressible Liquid," by E. O. Macagno and H. W. Ho, Report to Rock Island Arsenal under contract No. DA-11070-508 ORD-988.
"Interpretation of Data and Response of Probes in Unsteady Flow," by Philip G. Hubbard, Symposium on Measurement in Unsteady Flow A.S.M.E., May 21 - 23, 1962.

(4145) INTERFACIAL EFFECTS IN FLUID FLOW WITH DENSITY STRATIFICATION.

(b) Cooperative with U. S. Army Research Office (Durham).
(c) Dr. Enzo O. Macagno, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental; basic research and graduate theses.
(e) On stability of two-layered flow and subsequent mixing. Effect of thickness of interlayer on stability. Effect of stratification on turbulence propagation. Role of interfacial shear in stable stratified flow. Apparatus is now ready for study of stability and mixing of two layers flowing in the same direction.

(4146) EFFECT OF GATE LIP SHAPE UPON DOWNPULL.

(b) Laboratory project.
(c) Dr. Eduard Naudascher, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental; applied, for M. S. thesis.
(e) Pressure distribution under high-pressure gates is being measured for various lip shapes. Coefficients are to be established for the analysis of vertical forces acting upon the gate.

(4147) RESISTANCE OF CYLINDRICAL PIERS IN SUPER-CRITICAL FLOW.

(b) Laboratory project.
(c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental, M. S. thesis.
(e) Drag is studied as function of Froude number, relative depth, and relative spacing of piers.
(h) "The Resistance of Piers in High-Velocity Flow," by Tsu-ying Hsieh, M.S. thesis, State University of Iowa, August 1962. (Available on loan).

(4148) MEAN-FLOW AND TURBULENCE CHARACTERISTICS OF RIVER BENDS.

(b) Supported by the National Science Foundation.
(c) Dr. Lucien M. Brush, Jr., Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental; basic research; Ph.D. dissertation and M.S. thesis.
(e) To determine the mean-flow and turbulence characteristics of flow in a model river bend. Pressure, velocity, and shear stress measurements are to be made in the curved channel for smooth, rough, and movable beds.

(4149) DRAG OF SUPERCAVITATING BODIES OF REVOLUTION.

(b) Bureau of Ships, Office of Naval Research.
(c) Dr. Louis Landweber, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Theoretical; applied research.
(e) Method of computing pressure distributions on supercavitating bodies of revolution being developed. Equipment for measuring drag being prepared.
(g) Computer program for a proposed method of computing pressure distributions has been prepared.

(4560) HEAD LOSS IN TRAPEZOIDAL CHANNEL AT 90 DEGREE BEND AS FUNCTION OF BEND WIDTH.

(b) Laboratory project.
(c) Prof. J. W. Howe, Dept. of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa.
(d) Experimental; for M.S. thesis.
(e) Determination of degree of widening required at bend to produce minimum head loss.

IOWA STATE UNIVERSITY, Department of Agronomy.

(3079) MOVEMENT OF WATER IN SOILS.

(b) Laboratory project.
(c) Dr. Don Kirkham, Department of Agronomy, Iowa State University.
(d) Theoretical and applied research; Doctor's thesis.
(e) Theoretical work done on the movement of ground water in soil, particularly in the saturated phase continues. Work in the unsaturated phase, using the mass spectrometer with deuterium as a tracer was concluded and the observations are being prepared for publication. Mr. John C. Corey is continuing isotope work on water movement in the unsaturated state (miscible displacement) in cooperation with the Iowa State University Institute for Atomic Research.
(h) "Deuterium and the Self-Diffusion Coefficient of Soil Moisture," by R. J. Kunze and Don Kirkham, Soil Sci. Soc. Amer. Proc., Vol. 25: 9-12. 1961 (joint research with Inst. for Atomic Research).
"An Upper Limit for the Height of the Water Table in Drainage Design Formulas," by Don Kirkham, Proc. Int. Soil Sci. Soc., Seventh Congress, Madison, Wisconsin August, 1960. Commission VI, Vol. 1, pp 486 - 492, 1961.
"Diffusion Equation Calculations of Field Soil Water Infiltration Profiles," by D. R. Nielsen, Don Kirkham and W. R. Van Wijk. Soil Sci. Soc. Amer. Proc., 25: 165-168. 1961. Project 998.
"Graphical Solution and Interpretation of a new Drain-Spacing Formula," by S. Toksöz and Don Kirkham. Jour. Geophys. Res., 66: 509-515. February 1961.
"Isotopes Methods and Uses in Soil Physics Research," by Don Kirkham and R. J. Kunze. Advances in Agronomy. Vol. 14, pp. 325-358, 1962.
"Simplified Accounting for Membrane Impedance in Capillary Conductivity Determinations," by R. J. Kunze and Don Kirkham, Soil Sci. Soc. Amer. Proc., 26:421-426. 1962.

(4592) MOVEMENT OF WATER FROM WASTE RECHARGE INSTALLATIONS.

(b) U. S. Department of Health, Education, and Welfare, Public Health Service, National Institute of Health.
(c) Dr. Don Kirkham, Department of Agronomy, Iowa State Univ., Ames, Iowa.
(d) Theoretical and field investigation; basic and applied research; master's and doctor's thesis.
(e) The purpose of this project is to discover laws which predict, from the geometry of the waste recharge installation, and from the physical properties of the soil about it, how fast, and how far at certain times, water will move from the installation. This will be accomplished by (1) obtaining empirical laws governing seepage of water from an idealized scaled model (2) testing by full-scale field experiments to see if the empirical laws found in (1) above need to be modified when applied to field conditions, and (3) formulating rational relations between the water movement, the geometry of the system and the soil conditions, by setting up and solving the appropriate seepage differential equations and checking the result against the experimental data from (1) and (2) above.
(g) Data for the first year is being compiled.

IOWA STATE UNIVERSITY, Department of Agricultural Engineering.

Inquiries concerning the following projects should be addressed to Dr. H. P. Johnson, Department of Agricultural Engineering, Iowa State University, Ames, Iowa.

(2330) DEPTH, SPACING AND HYDRAULICS OF TILE DRAINS.

(b) Laboratory project.
(d) Theoretical and field investigation; basic and applied research; master's and doctor's thesis.
(e) Analytical and experimental approach is being studied to determine depth and spacing of tiled drains by analyzing soil characteristics and geometry of systems. Work is cooperative with Dr. Kirkham, Soil Physics Department of Agronomy. Studies of the relationship of hydrologic and applied hydraulic problems of field tile systems being made.
(g) Further studies of unsteady flow through porous media by the use of models are being conducted in the Department of Agronomy under the direction of Dr. Kirkham.
(h) "Unsteady-state Drainage of Fluid from a Vertical Column of Porous Material," by J. T. Ligon, H. P. Johnson, and Don Kirkham. Submitted for publication.
"Glass Bead Glycerol Model for Studying the Falling Water Table Between Open Ditch Drains," by J. T. Ligon, H. P. Johnson and Don Kirkham. Submitted for publication to Agricultural Engineering Journal.

(2331) SURFACE RUNOFF FROM AGRICULTURAL WATERSHEDS.

(b) Laboratory project.
(d) Theoretical; applied research; doctoral thesis.
(e) A study designed to obtain frequencies of runoff for different soils, moisture conditions and cover has been completed. The elements of point rainfall intensity, infiltration rates, and the unit hydrograph are being integrated in such a form that most of the work involved in finding the frequencies of flow can be completed with a computer.
(g) Completed.
(h) "Derivation of Hydrographs for Small Watersheds from Measurable Physical Characteristics," by D. M. Gray, Research Bulletin 506, Agricultural and Home Economics Experiment Station, Iowa State Univ., Ames, Iowa, 1962.
"Hydrograph Development for Agricultural Watersheds Based on Point Rainfall Records," by D. B. Palmer, Ph.D. Thesis, Iowa State Univ., November 1962.

(2333) IMPROVEMENT OF SURFACE DRAINS WITH TILE BLIND INLETS.

(b) Laboratory project.
(d) Field investigation; design.
(e) Field study is being continued to determine the effect of different tile backfill material on the flow of water into the tile drains.
(h) "Field Evaluation of Flow Through Blind Inlets," by D. B. Palmer and H. P. Johnson, Transactions of ASAE, 5:58-60,61. 1962.

(2334) RUNOFF FROM SMALL WATERSHEDS.

(b) Laboratory project.
(d) Field investigation; applied research; design.
(e) Measurements of rainfall and surface runoff being made on seven agricultural watersheds. Gaging of six small agricultural watersheds with uniform cropping to be initiated in 1963.

(4150) COMPARISON OF SYNTHETIC UNIT GRAPH METHODS.

(b) Laboratory project.
(d) Experimental, applied research; master's thesis.
(e) Three synthetic unit graph methods developed for application to small watersheds are being compared with actual unit graphs from given watersheds. The effect of duration of storm, and distribution of rainfall with time on the storm hydrograph is being studied.
(h) "Comparison of Synthetic Storm Hydrographs for Selected Rainfall Patterns," by T. L Hanson, Master's Thesis, Iowa State Univ., 1962.

THE JOHNS HOPKINS UNIVERSITY, Applied Physics Lab.

(2335) APPLICATION OF SWITCHING TECHNIQUES TO HYDRAULIC CONTROL SYSTEMS.

(b) Bureau of Weapons, Department of the Navy.
(d) Theoretical and experimental; applied development and design.
(e) Study the dynamic qualities of an acceleration switching hydraulic servomechanism while operating in a closed loop under the presence of various loads and environmental conditions on the transfer valve, actuator and feedback transducer.
(g) The operation of a broad bandpass servomechanism driving a low resonant frequency linkage has resulted in radial design compromises to prevent instability. Extension of acceleration switching techniques without any mechanical modifications has permitted closed loop operation with bandpasses equal to or exceeding the linkage characteristics.
(h) "Design of a Hydraulic Servo with Improved Bandpass Characteristics When Driving a Resonant Mechanical Load," APL/JHU CM-962, by W. Seamone.

(3207) ACCELERATION SWITCHING HYDRAULIC SERVOMECHANISMS UNDER EXTREME ENVIRONMENTAL CONDITIONS.

(b) Bureau of Weapons, Department of the Navy.
(d) Experimental; applied development and design.
(e) Extend to regions of extreme high temperature a servomechanism capable of high performance and horsepower (up to 10 H.P.). The servo valve, actuator and feedback transducer must operate under environmental extremes while the electronic circuitry is maintained in a protected area.
(g) Tests have been conducted on hydraulic servo components under steady state temperature conditions of 700 degrees F ambient and 500 degrees F oil temperature. Thermal shock temperature tests have been conducted on servo packages to 400 degrees F to study transient temperatures.
(h) "Hydraulic (Acceleration Switching) Servo Dynamic Performance Under Extreme High Temperature Environment," APL/JHU CF-2737, by W. Seamone and K. Duning.
"APL/JHU High Temperature Test Laboratory," APL/JHU CF-2837, by M. Shandor.

(3435) HYDRAULIC SUPPLY LINE CHARACTERISTICS.

(b) Bureau of Weapons, Department of the Navy.
(d) Theoretical; experimental.
(e) High performance hydraulic servomechanisms can excite the pressure and return lines into pressure oscillation. Establishment of the physical relationship which could cause pressure oscillation as well as performance deterioration in the servo valve performance is being investigated.
(f) Continuing low priority research study.
(g) The switching activity of an acceleration switching hydraulic servomechanism was noted to create pressure oscillation under specified conditions in length of supply lines. Analysis and experiments have shown that pressure oscillations occur when the acoustic frequency of the hydraulic fluid column is in specific relationship to that of the switching frequency. Where line length changes cannot be used, methods of detuning the supply lines by volume chamber or acoustic filter is developed.

(3436) ADAPTIVE ELECTRO HYDRAULIC SERVOMECHANISMS.

(b) Bureau of Weapons, Department of the Navy.
(d) Theoretical and experimental.

(e) Techniques have been developed for designing linear servomechanisms with a limit cycle instability about a relay type non-linearity. The closed loop characteristics of this servomechanism becomes invariant to any pure gain changes occurring in the linear elements. This servomechanism, categorized as a self-oscillating control servomechanism, appeared to be an evolutionary improvement over the acceleration switching hydraulic servomechanism.

(g) A self-oscillating rate servomechanism has been operated with the loop closed around the valve spool position. Predictable self-oscillation frequency was achieved and dynamic performance bandpass was independent of hydraulic supply pressure between 500 and 2000 psi. The bandpass of both servomechanisms exceeded 60 cycles per second with the latter operating a complex mechanical load system.

THE JOHNS HOPKINS UNIVERSITY, Department of Sanitary Engineering and Water Resources, School of Engrg.

Inquiries concerning the following projects should be addressed to Dr. John C. Geyer, Chairman, Dept. of Sanitary Engineering and Water Resources, The Johns Hopkins University, Baltimore 18, Maryland.

(856) HYDROLOGY OF STORM DRAINAGE SYSTEMS IN URBAN AREAS.

(b) Baltimore City, Baltimore County, Maryland State Roads Commission, and the U. S. Bureau of Public Roads.

(d) Field investigation; basic research and design.

(e) Study of rainfall and runoff relationships as affected by various drainage area parameters. At present, runoff from 6 urban areas ranging in size from 10 to 150 acres are gaged, 5 by stage instruments and 3 by Parshall Flumes. Three recording systems which simultaneously record rainfall and runoff from 12 inlet areas provide good opportunity for detailed study. About 10 years of rainfall records now exist for a network of 12 recording gages covering an area of 50 square miles.

(g) A study of the Baltimore rainfall data for the period 1894-1955 shows: (1) The critical storm in the Baltimore area is the summer type cloud burst. About two-thirds of the storms - greater than 2 year frequency occur in the months of July and August. Winter storms are not important for design purposes. (2) The maximum average rainfall rate (for durations up to 60 minutes) generally occurs at the beginning of the storm. (3) Rainfall intensities (during 15, 30, and 60 minute durations) for frequencies greater than 2 years are not uniform. Difference between maximum intensity and average intensity over the duration range from 30 percent (for the 15 minute duration) to 75 percent (for the 60 minute duration). Intensities greater than those indicated by rainfall frequency curves occur during more than half the period of the 15, 30 and 60 minute durations studied. Consequently the design storm assumed in the Rational Method is unrealistic. (4) Gagings made by this project and by the Corps of Engineers indicate that where a check on the Rational Method is possible, the Rational Method produces inconsistent results. Further analyses are continuing.

(h) "Progress Report on the Storm Drainage Research Project, June 1962," by John C. Schaake, Department of Sanitary Engineering and Water Resources, The Johns Hopkins Univ., Baltimore 18, Md. A limited number of copies are available on request.

(3437) RESIDENTIAL WATER USE RESEARCH PROJECT.

(b) Federal Housing Administration.

(d) Field investigation; applied research and design.

(e) This project is directed toward obtaining data on maximum hourly demands and water use patterns in residential areas having varying populations and located in various climatic regions throughout the country. It also is directed toward obtaining information on the effect of lawn sprinkling and other large water uses on maximum demands. The purpose of the project is to obtain a rational design criteria for water distribution systems, to provide a basis for evaluating water rate structures and a basis for improving system operation.

(g) Peak demands in residential areas can be described mathematically based upon statistical evaluation of field data. Peak demands can be determined by segregating residential water use into (1) domestic or short duration uses and (2) lawn sprinkling or long duration uses. The average consumption and the rate of sprinkling per residence increases according to size of lot. The probability of occurrence of sprinkling demands varies with the season and climate and the time of day; while the probability of occurrence of domestic use varies with the number of persons per home and the time of day. The characteristics of the total demand on a distribution system serving residential areas have been tentatively established. Correlation of residential demands with sewage flows, and seasonal and climactic factors is the subject of continuing investigation. The data on water demands of commercial establishments associated with residential areas shows that peak commercial uses frequently are not imposed on sprinkling demands and consequently are situated favorably on the hydrograph of peak daily demands.

(3438) RESIDENTIAL SEWERAGE RESEARCH PROJECT.

(b) Federal Housing Administration.

(d) Field investigation; operation and design.

(e) Examination of adequacy and utility of residential sewerage system design criteria. Determination of the effects of parameters of design, construction, loading, and natural phenomena on operation of sewerage systems. Research includes analysis and study of representative sewerage systems throughout the country.

(g) Sewage flow records presently being compiled from four representative residential areas. The minimum duration of flow study in each area is one year. Operation and maintenance investigation will provide correlations of cause and frequency of sewer stoppages with sewer slope, length of lateral behind stoppage, size of pipe, type of joint material, frequency of cleaning; and maintenance and operating costs of lift stations.

(h) Residential Sewerage Research Project Progress Reports 1, 2, 3, 4. Sewer Stoppage Experience, Springfield, Missouri, 1956-1960. Sewer Stoppage Experience, Bradenton, Florida, 1960-61. Sewer Stoppage Experience, Baltimore County, Maryland, 1959-61.

UNIVERSITY OF KANSAS, Dept. of Mechanics and Aerospace Engineering.

Inquiries concerning the following projects should be addressed to Dr. Y. S. Yu, Dept of Mechanics and Aerospace Engineering, Univ. of Kansas, Lawrence, Kansas.

(3081) DIFFUSION OF A JET FORMED AT AN ABRUPT ENLARGEMENT IN TWO-DIMENSIONAL FLOW.

(b) Tennessee Valley Authority, Norris, Tenn.

(d) Experimental; basic research.

(e) Formation of two-dimensional vortices in

flow behind a vertical gate has been studied. The purpose is to analyze the effect of forced oscillations of the gate on vortex formation.

(f) Terminated.

(g) A gate oscillating in a plane normal to flow through a conduit generates stable vortices which form periodically at a frequency equal to that of the oscillating gate. These regular vortices were not present unless the Strouhal number of the gate motion is greater than about 1/2. For lower Strouhal number, vortices occur irregularly and at an average frequency higher than that for the gate.

(h) "A Study of Flow through Abrupt Two-Dimensional Expansions, Progress Report IV--Effect of Gate Oscillation," by Svein Vigander, Studies in Engineering Mechanics, Report No. 15, June, 1962.

(3742) DIVERSION OF FLOW WITH SUCTION APPLIED TO SLOTS BENEATH A SHALLOW STREAM HAVING A FREE SURFACE.

(b) Kimberly-Clark Corporation and the Dept. of Mech. and Aero. Engrg.

(d) Theoretical and experimental; basic research; also master's thesis.

(e) Experimental verification of a momentum analysis for the drainage into an inclined slot with resistance imposed by a moving screen is sought.

(f) Terminated.

(g) A one-dimensional analysis for withdrawal of part of a shallow, high-speed flow through a wire screen into a single slot with suction underneath has been made. The discharge coefficient of flow into the slot depends on the geometry of the slot, the suction pressure, and the resistance of the wire screen.

(h) "A Study of the Dynamics of Flow through Suction-Box Covers," by William H. Y. Lee, Studies in Engineering Mechanics, Report No. 11, February, 1962.

(3743) STUDY OF THE MECHANICS OF DIVIDED FLOW.

(b) National Science Foundation.

(d) Theoretical and experimental; basic research.

(e) A study of the instability of flow at branches of a manifold and of flow into a slot in a plane wall of a semi-infinite flow.

(g) The pressure pulsations originated at the branch of flow into symmetrical laterals of circular and rectangular sections were measured for different flow conditions. Experiments in rectangular duct show that large vortices are formed due to separation of flow from the front and the back walls of the main duct. The vortices are unstable and cause pulsation of local pressure near the branch. A free-streamline analysis is made for flow into a slot.

(h) "A Study of Pressure Pulsations and Mass-Flow Fluctuations in Flow through Symmetrical Laterals," by John V. Otts, M. S. Thesis, the University of Kansas, June 1962. "Characteristics of Flow at Division into Symmetrical Laterals," by Carl T. Herakovich, M. S. Thesis, the University of Kansas, June, 1962.

(3745) BASIC CHARACTERISTICS OF AN OVERLAND FLOW.

(b) Waterways Experiment Station, Corps of Engineers, U. S. Dept. of the Army.

(d) Theoretical; basic research.

(e) Data from experiments made by the Los Angeles District, Corps of Engineers, on the controlled surface runoff due to rainfall on an impervious plane slope are analyzed. The objective is to provide an improved method for estimating overland flow in the drainage of airfield and expressways.

(g) Runoff of rain falling on an impervious surface can be predicted by means of numerical computations. For the usually small slopes and depths which occur on highways or airstrips, the flow is quasi-steady and effectively uniform. The computed runoff and depth hydrographs agree satisfactorily with the measurements.

(h) "Runoff from Impervious Surfaces," by Y. S. Yu and John S. McNown, Progress Report, May, 1962. Final report in preparation.

(4151) SEPARATION OF FLOW AT INTERIOR CORNERS.

(b) Kimberly-Clark Corporation, Neenah, Wis.

(d) Theoretical and experimental; basic research.

(e) The geometric characteristics of two-dimensional zones of separation at interior corners between two plane boundaries are being investigated. Experiments will span the range from laminar to fully turbulent flows.

(g) Experiments on the separation of turbulent boundary-layer flow at interior corners show that zone of separation decreases in size with increasing Reynolds number, decreasing contraction ratio, and decreasing angle of the corner.

(h) "Separation of Flow at Interior Corners," by Karl G. Maurer, Studies in Engineering Mechanics, Report No. 14, the University of Kansas, June 1962.

(4152) ROUGHNESS OF TURBULENT JETS.

(b) Laboratory project.

(d) Experimental, basic research.

(e) The surface configuration of liquid jets formed from fully turbulent flow discharging freely from pipes into air is studied.

(g) A method has been developed for measuring the continuous variation of the interface of air and a turbulent water jet. The rms-value of the height of variation of the interface at a fixed station and its frequency distribution were measured. The results are presented on the basis of three dimensionless parameters.

(h) "Measurement of the Roughness of Free Turbulent Jets of Water," by F. R. Swanson, M. S. Thesis, the University of Kansas, September, 1962.

(4153) INTERACTION OF A FIXED, VERTICAL WALL WITH A TRAIN OF SURFACE WAVES IN SHALLOW WATER.

(b) Laboratory project.

(d) Theoretical and experimental; basic research for M.S. thesis.

(e) The reflection and transmission of surface waves in the presence of a fixed barrier in shallow water is studied.

(h) "Surface Waves in the Presence of A Vertical Barrier in Shallow Water; Theory and Experiments," by S. M. Tan, M. S. Thesis, the University of Kansas, August, 1962.

(4641) HYDRODYNAMIC STABILITY OF FLOW BETWEEN TWO CONCENTRIC ROTATING CYLINDERS.

(b) Laboratory project.

(d) Theoretical; basic research for M. S. thesis.

(e) Mathematical solution of Taylor's problem for finite radii of the concentric cylinders is sought.

(4642) ON POTENTIAL FLOW PROBLEMS WITH FREE STREAMLINES.

(b) Laboratory project.

(d) Theoretical; basic research for M. S. thesis.

(e) A synthetic study on methods of solution of potential flow problems with free streamlines.

(4643) MECHANICS OF BLOOD FLOW.

(b) Laboratory project financed by the NASA grant to the University of Kansas.

(d) Theoretical and experimental; basic research.

(e) A study of flow problems pertaining to blood circulating in a vascular system.

LEHIGH UNIVERSITY, Department of Civil Engineering.

Inquiries concerning the following projects and requests for reprints and technical reports should be addressed to Prof. J. B. Herbich, Chairman, Hydraulics Div., Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pennsylvania.

(2543) STUDY OF CONDUIT EXIT PORTALS.

(b) Laboratory Project.
(d) Experimental: M. S. Thesis.
(f) General pressure-distribution study completed.
(g) Tests of square and circular conduit with free-jet, horizontal apron, and three different wall flares, have been completed.

(3084) STUDY ON IMPROVING DESIGN OF A HOPPER DREDGE PUMP.

(b) District Engineer, U.S. Army Engineer Dist., Marine Division, Philadelphia, Corps of Engineers.
(d) Applied and Basic Research.
(e) The immediate purpose of the study is to improve design of a hopper dredge centrifugal pump for pumping silt-clay water mixtures. The long-term objective is to determine the effect of Bingham Body-type of fluid on pumping characteristics. The project has been divided into four phases: (1) Model test of existing dredge pump; (2) recommendations for design changes of the dredge pump; (3) model investigation of the modified design of the dredge pump; and (4) analysis of the investigation and final recommendations. Phase 1 involved installation in the hydraulic laboratory of a 1:8 scale model of the dredge pump now used on the U.S. Corps of Engineers dredge ESSAYONS. Water as well as silt-clay-water mixtures (Bingham Body-type of fluid) were pumped and complete characteristics of the pump obtained for capacity of 0 to 1200 gallons per minute, speed of 1150 to 1900 revolutions per minute, and liquid concentrations of 1000 and 1380 grams per liter. Phases 2 and 3 involve modifications in the shape of vane and changes in the exit vane angle of the impeller. Experimental tests indicate considerable improvement in pump efficiency. Analysis of the experimental data resulted in recommendations for changes in pump design.
(f) 1, 2, 3 and 4 completed.
(g) Considerable improvement in pump efficiency has been achieved.

(3085) STUDY OF SCALE EFFECT BETWEEN MODEL AND PROTOTYPE SPILLWAYS.

(b) Laboratory project.
(d) Graduate students' project.
(e) A 1:100 scale two-dimensional model built of Chief Joseph Dam. Prototype crest pressures compared with the data obtained on the model.
(f) Completed.
(g) Very good correlation obtained between the model and prototype.

(3086) INVESTIGATION OF DESIGN CRITERIA OF SPUR DIKES.

(b) Modjeski and Masters, Consulting Engineers, Harrisburg, Pa., Lehigh University Inst. of Research.
(d) Analytical and experimental.
(e) The project has been divided into four phases: (a) Literature survey; (b) analytical study; (c) experimental study in a fixed-bed model to determine the desired lengths and shapes of spur dikes to provide uniform velocity distribution in the waterway between bridge abutments; (d) experimental study in a movable-bed model to verify findings in part c. A spur dike has been defined as a projection extending upstream from the bridge abutments.
(f) Phases (a), (b) and (c) completed; phase (d) active.
(g) Preliminary investigation indicates that a properly designed spur dike can produce a fairly uniform velocity distribution between the abutments.

(3441) STUDY OF SCALE EFFECT BETWEEN MODEL AND PROTOTYPE 270 DEGREE BENDS FOR FLOW OF SILT-CLAY-WATER MIXTURES.

(b) Laboratory project.
(d) M. S. Thesis.
(e) Four-, six-, and eight-inch diameter 90 degree elbows assembled to form 270 degree bends. Head loss measurements obtained for various flows and concentrations of silt-clay-water mixtures. Prediction equations have been investigated.
(f) Completed.
(g) No evidence of appreciable scale effect observed.

(3442) SUGGESTED DESIGN CHANGES FOR A CENTRIFUGAL PUMP IMPELLER HANDLING DREDGED MUD.

(b) Research report requirement of master's degree.
(d) Theoretical.
(e) Design changes in centrifugal pump impeller for handling mud are suggested on basis of past research and theoretical considerations.
(f) Completed.

(3746) ANALYSIS OF FLOW PATTERN IN VOLUTE OF A CENTRIFUGAL PUMP.

(b) Research report requirement of master's degree. District Engineer, U. S. Army Engineer District, Marine Division, Phila. Corps of Engineers.
(d) Experimental.
(e) High-speed movies of flow taken through a transparent plexiglas volute casing were analyzed. Velocity distribution as well as distribution of the exit angle between the impeller vanes as fluid leaves the impeller were determined.
(f) Completed.
(h) "Modifications in Design Improve Dredge Pump Efficiency," by John B. Herbich, Fritz Lab. Report No. 277.35, Sept. 1962, 146 pages.

(3747) FRICTION HEAD LOSSES IN CIRCULAR PIPES FOR A BINGHAM-BODY FLUID.

(b) Laboratory project.
(d) Experimental and theoretical.
(e) The object of the study is the determination of the pipe flow characteristics of slurries of various concentrations. The slurries do not behave as fluids of constant viscosity so that it is not possible to use conventiona methods for prediction of head losses in pipes conveying them. Tests are being conducted in 6-inch, 3-inch, and 2-inch pipelin with velocities from less than 1 fps to over 30 fps.
(f) Suspended.

(4154) DREDGE PUMP DESIGN.

(b) National Bulk Carriers, Inc.
(d) Experimental.
(e) The objective of the investigation is to obtain the efficiency and head-capacity curves, to check the effect of the reduced vane exit angle, and to determine the efficiency of a model dredge pump while pumping silt-clay-water mixture of specific gravity equal to 1.17. The experimental tests were carried out on a 1/8 model pump of the National Bulk Carriers Hopper Dredge, S. S. Zulia.
(f) Completed.
(h) Report in preparation.

(4155) WAVE RUN-UP ON COMPOSITE BEACHES.

(d) Graduate students' project. Experimental, applied research for design.
(e) The main object of the study is to verify existing equations for determining the height of wave run-up and obtain the limits of application of the equation for long beach berms.
The study is conducted in a 67 ft. long, 2 ft. wide and 2 ft. deep wave channel equipped with pendulum-type wave generator and efficient absorbers.
(h) "A Study of the Effect of Horizontal Berm Variation on Wave Run-Up Upon A Composite Beach Slope," by J. B. Herbich, R. M. Sorensen and J. H. Willenbrock, Project Report No. 35, Fritz Laboratory Project Report No. 293.35, May 1962, 104 pages.

(4156) MULTIPLE DREDGE PUMP SYSTEMS.

(b) National Bulk Carriers, Inc.
(d) Experimental and theoretical.
(e) The study is conducted to determine the effect on total production of dredge pumps with separate discharges and a combined discharge. The investigation is divided into two parts: (a) One pair of pumps is handling a mixture of water and solids, the other is pumping only water. It is required to determine what percentage of its normal output will the dredge pump passing the mixture attain. (b) If one of a pair of dredge pumps, both handling water-solids mixtures, is revolving slower than the other one, how does the total discharge compare to the total if the discharges were not combined?
(f) Completed.
(h) "Efficiency of Pumping and Piping Layout," by Richard G. Warnock, John B. Herbich, Project Report No. 37, Fritz Eng. Laboratory, Lehigh University, Fritz Lab. Report No. 294.1, October 1962, 46 pages.

(4644) STUDY OF THE GRAVITY WAVE REFLECTIONS FROM FLOATING RECTANGULAR BODIES.

(b) Research report requirement of master's degree.
(d) Experimental.
(e) The object of the study is to determine the magnitude of wave reflections from rectangular floating bodies. Tests are being conducted in a 67-ft. long, 2 ft.-wide and 2 ft.-deep wave channel equipped with pendulum-type wave generator and efficient absorbers.
(h) Report in preparation.

(4645) EFFECT OF LENGTH AND SPACING OF SPUR DIKES.

(b) Laboratory report.
(d) Experimental and theoretical; M. S. Thesis.
(e) The object of the study is to determine the effect of length and spacing of spur dikes on the magnitude of scour in uniform flow. The experiments are conducted in a 10-ft. wide, 35-ft. long open channel with movable sand bed. Scour patterns are observed and analyzed.
(h) "Effect of Length and Spacing of Spur Dikes on Scour," by D. R. Joshi, M. S. thesis, Civil Engineering Department, Lehigh Univ., 1963.

LOUISIANA STATE UNIVERSITY AND A AND M COLLEGE, Agricultural Engineering Department.

(4157) FURROW IRRIGATION IN SUGAR CANE.

(b) Laboratory project
(c) Mr. James E. Wimberly, Agri. Engr. Dept., Louisiana State University, Baton Rouge, La.
(d) Experimental; applied research, master's thesis.
(e) A study of infiltration rates and furrow sizes for soil types in the sugar cane area.
(f) Completed.
(g) Equations for prediction of the rate of advance of the water front for eighteen inch furrows on 0.14 ft./100 ft. slope were developed for three soil types:

Soil Type	Equation
Sandy Loam	$T = 0.098\ D^{1.264}\ Q^{-0.520}$
Clay Loam	$T = 0.160\ D^{1.294}\ Q^{-0.549}$
Clay	$T = 0.600\ D^{1.309}\ Q^{-1.167}$

where
T = Time elapsed, minutes,
D = Distance water front has advanced, feet,
Q = Furrow stream inflow, gallons per minute.

The coefficients obtained for the three soil types were developed from multiple regression analyses based on 268 observations with multiple correlation coefficients above 0.95 for each experiment. The prediction forms are valid in the ranges $0 \leq D \leq 1000$ ft., $0 \leq Q \leq 60$ gallons per minute.
(h) "Design of Furrow Irrigation for Sugar Cane", James E. Wimberly, Paper No. 62-225, available from American Society of Agricultural Engineers, St. Joseph, Michigan.

(4489) SUBIRRIGATION WITH PERFORATED TUBES.

(b) Laboratory project.
(c) Dr. Harry J. Braud, Jr., La. State University Agricultural Engineering Dept., Baton Rouge, Louisiana.
(d) Experimental; design and development.
(e) The hydraulic behavior of small plastic perforated tubes embedded in a soil medium for subirrigation is being investigated. Flow at low Reynolds number is utilized. Observations are made of combined tube friction loss, orifice head loss and hydrostatic pressures resisting discharge from the perforations. Discharge rates from drilled holes and slits are being studied.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Department of Civil Engineering, Hydrodynamics Laboratory.

Requests for reprints and Technical Reports should be addressed to Dr. Arthur T. Ippen, Professor of Hydraulics, Hydrodynamics Laboratory, Mass. Inst. of Technology, Cambridge 39, Mass.

(307) MECHANICS OF STRATIFIED FLOW.

(b) Tennessee Valley Authority.
(c) Prof. D. R. F. Harleman, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Theoretical and experimental; basic and applied research.
(e) General studies on characteristics of flows in which vertical density gradients are present. Present studies are concerned with the performance of intake structures for condensing water from the cool layer and with the recirculation between the warm water outlet and the cool water intake.
(g) Experimental and analytical studies have dealt with the limiting dimensions for skimmer walls to insure maximum performance with respect to withdrawals from the cool water layer. It was also found that recirculation of cooling water is dependent on the design of the intake structures and can be held to a minimum by proper dimensioning of these structures. The parameters governing the design are defined for general use.
(h) "Control Structures in Stratified Flows," by D. R. F. Harleman and Y. Goda, Hydrodynamics Laboratory Report No. 54, May 1962.
"The Effect of Intake Design on Condenser

Water Recirculation," by D. R. F. Harleman and J. M. Garrison, Hydrodynamics Lab. Report No. 56, August 1962.

(1609) STUDY OF BEACH PROCESSES IN THE INSHORE AND FORESHORE ZONES.

(b) Beach Erosion Board, U. S. Army Corps of Engineers.
(c) Professor P. S. Eagleson, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental and theoretical; basic research.
(e) Study of the surface profile and internal kinematics of a shoaling oscillatory wave up to and beyond the breaker.
(g) The theoretical phase is seeking an irrotational description of finite amplitude waves which yields mass transport and is valid up to breaking on an impermeable bottom of constant slope. The experimental phase involves the measurement of wave profile and orbital velocities. An orbital velocity probe utilizing a thermistor as the sensing element has been developed.

(2801) INTERACTION OF WAVES WITH SUBMERGED AND FLOATING BODIES.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. A. T. Ippen, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Theoretical and experimental; basic research.
(e) The purpose of the study is to determine the wave reflecting and transmitting characteristics of different types of structures suitable for application to floating or moored breakwaters.
(g) Two problems are currently under investigation (1) A study of the effect of a gradual decrease of depth on a train of shallow water surface waves. Reflection and transmission coefficients are being measured for various wave lengths and depths. Results are compared with existing theories. Energy losses due to separation at corners of the sloped bottom are believed to be responsible for differences between theory and experiment. (2) A new type of submerged breakwater consisting of an array of open tubes with their axes parallel to the direction of wave propagation is being tested. Randomness of position and tube length and total force on the array are being investigated in relation to the transmission coefficient of the breakwater.
(h) "The Effect of a Gradual Change of Depth on a Train of Surface Waves," by M. L. Gagnon and M. V. Bocco, Master's Thesis, MIT, June 1962.
"Characteristics of an Open-Tube Wave Attenuation System," by A. W. Barnett, Master's Thesis, MIT, June 1962.

(2802) EXPERIMENTAL STUDY OF WAKE MECHANICS.

(b) Office of Naval Research, David Taylor Model Basin, Dept. of the Navy.
(c) Prof. J. W. Daily, Prof. P. S. Eagleson, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental and theoretical; basic research (doctoral theses).
(e) A study of the effect of body geometry and support stiffness on the relationship between wake structure and flow-induced body vibration.
(f) Inactive.
(g) Flat plates are spring mounted in a water tunnel. Plate vibration and turbulent wake structure are measured. Moment coefficients are obtained which define the nature of the self-excitation experienced and allow selection of system constants so that self-excitation may be avoided in design.
(h) "The Effects of Trailing Edge Geometry and Chord Length on the Early Wake of Stationary Flat Plates," by P. S. Eagleson, J. W. Daily, and R. A. Grace, Hydrodynamics Lab. Report No. 51, April 1962.
"Flow-Induced Vibration of Flat Plates - The Mechanism of Self-Excitation," by P. S. Eagleson, J. W. Daily, and G. K. Noutsopoulos, Hydrodynamics Laboratory Report No. 58, February 1963.

(3443) COMPUTER SIMULATION OF THE COMPLETE TRANSIENT PROBLEM IN A HYDRO-POWER PLANT.

(b) U. S. Army Corps of Engineers Division, Missouri River.
(c) Professor A. T. Ippen, Professor P. S. Eagleson.
(d) Theoretical, field tests; applied research.
(e) Development of a digital computer program of general utility and proven validity for performing design analyses involving the response of hydro-power plant systems to load fluctuation.
(g) Assistance has been furnished the Corps of Engineers in the planning and conduct of a comprehensive field test of Garrison Power Plant and in the planning of similar tests at Oahe Power Plant. The tests involve measurement of all pertinent mechanical, electrical, and hydraulic variables under conditions of acceptance, rejection and oscillation of load. Digital computer programs have been written for the problem of surge tank stability and to yield the system behavior under load rejection.
(h) "Stability of Restricted Orifice Surge Tanks Studied by Digital Computer," by A. C. Tedrow, Master's Thesis, MIT, September 1962.
"Single Tee Loss Coefficients Applied to Double Surge Tanks With Restricted Orifices," by G. E. Hecker, Master's Thesis, MIT, Sept. 1962.

(3444) EFFECTS OF BASIN GEOMETRY AND VISCOUS DAMPING ON THE AMPLITUDE OF RESONANT OSCILLATIONS IN HARBORS.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. A. T. Ippen, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Theoretical and experimental; basic research.
(e) Investigation of the response of a harbor to waves incident on the harbor opening, with open ocean conditions simulated in a basin of finite size.
(g) The characteristics of the response of a rectangular harbor in the vicinity of the lowest symmetrical resonant mode of oscillation are studied in a wave basin. The problem is concerned with the modelling of a prototype system in the laboratory with respect to the correct periods of resonant oscillations. A non-dissipative model system consisting of a small rectangular harbor directly connected to a larger wave basin was studied first and theoretical and experimental solutions were obtained. The aspect of the coupling of harbor and wave basin was found extremely important and masked the true nature of resonance. Experimental investigations are now in progress to determine the degree to which wave absorbers and filters must be applied in the wave basin to simulate proper harbor-open ocean conditions. Quantitative evaluation of the action of certain wave filters was attained by theory and experiment in preliminary studies.
(h) "Wave-Induced Oscillations in Harbors: The Problem of Coupling of Highly Reflective Basins," by A. T. Ippen and F. Raichlen, Hydrodynamics Laboratory Report No. 49, May 1962.
"Wave-Induced Oscillations in Harbors: Effect of Energy Dissipation in Coupled Basin Systems," by A. T. Ippen, F. Raichlen, and R. K. Sullivan, Hydrodynamics Laboratory Report No. 52, July 1962.

(3748) DISPERSION IN POROUS MEDIAN AND WASTE WATER RECHARGE.

(b) National Institutes of Health, U. S. Public

Health Service.
(c) Professor D. R. F. Harleman, Professor N. H. Brooks, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Theoretical and experimental; basic research (doctoral thesis).
(e) An investigation into the mechanism and the degree of dispersion of dissolved substances in radial, confined flow through a porous medium at velocities greater than the linear, Darcy range of fluid resistance. Results will be important to engineering projects in the recharging of aquifers with reclaimed waste water.
(g) The initial phase of this study first investigated longitudinal and lateral dispersion in steady, Darcy flow. Second, the problem of salinity intrusion in confined aquifers with and without tidal oscillations was studied theoretically and verified experimentally. Currently, longitudinal dispersion of dilute salt concentrations in fine gravels is being studied for Reynolds Numbers (based upon particle diameter) varying from 1 to 500. The dispersion coefficient is determined from the change in the maximum amplitude concentration of a harmonically varying input concentration. This work is preliminary to the radial flow investigation where the dispersion is initially governed by non-linear or turbulent flow and subsequently is controlled by laminar (linear) motion at large radii.
(h) "The Dynamics of Salt-Water Intrusion in Porous Media" by D. R. F. Harleman and R. R. Rumer, Jr., Hydrodynamics Laboratory Report No. 55, August 1962.
"Longitudinal Dispersion in Uniform Porous Media," by D. R. F. Harleman, P. F. Mehlhorn, and R. R. Rumer, Jr., Hydrodynamics Lab. Report No. 57, August 1962.

(3749) RESISTANCE OF ENCLOSED ROTATING DISKS.

(b) Office of Ordnance Research, U. S. Dept. of the Army.
(c) Professor J. W. Daily, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental and analytical; basic research.
(e) Effect of superposed throughflows on boundary layers, secondary motions and surface resistance of enclosed rotating disks.
(g) A qualitative survey of superposed throughflow effects has been completed. Quantitative measurements of torque and velocities induced by the disk rotation are being made. Unsteady periodicities disclosed in the qualitative survey are being examined in detail.
(h) "Effect of Superposed Throughflows on Motion Induced by Enclosed Rotating Disks," by R. E. A. Arndt, Master's Thesis, MIT, June 1962.
"Enclosed Rotating Disks with Superposed Throughflow: A Survey of Basic Effects," by J. W. Daily and R. E. A. Arndt, Hydrodynamics Laboratory Report No. 53, June 1962.

(3750) WAVE FORCES ON STRUCTURES.

(b) Laboratory project.
(c) Prof. D. R. F. Harleman, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Theoretical and experimental; applied research.
(e) The objective is the development of design procedures for the dynamic displacement response of the platform of a fixed offshore structure acted upon by a regular wave train.
(g) The offshore structure considered consists of a platform on four legs in a square configuration, with the waves impinging normal to one side of the square. The procedure of computation may be modified however for other leg configurations and wave directions. Morison's theory is used for drag forces and McCamy-Fuchs diffraction theory for inertia forces. Wave forces are expressed in terms of a Fourier series. Dynamic displacements of the structure are computed by machine and checked by model experiments for 32 cases. The ratios of maximum theoretical to experimental displacements vary from about 0.5 to 1.7. The largest waves were shown not necessarily the most critical for the structure. Instead the critical design wave is a function of the ratio of wave frequency to the natural frequency of the structure.
(h) "Wave-Induced Vibrations in Fixed Offshore Structures," by W. C. Nolan and V. C. Honsinger, Master's Thesis, MIT, May 1962.
"Dynamic Analysis of Offshore Structures," by D. R. F. Harleman, W. C. Nolan, and V. C. Honsinger, 8th Conference on Coastal Engineering, November 1962.

(4158) EXPERIMENTAL AND ANALYTICAL STUDY OF THE FORMATION OF LONGSHORE CURRENTS.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. P. S. Eagleson, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental and theoretical; basic research (doctoral thesis).
(e) Quantitative study of the mechanics of the formation of longshore currents.
(g) Current experiments are studying the strength of littoral currents generated on a straight, plane impermeable beach as a function of incident wave characteristics, beach roughness and beach slope.

(4159) INSTRUMENTATION SYSTEM FOR THE ANALYSIS OF COMPLEX WAVE FORMS.

(b) National Science Foundation.
(c) Prof. A. T. Ippen, Prof. J. W. Daily, Prof. P. S. Eagleson.
(d) Basic research facility.
(e) Selection and assembly of an analog computer for the calculation and plotting of correlation and spectrum functions. Design and construction of a mechanical time delay mechanism.
(g) Data are acquired on a portable, multichannel FM tape transport. A second transport permits frequency multiplication through rerecording and provides a 120-foot tape loop capability for the repetitive analysis of short records. Matched filters allow the determination of cross power spectral densities as well as the power spectral density of a single signal. The tape loop transport is being fitted with a mechanical time delay mechanism for the determination of correlation functions. Output of all operational modes is through an x-y plotter.

(4160) MOTION OF SUBMERGED BODIES BELOW A FREE SURFACE.

(b) Office of Naval Research, Dept. of the Navy.
(c) Professor A. T. Ippen, Professor J. F. Kennedy, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental and theoretical; basic research.
(e) An investigation of the interaction of a free surface and the turbulent wake generated by a moving body. The effect of a vertical density gradient on the mixing in the wake is also being studied.
(g) Velocity distributions have been measured at various distances behind a two-dimensional body moving at different velocities and various distances beneath the free surface in a homogeneous fluid. The drag has also been measured. An image method has been developed for predicting the velocity distribution in the wake of a body moving near a free surface or rigid boundary. Measured and predicted velocity profiles are in good agreement. The drag of the body was found to increase with decreasing distance from the free surface. The experiments are now being extended to include the effect of a

density gradient.

(h) "Free Surface Effects on the Two-Dimensional Wake Behind a Flat Plate Normal to the Direction of Motion," by F. R. Harty, Jr., Master's Thesis, MIT, September 1962.

(4646) RADIAL FREE SURFACE FLOW.

(b) Laboratory project.
(c) Professor A. T. Ippen, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Theoretical and experimental; basic research.
(e) The theory of the free surface sink and source flow is being developed including standing waves - hydraulic jumps.
(g) For certain super-critical ranges of flow the two-dimensional equations of motion have been solved with simplifying assumptions and the resulting so-called "backwater curves" have been verified experimentally in a previous study. The present investigation is concerned with the solution of the general differential equations without the previous restrictions, which is possible, however, only by numerical integration by by means of machine computation. A number of solutions have been obtained with the special computer program devised for a variety of radial free surface flows. A method has also been developed to cover the special case of the hydraulic jump in radial flow. An extensive experimental program has been carried out to verify the theoretical analysis.
(h) "Radial Free Surface Flow," by M. S. Higgins and C. D. Sadler, Master's Thesis, MIT, January 1963.

(4647) FREE SURFACE SHEARING FLOW OVER A WAVY BOUNDARY.

(b) National Science Foundation Institutional Grant.
(c) Prof. J. F. Kennedy, Prof. P. A. Drinker, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental.
(e) An investigation of the distributions of velocity and shear stress for a free surface flow moving over a sinusoidal-shaped bed.
(g) For supercritical flow, the surface profile and velocity profiles at various positions along the bed have been measured. Shear stresses were calculated from the measured velocity profiles. It was found that the surface profile, shear stress distribution, and perturbations of the velocity profile each have a phase shift from the bottom profile. This phase shift gives rise to a form drag on the wavy bottom. The perturbations of the velocity distribution, due to variations in local mean depth and velocity along the wavy bed, generate cross-waves, one cross-wave being formed by each period of the bed. These cross-waves cause a complex, three-dimensional surface profile.
(h) "An Investigation of Free Surface Shearing Flows Over a Fixed Wavy Boundary," by O. H. Shemdin, Master's Thesis, MIT, September 1962.

(4648) MECHANICS OF AERATION AND DISPERSION IN RIVER POLLUTION.

(b) National Institutes of Health, Public Health Service.
(c) Prof. D. R. F. Harleman, Prof. N. H. Brooks, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental and theoretical; basic research (doctoral thesis).
(e) A study of the basic mechanism of transfer of oxygen molecules from the atmosphere into turbulent water and investigations into the vertical diffusive transport and the longitudinal dispersive transport of the dissolved oxygen in a flowing stream with oxygen deficiency due to pollutants.
(g) In the first set of experiments turbulence is being produced with oscillating screens in a shallow tank of initially deaerated water, and the dissolved oxygen is measured as a function of time and depth by means of a specially built electro-chemical probe. One of the objectives is to separate the effects of the turbulence on the oxygen transfer across the surface from the turbulent diffusion within the body of the fluid. Theoretical solutions have been derived which do not depend on one-dimensional approximations.
(h) Discussion by D. R. F. Harleman and E. R. Holley, Jr. of "Turbulent Diffusion and the Reaeration Coefficient," by P. A. Krenkel and G. T. Orlob, Journal of the Sanitary Engineering Division, Proceedings, ASCE, Vol. 88, No. SA6, pp. 109-116, November 1962.

(4649) TURBULENT TRANSFER MECHANICS OF FLUID SUSPENSIONS OF SOLID PARTICLES.

(b) Pioneering Research Program, Institute of Paper Chemistry.
(c) Professor J. W. Daily, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental; basic research.
(e) Basic study of turbulent transfer mechanics of liquid flows with particles in suspension.
(g) This is a follow-up of the work on characteristics of dilute fiber suspensions previously reported. In that project during the last phase the role of the suspending medium on modifying turbulent shear flow was examined using nearly neutrally buoyant rigid particles. One phase was examination of the particle effects on response of velocity and total head probes. Initial experiments in the present study will include effects of particle shape and density using uniform shear flows. Later extension to non-uniform shear and shear-free turbulence is planned.
(h) "Solid Particle Effects on Total Head and Velocity Measurements in Suspensions," by R. L. Hardison, Master's Thesis, MIT, Nov. 1962.

(4650) HURRICANE BARRIER STUDIES.

(b) U. S. Army Engineer Division, New England, Corps of Engineers.
(c) Professor R. T. McLaughlin, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Analytical; applied research.
(e) Determination by digital computation of waves produced by storms in the vicinity of Narragansett Bay, Rhode Island, and selection of design wave for hurricane barriers at the entrance to the bay. Determination of optimum geometry for the barriers.
(g) Numerical methods for processing wind data and calculating wave generation and refraction have been set up and are being programmed for the digital computer. A system analysis for determining optimum geometry has been started.

(4651) REFRACTION OF TSUNAMI WAVES IN THE PRESENCE OF OCEANIC ISLANDS.

(b) U. S. Coast and Geodetic Survey.
(c) Prof. D. R. F. Harleman, Prof. L. N. Howard, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Theoretical and experimental; basic research.
(e) Analytical and experimental study of tsunami refraction using non-linear shallow water wave theory.
(g) Tsunami refraction problems are characterized by the fact that the wave lengths of the wave train and the base diameter of a typical island are of the same order of magnitude. Hence usual methods of analysis assuming small wave lengths relative to the refracting body are inadequate. A piston type wave generator has been constructed in a wide shallow channel capable of generating a finite wave train simulating an open ocean tsunami. Measurements of wave properties on a two-dimensional island geometry are

being made for comparison with theory.

(4652) SORTING OF BEACH SEDIMENTS BY SHALLOW WATER WAVES.

(b) Beach Erosion Board, U. S. Army Corps of Engineers.
(c) Prof. P. S. Eagleson, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental and theoretical; basic research.
(e) Application of the mechanics of discrete bed particle motion to the prediction of equilibrium characteristics of natural sand beaches.
(f) Inactive.
(g) Laboratory sand beaches having an initially constant slope were allowed to deform to equilibrium under a given incident wave. Bed load mechanics were shown to provide an improved criterion for aggrading vs. degrading profile classification as well as other factors relating to artificial beach nourishment and sediment sorting.
(h) "Laminar Damping of Oscillatory Waves," by P. S. Eagleson, Proceedings ASCE, Journal of Hydraulics Division, HY3, May 1962, Paper No. 3152.
"Equilibrium Characteristics of Sand Beaches," by P. S. Eagleson, B. Glenne, and J. A. Dracup, Proceedings ASCE, Journal of Hydraulics Div., Jan. 1963, Paper No. 3387.
"Equilibrium Characteristics of a Movable Bed Under a Standing Wave in Water," by P. P. Goldstern, Batchelor's Thesis, MIT, 1962.

(4653) WAVE-GENERATED SEDIMENT RIPPLES.

(b) National Science Foundation Institutional Grant.
(c) Prof. J. F. Kennedy, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental and theoretical.
(e) Sediment ripples generated by long and short gravity waves are being studied to determine the relation between the characteristics of the ripples, the bed material, and the properties of the generating waves. Sediments of different sizes and specific weights are being used. The effect of the roughening of the boundary, due to ripple formation, on the surface waves is also being investigated.
(g) Ripple geometry has been found to be quite sensitive to the characteristics of the generating waves, and to the properties of the bed material. The presence of even a small standing wave component, superimposed on the translational waves will cause the ripple characteristics to vary periodically along the length of the wave tank.

(4654) A NEW METHOD FOR THE SYSTEMATIC INVESTIGATION OF SEDIMENT TRANSPORT.

(b) National Science Foundation.
(c) Prof. A. T. Ippen, Prof. P. A. Drinker, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Theoretical and experimental; basic research.
(e) A research program to develop the general characteristics of the flow of fluid-sediment mixtures and of the interaction of fluid flow with movable boundaries.
(g) A study of sediment transport by shear flow in the annulus between two rotating drums rather than by flow in a channel has been initiated. A new experimental apparatus is under design which replaces the commonly employed longitudinal channel by an annular channel between two rotating drums, in which the normal gravitational field is replaced by a centrifugal force field. With the cylindrical drums rotating at different relative speeds a large variety of flow conditions can be established in the "endless" annular channel, covering a wide range of tractive forces on the sediment deposited on the wall of the outer drum under various modes of relative motion. The difficult recirculation of sediment and liquid necessary in conventional flumes is thus avoided and uniform flow conditions seem assured.

(4655) ENTRAINMENT OF COHESIVE SEDIMENTS.

(b) Office of Naval Research, Department of the Navy.
(c) Prof. J. F. Kennedy, Prof. C. C. Ladd, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental; basic research.
(e) A laboratory study of the factors that determine the erodibility of cohesive soils by water.
(g) The soil properties of the sediment, including the shear strength at very low compactive stresses, are measured. The soil is then placed in a recirculating laboratory flume and critical velocity and shear stress, at which erosion just begins, are measured. Several clays are being investigated.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Department of Mechanical Engineering.

(2807) THE HYDRAULIC ANALOGY APPLIED TO COMPRESSIBIE FLOW IN THE PARTIAL ADMISSION TURBINE.

(b) Office of Naval Research and United States Naval Underwater Ordnance Station.
(c) Prof. Robert W. Mann, Room 3-459A, Mass. Inst. of Tech., Cambridge 39, Massachusetts.
(d) Theoretical and experimental; applied research for master's and doctoral theses.
(e) A study of time-varying two-dimensional compressible flow with the goal of design recommendations for partial admission turbine blading, although the results are generally applicable to time-varying two-dimensional geometries.
(g) The water table simulating the gas partial admission turbine has been revised and improved. New stereo-mapping cameras to record time-varying water height have been designed, fabricated, and tested. Feasibility studies have been conducted of several experimental apparati by means of which characteristics in the water table flow can be compared with gas turbine flow. A miniature piezo electric transducer for turbine shroud and wheel implantation has been designed and is being fabricated.
Experimental studies of fixed-geometry non-axisymmetric nozzle performance operative over a wide pressure ratio has indicated novel designs which maximize the whirl component by utilizing jet-deflection effect at off-design pressure ratios.
(h) "Photostereogrammetry Applied to Hydraulic Analogue Studies of Unsteady Gas Flow," R. W. Mann, Proceedings of the ASME Symposium on Measurements in Unsteady Flow, May 1962.
"Stereophotogrammetry Applied to Hydraulic Analogue Studies of Unsteady Gas Flow," Photogrammetric Engineering, Vol. XXVIII, No. 4, September, 1962.
"Off-Design Performance of Axisymmetric Nozzle with Oblique Exit Planes," E. J. Rogers Thesis (S.M.), Dept. of Mech. Engr., Mass. Inst. of Tech., Cambridge, Mass.
"Partial-Admission Turbines," Gunnar O. Ohlsson, Journal of the Aerospace Sciences, Vol. 29, 9, September 1962.
"Low Aspect Ratio Turbines," Gunnar O. Ohlsson, Paper No. 62-WA-38, ASME Winter Annual Meeting, November 1962.
"Supersonic Turbines," Gunnar O. Ohlsson, Paper No. 62-WA-37, ASME Winter Annual Meeting, November 1962.
"Cascade Performance From Tests with Wheel of Axial Outlet," by Gunnar O. Ohlsson Paper No. 62-WA-36, ASME Winter Annual Meeting, November 1962.
"Friction Drag on Bladed Discs in Housings," R. W. Mann and C. H. Marston, Trans. ASME.,

Paper No. 61-HYD-5, May 1961, also in Journal of Basic Engineering, Transactions of the ASME, Series D, December 1961.

(3092) JET-PIPE CONTROL VALVES.

(b) U. S. Air Force and Kearfott, Division of General Precision, Inc.
(c) Prof. J. L. Shearer, Prof. S. Y. Lee, Dept. of Mech. Engineering, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Applied research, thesis investigation.
(e) An analytical and experimental study of the steady-state and dynamic characteristics of pneumatic, hot-gas and hydraulic jet-pipe control devices. An investigation of the effects of turbulent diffusion of the fluid jets of jet-type devices and an associated investigation of the limitations of using potential flow solutions to predict the characteristics of jet-type devices are included in the overall study. Emphasis is on better understanding the fundamental behavior of jet-type devices.
(g) Experimental work conducted to date has produced useful information concerning the steady-state characteristics of conventional hydraulic and pneumatic jet-pipe valves. Optimum design conditions have been established based on certain criteria of merit.

(3448) FLOW THROUGH CONTROL VALVE ORIFICES.

(b) U. S. Air Force, Chandler-Evans Corp., and Hamilton Standard (Div. of United Aircraft).
(c) Prof. J. L. Shearer, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Applied research.
(e) Experimental investigation of the characteristics of flow through fixed area and variable area orifices with emphasis on resistance to fluid flow and the factors that lead to being able to predict the resistance characteristics over a wide range of Reynolds Numbers.
(g) A large scale model study has been conducted for short tube orifices with length-to-diameter ratios of 2 to 6 and over a diameter Reynolds Number range of 300 to 25,000. An empirical method has been developed for predicting the orifice discharge coefficient over the range of variables tested. Unsteady flow in seating type valves is also being investigated.
(h) "Flow Characteristics of Short-Tube Hydraulic Orifices," by D. J. Tapparo, Thesis (S.M.), Dept. of Mechanical Eng'g., Mass. Inst. of Tech., Cambridge, Mass., Aug. 1962.
"Transient Forces on Hydraulic Seating Type Valves," by F. T. Murray, Thesis (S.M.), Dept. of Mech. Eng'g., Mass. Inst. of Tech., Cambridge, Mass., Sept. 1961.

(3456) FLAME PROPAGATION AND STABILIZATION IN BOUNDARY LAYERS.

(b) National Science Foundation.
(c) Prof. T. Y. Toong, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Theoretical and experimental; basic research for doctoral and master's theses.
(e) Basic study of mechanisms of flame propagation and stabilization in a laminar boundary layer adjacent to a heated plate.
(f) Completed.
(g) A critical test of the equilibrium theory of flame stabilization in boundary layers has been obtained by the measurement of propagation speed of a two-dimensional laminar flame in these boundary layers.
A mechanism has been postulated and confirmed experimentally to explain flame oscillations in boundary layers.
(h) "Flame Propagation in Laminar Boundary Layers," by T. Y. Toong, J. R. Kelly and W. S. Wu, Ninth Symposium (International) on Combustion, Academic Press, New York, in press.
"Further Study on Flame Stabilization in a Boundary Layer: A Mechanism of Flame Oscillations," by W. S. Wu and T. Y. Toong, Ninth Symposium (International) on Combustion, Academic Press, New York, in press.

(3758) FILM BOILING INSIDE OF TUBES.

(b) National Science Foundation.
(c) Prof. W. M. Rohsenow, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental and Theoretical; Applied research To be used for theses.
(e) The investigation of heat transfer associate with forced convection film boiling inside horizontal and vertical tubes, which has been carried on here for the past two years, is being continued at the present time. In this case the tube wall temperature is hundreds of degrees above the local boiling point causing a vapor "film" to form between liquid and hot tube wall. In a vertical tube a relatively uniform film forms around the tube where the liquid vapor interface appears to have a rough and randomly oscillating shape. The difference between height times density in the liquid vapor films appears to cause the vapor to move up the tube much more rapidly than the liquid. Reasonable success has been achieved in predicting these flow rates and associated heat transfer rates by writing the momentum equation for the process. In most cases the vapor flow seems to be turbulent. The heat transfer rate is found both analytically and experimentally to be relatively insensitive to the inlet flow rate. During the past year, the same process was investigated in a horizontal tube. For the low quality ranges investigated, the flow remained stratified. The vapor generated around the tube, flows up to the top and then axially toward the tube exit. Thus, the flow exhibits a stratified character. Here, too, a combination of the application of heat transfer relations and momentum equation led to a successful prediction of tube wall temperature distribution in the electrically heated tube.

(4162) STABILITY OF HYDRAULIC VALVES.

(b) Hamilton Standard Div., and United Aircraft Corp.
(c) Prof. S. Y. Lee, Mech. Engineering Dept., Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Theoretical and experimental.
(e) Study the phase and amplitude relationship of several parameters of a control valve i.e. Force, Pressure, displacement, flow when the valve is forced to vary according to a sinusoidal function of time. It is hoped that by this study a better understanding will be gained of chattering valves.
(g) Apparatus was built. Considerable data gathered. Result not entirely conclusive but very promising.
(h) "Transient Forces on Hydraulic Seating Type Valves" by Murray Tuft, Thesis (S.M.) Dept. of Mechanical Engineering, Mass. Inst. of Tech., Sept. 1961.

(4490) COOLING OF HIGH-PERFORMANCE ELECTROMAGNETS.

(b) National Magnet Laboratory.
(c) Prof. W. M. Rohsenow, Room 1-212, M.I.T., Cambridge 39, Mass.
(d) Experimental; basic research. To be used for theses.
(e) The method of predicting heat transfer associated with high velocity subcooled liquid with boiling at the tube wall surface is being investigated. During the past year this project has shown how superposition of boiling and forced convection effects combine to predict heat transfer rates. It also has suggested and verified a theory for the heat transfer conditions necessary for initial nucleation--the conditions for beginning boiling. In addition, it has gathered data showing that the burnout heat flux increases as the tube diameter decreases, a result which was not expected a priori. Currently

this project is extending the investigation of prediction of burnout heat fluxes into the higher quality regions.

(h) "Forced-Convection Surface-Boiling Heat Transfer and Burnout in Tubes of Small Diameter" by A. E. Bergles and W. M. Rohsenow, Technical Report No. 8767-21, Engineering Projects Lab., M.I.T., May 1962.

(4491) THERMODYNAMIC PROPERTIES OF COMPRESSED LIQUID WATER.

(b) Mass. Inst. of Tech. Mechanical Engineering Department Research.
(c) Prof. Joseph H. Keenan, Mass. Inst. of Tech., Room 1-208, Cambridge 39, Mass.
(d) Analytical study of experimental data on water at subcritical temperatures. One master's candidate now doing a thesis.
(e) The purpose is to revise and extend the data on liquid water in "Thermodynamic Properties of Steam" by Keenan and Keyes.
(g) An accurate study of the region of maximum density was completed as a doctoral thesis about four years ago. A tentative study of temperatures from 0 to 320 degrees C was made in 1962.

(4492) PROPULSION DUE TO OSCILLATORY FIN MOTION.

(b) Thesis research for doctoral degree.
(c) Prof. A. H. Shapiro, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental and theoretical.
(e) Investigate shape and propulsion force for a flexible fin oscillating in a stream of fluid.

(4493) CAPILLARY TWO-PHASE FLOW.

(b) National Magnet Laboratory.
(c) Mr. P. Griffith, Mech. Engineering Dept., Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Determine density pressure drop and flow regime boundaries in capillary two-phase flow.
(e) The low velocity flow regime when surface forces exceed gravitational forces has been investigated.
(f) Almost completed.
(g) Pressure drop, density and flow regimes boundaries have been determined.

(4494) TWO-PHASE FLOW REGIME BOUNDARIES.

(b) Office of Naval Research, Dept. of the Navy.
(c) Mr. P. Griffith, Mech. Engineering Dept., Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Determine the limits on the slug flow, flow regime as the velocity is increased.
(e) Experimental and analytical work is proceeding using a two-phase flow--flow regime detector.

(4495) STABILITY OF AXIAL MOTIONS IN A ROTATING FLUID.

(b) Laboratory project.
(c) Mr. Joseph L. Smith, Jr., Dept. of Mech. Engineering, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) An experimental study for Master's Thesis.
(e) An investigation to determine the origin and nature of the unusual instabilities which occur when a column of fluid flows axially through a cylinder of rotating fluid.

(4496) THE FORMATION OF BUBBLES IN A FLUIDIZED BED.

(b) Laboratory project.
(c) Mr. Joseph L. Smith, Jr., Dept. of Mech. Engineering, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) An experimental and analytical investigation.
(e) The purpose is to understand the origin of bubbles within a uniformly fluidized bed (as distinguished from bubbles formed at the bed inlet).
(f) Completed.
(g) The stability of small perturbations in the bed void fraction was predicted analytically and bubbles within the bed were observed to originate from the growth of such small perturbations.

(4497) LOCAL VELOCITY MEASUREMENT IN AN INCOMPRESSIBLE MHD FLOW.

(b) WASD OF WADD.
(c) Mr. Douglas A. East, Room 3-208, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental; applied research, master's and doctor's theses.
(e) The work is a study of the behavior of three types of probes to measure local fluid velocity in liquid metal MHD flows: the Pitot tube, a miniature electromagnetic flowmeter and an aerofoil used as a two-dimensional Pitot tube
(h) "Electromagnetic Fluid Velocity Measurement," by B. G. Brown; thesis for S.B. degree, Mechanical Engineering, May 1962. (Request for photo copy should be addressed to: Librarian, Engineering Library, Mass. Inst. of Tech., Cambridge 39, Mass.).

(4498) USE OF ELECTROCHEMILUMINESCENCE FOR VISUALIZING FLOW FIELDS.

(b) Laboratory project.
(c) Mr. George S. Springer, Room 3-264, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental investigation; applied research.
(e) By use of an electrochemical process a bright glow is generated on the surface of the body, displaying the flow at the boundary layer without disturbing it.
The light intensity distribution, controlled by mass transfer, indicates the heat transfer on the surface of the body.

(4163) STABILITY OF LAMINAR FLOWS.

(b) National Science Foundation - (1960-61), Ford Foundation - (1961-present).
(c) Prof. Edward F. Kurtz, Jr. Room 3-356, M.I.T. Cambridge, Massachusetts
(d) Theoretical (experimental work planned for the future); basic research.
(e) Digital computer programs have been written for obtaining solutions for the Orr-Sommerfeld equation, the equation governing the disturbance-amplitude distribution in plane parallel laminar flows. A study of the stability of such flows over rigid surfaces has been completed. The stability of such flows over flexible boundaries is presently being studied.
(g) The stability of the Blasius flow over a rigid flat plate has been treated, and the results are in agreement with theoretical and experimental results available. The stability of the free-convection boundary layer has also been treated and has been found to be stable for sufficiently low Reynolds numbers. These results are in agreement with existing experimental data.
(h) "Computer-aided Analysis of Hydrodynamic Stability," by E. F. Kurtz, Jr. and S. H. Crandall, Journal of Math. and Physics. To be published.

UNIVERSITY OF MASSACHUSETTS, School of Engineering.

(2561) HYDROLOGY STUDIES IN WESTERN MASSACHUSETTS.

(b) Cooperative with the U.S. Soil Conservation Service, U. S. Geological Survey, and Mass. Water Resources Commission.
(c) Prof. George R. Higgins, Engineering Research Institute, Univ. of Mass., Amherst, Mass.
(d) Experimental-field and laboratory; for design of watershed yield, flood peak reduction and general information.
(e) Mass curve studies for reservoir and watershed yield have been done for nearly all the gaged streams in Massachusetts. Investigations to determine factors that affect base flow are being conducted. These include studies of soil types, drainage density, surface cover, and others deemed

pertinent. The purpose of the study is to determine general information for optimum use of water resources of the state. Particular emphasis on recreational aspects and low flow characteristics is presently being considered.

(h) Progress reports were submitted to the University Research Council in 1959 and 1960. A report for the Massachusetts Water Resources Commission is currently being prepared.

(3766) AN EXPERIMENTAL STUDY OF THE STABILITY OF STANDING (TRAPPED RING) VORTICES IN TWO-DIMENSIONAL INCOMPRESSIBLE FLOW.

(b) Laboratory project.
(c) Dr. Charles E. Carver, Jr., Professor of Civil Engineering, Dept. of Civil Engrg., Univ. of Mass., Amherst, Mass.
(d) Experimental; basic research.
(e) Using a Hele-Shaw table, a vortex is formed in a cusp and the tendency of the vortex to remain in the cusp is studied for various free stream velocities past the cusp as well as for various suction rates applied within the cusp in accordance with a theory of Ringleb.
(f) Inactive.
(g) Using dye, experimental streamlines and stagnation points agreed quite well with theory with and without suction. A small propeller was required to maintain the vortex within the cusp due to the overpowering viscous effect; hence vortex stability could not be studied.
(h) Master's thesis by H. Wang in preparation.

(4165) EXPERIMENTAL INVESTIGATION OF TWO-PHASE FLOW.

(b) Laboratory project.
(c) Senior student honors project, Dr. E. E. Lindsey supervisor, Associate Dean of Engrg., University of Massachusetts, Amherst, Mass.
(d) Experimental, basic research.
(e) Effect of surface tension of pressure drop and slip for two-phase flow; variation in phase ratios along a pipe.

(4166) AGITATION CHARACTERISTICS IN LIQUID-LIQUID SYSTEMS.

(b) National Science Foundation; University of Massachusetts Research Council.
(c) Associate Dean E. E. Lindsey, Engineering Research Institute, University of Mass., Amherst, Massachusetts.
(d) Experimental; basic research for master's thesis.
(e) Two immiscible or partly miscible liquids are used. Dispersions are produced in a dynamometer agitator and particle sizes of the sampled dispersion are measured by a light scattering technique. One thesis was concerned with developing the technique and study in geometrically similar, baffled tanks, another thesis with transient change in drop sizes at the start of agitation. Current project is to study variations in geometry. Work is starting on development of light-scattering probe to measure particle size directly in the mixing tank.
(g) Primary peaks in the drop size distribution occurred at 1 to 3 microns, secondary peaks at about 30 microns. Drop size distribution is essentially identical in geometrically similar vessels of different size of equal power/volume. There is a slight decrease in size with increased agitator speed. Comparison of two liquid systems indicates drop size decreases with increasing viscosity. Steady state drop size distribution occurred in 30 to 60 minutes.
(h) "An Approach to Characterizing Agitation by Dispersion Particle Size," by D. M. Sullivan and E. E. Lindsey, Industrial and Engineering Chemistry, Fundamentals Edition, 1, 87-93 (May 1962).

(4167) PRESSURE DROP ACROSS FITTINGS.

(b) Laboratory project.
(c) Dr. Kenneth D. Cashin, Assoc. Prof. of Chemical Engineering, Dept. of Chemical Engineering, Univ. of Mass., Amherst, Mass.
(d) Experimental; senior student honors project,
(e) Pressure drop is measured for a number of different pipe fittings placed in series and at different spacings; effect of approaching and leaving conditions investigated.
(g) Experiments underway.

(4656) THE EFFECT OF NON-NEWTONIAN FLUID INJECTION ON THE TURBULENT BOUNDARY LAYER OF A FLAT PLATE.

(b) Laboratory project.
(c) Dr. Charles E. Carver, Jr., Prof. of Civil Engrg., Univ. of Mass., Amherst, Mass.
(d) Experimental; basic research.
(e) A non-Newtonian fluid, obtained by mixing guar gum with water, is injected through transverse slots cut in a flat plate into the turbulent boundary layer. The flat plate is immersed in clear water with a free stream velocity U_o. A barium titanate crystal is installed flush with the surface of the plate a few inches downstream of the slot and is used to measure the intensity of turbulence with and without injection of the non-Newtonian fluid.

(4657) THE RESPONSE OF A DENSITY CURRENT TO A SINUSOIDAL PRESSURE PULSE.

(b) Laboratory project.
(c) Dr. Charles E. Carver, Jr., Professor of Civil Engineering, Univ. of Massachusetts, Amherst, Mass.
(d) Experimental; basic research.
(e) A system of oscillatory waves is imposed on the upper layer of a two-layered system consisting of clear and saline water. The response of the interface is observed in terms of the frequency and amplitude of the imposed waves at the free surface. The amplitude of the interfacial wave is seen to increase in accordance with an inviscid theory of Stokes. Conditions under which mixing at the interface occurs are recorded and are to be compared with existing viscous theory for instability at the interface.
(h) Master's thesis by Chao-ho Sung in preparation.

(4658) THE EFFECT OF HEADER GEOMETRY UPON FLUID FLOW CHARACTERISTICS IN NUCLEAR REACTORS AND HEAT EXCHANGERS.

(b) Laboratory project.
(c) Dean George A. Marston, Engineering Research Institute, University of Massachusetts, Amherst, Mass.
(d) Experimental; applied research.
(e) To determine the relationships between such variables as core and tube diameter, tube lattice and spacing, header height, etc., upon the individual flow per tube for a pressure vessel in which fluid is introduced through a single radial line placed at the base of the header.
(f) Inactive.
(h) "The Effects of Geometry on Fluid Flow Characteristics in Nuclear Reactors," by David Creamer, Master's thesis, 1960.

UNIVERSITY OF MICHIGAN, Ship Hydrodynamics Lab.

(4659) TRANSVERSE INERTIA VARIATIONS OF SERIES 60 SHIP HULL FORMS.

(b) Maritime Administration.
(c) Professor R. B. Couch, 450 West Engineering Building, Univ. of Mich., Ann Arbor, Mich.

(d) Experimental; design.
(e) Five ship hulls covering the normal range of fullness, are being designed and their models tested for EHP and SHP. The designs have the same displacement, principal dimensions, and sectional area curves as the Series 60 parents. Their transverse sections of extreme "V" rather than the "U" form of the original parent series.
(g) 3 propeller tests, 4 EHP tests, and 2 SHP tests are complete.

(4660) SCALE EFFECT AND BLOCKAGE EFFECT STUDIES ON BARGE MODELS.

(b) Laboratory project.
(c) Professor R. B. Couch, 450 West Engrg. Building, Univ. of Mich., Ann Arbor, Mich.
(d) Experimental; basic research.
(e) Studies on scale effect and tank blockage effect of full forms.

MISSOURI SCHOOL OF MINES AND METALLURGY, Dept. of Civil Engineering.

(319) WEIR STUDIES.

(b) Laboratory project.
(c) Prof. E. W. Carlton, Civil Engrg. Dept., Missouri School of Mines and Metallurgy, Rolla, Missouri.
(d) Experimental; basic research for master's thesis.
(e) Tests on rectangular weirs were made to determine effect of velocity of approach on the relation between crest depth and critical depth of an imaginary open channel having same dimensions as the weir opening.
(g) Study produced a simple, accurate and quick solution for plotting of M function. Relationship between the M function, and the critical depth is logarithmic. This greatly simplifies determination of critical flow where the critical depth is known or vice versa. A relationship exists between M function of channels of same shape but different dimensions. The velocity of approach does not affect the relationship between physical depth and crest depth.

(3775) VERTICAL WATER JET IMPACTING UPON A STILLING BASIN.

(b) Laboratory project.
(c) Prof. V. A. C. Gevecker, Civil Engineering Department, Missouri School of Mines and Metallurgy, Rolla, Missouri.
(d) Experimental; basic research for master's thesis.
(e) Tests being conducted on the terminal effect of a 3/8 inch water jet on a cylindrical stilling basin to determine side and bottom pressures, velocities and energy dissipated.

(4169) INVESTIGATION OF VERTICAL INTERNAL SPILLWAYS.

(b) Laboratory project.
(c) Prof. C. D. Muir, Assoc. Prof. of Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Missouri.
(d) Experimental; basic research for master's thesis.
(e) A scale model rockfill dam containing a vertical internal spillway was studied to determine factors affecting stage-discharge relationships.
(g) A correlation was found to exist between discharge through the dam and height of spillway, rock size, and head.
(h) "Investigation of Vertical Internal Spillways," by Paul R. Munger, Master's Thesis, Missouri School of Mines, 1961. (Available on loan).

(4661) A COMPUTER STUDY OF BACKWATER COMPUTATIONS.

(b) Laboratory project.
(c) Prof. C. D. Muir, Associate Professor of Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Missouri.
(d) Experimental; basic research for master's thesis.
(e) The effect of some approximations used in backwater calculations on the resulting surface profile were studied by use of a digital computer. Also, several methods of backwater computations were compared.
(g) The results of this study indicated that the use of approximations is feasible for curves above critical depth but are dependent on flow regime.
(h) "A Comparison of Backwater Profile Computations," by A. C. H. Young, Master's Thesis, Missouri School of Mines, 1962. (Available on loan).

(4662) HYDROLOGY OF SMALL MISSOURI WATERSHEDS.

(b) Laboratory project.
(c) Prof. C. D. Muir, Associate Professor of Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Missouri.
(d) Experimental; basic research for master's thesis.
(e) This study was for the purpose of correlating basin characteristics and mean annual flood for Missouri watersheds having a drainage area of less than ten square miles.
(f) Suspended.
(g) It was found that mean annual floods could be predicted and correlated to known data from forty-five Missouri watersheds by use of a shape factor (AL^2) and basin index ($AL^2S^{1/2}$).
(h) "A Study of Small Watersheds Within the State of Missouri," by Terrence E. Harbaugh, Master's Thesis, Missouri School of Mines, 1962. (Available on loan).

(4663) FLOW THROUGH A ROCKFILL DAM.

(b) Laboratory project.
(c) Prof. P. R. Munger, Assistant Professor of Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Missouri.
(d) Experimental; basic research for master's thesis.
(e) Model studies are being conducted on a rockfill dam with a sloping internal spillway to determine the characteristics of flow through such dams.
(g) Preliminary results indicate a relation exists between flow rate, head, core height and rock size.
(h) "Investigation of Flow Rates Through a Rockfill Dam," by J. R. Bayless, Master's thesis, Missouri School of Mines and Metallurgy, 1962.

MONTANA STATE COLLEGE, Agricultural Experiment Station.

(4664) EFFICIENT APPLICATION OF IRRIGATION WATER BY SURFACE FLOODING METHODS.

(b) Laboratory project.
(c) Prof. C. C. Bowman, Head, Agricultural Engineering Dept. Montana State College, Bozeman, Montana.
(d) This is a study to develop design criteria for more efficient application of irrigation water by flooding method. This is basic research at the present time, but will be applied research immediately upon completion of the first phase.

UNIVERSITY OF NEBRASKA, Hydrodynamics Laboratory, Dept. of Engineering Mechanics.

(3776) VORTEX FORMATION AND DRAG IN UNSTEADY FLOW PAST BLUFF BODIES.

(b) National Science Foundation.
(c) Prof. T. Sarpkaya, Dept. of Engineering Mechanics, Bancroft Hall 219, University of Nebraska, Lincoln 8, Nebraska.
(d) Experimental and theoretical study of drag and inertia in unsteady flow. Basic research for master's and Ph.D. thesis.
(e) Primary objects of the research are: To determine the growth and motion of vortices behind two dimensional bluff bodies subjected to unidirectional unsteady flow; to determine the various components of corresponding resistance; and to correlate a particular vortex configuration with the instantaneous resistance.
(g) The forces predicted on the basis of the moving and growing vortices are comparable in magnitude to forces which are observed. Resistance to unsteady flow is not to be thought of as a mere juxtaposition of resistances to steady flow augmented by an inertial force.
(h) "Lift, Drag, and Added Mass Coefficients for a Circular Cylinder Immersed in a Time Dependent Fluid Flow," by T. Sarpkaya, J. Appl. Mechs., ASME Paper No. 62-WA-61, 1962 Winter Annual Meeting of ASME.
"Vortex Formation and Resistance in Unsteady Flow," by T. Sarpkaya and C. J. Garrison, J. Appl. Mechs. ASME Paper No. 62-WA-62, 1962 Winter Annual Meeting of ASME.

(3780) MECHANISM OF TURBULENCE GENERATION IN PULSATING VISCOUS FLOW.

(b) Office of Ordnance Research, U. S. Dept of the Army, (Durham).
(c) Dr. T. Sarpkaya, Bancroft Hall 219, Univ. of Nebraska, Lincoln 8, Nebr.
(d) Experimental and theoretical basic research for master's and Ph.D. thesis.
(e) To understand the mechanism of turbulence generation in pulsating viscous flow superposed on a steady and initially laminar flow and to evaluate the resistance to fluid motion.
(g) Transition to turbulence takes place at much lower Reynolds numbers. When the amplitude ratio of the pulsating pressure gradient to steady one is not large, the maximum dissipation occurs at the wall. However, with the increase of the amplitude ratio the position of the maximum dissipation moves into the flowing fluid and its distance varies with time.

(3782) INDUCED MASS OF CONFINED FLUIDS.

(b) Laboratory project.
(c) Prof. T. Sarpkaya, Bancroft Hall 219, University of Nebraska, Lincoln 8, Nebr.
(d) Theoretical basic research; for master's thesis.
(e) When a confined fluid is suddenly accelerated through an opening, initial average acceleration is determined by the induced mass of the fluid system. Since the equation of the elastic wave propagagion cannot be solved for the boundary conditions imposed, solution of Laplace's equation is joined to that obtained from the wave equation through the application of the Schwartz-Christoffel transformation and electrical analogy.
(f) Completed.
(g) The effect of induced mass is most pronounced particularly for short conduits. Average times necessary for the reflection of an elastic wave from a given reservoir is determined.
(h) "Unsteady Flow of Fluids in Closed Systems," T. Sarpkaya, ASCE, J. of EM Div. EM3, Paper No. 3154, June 1962. (See discussion and closure in subsequent issues of the same journal.)

(4170) VIRTUAL MASS OF PARTLY SUBMERGED BODIES.

(b) Laboratory project.
(c) Prof. T. Sarpkaya, Bancroft Hall 219, Univ. of Nebraska, Lincoln 8, Nebr.
(d) Experimental and theoretical basic research.
(e) Study of the added mass of various objects partly submerged in a liquid.

(4486) ANNULAR TWO-PHASE FLOW.

(b) Laboratory project.
(c) Dr. T. Sarpkaya, University of Nebraska, Lincoln 8, Nebr.
(d) Experimental and theoretical for Ph.D.Thesis.
(e) Amplitude and frequencies of interfacial waves are studied. The interfacial structure influences the flow of gas in a manner similar to that of a rough wall pipe.
(g) The mean liquid film thickness increases with increase in flow rate at constant gas velocities; it decreases with an increase in gas velocity at constant liquid rate. Pressure gradient in the gas stream exceeds that for a smooth pipe at the same Reynolds number (gas) for gas velocities greater than some minimum value.

(4487) POTENTIAL FLOWS WITH UNISOTROPIC SINGULARITIES.

(b) Laboratory project.
(c) Dr. T. Sarpkaya, University of Nebraska, Lincoln 8, Nebr.
(d) Theoretical and for master's thesis.
(e) Mathematical singularities used have unisotropic characteristics. Potential flows resulting from the combinations of such singularities are studied.

(4488) A HEART PUMP THROUGH FLUID AMPLIFICATION.

(b) U. S. Public Health Service.
(c) Dr. T. Sarpkaya, University of Nebraska, Lincoln 8, Nebr.
(d) Theoretical and experimental applied research for master's thesis.
(e) To develop a total heart pump through the use of fluid-jet amplifiers and test it on certain animals.
(g) A pump has been built and is operating satisfactorily.

NEWPORT NEWS SHIPBUILDING AND DRY DOCK COMPANY.

Inquiries concerning the following projects should be addressed to Mr. C. H. Hancock, Hydraulic Lab., Newport News Shipbuilding and Dry Dock Company, Newport News, Virginia.

(123) HYDRAULIC TURBINE TESTS.

(b) Laboratory project.
(d) Experimental; for design data.
(e) Scale model turbines, using either Francis or propeller type runners, are tested for power and efficiency at various speeds.

(124) METER CALIBRATION TESTS.

(b) Laboratory project.
(d) Experimental.
(e) To establish calibration curve for determining correction for various rates of flow. Meters are tested at various rates of flow by weighing tank method. Time is recorded electronically by decade counters.

(901) SHIP MODEL RESISTANCE TESTS.

(b) Laboratory project.
(d) Experimental; for design data.
(e) Scale ship models are towed to determine effective horsepower, bare hull, required by the ship. Because of their small size, several models may be towed in a short period of time thus allowing much preliminary work to be done on the choice of lines. Final lines are checked by David Taylor Model Basin. To eliminate a large portion of this preliminary testing, a schedule of systematic models was arranged in which the beam-draft

ratio, the displacement-length ratio, and the prismatic coefficient are varied over a wide range. Towing this set of models is continuing and when completed will provide design data for a standard offset series covering a wide range.

(1132) HYDRAULIC PUMP TESTS.

(b) Laboratory project.
(d) Experimental; for design data.
(e) Scale model pumps are tested at constant speeds for head developed, power consumption, and efficiency at various rates of discharge. Cavitation tests are sometimes conducted by lowering the suction head to a point where the developed head and efficiency break down. Blade moments are measured by installing electric resistance strain gages on the pump blade stem. Shear strains are transmitted from the pump via a slip ring assembly.

(1133) CAVITATION TESTS OF HYDRAULIC TURBINE MODELS.

(b) Laboratory project.
(d) Experimental; for design data.
(e) Scale model turbines are tested on cavitation stand to determine sigma at which cavitation starts. Tests were run to determine runaway speeds at low sigma values.

(2582) AIR TESTS ON HYDRAULIC TURBINE MODEL.

(b) Laboratory project.
(d) Experimental; for design data.
(e) Plexiglas hydraulic turbine model is tested with air. Smoke and tufts are used in the flow visualization studies. Velocity and pressure distribution studies are made using a sensitive differential manometer. The gate moments obtained from the pressure distribution will be checked with a strain gage dynamometer.

(3111) PUMP-TURBINE TESTS.

(b) Laboratory project.
(d) Experimental; for design data.
(e) Pump-turbine models are tested either as a pump or turbine on this test stand. Cavitation as well as performance tests on pump, turbine or pump-turbine models can be made on this facility. Provision has been made to perform vane moment tests on adjustable blade turbine runners at the same time as performance tests.

(3783) AIR CONTENT CAVITATION OF TURBINES.

(b) Laboratory project.
(d) Experimental; applied research.
(e) Study of cavitation of hydraulic turbines as affected by the air quantity contained in the tunnel.

(3784) PITOT TUBE CALIBRATION.

(b) Laboratory project.
(d) Experimental.
(e) Calibration of a small 3-hole cylindrical search tube to determine accuracy as affected by blockage, pipe wall, angularity, discharge and fabrication.

(3785) VELOCITY PROFILE IN TURBINE MODEL.

(b) Laboratory project.
(d) Experimental; applied research and development.
(e) Determination of velocity distribution through a two-dimensional turbine affected by entrance angle, hub configuration, and distributor height.

(3786) FLOW STRAIGHTENERS.

(b) Laboratory project.
(d) Experimental and theoretical; applied research.
(e) Testing of different shapes for the straightening of flow in short pipes.

(3787) ADDED MASS OF TURBINES.

(b) Laboratory project.
(d) Experimental and theoretical; applied research.
(e) Determination of the effects of added mass of a propeller on the efficiency and blade moment step-up formulas from model to prototype.

(4665) SOUND LEVEL TESTS ON HYDRAULIC MACHINERY.

(b) Laboratory project.
(d) Experimental; for design data.
(e) Hydrophones are placed in the discharge of pump and turbine models under test in an effort to obtain a fresh look at hydromachinery testing. Sound spectrum levels are plotted against several parameters in an effort to obtain correlation between the characteristic shape of the sound level curves and the characteristic shape of power and efficiency curves.

(4666) INVESTIGATION OF EFFECTS OF HYDRAULIC TURBINE OPERATING CONDITIONS ON POWER SURGES.

(b) Laboratory project.
(d) Experimental and theoretical; applied research.
(e) A plexiglas hydraulic turbine model is tested to predict power swing rate and magnitude in hydraulic turbine installations as caused by draft tube vortex precession. Air is used as a test medium and ammonium chloride smoke for flow visualization. Velocity and pressure distribution studies are made in the draft tube using a 3-hole cylindrical search tube and sensitive two-fluid manometer.

NEW YORK UNIVERSITY, Department of Chemical Engrg.

(2583) EFFECT OF PARTICLE CONCENTRATION ON PRESSURE DROP AND SEDIMENTATION VELOCITY IN DILUTE BEDS OF PARTICLES.

(b) Grants from Texas Company and American Chemical Society; laboratory project.
(c) Professor J. Happel, Dept. of Chemical Engineering, New York University, Univ. Heights, New York, 53, New York.
(d) Theoretical; basic research for doctoral thesis.
(e) The slow translational motion of dilute beds of particles settling through viscous fluids subjected to the influence of cylindrical boundaries is being studied. This will ultimately enable a theoretical prediction of the effect of particle concentration on pressure drop and sedimentation velocity in beds of particles.

(3474) HEAT TRANSFER AND CHEMICAL REACTION RELATIVE TO BEDS OF SPHERICAL PARTICLES.

(b) Laboratory project.
(c) Prof. J. Happel, Dept. of Chemical Engineering, New York University, University Heights, New York, 53, New York.
(d) Theoretical; basic research for doctoral thesis.
(e) Analytical solution is developed by assuming a model where fluid is flowing between two concentric spheres which are maintained at different temperatures. The partial differential equations applicable are solved by assuming power series solutions in temperature and in spherical co-ordinate θ. The results will be compared to existing data on heat and mass transfer in packed and fluidized

beds.

(3788) BOUNDARY LAYER MASS TRANSFER WITH HETEROGENEOUS CATALYSIS.

(b) Grants from American Chemical Society and National Science Foundation; Laboratory project.
(c) Prof. J. Happel, Dept. of Chemical Engrg., New York University, University Heights, New York 53, New York.
(d) Theoretical; basic research for doctoral thesis.
(e) This work includes a study of the rate of gas-solid catalytic reactions in multi-particle systems. Using boundary layer theory in conjunction with a model consisting of a solid sphere inside a free-surface spherical cell, the relationship between rates of diffusion and rates of surface-catalyzed reactions is developed.
(f) Completed.
(g) Theoretical results for chemically dilute systems correlate existing mass transfer data reasonably well. It was found that molar convective transport to or from the surface affects the mass transfer rate and may give appreciably different results than those obtained from film theory or the dilute solution equation. A simple criterion is set up to determine when the dilute solution correlations can be used.
(h) "Boundary Layer Mass Transport with Heterogeneous Catalysis," by C. L. Kusik and John Happel, I & EC Fundamentals, Vol. 1, No. 3, p. 163-172, August, 1962.

(4172) PRESSURE LOSS IN ORIFICE BAFFLED HEAT EXCHANGERS.

(b) Laboratory project.
(c) Prof. Robert O. Parker, Department of Chemical Engineering, New York University, New York 53, New York.
(d) Experimental; basic research for master's degree.
(e) Project to determine pressure loss on the shell side of orifice baffled, shell and tube heat exchangers. Three exchangers are used in this experiment. All are exactly alike except for the fact that one has no clearance between the tube and tube hole, one has no clearance between the baffle and the ID of shell, and one has clearances at both points. This study will determine the effect of each flow stream, and the effect of their interaction.

(4173) DETERMINATION OF THE STOKE'S DRAG ON A PARTICLE FALLING IN AXISYMMETRIC FLOW IN A BOUNDED MEDIUM.

(b) Laboratory project.
(c) Prof. H. Brenner, Dept. of Chemical Engrg., New York University, New York 53, New York.
(d) Theoretical; basic research for master's degree.
(e) The purpose is to determine the effect of the walls of a container on the Stoke's drag of a particle falling in axisymmetric flow in a fluid. The shape of the container is beaker-like.

(4174) THE PRESSURE DIFFERENTIAL DUE TO A PARTICLE SETTLING IN A VISCOUS FLUID.

(b) Laboratory project.
(c) Prof. H. Brenner, Dept. of Chemical Engrg., New York University, New York 53, New York.
(d) Experimental; basic research for master's degree.
(e) Experiments are designed to verify certain theoretical relationships pertaining to the dynamics of a particle in a viscous fluid. Pressure differentials due to spheres settling at low Reynolds numbers in a cylinder containing a viscous fluid will be measured and correlated with particle drag.

NORTH CAROLINA STATE COLLEGE OF AGRICULTURE AND ENGINEERING OF THE UNIVERSITY OF NORTH CAROLINA, Department of Engineering Research.

(4667) UNSTEADY FREE SURFACE FLOWS.

(b) Laboratory project.
(c) Dr. M. Amein, Department of Civil Engrg., North Carolina State College, Raleigh, N. C.
(d) Experimental and theoretical; basic research.
(e) An experimental investigation on translatory motions with irregular profiles, on bore formations and on the propagation of unsteady motions through non-uniform flows is made in a glass-walled channel. The channel is 14 ft. long, 2 ft. wide with adjustable variable slope. The experimental results are analyzed by the nonlinear shallow water theory. The objective of the project is to seek improvements to the prevalent techniques for the computation of unsteady flows and to provide experimental data for further theoretical investigations.

(4668) STUDY OF VORTEX MOTION IN WAKE FLOWS.

(b) Laboratory project.
(c) Prof. Paul Harrawood, Department of Civil Engineering, North Carolina State College, Raleigh, North Carolina.
(d) Experimental and theoretical; doctoral thesis.
(e) An investigation of the eddy motions present in the wakes of bluff bodies in a streaming fluid, with particular attention given to the periodicity of eddy motions and to vortex strength.

(4669) AN INVESTIGATION OF THE STABILITY OF FLOW IN CIRCULAR SEDIMENTATION BASINS.

(b) Laboratory project.
(c) Professor Charles Smallwood, Jr., Dept. of Civil Engrg., North Carolina State College, Raleigh, North Carolina.
(d) Experimental; master's thesis.
(e) A semi-circular center-fed model basin was built with a transparent back for visual examination of the flow pattern. A uranine dye tracer was used to determine flow through waves for the basin. Stability was measured by the reproducibility of the time-effluent dye concentration waves. In an attempt to stabilize the flow radial baffles were placed in the basin to reduce the angle of divergence and to provide solid boundaries in the divergent flow.
(f) Completed.
(g) The baffles had no detectable effect. The flow pattern was characterized by a short-circuit along the tank bottom and a back-flow in the upper portion of the tank.

NORTH DAKOTA STATE UNIVERSITY, Agricultural Engrg. Dept.

(3121) PREFABRICATED DITCH LININGS.

(b) Laboratory project.
(c) Prof. Harold Holmen, Assistant Agricultural Engineer, Agricultural Engineering Dept., North Dakota State University, Fargo, N. Dak.
(d) Experimental; applied research.
(e) The work involves field testing to check the durability of 4 to 10 mil black polyethylene linings that have been in place over 2 years in farm irrigation ditches.
(g) Six and ten mil buried linings were in excellent condition after two years of service.

(3475) SURFACE DRAINAGE.

(b) Laboratory project.
(c) Prof. Harold Holmen, Assistant Agricultural Engineer, Agricultural Engineering Dept.,

North Dakota State University, Fargo, N. Dak.
(d) Field investigation; applied research.
(e) Field ditches were constructed on college farm to study improvements in drainage conditions. Snow accumulation in open drains was studied again.
(g) An abnormally wet season prevented any work on field ditch construction until the last part of August. Spring thaw in surface drains was at least 1 month later than in past years, but snow accumulation pattern was about the same as the previous year.

(4175) WATER INTAKE RATES AND PHYSIOCHEMICAL PROPERTIES OF IRRIGABLE SOILS.

(b) Joint laboratory project between Department of Agricultural Engineering and Department of Soils.
(c) Prof. Harold Holmen, Assistant Agricultural Engineer, Agricultural Engineering Dept., North Dakota State University, Fargo, N. Dak.
(d) Experimental, basic research, and Master's thesis.
(e) Intake rates of irrigated soils were measured by the inflow-outflow method, the double ring infiltrometer, and by the Purdue sprinkling infiltrometer. The change in intake rates caused by land leveling, tillage practices, seasonal change, and compaction from farm machinery is being studied. The physical and chemical properties and the moisture profile of the soil are being measured before, and after irrigations.
(g) The intake rate decreased slightly during the irrigation season. A lower rate was obtained with the double ring method than with the inflow-outflow method when measuring intake rates on three year old alfalfa plots.
(h) "Water infiltration rates of an Irrigated Soil," Jerome M. Schaack, unpublished MS Thesis, North Dakota State University, March 1962.

NORTHWESTERN UNIVERSITY, The Technological Institute.

(3476) FLOOD WAVE ROUTING.

(b) Northwestern Technological Institute.
(c) Prof. W. S. Hamilton, Dept. of Civil Engrg., Northwestern University, Evanston, Ill.
(d) Theoretical and analytical for doctoral and masters theses.
(e) The purpose is to calculate the movement of flood waves in prismatic and natural channels. Finite difference equations based on (a) method of characteristics and (b) basic equations of momentum and continuity are to be programmed separately for solution on a digital computer.
(g) It has been found best to use difference equations along characteristics near the upstream and downstream boundaries and a backward difference method based directly on momentum and continuity equations and a rectangular grid for the region not near the boundaries. Program found to give unstable results.
(h) Theses in preparation.

(3792) RESPONSE OF A BOILING CHANNEL TO INPUT FLUCTUATIONS.

(b) Laboratory project.
(c) Prof. S. G. Bankoff, The Technological Inst., Northwestern University, Evanston, Illinois.
(d) Basic theoretical research; doctoral thesis.
(e) An analog computer study of the response of a boiling channel with saturated feed under natural and forced circulation conditions to power and flow input fluctuations. The basic momentum mass and energy balances are differenced in the height variable. The only assumption is the applicability of the variable density single fluid model.
(f) Completed.
(g) A frequency notch appears in the exit void fraction and the power-exit void fraction transfer function with four or more nodes, and is not present with fewer nodes. It is significant because all previous studies have assumed axial lumping of the boiling section. The propagation velocity of a density disturbance based upon the notch frequency, is intermediate between the gas and mixture average velocities.
(h) Paper to be submitted to International Journal of Heat and Mass Transfer.

(3793) TWO-PHASE FLOW STRUCTURE.

(b) Argonne National Laboratory.
(c) S. G. Bankoff, Chemical Engrg. Dept., Northwestern Tech. Inst.
(d) Experimental basic research, doctoral and master's theses.
(e) Development of resistivity probe for determination of local void fraction, local bubble frequency, and local bubble size distributions in mercury-nitrogen flow, and also an impact probe for local liquid velocity measurement. Determination of flow structure in mercury-nitrogen flow in vertical one inch pipe. Extension of the probe to air-water flow, and determination of air-water flow structure.
(f) Mercury-nitrogen work completed. Air-water work active.
(g) Resolution of resistivity probe allows individual bubbles 0.1" diameter to be observed in mercury-nitrogen flow. Extensive void fraction and velocity profiles obtained. Slug length distributions, bubble frequency spatial distributions, also obtained. Air-water probe looks quite promising.
(h) Argonne Nat. Lab. report forthcoming. Ph.D. thesis, L. G. Neal, Chemical Engineering Department, Northwestern University.

(3799) FORCES ON SUBMERGED BODIES IN UNSTEADY MOTION.

(b) Northwestern Technological Institute.
(c) Professor W. S. Hamilton, Dept. of Civil Engineering, Northwestern University, Evanston, Illinois.
(d) Theoretical and experimental; for doctoral thesis.
(e) The purpose is to evaluate forces acting on accelerating submerged bodies in a fluid and apply the results to the motion of the snow and dust particles in the atmospheric boundary layer. The theoretical investigations included the determination of the forces acting on arbitrarily accelerating plates. Experiments have been completed on a sphere oscillating in oil.
(f) First phase completed. Second phase on motion that is not harmonic being analyzed.
(g) The forces acting on an arbitrarily accelerating infinitely long plates have been determined theoretically. Data on simple harmonic motion up to a Reynolds number of 60 correlated in terms of velocity, acceleration and history coefficients.
(h) Ph.D. Thesis completed Aug. 1962; paper under preparation.

(4670) THE EFFECT OF SURFACE ACTIVE AGENTS ON THE STABILITY OF FALLING LIQUID FILMS.

(b) Northwestern University.
(c) Mr. Stephen Whitaker, Chemical Engrg. Dept., Northwestern Tech. Inst., Northwestern Univ., Evanston, Illinois.
(d) Experimental.
(e) Small amounts of surface active agents are often used to suppress the ripples or waves that tend to form on falling liquid films. The presence of a surface active agent at a gas-liquid surface gives rise to three phenomena: (a) lowered surface tension, (b) increased surface viscosity, (c) the possibility of surface tension gradients.

An experimental study is being undertaken in order to determine the role of these phenomena in stabilizing falling liquid films.

(4671) MAGNETOVISCOUS FLUID FLOW.

(b) Laboratory project.
(c) Mr. Thomas P. Anderson, Gas Dynamics Lab., Northwestern University, Evanston, Illinois.
(d) Experimental and theoretical basic research.
(e) A study of the flow of a class of suspensions that exhibit marked changes in effective viscosity under the influence of applied magnetic fields.
(g) Preliminary experiments have been conducted on a suspension of micron sized iron particles in an oil base. Using a cylindrical geometry and an applied field of approximately 500 amp turns changes in viscosity of more than a factor 2 have been measured. In addition it appears that the fluid is non-Newtonian in character and the effect is influenced considerably by the magnitude of the velocity.

UNIVERSITY OF NOTRE DAME, Department of Civil Engrg.

(3124) HISTORY OF HYDROMETRY IN THE UNITED STATES.

(c) Dr. S. Kolupaila, Dept. of Civil Engineering, University of Notre Dame, Notre Dame, Ind.
(g) Part 1, Early history of hydrometry, was published in 1960. Part II, Modern history of hydrometry in the USA, is being prepared for publication.

(3802) COMPONENT RUNNER FOR THE CURRENT METER.

(g) Recent success in application for turbine testing is evaluated.
(h) A paper on measurement of angular and pulsating flow presented at the Conference on Hydraulics and Fluid Mechanics at the University of Western Australia, Nedlands, by Dr. S. Kolupaila, Dec. 11, 1962, is to be published in the Proceedings of the Conference.

(3803) ANALOG SIMULATION OF DEFORMABLE HYDRODYNAMIC BOUNDARIES.

(b) National Science Foundation.
(c) Dr. A. G. Strandhagen, Dept. of Engineering Science, University of Notre Dame, Notre Dame, Indiana.
(d) Theoretical and experimental.
(e) Two-dimensional conducting sheet is used to simulate the flow past submerged bodies. Both irrotational and cavity flow are considered.
(g) Analog results are in agreement with several cases of cavitating hydrofoil flow.
(h) Master's thesis completed by J. Sellers.

(4179) RIVER HYDROLOGY, SURVEY AND SELECTED BIBLIOGRAPHY.

(c) Dr. S. Kolupaila, Dept. of Civil Engineering.
(g) Search continues, manuscript is prepared, publication is planned for December 1964.

(4672) THEORY OF THE HYDROMETRIC ROD.

(b) Laboratory project.
(c) Dr. Nobumasa Kasugaya, Prof. of Hydrology, Chuo Univ., Civil Engineering Dept., Tokyo, Japan.
(d) Theoretical investigation, applied research.
(e) Two problems solved under assumption of velocity distribution according to the logarithmic law and n-power parabolic law: (1) Relationship between the measured velocity and the average velocity on a vertical in a river cross-section; (2) angle of inclination of a rod submerged in river.
(g) Work carried out during a visit of Dr. Kasugaya at the University of Notre Dame in cooperation with Dr. S. Kolupaila. More accurate formulas were derived and tables of correction factors prepared.

OHIO STATE UNIVERSITY, Department of Mechanical Engineering.

(4673) A STUDY ON THE RELATIONSHIP OF UPSTREAM FLOW DISTORTION AND ACCURACY OF ORIFICE METERS.

(b) American Gas Association.
(c) Mr. Charles F. Sepsy, 206 West 18th Ave., The Ohio State University, Columbus 10, Ohio.

(4674) STUDY OF UPSTREAM NON-UNIFORMITIES RELATED TO FLUID METER PERFORMANCE.

(b) National Science Foundation.
(c) Mr. Charles F. Sepsy, 206 West 18th Ave., The Ohio State Univ., Columbus 10, Ohio.
(e) To generalize the influence of and define prediction methods to account for effects of upstream non-uniformities on the performance of fluid meters.

(4675) CALIBRATION OF DIFFERENTIAL HEADMETERS.

(b) Engineering Experiment Station, Ohio State University.
(c) Mr. Charles F. Sepsy, 206 West 18th Ave., The Ohio State University, Columbus 10, Ohio.
(e) To provide service in the calibration of orifice meters, venturies and nozzles for industry. Calibration of the meter is accomplished by a volumetric method. The calibrating fluid is water.

OKLAHOMA STATE UNIVERSITY, Agricultural Engineering Department.

(2365) HYDROLOGIC STUDIES ON SMALL GRASS-COVERED WATERSHEDS.

(b) Agricultural Experiment Station cooperative with Agricultural Research Service.
(c) Prof. F. R. Crow, Okla. State Univ., Dept. of Agricultural Engrg., Stillwater, Okla.
(d) Field investigation; applied research.
(e) Measurements are being made to provide hydrologic data on total watershed runoff and peak rates of runoff from three small grass-covered watersheds (17 to 206 acres) in north central Oklahoma. Highway culverts, modified by the addition of weir sills, are being used as runoff measuring devices.
(g) Intensive model tests of culverts equipped with weir sills completed. Ten year data on precipitation and runoff completed.

(2828) THE EFFECTIVENESS OF MONOMOLECULAR FILMS FOR REDUCING EVAPORATION FROM RESERVOIRS.

(b) Oklahoma Agricultural Experiment Station, cooperative with U. S. Bureau of Reclamation.
(c) Prof. F. R. Crow, Oklahoma State Univ., Dept. of Agricultural Engineering, Stillwater, Oklahoma.
(d) Experimental; applied research.
(e) Two paired plastic lined ponds, designed for evaporation research, are being used to study various aspects of evaporation reduction by monomolecular films. Apparatus has been developed for automatic application of hexaoctadecanol slurry. Present research is on the effects of wind on monolayers and development and testing of methods of alleviating adverse effects of wind.
(g) Evaporation reductions of 25 to 40% have been obtained in long duration tests using slurry method of applying films. Curves have been developed relating wind speed and

required film application rate. In current research a system of floating barriers is used to confine the monolayer to reduce frequency of application. Various height/spacing ratios have been tested. The effect of the barriers, with and without monolayer, on evaporation is being studied.

(3804) THE HYDRAULICS OF CONSERVATION CHANNELS.

(b) Agricultural Research Service, U.S. Dept. of Agriculture in cooperation with the Oklahoma Agricultural Experiment Station.
(c) Mr. W. O. Ree, Agr. Research Service, Soil and Water Conservation Research Div. Southern Plains Branch, Stillwater, Okla.
(d) Experimental; applied research.
(e) Vegetation lined waterways of the kind used to convey short duration flood flows from small watersheds are constructed full size on the grounds of an outdoor hydraulic laboratory. Flow tests are made on these experimental channels to determine the protective ability of various grasses and to evaluate the flow friction factors under different conditions of growth. Perennial and annual grasses for the temporary protection of newly constructed earth waterways are both considered in these studies. Temporary liners of various fibers including jute, paper and glass are also tested.
(g) Manning's n values have been determined for various grass species. The physical characteristics of the vegetation and the flow character both influence the flow retardance factor so special design diagrams have been prepared to aid in solving flow problems under these conditions.

(4676) THE HYDRAULICS OF OVERLAND FLOW.

(b) Oklahoma Agricultural Experiment Station cooperative with Agricultural Research Service, U. S. Dept. of Agriculture.
(c) Prof. F. R. Crow, Oklahoma State Univ., Dept. of Agricultural Engineering, Stillwater, Oklahoma.
(d) Experimental; applied research.
(e) A study of the basic relationships involved in the hydraulics of overland flow. Now in its initial phase, the research is being done at the Stillwater outdoor hydraulic lab. Test channels, 96 ft long will be subjected to simulated rainfall of various intensities and droplet sizes. The water surface profile will be studied for transient and equilibrium states for channels surfaced with cement mortar and also for earth channels vegetated with wheat.

OREGON STATE COLLEGE, Hydraulics Laboratory.

(3805) INVESTIGATION OF SUPERCRITICAL FLOW CHANNEL JUNCTIONS.

(b) U. S. Dept. of Commerce, Bureau of Public Roads.
(c) Prof. C. E. Behlke, Dept. of Civil Engrg., Oregon State University, Corvallis, Oregon.
(d) Theoretical and experimental; applied research.
(e) Wave effects resulting from the junction of two supercritical, open channel flows are being studied to determine the magnitude and the location of the wave pile up on the channel walls. Only rectangular channels are presently being considered. Trapezoidal channels will be considered later.
(g) The prediction of wall pile-up.

THE PENNSYLVANIA STATE UNIVERSITY, Ordnance Research Laboratory, College of Engineering and Architecture, University Park, Pennsylvania, Dr. John C. Johnson, Director. Work done under Dr. G. F. Wislicenus, Director of the Garfield Thomas Water Tunnel.

(2832) MEASUREMENT OF FORCES ON A MODEL IN A WATER TUNNEL.

(b) Laboratory project sponsored by the Bureau of Naval Weapons.
(c) Messrs. G. B. Gurney and T. E. Peirce, Ordnance Research Laboratory, University Park, Pennsylvania.
(d) Experimental; developmental.
(e) The problem concerns the measurement of forces on models in a water tunnel over a velocity range up to 80 feet per second, pressure ranges of 3 to 60 pounds per square inch absolute.
(g) Two four component (lift, axial force, pitching and rolling moment) balances for use in water tunnels utilizing strain gaged pre-tensioned flexure beams as the force sensing devices have been in successful operation for four years. A Planar Motion Mechanism capable of imparting pitching and heaving motions to models is now under construction and should be in operation in March of 1963. The balance assoicated with this mechanism will measure all the hydrodynamic stability coefficients required in the equations of motion for a submerged body with four (4) degrees of freedom. These equations include the static, damping and acceleration derivatives. A balance which will measure unsteady forces on propulsors has been developed and successfully tested.
(h) "An Analysis of Force Measurements," by G. B. Gurney, M. S. Thesis, Department of Engineering Mechanics, The Pennsylvania State University, September 1962.

(3143) REDUCTION OF SKIN FRICTION DRAG.

(b) Joint program of investigation with the General Electric Company, the United States Rubber Company and the Northrop Corporation sponsored by the Bureau of Naval Weapons.
(c) Dr. John Lumley and Mr. John McMahon, Ordnance Research Laboratory, University Park, Pennsylvania.
(d) Experimental, basic research; theoretical and applied research.
(e) Investigations into the application of boundary layer control through suction and compliant surfaces for underwater bodies.
(g) A theoretical analysis of the mechanism by which an admissive boundary may reduce the skin friction has been completed. Experimental measurements of boundary layer transition and thickness aft of the transition have been made for a number of flat plates which were covered with a compliant surface.
(h) "Stability of Plane Couette Flow over an Admissive Boundary," by J. L. Lumley and J. F. McMahon, Presented at American Physical Society, November 1962, Norman, Oklahoma. "Some Comments on Drag Reduction," American Rocket Society, J. L. Lumley, ARS Preprint #2642-62.

(3486) TURBULENCE MEASUREMENTS IN WATER.

(b) Laboratory project sponsored by the Bureau of Naval Weapons.
(c) Dr. John Lumley, Ordnance Research Lab., University Park, Pennsylvania.
(d) Experimental.
(e) Using a constant temperature probe, some turbulent flows at high Reynolds numbers will be investigated with particular attention to homogeneous grid-produced turbulence and turbulent dispersion in a shear flow.
(g) Measurements have been taken in a small water tunnel settling section determining the effect of various screens and honeycombs on turbulence.
(h) "The Constant Temperature Hot-Thermistor Anemometer," Symposium on Measurements in Unsteady Flow, ASME Proceedings, May 21-23, 1962, pp. 75-82.

(3487) FLOW DISTORTION FEEDING INTO A PROPELLER.

(b) Laboratory project sponsored by the Bureau of Naval Weapons.
(c) Mr. J. J. Eisenhuth, Ordnance Research Lab., University Park, Pennsylvania.
(d) Theoretical and experimental.
(e) This is a study of the interaction effects between control surfaces and a propeller when the surfaces are located in front of the propeller and feed a distorted flow into it. The primary goal is to determine how effectively the propeller cancels the forces produced by the control surfaces.

(3488) FLOW OVER A BODY OF REVOLUTION WITH STABILIZING SURFACES.

(b) Laboratory project sponsored by the Bureau of Naval Weapons.
(c) Mr. E. J. Rodgers, Ordnance Research Lab., University Park, Pennsylvania.
(d) Theoretical and experimental.
(e) This study is directed toward the understanding of the flow conditions around a body of revolution with stabilizing fins under conditions of pitch and/or yaw. The eventual goal is to be able to predict more precisely the hydrodynamic coefficients of such a body by virtue of a better understanding of the flow conditions.

(3807) INVESTIGATION OF THE CAVITATION CHARACTERISTICS OF A FEW SIMPLE LIQUIDS.

(b) Laboratory project sponsored by NASA.
(c) Dr. J. W. Holl, Ordnance Research Lab., University Park, Pennsylvania.
(d) Experimental, analytical; basic research.
(e) To investigate experimentally the cavitation characteristics of a few simple (as regards to vapor pressure and handling) liquids under conditions occurring in space and aircraft pumping machinery, and analyze the results so that a reliable basis for theory applicable to these conditions can be formulated.
A small high speed water tunnel having test section velocities of 370 feet per second, pressures to 1000 pounds per square inch, temperatures to 300 degrees Fahrenheit, has been constructed and has been in operation since April of 1962.
(g) Preliminary tests of nozzles in the high speed water tunnel have shown that critical cavitation numbers increase with velocity. This increase is greater for nozzles with an abrupt contour.
(h) "Experimental Investigations of Incipient and Desinent Cavitation," by A. F. Lehman, J. O. Young, presented at ASME Aviation and Space, Hydraulic, and Gas Turbine Conference, Los Angeles, March 3-7, 1963.

(4180) UNSTEADY FLOW INVESTIGATIONS AROUND AN ELLIPSOID OF REVOLUTION.

(b) Laboratory project sponsored by Bureau of Naval Weapons.
(c) Mr. Maurice Sevik, Ordnance Research Lab., University Park, Pennsylvania.
(d) Experimental and theoretical study of unsteady forces acting on an ellipsoid of revolution over a range of Reynolds numbers and body attack angles. Instantaneous values of forces and moments have been measured for Reynolds numbers up to 10^7 in a water tunnel with body attack angles of zero, 5 and 10 degrees. Measurements have been made with the ellipsoid performing small oscillations in a direction normal to the main flow.

(4181) DETERMINATION OF EFFECT OF TUNNEL BOUNDARIES ON THE FORCES ACTING ON A MODEL.

(b) Laboratory project sponsored by Bureau of Naval Weapons.
(c) Mr. Thomas Peirce, Ordnance Research Lab., University Park, Pennsylvania.
(d) Theoretical and experimental.
(e) Investigation of the errors introduced by the physical boundaries of tunnel walls on the measured forces on large models. The investigation covers both the axially symmetric case and when the models are at low angles of attack. Establishing the means for correcting these errors is also a part of this investigation.
(g) For the axially symmetric case the installation of a tunnel liner has produced satisfactory results.

(4677) THE INVESTIGATION OF TWO-DIMENSIONAL UNSTEADY CAVITY FLOWS ABOUT FIXED SYMMETRIC BLUFF BODIES.

(b) Laboratory project sponsored by Bureau of Ships, David Taylor Model Basin.
(c) Dr. B. W. McCormick, J. O. Young, Ordnance Research Laboratory, University Park, Pennsylvania.
(d) Experimental and theoretical.
(e) An investigation of the wake region behind supercavitating, bluff, two-dimensional body shapes will be undertaken for the purpose of defining the flow characteristics and the variables which affect fully developed, periodic, cavity flow.
(h) "Preliminary Investigation of the Unsteady Cavity and Wake Behind a Wedge at Zero Angle of Attack," by J. O. Young, TN 5.3410-07, January 18, 1962.

(4678) HYDRAULIC SERVOMECHANISM FOR AN UNDERWATER MISSILE.

(b) Laboratory project sponsored by the Bureau of Naval Weapons and conducted under Dr. C. L. Key, Asst. Director, Ordnance Research Laboratory.
(c) Messrs. H. M. Jensen and R. E. Kershaw, Ordnance Research Laboratory, University Park, Pennsylvania.
(d) Experimental, applied development and design.
(e) A high-performance hydraulic servomechanism for control of rudders and elevators in an underwater missile system. Specific design problems were instability caused by a resonant linkage and high-frequency oscillation of the servovalve.
(f) Design is complete and field tests will soon be conducted.
(g) Stability was achieved by increasing the resonant frequency of the linkage, providing hydraulic damping with a bypass orifice, and lag-lead phase compensation in the servo amplifier. The high-frequency oscillation was eliminated by increasing the diameter of activator ports.

PURDUE UNIVERSITY, Agricultural Experiment Station.

(2596) THE USE OF A RAINFALL SIMULATOR FOR SOIL AND WATER MANAGEMENT STUDIES.

(b) Soil and Water Conservation Research Div., Agricultural Research Service, USDA and Purdue University. (See Agricultural Research Service, Corn Belt Branch, Project No. 4276).
(c) Mr. L. Donald Meyer, ARS-SWC, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
(d) Field investigation; applied research.
(e) The rainfall simulator is used on runoff plots for comparison of treatments which effect erosion and infiltration. Research includes studies of tillage methods, crop residue management, slope, soil type, crop rotations, and intensity histograms.
(h) "Crop Residues as Surface Mulches for Controlling Erosion on Sloping Land under Intensive Cropping," by L. D. Meyer and J. V. Mannering, ASAE Paper No. 62-714, 1962.

(2597) THE EFFECTS OF TILLAGE ON RUNOFF AND EROSION.

(b) Laboratory project.
(c) Dr. E. J. Monke, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
(d) Field investigation; applied research.
(e) Runoff is measured from 15 watersheds in five different tillage systems. These systems involve two surface soil treatments and three subsoil treatments, including subsoil fertilization and vertical mulching. Hydrologic analyses of these small watersheds are used to evaluate the effects of tillage on soil moisture, crop growth and yield, and runoff.
(f) To be continued as part of another project.
(h) "Some Observations on the Effect of Vertical Mulching," by R. D. Frazier and A. R. Bertrand, Indiana Acad. of Sci., Vol. 69, 1959.

(2835) PRELIMINARY INVESTIGATION OF WATER TABLE IN SANDY SOIL.

(b) Laboratory project.
(c) Dr. E. J. Monke, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
(d) Field investigation; applied research.
(e) The water table in a sandy field is controlled from an adjacent supply ditch in which the water level is kept high. Depths to the water table are continuously measured during the growing season at various distances from the ditch and correlated with crop yield data.
(f) Suspended.
(g) The maintenance of the water table at two feet below the surface in Maumee fine sandy loam significantly increased corn yields in years when extended drought periods occurred during the growing season. Based upon drawdown curves, a favorable water table level can be maintained by ditches spaced 600 feet apart.
(h) "Water Table Control on Maumee Fine Sandy Loam," by W. D. Lembke, Agr. Exp. Sta. Bull., Purdue Univ., (in press).

(2837) TREATMENT OF SURFACE WATERS FOR DOMESTIC USE ON THE FARM.

(b) Laboratory project.
(c) Dr. E. J. Monke, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
(d) Field investigation; applied and basic research.
(e) The treatment of pond water by use of slow sand and diatomaceous earth filters is being evaluated. Improved designs are under investigation. The effects of algae growth and coagulation-sedimentation methods on filtration processes are being studied.
(h) "Automation of a Diatomaceous Earth Water Treatment System for Farmstead Use," by K. J. Albrecht and E. J. Monke, ASAE Paper No. 61-310, 1961.
"Diatomaceous Earth Filtration of Pond Water for Domestic Use," by E. J. Monke, H. R. Wilke, L. G. Laudenschlager, and K. J. Albrecht, ASAE Paper No. 62-210, 1962.
"Use of Gypsum on the Flocculation Behavior of Clays in an Aqueous Solution," by J. Doorenbos, M. S. thesis, Purdue Univ., 1962.

(3490) INVESTIGATION OF FLOW CHARACTERISTICS IN DRAIN TILE AND THE RELATIONSHIP OF THESE FLOW CHARACTERISTICS TO SEDIMENTATION.

(b) Laboratory project.
(c) Mr. L. F. Huggins, Agricultural Engineering Department, Purdue Univ., Lafayette, Indiana.
(d) Experimental; basic research.
(e) Flow of water through a partially filled transparent drain is being observed on steep slopes. Three regimes of flow occurring below a hydraulic jump are being studied to determine their effect on the design of circular drains.
(h) "A Model Study of Flow in Steep Tile Drains," by W. D. Lembke, J. W. Delleur, and E. J. Monke, ASAE Paper No. 62-224, 1962.

(3808) DEVELOPMENT AND REFINEMENT OF METHODS FOR ESTIMATING FIELD RUNOFF AND SOIL LOSS.

(b) Soil and Water Conservation Research Div., USDA, and Purdue University. (See Agri. Research Service, Corn Belt Branch, Project No. 4274).
(c) Mr. Walter H. Wischmeier, ARS-SWC, Agric. Engineering Dept., Purdue Univ., Lafayette, Indiana.
(d) Experimental; development.
(e) The relationships of numerous rainstorm characteristics, topographic features, soil characteristics and surface conditions to field runoff and soil erosion are being evaluated from plot data obtained under natural and/or simulated rainfall. Basic plot and small watershed data on an individual storm basis have been assembled in an ARS central runoff and soil-loss data lab. at Purdue Univ., from 24 states. The data represent results of cooperative research studies over the past 32 years at 47 locations.
(g) An improved soil-loss equation to help guide farm planning for soil and water conservation was developed and published. Data for locality evaluations of the rainfall factor and the cropping-management factor in the equation have been disseminated in ready-reference form. New data from plot studies under natural rainfall and from studies under simulated rainfall have been included in continuing investigations to improve the accuracy of the soil, topographic and practice factors in the equation.
(h) "Soil-Loss Estimation as a Tool in Soil and Water Management Planning," by W. H. Wischmeier and D. D. Smith, International Association of Scientific Hydrology, Commission on Land Erosion, Report No. 59, 1962.
"Erosion Rates and Contributing Factors in Semi-Arid Regions," by W. H. Wischmeier, Proceedings of International Seminar on Water and Soil Utilization, Brookings, South Dakota, July 1962, (in press).

(4182) THE MECHANICS OF EROSION OF RAINFALL AND RUNOFF.

(b) Soil and Water Conservation Research Div., Agricultural Research Service, USDA and Purdue University.
(c) Mr. L. Donald Meyer, ARS-SWC, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
(d) Experimental; basic research.
(e) The splash and runoff of simulated soil particles from an area 0.6 meters wide by 3.0 meters long is being investigated. Variables during the initial phases include particle size, inclination of slope, rate of runoff, and simulated rainfall.

(4183) SUBSURFACE DRAINAGE OF BLOUNT SILT LOAM.

(b) Laboratory project.
(c) Dr. E. J. Monke, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
(d) Field investigation; applied research.
(e) Various spacings between parallel subsurface drains are under investigation to determine their effectiveness in water removal and crop response. Continuous records of tile discharge are being made and crop yields are determined at harvest time.

(4681) EVALUATION OF PLASTIC-LINED MOLE DRAINS AND INSTALLATION EQUIPMENT IN MUCK SOILS.

(b) Soil and Water Conservation Research Div.,

USDA, and Purdue University. (See Agri. Research Service, Corn Belt Branch, Project No. 4271).
(c) Dr. E. J. Monke, Agricultural Engineering Department, Purdue Univ., Lafayette, Ind.
(d) Field investigation; applied research.
(e) The primary purpose of this investigation is to determine the stability with time of various cross-sectional types of plastic-lined mole drains in muck soil. Secondary objectives are concerned with the improvement of the installation equipment.

PURDUE UNIVERSITY, Department of Agronomy.

(4185) ANALYSIS OF THE DYNAMICS OF MOISTURE FLOW IN SOILS.

(b) Laboratory project.
(c) Dr. Dale Swartzendruber, Department of Agronomy, Purdue University, Lafayette, Ind.
(d) Theoretical and experimental; basic and applied.
(e) The flow of water to tube drains in stratified soils was evaluated theoretically by an approximate method originally developed in Russia. In a second study, a refined non-Darcy flow equation was developed and evaluated.
(f) Completed.
(g) In the approximation analysis, the layered system is considered in three special, mathematically degenerate cases, which then yield the approximate flow rate. The approximate values conformed reasonably well with values found by essentially exact methods. The approximation is widely applicable, and yields good physical insight into many complex problems. In the second study, data from the literature were analyzed from the standpoint of non-Darcy behavior. In many cases, it was found that the one-dimensional flow velocity increased more than proportionally with the hydraulic gradient. This behavior could be described quite well with a 3-parameter equation, which contains Darcy's law as a special case.
(h) "Approximate Water Flow Rates for Tube Drains in Stratified Soils," by D. Swartzendruber, J. Geophys. Res. 67, No. 6, Pages 2395-2402, 1962.
"Non-Darcy Flow Behavior in Liquid-Saturated Porous Media," D. Swartzendruber, J. Geophys. Res. 67, No. 12, pp. 5205-5213, 1962.

(4186) MECHANISMS OF HYDRAULIC CONDUCTIVITY DECREASE IN WATER-SATURATED SOILS.

(b) Laboratory project and Purdue Research Foundation.
(c) Dr. Dale Swartzendruber, Department of Agronomy, Purdue University, Lafayette, Ind.
(d) Experimental; basic research for Ph.D. thesis.
(e) The effect of gases on the hydraulic conductivity of porous media was studied for air and methane. The presence of entrapped air was determined with a compression technique.
(g) As phenol-containing water was passed continuously through quartz sand initially wetted at atmospheric pressure, the hydraulic conductivity increased and reached a plateau maximum. The compressibility of the system, which reflects the entrapped gaseous air content, decreased sharply at first, but continued to decrease slowly even during the plateau of hydraulic conductivity. When phenol was absent, the hydraulic conductivity reached a peak maximum and thereafter declined. However, the compressibility still decreased sharply initially, and continued to decrease slowly. This indicates that the eventual decline in hydraulic conductivity was not caused by a release of gas from the permeating water. The presence of dissolved methane in the permeating water was found not to decrease the hydraulic conductivity of sand during prolonged flow. In fact, there was a slight tendency for methane to increase the hydraulic conductivity, as compared with water not containing methane.

(4679) FLOW LAWS FOR THE MOVEMENT OF WATER IN SOIL.

(b) Laboratory project.
(c) Dr. Dale Swartzendruber, Department of Agronomy, Purdue Univ., Lafayette, Indiana.
(d) Experimental and theoretical; basic for Ph.D. thesis.
(e) The validity of Darcy's law for various porous media, with and without clay, will be studied for both saturated and partially saturated media. One-dimensional flow velocity will be determined as a function of driving gradient, at various constant water contents. Mathematical relationships for flow as a function of gradient will also be sought.
(g) Assuming Darcy's law valid for unsaturated soil water flow, along with soil capillary potential as a unique function of moisture content, implies direct proportionality between one-dimensional flow velocity and moisture gradient, for constant moisture content. An analysis of this type was performed for the horizontal absorption of water into a silty clay loam soil. Proportionality was found to hold at the higher moisture contents, but not at the lower moisture contents. Deviations were of the type in which the flow velocity increased more than proportionally with the hydraulic gradient.
(h) "Non-Darcy Behavior and the Flow of Water in Unsaturated Soils," by D. Swartzendruber, submitted to Soil Sci. Soc. Am. Proc.

(4680) THE EFFECT OF SUBSOIL TREATMENT ON SOIL CONDITIONS, CROP GROWTH AND RUNOFF.

(b) Laboratory project.
(c) Dr. H. Kohnke, Agronomy Department, Purdue University, Lafayette, Indiana.
(d) Field investigation, applied research.
(e) Soil conditions, crop growth and peak rates of runoff are measured on 15 watersheds under three different systems of subsoil management. These treatments are: subsoil fertilization, vertical mulching and untreated subsoil. It is the purpose to determine what effects the subsoil treatments have on soil conditions, crop growth and runoff.
(g) As long as vertical mulch channels stay open at the soil surface, they reduce runoff rates. Subsoil fertilization has a minor effect on runoff.

PURDUE UNIVERSITY, Chemical Engineering Department.

(4188) SAMPLING OF HETEROGENEOUS FLUIDS IN FLOW.

(b) American Petroleum Institute.
(c) Mr. J. H. Rushton, School of Chemical Engineering, Purdue Univ., Lafayette, Ind.
(d) Both an experimental and theoretical project. Essentially an experimental project to which basic fluid mechanics is applied. Proposals for accurate methods of sampling in commercial type operations will be made at the end of the program. Five Master theses have been completed, several others will follow.
(e) The work is for the purpose of developing methods whereby the accuracy of sampling can be maximized for heterogeneous materials flowing through pipe lines. The flowing fluids handled contain immiscible solids and liquids. Work is done in several sizes of pipes so that scale-up information will be available.
(f) Work is approximately 80% completed.
(g) For small quantities of solids and liquids the vertical distribution in a horizontal pipe has been determined for various rates

of flow. A technique has been devised to relate a sample at one point in the pipe to the average stream flowing in the pipe. Isokinetic sampling is important, particularly for large sized particles and for mixtures where the components vary widely in density. It appears that satisfactory results can be achieved by sampling between a position one third pipe diameter above the bottom of a horizontal pipe and the center line, provided the sample is withdrawn at a velocity equal to the average velocity of flow.

(h) Progress reports have been made to the American Petroleum Institute. No printed publications at this date.

(4190) CALCULATION OF COMPLETE BATCH SETTLING BEHAVIOR FOR RIGID SPHERES IN A NEWTONIAN FLUID.

(b) Laboratory project.
(c) Prof. Paul T. Shannon, School of Chemical Engineering, Purdue University, Lafayette, Indiana.
(d) Theoretical and experimental; basic research for M. S. thesis.
(e) As part of a continuing study of the dynamic behavior of multiparticle-fluid systems, additional batch settling data on 68 μ spherical glass beads in water was obtained over a wide range of initial solids concentrations. This work was done to confirm previous results at different weight of solids per unit area and to study closely the rising concentration gradient predicted by the theory.
(g) Solids flux plats based on the initial batch settling rates were obtained by fitting third and fourth order polynomial equations in initial reduced solids concentration (solids conc./solids density) to the experimental settling rate data. A computer program was written to theoretically predict the entire batch settling behavior of the slurries, using only the initial rate data, based on the postulate that the solids settling rate is a function of the local solids concentration only. The rising concentration gradient predicted by the theory was observed and photographed and was as predicted.
The predicted total batch settling curves agreed within experimental uncertainty with the experimental results. This validates the basic postulate for systems of uniform spheres in a Newtonian fluid. Minor deviations were attributed to small initial concentration gradients and to particle segregation.
(h) M. S. Thesis by E. P. Stroupe, Purdue Univ., January 1962.
M. S. Thesis by R. D. DeHaas, Purdue Univ., January 1963.
The first two of a series of articles based on the work to date have been submitted for publication in the I&EC Fundamentals Quarterly. Copies of these manuscripts can be secured by I&EC subscribers from: Research Results Service, I&EC, 1155 Sixteenth Street, N. W. Washington 6, D. C.
"Batch and Continuous Thickening. Part I. Basic Theory. Solids Flux for Rigid Spheres." Ms. No. 62-206, $4.00.
"Batch and Continuous Thickening. Part II. Prediction of Batch Settling Behavior. Results for Rigid Spheres." Ms. No. 62-318, $3.00.

(4682) SURFACE VELOCITIES OF LIQUID FILM IN CONCURRENT WETTED-WALL COLUMN.

(b) Department supported laboratory project.
(c) Mr. W. H. Tucker, School of Chemical Engrg., Purdue University, Lafayette, Indiana.
(d) Experimental; applied research, M.S. Thesis.
(e) High velocity gas and liquid flowing downward in a wetted-wall column. The surface velocity of the liquid film is being measured to determine the nature of the momentum transfer from the gas to the liquid phase.
(g) Preliminary results are being extended to non-aqueous liquids and liquids containing surfactants.

(4683) RESIDENCE TIME STUDIES IN A CONCURRENT WETTED WALL COLUMN.

(b) Department supported laboratory project.
(c) Mr. W. H. Tucker, School of Chemical Engrg., Purdue University, Lafayette, Indiana.
(d) Experimental; applied research, M.S. thesis.
(e) High velocity gas and liquid flowing downward in a wetted-wall column. The shear on the liquid surface by the high velocity gas causes mixing of the liquid film. Residence time measurements were attempted to provide a tool for measuring the effectiveness of mixing, to replace mass transfer experiments.
(f) Discontinued.
(g) Experimental problems resulted in essentially negative conclusions. Preliminary surface velocity measurement appeared to be more fruitful and these preliminary data provided the basis for the next project.
(h) M.S. Thesis by L. Subbaiyan, Purdue Univ., January 1962.

PURDUE UNIVERSITY, School of Civil Engineering.

(2839) HYDRAULICS OF RIVER FLOW UNDER ARCH BRIDGES.

(b) State Highway Department of Indiana and Bureau of Public Roads.
(c) Dr. J. W. Delleur, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
(d) Experimental; for design and master's theses.
(e) The purpose of the research is to study systematically the hydraulic efficiency of waterways under arch bridges, to provide a criterion for determining the proper clear span of arch bridges so as to compensate for the loss of efficiency at high flows, and to provide a method for computing the backwater upstream of arch bridges, and indirect flood discharge measurements.
(g) Preliminary small scale model investigation has been completed. Large scale testing of two and three dimensional semi-circular and circular segment models in both smooth and rough boundaries including a number of skewed, eccentric and dual bridges have been completed. The large scale tests were conducted in a tilting flume 5 ft. wide and 64 ft. long.
(h) "A Preliminary Model Investigation of Hydraulics of River Flow under Arch Bridges," by S. T. Husain, M.S. Thesis, January 1959.
"Hydraulics of River Flow Backwater Effects of Semi-Circular Constrictions in a Smooth Channel," by H. J. Owen, A. Sooky and S. T. Husain, M.S. Thesis, January, 1960.
"Hydraulics of River Flow Under Arch Bridges, Progress Report No. 3," by P. F. Biery and J. W. Delleur, Joint Highway Research Proj., Purdue University, September 21, 1960.
"Hydraulics of Single Span Arch Bridge Constrictions," by P. F. Biery, Master's Thesis, Purdue University, January, 1961.
Discussion by P. F. Biery and J. W. Delleur of paper "Roughness Spacing in Rigid Open Channels," by W. W. Sayre and M. L. Albertson in Journal of the Hydraulics Division, Vol. 87, HY5, ASCE, September 1961.
"Hydraulics of Single Span Arch Bridge Constrictions," by P. F. Biery and J. W. Delleur, Journal of the Hydraulics Division, Vol. 88, No. HY 2, ASCE, March 1962.

(2840) MECHANISM OF TURBULENCE IN FREE SURFACE FLOW.

(b) National Science Foundation, Purdue Research Foundation.
(c) Dr. J. W. Delleur and Dr. G. H. Toebes, Hydraulic Laboratory, School of Civil Engrg.,

Purdue University, Lafayette, Indiana.
(d) Theoretical and experimental.
(e) Investigation of the mechanism of turbulence in free surface flow. The analytical part of the project will investigate important flow characteristics such as the spectrum of turbulence, correlation of velocities in the turbulent field, degree of isotropy and the various velocity functions in open channel flow. The experimental portion of the program will make tests coincident with theoretical studies.
(g) Hot-wire instrumentation for liquids is being used in the study of the mean and fluctuating velocity components in partially developed flow in small test flume of variable slope. Building of a larger test flume is being completed. The flume has variable longitudinal slope and changeable cross section. The cross section may be rectangular or trapezoidal with different side slopes.
(h) "Secondary Flow in Straight Open Channels," by J. W. Delleur and D. S. McManus, 6th Midwestern Conference on Fluid Mechanics, University of Texas, September, 1959. "Mechanism of Turbulence in Free Surface Flow," by J. W. Delleur, Progress Report No. 1, July 1961.

(2841) STUDY OF RUNOFF FROM SMALL WATERSHEDS FOR HIGHWAY DRAINAGE DESIGN IN INDIANA.

(b) State Highway Department of Indiana.
(c) Dr. J. W. Delleur, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
(d) Analysis and statistical investigation for Ph.D. thesis.
(e) The purpose of the research is to study the hydrology of watersheds less than 200 square miles throughout the State of Indiana, to improve the existing methods for estimating the runoff from small watersheds, and to improve the present methods of design of highway drainage structures servicing small watersheds. A statistical analysis by means of the extreme values method has been completed. Graphical relations which permit derivation of peak flow as function of five geomorphological parameters of the watershed have been prepared. A synthetic instantaneous unit hydrograph has been developed for Indiana. It is described by means of two parameters which were evaluated in terms of three geomorphological characteristics. The design storm was based on the Weather Bureau study of stories with different durations and frequencies.
(g) Runoff and rainfall data are being collected, and runoff statistical and geomorphological analysis has been completed.

(3146) HYDROMECHANICS OF FLUID COLLECTOR SYSTEM IN POROUS MEDIA.

(b) Purdue Research Foundation.
(c) Dr. G. H. Toebes, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
(d) Theoretical, and experimental; for Ph.D. thesis.
(e) Analytical and experimental investigations of the gravity flow field around horizontal collector wells.
(g) The exact solution for gravity flow towards a sink strip was derived. Slow convergence of relaxation methods, utilizing a digital computer necessitated the use of an hydraulic model equipped with an electric free surface probe. Results permitted the formulation of a discharge formula as well as a number of design recommendations. A novel method for increasing the well yield, called "vacuum pumping", has been given.

(3491) NUMERICAL METHODS IN ANALYSIS OF HYDROMECHANICS PROBLEMS.

(b) Laboratory project. Hydraulics Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
(c) Dr. J. W. Delleur, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
(d) Analytical.
(e) The purpose of the research is to make available to the hydraulic engineers the mathematical tools which are normally beyond his competence.
(g) The use of the calculus of variation in the solution of laminar flow problems has been investigated. An approximate numerical method of solution of laminar flow in noncircular conduits has been developed.
(h) "Variational Methods in Fluid Dynamics," by J. W. Delleur and A. A. Sooky, Journal of the Engineering Mechanics Div., Vol. 87, No. EM 6, December, 1961.

(3492) TRANSIENT DEVELOPMENT OF THE FREE SURFACE IN A HOMOGENEOUS EARTH DAM.

(b) Purdue Research Foundation.
(c) Dr. M. E. Harr, School of Civil Engineering, Department of Soil Mechanics, Purdue Univ., Lafayette, Indiana.
(d) Theoretical for Ph.D. thesis.
(e) The study is aimed at the development of a rational treatment of the "rapid drawdown" condition for the analysis of earth and rockfill dams.
(f) Completed.
(h) Published by Geotechnique, (Dec. 1962).

(4191) MEANDER-FLOOD PLAIN MODEL.

(b) Purdue Research Foundation; Agricultural Research Service, Soil and Water Conservation and Research Div., U. S. Dept. of Agriculture.
(c) Dr. G. H. Toebes, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
(d) Analytical and experimental research for Ph.D. thesis.
(e) The study is aimed at formulating bounds for the overall energy losses occurring in flows through meander-flood plain geometries and to increase the knowledge on the spatial distribution of energy dissipation for such flow fields.
(g) Several experimental stage-discharge relationships are available. A number of detailed measurements of the velocity distribution, direction of flow and free surface topography have been in a 5' x 30' rigid bed model with adjustable slope, side wall and channel dimensions.

(4192) PERFORMANCE CHARACTERISTICS OF EAGLE CREEK RESERVOIR SPILLWAY.

(b) Dodson, Kinney and Linblom, consultants to the Indianapolis Flood Control District.
(c) Dr. G. H. Toebes, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
(d) Experimental, design.
(e) The overflow spillway for Eagle Creek reservoir near Indianapolis, with a design discharge of 160,000 cfs is situated only 700 feet from a major Interstate Highway. The road will at larger flow act as a broad crested weir giving rise to an unusually flat tailwater rating curve.
(g) Tests have led to several modifications of the original design.

(4684) GROUNDWATER AND SEEPAGE.

(b) School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
(c) Dr. M. E. Harr, School of Civil Engineering, Purdue University, Lafayette, Indiana.
(d) Textbook.
(e) Presents an organized, self-contained development of groundwater and seepage theory.

Includes many works of Russian Investigators. Numerous examples and problems presented.
(f) Completed.
(h) "Ground Water and Seepage," by M. E. Harr, McGraw-Hill Book Company, N. Y., 1962.

(4685) DEVELOPMENT OF THE FREE SURFACE FOR FLOW AROUND PILING.

(b) School of Civil Engineering, Purdue Univ.
(c) Dr. M. E. Harr, School of Civil Engrg., Purdue Univ., Lafayette, Indiana.
(d) Experimental and theoretical for M.S. Thesis.
(e) The study is aimed at the development of a rational method of determining the locus of the free surface for flow around piling and thus permit more reliable estimates of factors of safety with respect to piping.

PURDUE UNIVERSITY, School of Electrical Engineering.

(4499) AN INVESTIGATION OF PULSE WIDTH MODULATED HYDRAULIC CONTROL SYSTEMS.

(b) Laboratory project.
(c) Dr. J. E. Gibson, Dir., Control and Information Systems Lab., School of Electrical Engineering, Purdue Univ., Lafayette, Ind.
(d) Experimental and analytical investigation; basic research.
(e) Experimental work is being conducted to investigate the feasibility of a new type of pulse width modulating valve. In addition, some analytical work has been done to study the use of a pulse width modulated valve in a dual mode hydraulic servo.
(g) Some analytical results have been obtained in which mathematical models for the pulse width valve system have been derived. A method for estimating transient responses of a system with coulomb friction has been developed.
(h) "An Analysis of Pulse Width Modulated Hydraulic Control Systems," D. E. Boddy, Control and Information Systems Laboratory memorandum CISL 62-19, School of Electrical Engineering, Purdue Univ., 42 pages, Oct. 17, 1962.

PURDUE UNIVERSITY, Jet Propulsion Center.

(2374) MASS TRANSFER IN TWO-PHASE ANNULAR FLOW OF LIQUIDS IN A VERTICAL TUBE.

(b) National Science Foundation.
(c) Dr. M. J. Zucrow, Jet Propulsion Center, Purdue University, Lafayette, Indiana.
(d) Experimental and theoretical; basic research for Ph.D. degree.
(e) This problem is concerned with the analytical and experimental study of the mass transfer from an annular liquid film on the inside wall of a vertical circular tube to a co-current gas flow in the core of the tube. Systematic experiments will be conducted for determining the effect of the rates of flow of air and liquid, and the temperature difference between air and liquid upon the rate of mass transfer from the liquid film.

PURDUE UNIVERSITY, School of Mechanical Engineering.

(4686) FULLY-DEVELOPED TURBULENT FLOW IN TUBES OF ANNULAR CROSS-SECTION.

(b) Laboratory project.
(c) Dr. J. B. Jones, Prof. of Mechanical Engrg., Purdue University, Lafayette, Indiana.
(d) Experimental basic research for doctoral thesis.
(e) The data on the turbulence structure of fully-developed flow in circular pipes presented by J. Laufer and by V. A. Sandborn and the similar data for flow between parallel walls from J. Laufer and from G. Comte-Bellot are quite valuable in many studies of turbulent shear flow. The purpose of this project is to obtain such data on flow in annuli, the third type of channel flow which in the steady, fully-developed case can be described in terms of a single spatial coordinate. It is hoped that also some of the conflicts among previously published velocity distributions can be resolved.

(4687) FULLY-DEVELOPED TURBULENT FLOW IN RECTANGULAR CHANNELS.

(b) Laboratory project.
(c) Dr. J. B. Jones, Prof. of Mechanical Engrg., Purdue University, Lafayette, Indiana.
(d) Experimental basic research for doctoral thesis.
(e) The purpose of this investigation is to obtain knowledge of the relationships among velocity distributions, secondary flows, and turbulence characteristics in fully-developed incompressible flow in channels of rectangular cross-section. In addition to the velocity and turbulence measurements, local wall shear stresses are to be measured by means of a thermal element.

(4688) EVALUATION OF INCOMPRESSIBLE TURBULENT BOUNDARY LAYER PREDICTION METHODS APPLIED TO DIFFUSERS.

(b) Laboratory project.
(c) Dr. R. W. Fox, Assistant Prof. of Mechanical Engineering, Purdue University, Lafayette, Indiana.
(d) Analytical applied research for master's thesis.
(e) This study contains a summary of available incompressible turbulent boundary layer prediction methods; their applicability to diffuser flows was investigated, and their assumptions and empirical approximations were considered and discussed. Several of the methods were applied to two-dimensional diffuser flows and the results were compared to available experimental data.
(f) Completed.
(g) Several prediction methods were found to give reasonable values of diffuser length for first appreciable stall. Predicted pressure recovery values were reasonable although about 25 percent lower than those given by available correlations of experimental data for optimum pressure recovery. The results of this study indicate that pressure recoveries for non-separating diffusers can be calculated with a reasonable degree of accuracy.
(h) "Evaluation of Incompressible Turbulent Boundary Layer Prediction Methods Applied to Diffusers," by Alan T. McDonald, M.S. Thesis, June 1962 (available on loan).

(4689) LAMINAR BOUNDARY LAYER ABOUT A SPINNING AXISYMMETRIC BODY OF REVOLUTION AT A HIGH VALUE OF ANGULAR VELOCITY.

(b) Laboratory project.
(c) Dr. E. J. Wellman, Assoc. Prof. of Mech. Engrg., Purdue Univ., Lafayette, Indiana.
(d) Analytical research for master's thesis.
(e) At high values of angular velocity, previous research has indicated that the standard boundary layer equations do not accurately predict the drag for a spinning body nor the torque required to maintain rotation. Modified boundary layer equations were developed by including in the circumferential Navier-Stokes equation the largest of the terms neglected in the conventional analysis. Integral equations of the azimuthal direction boundary layer equation and the modified circumferential direction boundary layer equation were formed. The potential flow pressure gradient was assumed and a Pohlhauser fourth order velocity profile was used.

Boundary layer thicknesses were calculated for both the conventional and the modified equations as applied to a selected shape. The solutions were obtained by numerical integration using an RPC 4000 digital computer.

(f) Completed.

(g) The results indicated a thicker azimuthal boundary layer and a thinner circumferential thickness, both of these effects being greater near the maximum body diameter than near the nose. The thicker azimuthal boundary layer confirmed previous experimental results of O. Parr.

(h) "Laminar Boundary Layer about a Spinning Axisymmetric Body of Revolution at a High Value of Angular Velocity," Howard J. Deacon, Jr. Master's thesis, January, 1963 (available on loan).

(4690) EXPERIMENTAL DETERMINATION OF THE INLET LENGTH AND CRITICAL REYNOLDS NUMBER FOR PULSATING FLOW IN RIGID TUBES.

(b) Laboratory project.

(c) Dr. R. W. Fox, Assistant Prof. of Mech. Engineering, Purdue University, Lafayette, Indiana.

(d) Experimental basic research for doctoral thesis.

(e) The calculation of volume flow rates from pressure gradient measurements in the cardiovascular system are based on the assumptions of fully-developed laminar flow. The purpose of this investigation is to determine experimentally the entrance length and critical Reynolds number for pulsating flow. Conflicting data are available as to the effect of pulsations on the critical Reynolds number in tube flow. It is hoped that visualization techniques employed will shed some light on the mechanism of transition in tube flow. It is anticipated that this work will also provide a point of departure and reference point for additional work on pulsating flow in elastic tubes.

PURDUE UNIVERSITY, Automatic Control Laboratory, School of Mechanical Engineering.

(4197) FLUID LINE DYNAMICS.

(b) National Aeronautics and Space Administration.

(c) Mr. Raymond E. Goodson, Purdue University, School of Mechanical Engineering, Lafayette, Indiana.

(d) Theoretical and experimental project; Master's and Doctor's Thesis Research.

(e) The research work on fluid lines is being done so as to establish mathematical models for the dynamic response of fluid conduits. Viscosity, boundary effects and line vibration are being considered in the analytical work. Experimental investigation is being conducted by making frequency response runs on fluid lines. A sinusoidal signal is supplied to a valve controlling flow to a line. Unsteady fluid pressure and flow are measured at the line inlet and outlet. The theoretical work is then compared with the experimental results. The effects of bends, longitudinal vibration and different diameters of pipes are being treated. To facilitate analysis using the mathematical models, approximations are being developed which allow the partial differential equations describing the distributed flow of a line to be replaced by ordinary differential equations in time relating fluid variables at two cross-sections of a line separated by a distance L. These approximations include viscosity and the effect of an elastic tube.

(g) The results indicate that the mathematical models developed are valid to describe line dynamics and that relatively simple approximations to line dynamics may be made with certain restrictions.

(h) "Simplification of Hydraulic Line Dynamics by Use of Infinite Products," by R. Oldenburger and R. E. Goodson, American Society of Mechanical Engineers Paper No. 62-WA-55, 1962.
"Dynamic Response of Fluid Flow Through Straight and Curved Lines," by A. F. D'Souza, Ph.D. Thesis, Submitted to Purdue University (Mechanical Engineering) January, 1963.
"Experimental Dynamic Response," by W. J. Roberts, M. S. Thesis in Mechanical Engrg., Submitted to Purdue University January, 1963.
"Viscous and Boundary Effects in Fluid Lines," by R. E. Goodson, Ph.D. Thesis in Mechanical Engineering, Submitted to Purdue University January, 1963.

ST. ANTHONY FALLS HYDRAULIC LABORATORY, UNIVERSITY OF MINNESOTA.

Inquiries concerning Projects 2144, 2603, 3153, 3164, 3499, 3502, 3819, 3822, 3824, 4199, 4200, 4201, 4202, 4203, 4206, 4207, 4209, and 4691 to 4700, inclusive should be addressed to Dr. Lorenz G. Straub, Director, St. Anthony Falls Hydraulic Laboratory, Miss. River at Third Avenue S.E., Minneapolis 14, Minn.

Inquiries concerning Projects 111, 1168, and 2386, which are conducted in cooperation with the Agricultural Research Service, should be addressed to Mr. Fred W. Blaisdell, Hydraulic Engineer, Soil and Water Conservation Research Division, Agricultural Research Service, St. Anthony Falls Hydraulic Lab., Minneapolis 14, Minnesota.

Inquiries concerning Project No. 194, which is conducted in cooperation with the Corps of Engineers and the U. S. Geological Survey, should be addressed to Engineer in Charge, Mr. Byrnon Colby, Federal Inter-Agency Sedimentation Project, St. Anthony Falls Hydraulic Laboratory, Mississippi River at Third Avenue, Minneapolis 14, Minnesota.

(111) CLOSED CONDUIT SPILLWAY.

(b) Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Minnesota Agricultural Expt. Station and the St. Anthony Falls Hydraulic Laboratory.

(d) Experimental; generalized applied research for development and design.

(e) A two-sided drop inlet having a width equal to the pipe diameter and a variable length is currently being tested. The anti-vortex device consists of a horizontal plate supported above the crest of the drop inlet by end piers. The characteristics, performance, losses, and pressures in the drop inlet and on the anti-vortex plate are being determined for various combinations of drop inlet length, and height and overhang of the anti-vortex plate. Water is used as the model fluid to determine the performance characteristics, and head-discharge relationships during flows of water-air mixtures. For full flow, air is used as the model fluid to determine the various energy loss coefficients and the pressure coefficients.

(g) The theory of closed conduit spillways has been developed, verified, and published. Results of tests on many forms of the closed conduit spillway entrance have been published. Pipe culverts laid on steep slopes may flow completely full even though the outlet discharges freely. Generalized methods for analysis and reporting of the results have been developed. The use of air as the model fluid has been verified by comparing test results with those obtained using water as the model fluid. The drop inlet with the horizontal anti-vortex device causes the spillway to act as a self-regulating siphon when the headpool level approximates the anti-vortex plate elevation. The height of the anti-vortex plate above the

drop inlet crest and the overhang of the anti-vortex plate determine the effectiveness of the plate as an anti-vortex device. For one form of the inlet, tests have been made to determine the crest loss coefficient, the barrel entrance loss coefficient, the pressures on the plate and the drop inlet, the general performance of the inlet, minimum and maximum permissible plate heights, and the head-discharge relationship for plate control. Variables have been the length of the drop inlet, the barrel slope, and the height and overhang of the anti-vortex plate. The effect of sidewall thickness on the crest loss coefficient remains to be determined for the two-way drop inlet with horizontal flat floor.

(1168) A STUDY OF CANTILEVERED OUTLETS.

(b) Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Minnesota Agricultural Expt. Station and the St. Anthony Falls Hydraulic Laboratory.
(d) Experimental; generalized applied research for design.
(e) Pipe outlet conduits for small spillways are frequently cantilevered beyond the toe of the earth dam. Attempts will be made to determine quantitatively the size of the scour hole to be expected under various field conditions.
(f) Suspended.

(1929) DRAIN TILE JUNCTION LOSSES.

(b) Minnesota Agricultural Expt. Station in cooperation with the Agricultural Research Service, U. S. Dept. of Agriculture and the St. Anthony Falls Hydraulic Laboratory.
(c) Prof. Philip W. Manson, University of Minnesota, St. Paul Campus, St. Paul, Minn.
(d) Experimental; generalized applied research for design.
(e) The junction losses in drain tile flowing full are determined for laterals of different sizes entering mains of different sizes at various angles. The laterals enter the main at the centerline. Additional tests have been made with the crowns (or inverts) of both main and lateral in the same plane.
(f) Completed.
(g) Tests have been completed on sharp edge junctions entering the main at angles varying in 15 degree increments from 15 degrees to 165 degrees. Both the lateral and the main are completely full. The tests cover all possible combinations of discharge in the lateral and in the main. Laterals having areas 1/1, 1/2, 1/4, 1/7, and 1/16 that of the main have been tested. A color motion picture film entitled "Energy Losses at Converging Pipe Junctions" has been completed and is available. The 16 mm film is 800 feet long.
(h) "Loss of Energy at Sharp-Edged Pipe Junctions" by Fred W. Blaisdell and Philip W. Manson. Submitted for publication.

(2386) GENERALIZED DESIGN OF TRANSITIONS FOR SUPERCRITICAL VELOCITIES.

(b) Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Minnesota Agricultural Experiment Station and the St. Anthony Falls Hydraulic Lab.
(d) Experimental; generalized applied research for development and design.
(e) Studies will be made to develop a transition and to determine the rules for its design. The transition will be used to change the flow cross section from circular to rectangular when the velocities are supercritical.
(f) Suspended.

(2144) EXPERIMENTAL AND ANALYTICAL STUDIES OF HYDROFOILS.

(b) Office of Naval Research, Department of the Navy.
(d) Experimental and analytical; basic research.
(e) Investigation of the air entrainment phenomenon of an artificially ventilated hydrofoil of finite span in the vicinity of a free surface.
(g) A semi-empirical expression has been previously derived to predict the air requirements for a ventilated cavity in the reentrant jet regime. The application of this expression has been extended to include foils of large camber also, such as foils with trailing edge flaps. Non-rectangular planforms were also investigated. Foils with thick cavities operating near the free surface exhibited no cavity pulsation or instability whereas pulsation was observed for thin cavities at high air flow rates.
(h) "Ventilated Cavities on Submerged Three-Dimensional Hydrofoils," Schiebe, F. R. Wetzel, J. M., St. Anthony Falls Hydraulic Laboratory Technical Paper No. 36, Series B. December 1961.

(2603) WATER TUNNEL AIR CONTENT STUDIES.

(b) David Taylor Model Basin, Dept. of the Navy.
(d) Analytical and experimental applied research.
(e) Establishment of procedures for accoustically measuring the size and number of small gas bubbles existing in water.
(g) Studies have validated the use of acoustic attenuation as a measure of the presence of gas bubbles in water. Continuing work will develop an instrument for a specific water tunnel application.
(h) Interim report in preparation.

(3153) FLOW ABOUT BODIES AT SMALL CAVITATION NUMBERS.

(b) Office of Naval Research, Department of the Navy.
(d) Experimental and analytical; basic research.
(e) The major interest is now in unsteady supercavitating flow. Both material and ventilated cavitation is under study. Unsteady flows of various types are under study experimentally in the free-jet water tunnel: (1) Variation of cavity pressure by adding air at variable rate; (2) variation of body angle of attack; (3) variation of free-stream velocity; and (4) variation of ambient pressure. Theoretical work on unsteady flows of symmetrical bodies is also underway.
(h) "Pulsation of Ventilated Cavities," by C. S. Song, Journal of Ship Research, Vol. 5, No. 4, pp. 8-20, March 1962.
"Unsteady, Symmetrical, Supercavitating Flows Past a Thin Wedge in a Jet," by C. S. Song, St. Anthony Falls Hydraulic Laboratory Technical Paper No. 34, Series B, 48 pp., January 1962.
"Unsteady, Symmetrical, Supercavitating Flows Past a Thin Wedge in a Solid Wall Channel," by C. S. Song and F. Y. Tsai, St. Anthony Falls Hydraulic Laboratory Technical Paper No. 38, Series B, 24 pp., June 1962.
"A Dynamometer for the Two-Dimensional Free-Jet Water Tunnel Test Section," by E. Silberman and R. H. Daugherty, St. Anthony Falls Hydraulic Laboratory Technical Paper No. 40, Series B, 18 pp., June 1962.
"A Note on the Linear Theory of Two-Dimensional Separated Flows about Thin Bodies," by C. S. Song, St. Anthony Falls Hydraulic Laboratory Technical Paper No. 39, Series B, 39 pp., August 1962.

(3164) SCOUR AROUND BRIDGE PIERS.

(b) Laboratory project.
(d) Experimental and analytical; Ph.D. thesis.
(e) Prediction and measurements of ultimate depths of scour around known shape and size of pier.

(f) Completed.
(g) Depth of scour around bridge piers of known shape can be predicted with reasonable accuracy utilizing idealized flow pattern and principles of sediment transport.
(h) "A Theoretical and Experimental Determination of the Erosion Pattern Caused by Obstructions in an Alluvial Channel with Particular Reference to Vertical Circular Cylindrical Piers," by Zal S. Tarapore, Ph.D. Thesis, University of Minnesota, February 1962. (Available at University of Minnesota Library).

(3499) STUDIES OF HYDROFOIL CONFIGURATIONS IN REGULAR WAVES.

(b) David Taylor Model Basin, Department of the Navy.
(d) Experimental, basic research.
(e) Experimental investigation of the heaving and pitching motions of two hydrofoil configurations in regular head and following seas.
(f) Completed.
(g) Foil configurations consisted of various arrangements of dihedral and flat foils. The measured heave and pitch amplitudes compared well with quasi-steady linearized theory. Non-linearities had little effect on the amplitudes of the oscillatory motions. The major effect of non-linearities was to produce a steady downward component of heave. The measured component was in most cases greater than that derived from analog computer solutions of the non-linear equations.
(h) "Longitudinal Motions and Stability of Two Hydrofoil Systems Free to Heave and Pitch in Regular Waves," by J. M. Wetzel, and W. H. C. Maxwell, St. Anthony Falls Hydraulic Lab. Technical Paper No. 37, Series B, December 1961.

(3502) MANGLA SPILLWAY STUDIES.

(b) Harza Engineering Company, Chicago; Binnie, Deacon, and Gourley, London; Government of Pakistan.
(d) Experimental; design and operation.
(e) A 1:300 scale section model consisting of half the control structure and basin and a 1:150 scale comprehensive model for study of all important hydraulic features. A 1:216 scale section model consisting of two control structure gates for study of pressures and gate calibration. A 1:300 scale comprehensive approach model for study of flow conditions in approach. Two 1:150 scale section models, one a detailed study of pressures on baffle blocks, one a detailed study of waves on the basin side walls. Typical dimensions of earth fill dam spillway include a drop in water level of 330 ft, and a design discharge of 1,100,000 cfs through a two-stage stilling basin energy dissipator.

(3819) DESIGN STUDIES FOR SOUTH SASKATCHEWAN RIVER PROJECT.

(b) Canada Department of Agriculture, Prairie Farm Rehabilitation Administration, Regina, Saskatchewan.
(d) Experimental; applied research.
(e) Experimental studies of the preliminary design of components of the diversion tunnel system and spillway system of South Saskatchewan River Project.
(f) Completed.
(g) Tests of the diversion system showed good agreement between computed and measured head-discharge curves. Other tests indicated that the design of the diversion and spillway systems is sound but that some saving could be effected in the temporary stilling basins and that the way the spillway stilling basin could be improved was by lowering of the floor.
(h) Reports to sponsor.

(3822) FLOW OVER VIBRATING PLATES.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental; applied research.
(e) Studies on a water tunnel with one wall externally excited into forced vibration to determine the effect of wall vibration on the boundary layer.
(f) Completed.
(g) Theoretical analysis predicted no overall effect except for very limber plates and very low flow velocities. No effect was measurable experimentally for any conditions tested.
(h) "Turbulent Boundary Layer Flow over a Flat Plate Vibrating with Transverse Standing Waves," by Albert G. Mercer, St. Anthony Falls Hydraulic Laboratory Technical Paper No. 41, Series B, September 1962.

(3824) SURFACE CHARACTERISTICS OF AIR ENTRAINED FLOW IN STEEP CHANNELS.

(b) Laboratory project.
(d) Analytical and experimental investigation of the air concentration, velocity distribution, and surface roughness of water flow in steep open channels, Ph.D. thesis.
(e) Experimental investigation was carried out on the SAF high velocity channel for slopes up to 53 degrees. Velocities were measured by means of a pitot tube and high speed photography. Air concentration was measured by the SAF concentration meter. The surface elevation was measured by a device which measures the average time the surface is above a given elevation.
(f) Experimental work completed.

(4199) GEOMETRY OF AIR CAVITIES IN A BOUNDARY LAYER.

(b) David Taylor Model Basin, Dept. of the Navy.
(d) Experimental; basic research.
(e) Experiments performed to observe the geometry of the air cavity formed downstream of wedges mounted on channel wall when air is introduced through parts on downstream face of the wedge. Geometry of cavity and air demand will be observed in relation to wedge length and thickness for case of single wedge and for a series of wedges at various longitudinal spacings. The ultimate objective is to study drag reduction due to presence of air in boundary layer.
(f) Active.
(g) Cavity geometry obtained for single wedges of 0 degrees, 2.5 degrees, and 5 degrees semi-angle.

(4200) INVESTIGATION OF THE FORCES AND INTERFERENCE EFFECT OF TANDEM FLAT HYDROFOILS.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental basic research.
(e) Investigation of the lift and drag forces on the aft foil of a tandem hydrofoil configuration to determine the effect of the downwash and wave generated by the forward foil. Both non-cavitating and ventilated foils were of interest.
(g) The experimental work with noncavitating foils has been completed. Satisfactory agreement between theoretical and experimental downwash angles and surface wave profiles was obtained for a wide range of foil separations. Force data were also taken for the foil moving through a regular wave train. Data agreed with quasi-steady theory for small reduced frequencies, and at the higher reduced frequencies consideration of unsteadiness effects improved the correlation. Results for ventilated foils are not yet available.
(h) "Tandem Interference Effects of Flat Non-Cavitating Hydrofoils," by J. M. Wetzel, and W. H. C. Maxwell, St. Anthony Falls Hydraulic Laboratory Project Report No. 61, May 1962.

(4201) GURI HYDROELECTRIC PROJECT MODEL STUDIES.

(b) Harza Engineering Company, Chicago, Corp. Venezolano de Guayana.
(d) Experimental, design and operation.
(e) Preliminary study for the design of the Guri Hydroelectric development on the Caroni River, Venezuela using a 1:394 comprehensive spillway model, 1:197 spillway section model and a 1:197 comprehensive model. Studies include spillway design, channel closure and cofferdam studies.

(4202) MICRO BUBBLE STUDIES.

(b) David Taylor Model Basin, Dept. of the Navy.
(d) Analytical and experimental applied research.
(e) Measurement of micro bubble structure of laboratory and natural waters before and after exposure to dynamic disturbances characteristic of common forms of hydraulic machinery with the ultimate objective of correlating micro bubble structure with critical cavitation performance.
(h) "Gas Bubbles: Their Occurrence, Measurement, and Influence in Cavitation Testing," by John F. Ripken and John M. Killen, Symposium on Cavitation and Hydraulic Machinery, International Association for Hydraulic Research, Sendai, Japan September 1962.

(4203) HYDRAULIC DESIGN OF AN OVERFALL FOUNDED ON PERMEABLE SOILS.

(b) Laboratory project.
(d) Theoretical and experimental for Ph.D. thesis.
(e) Stability of the hydraulic overfall founded on limited depth of permeable soils, under the influence of infiltering flow underneath the structure, and also in the presence of adverse surface flow conditions was studied. Magnitude and direction of the exit velocity is taken as the criterion for determining the stability. Experimental work necessary to support theoretical results was also conducted.
(f) Completed.
(h) "Hydraulic Design of an Overfall Founded on Permeable Soils," by G. Subba Rao, Ph.D. Thesis, University of Minnesota (available through University of Minnesota Library), June 1962.

(4206) AN EXPERIMENTAL INVESTIGATION OF THE VARIATION OF VELOCITY DISTRIBUTION WITH TIME IN A DECAYING VORTEX.

(b) M. Sc. thesis study.
(f) Completed.
(g) Experiments were conducted in a circular tank with tangential inflow and with outflow through an outlet in the center of the tank floor. Velocity distributions were measured by photographs of confetti streaks for steady state vortices with different discharges through the tank and with different outlet diameters. Unsteady state velocity distributions were also measured in the same way for different instants after flow through the tank was stopped. The observed velocity profiles were compared with theory. By this comparison values of the kinematic eddy viscosity were estimated. Values of kinematic eddy viscosity for different runs were related by means of Kolmogoroff's theory of turbulence.
(h) "Experimental Study of Velocity Profiles in a Decaying Turbulent Vortex," by H. R. Whiteley, thesis submitted to University of Minnesota in partial fulfillment of requirements for M.S. in C.E. degree, 195 pp., March 1962.

(4207) THE INFLUENCE OF ENTRAINED GAS NUCLEI ON THE CAVITATION NOISE SPECTRUM MEASURED ON A TEST BODY IN A WATER TUNNEL.

(b) Laboratory project.
(c) Mr. F. R. Schiebe, Associate Scientist, St. Anthony Falls Hydraulic Laboratory.
(d) Experimental, basic research, Master of Science thesis.
(e) In this study the noise spectrum of cavitation was studied for cavitation which was slightly more developed than at incipience. The free gas content of the tunnel water was varied from two parts per million to greater than 300 parts per million by volume and the effect noted on sound spectrums obtained by hydrophones mounted on the tunnel wall and in the test body in the immediate region of the cavitation.
(f) Completed.
(g) Significant changes in the shape of the noise spectrum were noted and explained. The gas content of the nuclei reduces the intensity of the cavity collapse. The uncavitated nuclei in the surrounding water scattered and attenuated the noise made by the cavitating nuclei.
(h) "The Influence of Entrained Gas Nuclei on the Cavitation Noise Spectrum on a Test Body in a Water Tunnel," by F. R. Schiebe, Masters thesis, University of Minnesota, August 17, 1962.

(4209) THE INFLUENCE OF ELECTROKINETIC PHENOMENA ON THE HYDRAULIC AND ELECTROOSMOTIC PERMEABILITY OF UNIFORM VERY FINE SANDS.

(b) Laboratory project.
(d) Experimental and theoretical; Ph.D. thesis.
(e) Accurately sized, narrow range, angular quartz particles and spherical glass beads were tightly placed in a permeameter with reversible silver-silver chloride electrodes at the ends of the test section. Streaming potential, streaming current, electrical resistivity of low conductivity liquid, and filter velocity were precisely measured. Studies include: (1) Flow retardation from return electroosmosis; (2) analysis of electroosmotic permeability factors with respect to particle characteristics and hydraulic permeability, and (3) comparisons of streaming current and filter velocity at varying Reynolds numbers.
(g) It has been found that the streaming current-potential varies linearly with hydraulic gradient to a slightly higher Reynolds number than the filter velocity. Lack of complete deaeration causes a larger reduction in the filter velocity than the streaming. When "boiling" action takes place anomalous relations between the filter velocity and streaming current occur.

(4691) A STUDY OF DRAG REDUCTION BY THE USE OF NON-NEWTONIAN BOUNDARY LAYER ADDITIVES.

(b) David Taylor Model Basin, Department of the Navy.
(d) Analytical and experimental applied research.
(e) A study of boundary layer mechanics and resulting shear forces for high velocity pipe flow of dilute water solutions possessing non-Newtonian characteristics.

(4692) THE INTERFERENCE EFFECT OF SUPPORT BENTS ON THE BACKWATER EFFECT OF SUBMERGED CYLINDERS IN OPEN CHANNELS.

(b) Project conducted for master's thesis.
(c) Dr. Alvin G. Anderson, Professor, Civil Engineering, St. Anthony Falls Hydraulic Laboratory, Minneapolis 14, Minnesota.
(d) Experimental, for master's thesis.
(e) The problem of backwater arises in natural and artificial waterways when a pipe crosses a river beneath the surface. From preliminary tests, the backwater from support bents, built from pairs of cylindrical vertical pipes with wooden caps, and the backwater from cylindrical pipes transverse to the flow, cannot be added to give the backwater effect of the bents and transverse pipe in combination. It is my purpose to determine some means of estimating this interference effect.

(4693) JET FLAPS ON SUPERCAVITATING HYDROFOILS FOR LIFT CONTROL.

(b) Bureau of Ships, Department of the Navy.
(d) Experimental; basic research.
(e) Experimental research will be conducted in the free-jet water tunnel with both natural and artificial cavities. Jet momentum, lift, drag and moment will be measured, and the influence of the jet on the cavity and on the flow will be observed.

(4694) ANGAT PROJECT.

(b) Harza Engineering Co., Chicago; Engineering and Development Corp. of the Philippines, Manila; National Power Corporation, Manila.
(d) Experimental; applied.
(e) Experimental studies are being carried out on a 1:118 scale comprehensive model to verify proposed designs for the spillway structure and achieve optimum dimensions for the various components.

(4695) A STUDY OF THE HYDRAULIC EXIT GRADIENT FOR FLOW THROUGH A GRANULAR MEDIA.

(b) Laboratory project.
(c) Mr. Harvard Aas, Junior Engineer, St. Anthony Falls Hydraulic Laboratory, Univ. of Minnesota, Minneapolis 14, Minn.
(d) The project is for a master's thesis, classified as basic research, with theoretical and experimental aspects.
(e) The project deals with upwards flow through a granular media. Materials used were basalt and concrete sand with sizes ranging from 0.5 to 5 mm. The hydraulic conditions present when the flow through the granular bed transfers the bed from a dense to a fluidized state is studied.

(4696) THEORETICAL INVESTIGATION OF TWO-DIMENSIONAL UNSTEADY, SUPERCAVITATED HYDROFOIL FLOWS WITH FREE-SURFACE BOUNDARY CONDITIONS.

(b) David Taylor Model Basin, Dept. of the Navy.
(d) Theoretical, basic research.
(e) The main purpose is to find the unsteady force and moment acting on a supercavitated hydrofoil moving under a waving free surface.

(4697) KARNAFULI PROJECT.

(b) Agency for International Development.
(d) Experimental; applied research.
(e) Experimental review of flow conditions leading to partial failure of Karnafuli Spillway. Study will involve measurements of average and transient pressures in spillway area plus experimental and analytical studies of impact forces caused by logs passing over the spillway.

(4698) MANGLA DIVERSION OUTLET STUDIES.

(b) Harza Engineering Co., Chicago; Binnie and Partners, London; Government of Pakistan.
(d) Experimental; design review.
(e) Experimental studies were performed on a 1:144 scale comprehensive model and on a sectional model to assist in the review of preliminary plans for the diversion outlet structure at Mangla Dam. The outlet structure is designed for a possible diversion discharge of 300,000 cfs.
(f) Completed.
(g) The preliminary design was considered to be basically sound; further studies of the rip-rap design and energy dissipation in front of one tunnel were recommended.

(4699) FORCE CHARACTERISTICS OF A CAVITATING BODY IN A COMPRESSIBLE LIQUID MIXTURE.

(b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
(d) Experimental, basic research.
(e) Investigation of the force characteristics of a cavitating body in a flowing air-water mixture.

(4700) OSCILLATORY LIFT AND DRAG FORCES ON VENTILATED HYDROFOILS IN REGULAR WAVES.

(b) Office of Naval Research, Department of the Navy.
(d) Experimental; basic research.
(e) Investigation of the force characteristics of a ventilated hydrofoil of finite span with trailing edge flaps in both smooth and rough water.
(g) Experimental measurements were made in smooth water of the lift and drag for ventilated, flapped foils for a number of flap angles and cavitation numbers. Data extrapolated to zero cavitation number agreed well with theory. The oscillatory forces on a restrained, ventilated foil moving through a regular wave train were satisfactorily predicted with quasi-steady theory for small cavitation numbers. The agreement deteriorated somewhat at the higher cavitation numbers.

INTER-AGENCY SEDIMENTATION PROJECT IN COOPERATION WITH ST. ANTHONY FALLS HYDRAULIC LABORATORY.

(194) A STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS.

(b) Subcommittee on Sedimentation, Inter-Agency Committee on Water Resources, Personnel of the U. S. Army Corps of Engineers and the U. S. Geological Survey are actively engaged on the project.
(c) Engineer in Charge, Mr. Byrnon C. Colby, Federal Inter-Agency Sedimentation Project, St. Anthony Falls Hydraulic Laboratory, Hennepin Island and Third Avenue S. E., Minneapolis 14, Minnesota.
(d) Experimental; applied research and development.
(e) Drawings and specifications are available to facilitate the manufacture of suspended-sediment and bed-material samplers, particle-size analyzers and associated laboratory equipment. Approved designs for the measurement of suspended sediment include a single-stage sampler, 4-, 22- and 62-pound samplers, and electrically-operated samplers weighing 100 and 300 pounds. Samplers for the measurement of bed material include a piston type hand-operated sampler, a 30-pound hand-line sampler, and a 100-pound sampler for cable suspension. Additional apparatus embrace a sediment sample splitter, a bottom-withdrawal sedimentation tube for size analyses, and a visual-accumulation sedimentation tube with recording equipment for particle size analyses of sands. The primary objective of the current program is the development of an instrument to automatically record suspended-sediment concentrations in flowing streams.
(g) Field and laboratory tests have been continued on intermittent pumping type samplers, turbidimeters, and on electronic, ultrasonic and nuclear sensing devices. Improvement in the design of pumping type samplers have resulted from field tests by cooperating agencies. Field tests of the nuclear density probe will be continued in 1963. The design of the sedimentation chamber for the ultrasonic device has been improved, and a turbidity meter using transmitted light is being developed for measuring the concentration of particles suspended in a fluid. A report by Gordon Flammer is scheduled for publication in 1963 in the U.S. Geological Survey Bulletin 1141, under the heading "Ultrasonic Measurement of Suspended Sediment". A progress report is being prepared on electronic sensing of sediment. Report No. 14, titled "Determination of Fluvial Sediment Discharge," is being prepared for publication in 1963.
(h) "The Single-Stage Sampler for Suspended

Sediment," Report No. 13, 105 pages, 1961. "Investigation of a Pumping Sampler with Alternate Suspended-Sediment Handling Systems," Report Q - Progress Report, 90 Pages, June 1962.

SCRIPPS INSTITUTION OF OCEANOGRAPHY, University of California.

(4500) A STUDY OF INTERNAL WAVES IN THE OCEAN.

(b) Laboratory project.
(c) Dr. Charles S. Cox, The Scripps Institution of Oceanography, La Jolla, California.
(d) The project is theoretical, including field investigation and is basic research.

(4501) STUDY OF OCEANIC AND ATMOSPHERIC TIDES.

(b) Laboratory project.
(c) Mr. Frank Snodgrass, Institute of Geophysics and Planetary Physics, Univ. of Calif., San Diego, La Jolla, Calif.
(d) Basic research; both theoretical and field investigation.
(e) For the last forty years the study of ocean tides has been neglected. We are making use of two recent developments to undertake this study: (1) Pressure transducers capable of measuring ocean tides to the nearest centimeter in the open sea, and (2) modern high-speed computers capable (barely) of solving the partial differential equation for tide generation, subject to realistic boundary conditions. We propose to make a combined attack, with the theoretical approach serving to indicate critical locations for the deep-sea stations, and the recorded tides serving as a guide to the underlying theory (particularly with respect to the dissipation hypothesis).
We propose, furthermore, to analyze very long series of atmospheric pressure records for minor lunar tidal constituents, as a means of empirically establishing the resonance characteristics near twelve hours.

(4502) LONG RANGE OCEANOGRAPHY.

(b) Office of Naval Research laboratory project.
(c) Prof. Walter H. Munk, Assoc. Director, Institute of Geophysics and Planetary Physics, University of California, San Diego, La Jolla, California.
(d) Basic research; both theoretical and field investigation.
(e) Long ocean waves, with frequencies between 0.2 and 10 cycles per hour (cph), have been recorded simultaneously at La Jolla on the California coast and at San Clemente Island, about 100 km seaward. The spectral power is greatest at the lowest frequencies but remains fairly uniform (about x 10 cm /cph) between 0.7 and 10 cph. Comparison of the island and shore records shows that at the lowest frequencies (below 0.7 cph) the two records are consistently in phase and highly coherent, as might be expected; whereas above 0.7 cph they are out of phase, and the coherence is low. The phase reversal is fairly abrupt and suggests standing wave patterns, with the implication that the coast must be a good reflector. The failure of the coherence to recover after phase reversal suggests multiple modes, with an appreciable fraction of energy associated with in-phase modes even after most of the energy is out of phase. It is inferred that the observed waves are not only ones that cross the shelf from the deep sea but that comparable energy is present in "trapped" waves that have somehow been excited upon the shelf.
During the Chilean tsunami of 23 May 1960 precise readings were digitally recorded every 15 seconds by the La Jolla low-frequency wave instrument. The tsunami remained above background for a week. The record gave a good opportunity of measuring the decay of tsunami energy as a function of frequency. Energy is reduced by 1/e about once each half day. The decay is somewhat more rapid at high frequencies and at high energy densities.
By virtue of having measured the background spectrum and the dissipation spectrum we can now estimate the generation spectrum. It turns out that overtones of the frequency range 1 erg cm sec per unit frequency band must be transferred to the ocean in order for the spectrum to persist at the observed level. The inferred rate of dissipation of the tsunami agrees within a factor of 2 with the dissipation of tides as inferred from the motion of the moon and sun.
An attempt is made to interpret physically the observed decay time of tsunamis of approximately half day. For the Pacific Basin the "collision time" (mean free path divided by phase velocity) is of the same order as the damping time, and this suggests a substantial absorption during impact with the coastline. The "diffusion time" is the time required for the initial impulse to be sufficiently scattered so that the wave energy is essentially homogeneous throughout the Pacific basin and directionally isotropic. Apparently this chaotic condition is approached after a couple of collisions. There is a sustained leakage into the Indian and Atlantic Oceans (largely via the Indian Ocean); under favorable circumstances the leakage energy should be barely detectable in these other ocean basins.
An important problem is to specify the geographic and physical processes responsible for the dissipation of tsunami energy. Our contribution to this problem is minor. One feature that may have been overlooked is that in the case of narrow entrances into inland seas and harbors the "absorption cross section" is likely to exceed by a large factor the physical cross section of the mouth, and under favorable circumstances it may approach a wave length. There are many other possible mechanisms for dissipation: diffusion of energy into the porous rock of volcanic islands and coral reefs; dissipation beneath the Antarctic ice sheet; etc. Some of these are briefly discussed; the definitive study remains to be done.
Perhaps the most important news is that the digital tide recorder is now in operation. It records digitally every 5 minutes sea level to the nearest .05mm and atmospheric pressure to the nearest .1 dynes cm
We have made considerable progress with our system of data analysis BOMM. Some description was contained in last year's progress report where we stated that the system was about half completed. We now estimate that it is about 80% completed.

UNIVERSITY OF SOUTH CAROLINA, College of Engineering, Department of Civil Engineering.

Inquiries concerning the following projects should be addressed to Dr. Harold Flinsch, Civil Engrg. Department, University of South Carolina, Columbia, South Carolina.

(4) THE DEVELOPMENT OF SURFACE WAVES BY WIND.

(b) Laboratory project.
(d) General theoretical, experimental, and field research.
(e) Research on the theories of surface wave origin and growth, on measurements in the laboratory and in nature, and on the comparative results of theory and measurement. Equipment has been assembled for telemetering and recording wave height, period, and direction.
(g) A lake shore receiving and recording station is under construction.

(1631) THE EFFECT OF WAVES ON BEACHES.

(b) Laboratory project.
(d) General theoretical, experimental, and field research.
(e) Research on beach slopes and contours, in the laboratory and in nature.
(g) Eight-directional wave tank has been completed.

(1907) SHIP STABILITY AND ROLLING PERIOD.

(b) Laboratory project.
(d) General theoretical, experimental, and field research.
(e) Rolling and pitching period and metacentric height relationships are studied for stationary and moving ships, in still water and under wave action.
(g) Model experiments have been assembled in a brief report.

(4701) THE EFFECT OF TIDES ON HARBORS, BAYS, AND ESTUARIES.

(b) Laboratory project.
(d) General theoretical, experimental, and field research.
(e) A study of the scouring or shoaling effect of tidal currents in South Carolina harbors and estuaries.

SOUTHWEST RESEARCH INSTITUTE, Department of Mechanical Sciences.

(3826) HYDRODYNAMICS OF SHIP SLAMMING.

(b) Bureau of Ships, Department of the Navy (DTMB technical supervision).
(c) Dr. H. N. Abramson, Director, Department of Mechanical Sciences, Southwest Research Inst., 8500 Culebra Road, San Antonio 6, Texas.
(d) Theoretical; applied research.
(e) Study of pressure distribution on bodies of arbitrary cross-section entering a plane water surface.

(3828) STUDIES IN HYDROELASTICITY.

(b) Bureau of Ships, Department of the Navy (DTMB technical supervision).
(c) Dr. H. N. Abramson, Director, Dept. of Mechanical Sciences, Southwest Research Inst., 8500 Culebra Road, San Antonio 6, Texas.
(d) Experimental, theoretical; applied research.
(e) Present work includes the design, construction, and testing of flexible hydrofoil models to obtain data on unsteady hydrodynamic lift and moment for a variety of operating conditions.
(h) "An Aerodynamic Analysis for Flutter in Oseen-Type Viscous Flow," by W. H. Chu, Jour. Aerospace Sci., Vol. 29, pp. 781-789, July 1962.
Other Southwest Research Inst. Technical reports.

(4216) STUDIES OF FUEL SLOSHING.

(b) National Aeronautics and Space Admin., Marshall Space Flight Center.
(c) Dr. H. N. Abramson, Director, Department of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio 6, Texas.
(d) Theoretical and experimental; applied research.
(e) Studies of forces and moments in missile fuel tanks resulting from sloshing motions of fuel.
(h) "Some Notes on Liquid Sloshing in Compartmented Cylindrical Tanks," by H. N. Abramson, L. R. Garza and D. D. Kana, ARS Journal, Vol. 32, pp. 978-980, June 1962.
"Liquid Sloshing in Spherical Tanks," by H. N. Abramson, W. H. Chu and L. R. Garza, ARS Journal (in press).
Two additional Southwest Research Institute technical reports.

(4217) LIQUID DYNAMIC BEHAVIOR IN ROCKET TANKS.

(b) National Aeronautics and Space Administration, Washington, D. C.
(c) Dr. H. N. Abramson, Director, Department of Mechanical Sciences, Southwest Research Inst., 8500 Culebra Road, San Antonio 6, Texas.
(d) Theoretical and experimental; applied research.
(e) Studies of liquid dynamic behavior in elastic tanks.
(h) "Some Studies of Liquid Rotation and Vortexing in Rocket Propellant Tanks," by H. N. Abramson, W. H. Chu, L. R. Garza and G. E. Ransleben, Jr., Tech. Rept. No. 1 December 1960 (also, NASA Technical Note D-1212, January 1962.)
"A Discrepancy in the Published Results on Heat Transfer to Cryogenic Fluids," by W. Squire, Int. Jour. of Heat and Mass Transfer, Vol. 3, p. 347, (1961).
"Breathing Vibrations of a Circular Cylindrical Shell With an Internal Liquid," by U. S. Lindholm, D. D. Kana and H. N. Abramson, Jour. Aerospace Sci., Vol. 29, pp. 1052-1059, September 1962.
"Bending Vibrations of a Circular Cylindrical Shell Containing an Internal Liquid With a Free Surface," by U. S. Lindholm, W. H. Chu, D. D. Kana and H. N. Abramson, Tech. Rept. No. 4, March 1962 (also, preprint IAS Annual Meeting, January 1963).
One additional Southwest Research Institute technical report.

(4218) LIQUID MOTION IN SPHERICAL TANKS.

(b) Laboratory project.
(c) Mr. Wen-Hwa Chu, Senior Research Engineer, Department of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio 6, Texas.
(d) Theoretical; applied research.
(e) Analysis of liquid motion in spherical tank of arbitrary depth and development of equivalent mechanical analogy.
(f) Completed.
(h) "Liquid Sloshing in a Spherical Tank Filled to an Arbitrary Depth," by Wen-Hwa Chu, Southwest Research Institute Technical Rept., December 1962.

(4702) HYDRODYNAMICS OF SHIP ANTI-ROLL TANKS.

(b) Bureau of Ships, Department of the Navy (DTMB technical supervision).
(c) Mr. John F. Dalzell, Senior Research Engineer, Department of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio 6, Texas.
(d) Theoretical and experimental; applied research.
(e) Studies of forces and damping effects in passive anti-roll stabilization tanks for ships.

(4703) VIBRATION OF SUBMERGED ELASTIC PLATES.

(b) Bureau of Ships, Department of the Navy (DTMB technical supervision).
(c) Dr. H. N. Abramson, Director, Department of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio 6, Texas.
(d) Theoretical and experimental; applied research.
(e) Study of the vibration characteristics of elastic cantilever plates submerged in water.
(h) "Elastic Vibration Characteristics of Cantilever Plates in Water," by U. S. Lindholm, D. D. Kana, W. H. Chu, and H. N. Abramson, Tech. Rept. No. 1, Contract NObs-86396(X), Southwest Research Institute,

August 1962.

(4704) VIBRATION OF HYDROFOIL STRUCTURES.

(b) Bureau of Ships, Department of the Navy (DTMB technical supervision).
(c) Mr. Guido E. Ransleben, Jr., Senior Research Engineer, Department of Mechanical Sciences, Southwest Research Institute, 8500 Culebra Road, San Antonio 6, Texas.
(d) Theoretical and experimental; applied research.
(e) Study of the vibration characteristics of hydrofoil-type structures.

STANFORD UNIVERSITY, Department of Civil Engineering.

(1946) SYNTHESIS OF HYDROGRAPHS FOR SMALL AREAS.

(b) National Science Foundation.
(c) Prof. Ray K. Linsley and N. H. Crawford, Dept. of Civil Engineering, Stanford Univ., Stanford, Calif.
(d) Theoretical and field research.
(e) A study of the runoff process with a view to estimating the streamflow hydrograph from rainfall and eventually by statistical means.
(g) A simplified mathematical treatment of non-equilibrium overland flow has been developed. Studies on the computation of the hydrograph from rainfall excess by use of fluid mechanics and a statistical analysis of soil-moisture frequency are underway. A conceptual model has been programmed for the digital computer to permit synthesis of continuous streamflow from hourly rainfall. Testing and refinement of the model is underway. Analysis of results to develop procedures applicable to ungaged basins will follow.
(h) "Synthesis of Continuous Streamflow Hydrographs on a Digital Computer," by N. H. Crawford and R. K. Linsley, Tech. Rept. No. 12, Dept. of Civil Engineering, Stanford University, July 1962.

(2151) MODEL STUDY OF PETERS DAM CHUTE SPILLWAY.

(b) Laboratory project.
(c) Prof. John K. Vennard, Dept. of Civil Engrg., Stanford University.
(d) Experimental; engineer thesis.
(e) Comparison of spillway performance and design predictions.
(g) Experimental work completed; thesis being written.

(2614) PIPE FRICTION IN UNSTEADY FLOW.

(b) Laboratory project.
(c) Prof. John K. Vennard, Dept. of Civil Engineering, Stanford University.
(d) Experimental and analytical; Ph.D. thesis.
(e) Comparison of friction processes for steady and unsteady states.
(g) Experimental work completed and analyzed; thesis being written.

(3507) STUDY OF INFILTRATION.

(b) U. S. Public Health Service.
(c) Prof. Joseph B. Franzini, Dept. of Civil Engineering, Stanford University, Stanford, California.
(d) Theoretical investigation; laboratory and field studies; basic research; Ph.D. theses.
(e) An attempt is being made to develop relations between soil parameters and infiltration capacities. Investigation is being extended to unsteady unsaturated flow through soils as experienced in capillary rise, drainage, and infiltration situations.
(g) An analytic approach to the solution of unsteady unsaturated flow in soils has been developed. If the initial moisture condition and the hydraulic and capillary characteristics of the soil are known, the method permits prediction of the future disposition of soil moisture. Experimental equipment using a gamma source for moisture content determination is under construction.
(h) Thesis being written.

(3508) EVAPORATION SUPPRESSION.

(b) U. S. Public Health Service.
(c) Prof. Joseph B. Franzini, Dept. of Civil Engineering, Stanford University, Stanford, California.
(d) Laboratory and field investigations.
(e) Field studies with Class A evaporation pans have been employed to evaluate the evaporation reduction capabilities and biological attrition resistances of various monomolecular films. In a full scale program at a 40 acre lake methods of application of the film were investigated together with the effect of the film on biota.
(f) The research is being extended to a study of evaporation from soils. The effect of adding long-chain fatty alcohols to the soil to reduce evaporation is being investigated.
(g) Full scale field tests using hexadecanol on a 40 acre lake during the summer of 1960 gave an evaporation reduction of 18 percent.

(4219) SUPERCAVITATING HYDROFOIL THEORY.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Prof. R. L. Street, Dept. of Civil Engrg., Stanford Univ., Stanford, Calif.
(d) Theoretical, basic research for Ph.D. thesis.
(e) The forces on supercavitating hydrofoils having large curvature are being studied. In addition studies are being conducted on the effects of gravity and rotation on the forces acting on supercavitating hydrofoils and wedges.
(g) Rotation and gravity have been shown to have significant effects on forces acting in supercavitating flows. Additional theoretical work in progress.
(h) "A Linearized Theory for Rotational Supercavitating Flow," by Robert L. Street, Tech. Rept. No. 16, Department of Civil Engr., Stanford University, 1962. Other reports in preparation.

(4705) HYDRAULICS OF OPEN CHANNELS.

(b) Laboratory Project.
(c) Prof. Joseph B. Franzini.
(d) Theoretical investigation and experimental program; Ph.D. theses.
(e) Several aspects of open-channel flow are under investigation including (1) velocity and shear distribution in open channels having different cross-sectional shapes, (2) characteristics of flow in a channel that simulates the cross-section of a river. In particular, the case where supercritical flow in the main channel section changes to subcritical flow in the overbank-stage section is being investigated.
(f) Analytic approach to (1) above is underway. A 50 ft. flume for (2) above has been built and experimental work has commenced.

(4706) INVESTIGATION OF THIN-FILM LIQUID FLOW OVER SOLID BODIES OF DIFFERENT SHAPE.

(b) Laboratory project.
(c) Prof. Joseph B. Franzini.
(d) Theoretical and experimental investigation; Ph.D. thesis.
(e) The characteristics of thin-film liquid flow over solid bodies (spheres, ellipsoids, cones, cylinders, and composites) are being investigated. In later stages of the research it is anticipated that the results from flow over single bodies will be applied to packings so that the research can be extended to the hydraulics of trickling filters.

(f) Preliminary analysis for thin-film liquid flow over spheres and ellipsoids has been completed. Experimental rig is under construction.

(4707) FREE SURFACE FLOW OVER SPILLWAYS.

(b) Laboratory project.
(c) Prof. R. L. Street, Dept. of Civil Engr., Stanford Univ. Stanford, Calif.
(d) Theoretical, basic research for doctoral thesis.
(e) Analytic methods are being developed to determine the shape of the free surface on and up-stream of spillways.
(g) Theoretical work is in progress.

(4708) SEEPAGE FROM CHANNELS AND RESERVOIRS.

(b) Laboratory project.
(c) Prof. B. Perry, Dept. of Civil Engr., Stanford, Calif.
(d) Theoretical basic research for doctoral thesis.
(e) To determine effects of variable permeability and three dimensional flow in seepage problems.
(f) Completed.
(g) First and second order perturbation theories are given for seepage from ditches and ponds through different types of soils.
(h) "Hydrodynamics of Seepage from Channels and Reservoirs," by Ahmed El-Amin El-Nimr, Doctoral Dissertation, Dept. of Civil Engr. Stanford University June 1962. Report in preparation.

STEVENS INSTITUTE OF TECHNOLOGY, Davidson Laboratory.

(2154) INVESTIGATION OF SHIP MOTIONS AND HIGH SPEED SHIP FORMS.

(b) ONR and BuShips, Dept. of the Navy.
(c) Prof. Earl M. Uram, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
(d) Theoretical and experimental; basic research.
(e) The development of a calculation method for predicting ship motions in a seaway. Investigation of hydrodynamic and motion characteristics of high speed ship forms for supercritical operation in search of considerable improvement of seakeeping qualities and powering requirements.
(g) Parametric studies utilizing analog and digital computers of the stability, powering, and design characteristics of a semi-submerged craft similar in nature to a shallow-running submarine incorporating a surface piercing hydrofoil system to provide inherent heave, pitch and roll stability. Towing tank tests of a model of the craft are scheduled. An analytical study to determine the optimum drag configurations for such semi-submerged vehicles is also in progress. Calculations to determine ship motions in quartering seas are planned.
(h) "Research on High Speed Ship Forms," by E. M. Uram, Fourth Symposium - Ship Behavior at Sea, Stevens Institute of Technology, June 1962.

(2155) SEAKEEPING QUALITIES OF SHIPS AT ALL HEADINGS TO WAVES.

(b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
(c) Mr. P. A. Lalangas, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
(d) Theoretical and experimental; basic research.
(e) To investigate the coupled responses of ship models at all headings to waves in order to assist in the prediction of sea-keeping qualities and to evaluate means of reducing or controlling ship motions so as to increase sea speeds. Three specific objectives are: (1) Extension of theoretical work on the lateral forces acting on spheroids at a free surface to cover the case of a thin ship. (2) Measurements of sway force and yaw moment exerted by waves on a completely restrained surface ship model (Series 60, 0.60 block coefficient). (3) Experimental investigation of the applicability of linear systems analysis techniques to rolling and swaying motions of a ship model in irregular long-crested beam seas.
(g) Good agreement is shown between strip theory calculations and measured forces and moments exerted by waves on a completely restrained surface ship model.
(h) "Measurements of the Mean Lateral Force and Yawing Moment on a Series 60 Model in Oblique Regular Waves," by P. G. Spens and P. A. Lalangas, Davidson Laboratory Report 880.
"Lateral and Vertical Forces and Moments on a Restrained Series 60 Model at Zero Speed in Oblique Regular Waves," by P. A. Lalangas, Davidson Laboratory Report 920.

(2390) CONTROLLED FINS FOR REDUCING SHIP PITCHING.

(b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
(c) Mr. P. G. Spens, Davidson Laboratory, Stevens Institute of Tech., 711 Hudson St., Hoboken, New Jersey.
(d) Experimental and analytical; applied research.
(e) To determine the most desirable action of controllable fins at the bow or stern of a ship to reduce pitching in regular and irregular head seas.
(f) Completed.
(g) Model tests have been made with servo-controlled oscillating stern fins, with and without fixed bow fins, in regular and irregular waves. It appears that the reduction in extreme pitching motions in irregular waves is of the same order as the pitch reduction in regular waves. For a Mariner class ship, oscillating stern fins give a pitch reduction of 2 degrees (double amplitude) for an oscillating fin force of about plus or minus 250 tons.
(h) "Research on the Reduction of Pitching Motions of Ships by Controllable Fins," by Paul G. Spens, D. L. Report 913, July 1962.

(2393) MOTIONS AND BENDING MOMENTS OF SHIPS IN WAVES.

(b) Bureau of Ships, Department of the Navy (DTMB Technical Supervision).
(c) Mr. Edward Numata, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Experimental and analytical; applied research
(e) Measurements of motions and external bending moments and shear of a jointed model of a high-speed naval vessel underway in irregular head waves of various degrees of severity in a towing tank. Results have been analyzed by cross-spectral techniques to determine frequency response functions, and indicate degree of applicability of superposition theory to ship response in extreme seas.
(f) Completed.
(h) "Some Further Experiments on the Application of Linear Superposition Techniques to the Responses of Destroyer Model in Extreme Irregular Long-Crested Head Seas," by John F. Dalzell, Davidson Laboratory Preliminary Report 918, September 1962.

(2616) THE BLADE-FREQUENCY FORCE GENERATED BY A PROPELLER ON A BODY OF REVOLUTION.

(b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
(c) Dr. J. P. Breslin, Director, and Dr. S. Tsakonas, Head of Fluid Dynamic Division,

Davidson Laboratory, Stevens Institute of Tech., 711 Hudson Street, Hoboken, N. J.
(d) Theoretical; applied research.
(e) The purpose is to evaluate the importance of the pulsating near field of the propeller in generating vibratory forces on ships and to determine the attenuation of these forces with tip clearance and number of blades. Case of axial propeller in water has been evaluated. Case of offset propeller near an infinitely long cylinder has also been analyzed.
(g) Results indicate that small amplitude vibratory force can be attributed to the oscillating pressure field generated by an operating marine propeller.
(h) Report in preparation.

(3516) INVESTIGATION OF HULL BENDING MOMENTS IN WAVES OF EXTREME STEEPNESS.

(b) Ship Structure Committee.
(c) Mr. Edward Numata, Davidson Laboratory, Stevens Institute of Tech., 711 Hudson St., Hoboken, N. J.
(d) Experimental; applied research.
(e) Model tests were carried out to determine midship bending moments in very steep waves. Objective is to determine if an upper limit of wave bending moments exists. Six models were tested over a moderate range of speeds in waves of various lengths and several heights.
(f) In final stage.
(g) Bending moment is found to be linear in waves of small and moderate steepness. Nonlinearity with wave steepness of bending moment appears with very high waves and its nature varies with wave length and model. No dramatic upper limits of midship wave bending moment have been found.

(3830) RADIATION OF A MARINE PROPELLER PRESSURE WAVE FROM ELASTIC PLATE AND CYLINDER.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Dr. S. Tsakonas, Head of Fluid Dynamics Div. and C. Y. Chen, Research Engineer, Davidson Laboratory, Stevens Institute of Tech., 711 Hudson St., Hoboken, N. J.
(d) Theoretical; applied research.
(e) The purpose is to evaluate the sound pressure field radiated from the pulsating boundary of an elastic plate and cylinder when these are subjected to vibratory pressures generated by a marine propeller. This study will determine the extent of the contribution of the elastic boundary in amplifying the sound level generated by a propeller.
(g) A formal solution for the case of an elastic cylinder has been obtained in the transform plane. Expressions for the velocity potential for the scattered and reduced waves with the corresponding pressure signals have been developed. Limiting cases for the far-acoustic field and near-hydrodynamic field are being considered. Calculations made for the far-field case indicate the pressure signal obtained from the rigid body scattering mechanism is the most important contribution in the case of cylindrical beam whereas the radiated component of the pressure is the main contribution in the case of the infinitely long elastic plate.
(h) Report in preparation.

(3832) FORMULATION OF EQUATIONS FOR SUBMARINE TRAJECTORIES WITH SIX DEGREES OF FREEDOM.

(b) David Taylor Model Basin, Dept. of the Navy.
(c) Mr. James White, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
(d) Theoretical; applied research.
(e) Equations of a very general nature are being formulated to study the transient and steady state turning motion of deeply submerged submarines.
(f) Completed. Preliminary report in preparation.
(g) Partial differential equations for the motion of a deeply submerged submarine with six degrees of freedom are being written in accordance with the SNAME, "Nomenclature for Treating the Motion of a Submerged Body Through a Fluid". The hydrodynamic forces and moments will be expressed in terms of third order Taylor series expansions which contain all of the cross-coupling terms. Particular emphasis is being placed on the terms expressing roll instability due to yaw and pitch. The thrust exerted on the submarine is to be expressed as a function of speed of advance and propeller R.P.M. The effects of the interaction of bow planes on stern planes, the effect of propeller R.P.M. on stern plane effectiveness, and the effect or changes in ballast are also included.
(h) Final report in preparation.

(3833) EXPERIMENTAL AND ANALYTICAL STUDY OF FLUTTER OF SUBMERGED HYDROFOILS.

(b) David Taylor Model Basin, Office of Naval Research, Navy Dept.
(c) Mr. Charles J. Henry, Research Engineer, Davidson Laboratory, Stevens Inst. of Tech., Hoboken, N. J.
(d) Experimental and theoretical; basic research.
(e) To determine experimentally the conditions for flutter of submerged hydrofoils and to compare theoretical and experimental results.
(f) Completed.
(g) Measured flutter speeds did not agree with those predicted using aeroelastic flutter theory for a two degree of freedom system in two-dimensional flow. The predicted asymptotic behavior of flutter speed with decreasing density ratio was confirmed experimentally but at lower values. Discrepancies were found between the measured and predicted decay rates from an initial disturbance at and below the flutter speeds, whereas the measured and predicted response frequencies and complex amplitude ratio were in agreement in all cases. The added mass forces were found to be more accurately represented by the theory than the circulatory forces.
(h) "Hydrofoil Flutter Phenomenon and Airfoil Flutter Theory - Volume II: Center of Gravity Location," by Charles J. Henry and M. Raihan Ali, Davidson Laboratory Report 911, July 1962.

(4220) ANALYTICAL INVESTIGATION OF COURSE STABILITY AND STEERING QUALITIES OF SHIPS.

(b) David Taylor Model Basin.
(c) Miss Winnifred R. Jacobs, Senior Research Engineer, Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
(d) Theoretical; applied research.
(e) Data available on 8 Taylor Series models are being reanalyzed in order to develop a rational method for estimating the course stability and steering qualities of ships.

(4221) UNSTEADY FORCES AND MOTIONS ON A HYDROFOIL MOVING UNDER AN IRREGULAR SEA.

(b) Office of Naval Research, Fluid Mechanics Branch, Dept. of the Navy.
(c) Dr. S. Tsakonas, Head of Fluid Dynamics Div. and Mr. Charles Henry, Research Engineer, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
(d) Theoretical and experimental; applied research.
(e) To determine by model tests and basic analytical studies the unsteady forces acting on a fixed, non-cavitating, finite-aspect-ratio hydrofoil and the motions of a single hydrofoil (elastically supported) when submerged and moving under an irregular

seaway.

(4222) APPLICATION OF LIFTING SURFACE THEORY TO MARINE PROPELLERS.

(b) David Taylor Model Basin, Bureau of Ships, Navy Dept.
(c) Dr. J. Shioiri, visiting scientist from Tokyo University, and Dr. S. Tsakonas, Head of Fluid Dynamics Division, Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
(d) Theoretical; applied research.
(e) To adapt the existing lifting-surface theory of aerodynamics to the marine propeller case and to study the resulting surface integral equation for various chordwise and spanwise loading distributions. The purpose of this study is to evaluate the blade loading more realistically in terms of the geometric characteristics of the propeller and the inflow conditions, since the loading is immediately related to vibratory thrust and torque, to ship vibration and to underwater sound generators.
(g) The surface integral equation has been derived and the case of a propeller represented by the Weissinger three-dimensional model has been considered. Calculations for the evaluation of the kernel have been made at various order of harmonics for sector type blade at different blade ratios and pitch of advance of a four-bladed propeller. Results indicate that the overall correction from the two-dimensional to three-dimensional is much more pronounced in the stationary case than in the unsteady flow case.
(h) Report in preparation.

(4223) MARINE PROPELLER NOISE DUE TO BLADE THICKNESS.

(b) Bureau of Naval Weapons, Navy Department.
(c) Dr. S. Tsakonas, Head of Fluid Dynamic Division and Miss W. R. Jacobs, Senior Research Engineer, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
(d) Theoretical; applied research.
(e) To investigate theoretically the effect of the propeller blade thickness on the pressure signal for the acoustic and hydrodynamic field cases.
(f) Discontinued due to lack of funds.

(4224) INFLUENCE OF AFTERBODY SHAPE ON ANGULAR HARMONIC CONTENT OF THE WAKE OF SINGLE SCREW SHIPS.

(b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
(c) Dr. J. P. Breslin, Director, Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.
(d) Theoretical; applied research.
(e) Analyses of existing wakes of 20 foot models to determine the variation of 3rd, 4th and 5th blade angular harmonic coefficients with hull shape. Theoretical analysis of potential wake of thin ship forms having U- and V-shaped stern sections.
(g) The approximate three-dimensional closed form solution for the axial velocity ratios in the wake at the propeller plane was determined and applied to the specific case of U- and V-shaped body profiles. Using thin ship theory, the approach consisted of determination of the potential function for a distribution of three-dimensional sources. The strength of the source system was assumed to be proportional to the slope at the ship surface. The forebody contribution was found by inspection to be negligibly small. Free surface effects were neglected.
An exact and an approximate two-dimensional closed form solution, obtained from the approximate three-dimensional treatment, was obtained and the axial velocity ratios computed in the wake at the plane of the propeller.
Harmonic analyses of both the approximate three-dimensional and approximate and exact two-dimensional results at the plane of the propeller were conducted, by means of an IBM 1620 computer, to determine the amplitude content of the second through fifth harmonics.

(4225) INVESTIGATION OF SURFACE PIERCING STRUTS.

(b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
(c) Mr. Daniel Savitsky, Manager, Applied Mechanics Group, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Experimental; applied research.
(e) To determine the total drag, side force and spray drag component on vertical surface piercing struts as a function of thickness ratio; depth of submersion; angle of yaw and leading edge radius.
(f) Completed.
(g) The combined effect of free surface and lower tip on the residue drag (so-called spray drag and tip drag) was found to decrease with reduction of leading edge radius and thickness ratio going down to a negative effect for the lowest thickness and leading edge radius used.
Side force measurements were made of one strut model at different aspect ratios and speeds and three yaw angles (α = 0°, 3°, 6°). At the low aspect ratios used (0.5 to 3.0), the side force slope

$$\frac{dC_s}{d\alpha}$$

is found to be approximated by the empirical relationship

$$\frac{dC_s}{d\alpha} = \frac{1}{.36 + \frac{1}{2AR}}$$

(h) "Experimental Study of Surface Piercing Struts," by Stephen Chen, Davidson Lab. Report 930, December 1962.

(4226) INVESTIGATION OF SURFACE-PIERCING FULLY VENTILATED DIHEDRAL HYDROFOILS.

(b) Office of Naval Research, Dept. of the Navy.
(c) Mr. P. Ward Brown, Chief of High Speed Craft Division, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson Street, Hoboken, N. J.
(d) Experimental and theoretical; applied research.
(e) A continuing investigation aimed at providing basic design information on three-dimensional hydrofoils operating near a water surface, under conditions of either fully ventilated flow or fully cavitated flow. To date the forces and moments on a series of surface piercing dihedral hydrofoils have been measured and the dynamics of systems employing such foils has been studied, including the problem of a hydrofoil impacting on the water surface and the stability of hydrofoil craft.
(g) Analytical expressions for the forces and moments on surface piercing fully ventilated dihedral hydrofoils have been obtained and confirmed experimentally. A theory covering the impact phenomena of hydrofoils, and particularly applicable to seaplanes, has also been evolved and confirmed by experiment. A parametric study of the effect of system geometry on hydrofoil system dynamic stability has been completed. In order to check the stability theory a simple experimental free oscillation technique has been developed and has been used to obtain direct verification of the theoretical expressions for the stability derivatives. Forthcoming reports will present the findings of the stability

investigation and will extend the data on forces and moments to include the effect of sweep and taper.

(h) "Experimental Determination of Surface-Piercing, Fully Ventilated Hydrofoil Stability Derivatives by a Free Oscillation Technique," by Gerard Fridsma and P. Ward Brown, D. L. Report 897, November 1962. "Hydrofoil Motions in Irregular Seas," by Richard P. Bernicker, D. L. Report 909, November 1962.

(4227) SMOOTH WATER BEHAVIOR OF SURFACE-PIERCING HYDROFOIL VESSEL.

(b) Office of Naval Research, Fluid Dynamics Branch, Navy Dept.

(c) Mr. A. Strumpf, Head Underwater Weapons Div., Davidson Lab., Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.

(d) Theoretical and experimental; applied research.

(e) An experimental and theoretical study is being made of the smooth water operation of a 110-ton craft supported by a tandem set of surface-piercing hydrofoils. The aim of the study is to develop equations of motion and obtain the hydrodynamic data necessary to permit the behavior of the hydrofoil boat to be predicted in the case of coupled six degree of freedom motions. Previous work has been restricted mainly to the study of the pure pitching and heaving motions of various types of hydrofoil systems.
In the experimental phase of the present study, the rotating arm facility is being used to measure three orthogonal forces and three moments acting on each foil under a variety of combinations of depth, pitch angle, sideslip angle, roll angle, turning angular velocity, Froude number, and control surface angles. The results will yield realistic hydrodynamic data that can be used both in structural and motion analyses of the system.
The steady turning performance of the vehicle will be predicted theoretically and compared with the experimental results. General dynamic stability criteria will be formulated and used to predict the stability of the vehicle. Various types of motions of the hydrofoil boat will be investigated theoretically, making use of theoretical and experimental force and moment data in the predictions.

(g) The experimental results show that the lift developed by the rear foil is reduced appreciably by the pressure of the forward foil. The rear foil also ventilates under design conditions. For the first time a number of hydrodynamic derivatives with respect to turning angular velocity were obtained from the experimental test results.

(h) Progress Reports may be obtained through Correspondent.

(4228) FLUTTER OF HYDROFOILS ON FLEXIBLE STRUCTURES.

(b) David Taylor Model Basin, Bureau of Ships, Dept. of the Navy.

(c) Mr. Charles J. Henry, Research Engineer, Davidson Laboratory, Stevens Inst. of Tech., Hoboken, N. J.

(d) Theoretical; basic research.

(e) The variation of flutter speed and frequency will be found for a hydrofoil connected to a free-free beam. The effects of including varying numbers of modes for beam and foil will be investigated. In addition, the effect of beam parameters will be studied. The beam-foil system will, in the final analysis, represent as close as possible a ship-rudder system.

(4229) THE BOUNDARY LAYER UNDER PROGRESSIVE AND STANDING WAVES.

(b) Office of Naval Research, Dept. of the Navy.

(c) Dr. S. J. Lukasik, Chief, Fluid Physics Division, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.

(d) Experimental, theoretical, and field investigations; basic research.

(e) The purpose of this work is to study energy loss processes in shallow water waves. Theoretically, this is of interest because unsteady viscous flows have received relatively little attention, particularly the case of an oscillatory flow with no mean flow. Analytical and numerical solutions of the non-linear Navier-Stokes equations are under investigation. Laboratory measurements in the Stevens shallow water wave channel have been made of the wave attenuation coefficient of a progressive wave, the bottom shear stress under a progressive wave, and the time decay of standing waves. Field measurements of the bottom pressure and bottom velocity in 40 foot depths have been made off Block Island, R.I. These field measurements provide the possibility of determining the applicability of the laboratory measurements and the theoretical studies to the geophysical problem of the energy loss by ocean waves in shallow coastal waters.

(g) It has been established in laboratory experiments both at Stevens and MIT that there is an attenuation coefficient for shallow water waves that is in order-of-magnitude agreement with simple theoretical predictions. When examined in detail, however, the measured attenuation is slightly in excess of the prediction. by about 40%. An analytical solution of the Navier-Stokes equation after the start-up of a progressive wave including the largest terms in the non-linear convective acceleration has shown that these terms cannot be responsible for the excess attenuation. Ocean swell measurements of the bottom pressure, potential velocity, boundary layer velocity, and bottom shear stress have shown agreement with predictions based on existing potential and viscous flow theories.

(h) "Pressure-Velocity Correlations in Ocean Swell," by S. J. Lukasik, et al, J. Geophys. Res., 67 3575(A), (1962).
"Laminar Boundary Layer Under a Wave," by C. E. Grosch, Phys. Fluids, 7 1163, (1962).

(4231) PREDICTION OF TRAJECTORIES OF AN UNDERWATER MISSILE.

(b) Bureau of Naval Weapons, Dept. of the Navy.

(c) Mr. Howard Dugoff, Research Engineer, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, N. J.

(d) Theoretical investigation; applied research.

(e) The main purpose of the study is to determine whether the observed underwater flight of the Basic Finner Missile can be predicted using equations of motion and hydrodynamic coefficients obtained from experiment or theory. The project is part of a larger program, sponsored by the Bureau of Naval Weapons, to verify present-day trajectory prediction methods.

(f) Completed. Final report is to be published.

(g) Trajectories could not be predicted successfully using hydrodynamic coefficients obtained from the experimental data alone. However, theoretical coefficients yielded predictions which agreed well with the observed (planar) motions. The computed trajectories were particularly sensitive to changes in individual hydrodynamic static and damping rate coefficients. However, when the values of these coefficients were kept consistent with relations expressing their physical interdependence, they could be varied over fairly wide ranges without appreciably affecting the predictions.

(h) "Prediction of Trajectories for an Underwater Missile," by Howard Dugoff, DL Report

No. 898, to be published.

(4709) SURFACE PIERCING HYDROFOIL FLUTTER.

(b) David Taylor Model Basin, Office of Naval Research, Dept. of the Navy.
(c) Mr. Charles J. Henry, Research Engineer, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson Street, Hoboken, N. J.
(d) Theoretical and experimental; applied research.
(e) Measured and predicted flutter speeds will be compared for a surface piercing hydrofoil with two degrees of freedom.

(4710) FLUTTER OF HYDROFOILS ON FLEXIBLE STRUCTURES.

(b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
(c) Mr. Charles J. Henry, Research Engineer, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Theoretical; basic research.
(e) The variation of flutter speed and frequency will be found for a hydrofoil connected to a free-free beam. The effects of including varying numbers of modes for beam and foil will be investigated. In addition, the effect of beam parameters will be studied. The beam-foil system will, in the final analysis, represent as close as possible a ship-rudder system.

(4711) STUDY OF THE PROPELLER SINGING PHENOMENON.

(b) David Taylor Model Basin, Office of Naval Research, Dept. of the Navy.
(c) Dr. S. Tsakonas, Head of Fluid Dynamics Division, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson St., Hoboken, New Jersey.
(d) Theoretical; applied research.
(e) To study the propeller singing phenomenon as a self-excited vibration system composed of the Karman vortex-shedding mechanism and the propeller blade.

(4712) INTERFERENCE EFFECTS OF A SUBMERGED HYDROFOIL ON A SURFACE-PIERCING STRUT.

(b) Office of Naval Research, Department of the Navy.
(c) Mr. Y. Chey, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Experimental and theoretical; applied research.
(e) To conduct experimental and theoretical studies on the mutual interference effects between a submerged hydrofoil and a vertical surface-piercing strut with respect to total lift, total drag, hydrofoil drag, side force, roll moment, and inception of ventilation.

(4713) EXPERIMENTAL STUDY OF PROPELLER-INDUCED VIBRATORY PRESSURES ON SIMPLE SHIP SURFACES.

(b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
(c) Mr. T. Kowalski, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Experimental; applied research.
(e) To measure the vibratory pressure signatures of a marine propeller model operating in uniform flow adjacent to a horizontal circular cylinder representing a ship hull, and to compare these results with theoretical predictions.

(4714) RESEARCH ON SHIP CONTROLLABILITY.

(b) Maritime Administration, U. S. Department of Commerce.
(c) Mr. C. L. Crane, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Experimental; applied research.
(e) To survey recent developments in the field of steering and maneuvering of ships, thus providing a basis for planning a long range research program. An initial investigation, now completed, covered the general steering characteristics of the Series 60, 0.60 block coefficient hull form taken as representative of a typical high-speed cargo ship. Future work will include (1) a model series investigation to obtain the effects on controllability of systematic variations in underwater hull and appendage characteristics, (2) full-scale steering and maneuvering tests of a merchant ship in calm water, and (3) model steering tests in quartering seas.
(g) Good agreement between the Series 60 model free turning test results and predictions based on force and moment derivatives from rotating arm tests indicate that the linear motion prediction method is a useful tool for analyzing steering qualities. Frequency response and harmonic analysis techniques were used with the derivative results to predict model zig-zag maneuvers.
(h) "Research on Ship Controllability," by H. Eda and C. L. Crane, Part I: Survey and Long Range Program, D. L. Report 922; Part II: Steering Characteristics of the Series 60 (C_b = 0.60), D. L. Report 923.

UNIVERSITY OF TEXAS, Department of Civil Engineering.

Inquiries concerning Projects Nos. 2162, 2397, 3524, 4234, 4235 and 4715 should be addressed to Dr. Walter L. Moore, Dept. of Civil Engineering, Univ. of Texas, Austin 12, Texas.

(2161) CHARACTERISTICS OF A HYDRAULIC JUMP AT AN ABRUPT CHANGE IN BOTTOM ELEVATION.

(b) University of Texas Research Institute and Bureau of Engineering Research.
(c) Dr. Carl W. Morgan, Assoc. Prof. of Civil Engineering, Univ. of Texas, Austin, Texas.
(d) Experimental.
(e) Experimental determinations are made of the flow characteristics at two-dimensional channel drops and rises. The velocity distribution and surface profile will be determined throughout the length of the jump for various relative changes in bottom elevation. The longitudinal location of the jump in relation to the change in bottom elevation will be varied over a broad range in distinction to previous related investigations in which relative location of the jump was held constant.
(g) Results for the abrupt drop are complete and have been published. For a given entering Froude number lying between 2 and 8 three types of jump may form, the type and its longitudinal location depending only on the relative downstream depth. The velocities near the bottom below the drop are always less than the mean velocity in the downstream channel for the jump type of maximum height. Experimental measurements have been made on the related investigation for an abrupt rise and report is being prepared.

(2162) HYDROLOGIC STUDIES, WALLER CREEK WATERSHED.

(b) Cooperative with U. S. Geological Survey.
(d) Field investigation; applied research.
(e) Measurements of rainfall and runoff for a 4 square mile and a 2 square mile portion of the Waller Creek watershed are being made to provide basic information for estimating runoff from small urban watersheds in the Southwest area. Two stream flow stations and a rain gage net are in operation. Studies of the correlation between runoff, rainfall, and the characteristics of the drainage basin are being made by various proposed methods to serve as a base for

comparison with the data as it is collected from the stream.

(g) The records are now long enough to begin comparing with peak discharge estimates previously given at least for short recurrence intervals. A start is being made on this analysis.

(2397) EFFECT OF UPSTREAM DEVELOPMENT ON THE RUNOFF FROM SMALL WATERSHEDS IN THE SOUTHWEST.

(b) Laboratory project.
(d) Field investigation (thesis).
(e) For selected watersheds rainfall runoff relations are being developed on a storm by storm basis. Multiple correlation diagrams, based on data before changes in the watershed, have been developed and used to compute runoff for later periods. Comparison of these computed runoff values with measured values is taken as an index of the effect of watershed development.
(g) The first results were not conclusive because of random error in the computed values. Further studies are being made on another watershed with an improved method which better accounts for the spacial variation of rainfall.

(2874) AN INVESTIGATION OF THE SCOUR RESISTANCE OF COHESIVE SEDIMENTS.

(b) The University of Texas Research Institute.
(c) Dr. Frank D. Masch, Department of Civil Engineering, The University of Texas, Austin 12, Texas.
(d) Analytical and experimental (laboratory).
(e) Exploratory tests have been made with two different schemes, one with radially outward flow between a circular disc and the soil sample, and one with a submerged vertical circular jet impinging on a horizontal soil surface. With the first scheme it was not possible to obtain the necessary precision of measurement at low scour rates, but with the second scheme satisfactory measurements were obtained. A correlation based on dimensional analysis gave consistent results in evaluating the relative scour resistance of several materials. Apparatus has been fabricated for a new test which permits direct evaluation of the shear stress at the soil surface. In this test a cylindrical soil sample is submerged in a transparent concentric cylinder which can be rotated at a controlled speed to generate a shear stress on the soil surface. Attempts are being made to relate the scour resistance to other measurable soil properties, and finally to interpret the results in relation to field observations.
(g) The apparatus to determine shear stress at the soil surface has been constructed and calibrated, a test procedure has been developed, and tests have been conducted on soil samples.
(h) "Experiments on the Scour Resistance of Cohesive Sediments," by W. L. Moore and F. D. Masch, Jour. Geophysical Research. Vol. 67, No. 4, April, 1962.

(3522) LONG TIME FLUCTUATIONS IN STREAM RUNOFF.

(b) Laboratory project.
(c) Dr. Carl W. Morgan, Dept. of Civil Engrg., Univ. of Texas, Austin 12, Texas.
(d) Analytical and field study.
(e) Values of runoff from selected drainage areas in the lower Mississippi River Basin and in basins of the rivers emptying directly into the Gulf of Mexico were studied. Variations in the runoff values for each stream were considered and these trends compared with solar variations. The relative sunspot numbers were used as the measure of solar variations and were correlated with the mean annual runoff. Further correlations are being made with different "lag" periods between solar activity and surface runoff.
(g) The gradual shifting of the centers of runoff excess and deficiency is consistent rather than random and appears to represent a gradual cyclic change in the runoff pattern It appears that the locations of the centers of runoff deficiency are following roughly the same path that they did some 22 to 24 years previously. Correlation coefficients of plus 0.2 to plus 0.5 are obtained for selected rivers in Mississippi, Alabama, Georgia, and Arkansas when sunspot numbers in the 11-year sunspot cycle are correlated with runoff. Texas streams do not give significant correlation with the 11-year sunspot cycle but give better correlation if runoff is compared with the double sunspot cycle in which sunspot numbers are assumed as negative in alternate cycles.

(3524) GROUND WATER FLOW AND SEEPAGE IN NON-HOMOGENEOUS, NON-ISOTROPIC SEDIMENTS.

(b) Laboratory project.
(d) Theoretical, basic.
(e) A relaxation solution for the Laplace equation has been developed which is applicable across a boundary between two regions of different permeabilities. It is believed that the method can be expanded to apply to any specified non-homogeneous and non-isotropic condition. It is intended that the solution be set up for computation on an electronic computer and that selected numerical solutions be checked against those from an electrolytic tank.

(4234) EVAPORATION REDUCTION BY CONTROL OF ADVECTED ENERGY.

(b) Partial sponsorship by the Lower Colorado River Authority of Texas.
(d) A Master's thesis involving theoretical and field investigation.
(e) Measurements have been made to determine the temperature field in Lake Travis for the 1962-63 season. A method was developed to estimate the effect of withdrawing water from near the lake surface. Monthly estimates of the resulting temperature field and reduction in evaporation were made.

(4235) TWO-PHASE FLOW IN CONDUITS.

(b) Laboratory project.
(d) Experimental master's thesis.
(e) It is apparent that for a two-phase flow system with a liquid and gas, many different types of flow are possible. This investigation explored the use of sound measurements to detect the type of flow present, in a metal pipe. Various types of flow were established in a thin-walled aluminum pipe, 1.66 I.D., with a transparent plastic section at each end. Records of the sound pattern were made with different pick-ups and correlated with the visual observation of the flow type. Magnetic tape records of the sound were also made.
(g) Study of the recorded sound patterns revealed some identifiable characteristics related to the type of two-phase flow in the line. Additional work is needed to refine techniques and try other sound pick-up and recording methods.

(4715) CONTROL OF CROSS WAVES IN AN OPEN CHANNEL DOWNSTREAM FROM A CURVE WITH SUPER-CRITICAL FLOW.

(b) Laboratory.
(e) Various methods have been investigated for controlling cross-waves in an open channel downstream from a curve with super-critical flow. A simple method that has not been previously investigated is the design of radius and deflection angle so that the

disturbance caused at the entrance to the curve will be cancelled by the one caused at the end of the curve. Laboratory studies were made to explore this method.

(g) Preliminary results indicate that the curve can be so proportional as to effectively eliminate cross waves in the downstream channel. The disturbance within the curve remains large as predicted by the work of Ippen.

(4716) DRAG FORCES IN VELOCITY GRADIENT FIELDS.

(b) David Taylor Model Basin, Dept. of the Navy.
(c) Dr. Frank D. Masch and Dr. Walter L. Moore, Department of Civil Engineering, The Univ. of Texas, Austin 12, Texas.
(d) Theoretical and experimental; basic research.
(e) The investigation is being conducted to determine the effect of a velocity gradient on the local and conventional drag coefficients for cylinders of varying L/D ratio and at different Reynolds Numbers. The study will be extended to other shapes.

(g) Preliminary studies have demonstrated that the velocity gradient along a cylinder affects the drag coefficient. The local drag coefficient decreases along the cylinder in the direction toward the end of the cylinder where the velocity is high The reduction in drag coefficient is related to a dimensionless measure of the velocity gradient along the cylinder.

(h) "Drag Forces in Velocity Gradient Flow," by F. D. Masch and W. L. Moore, Jour. Hyd. Div., Proc. A.S.C.E., Vol. 86, No. HY 7, July, 1960.

(4717) TWO-FLUID FLOW IN A POROUS MEDIUM.

(b) Laboratory project.
(c) Dr. L. R. Mack, Department of Civil Engineering, Univ. of Texas, Austin 12, Texas.
(d) Theoretical; basic research.
(e) The velocity distribution within and the shape of the interface between two immiscible fluids of different densities flowing through a uniform isotropic porous medium toward a well is sought. This problem is of interest in both petroleum engineering and ground-water hydrology.

(g) A method has been devised for satisfying the governing equations, including the non-linear boundary conditions at the interface. This method is applicable to both two-dimensional and axisymmetric systems.

UTAH STATE UNIVERSITY, Engineering Experiment Sta.

(3183) DYNAMICS OF FLOW IN STEEP, ROUGH, OPEN CHANNELS.

(b) Laboratory and field project; Rocky Mt. Exp. Sta.; U. S. Forest Service; Nat'l Sci. Found.
(c) Dr. Dean F. Peterson, Dean of Engineering, Utah State University, Logan, Utah.
(d) Experimental, theoretical, field investigation; basic research for doctoral theses.
(e) A basic study of relationships involved in flow in steep, rough channels where the roughness is relatively an appreciable part of the depth, and where channels are sufficiently steep or steeper than a slope such that supercritical flow can occur in connection with contractions caused by the roughnesses. The work is basic, however, it will have application to steep mountain streams and to hydraulic structures.
The objective of the work is to relate descriptive parameters describing the size and configuration of the bed roughness to slope, depth and discharge of channels of this class. Studies began using simple bar and cube roughness elements and have progressed through the use of beds formed by giving natural gravel elements of various size, gradation and intensity to the bed. Detailed studies of bed geometry have been made at nineteen natural stream sites. Statistical parameters for measuring and describing these configurations which have hydraulic significance are being developed following approaches suggested by the laboratory studies. Piezometric-type stage recorders have been set up at five sites where discharge and slope will be measured in order to test the significance of the proposed bed parameters.
A laboratory model study is underway of the mechanics of paving of steep rough streams using a bed consisting of graded sand and gravel elements. Slope and discharge will be varied and observations as to the resulting stream channel development, paving, depth and breadth of stream and configuration of bed elements will be made.
A flume study of air entrainment in artificial streams of the class covered by this project is being planned.

(g) Three sizes of graded gravel elements having maximum sizes 4", 3" and 2" and three values of intensity in the ratios of 1, 1/4 and 1/8 of maximum areal compaction were tested under flume conditions. Some 500 runs led to good correlations of the form

$$V = C_1 \left(\frac{D}{a_o}\right)^{1/3} \left(\frac{l}{a_1}\right)^{1/3} gDs$$

for tranquil and tumbling regimes and to

$$V = C_2 \, f \, \frac{l}{a_2} \, gDs$$

for rapid flow where a_o, a_1 a_2 are bed element size parameters l is a bed element spacing parameter, D is a piezometric average depth above mean bed elevation, and f represents an experimentally developed non-dimensional function.
Results of the field studies or of the model studies of paving are not yet available.

(h) Closing discussion of "Flume Studies of Flow in Steep Rough Channels," by Dean F. Peterson and P. K. Mohanty. Journal of Hydraulics Division. Proceedings of American Society of Civil Engineers. V 88 (HY3) May 1962.

(3185) HYDRAULICS OF SURFACE IRRIGATION.

(b) Public Health Service.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State University, Logan, Utah.
(d) Experimental, theoretical; basic research; Doctoral dissertation.
(e) Hydrodynamic and field study of movement of water over a porous surface when intake varies with time. Free surface and the rate of advance are defined.

(g) Differential equations have been obtained defining the free surface and the rate of advance. Solutions have been compared with field measurement of the rate of advance. The results are within ten percent of field observations. High speed computers to obtain typical solutions will be used.
A companion study is based upon utilizing empirical relationships as a foundation for subsequent development of rate of advance functions. The results compare well with measured values.

(3525) MEASUREMENT OF FLOW FROM HORIZONTAL PIPE BY THE COORDINATE METHOD.

(b) Laboratory project.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State University, Logan, Utah.
(d) Experimental; theoretical; applied research.
(e) The error involved in the conventional method of measurement is shown to be large. The coefficient has been defined and parameters developed so that more accurate

measurements can be obtained in a quick, easy method of water measurement.
(f) Completed.
(h) A bulletin outlining field procedure to be followed with the method is now being prepared.

(3527) DEVELOPMENT OF LOW COST WATER LEVEL RECORDER.

(b) Laboratory project.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State University, Logan, Utah.
(d) Experimental, development.
(e) In general, the available instrumentation for measuring fluctuation in water level is costly. Most equipment is designed for a wide range of application. However, many areas require only a limited fluctuation in water level. This is particularly true in irrigation practice. Objective of the project is to develop a low-cost recorder which will fit these needs and thereby permit a more extensive use.
(g) A water level recorder has been developed which does meet the requirements and is now being modified and adapted for commercial production.

(3528) THE EFFECT OF SEDIMENT PROPERTIES ON THE ATTENUATION OF AN ULTRASONIC PLANE WAVE.

(b) National Science Foundation.
(c) Dr. Gordon H. Flammer, Civil and Irrigation Engineering Department, Utah State Univ., Logan, Utah.
(d) Theoretical and experimental; basic research.
(e) Some theoretical and experimental work has been performed on the attenuation of an ultrasonic plane wave passing through a sediment suspension. However, prior work is still very limited in scope, particularly over certain loss regions. This study is using a standard pulse technique to investigate a wide range of sediments both natural and manufactured over the various loss ranges. Of primary concern is the effect of the various sediment properties on the attenuation.
(g) Natural sediments have been completed and an M. S. thesis has been prepared giving the results. Manufactured sediments of known properties are now being tested and a Ph.D. dissertation will result from this study.
(h) A publication is now available on work done previous to this project entitled, "Ultrasonic Measurement of Suspended Sediment," by Gordon H. Flammer, Geological Survey Bulletin 1140A, December 1962. An M. S. thesis has been completed on the project and is available under the following title: "The Effect of the Properties of Natural Sediments on the Attenuation of an Ultrasonic Plane Wave," by Yung-Huang Kuo. M. S. thesis, Utah State University, Logan, Utah, 1961.

(3530) WATER REQUIREMENTS OF MARSHLANDS.

(b) Utah State Fish and Game Dept.
(c) Mr. Jerald E. Christiansen, Professor Civil and Irrigation Engineering, Utah State Univ., Logan, Utah.
(d) Field investigations; applied research, Master's theses.
(e) Large areas of marshy lands adjacent to Great Salt Lake have been developed and improved by the State Fish and Game Dept., and the Federal Wildlife Service, as Migratory Bird Refuges. Available streams flow from several of the major streams flowing into these areas where the water is impounded behind dikes to create habitat suitable for nesting, feeding and resting of water fowl. Millions of ducks and geese utilize this area each year during their migratory flights.
(g) The basic purpose of the study is to determine the quantities of water necessary for marshlands in order to maintain them in a productive state.
(h) Several progress reports have been written.

(3843) A SHAPE AND FRICTION FACTOR RELATIONSHIP BETWEEN SMOOTH, RECTANGULAR, AND CIRCULAR CHANNELS.

(b) Laboratory project.
(c) Dr. Gordon H. Flammer, Associate Professor, Civil and Irrigation Engineering Dept., Utah State University, Logan, Utah.
(d) Theoretical; basic research for master's thesis.
(e) This study has been made to determine a shape factor relationship so that the friction factors (Moody curves) for circular pipes can be used with rectangular shaped channels. To accomplish this, head loss data has been taken, through a wide range of Reynold's numbers, from a number of rectangular channels varying from approximately a square to a channel approximately 3/8 inches by 4 inches.
Only one material was used in constructing the channels and the narrow dimension of the channel was held constant.
Friction factor values for circular pipe have often been used for shapes other than circular; and for shapes that are not too far from a circle. The error is appreciable however, for channels that are far removed from a circle.
(f) Completed. Some difficulty was encountered due to leakage with the equipment used. Funds were not available to construct suitable leakproof equipment and therefore the results are somewhat inconclusive due to the leakage problem. Funds are being sought for further study using adequate apparatus.
(g) It is anticipated that this study will result in more realistic friction factors for rectangular channels.

(3844) THE REMOVAL OF HIGH TURBIDITY WITH RAPID SAND FILTERS.

(b) Laboratory project.
(c) Prof. Elliot Rich, Civil and Irrigation Engineering Department, Utah State Univ., Logan, Utah.
(d) Experimental, theoretical; basic research for a master's thesis.
(e) A study of the efficiency of rapid sand filtration was conducted under conditions of varying initial turbidity and application rate. The turbidity ranged from 50 to 400 parts per million and the flow rate from .25 to 5.5 gal/min/ft2 of filter area. The same sand 0.505 mm mean diameter, was used in all the tests; and its depth was held constant at 30 inches. The filter was constructed from a plastic tube, 3-1/2 inches in diameter to minimize wall effects, and was equipped with an overflow so a constant head of 44 inches would be maintained above the sand.
(f) Completed.
(g) The results of this experiment indicates that rapid sand filtration could be used as a means of pretreating water if initial turbidity is under 200 parts per million and flow rate is maintained below 4 gallons per minute per square foot. To obtain a finished product with a turbidity under 10 parts per million or initial turbidities greater than 200 parts per million multiple filtration should be used with the effluent from one filter being fed directly to the next filter.

(3845) WATERSHED MODEL STUDIES.

(b) Agricultural Research Service, U. S. Dept. of Agriculture.
(c) Prof. Jay M. Bagley, Civil and Irrigation Engineering, Utah State University, Logan,

Utah.
(d) Experimental; basic research for master's thesis.
(e) The purpose is to establish techniques and model-prototype laws so that watersheds can be intensively studied in a laboratory. For this study, a small watershed is being modeled in size, shape, and topography encompassing provisions for varying the permeability of the model's surface. Water to represent precipitation in various patterns will be applied over the model watershed. By the nature of the proposed study, the dominant factors influencing the characteristic shape of the run-off hydrography are: (1) Watershed shape; (2) rainfall intensity; (3) rainfall duration; and (4) time element being a function of a composition roughness factor.
The study is divided into two phases. In the first phase, the object is to simulate the run-off hydrography using a physical model with an impervious surface. Thus, it is known that the simulated hydrograph will be distorted volumetrically. The second phase has the added objective of an investigation of the relationship between infiltration and run-off.
(g) A better understanding of the parameters influencing the rainfall-run-off relationship of arid southwestern watershed are being obtained. Ultimately, this will result in better design of structures built to contain, convey, or bridge the run-off water of this area.

(3846) CONSTRUCTION OF AN INTERSTATE HIGHWAY ACROSS THE SALT FLATS NEAR WENDOVER, UTAH.

(b) Utah State Road Commission.
(c) Prof. Jerry E. Christiansen, Civil and Irrigation Engineering, Utah State Univ., Logan, Utah.
(d) Field investigation for design and development of Interstate highway.
(e) The design and construction of an interstate highway across the salt flats near Wendover, Utah, poses a number of problems that require solutions. This is one of the few places in the world where a highway must be built over a salt bed. The maintenance of the present highway and railway that traverses these salt flats has been difficult. It is hoped that a better understanding of the problem, based on extensive field and laboratory investigations of materials on which the highway will be built, will result in a design that will be relatively free of maintenance problems. The objective, therefore, is to fully determine the characteristics of the salt bed and the underlying soil materials to considerable depth. The work completed to date has been concerned primarily with the permeability of the sub-soil materials to the flow of water. Surprisingly, it has been found there are very permeable strata underlying the salt. These are of considerable concern because of the movement of partially saturated solutions through these permeable zones which tends to dissolve and remove salt, resulting in uneven settlement of the roadway.
(g) A sound and economic design depends upon a complete knowledge of the materials involved. Investigations should be of definite practical value in determining the basic requirements for the design and construction of the multimillion dollar highway, which will be built within the next few years. Economies in design should result from the studies being undertaken.
(h) Several progress reports have been written.

(4236) METHODS FOR PREDICTING MEAN ANNUAL WATER YIELDS IN UTAH.

(b) Utah Water and Power Board and Utah State Engineer.
(c) Prof. Jay M. Bagley, Civil and Irrigation Engineering Dept., Utah State University, Logan, Utah.
(d) Experimental; applied research.
(e) This work was undertaken to develop methods of obtaining economical and reasonably accurate determinations of watershed yield where stream gaging records are not available. Certain relatively easily obtained parameters characterizing the physical and climatic factors have been correlated with water yield for a number of watersheds having good records of stream flow.
(f) Completed.
(g) Regression equations have been developed for estimating water yield from physical characteristics of basins in various regions of Utah. Based on the developments of this study, a water yield map for the entire state of Utah is being prepared. The map, equations and graphs should aid materially in broadening the coverage of hydrologic information needed for first stage planning of a long range state-wide nature.
(h) "A Method for Predicting Surface Run-Off from Watersheds with Limited Hydrographic Data," by Roland W. Jeppson, Master's Thesis, Utah State University, 1960.
"Methods for Predicting Mean Annual Water Yields in Utah," by Jay M. Bagley, Roland W. Jeppson, Yin Auyeung, Cleve H. Milligan. (Manuscript in preparation.)

(4237) EFFECT OF VARIOUS IRRIGATION TECHNIQUES ON SOIL AERATION, SOIL STRUCTURE AND CROP RESPONSE.

(b) Utah Agricultural Experiment Station (State Funded Project #591).
(c) Prof. Jack Keller, Utah Agricultural Expt. Station, Utah State University, Logan, Utah.
(d) Laboratory, experimental and field investigations; applied research.
(e) Where saturating rainfalls are infrequent it appears likely that land productivity is closely related to the effects of irrigation on soil aeration and structure. With present day irrigation technology, the design engineer and irrigator have some degree of control over both soil aeration and structure; however, the extent of control and effects on crop response have not been determined.
This project proposes to develop criteria (useful in the design and management of irrigation systems) based on crop responses as affected by soil aeration and structure. A review of literature shows that bulk structural tests such as capillary rise, moisture release, modulus of rupture and various permeability measurements have given indexes that can be related to crop response. In order to establish limits for the proposed field investigations, it is the intent that the first phase of the project be a laboratory study of simulated field irrigation techniques.
(g) The laboratory phase of the project is set up and in operation. A water applicator which will produce uniform application rates of from .02"/hr to 2"/hr with drop sizes of 2 mm or 3 mm has been developed. The present laboratory phase is the study of the effect of water application rate on the structural characteristics of several soils. Water is applied in the surface of the soil samples contained in 6" clay flower pots fitted with porous tension cup bottoms and air diffusion rings.
(h) Two progress reports have been written.

(4239) MECHANICS OF EVAPOTRANSPIRATION.

(b) Laboratory.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State University, Logan, Utah.
(d) Theoretical; basic research.
(e) An analysis of water movement from the soil, through the plant and into the atmosphere

is made using basic hydraulic properties of flow. The mechanism of water transmission within the plant is given particular attention.

(f) Completed.

(h) "Mechanics of Evapotranspiration," by David W. Hendricks and Vaughn E. Hansen. Publication pending. Journal and Transactions of American Society of Civil Engineers, 1962.

(4240) THE INFLUENCE OF PRECIPITATION CHARACTERISTICS ON THE WATER AVAILABLE FOR DOWNWARD MOVEMENT INTO THE SOIL.

(b) Western Soil and Water Research Project with 12 western states collaborating through U.S.D.A. and State Agricultural Experiment Stations.

(c) Mr. C. H. Milligan, Head Civil and Irrigation Department, Utah State University, Logan, Utah.

(d) Theoretical and experimental; applied research. One M.S. degree candidate is working on the project at present.

(e) The purpose of the project is to delineate the characteristics of precipitation including intensity, drop size, terminal velocity, angle of attack, etc. which affect interception and infiltration of the precipitation, and to find functional relationships which relate these characteristics to infiltration and interception.

(g) Project active but just getting underway.

(4241) IMPROVEMENT OF STREAMFLOW FORECASTING.

(b) Laboratory project.

(c) Mr. C. H. Milligan, Head, Civil and Irrigation Dept., Utah State Univ., Logan, Utah.

(d) Experimental, theoretical, and field; applied research.

(e) The purpose of the project is to develop procedures for utilization of antecedent precipitation, temperature, soil moisture, runoff, and snow survey data in the prediction of streamflow for the coming irrigation season.
The procedure is largely statistical and is programmed for high speed computer solutions. Trigonometric series are used to represent trends in antecedent rainfall, temperature, soil moisture, and streamflow.
The Fourier coefficients along with total water content of the snow cover on a given prediction date are correlated with runoff by months. Regression coefficients determined from data from the past are utilized in equations to complete the predicted values.

(g) Results are promising but a longer record is needed to test the validity of the procedures.

(h) "The Use of Fourier Series in Streamflow Forecasting," by C. H. Milligan, Proceedings Western Snow Conference, 1956.

(4718) THE EFFECT OF PRONOUNCED BOTTOM CURVATURE ON THE VELOCITY PROFILE IN A WIDE OPEN CHANNEL.

(b) Laboratory project.

(c) Dr. Gordon H. Flammer, Associate Professor, Civil and Irrigation Engineering Dept., Utah State University, Logan, Utah.

(d) Experimental, theoretical; basic research for M.S. thesis.

(e) The nature of the project is to study the distortion of a one-dimensional velocity profile caused by significant streamline curvature and to act as a pilot study in setting up a research program whose ultimate aim will be to discover the relationship for the effect of streamline curvature on two and three dimensional velocity profiles. Initially the distortion of a one dimensional velocity profile by a curved bed will be studied. Based upon the results of this simplified approach, studies will be extended to two and three dimensional velocity profiles.

(g) The project has just been initiated, and no results are available.

(4719) FREE SURFACE FLOW AROUND A HEMISPHERICAL ROUGHNESS ELEMENT.

(b) Laboratory project.

(c) Dr. Gordon H. Flammer, Associate Professor, Civil and Irrigation Engineering Dept., Utah State University, Logan, Utah.

(d) Experimental and theoretical research toward a Master's thesis.

(e) This study was made to gain further information on flow characteristics (primarily drag) around a hemispherical roughness element where the element size is of the order of the depth of the free surface flow. To accomplish this, water surface data, velocity profile data and primarily drag data was taken for a range of Froude numbers. The thesis attempts to answer certain questions concerning the effects on a single large hemispherical roughness element in open channel flow. Of particular interest is the flow condition where the element has an effect on the fluid surface configuration.
An M.S. thesis is being prepared on this project. This work, however, is considered to be only preliminary to a continued study of much wider proportions.

(g) The results of this investigation may be summarized as follows: (1) The drag force on the hemisphere is due primarily to wave drag in the Froude number range 0.35 to 2.50 and for submergence intervals v/k up to 1.2. (2) At a given submergence interval the coefficient of drag decreases as the Froude number increases up to 1.5. (3) The coefficient of drag is constant above a Froude number of 1.5 for all submergence intervals. This constant value is approximately 0.2. (4) The drag coefficient increases with an increase in submergence in the Froude number range up to 1.5. (5) The relationship between the coefficient of drag and the Froude number tends to become linear as the submergence increases.

(h) An M.S. thesis is currently being prepared under the following title, "Free Surface Flow Around Hemispherical Roughness Element," by Dirk Van Woerden. M.S. Thesis, Utah State University, Logan, Utah, 1962.

WASHINGTON STATE UNIVERSITY, The R. L. Albrook Hydraulic Laboratory.

Inquiries concerning the following projects should be addressed to Dr. E. Roy Tinney, Head, The R. L. Albrook Hydraulic Laboratory, Division of Industrial Research, Washington State University, Pullman, Washington.

(1689) STUDY OF FLUID FLOW IN PIPE NETWORKS.

(b) Personnel responsible for the design and/or operation of water and gas distribution systems.

(d) Analyses by analogue and digital computers.

(e) Flow distributions have been made with the McIlroy Analyzer for over 50 cities, several gas systems, an air system, a generator cooling system, and several other unique systems. Losses throughout the system are obtained. Engineers use the analogue to design system pumps, tanks, and piping additions or revisions.

(2631) ROCKY REACH HYDROELECTRIC DEVELOPMENT.

(b) Chelan County Public Utility District No. 1.

(d) Experimental; design.

(e) Hydraulic model studies on several problems of design and operation have been essentially completed. Construction

sequences, fishway design and operation, spillway energy dissipators, spillway capacity, downstream erosion and waves, and spillway operation all underwent detailed investigation on six hydraulic models over a period of more than six years. Sound motion picture films are now being prepared on the use of the models.

(g) The energy dissipator, consisting of a 14-foot high solid baffle a high slotted end-sill and spillway nappe deflectors, adequately dissipated the energy in the spillway flow. Vortices ranging from 2 to 30 feet in diameter will not adversely affect the spillway gates.

(h) "Fishway Models Rocky Reach Hydroelectric Project," by Claud C. Lomax, Jr., Part II - Technical Report No. 9, Washington State Institute of Technology, December 1958, 62 pages.
"Hydraulic Model Studies of Spillway Vortices Rocky Reach Hydroelectric Project," by Howard D. Copp, Research Report No. 61/9-31, Washington State Institute of Technology, February 24, 1961, 37 pages.

(3534) WELLS HYDRO-COMBINE FLUME MODEL.

(b) Bechtel Corporation.
(d) Experimental; design.
(e) A 1:23.3 scale model of a section of the spillway-power unit is undergoing tests to evaluate hydraulic characteristics of an unusual design for hydro-electric developments. Tests thus far completed indicate that the power units or the spillway, when operated as separate units, perform the same as conventional designs. When operated simultaneously, the spillway flow is predominant. No harmful forced vibrations are anticipated, the spillway discharge coefficient is about the same as conventional ogee spillways, and the spill increased the operating head on the power units through a local tailwater depression.

(g) Tests on design details and spillway gate vibrations are continuing.

(h) "Preliminary Report on Hydraulic Sectional Model Studies, Wells Hydro-Combine," by H. D. Copp, Research Report No. 62/9-128, Washington State Institute of Technology, October, 1962.

(3848) CALIBRATION OF FLOW METERING FLUMES.

(b) Agricultural Research Service, Boise, Idaho.
(d) Experimental; design.
(e) Metering flumes are being placed on several streams within an experimental watershed in southern Idaho. Desirable shapes, location of head measuring taps, orientation and elevation of invert of these flumes are being investigated by hydraulic model. The effect of flow rate, upstream and downstream topography, and sediment deposition are considered. Calibration of two metering devices have been completed by use of the models and one prototype flume is now constructed.

(h) "Reynolds Creek Experimental Watershed Flume Calibration Studies," by George L. Bloomsburg and E. Roy Tinney, Interim Report to Agricultural Research Service, Washington State Institute of Technology, October 26, 1960, 11 pages.

(3849) FLOW IN NONCIRCULAR CONDUITS.

(b) Laboratory project supported in part by Nat. Acad. Sciences grant to Dr. Jamil Malaika.
(d) Theoretical and experimental; basic research.
(e) The effect of cross-sectional shape on friction loss in the fully turbulent regions were investigated by studying the flow in circular, square, elliptical, rectangular, and rhombic conduits.
(f) Completed.
(h) "Flow in Noncircular Conduits," by J. Malaika, ASCE, Vol. 88, No. HY6, November, 1962.
"Flow in Noncircular Conduits," by J. Malaika, Bulletin No. 264, Washington State Institute of Technology, June, 1962.

(4243) UMPQUA RIVER ESTUARY MODEL.

(b) U. S. Department of Health, Education and Welfare.
(d) Experimental.
(e) A highly distorted model (horizontal scale 1:3000, vertical scale 1:1000) of the Umpqua River Estuary, including the confluence of the Umpqua and Smith Rivers, has been constructed, verified, and used for pollution potential tests for various outfall locations and conditions.
Pollution tests were conducted under conditions of a relatively well-mixed salinity distribution. Flushing tests were conducted as well.
(f) Completed.
(g) Such highly distorted models satisfactorily reproduce prototype data on tides and salinity distribution. Model indicated significant effect of deep holes and river confluences on dispersion of pollutants.
(h) "Umpqua Estuary Model Study," by John S. Gladwell and E. Roy Tinney, Bulletin 265, Washington State Institute of Technology, August, 1962.

(4244) SULTAN DAM NO. 1.

(b) R. W. Beck and Associates.
(d) Experimental; design.
(e) Final tests were conducted in the 1:50 scale model of the Sultan Dam to determine the best arrangement for the tunnel spillway and morning-glory intake. Data were recorded to determine the spillway rating curve pressure patterns and aeration conditions. A total of 681 tests were conducted in this model before a suitable solution was found. The second stage tunnel will have a capacity of 80,000 cfs.
(g) A two-stage tunnel spillway was found to be satisfactory with the second stage formed by adding a 38-ft. diameter shaft with a new morning-glory intake.
(h) "Sultan Model Studies," (Spillway Model Studies of the Sultan River Project, Dam No. 1), Bulletin No. 263, by Manuel Th. Arce and David T. Higgins, Washington State Institute of Technology, December, 1962, 105 pages.

(4245) HYDRODYNAMIC INVESTIGATION.

(b) Laboratory project.
(d) Theoretical and experimental; applied research.
(e) Tests are being made on nappe deflectors adjacent to spillway piers to obtain design data and permit selection of this type of energy dissipator prior to experimental testing in connection with a specific application. This type of energy dissipator has been used on Rocky Reach and Noxon Rapids dams and is being considered for use at Chungju dam, in Korea.
(f) Suspended.
(g) Stilling basins can be considerably shortened and raised with the use of nappe deflectors.
(h) "Chungju Hydraulic Model Studies," by E. Roy Tinney and Manuel Th. Arce, Bulletin No. 252, Washington State Institute of Technology, February, 1961, pp. 10-14.

(4246) ROUND BUTTE TRIFURCATION MODEL.

(b) Portland General Electric Company.
(d) Experimental; design.
(e) A 1:23.7 scale model of a power penstock trifurcation was constructed and investigated for head loss and undue structural vibrations.

(f) Completed.
(g) Head losses were minimal, information regarding structural vibration was used in the structural design.
(h) "Round Butte Penstock Trifurcation," by John S. Gladwell and E. Roy Tinney, Bulletin No. 260, Wash. State Inst. of Tech., May 1962.

(4720) PACKWOOD DROP STRUCTURE MODEL.

(b) R. W. Beck and Associates.
(d) Experimental, design.
(e) Model studies of the drop structure for Packwood Hydroelectric Project were performed to determine the shape of the spillway crest and its free-flow capacity. The prototype has a maximum capacity of 8000 cfs and the model was constructed to a 1:20 scale.
(f) Completed.
(g) The original designs were modified to provide better aeration and to stiffen the weir.
(h) "Packwood Model Studies," by Manuel Th. Arce, Research Report No. 62/9-12, Wash. State Institute of Tech., October 12, 1962.

(4721) MODEL CALIBRATION OF ROCK ISLAND SPILLWAY.

(b) Public Utility District of Grant Co., Wash.
(d) Experimental; analytical.
(e) A 1:50 scale model of the west section of the Rock Island Dam spillway was constructed. Tests are continuing to determine the discharge coefficients for each bay as they may be influenced by adjacent and nearby bays, tailwater and apron elevations, and distribution of flow approaching the spillway discharges in connection with power losses due to tailwater encroachment at Rock Island by the Wanapum pool.
(h) "Hydraulic Model Studies for the Calibration of the Rock Island Spillway," C. C. Lomax, Interim Research Rpt. No. 62/9-110, Wash. State Inst. of Tech., Sept. 13, 1962, 58 pp.

(4722) BOUNDARY COMPREHENSIVE MODEL.

(b) Bechtel - Leedshill.
(d) Experimental; design.
(e) A 1:65 scale model of approximately 0.6 miles of the Pend Oreille River approximately the arch dam, forebay, and spillways have been constructed. Investigations have been concerned to date primarily with the sluice ring orientation and approach channel design. The sluice ring is particularly of concern because it must pass flows of approximately 280,000 cfs at a depth which results in velocities of about 100 f.p.s.

(4723) BOUNDARY PROJECT SLUICEWAY MODEL.

(b) Bechtel Corporation.
(d) Experimental; design.
(e) A 1:25 scale model of low level sluiceways has permitted experimental investigation of sluiceway design and the determination of a suitable intake shape that will operate cavitation free, under heads up to 190 ft. Sluiceway gate vibration tests will be conducted.
(g) The original intake shape, designed according to conventional procedures was not cavitation free. A converging section formed by a rising invert was found necessary.

(4724) WELLS COMPREHENSIVE MODEL.

(b) Bechtel Corporation.
(d) Experimental; design.
(e) A 1:78 model of the Wells Hydrocombine has been constructed to study erosion, waves, passage of migratory fish. Spillway capacity and construction sequences since the power house and spillway are combined into one structure several unique problems in design and operation must be investigated. The model is 44 feet wide and 66 feet long and will pass the equivalent of 1,300,000 cfs.

UNIVERSITY OF WASHINGTON, Charles W. Harris Hydraulics Laboratory.

(3853) FLOW THROUGH AN ARRAY OF CYLINDERS.

(b) Laboratory project.
(c) Prof. Ronald E. Nece, Dept. of Civil Engrg., Univ. of Washington, Seattle 5, Washington.
(d) Experimental; basic research.
(e) Hydrodynamic forces are to be determined on one of a row of circular cylinders. Cylinder spacing and orientation of the single row with respect to a uniform approach flow are to be varied.
(f) Suspended.
(g) Proximity effects upon drag coefficients have been determined for two cylinder row orientations for the case of laminar boundary layers on the cylinders.
(h) One M.S. Thesis completed (available on loan).

(4725) FLUID ENTRAINMENT THROUGH DISCRETE OPENINGS IN SUBMERGED PIPELINES.

(b) Laboratory project.
(c) Prof. R. E. Nece, Dept. of Civil Engineering, University of Washington, Seattle 5, Wash.
(d) Experimental; basic and applied research.
(e) The mechanism of the entrainment of a fluid from an infinite still reservoir through discrete ports into a conduit flowing full is to be studied experimentally and analytically.
(g) Data have been obtained for single circular ports of different sizes and various edge configurations.
(h) One M.S. Thesis completed (available on loan).

(4726) A STUDY OF VELOCITY BARRIER DEVICE FOR DOWNSTREAM MIGRANT BYPASS.

(b) Columbia Fisheries Program Office, U. S. Bureau of Commercial Fisheries, Portland, Ore.
(c) Prof. H. S. Strausser, 317 Hydraulics Lab., University of Washington, Seattle 5, Wash.
(d) Experimental investigation; developmental research.
(e) The problem requires a structure which will guide downstream migrant fish into a collection facility with a minimum obstruction to flow. The methods under study utilize velocity changes which would attract or repel the fish, thereby steering them into a desired location.
(g) No satisfactory results as yet.

(4727) A STUDY OF THE DOWNSTREAM MIGRANT BYPASS FOR THE THREE-MILE DITCH, UMATILLA, OREGON.

(b) Columbia Fisheries Program Office, U. S. Bureau of Commercial Fisheries, Portland, Ore.
(c) Prof. H. S. Strausser, 317 Hydraulics Lab., University of Washington, Seattle 5, Wash.
(d) Experimental investigation; developmental.
(e) A fish bypass was designed to be placed at the terminus of a standard louver guiding device. Device can be used on existing dam structures without having to pass through structure itself.
(f) Completed.
(g) The design developed is apparently working satisfactorily under field conditions.
(h) Unpublished report available on loan from correspondent, H. S. Strausser.

(4728) THE INTERACTION EFFECTS OF FIXED SEMI-IMMERSED CIRCULAR CYLINDER WITH A TRAIN OF PROGRESSIVE OSCILLATORY WAVES IN A CHANNEL OF FINITE DEPTH.

(b) The exploratory work has been done supported in part by an NDEA Fellowship. Proposals are being prepared to continue the work.
(c) Prof. E. P. Richey, Dept. of Civil Engrg., Univ. of Wash., Seattle 5, Washington.
(d) Basic theoretical research with experimental verification for a doctoral thesis.
(e) The objective of the work is to obtain an analysis of the problem which can be used to determine force components and coefficients of reflection and transmission.

(4729) DESIGN OF EQUIPMENT TO DETERMINE MINIMUM VELOCITY TO ORIENT SMALL FISH.

(b) U. S. Army Corps of Engineers.
(c) Prof. J. C. Kent, 201 More Hall, Univ. of Washington, Seattle 5, Washington.
(d) Experimental and basic research.
(e) Flow through two channels is held at constant depth and controlled at identical flow rates by use of orifices and differential manometers.
(f) Completed.
(g) The flow is extremely uniform indicating practically no variation in velocity between the two channels.
(h) "Discrimination of Low Water Velocity by Juvenile Salmon," Technical Report to U. S. Army Corps of Engineers, No. 52., College of Fisheries, University of Washington, Seattle 5, Washington.

UNIVERSITY OF WASHINGTON, Fisheries Research Inst.

(3535) EFFECTS OF LOGGING ON PRODUCTIVITY OF PINK SALMON STREAMS IN ALASKA.

(b) Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service, Juneau, Alaska, is contracting agency. Co-operating agency is Alaska Forest Research Center, U. S. Forest Service, Juneau, Alaska.
(c) Prof. Donald E. Bevan, Research Associate Professor, Fisheries Research Institute, University of Washington, Seattle 5, Wash.
(d) Experimental, theoretical, and field investigation; basic and applied research, including master's and doctoral thesis research.
(e) To identify environmental factors causing mortality of pink salmon embryos; (2) to gain a more complete understanding of interrelationships among spawning behavior, physical and biological attributes of the stream and spawning bed, and mortality of embryos; (3) to determine how the quality of the spawning bed environment as it pertains to growth, development, and mortality of embryos is affected by logging; and (4) to determine criteria for the improvement of natural spawning areas to increase production of juvenile salmon. Included among active routine studies are hydrological conditions, intragravel water quality, spawning bed quality, and channel debris evaluation. Included among active basic studies are composition and source of suspended sediment and bed load, relationship between surface and intragravel water, and sources of intragravel water.
(g) Methods have been developed for routine field measurement of dissolved oxygen content of intragravel water, gravel composition, and mortality of salmon embryos. Gravel shift has been identified as an important natural cause of embryonic mortality. A theoretical model of factors controlling interchange between stream and intragravel water has been proposed and tested qualitatively.
(h) "A Method of Estimating Mortality of Pink Salmon Eggs and Larvae," by William J. McNeil. Contribution No. 119, 28 pp. manuscript, (in press).
"Mortality of Pink and Chum Salmon Eggs and Larvae in Southeast Alaska Streams," by William J. McNeil. Ph.D. Thesis, Univ. of Washington, Seattle, 270 pp., 1962.

(4247) IMPROVEMENT OF SALMON SPAWNING AREAS IN INDIAN CREEK, ALASKA.

(b) U.S. Forest Service, Juneau, Alaska, Bureau of Commercial Fisheries.
(c) Prof. Donald E. Bevan, Research Associate Professor, Fisheries Research Institute, University of Washington, Seattle 5, Wash.
(d) Experimental, theoretical, and field investigation basic and applied research, including thesis research.
(e) Artificial spawning areas have been constructed on Indian Creek on Prince of Wales Island within the Tongass National Forest, Alaska. The project is to test the general hydraulic considerations associated with the design of improved pink salmon spawning areas in natural streams. Objectives of the research program are to test the design of artificial improvements to salmon spawning grounds. The problem is to determine if we can provide, at reasonable cost, small areas of stable permeable gravel in which low water flow of stream will be concentrated The evaluation of artificially constructed channels will provide information of the detailed requirements of spawning fish as well as the requirements of eggs and larvae. Further information will be obtained on movement of bed material as no stream flow regulation is provided.
(g) Data currently being analyzed.

(4730) DETERMINING CHANGES IN SIZE COMPOSITION IN STREAMBED MATERIAL IN LOGGED WATERSHEDS.

(b) Institute of Forest Products.
(c) Prof. Donald E. Bevan, Fisheries Hall #2, University of Washington, Seattle 5, Wash.
(d) Experimental, theoretical and field investigation; applied research for M.S. thesis.
(e) The research is to evaluate ecological changes in salmon streams caused by deforestation. Soil erosion, subsequent logging operations in a watershed, may cause large quantities of fine particles to be deposited in the beds of the streams adjacent to logging areas. The presence of fine materials reduces the permeability of the stream and gravel thereby reducing the rates of waterflow in the streambed and the rate of exchange of inter-gravel water. The rate of exchange between the inter-gravel and stream water limits the quality of the inter-gravel environment of the habitat for salmon eggs and larvae. The results of the proposed investigation will assist in determining if logging will affect salmon production. The objectives of the study are: (1) To evaluate the present gravel sampling procedures and index of streambed quality for salmon; (2) to determine the physical factors controlling the size of the particles within the stream bed; (3) determine if streambed composition can be used to measure effects of logging on salmon.
(g) Field data has been gathered. Analysis is in process.

UNIVERSITY OF WISCONSIN, Hydraulics Laboratory.

(149) THE EFFECT OF SUBMERGENCE ON FLOW CHARACTERISTICS OF HYDRAULIC STRUCTURES.

(b) Laboratory project.
(c) Prof. J. R. Villemonte, Hydraulics Lab., Univ. of Wisconsin, Madison 6, Wisconsin.
(d) Theoretical and experimental; basic and applied research for M.S. degree.
(e) The effects of submergence on discharge of large circular thin-plate weirs and orifices and broad-crested weirs are being studied.
(f) Suspended.
(g) General correlation equations have been developed for all thin-plate weirs, Parshall Flumes, and one type of Ogee spillway.

(956) ENERGY LOSS IN LIQUID FLOW IN PIPES AND FITTINGS UNDER HIGH PRESSURE.

(b) Laboratory project in cooperation with the Ladish Company, Cudahy, Wisconsin, and the Wisconsin Alumni Research Foundation.
(c) Prof. J. R. Villemonte, Hydraulics Lab., Univ. of Wisconsin, Madison 6, Wisconsin.

(d) Theoretical and experimental; applied research and design for B.S., M.S. and Ph.D. theses.
(e) Energy loss measurements in straight pipes and fittings have been completed on sizes 1/4 inch to 2 inches. Pressure range 0-2500 psi, temperature range 60 to 120 degrees F. Reynolds number range 50 to 150,000.
(f) Suspended.
(g) If viscosity, density, and temperature relations are known, the standard pipe friction theory applies at high pressures. The fitting loss constants for laminar flow are about 3 times those for turbulent flow when N_R = 2000. The loss gradually reduces to zero at N_R = 150.

(1181) VORTEX FLOW FROM HORIZONTAL THIN-PLATE ORIFICES.

(b) Wisconsin Alumni Research Foundation and J. C. Stevens, Consulting Engineer, Portland, Oregon.
(c) Prof. J. R. Villemonte, Hydraulics Lab., Univ. of Wisconsin, Madison 6, Wisconsin.
(d) Theoretical and experimental; basic research for M.S. and Ph.D. theses.
(e) The effects of vorticity on orifice discharge were studied over a wide range of vorticity, head, and orifice size.
(g) A new parameter, the vortex number, was developed as the ratio of inertial and centrifugal forces. A general correlation procedure was also developed for estimating discharge rates through orifices with varying degrees of vorticity.
(h) "Vortex Flow through Horizontal Orifices," by J. C. Stevens and R. C. Kolf Trans. ASCE, Vol 124, p. 871, 1959.
"The Vortex Chamber as an Automatic Flow-Control Device," by R. C. Kolf and P. B. Zielinski, Journal Hydraulics Div., ASCE, December 1959.

(3539) THE EFFECT OF BOUNDARY ROUGHNESS AND CONFIGURATION ON TURBULENCE LEVEL AND VELOCITY DISTRIBUTION.

(b) Wisconsin Alumni Research Foundation.
(c) Prof. J. R. Villemonte, Hydraulics Lab., Univ. of Wisconsin, Madison 6, Wisconsin.
(d) Theoretical and experimental; basic research for M.S. and Ph.D. theses.
(e) New instrumentation has been developed to measure turbulence levels in pipes and ducts. The effects of boundary roughnesses on the decay of extra turbulence caused by a variety of boundary configurations is being studied.
(g) New equations have been developed for estimating losses due to combined and divided flow.
(h) "Momentum and Energy changes in Disturbed Laminar Flow," by S. Kar and J. R. Villemonte, presented at Annual Conference of Hydraulics Division of ASCE, August 1962.

(3540) MODEL STUDIES OF PUMP INLET STRUCTURES.

(b) Wisconsin Alumni Research Foundation in cooperation with the Government of West Bengal, India.
(c) Prof. J. R. Villemonte, Hydraulics Lab., University of Wisconsin, Madison 6, Wis.
(d) Experimental; design for M.S. thesis.
(e) A 1/16-scale model of the inlet structure for one of four axial flow pumps at the Uttarbhag Pumping Station (Sonarpur, India) has been made. Studies of inlet flow patterns and pressure coefficients for a wide variety of flow situations are being made for the purpose of reducing the cavitation threshold.
(f) Completed.
(g) Pressure coefficients were computed at 37 points on the model over a wide range of flows.
(h) "Model studies of Inlet to Uttarbhag Pumping Station," by C. K. Sarkar, J. R. Villemonte, and S. Kar, Proceedings of Symposium on Hydraulic Structures, Indian Institute of Science, Bangalone, January 1962.

(3541) HYDRAULIC CHARACTERISTICS OF CIRCULAR SEDIMENTATION BASINS.

(b) National Institutes of Health, Washington, D. C.
(c) Prof. G. A. Rohlich and Prof. J. R. Villemon Hydraulics Laboratory, University of Wisconsin, Madison 6, Wisconsin.
(d) Experimental; basic research and design for M.S. and Ph.D. theses.
(e) A versatile, transparent, 6-foot diameter cylindrical basin has been constructed which will permit model studies at depth to diameter ratios of 0.67 to 0.083. Flow patterns and dispersion characteristics will be observed over a wide range of overflow rates. New instrumentation for measuring small velocities and dispersion functions are being developed.
(g) Hydraulic characteristics have been determined for a wide range of flows and inlet and outlet situations. New criteria have been developed.
(h) "Hydraulic Characteristics of Circular Sedimentation Basins," by J. R. Villemonte and G. A. Rohlich, Proceedings 17th Annual Conference on Industrial Waste Treatment, Purdue University, May 1962.

(3854) REACTION JET INLET FOR OIL-WATER SEPARATORS.

(b) The American Petroleum Inst.
(c) Prof. G. A. Rohlich and Prof. J. R. Villemonte, Hydraulics Laboratory, Univ. of Wisconsin, Madison 6, Wisconsin.
(d) Experimental; basic research and design for master's and doctoral theses.
(e) A transparent basin 5 feet wide, 10 feet lo and 3 feet deep has been constructed. Investigations will be made using various sizes and spacings of the stengel reaction jets at the entrance to the basin to determine the effects of jet inflow on the hydraulic characteristics.
(f) Completed.
(g) Hydraulic characteristics for rectangular basins with Reaction Jet inlet devices were observed using a wide range of flows.
(h) Several unpublished M.S. theses.

(4251) CHANNEL DYNAMICS ABOVE GULLY CONTROL STRUCTURES.

(b) U.S. Department of Agriculture, Agricultural Research Service.
(c) Dr. Arno T. Lenz, Chairman, Dept. of Civil Engineering, University of Wisconsin, 1513 University Aveue, Madison 5, Wisconsin.
(d) Theoretical study and field investigation of basic research in channel dynamics for Ph.D. thesis.
(e) Data from field surveys of 44 gully control structures in Southwestern Wisconsin have been analyzed to develop procedures for estimating quantitatively the dynamic changes in channel profiles which occur when a gully control or sediment detention structure is built.
(f) Completed.
(g) An equation has been developed for the ratio of the average deposition slope to the original channel slope as a function of past and present hydraulic and sediment parameters.
(h) "Channel Dynamics Above Gully-Control Structures," by D. A. Woolhiser, Univ. of Wisconsin Ph.D. thesis.

(4252) FLOW OF A DENSITY STRATIFIED FLUID.

(b) Laboratory Project.
(c) Prof. P. L. Monkmeyer, Hydraulics Laboratory, University of Wisconsin, Madison 6, Wisc.
(d) Theoretical and experimental; basic research.

(e) Dynamic characteristics of compressible and incompressible density - stratified fluids, are being investigated. Both steady and unsteady flow problems relating to internal gravity waves are included in the study.
(g) Linearized equations for steady, inviscid, compressible flow in atmospheres with various density distribution have been developed and solved for simple boundary configurations.
(h) "The Steady-State Dynamics of an Ideal, Density-Stratified Atmosphere," by P. L. Monkmeyer, Ph.D. thesis, Cornell University, 1962.

(4731) THE EFFECT OF VISCOSITY OF DISCHARGE THROUGH SPECIAL ORIFICES.

(b) W. A. Kates Co., Deerfield, Illinois.
(c) Prof. J. R. Villemonte, Hydraulics Lab., University of Wisconsin, Madison 6, Wisc.
(d) Experimental; applied research.
(e) The variation of the orifice coefficient with Reynolds number is being studied for a wide variety of slot orifices in cylindrical surfaces.

(4732) UNIT HYDROGRAPH INVESTIGATIONS.

(b) Laboratory project.
(c) Dr. Arno T. Lenz, Chairman, Dept. of Civil Engineering, 1513 University Avenue, Madison 5, Wisconsin.
(d) Theoretical study and field investigation of the unit hydrograph. Basic research for Ph.D. thesis.
(e) The dimensionless unit hydrograph is being used as a tool in the study of the basin characteristics which affect the unit hydrograph.

(4733) THE TRANSFORMATION OF RAINFALL ON THREE BASINS IN NORTH CENTRAL WISCONSIN.

(b) Laboratory project.
(c) Dr. A. T. Lenz, Chairman, Dept. of Civil Engineering, University of Wisconsin, 1513 University Avenue, Madison 5, Wisconsin.
(d) Experimental and theoretical with field investigation; basic research for Ph.D. thesis.
(e) This study is to determine the relationships existing between rainfall, stream runoff, infiltration, groundwater, and evapotranspiration with respect to three drainage basins in North Central Wisconsin which have both similar and dissimilar soil types and aquifers, based on published data.

(4734) FLOW BETWEEN CONCENTRIC ROTATING CYLINDERS.

(b) Wisconsin Alumni Research Foundation and Fairbanks Morse Co.
(c) Prof. P. L. Monkmeyer, Hydraulics Lab., University of Wisconsin, Madison 6, Wisc.
(d) Theoretical and experimental; basic research for Ph.D. thesis.
(e) Development of theory for increased resistance to axial flow due to rotation of bounding cylinders, for turbulent flow conditions; laboratory investigation of functional resistance, torque requirements; stability considerations and transition for flow between concentric cylinders.
(g) An approximate theory for increased resistance to axial flow due to rotation of bounding cylinders, for turbulent flow has been developed.

(4735) MODEL STUDY OF A PROPOSED BARRAGE AT MUSCODA, ON THE WISCONSIN RIVER.

(b) Muscoda Development Corporation, Muscoda, Wisconsin.
(c) Prof. J. R. Villemonte and Prof. P. L. Monkmeyer, Hydraulics Laboratory, University of Wisconsin, Madison 6, Wisconsin.
(d) Experimental; applied research and design for M.S. thesis.
(e) A model study is underway to determine the scour patterns and characteristics downstream of a proposed barrage across the Wisconsin River at Muscoda. A second model is being constructed to study the stability of the proposed rock fill section at key locations.

(4736) UNSTEADY FLOW IN POROUS MEDIA.

(b) Laboratory project.
(c) Prof. P. L. Monkmeyer, Hydraulics Lab., University of Wisconsin, Madison 6, Wisconsin.
(d) Theoretical; basic research for M.S. thesis.
(e) Computer solutions of a general nature are under investigation for problems involving unsteady, unconfined flow toward a well. Graphical methods for application to specific problems are being developed.

WOODS HOLE OCEANOGRAPHIC INSTITUTION.

(4737) EXPERIMENTAL HYDRODYNAMICS OF ROTATING SYSTEM.

(b) Office of Naval Research, Dept. of the Navy.
(c) Dr. Alan J. Faller, WHOI, Woods Hole, Mass.
(d) Experimental, theoretical, field investigations; basic research.
(e) Hydrodynamics of rotating systems with specific application as experimental models of geophysical fluid circulation.
(g) Determination of stability criteria of Ekman boundary layer flows and application of these results to oceanic and atmospheric systems.
(h) "The Development of Fluid Model Analogues of Atmospheric Circulations," by Alan J. Faller, Final Report, Contract AF 19(604)-4982, GRD, AFCRL.
"An Experimental Analogy to and Proposed Explanation of Hurricane Spiral Bands," by Alan J. Faller, Proc. 2nd Tech. Conf. on Hurricanes, Amer. Met. Soc. June 27-30, 1961, Miami Beach, Florida.
"An Experimental Study of the Instability of the Laminar Ekman Boundary Layer," by Alan J. Faller, J. of Fluid Mech. (in press).

(4738) SYNOPTIC OCEANOGRAPHY - SURFACE EFFECTS.

(b) Office of Naval Research, Dept. of the Navy.
(c) Mr. Raymond G. Stevens, Woods Hole Oceanographic Institution, Woods Hole, Mass.
(d) Experimental, field investigation, basic research, doctoral dissertation.
(e) Measurement of the directional spectrum of wind generated gravity waves in the generating area.
(g) Directional spectra have been measured in Buzzards Bay, Massachusetts, and Panama City, Florida.
(h) "A Data Acquisition and Analysis System for Oceanographic Measurements," by D. D. Ketchum and R. G. Stevens, Marine Sciences Instrumentation Vol. 1, Plenum Press, pp 55-60, 1962.
"A Fast Response Cup Anemometer for Measurement of Turbulent Wind Over the Ocean," by Marine Sciences Instrumentation Vol. 2, Plenum Press (in press).

WORCESTER POLYTECHNIC INSTITUTE, Alden Hydraulic Laboratory.

Inquiries concerning the following projects should be addressed to Professor Leslie J. Hooper, Director, Alden Hydraulic Laboratory, Worcester Polytechnic Institute, Worcester 9, Mass.

(1963) METER CALIBRATION.

(b) Foxboro, Company, Foxboro, Mass.
(d) Experimental, for design.

(e) Calibration of various sizes of magnetic flow tubes (1" to 36" diameter).
(f) Test in progress.

(3859) METER CALIBRATIONS.

(b) B-I-F Industries, Providence, R. I.
(d) Experimental, for design.
(e) Calibration of a variety of flow measuring devices including flow nozzles, open flow nozzles and venturi meters were calibrated. Calibrations were at times performed in the standard test loop and in some cases in a mock-up in place conditions.
(f) Tests in progress.

(4255) METER CALIBRATIONS.

(b) Penn Meter Company, Philadelphia, Pa.
(d) Experimental; for design.
(e) Calibration of open flow nozzles and flow tubes from 2" to 48" in diameter.
(f) Tests in progress.

(4739) CHONG PYONG HYDROELECTRIC PROJECT.

(b) Stone and Webster Engineering Corp., Boston, Mass.
(d) Experimental; for design.
(e) A 1/50 scale model of a section of the spillway was installed in the 3 foot glass sided flume of the laboratory. Calibration of the spillway and flood gates was performed. Tests were also conducted on a variety of apron designs for different sections of the spillway.

(4740) CHONG PYONG HYDROELECTRIC PROJECT.

(b) Stone and Webster Engineering Corp., Boston, Mass.
(d) Experimental, for design.
(e) A 1/75 scale model of a reach of the North Han River in the Republic of Korea is under construction for the Korea Electric Co. The model will include the spillway and powerhouse as well as river topography up and downstream of the development. Studies will be made of the flow characteristics for various operating conditions.
(g) Model under construction.

(4741) CORNWALL PUMPED STORAGE DEVELOPMENT.

(b) Uhl, Hall and Rich, Boston, Mass.
(d) Experimental, for design.
(e) A 1/80 scale model of the intake at the upper reservoir will be constructed including local topography near the intake. The studies will involve the flow patterns and possible surface disturbances in the reservoir as well as the flow in the first few diameters of the vertical shaft of the intake.
(g) Model under construction.

(4742) RIO LAS DAMAS HYDROELECTRIC PROJECT.

(b) Jackson and Moreland International Inc., Boston, Mass.
(d) A 1/20 scale model of a section of the proposed spillway was constructed in the two foot wooden flume at the laboratory. Enough length was provided to accommodate a stretch of the river upstream of the dam and the apron and stilling basin pool on the downstream side. Tests involved the performance of the spillway with various flows and with stop logs in place at the crest. Also studied was the apron design and the adequacy of wing walls and rip-rap bank protection downstream.
(f) Completed.
(h) Report completed.

(4743) HYDRAULIC CYCLONE.

(b) Bird Machine Co., South Walpole, Mass.
(d) Experimental, for design.
(e) Evaluation of the percentage breakup of the flow between the two discharge paths (accepts and rejects) in a cyclong type separator was made. The flow pattern in various sections of the machine was measured in the course of the studies.
(g) Tests in progress.

(4744) FLOW DIFFUSER.

(b) Rice-Barton Corp., Worcester, Mass.
(d) Experimental; for design.
(e) A variety of modifications to a standard diffuser have been designed and tested with the purpose of reducing the length while maintaining or producing a uniform exit velocity.
(g) Tests in progress.

(4745) METER CALIBRATION.

(b) Knolls Atomic Power Laboratory, Schenectady, New York.
(d) Experimental; for design.
(e) A variety of flow measuring devices in all stages of development have been calibrated. Types included orifice plates, venturi tubes and ultrasonic flowmeters (Gulton and Narda Ultrasonics).
(g) Tests in progress.

(4746) METER CALIBRATIONS.

(b) Hagan Chemicals and Controls, Inc., Pittsburgh, Penn.
(d) Experimental, for design.
(e) Calibration of a variety of sizes and designs of flow nozzles.
(g) Tests in progress.

(4747) SCALE PIT.

(b) Morgan Construction Co., Worcester, Mass.
(d) Experimental; for design.
(e) A 1/12 scale model of a circular scale pit was constructed and tested. The tests were used to determine the effectiveness of the pit in removing steel mill scale from the wash water. In addition tests were conducted with a variety of floor configurations in order to induce the scale to settle in a pattern such as to facilitate removal.
(f) Completed.

(4748) FRICTIONAL LOSS IN PLASTIC PIPE.

(b) International Pipe and Ceramics Corp., Wharton, New Jersey.
(e) Sections of 8" and 12" PVC pipe were installed with instrumentation in the laboratory line. Tests were conducted to determine head loss and friction coefficients for a full pipe as well as for the pipe set at a number of slopes and flowing partially full.
(h) Report in preparation.

(4749) DYNAMICS OF CAVITATION ON SPHERE.

(b) Laboratory project.
(d) Experimental; for design.
(e) An investigation and analysis were performed on the dynamic characteristics of a nonrotating sphere in cavitating flow. The spheres were launched underwater at velocities between 60 and 130 feet per second to produce the transient cavitating flow behind the sphere. Observations of drag coefficient, slope of cavity and the reentrant jet were made during the study.
(f) Completed.
(h) Master's Thesis entitled "The Dynamic Characteristics of a Nonrotating Sphere in Transient Cavitating Flow," by Ronald D. Kangas, in our file at Worcester Polytechnic Institute, Worcester, Mass.

(4750) LOW VELOCITY METER.

(b) Laboratory project.
(d) Experimental, for thesis.
(e) The design of a flow meter capable of measuring velocities in water by means of a dynamic force sensor was carried out. Velocities in the range from 0.8 to 6 inches per second were indicated by a strain gage type of instrument. Instantaneous readings and insensitivity to water temperature are among the advantages. The instrument was constructed and calibrated in the laboratory calibration towing tank.
(f) Completed.
(h) Master's Thesis entitled,"A Force-Velocity Meter for Low Velocities," by Raymond L. George is on file at Worcester Polytechnic Institute, Worcester, Mass.

(4751) LOW VELOCITY METER.

(b) Laboratory project.
(d) Experimental, for thesis.
(e) The design of a low velocity thermistor flowmeter with ambient temperature compensation was designed, constructed and tested. The meter was designed to operate in water flow at velocities from 0.04 to 0.5 feet per second. Flow direction was indicated by use of a matched pair of thermistors.
(f) Completed.
(h) "The Design and Operation of Low Velocity Thermistor Flowmeter with Ambient Temperature Compensation," by Wallace C. Flower is on file at Worcester Polytechnic Institute, Worcester, Mass.

UNIVERSITY OF CALIFORNIA, College of Agriculture, Department of Irrigation.

(21) THE MECHANICS OF WATER DROPLET AND SPRAY FORMATION FROM SPRINKLER NOZZLES.

(b) California Agricultural Experiment Station.
(c) Dr. J. R. Davis, Dept. of Irrigation, Univ. of California, Davis, California.
(d) Experimental; theoretical and laboratory investigation.
(e) Investigations to evaluate the causes of wave formation of the jet, to evaluate the nature of the wave system, and to determine the relation between turbulence in the nozzle and the formation of discontinuous water drops.
(f) Completed.
(g) Results include the development of the electric needle technique for describing the frequency, amplitude and wave length of the wave system. The distance from the nozzle to the point at which the jet begins to break up has been related to Weber number and Reynold's number. For smooth nozzles, Weber number appears to be the only parameter.

(23) HYDROLOGY OF IRRIGATION SUPPLIES IN CALIFORNIA.

(b) California Agricultural Experiment Station.
(c) Prof. R. H. Burgy and Mr. D. C. Lewis, Dept. of Irrigation, Univ. of Calif., Davis, California.
(d) Experimental and field investigation; applied research.
(e) Hydrologic investigations of mountain watersheds are being conducted on pilot watersheds in three areas of the state. Measurements are being made of rainfall, surface runoff, erosion, and groundwater storage and outflow. The hydrologic effect of vegetative conversions on the watersheds is under long-range study. Radioactive tracers are used to study groundwater movement and depth of rooting of trees. A neutron moisture meter is used to measure moisture content in the soil and rock above the water table. Micrometeorological techniques and equipment are being tested to provide an independent evaluation of evapotranspiration from the study watersheds.
(h) "Water Use by Native Vegetation and Hydrologic Studies," by D. C. Lewis and R. H. Burgy, Annual Report No. 3, 1961-62, Dept. of Irrigation, University of California, Davis, California.

(1819) DRAINAGE IN RELATION TO IRRIGATION.

(b) California Agricultural Experiment Station.
(c) Dr. J. N. Luthin and Mr. R. V. Worstell, University of California, Davis, California.
(d) Basic and applied research.
(e) A study of glass fiber filter materials for drains showed them satisfactory in preventing soil particles from entering the drain and in conducting water from the soil to the cracks or perforations of the drain tube.
A study of sound transmission through soils in relation to moisture content showed that water films exert a load on the soil particles which increases the velocity of sound transmission in the low moisture-tension ranges.
Data are being collected to evaluate the capillary pressure behind the wetted front to be used in an analysis of the seepage of water from a cavity into a dry soil.
The four-electrode probe method is being used to monitor soil salinity variations in two field studies of saline reclamation as related to irrigation and drainage. Early results indicate this method may become a useful tool.
The large drainage tank was filled with soil, equipped with a system of primary instrumentation and two preliminary runs were made to test out the entire setup and establish operating procedures. Some improvements are to be made but the tank is operational for many studies.
(h) "The Propagation of Elastic Waves in Unconsolidated Granular Media," by W. H. Brutsaert Ph.D. Thesis, University of California, Davis, California, 1962.
"Drainage Salinity Investigations in the Five Points, Tranquillity Area, Fresno County, California," by J. N. Luthin, J. W. Biggar, Report submitted to Bureau of Reclamation, U. S. Dept. Int., 1962.
"An Investigation of Perforated Pipe and Fiberglass Filters for Subsurface Drainage," by D. G. Watts, Master's Thesis, University of California, Davis, California, 1962.
"Thick Fiberglass Filters for Subsurface Drains," by D. G. Watts and J. N. Luthin, submitted for publication in Hilgardia, 1962.

(3866) HYDRAULICS OF SURFACE IRRIGATION SYSTEMS.

(b) California Agricultural Experiment Station.
(c) Dr. J. R. Davis, Department of Irrigation, University of California, Davis, Calif.
(d) Experimental; laboratory and field investigation.
(e) Rational approaches to defining the flow of water in vegetative channels, dimensional analyses and model studies of rate of water advance in borders. Evaluations of criteria for design of tail water return systems, measurement of flow in small irrigation streams, and evaluation of irrigation efficiency concepts.

(4086) MISCIBLE AND IMMISCIBLE FLUID DISPLACEMENTS IN RELATION TO SOLUTE MOVEMENT IN SOIL AND OTHER POROUS MATERIAL.

(b) California Agricultural Experiment Station.
(c) Drs. J. W. Biggar and D. R. Nielsen, Dept. of Irrigation University of California, Davis, California.
(d) Theoretical and experimental; basic and applied.
(e) The simultaneous transport of fluids and solutes through porous media is under investigation. The mixing and spreading of the fluids in the medium, the interaction of the

fluids with each other and the medium have been studied. The work will help define the nature of the porous structure of materials, and the coupling between velocity and diffusion in the dispersion process. Leaching phenomena, disposal of industrial and radioactive wastes, and the movement of pesticides in soil water depend upon the dispersion process.

(g) Mathematical models of dispersion previously reported have been compared with experimental data obtained from studies on soil, glass beads, sandstone and sand columns. More recently the effects of the density and viscosity of the fluids on the mixing has been studied using Cl^{36} and glass bead medium. Leaching Phenomenon, disposal of industrial and radioactive wastes and the movement of pesticides in soil water involve dispersion processes.

(h) "Miscible Displacement: II. Behavior of Tracers," by J. W. Biggar, and D. R. Nielsen, Soil Sci. Soc. Amer. Proc. 26:125-128, 1962. "Miscible Displacement: III. Theoretical Considerations," by D. R. Nielsen, and J. W. Biggar, Soil Sci. Soc. Amer. Proc. 26:216-221, 1962. "Some Comments on Molecular Diffusion and Hydrodynamic Dispersion in Porous Media," by J. W. Biggar and D. R. Nielsen, J. Geophys. Res. 67:3636, 1962.

(4087) DYNAMIC PROJECT PLANNING.

(b) California Agricultural Experiment Station.
(c) Dr. V. H. Scott, Department of Irrigation, University of California, Davis, California.
(d) Developmental design.
(e) This study is to develop an approach to the engineering aspects of project planning particularly adaptable for such areas where (1) water requirements whether for irrigation or other uses are supplied through pumping from wells, and (2) where problems of increased cost of pumping due to lowering the water wells, deterioration of water quality, and/or reduction in yield of wells due to depletion of available ground water supply occur.
(g) Detailed analysis has shown that dynamic project planning is a satisfactory engineering technique when applied to situations where development of water facilities is undertaken for presently unused water supplies in areas with a ground water deficiency.

(4088) IRROTATIONAL FLOW OVER A VERTICAL, SHARP-CRESTED WEIR.

(b) California Agricultural Experiment Station.
(c) Prof. Theodor S. Strelkoff, Acting Assistant Professor, Dept. of Irrigation, Univ. of California, Davis, California.
(d) Theoretical, basic research, in part for doctoral dissertation.
(e) An integral equation has been derived for the two-dimensional flow over a weir through application of the methods of complex variables and vorticity distribution. The equation, representing satisfaction of the constant-pressure condition on the free surfaces, involves no approximations or linearizations. An iterative solution similar to the Neumann treatment of Fredholm integral equations has been developed and programmed for the IBM 7090 digital computer.

(4857) USE OF WELLS IN AREA DEVELOPMENT.

(b) California Agricultural Experiment Station.
(c) Dr. V. H. Scott, Department of Irrigation, University of California, Davis, California.
(d) Theoretical and field research including doctoral thesis research.
(e) To consider the influence of a decreasing discharge rate in developing a general solution for unsteady flow to wells. Such a solution is of importance in calculating the transmissibility and storage coefficients of an aquifer from short-time pumping tests, and in water supply and drainage problems where seasonal water requirements vary or a certain schedule of pumping is to be followed. Field tests are being used to check the theory.
(g) A general analytical solution has been developed for unsteady flow of groundwater to a well having a decreasing discharge rate. A graphical solution has been proposed to determine the aquifer characteristics from pumping test data. The graphical solution requires the numerical computation and tabulation of a mathematical function called the "variable well function". Values of this function have been determined.
(h) "Non-Steady Flow to a Well for Decreasing Rate of Discharge," by M. Abu-Zied, Ph.D. in Engineering Thesis, University of California, Davis, California. Aug. 1962.

CATHOLIC UNIVERSITY OF AMERICA, Department of Civil Engineering.

(3030) TRANSIENT FLOW THROUGH POROUS INCOMPRESSIBLE MEDIA WITH VARIOUS BOUNDARY CONDITIONS.

(b) Experimental part was supported by the National Research Council of Canada.
(c) Dr. B. S. Browzin, Professor of Civil Engrg., The Catholic University of America, Wash. 17, D. C.
(d) Experimental and theoretical; basic research.
(e) The unsteady laminar flow was reproduced by a highly viscous liquid flowing between closely spaced translucid plates on a number of models with geometric boundaries representing various types of earth dams on impervious foundations and earth massives crossed by open channels, when boundary conditions are of transient character with respect to the time. Experimental part concerning earth dams and earth massives on impervious foundations completed. The theoretical part of the research completed for the case of rapid drawdown in homogeneous dams. The theoretical research of cases of gradual drawdown, of non-homogeneous dams, of tailwater condition, and the drawdown in canals is progressing.
(g) An approximate function relating, by dimensionless parameters, the shape and the position of free surface of flow through the earth dam, following rapid reservoir drawdown, to the geometry of the dam was obtained theoretically and confirmed by experiments.
(h) "Nonsteady-State Flow in Homogeneous Earth Dams after Rapid Drawdown," Proceedings of the Fifth International Conference on Soil Mechanics and Foundation Engineering, Vol. II, p. 551, Paris 1961. "Nichtstationare Sickerstromungen in homogenen Erddammen und Erdkorpern," pp. 259, Doctoral dissertation at the Rheinisch-Westfaelische Technische Hochschule Aachen. The book is available at the library of the National Research Council of Canada, Ottawa 2, Ontario.

(3031) THE VARIATION OF HYDROLOGIC FACTORS AND THEIR INFLUENCE ON RIVER REGIMES IN THE GREAT LAKES-ST. LAWRENCE DRAINAGE AREA.

(b) Laboratory project.
(c) Dr. B. S. Browzin, Professor of Civil Engrg., The Catholic University of America, Wash. 17, D. C.
(d) Basic research.
(e) Research is based on long range flow and meteorologic record. Flow and precipitation data on U.S. and Canada stations were statistically investigated in order to obtain river regime characteristics.
(f) Completed.
(g) Classified discharges for long range gauging

stations are calculated. Characteristic parameters for river classification of the area are obtained, water-balance in the basin is calculated; average, maximum and minimum run-off for the period of available observations is analysed.

(h) "On Classification of Rivers in the Great Lakes-St. Lawrence Basin," Proceedings. Fifth Conference on Great Lakes Research, Toronto, Canada, April 9-10, 1962. p. 86. Publ. University of Michigan, Ann Arbor. "Runoff in the Great Lakes-St. Lawrence Basin, Including General Principles of River Classification." Monograph in preparation.

UNIVERSITY OF MICHIGAN, Department of Civil Engrg.

(3769) WAVE REFRACTION IN A TRAPEZOIDAL CHANNEL.

(b) Laboratory project.
(c) Prof. E. F. Brater, Prof. of Hydraulic Engineering, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich.
(d) Theoretical and experimental; basic research for doctoral thesis.
(e) Investigation of the refraction of waves which enter a trapezoidal channel from deeper water.
(f) Project completed.
(g) Graphical procedure for applying Stoke's equations to refraction developed. Analytical model for momentum transfer along wave crests was derived.
(h) Thesis on file in University of Michigan library.

(3770) ROLL WAVES.

(b) Laboratory project.
(c) Prof. E. F. Brater, Prof. of Hydraulic Engrg., Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich.
(d) Theoretical and experimental; basic research for doctoral thesis.
(e) Investigation of the characteristics of a wave generated by a disturbance at the entrance to a channel.
(f) Project completed.
(g) The method of characteristics and the digital computer were applied to the problem of the generation and decay of a disturbance in uniform flow.
(h) Thesis on file in University of Michigan library.

(4168) UNSTEADY GRAVITY FLOW OF LIQUIDS THROUGH POROUS MEDIA.

(b) Laboratory project.
(c) Prof. V. L. Streeter, Prof. of Hydraulics, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich.
(d) Theoretical and experimental; basic research for doctoral thesis.
(e) Study of flow through porous media, for cases of free surface flow with upstream free surface varying with time.
(f) Project completed.
(g) Method of solution using method of characteristics and digital computer was developed and checked.
(h) Thesis on file in University of Michigan library.

(4858) WATER HAMMER: RESONANCE IN TRIPLEX PUMP SUCTION AND DISCHARGE LINES.

(b) Union Pump Company.
(c) Prof. V. L. Streeter, Prof. of Hydraulics, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich.
(d) Theoretical and experimental; basic research.
(e) Theoretical determination of resonance-free suction lines and experimental study of actual transients.

(4859) PULSATILE FLOW THROUGH ARTERIES.

(b) National Institutes of Health.
(c) Prof. V. L. Streeter, Prof. of Hydraulics, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich.
(d) Theoretical and experimental; basic research.
(e) Computer simulation of portions of the arterial tree; experimental studies of energy dissipation in pulsatile flow through distensible tubes.
(h) "Pulsatile Pressure and Flow through Distensible Vessels," Circulation Research, in press.

(4860) WATER HAMMER: FAILURE OF PUMPS.

(b) National Science Foundation.
(c) Prof. V. L. Streeter, Prof. of Hydraulics, Dept. of Civil Engrg., College of Engrg., University of Mich., Ann Arbor, Mich.
(d) Theoretical.
(e) Study of water hammer in suction and discharge lines of large pumping stations with multiple pumps when one or more lose their power. Dimensionless, homologous complete characteristics used with computer program for water hammer based on methods of characteristics.

(4861) WATER HAMMER, ITS EFFECT ON MINOR LOSSES.

(b) National Science Foundation.
(c) Prof. V. L. Streeter, Prof. of Hydraulics, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich.
(d) Theoretical and experimental; basic research for doctoral thesis.
(e) Investigation of effect of minor losses on water hammer pulses, the losses being developed from a series of closely-spaced orifices. Transmission and reflection coefficients obtained by theory; then programmed into a water hammer solution for the experimental set-up.
(f) Experimental work completed.
(g) Transmission and reflection due to a minor loss of $K\ V^2/2g$ each equal to $K/2\ V^2/2g$.

(4862) WATER HAMMER, LIQUID COLUMN SEPARATION.

(b) National Science Foundation.
(c) Prof. V. L. Streeter, Prof. of Hydraulics, Dept. of Civil Engrg., College of Engrg., Univ. of Mich., Ann Arbor, Mich.
(d) Theoretical and experimental; basic research for doctoral thesis.
(e) Study of shape of separated liquid free surface in a horizontal pipe.

UNIVERSITY OF MINNESOTA, Agricultural Experiment Station.

(1929) DRAIN TILE JUNCTION LOSSES.

Cooperative with St. Anthony Falls Hydraulic Laboratory. See page 67.

(2350) DRAINAGE OF AGRICULTURAL LAND BY PUMPING.

(b) Field and laboratory project.
(c) Prof. Curtis L. Larson, Dept. of Agricultural Engineering, Univ. of Minnesota, St. Paul 1, Minnesota.
(d) Theoretical and field investigations; applied research.
(e) The project has three phases: (1) The development of basic relations for planning pump drainage systems, (2) the study of rates of drainage, and (3) the study of factors affecting the efficiency.
(g) Continuous measurements of farm tile flow from mineral or organic soil are made, as well as precipitation amounts.
(h) "Tile Flow and Power Use Data for Pump Drainage Systems," by C. L. Larson and D. M. Manbeck. Trans. of the American Society of Agricultural Engineers, 5(2):207-209, 1962.

(2576) CONSTRUCTION, DEVELOPMENT, AND PUMPING OF

SHALLOW WELLS FOR IRRIGATION.

(b) Field project.
(c) Prof. Evan R. Allred, Dept. of Agricultural Engineering, Univ. of Minn., St. Paul 1, Minn.
(d) Field investigation; applied research and development.
(e) The objectives of the project are: (1) To study and develop inexpensive methods for construction of shallow irrigation wells, (2) determine hydraulic permeability and characteristics of various aquifers, and (3) to survey and determine extent and availability of shallow ground water sources for irrigation in Minnesota.

(3470) HYDRAULIC PERFORMANCE OF IRRIGATION BOOM-SPRINKLERS.

(b) Field and laboratory project.
(c) Prof. Evan R. Allred, Dept. of Agricultural Engineering, Univ. of Minn., St. Paul 1, Minn.
(d) Primarily field investigation; applied research.
(e) The objective of the project is to determine the effect of wind velocity, nozzle arrangement, rotation speed and operating pressure on the distribution from irrigation boom-sprinklers.
(f) Completed.
(h) "Effect of Wind Resistance on Rotational Speed of Boom Sprinklers," by E. R. Allred and R. E. Machmeier, Trans. of the American Society of Agricultural Engineers, 5(2)218-225, 1962.
"Operating Performance of a Boom Sprinkler," by R. E. Machmeier and E. R. Allred, Trans. of the American Society of Agricultural Engineers, 5(2):220-225, 1962.

NEW YORK UNIVERSITY, Department of Meteorology and Oceanography.

(3120) OFFICE OF NAVAL RESEARCH ATMOSPHERE INTERACTION AND WAVE PROJECT.

(b) Geophysics Branch, Office of Naval Research, Department of the Navy.
(c) Prof. Gerhard Neumann, Prof. of Oceanography and Prof. Willard J. Pierson, Prof. of Oceanography, New York University, New York 53, New York.
(d) Experimental and theoretical; basic and applied research.
(e) Study of wave generation and propagation in deep water; nonlinear properties of capillary and gravity waves in both Eulerian and Lagrangian form. Observations of temperature, humidity, and wind over the sea surface. Albedo measurements. Wind stress over the water surface. The prediction of large scale oceanic circulations. Theoretical and observational studies of turbulence in water. Diffusion studies.
(g) Models of random seas in Lagrangian form have been developed that look promising. Field work will be augmented by the acquisition of a T-boat and additional scientific equipment for it.
(h) "An Experiment in Numerical Forecasting in Deep Water Ocean Waves," by L. Baer. Lockheed Missiles and Space Division, June 15, 1962.
"Polarization of Sunlight Reflected from the Sea Surface," by J. Pandolfo. Submitted to Jour. of Geophysical Research, April 1962.
"Some New Unsolved Problems in Connection With Random Processes of Interest in Geophysics," by W. J. Pierson. Tech. Report, New York University, under contract Nonr 285(03).
"Perturbation Analysis of the Navier-Stokes Equations in Lagrangian Form with Selected Linear Solutions," by W. J. Pierson. Jour. Geophys. Res., vol. 67, no. 8, July 1962.
"The Average Horizontal Wind Driven Mass Transport of the Atlantic for February as Obtained by Numerical Methods," by D. M. Garner, G. Neumann, and W. J. Pierson. Tech. Report prepared for Office of Naval Research under contract Nonr 285(03). New York University, College of Engineering, Dec. 1962.
"Some Studies on the Ocean Circulation," by D. M. Garner. Tech. Report under Contr. Nonr 285(03), New York University, College of Engineering, Oct. 1962.

ROBERT TAGGART INCORPORATED.

(4863) DIMENSIONAL EFFECTS ON HYDROPHONE OUTPUT IN THE NEAR FIELD.

(b) David Taylor Model Basin, Department of the Navy.
(c) Mr. Robert Taggart, Robert Taggart Inc., 400 Arlington Boulevard, Falls Church, Va.
(d) Experimental; applied research.
(e) Measurements were made of the outputs of two cylindrically shaped hydrophones, 5/8" and 2" diameter, whose bases formed the active area. The hydrophones were mounted in a closed trunk over a flat flexible plate forming part of the wall of a rectangular water tunnel. The distances between the active face and the plate were 1/8", 1/4", 1/2", 1", 2" and 4", while the flow velocities through the main pipe ranged from 6 to 13 kts. These tests were conducted to determine whether a "distance" effect, previously noted, could be reproduced in a laboratory facility.
(f) Completed.
(g) It was found that a relation did exist between output levels and distance, the higher level occurring at the closest position. During the process of reducing the data, there was some evidence of an "area" effect also, at least for the two closest positions of the hydrophones.
(h) "Dimensional Effects on Hydrophone Output in the Near Field," Report RT-5703 to David Taylor Model Basin (Contract NObs 86122) February 1963.

(4864) SEA-CHEST STRAINER PLATE SUCTION.

(b) Bureau of Ships, Department of the Navy.
(c) Mr. Robert Taggart, Robert Taggart Inc., 400 Arlington Boulevard, Falls Church, Va.
(d) Experimental; applied research.
(e) An investigation is being carried out in a 2" x 8" plastic water tunnel, to determine the acoustic effects of the flow of water through a model strainer plate. The plate is mounted in a model sea-chest on the lower wall of the tunnel and suction is applied either by gravity or by an eductor operating on a 40 psi system. All throttling and flow control is effected by Flex valves to minimize noise.
Flush-mounted hydrophones and accelerometers are used to determine the boundary-layer pressure fluctuations and the acoustic radiation at several locations near the strainer plate, for various suction ratios.
(g) Preliminary results show that for the suction ratios used, flush-mounted hydrophones of small active area are not sensitive enough to measure radiated noise. On the other hand, an accelerometer located in the sea-chest indicated a definite rise in the noise spectrum level with various suction ratios.

UNIVERSITY OF TENNESSEE, Hydraulic Laboratory, Dept. of Civil Engineering.

Inquiries concerning the following projects should be addressed to Mr. William A. Miller, Jr., Acting Head of Hydraulic Laboratory, University of Tenn.,

Knoxville 16, Tenn.

(2619) BOUNDARY-ROUGHNESS EFFECTS UPON TURBULENT FLOW.

(b) Laboratory project.
(d) Experimental; basic research.
(e) Extended study of specific effects of certain characteristics of roughness-element geometry upon turbulent flow over rough surfaces.
(f) Suspended indefinitely.
(g) Measurement of resistance characteristics and of velocity distributions have been made for 35 patterns of depression, projection, and ring-and-groove roughness.

(4865) AN ANALYSIS OF CHARACTERISTICS OF DEPRESSION-TYPE ROUGHNESS FOR TURBULENT FLOW IN PIPES.

(b) Laboratory project.
(d) Experimental; for master's thesis.
(e) Analysis and discussion of results of experimental measurements of velocity distribution and resistance characteristics for cylindrical depression type roughness elements; effect of various roughness properties; comparisons.
(g) Effects of size, spacing, roughness density noted and evaluated.
(h) Thesis to be available by August 1963.

TEXAS A AND M COLLEGE, Department of Oceanography and Meteorology.

Inquiries concerning the following projects should be addressed to Prof. R. O. Reid, Texas A and M College, College Station, Texas.

(4233) THE EXCHANGE CHARACTERISTICS AND SALINITY REGIME OF SHALLOW WATER BAY SYSTEMS.

(b) Nat'l. Science Foundation, Grant NSF-F 19780.
(d) Analysis methodology; applied research.
(e) The object is to develop a numerical model which can reproduce the temporal changes in the gross features of the salinity distribution in a shallow bay in response to changes in control factors and to determine changes in the variance spectrum of the detailed features as related to the spectral statistics of the control factors.
(f) Initiated, Sept. 1961.
(g) Studies being undertaken include evaluation of the spectra and cross-spectra of salinity and river discharge data for Lake Pontchartrain, La., over a period of eleven years. Also multiple regression techniques have been employed to evaluate the effective exchange coefficient between the bay and the adjoining Gulf associated with tidal exchange.
(h) Dissertation by Mr. T. Sakou on the results of the investigations is in preparation.

(4866) MODIFICATION OF TWO-DIMENSIONAL LONG WAVES OVER VARIABLE BOTTOM TOPOGRAPHY.

(b) Beach Erosion Board, DA-49-055-CIV-ENG-63-9.
(d) Theoretical.
(e) The objective is to investigate the modification of free gravity waves in variable depth, including reflection and transmission aspects, especially considering those long wave phenomena where simple refraction theory is inadequate.
(f) Initiated, March 1963.
(g) Of particular concern is the propagational aspects of a tsunami wave packet in the vicinity of a continental shelf. Methods are being developed to take into account vertical acceleration which is usually ignored when treating long waves.
(h) Paper in preparation on "Variational Formulation for Long Waves in Variable Depth," by R. O. Reid and A. C. Vastano.

U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, Soil and Water Conservation Research Division.

CORN BELT BRANCH, University of Minnesota, St. Paul, Minn., Dr. C. A. Van Doren, Branch Chief.

(66) HYDROLOGIC STUDIES, RALSTON CREEK WATERSHED.

See Iowa Institute of Hydraulic Research, page 37.

(1723) THE HYDRAULICS OF CONSERVATION STRUCTURES.

See St. Anthony Falls Hydraulic Laboratory Projects Nos. 111, 1168, 1929, and 2386. See also U. S. Department of Agriculture, Agricultural Research Service, Soil and Water Conservation Research Div., Southern Plains Branch, Project No. 4335, and Illinois State Water Survey Division Project No. 1865.

(b) Cooperative with the Minnesota Agricultural Experiment Station, the St. Anthony Falls Hydraulic Laboratory, and the Illinois State Water Survey.
(c) Mr. Fred W. Blaisdell, Hydraulic Engineer, St. Anthony Falls Hydraulic Laboratory, 3rd Ave. S. E., at Mississippi River, Minneapolis, Minnesota.
(d) Experimental; applied research for development and design.
(e) Research dealing with the design, construction, and testing of structures for conserving and controlling soil and water are carried out. Studies during the past year have been concerned with the two-way drop inlet for closed conduit spillways. The width of this drop inlet is equal to the barrel diameter. Its length varies. Water flows only over the two sides. The end walls support a horizontal plate over the drop inlet which acts as an anti-vortex device. The overhang of the plate supports a trash guard. Tests are conducted using both water and air as the model fluid to determine the performance, loss coefficients, and pressure coefficients for the drop inlet. Cooperation with and co-ordination of the tests at the Stillwater, Oklahoma, Outdoor Hydraulic Laboratory and the Illinois State Water Survey is maintained.
(g) If the anti-vortex plate is too low, undesirable orifice flow will control the discharge. If the anti-vortex plate is too high, harmful vortices will form under the plate. Rules for determining acceptable plate heights have been determined. The overhang of the plate must be greater than a certain minimum to insure satisfactory performance. The action of the two-way drop inlet is that of a self-regulating siphon. The tests using air agree with the results obtained from the water tests and are much easier to perform. Air is used as the model fluid only for the condition of full conduit flow.

(2316) RUNOFF FROM SMALL AGRICULTURAL AREAS IN ILLINOIS.

See University of Illinois, Department of Agricultural Engineering, page 34.

(4191) HYDRAULICS OF FLOW THROUGH MEANDER-FLOOD PLAIN GEOMETRY.

See Purdue University, School of Civil Engineering, page 64.

(4264) HYDROLOGIC STUDIES ON AGRICULTURAL WATERSHEDS IN WISCONSIN.

(b) Laboratory project, cooperative with the Wisconsin Agricultural Experiment Station and the Wisconsin Valley Improvement Co.
(c) Mr. K. E. Saxton, Hydraulic Engineer, 3230 University Avenue, Madison, Wisconsin.
(d) Field investigation and office analysis.
(e) Various records of runoff, ground water, precipitation and climatic factors, soil moisture, land use, and agricultural conditions and practices are maintained for 22 agricultural watersheds ranging in size from 2.7 to 11,000 acres in the vicinity of LaCrosse, Fennimore, Colby and at other locations in Wisconsin. Analyses are made to evaluate the factors affecting flood flows, hydrograph characteristics, and the yield of stream flow.

(4265) PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS ON THE UNGLACIATED ALLEGHENY PLATEAU.

(b) Laboratory project, cooperative with Ohio Agricultural Experiment Station.
(c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, ARS, Coshocton, Ohio.
(d) Field investigation and office analysis.
(e) To develop methods of characterizing watershed precipitation related to runoff rates and volumes and to evaluate "normalcy" of sample periods.
(g) Records of dense network of rain gages are being analyzed to determine network specifications for characterizing rainfall for runoff rates and volumes. Shielded and tilted catchment surfaces of rain gages have been installed in the field along with wind recording apparatus for studying the effect of wind on the rain gage catch and how the latter evaluates the rainfall on sloping land surfaces of a single aspect.
(h) "Seasonal and Areal Effects on Small Watershed Streamflow," by J. L. McGuinness and L. L. Harrold, Jour. Geophy. Res. 67:4327-4334, Oct. 1962.

(4266) SURFACE RUNOFF AND INTERFLOW STUDIES IN THE UNGLACIATED ALLEGHENY PLATEAU.

(b) Laboratory project, cooperative with the Ohio Agricultural Experiment Station.
(c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, ARS, Coshocton, Ohio.
(d) Field investigation and office analysis.
(e) To evaluate the factors affecting the volume of storm surface runoff and interflow from various combinations of upland watershed soil, cover, and treatment, and to study the basic factors affecting the hydrograph of these flows under various soil-cover combinations.
(g) Work is continuing on these studies. Storm flow totals from all unit source watersheds along with specific watershed and climatic parameters have been assembled for all the major storm runoff periods of record. Computer analysis of these data is being made to test for parameter significance.

(4267) STUDIES OF RUNOFF FROM COMPLEX WATERSHEDS IN THE UNGLACIATED ALLEGHENY PLATEAU.

(b) Laboratory project, cooperative with the Ohio Agricultural Experiment Station.
(c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, ARS, Coshocton, Ohio.
(d) Field investigation and office analysis.
(e) To determine how flows from incremental areas combine to produce hydrographs of stream flow on larger complex watersheds; determine the effects of climate and watershed characteristics on rates and amounts of runoff; and develop methods for predicting the magnitude and frequency of flows from ungaged watersheds.
(g) Work is continuing on these studies. Preliminary analysis showed that the summation of flow from incremental areas accounted for, at the best, only 70 percent of the storm flow measured for the larger complex watershed. Base flow was at a mini. Interflow studies are being made to evaluate the magnitude and timing of this quick return flow as a factor in flood stream flow.

Geologic investigations of aquifers contributing to stream flow are included in the study of the effects of watershed characteristics and management of stream flow. Their effect is an important factor, as runoff volumes increase rapidly with watershed size up to areas of 1,000 acres. A small watershed has been thoroughly instrumented to identify and evaluate shallow-depth interflow.

(h) "Seasonal and Areal Effects on Small Watershed Streamflow," by J. L. McGuinness and L. L. Harrold, Jour. Geophy. Res. 67:4327-4334, Oct. 1962.
"Explanation of the Coshocton Watershed Hydrology Research Station," Proc. 9th Nat'l Watershed Congr., 104-115, Oct. 1962.
"Estimating Flood Volumes and Hydrographs Corresponding to Peak Flows of Given Frequencies for Small Agricultural Watersheds," Jour. Geophy. Res. 67:4341-4346, Oct. 1962.

(4268) STUDIES IN SUBSURFACE HYDROLOGY IN THE UNGLACIATED ALLEGHENY PLATEAU.

(b) Laboratory project, cooperative with the Ohio Agricultural Experiment Station.
(c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, ARS, Coshocton, Ohio.
(d) Field investigation and office analysis.
(e) To evaluate ground-water and interflow contributions to stream discharge of agriculture watersheds and the recharge to aquifers under various watershed and climatic conditions.
(g) Work is continuing on geologic mapping for identifying and evaluating aquifer flow to stream discharge. Catchment areas of these contributing aquifers is being mapped. Studies of interflow have been started on the upland watersheds to help account for that storm flow at the complex watershed runoff gages not measured as upland surface runoff.
(h) "Seasonal and Areal Effects on Small Watershed Streamflow," by J. L. McGuinness and L. L. Harrold, Jour. Geophy. Res. 67:4327-4334, October 1962.

(4269) MOISTURE REGIMES OF SOILS IN THE UNGLACIATED ALLEGHENY PLATEAU.

(b) Laboratory project, cooperative with the Ohio Agricultural Experiment Station.
(c) Mr. L. L. Harrold, Supervisory Hydraulic Engineer, ARS, Coshocton, Ohio.
(d) Field investigation and office analysis.
(e) To maintain the soil moisture inventory of agricultural watersheds; to evaluate the effect thereon of soil, land use, and climate; to develop methods of estimating soil moisture quantities under various land use and climatic conditions; and to determine the influence of frozen soil and frost structure on water movement.
(g) Nuclear soil-moisture equipment is now providing good data on soil moisture down to 90-inch depths. They show material variations in moisture within a small watershed. Presently, methods of evaluating watershed soil moisture are being studied. Effect of vegetation of different rooting depths on soil moisture is being evaluated. Deep-rooted crops extract moisture to depths unaffected by shallow-rooted crops. In dry seasons, the former consumes more water than the latter, resulting in less percolation to ground water reservoirs. Lysimeters, 8 feet deep and 1/500 acre area of undisturbed soil record weight changes and percolation.
(h) "Errors in Evaluations of Dew Amounts by the Coshocton Lysimeters," Bul. International Assoc. Sc. Hydrol. Vol. II, No. 3, 73-74, Sept. 1962.
"Some Aspects of Watershed Hydrology as Determined from Soil Moisture Data," Jour. Geophy. Res. 67:3425-3435, October 1962.

(4270) CHARACTERISTICS OF FLOW IN IRRIGATION FURROWS.

(b) Laboratory project in cooperation with the Missouri Agricultural Experiment Station.
(c) Mr. John F. Thornton, Agricultural Engineer, Building T-12, University of Missouri, Columbia, Missouri.
(d) Experimental and field investigations, both basic and applied.
(e) The purpose of the study is to investigate the hydraulics of flow in irrigation furrows, as influenced by furrow shape, slope, roughness, and rate of flow. Develop engineering techniques that will provide maximum effective control and management of irrigation water.
(g) The work is continuing on the basic hydraulic aspects of flow in irrigation furrows to contribute to better understanding of furrow irrigation and the ultimate achievement of more efficient use of water.

(4271) PLASTIC-LINED MOLE DRAIN STUDIES.

(b) Laboratory project in cooperation with the Ohio Agricultural Experiment Station.
(c) Mr. James L. Fouss, Agricultural Engineer, Agricultural Engineering Dept., Ohio State University, Columbus, Ohio.
(d) Experimental and field investigations, both basic and applied.
(e) The purpose of these investigations is to improve plastic mole drainage techniques and test the effectiveness of other surface drainage systems. Tile, mole and other sub-surface drainage systems are developed and their effectiveness determined.
(g) The work is continuing on improving plastic mole drainage techniques and the effectiveness of other surface drainage systems.
(h) "Plastic-Lined Mole Drains," by James L. Fouss and W. W. Donnan, Agricultural Engrg., Vol. 43, pp. 512-515, September 1962.
"A New Machine to Lay Plastic Drains," by James L. Fouss, Civil Engineering, (In Press).

(4273) SURFACE AND SUBSURFACE DRAINAGE.

(b) Laboratory project in cooperation with the Minnesota Agricultural Experiment Station.
(c) Mr. Lee Hermsmeier, Agricultural Engineer, North Central Soil Conservation Field Station, Morris, Minnesota.
(d) Experimental and field investigations, both basic and applied.
(e) The purpose of these investigations is to develop engineering techniques that will provide maximum effective control and management of water. Techniques are developed for managing surface water flow through land forming and surface drainage systems. Tile, mole and other subsurface drainage systems are developed and their effectiveness determined.
(g) Work is continuing on land forming and the development of improved surface drainage systems, the effectiveness of field diversions, improved plastic mole drainage techniques and effectiveness of other subsurface drainage systems.

(4274) NATIONAL SUMMARIZATION AND ANALYSIS OF RUNOFF AND SOIL-LOSS DATA.

See Purdue University, Agricultural Engrg. Dept. No. (3808).

(b) Laboratory project, cooperative with the Purdue Agricultural Experiment Station.
(c) Mr. W. H. Wischmeier, Research Statistician, ARS, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
(d) Data analyses, applied research.
(e) Objectives of the national data summarization and analysis project are (1) to consolidate all available past, current, and future runoff, soil loss and related data in standardized form to make them available for

application of current methods of hydrologic and statistical analyses; (2) to analyze the data on an over-all basis, with special emphasis on identification and evaluation of significant factor interactions; and (3) to develop bases for prediction of runoff and soil losses from different landscapes under various land use and management conditions. In analyses of the assembled data, special emphasis is directed toward identification and evaluation of factors and interaction effects responsible for the frequent wide differences in results of localized studies at various locations. Over-all results are reduced to charts and tables readily usable by application technicians.

(g) Runoff, soil-loss and related data collected since 1930 on 47 cooperative research stations in 24 states have been assembled and transferred in detail to punched cards to facilitate organization, selection and analyses and to provide a compact permanent record. A rainfall-erosion index was derived, and an improved soil-loss equation was developed that is universally applicable wherever locality evaluations of its component factors are available. Ready reference information for locality evaluations of some of the factors has been completed. Work on more accurate evaluations of the other factors is in progress.

(h) "Soil-Loss Estimation as a Tool in Soil and Water Management Planning," by W. H. Wischmeier and D. D. Smith, International Association of Scientific Hydrology, Commission on Land Erosion, Report No. 59, 1962.
"Erosion Rates and Contributing Factors in Semi-Arid Regions," by W. H. Wischmeier, Proceedings of International Seminar on Water and Soil Utilization, Brookings, South Dakota, July 1962. (In press).
"Soil Loss Prediction for the North Central States," mimeographed report of SCS-ARS-AES workshop held at Chicago, Illinois, Jan. 1962.
"Soil-Erodibility Evaluations for Soils on the Runoff and Erosion Stations," by T. C. Olson and W. H. Wischmeier, Soil Science Society of America Proceedings, (In Press).
"Storms and Soil Conservation," by W. H. Wischmeier, Journal of Soil and Water Conservation, Vol. 17, pp. 55-59, 1962.
"Rainfall Erosion Potential," by W. H. Wischmeier, Agricultural Engineering, Vol. 43, pp. 212-215, 225, 1962.

(4275) THE MECHANICS OF EROSION BY RAINFALL AND RUNOFF.

See Purdue University, Agricultural Expt. Station, Project No. (4182).

(b) Laboratory project, cooperative with the Minnesota, Purdue and Iowa Agricultural Experiment Stations.

(c) Mr. W. H. Wischmeier, Investigations Leader, ARS, Agricultural Engineering Dept., Purdue University, Lafayette, Indiana.

(d) Experimental; laboratory investigations, basic research.

(e) Investigations designed to obtain fundamental information on the mechanics of rainfall, runoff, and erosion are carried on at three locations in the Cornbelt. C. K. Mutchler, ARS Agricultural Engineer at the North Central Soil Conservation Field Station, Morris, Minnesota, is using a drop tower to investigate raindrop splash patterns as affected by various degrees of soil softness, surface irregularity and surface detention. Single and multiple drops of controlled sizes strike the various targets after a free fall through stagnant air from a height of 30 feet. L. D. Meyer, ARS Agricultural Engineer at Purdue University, is investigating the mechanics of soil particle movement under thin films of water. Primary and interaction effects of particle size, slope, and velocity of flow are being investigated. Non-cohesive particles (glass beads) used in the initial phase of the study will later be replaced by sand and/or soil. Dr. W. C. Moldenhauer, ARS Soil Scientist at Ames, Iowa, is investigating the effects of rainfall on surface conditions, erodibility, and physical properties of various soils.

(h) "An Applicator for a Laboratory Rainfall Simulator," by C. K. Mutchler and W. C. Moldenhauer, ASAE paper No. 62-718, 1962.

(4276) IMPROVED PRACTICES FOR CONTROL OF RUNOFF AND EROSION.

(b) Laboratory project in cooperation with the Purdue Agricultural Experiment Station.

(c) Mr. J. V. Mannering, Soil Scientist, ARS, Department of Agronomy, Purdue University, Lafayette, Indiana.

(d) Experimental; field investigations, applied research.

(e) The purpose of these studies is to determine the effects of soil properties, slope characteristics, type and extent of canopy cover, quantity and management of crop residues, seedbed and tillage practices, and various factor interactions on infiltration and erosion. Replicated tests are conducted on selected plots on Purdue-owned and privately-owned farms in Indiana and adjoining states under simulated rainfall applied with the ARS-Purdue "Rainulator".

(g) Investigations in 1962 included: (1) effects of minimum-tillage practices for corn on infiltration and soil erosion; (2) determination of relative erodibilities of various soils in Indiana; (3) effect of rotation meadows on runoff and erosion from successive years of corn following the meadow; and (4) residual erosion-control effectiveness of meadows on erodibility of fallow soils.

(h) "Cut that Crust and Let the Water In," by A. R. Bertrand and J. B. Mannering, Crops and Soils, (In Press).
"Crop Residues as Surface Mulches for Controlling Erosion on Sloping Land under Intensive Cropping," by L. D. Meyer and J. V. Mannering, Presented at ASAE Meeting, Paper No. 62-714, 1962.
"The Effects of Various Rates of Surface Mulch on Infiltration and Erosion," by J. V. Mannering L. D. Meyer, Proceedings, Soil Science Society of America, Vol. 27, pp. 84-86, 1963.

(4277) SOIL ERODIBILITY DETERMINATIONS.

(b) Laboratory project, cooperative with the Purdue Agricultural Experiment Station.

(c) Mr. T. C. Olson, Soil Scientist, and Mr. W. H. Wischmeier, Research Statistician, ARS, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.

(d) Experimental; laboratory and field investigations, basic and applied.

(e) The purpose of this study is to identify and evaluate the soil properties and profile characteristics which influence erodibility of the soil and to combine these in a multiple regression equation. The equation would serve to evaluate the soil-erodibility factor of soils for use in the universal erosion equation. Infiltration and soil-loss measurements will be made on a broad range of soils under identical simulated rainstorms

(g) The relative erodibilities of certain soils have been determined, but more data will be needed to define the relationships needed for the desired soil-erodibility prediction equation. Studies are continuing.

(h) "The Erodibility of Some Indiana Soils," by T. C. Olson, J. V. Mannering and C. B. Johnson, Proceedings, Indiana Academy of Science, 1962.

(4278) RAINFALL ENERGY AND SOIL EROSION RELATIONSHIPS.

(b) Laboratory project, cooperative with the Illinois Agricultural Experiment Station.
(c) Mr. L. C. Johnson, Soil Scientist, 276 Davenport Hall, University of Illinois, Urbana, Illinois.
(d) Experimental; field investigation.
(e) The purpose of this study is (1) to obtain an experimental check on the computed rainfall intensity-kinetic energy relationship, and (2) to study the physical phenomena and changes associated with the infiltration of natural rain into soils. Three replications of fallow and continuous corn are under both hydrological and meteorological measurements.
(g) Data is being collected and analysis is in progress.

(4279) RUNOFF AND EROSION STUDIES IN IOWA.

(b) Laboratory project, cooperative with the Iowa Agricultural Experiment Station.
(c) Dr. W. C. Moldenhauer, Soil Scientist, 225 Agronomy Bldg., Iowa State University, Ames, Iowa.
(d) Experimental; field investigations, applied research.
(e) To evaluate soil and crop management practices in relation to water management and erosion control on the major Iowa soils. Runoff, soil loss and related data are being taken on 65 fractional-acre plots under natural rainfall.
(g) Consistent good management of abundant crop residues has continued to prove very effective in reducing runoff and erosion, even from plots in continuous corn. Several significant treatment changes were introduced on the plots in 1962.
(h) "Types of Erosion Damage," by W. C. Moldenhauer, Chapter 3 of FAO Soil Conservation Booklet, 1962.
"Soil and Water Losses," by W. C. Moldenhauer, Western Iowa Experimental Farm Annual Progress Report.
"Soil Loss, Aggregation, Yields and Organic Matter on Marshall Silt Loam as Affected by Crop Management," by W. C. Moldenhauer, prepared for submission to Soil Science Society of America Proceedings, 1962.

(4280) RUNOFF AND EROSION STUDIES ON THE SLOPING LANDS OF WISCONSIN.

(b) Laboratory project, cooperative with the Wisconsin Agricultural Experiment Station.
(c) Mr. O. E. Hays, Soil Scientist, P. O. Box 872, LaCrosse, Wisconsin.
(d) Experimental; field investigations, applied research.
(e) The purpose of these studies is to obtain information on the effects of the basic factors (climatic, topographic, soil, cover, and management) on runoff and soil loss. Hydrological and meteorological measurements are made on 66 fractional-acre plots and two small watersheds to evaluate the following with respect to runoff and erosion: (1) chemical treatments and interseeding methods for pasture renovation; (2) practices required to control erosion in corn following corn on steep slopes; (3) Strip cropping; (4) different types of seedbed for corn and small grain; (5) keeping corn clean with the use of weedicides; and (6) effect of degree of land slope. A new farm purchased by the State near Lancaster will be utilized partially for future investigations of runoff and erosion problems on the following Fayette soils.
(g) On corn after hay, wheeltrack planting and seedbed preparation with a field cultivator each reduced runoff by 50 percent and soil loss about 75 percent. Corn stover mulch in corn following corn gave excellent control of runoff and erosion on 16 percent slope, Fayette soil. Interseeding legumes in wide-row corn established meadows which produced yields comparable to those established in small grain and greatly reduced total rotation soil loss.
(h) "Corn Stover Mulch for Control of Runoff and Erosion on Land Planted to Corn after Corn," by R. E. Taylor and O. E. Hays, submitted to Soil Science Society of America Proceedings.

(4281) RUNOFF AND EROSION STUDIES IN THE MIDWEST CLAYPANS.

(b) Laboratory project, cooperative with the Missouri Agricultural Experiment Station.
(c) Mr. J. F. Thornton, ARS, Agricultural Engineering Dept., Univ. of Missouri, Columbia, Missouri.
(d) Experimental; field investigation, applied research.
(e) To evaluate effects of soil treatments, tillage practices and supplemental irrigation on runoff and erosion from Midwest Claypan soils. Measurements of runoff, soil loss and concomitant variables on a series of fractional-acre plots and small watersheds under natural rainfall are continuing.
(g) Fertilization adequate to produce high crop yields and large quantities of plant residues greatly reduced the formerly serious soil and water losses from sloping claypan soils. Seedbed preparation by subtillage, which left shredded cornstalks on or near the surface, significantly reduced erosion losses even from very high intensity storms.

(4282) RUNOFF AND EROSION STUDIES IN MINNESOTA.

(b) Laboratory project, cooperative with the Minnesota Agricultural Experiment Station.
(c) Mr. C. K. Mutchler and Mr. R. A. Young, Agricultural Engineers, North Central Soil Conservation Field Station, Morris, Minn.
(d) Experimental; field investigations, applied research.
(e) Water and soil loss measurements under natural rainfall are obtained from fallow, continuous corn and rotation corn to characterize runoff and erosion on Barnes silty clay loam in the North Central Region. Simulated rainstorms applied with the Rainulator in each of three cropstage periods are used to evaluate the relationships of runoff and erosion to percent land slope, shape of slope, row direction, intensive cropping, residue management, tillage practices and other factors. Soil and water losses resulting from thaw and snow melt will also be measured and associated with cover and management.
(h) "Runoff Plot Design and Installation," by C. K. Mutchler, USDA, ARS 41-79.
"Construction and Operation of a 16-Unit Rainulator," by L. F. Hermsmeier, L. D. Meyer, A. P. Barnett and R. A. Young, USDA, ARS 41-62.

(4817) RUNOFF AND EROSION STUDIES IN EASTERN SOUTH DAKOTA.

(b) Laboratory project, cooperative with the South Dakota Agricultural Experiment Station.
(c) Mr. C. R. Umback, Agricultural Engineer, ARS, South Dakota State College, Brookings, South Dakota.
(d) Experimental; field investigations, applied research.
(e) Water and soil loss measurements under natural rainfall are obtained from fallow, continuous corn, and continuous oats plots to characterize runoff and erosion on the Poinsett soils of Eastern South Dakota. Simulated rainstorms applied with the Rainulator in each of three cropstage periods are used to evaluate the cropping-management factor in the erosion equation for flax, sorghum, corn and oats grown in various sequences in this general climatic region. These studies are conducted on an experimental farm near Madison, which is

operated as a substation of the Morris, Minnesota, field station.

(4818) INVESTIGATION OF VALIDITY OF DARCY PROPORTIONALITY IN FLOW OF WATER IN UNSATURATED SOILS.

(b) Laboratory project, cooperative with the South Dakota and Purdue Agricultural Experiment Stations.
(c) Mr. T. C. Olson, Soil Scientist, ARS, Dept. of Agronomy, Purdue University, Lafayette, Indiana.
(d) Experimental; basic research. (Doctoral thesis).
(e) The purpose of this study is to assess the validity of Darcy's proportionality in unsaturated water flow through soil containing varying amounts of clay. If non-Darcy behavior is found, the validity of a recently proposed modified equation which uses three parameters instead of one will be tested.

U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, Soil and Water Conservation Research Division.

NORTHEAST BRANCH, Plant Industry Station, Beltsville, Maryland, Mr. W. W. Pate Branch Chief.

(3867) IRRIGATION AND DRAINAGE FACILITIES.

(b) Laboratory project, cooperative with Virginia Agricultural Experiment Station.
(c) Mr. J. Nick Jones, Agricultural Engineer, Agricultural Engineering Dept., Virginia Polytechnic Inst., Blacksburg, Virginia.
(d) Field investigations.
(e) The irrigation study seeks to determine the effect of selected irrigation procedures on quality and yield of tobacco on Cecil soils of the Piedmont plateau. Landforming to permit use of machinery, facilitate irrigation, and provide for disposal of surface water, are major objectives of the drainage studies. Both meteorological and hydrological measurements are made. Landforming studies were conducted on Coastal Plains soils in eastern Virginia, and on Piedmont Valley soils.
(f) The irrigation studies were initiated in 1961 and first records will be taken in 1962. Landforming studies for disposal of excess water in the Coastal Plains are essentially completed.

(4283) A STUDY OF FLOOD FLOWS AND THEIR EFFECTS ON STREAM CHANNELS.

(b) Cooperative project with Soil Conservation Service and Cornell University.
(c) Mr. R. P. Apmann, Hydraulic Engineer, 21 South Grove Street, East Aurora, N. Y.
(d) Experimental field investigations.
(e) To determine the important streamflow qualities which materially affect the intensity of attack upon the stream channel periphery material and the variation throughout the flow boundary of forces destructive to the channel periphery material. Investigations are conducted on selected natural reaches of Buffalo Creek and tributaries in the vicinity of East Aurora, New York and on the Pequest River in Warren County, New Jersey.

(4284) DEVELOPMENT AND EVALUATION OF METHODS FOR CHANNEL STABILIZATION.

(b) Cooperative project with Soil Conservation Service and Cornell University.
(c) Mr. R. P. Apmann, Hydraulic Engineer, 21 South Grove Street, East Aurora, New York.
(d) Experimental field investigations.
(e) To develop economical methods for streambank stabilization through observation and measurement of the effectiveness of various vegetal and structural measures in relation to streamflow over a range of streamflow conditions and channel geometry. Principal investigations are conducted on Buffalo Creek and tributaries in the vicinity of East Aurora, New York.

(4285) CHANNEL HYDRAULICS AND FLOOD ROUTING IN STEEP MOUNTAIN STREAMS.

(b) Cooperative project with the Vermont Agricultural Experiment Station and College of Technology of the University of Vermont, Vermont Water Conservation Board, and Soil Conservation Service.
(c) Mr. M. L. Johnson, Hydraulic Engineer, Route 2, Danville, Vermont.
(d) Experimental field investigations.
(e) Studies on a 1.5-mile reach of the Sleepers River channel involving determination of: travel speed of controlled waves of different volumes; profiles of natural and controlled waves of different volumes; practical field methods of measuring the friction slope of mountain channels; comparisons between results obtained with flood routing formulas and observed flood wave data; and the relationship between channel efficiency, flow duration curves, and watershed morphology.

(4286) INFLUENCE OF SNOW AND FROZEN SOIL ON RUNOFF.

(b) Cooperative project with the Vermont Agricultural Experiment Station, Vermont Water Conservation Board, and Soil Conservation Service and College of Technology of the University of Vermont.
(c) Mr. M. L. Johnson, Hydraulic Engineer, Route 2, Danville, Vermont.
(d) Experimental field investigations.
(e) This study on the 43-square mile Sleepers River watershed is concerned with the factors influencing the accumulation and melting of snow; the relationship of frozen soil to runoff; and the development of methods for predicting runoff associated with snow melt. Data are collected and analyzed from snow courses, precipitation gages, temperature records, heat budgets, soil moisture, frost measurements and snow melt in conjunction with streamflow records at nine stations in the subdivided watershed.

(4287) PRECIPITATION PATTERNS AND CHARACTERISTICS.

(b) Cooperative project with the Vermont Agricultural Experiment Station and College of Technology of the University of Vermont, Vermont Water Conservation Board, and Soil Conservation Service.
(c) Mr. E. T. Engman, Hydraulic Engineer, Route 2, Danville, Vermont.
(d) Experimental field investigations.
(e) The purpose of this study is to develop a method for calculating average precipitation on the 43-square mile Sleepers River watershed and its subdivisions in relation to elevation, storm source and direction; to study the behavior of summer convective storms in the northeast; and to provide information on rainfall depth-area-duration in relation to point rainfall in this part of the northeast.

(4288) INFLUENCE OF SOIL AND LAND USE ON STREAMFLOW FROM AGRICULTURAL WATERSHEDS.

(b) Cooperative project with the Vermont Agricultural Experiment Station and College of Technology of the University of Vermont, Vermont Water Conservation Board, and Soil Conservation Service.
(c) Mr. G. H. Comer, Hydraulic Engineer, Route 2, Danville, Vermont.
(d) Experimental field investigations.
(e) Investigations of the influence of land use, climatic factors, and physical characteristics such as soils, geology, and topography

upon runoff rates and water yields from the 43-square mile Sleepers River watershed and its important subdivisions to derive relationships for predicting the hydrologic performance of ungaged watersheds in the other parts of the physiographic area.

(4289) SUBSURFACE CONTRIBUTIONS TO STREAMFLOW IN SLEEPERS RIVER WATERSHED.

(b) Cooperative project with the Vermont Agricultural Experiment Station and College of Technology of the University of Vermont, Vermont Water Conservation Board, and Soil Conservation Service.
(c) Mr. G. H. Comer, Hydraulic Engineer, Route 2, Danville, Vermont.
(d) Experimental field investigations.
(e) Development of procedures for separating streamflow into components of surface runoff and contributions from underlying aquifers in the Sleepers River Watershed with consideration of the effects of vegetation and evapo-transpiration on water yields.

(4290) GROUNDWATER ACCRETION AND MOVEMENT IN RELATION TO WATERSHED CHARACTERISTICS.

(b) Cooperative project with the Vermont Agricultural Experiment Station and College of Technology of the University of Vermont, Vermont Water Conservation Board, and Soil Conservation Service.
(c) Mr. E. T. Engman, Hydraulic Engineer, Route 2, Danville, Vermont.
(d) Experimental field investigations.
(e) To develop information on ground water accretion and movement as affected by land use, soils, geology, and topography; and to develop methods for predicting ground water accretion and movement in relation to the physical, hydraulic, and meteorological characteristics of the 43-square mile Sleepers River Watershed.

(4291) INFLUENCE OF LAND USE ON THE HYDROLOGY OF AGRICULTURAL WATERSHEDS IN VIRGINIA.

(b) Cooperative project with the Virginia Agricultural Expt. Sta., Virginia Polytechnic Inst., and the Soil Conservation Service.
(c) Mr. J. B. Burford, Hydraulic Engineer, Agricultural Engineering Department, Virginia Polytechnic Inst., Blacksburg, Va.
(d) Experimental field investigations.
(e) To provide additional knowledge concerning the disposition of precipitation in agricultural watersheds, and to develop procedures based upon watershed characteristics, climatic factors, and various land use practices for the prediction of flood peaks and seasonal and annual water yields in three physiographic areas. Hydrologic, geologic, soils, plant cover and cultural data are being obtained on 4 unit source watersheds varying in size from 3.5 to 19.3 acres in the Appalachian Valleys and Ridges and on 10 complex watersheds from 182 to 3,054 acres in the Appalachian Valleys and Ridges, Blue Ridge Mountains, and the Piedmont Plateau.
(g) The instrumentation for the 10 complex watersheds is complete. Hydrologic data on all watersheds are being tabulated, summarized, and analyzed as the data are being accumulated.

(4292) HYDROLOGIC EFFECTS OF CHISELING SHALLOW SHALE SOIL IN WEST VIRGINIA APPALACHIAN VALLEYS AND RIDGES.

(b) Cooperative with West Virginia Agricultural Experiment Station and the Soil Conservation Service.
(c) Mr. V. O. Shanholtz, Hydraulic Engineer, 409 Grant Avenue, Morgantown, West Virginia.
(d) Experimental field investigations.
(e) The purpose of this study is to determine the effect of chiseling shallow shale subsoil upon rainfall-runoff relationships on small watersheds. Measurements for calibration of four 10-acre watersheds have been underway since the spring of 1958. Two of the watersheds will be treated following the calibration period.

(4293) MECHANICS OF EROSION.

(b) Laboratory project, cooperative with New Hampshire Agricultural Experiment Station.
(c) Mr. R. S. Palmer, Agricultural Engineer, University of New Hampshire, Agricultural Engineering Dept., Durham, New Hampshire.
(d) Field and laboratory studies, both basic and applied, for development and design.
(e) The purpose of these investigations is: (1) To determine the impact forces of various size water drops in relation to the nature of the soil surface, depth of water layer, and soil type; and, (2) to investigate soil and water problems involved in gully formation and to develop more effective control measures.
(g) A laboratory apparatus has been designed for producing raindrops of varying sizes and frequencies. Gully development along river terraces in New England is confined to a period of about one week during the spring thaw. Gully development apparently is most serious with a combination of shallow frost penetration and heavy runoff from snow melt. Installing dikes along the terrace edge appears to be an effective control measure.
(h) "Waterdrop Impactometer," by R. S. Palmer, Agricultural Engineering, Instrument News Section, (In Press).
"Gullies of New England: Casual Factors, Control, and Prevention," by R. S. Palmer, presented at Winter Meeting of ASAE, Chicago, Illinois, December 1962.
"An Apparatus for Forming Water Drops," by R. S. Palmer, USDA Production Research Report No. 63, 28 pages, 1962.
"Gully Control in the Connecticut River Valley," by R. S. Palmer, Journal of Soil and Water Conservation, Vol. 17, page 82, 1962.
"Water Jet Break-up from Stainless Steel Tubes," by R. S. Palmer, Agricultural Engrg., Vol. 43, pp. 456-457, 1962.

(4294) ERODIBILITY OF SOILS IN THE NORTHEAST.

(b) Laboratory project, cooperative with Maine Agricultural Experiment Station.
(c) Mr. Eliot Epstein, Soil Scientist, Univ. of Maine, Orono, Maine.
(d) Laboratory and field investigations both basic and applied for development and design.
(e) The purpose of these investigations is to obtain fundamental information on the erodibility of Northeast soils and to determine the interrelations of climate, cover (including rock fragments), runoff, and soil loss.
(g) Removal of rocks that interfere with sorting of potatoes by mechanical harvesters resulted in increased runoff and soil erosion and decreased crop yields during the first year of the study. Installations were completed on a laboratory rainfall simulator where basic studies on soil erodibility are being initiated.
(h) "Design, Construction, and Calibration of a Laboratory Rainfall Simulator," by Eliot Epstein, presented at ASAE, North Atlantic Section Meeting, Morgantown, W. Va., Aug. 1962.

(4295) TILLAGE PRACTICES AND DIVERSION TERRACES FOR WATER AND EROSION CONTROL.

(b) Laboratory project, cooperative with the New York Agricultural Experiment Station, and the Soil Conservation Service.
(c) Mr. George R. Free, Soil Scientist, Bailey Hall, Cornell University, Ithaca, New York.

(d) Field investigations.
(e) The purpose of these investigations is to determine the inter-relation of tillage, topography, climate, runoff and soil loss, and to evaluate the effectiveness of diversion terraces for controlling surface and subsurface flow.
(g) Work is continuing on the effectiveness of conventional, mulch and minimum tillage for corn on runoff and erosion from slopes of different steepness and length and on the effect of diversion terraces on surface soil moisture during critical crop growth stages for several sloping soils having seepage problems.

(4819) DEVELOPMENT AND EVALUATION OF DRAINAGE PRACTICES IN THE NORTHEAST.

(b) Laboratory project cooperative with the Vermont Agricultural Experiment Station and the Soil Conservation Service.
(c) Mr. Joseph Bornstein, Agricultural Engineer, University of Vermont, Burlington, Vermont.
(d) Field investigation both basic and applied research.
(e) The purpose of this study is to develop and evaluate drainage practices for sloping lands of the Northeast. This involves development of techniques for determining directional components of subsurface water flow before and after installation of drainage treatments. Surface drainage practices are instrumented to measure runoff from rainfall and snowmelt.
(f) Instrumentation of this project has just been completed. Preliminary piezometric data are available.

(4820) HYDROGRAPH LABORATORY.

(b) Laboratory project. Cooperative efforts on occasion.
(c) Mr. H. N. Holtan, Director, Hydrograph Laboratory, ARS, Beltsville, Md.
(d) Basic and applied research.
(e) The purposes of this project are to evolve and test new concepts, theories and principles for understanding the hydrologic processes on agricultural watersheds; to test and adapt information from various sources for application to water control and related problems encountered in watershed engineering; to conduct special analyses involving ARS data from more than one Station or more than one Branch that can be more adequately carried out at a central location which has available a full-time staff of scientists with specialized training in hydraulics, hydrology, meteorology, and mathematics; and to provide case assistance to field personnel detailed to the Laboratory for specific analyses as requested by the field.
(g) The Hydrograph Laboratory, in cooperation with the Central Technical Unit of the Soil Conservation Service, is currently programming hydrologic computations for use with digital computers for design and analysis of watershed protection programs. Thus far, sub-programs have been derived for the development of hydrographs from known or assumed rainfall, the routing of such hydrographs through reservoirs, and for the summation of hydrographs tributary to a reach. Working closely with the Engineering Division of the Soil Conservation Service, the Hydrograph Laboratory has made a study of effective rainfall as influenced by irrigation practice for key stations selected over the nation. Further, a study of average annual rainfall over the nation resulted in a map indicating a measure of the variation of annual rainfall about the mean for various locations. Studies of infiltration, runoff, and water yields are on a continuing basis.
(h) "Estimating Dependable Annual Streamflow in the Unglaciated Allegheny Plateau," by D. L. Brakensiek, ARS 41-56, November 1961.
"Effective Rainfall," by D. M. Hershfield, Weekly Weather and Crop Bull., Nov. 12, 1962.
"Extreme Rainfall Relationships," by D. M. Hershfield, Jour. of the Hydraulics Div., Proc. of the ASCE, Vol. 8, No. HY-6.
"A Note on the Variability of Annual Rainfall," by D. M. Hershfield, Journal of Applied Meteorology, December 1962, 3 pp.
Closing Discussion of "Estimating the Probable Maximum Precipitation," by D. M. Hershfield, Journal of the Hydraulics Div., Proc. of the ASCE, July 1962.
"A Concept for Infiltration Estimates in Watershed Engineering," by H. N. Holtan, ARS 41-51, October 1961.
"Field Manual for Research in Agricultural Hydrology," Committee: H. N. Holtan, N. E. Minshall, L. L. Harrold, ARS, Agriculture Handbook No. 224.

(4821) EFFECTIVENESS OF STREAMBANK STABILIZATION AND PROTECTION MEASURES IN REDUCING SUSPENDED SEDIMENT LOAD.

(b) Cooperative project with Soil Conservation Service and Cornell University.
(c) Mr. R. P. Apmann, Hydraulic Engineer, 21 South Grove Street, East Aurora, New York.
(d) Experimental field investigations.
(e) To develop procedures for estimating effectiveness of streambank stabilization and other measures in reducing the sediment discharge of a stream. It is postulated that the total sediment load of a stream is directly related to the mean concentration of the suspended sediment for a flood series, and that changes in time of the mean concentration resulting from installation of streambank stabilization measures are indicative of changes in total sediment load. The streambank stabilization measures are being installed by Soil Conservation Service as part of the authorized flood prevention program in the Buffalo River watershed. Measurements of suspended sediment load concentration and of stream discharges are made for all floods above a certain magnitude.
(g) Preliminary analysis indicates that stream stabilization works installed between 1953 and 1961 have reduced the suspended sediment load of Buffalo Creek by about forty percent. The suspended sediment load of adjacent tributaries to Buffalo River with similar but untreated streambank problems have increased ten percent during the same period.

(4822) A STUDY OF THE MOVEMENT OF COARSE-TEXTURED BED MATERIAL OF A NEW YORK MOUNTAIN STREAM.

(b) Cooperative project with Soil Conservation Service and Cornell University.
(c) Mr. R. P. Apmann, Hydraulic Engineer, 21 South Grove Street, East Aurora, New York.
(d) Experimental field investigations.
(e) To relate the quantities of transported bed materials to flood discharge rates and durations, to determine applicability of bed load equations in coarse material transport problems and, if appropriate, devise new or revised relationships. A stream reach and debris basin have been selected on the Little Hoosic River near New York for this study. Instrumentation of this site was completed in November 1962.

(4823) COMPILATION AND PUBLICATION OF SELECTED HYDROLOGIC DATA.

(b) Cooperative project with various State Experiment Stations and Land Grant Colleges and with the Soil Conservation Service.
(c) Mr. H. W. Hobbs, Hydraulic Engineer, Plant Industry Station, Beltsville, Md.
(d) Office assembling and processing of current hydrologic data.
(e) To provide information on monthly precipitation and runoff, annual maximum discharges and volumes of runoff, and selected runoff

events with associated data on rainfall, land use, and antecedent conditions for all current ARS research watersheds in the U. S. Hydrologic Data for 1960 and 1961 are currently being assembled and processed for publication. Hydrologic Data for 1962 and subsequent years will be published annually.

(h) "Monthly Precipitation and Runoff from Small Agricultural Watersheds in the United States," for years 1923 through 1955 was published in a report by Agricultural Research Service in June 1957.
"Annual Maximum Flows for Small Agricultural Watersheds in the United States," for years 1923 through 1957 was published in a report by Agricultural Research Service in June 1958.
"Selected Runoff Events for Small Agricultural Watersheds in the United States," for years 1933 to 1959 was published in a report by Agricultural Research Service in January 1960.
"1956-1959 Hydrologic Data for Experimental Agricultural Watersheds in the United States," will be published in 1963 as a Miscellaneous Publication of the U. S. Department of Agriculture.

U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, Soil and Water Conservation Div.

NORTHERN PLAINS BRANCH, P. O. Box 758, Fort Collins, Colo., Dr. C. E. Evans, Branch Chief.

(3217) HYDROLOGIC STUDIES OF GROUND WATER IN THE RED RIVER VALLEY OF NORTH DAKOTA.

(b) Laboratory project.
(c) Mr. L. C. Benz, Agricultural Engineer, P. O. Box 806, Grand Forks, North Dakota.
(d) Field investigation. Applied research.
(e) A field investigation covering more than 200 square miles to determine possible causes for a saline condition on a large area of land. Measurements consist of water tables, artesian conditions, soil and water physical and chemical data.
(g) Salt-affected soils are caused by high water tables, poor drainage conditions and saline artesian waters. High water tables are caused by precipitation. The salt source is the Dakota sandstone artesian aquifer.
(h) "Jetting Equipment and Techniques in a Drainage and Salinity Study," by R. H. Mickelson, L. C. Benz, C. W. Carlson and F. M. Sandoval. Trans. ASAE 4(2): 222-228. 1961 (Reprints available from authors)

(4296) HYDRAULICS OF SUB-CRITICAL FLOWS IN SMALL, ROUGH CHANNELS.

(b) Laboratory project, cooperative with the Colorado Agricultural Experiment Station.
(c) Mr. E. Gordon Kruse, Agricultural Engineer, Hydraulic Laboratory, Colorado State Univ., Fort Collins, Colorado.
(d) Experimental investigations; basic and applied, portions used for masters and doctoral theses.
(e) This study is an experimental investigation utilizing a tilting flume in which a small channel 60-feet long is formed by natural soil which is fixed in position against movement by chemical spray. A variety of roughness forms can be created on the bed. The relation of roughness dimensions and channel shape to flow resistance is determined for a range of channel slopes and flow depths.
(f) Discontinued.
(g) Relationships between resistance coefficients and measured roughness dimensions were developed for both laminar and turbulent flows. The transition between these flows was found to occur at a Reynolds number (RV/v) of 500 for these channels. For low Reynolds number flows (Re less than 500) over rough boundaries, normal flow depth was proportional to discharge, viscosity and roughness height and inversely proportional to roughness spacing and channel slope. For turbulent flows, resistance was a logarithmic function of roughness height and flow depth. The standard deviation of bed elevation measurements was used in both cases to represent the effective height of the nonuniform roughness elements. Effects of roughness spacing and channel shape on flow resistance could not be detected for turbulent flows.
(h) "The Influence of a Rough Boundary on Laminar Flow," by Charles W. Huntley, Unpublished Masters Thesis, Colo. State Univ., 86 p., June, 1961.
"Effects of Boundary Roughness and Channel Shape on Resistance to Flow of Water in Very Small Open Channels," E. Gordon Kruse, Ph.D. Dissertation, Colorado State Univ., 198 p., August, 1962.
"The Hydraulics of Small, Rough Irrigation Channels," E. Gordon Kruse, Submitted for publication in Proceedings of the Fifth Congress, International Commission on Irrigation and Drainage.

(4297) COOPERATIVE WATER YIELD PROCEDURES STUDY.

(b) Laboratory project, cooperative with Soil Conservation Service, USDA, and the Bureau of Reclamation, USDI.
(c) Mr. A. L. Sharp, Supervisory Hydraulic Engineer, Rm. 505, Rudge and Guenzel Bldg., 134 S. 12th Street, Lincoln 8, Nebraska.
(d) Office analyses, applied research.
(e) To develop and test methods for use by field engineers to evaluate the downstream effects of upstream conservation use and treatment of land on water yields of creeks and rivers. The project is one purely of analytic hydrology. The project uses available hydrologic and other data wherever it is available. It secures no new hydrologic data such as streamflow data, climatic data, or land-treatment data. The project is nearing completion.
(g) To date it has been demonstrated that it cannot be proved statistically significantly that there are downstream effects on streamflow of upstream conservation treatment and use of land, although it is axiomatic that in subhumid to arid areas such effects must exist. A rational method of evaluating such effects has been developed and tested. The method will be published in an Agricultural Handbook of the study, due late in 1963.
(h) "Transmission Losses in Natural Stream Valleys," Journal of the Hydraulics Div., ASCE, Vol. 88, No. HY5, Part 1, Sept. 1962.

(4298) COMPARISONS OF RATES AND AMOUNTS OF RUNOFF FROM SMALL SINGLE-COVER WATERSHEDS.

(b) Laboratory project, cooperative with the Nebraska Agricultural Experiment Station.
(c) Mr. J. A. Allis, Supervisory Hydraulic Engineer, P. O. Box 741, Hastings, Nebraska.
(d) Field investigations -- applied research.
(e) To evaluate the effect of (1) different land use treatment and (2) different crops on the runoff from single crop watersheds in the Central Great Plains, as one of the significant factors influencing runoff from complex watersheds. Replicate 4-acre single crop watersheds in meadow, pasture, cultivated and eroded cultivated land seeded to grass are instrumented with recording rain gages, flumes and waterstage recorders. Six cultivated watersheds are in a wheat-sorghum-fallow rotation. Mulch (subsurface) tillage, on the contour, is practiced. Effects of different crops and land uses on storm runoff rates and amounts are determined by analyzing hydrographs and histograms. Seasonal, annual, and long time effects are determined by analyzing precipitation and

runoff data.

(g) During the 4-year period, 1958-1961, tentative figures show that the average runoff from wheat-subtilled is 4.16 inches per year, sorghum-subtilled 3.91 inches and fallow-subtilled 4.77 inches. The runoff from pasture land averaged 2.24 inches per year and from native meadow only 0.70 inches. In the 4-year period the yearly rainfall varied from 20 inches to about 29 inches and averaged about 25 inches which is only about 0.5 inches per year higher than the long time average.

(4299) RUNOFF AND HYDROGRAPH CHARACTERISTICS OF LARGE MIXED-USE WATERSHEDS.

(b) Laboratory project, cooperative with the Nebraska Agricultural Experiment Station.

(c) Mr. J. A. Allis, Supervisory Hydraulic Engineer, P. O. Box 741, Hastings, Nebraska.

(d) Field investigations -- applied research.

(e) To determine characteristics of runoff from large mixed-use watersheds as related to, or affected by, precipitation, channel storage, transmission losses to valley alluvium, time of concentration, stream gradient, and watershed size. Three watersheds, in mixed use, 481, 2086 and 3490 acres in size, are instrumented with rain gages, weirs, and stage recorders for observing precipitation and runoff. Transmission losses to valley alluviums are estimated by use of gaged outflow and estimates of inflow from unit source areas of tributary land. These latter estimates are based on gaged rainfall on and runoff from small 4-acre single-use source area watersheds. Hydrographs and histograms are analyzed to obtain watershed retention (infiltration) rates and hydrograph characteristics.

(h) "Comparison of Storm Runoff Volumes," by John A. Allis, Agr. Engr. 43:220-223, April 1962.

(4300) COMPARISON OF RUNOFF AND SEDIMENT YIELDS FROM CONSERVATION AND CONVENTIONALLY FARMED WATERSHEDS.

(b) Laboratory project, cooperative with the Nebraska Agricultural Experiment Station.

(c) Mr. F. J. Dragoun, Hydraulic Engineer, P. O. Box 741, Hastings, Nebraska.

(d) Field investigations -- applied research.

(e) To determine the effects of conservation farming, land use, climate, and physiography on rates and amounts of runoff and sediment yields. Two 400-odd-acre watersheds, one conventionally farmed and the other conservation farmed, are equipped with recording rain gages, weirs and stage recorders, and sediment samplers, to measure precipitation, runoff, and sediment yields. The two watersheds were operated the same during a calibration period from 1939 to 1947. One was then treated by terracing, contour tillage and seeding eroded cultivated land to grass.

(g) An evaluation was made of the relationship of the kinetic energy of a rainstorm and other factors of rainfall and watershed characteristics as means of estimating sediment yields. The 4-year record, 1957-1960, on watersheds W-3 and W-5 was used. The analysis shows that on these complex watersheds there are three important factors to consider: (1) the interaction energy intensity factor, (2) the antecedent moisture condition, and (3) the season of the year. The best single predictor of sediment yield, of the factors examined, is the term $(Q + q_p)$ that is, the volume of runoff, in inches, plus peak rate of runoff in inches per hour.

(h) "Rainfall Energy as Related to Sediment Yield," by Frank J. Dragoun, Journal of Geophysical Research, Volume 67, No. 4, April 1962.

(4301) RELATIONSHIP BETWEEN INTENSITY OF GRAZING AND RUNOFF AMOUNTS ON FINE-TEXTURED SOILS.

(b) Laboratory project, cooperative with South Dakota Agricultural Experiment Station.

(c) Mr. J. W. Neuberger, Hyd. Engr., Newell Irrigation and Dryland Field Sta., Newell, S.Dak.

(d) Field investigations -- applied research.

(e) To determine the effects of light, moderate and heavy grazing and other factors such as precipitation, antecedent soil moisture, soil frost and snow accumulation, on rates and amounts of runoff from fine-textured range soils in southwestern South Dakota. Replicated plots of about 2 acres in each of the lightly, moderately and heavily grazed pastures are instrumented to observe runoff amounts (stage recorders and H-flumes) rates and amounts of precipitation (recording rain gages), soil moisture, soil frost and vegetative conditions. The studies are being made on the South Dakota Range Experiment Station near Cotton wood, South Dakota.

(4302) MEDICINE CREEK WATERSHED INVESTIGATIONS.

(b) Laboratory project, cooperative with the Soil Conservation Serv., U.S.G.S., Bu. of Reclamation and Neb. Agric. Experiment Station.

(c) Mr. V. I. Dvorak, Hydraulic Engineer, Room 505, Rudge & Guenzel Bldg., 134 South 12th Street, Lincoln 8, Nebraska.

(d) Field investigations; compilation and analysis of data.

(e) Data from this southwestern Nebraska project are being analyzed for the following purposes: (1) To estimate the long-time runoff and sediment yields from 8 years of observed hydrologic watershed data; (2) to determine if acquired runoff, sediment and channel data will adhere to the existing channel regime equations for six runoff stations; and (3) to compile and prepare a publication indicating what data have been collected as part of the cooperative investigations, and where these data may be found.

(g) The long-time sediment yields for the six watersheds have been computed by three different approaches. In each of these methods, the observed runoff and sediment data for 8 years were used for the projection

(h) Final report in preparation.

(4303) SEDIMENT YIELD AS RELATED TO GULLY AND CHANNEL EROSION.

(b) Laboratory project, cooperative with the Soil Conservation Service, and Nebraska and Kansas Agricultural Experiment Stations.

(c) Mr. V. I. Dvorak, Hydraulic Engineer, Rm. 505, Rudge & Guenzel Bldg., 134 S. 12th St., Lincoln 8, Nebraska.

(d) Field investigations; compilation and analysis of data.

(e) The objectives of this project are: (1) To determine and relate rates of gully and channel erosion to causal factors; (2) to provide basic data on rates of land loss and land depreciation due to gully erosion; and (3) to develop criteria, based upon hydrologic and physical factors, for estimating quantities of sediment derived from gully erosion.

(4304) SABETHA LAKE WATERSHED SEDIMENTATION STUDIES.

(b) Laboratory project, cooperative with the Soil Conservation Service and Kansas Agricultural Experiment Station.

(c) Mr. V. I. Dvorak, Hydraulic Engineer, Room 505, Rudge & Guenzel Bldg., 134 S. 12th St., Lincoln 8, Nebraska.

(d) Field investigations and office analysis.

(e) The objectives of this study are: (1) To determine the amount, rate, and character of the sediment yields from this 10-square mile watershed in northeast Kansas; (2) to

relate sediment accumulation in the reservoir with sediment yield, precipitation, runoff and other watershed characteristics.

(4305) TRAP EFFICIENCY OF RETARDING-TYPE RESERVOIRS.

(b) Laboratory project, cooperative with the Soil Conservation Service and the U. S. Geological Survey.
(c) Mr. H. G. Heinemann, Hydraulic Engineer, Rm. 505, Rudge & Guenzel Bldg., 134 S. 12th Street, Lincoln 8, Nebraska.
(d) Theoretical and field investigations, and office analyses.
(e) The trap efficiency of a reservoir is a measure of the effectiveness of the structure in retaining incoming sediment. Structures need to be designed and built with different degrees of trap efficiency, and information is needed so that the influencing parameters can be adjusted to provide the desired trap efficiency. In this study we are endeavoring to (1) collect and study data from retarding-type reservoirs in order to determine those factors that influence trap efficiency, and (2) derive and test methods for predicting the trap efficiency of retarding-type reservoirs.

(4306) SEDIMENT DISTRIBUTION IN FLOODWATER RETARDING-TYPE RESERVOIRS.

(b) Laboratory project, cooperative with the Soil Conservation Service and State Experiment Stations.
(c) Mr. H. G. Heinemann, Hydraulic Engineer, Rm. 505 Rudge & Guenzel Bldg., 134 S. 12th Street, Lincoln 8, Nebraska.
(d) Theoretical and field investigations, and office analyses.
(e) This study was undertaken to improve the design criteria for floodwater retarding-type reservoirs by: (1) determining those factors that influence sediment distribution and evaluating their importance, and (2) deriving and testing methods for predicting the horizontal and/or vertical sediment distribution in floodwater retarding-type reservoirs. This is important in determining the minimum elevation of the principal spillway and the required original capacities of various storage pools.

(4307) RESERVOIR FORMULAS AND THE VOLUME-WEIGHT OF RESERVOIR SEDIMENT.

(b) Laboratory project, cooperative with the Soil Conservation Service and State Agricultural Experiment Stations.
(c) Mr. H. G. Heinemann, Hydraulic Engineer, Room 505, Rudge & Guenzel Bldg., 134 S. 12th St., Lincoln 8, Nebraska.
(d) Field and theoretical investigations, and office analyses.
(e) This project provides criteria for more accurate determination of the sediment yield of watersheds from reservoir survey data. The investigations include: (1) Refinement of survey procedures and methods for determining reservoir capacities and sediment volume from reservoir sedimentation survey data: (2) explanation of variations in the volume weight of reservoir sediment; (3) recommendations on determination of the total weight of reservoir sediment; and (4) development of procedures for predicting the volume-weight of sediment in a proposed conservation structure.
(g) Considerable progress has been made on a study of formulas and methods for computing reservoir capacities and sediment volumes. Reservoirs having very good basic detailed surveys are being used to test various methods and formulas. The most consistent and reliable method for obtaining the reservoir capacity is by determining the area between a well-defined stage-area curve and the stage axis. Sediment yield information should always include a volume measurement and its volume-weight. Extensive studies have been started to study the volume-weight of sediment in reservoirs. On Sabetha Reservoir in Kansas, it was found that the volume-weight varies depending on the location of sediment in the reservoir, and also on the percent of clay (2 microns or smaller) present in the sediment.
(h) "Volume-Weight of Reservoir Sediment," by H. G. Heinemann, USDA, ARS, Soil and Water Conservation Research Division, Journal of the Hydraulics Division Proceedings of the American Society of Civil Engineers, Sept. 1962.
"Using the Gamma Probe to Determine the Volume-Weight of Reservoir Sediment," by H. G. Heinemann, USDA, ARS, Soil and Water Conservation Research Division, Publication No. 59 of the I.A.S.H. Commission of Land Erosion, pp 411-423.

(4309) ISOLATION AND RELATIVE EVALUATION OF RUNOFF PRODUCING POTENTIALS OF RANGE SITES OF WESTERN SOUTH DAKOTA.

(b) Laboratory project, cooperative with the South Dakota Agricultural Experiment Station.
(c) Mr. A. R. Kuhlman, Botanist, Newell Irrigation and Dryland Field Station, Newell, South Dakota.
(d) Field and laboratory investigations -- applied research.
(e) To evaluate relative runoff producing potentials of principal range sites of Western South Dakota including sandy, silty, shallow, thin breaks, panspots, overflow, clayey, and dense clay range sites as characteristic of D-4, D-10, and D-11 soil conservation problem areas in the Dakotas, Montana and Wyoming. To evaluate relatively the same range sites by rainfall simulators. To isolate vegetative factors such as standing vegetation, mulch, root systems and soil factors that cause differences in runoff from different range sites.

(4310) WATER YIELD AND SEDIMENT ACCUMULATION FROM RANGELAND WATERSHEDS.

(b) Laboratory project, cooperative with the South Dakota Agricultural Experiment Station.
(c) Mr. J. W. Neuberger, Hydraulic Engineer, Newell Irrigation and Dryland Field Station, Newell, South Dakota.
(d) Field investigations, applied research.
(e) To determine the frequency of water yields of various amounts from rangeland watersheds ranging in size from a few acres to 13,000 acres, and gross sediment yields (volumetric) from the same watersheds, as representative of the D-4, D-10, and D-11 soil conservation problem areas in eastern Montana, Wyoming and the Western Dakotas. Purposes of these studies are to provide data on water yields and information on which to estimate the probable useful life of ponds and reservoirs in the problem areas. The work is being done by gaging precipitation, measuring water yields in stockwater reservoirs, making reservoir sedimentation surveys, and securing data on watershed physical, topographic, ecologic and grazing use factors.
(g) Early trends indicate water yields from fine-textured soils of the area are four times those from medium-textured soils, and most water yield from the medium-textured soils results from snowmelt. Also, sediment yields from the fine-textured soils are double those from the medium-textured soils.

(4824) EVAPORATION AND SEEPAGE FROM RANGELAND STOCKPONDS.

(b) Laboratory project, cooperative with the South Dakota Agricultural Experiment Station.
(c) Mr. J. W. Neuberger, Hydraulic Engineer, Newell Irrigation and Dryland Field Station,

Newell, South Dakota.
(d) Field investigations -- applied research.
(e) To differentiate total stockpond water dissipation into evaporation and seepage and develop a basis for predicting expected stockpond water losses. The purpose of this study is to aid in the development of practical methods to reduce losses of water from stockponds to provide dependable water supplied for livestock.
(g) No definite results at this time, although stockponds on medium-textured soils show annual water losses exceeded inflow over 80 percent of the time, resulting in dry ponds nearly 50 percent of the time.

(4825) RESERVOIR SEDIMENTATION STUDIES.

(b) Laboratory project, cooperative with the Soil Conservation Service and State Agricultural Experiment Stations.
(c) Mr. H. G. Heinemann, Hydraulic Engineer, Room 505, 134 South 12th Street, Lincoln 8, Nebraska.
(d) Field and theoretical investigations, and office analyses.
(e) Numerous small reservoirs form the basis for this study. The objectives of this project are: (1) Determine the amounts, rates, and character of sediment yields from agricultural watersheds; and (2) relate sediment accumulation in the reservoirs with sediment yield, precipitation, runoff, watershed characteristics, and cultural practices. Sediment yield and related information are important factors in the planning and design of small reservoirs and other conservation installations.

(4826) HYDRAULIC CHARACTERISTICS OF PARTIALLY SATURATED POROUS MEDIA.

(b) Laboratory project, in cooperation with Colorado Agricultural Experiment Station.
(c) Mr. R. H. Brooks, Agricultural Engineer, Hydraulics Laboratory, Colorado State Univ., Fort Collins, Colorado.
(d) Basic research.
(e) Certain hydraulic characteristics of porous media must be known for laboratory modeling of complicated field problems involving water movement in soils. Problems involving flow of fluids in partially saturated soils often cannot be solved except by inferences derived from the performance of models. The purpose of the study is to be able to predict from equations how any porous medium will behave with respect to the functional relationship between permeability, degree of saturation (or fluid pressure) when certain media properties are known. A thorough understanding of the way permeability is effected by measurable properties of porous media might eliminate the necessity of selecting a porous medium by trial for use in model studies.
(g) A theory showing how the variables capillary pressure, water and air permeability are related to degree of saturation has been developed. Methods and equipment have been developed for measuring these variables using steady state experiments. Verification of the theory with experimental results has been good. It appears that hydraulic properties of partially saturated media can be described by three parameters: the bubbling pressure, P_b; a measure of the uniformity of the pores in the medium, η; and the saturated permeability K.
(h) "Hydraulic Characteristics of Porous Media," by R. H. Brooks and A. T. Corey; Annual Research Report 1960, 1961.

(4827) HYDRAULICS OF FLOW IN BORDER CHECK IRRIGATION SYSTEMS.

(b) Laboratory project, in cooperation with Nebraska Agricultural Experiment Station.
(c) Mr. O. W. Howe, Scotts Bluff Experiment Station, Route 2, Mitchell, Nebraska.
(d) Field investigation; applied research, design.
(e) This is a study of the operational characteristics of low-gradient border checks on a medium textured soil. It involves measurement of the efficiency of irrigation, uniformity of distribution, effect of uneven grade, kind of crop, stage of crop development, etc., upon irrigation efficiency. Soil moisture samples are taken before and after irrigation at intervals in the length of the run. Continuous measurements are taken of depth of water at these stations throughout the set. The purpose is to obtain relationships regarding the effect of crop retardance, slope, surface configuration, intake rate, on rate of advance of irrigation water. Such relationships will be useful in designing and operating low-gradient border check irrigation systems.
(g) Slopes of 0 to 0.05 percent gave highest irrigation efficiencies, around 90 percent, when crop retardance to the flow of water was small. Slopes of 0.10 to 0.15 percent were needed to offset the high retardance caused by fully developed sugar beet foliage.
(h) "Operational Characteristics of Low Gradient Border Checks on a Sandy Soil," by M. E. Jensen and O. W. Howe. Proc. of the International Commission on Irrigation and Drainage, Annual Bul. 1961. Reprints are not available.

(4828) DESIGN DATA FOR LEVEL OR NEARLY LEVEL BENCH IRRIGATION SYSTEMS ON HEAVY CLAY SOILS.

(b) Laboratory project, in cooperation with South Dakota Agricultural Experiment Station.
(c) Mr. Niel A. Dimick, Agricultural Engineer, Newell Irrigation and Dryland Field Station, Newell, South Dakota.
(d) Field investigations. Results will be used for design purposes.
(e) This is a study of the operational characteristics of low-gradient border checks on a fine textured soil. It involves measurement of the efficiency of irrigation, uniformity of distribution, and effect of uneven grade, kind of crop, stage of crop development, etc, upon irrigation efficiency. Soil moisture samples are taken before and after irrigation at intervals in the length of the run. Continuous measurements are taken of depth of water at these stations throughout the set. The purpose is to obtain relationships regarding the effect of crop retardance, slope, surface configuration, intake rate, on rate of advance of irrigation water. Such relationships will be useful in designing and operating low-gradient border check irrigation systems.
(g) No significant findings have been obtained as yet since this project was just initiated in 1962.

(4829) THE INFLUENCE OF RELIEF UPON VEGETATION, SOIL SALTS, AND WATER TABLES IN AN IMPERFECTLY DRAINED GLACIO-LACUSTRINE SALINE AREA OF INTERCONNECTING RIDGES AND DEPRESSIONS IN NORTH DAKOTA.

(b) Laboratory project.
(c) Mr. F. M. Sandoval, Soil Scientist, U. S. Field Station, Mandan, North Dakota or Mr. L. C. Benz, Agricultural Engineer, P. O. Box 806, Grand Forks, North Dakota.
(d) Field investigation; applied research.
(e) A field experiment of dimensions 450 x 800 feet in a ridge-depression micro-relief area where depressions are non-saline but ridges highly saline. Purpose of study is to determine reasons for the differences in salinity. Evaluated by measurements of ground-water gradients and studies of water

chemistry and soil physical and chemical data.
(f) Completed. Data being compiled for publication.
(g) Generally, greater leaching occurs in the depressions owing to impounded precipitation. Artesian pressures are present but play a minor role.

(4830) THE EFFECTIVENESS AND FEASIBLITY OF LOW-COST SUBSURFACE, PLASTIC DRAINS IN A SALINE, POORLY DRAINED AREA.

(b) Laboratory project.
(c) Mr. L. C. Benz, Agricultural Engineer, P. O. Box 806, Grand Forks, North Dakota.
(d) Field experiment; applied research.
(e) Experiment consists of nine lines, each 300 feet long, of either plastic tile or mole drains installed in a high water table and saline area. Purpose of experiment is to evaluate effectiveness of shallow, closely-spaced, plastic tile in a saline area.

(4831) LAND FORMING ON SALT-AFFECTED LACUSTRINE SOILS IN THE RED RIVER VALLEY HAVING AN INTERSECTING MINOR RIDGE-DEPRESSION TYPE OF MICRORELIEF.

(b) Laboratory project.
(c) Mr. L. C. Benz, Agricultural Engineer, P. O. Box 806, Grand Forks, North Dakota.
(d) Field experiment; applied research.
(e) Consists of four 5-acre plots under cultivation in a saline ridge-depression microrelief area. Two plots are leveled -- one having surface drainage, the other having only internal (tile) drainage (precipitation is impounded). One unleveled plot has internal drainage, the second one has none. Purpose of work is to determine effects of land forming and tile drainage on salt-affected land.

(4832) A STUDY OF THE FALLING WATER TABLE, SOIL MOISTURE, AND SOIL SALT TRANSLOCATION DURING THE WINTER MONTHS.

(b) Laboratory project.
(c) Mr. L. C. Benz, Agricultural Engineer, P. O. Box 806, Grand Forks, North Dakota.
(d) Field experiment; basic research.
(e) Experiment consists of two treatments (straw mulch and fallow) each replicated 3 times. Field plots are 60' x 60'. Measurements obtained are; soil moisture (neutron method), water tables, soil temperatures, freezing depth, water and soil physical and chemical data. Purpose of the experiment is to determine translocation of water table waters which recede during the winter months.

(4833) RELATIONSHIP OF MEASURED EVAPOTRANSPIRATION TO SOLAR RADIATION IN WESTERN U.S.A.

(b) Laboratory project, (joint project with Mr. M. E. Jensen, Northwest Branch.)
(c) Dr. H. R. Haise, Agricultural Research Service, P. O. Box 758, Fort Collins, Colo.
(d) Analytical and theoretical; basic and applied.
(e) Measurements of evapotranspiration rates for one- to three-week periods made by USDA personnel during the past 35 years have been re-evaluated and selected data for field and orchard crops are being related to solar radiation and air temperature using an energy balance approach. Solar radiation data for 20 locations in the Western U.S.A. have been summarized and procedures developed for estimating radiation for specific periods. The resulting relationships can be used for estimating evapotranspiration for various crops.
(f) Near completion.
(h) "Estimating Evapotranspiration for Various Crops Using Solar Radiation," by Marvin E. Jensen and Howard R. Haise. Proc. 1962 Sprinkler Irrigation Association Open Tech. Conference, March 4-6, 1962.

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NORTHWEST BRANCH, P. O. Box 2724, Boise, Idaho, Dr. J. S. Robins, Branch Chief.

(3550) THE EFFECT OF SPRINKLER PATTERN VARIATION ON IRRIGATION EFFICIENCY.

(b) Laboratory project.
(c) Mr. Claude H. Pair, Research Engineer (Irr.), Agricultural Research Service, P. O. Box 2724, Boise, Idaho.
(d) Experimental; applied research and design.
(e) To determine the effect of sprinkler pattern on field irrigation efficiency and develop a method for calculation of field water application efficiency for a sprinkler system from sprinkler pattern, wind velocity, humidity, temperature, irrigation period, and related factors. Another phase of this project is to test typical sprinkler heads for reproducibility of water distribution pattern.
(g) Tests conducted to date indicate that 90 percent of the water applied by the sprinklers to the plots could be accounted for in the catch cans and correction for evaporation using the Frost-Schwalen nomograph. Only 79 percent of the water could be accounted for by the soil sampling method when corrected for consumptive use of plants and evaporation from the sprinkler nozzle to the soil surface using the Frost-Schwalen nomograph. The losses not accounted for above are being investigated.

(3552) HYDRAULICS OF SURFACE IRRIGATION.

(b) Laboratory project.
(c) Mr. James A. Bondurant, Agricultural Engineer, Agricultural Research Service, P. O. Box 2724, Boise, Idaho.
(d) Experimental; field investigation, basic research.
(e) To investigate the factors that influence the advance and recession of water in an irrigation border strip.

(3553) MECHANIZATION OF SURFACE IRRIGATION.

(b) Laboratory project.
(c) Mr. James A. Bondurant, Agricultural Engr., Agricultural Research Service, P. O. Box 2724, Boise, Idaho.
(d) Experimental; design and development.
(e) To develop completely mechanized control systems for surface irrigation.
(g) Gates which will check the flow of water in a head ditch for a controllable period of time have been developed. These allow a field to be irrigated a portion at a time. When the flow of water into the head ditch is stopped, these gates automatically reset themselves and are ready for the next irrigation. Automatic gates for pipeline systems are also being developed.
(h) Patent application #192,609 "Sinking Float-Operated Irrigation Gate."
Patent application #199,546 "Automatic Irrigation Gate."

(4311) FLOOD HYDROGRAPHS BY ELECTRONIC ANALOG.

(b) Laboratory project, cooperative with the University of Idaho.
(c) Mr. J. Marvin Rosa, Hydraulic Engineer, P. O. Box 414, Moscow, Idaho.
(d) Analytical, basic and applied.
(e) Further development and adaption of electronic analog methods in the solution of flood routing problems and the prediction of flood hydrographs from agricultural and Foothill range watersheds of the northwest.

(4312) WATER YIELD AS INFLUENCED BY CHARACTERISTICS OF NORTHWESTERN RANGE WATERSHEDS.

(b) Laboratory project, cooperative with the University of Idaho.
(c) Mr. J. Marvin Rosa, Hydraulic Engineer, P. O. Box 414, Moscow, Idaho.
(d) Analytical.
(e) Regional analysis of water yield as affected by climatic, topographic, geologic, soil, land use and other characteristics and conditions of rangeland watersheds in the northwest.

(4313) SNOWMELT HYDROGRAPHS AS INFLUENCED BY CLIMATIC FACTORS AND WATERSHED CHARACTERISTICS.

(b) Laboratory project, cooperative with the University of Idaho.
(c) Mr. J. Marvin Rosa, Hydraulic Engineer, P. O. Box 414, Moscow, Idaho.
(d) Analytical, basic and applied.
(e) To develop improved methods for estimating daily hydrographs of streamflow from mountainous watersheds where the supply is from snowmelt and occasional rain and the evolution of a regional map of snowmelt design coefficients reflecting cover, geology and soils, exposure, elevation, latitude, etc.

(4314) PRECIPITATION CHARACTERISTICS OF A NORTHERN SEMI-DESERT WATERSHED.

(b) Laboratory project.
(c) Joel E. Fletcher, Soil Scientist, P. O. Box 2724, Boise, Idaho.
(d) Experimental, basic and applied.
(e) The 93 square mile Reynolds Creek Experimental Watershed, Owyhee County Idaho, has recording raingages to a density in excess of one per square mile. From this network, methods for evaluating rainfall amounts and intensities for different areas are being developed. Seasonal distribution with respect to amounts, character, and areal extent of precipitation are being measured.
(g) It appears that such characteristics of the thunderstorms as intensity, area, and duration are similar to those of the convective storms of Arizona and New Mexico.

(4315) THE DESIGN OF SELF-PROPELLED SPRINKLER SYSTEMS.

(b) Laboratory project.
(c) Mr. Claude H. Pair, Research Engineer (Irr.) P. O. Box 2724, Boise, Idaho.
(d) Experimental, applied research, design.
(e) Determine water application patterns of self-propelled sprinkler systems. Determine the effect of wind on application patterns of self-propelled sprinkler laterals, and develop method of designing self-propelled sprinkler laterals from theoretical formulas.
(g) Patterns of individual sprinklers making up the self-propelled moving lateral have been determined and are to be put together to see how the synthetic pattern compares with the field pattern of the moving lateral.

(4833) RELATIONSHIP OF MEASURED EVAPOTRANSPIRATION TO SOLAR RADIATION IN WESTERN U.S.A.

Cooperative with Northern Plains Branch.
See page 106.

(4834) INFLUENCE OF PHOTO SCALE, VEGETATION, TOPOGRAPHY, AND SNOW CONDITIONS ON PHOTOGRAMMETRIC MEASUREMENT OF SNOW COVER.

(b) Laboratory project.
(c) Mr. Charles F. Cooper, Botanist, P. O. Box 2724, Boise, Idaho.
(d) Experimental; basic and applied.
(e) This project seeks to determine the feasibility of determining the quantity of snow stored in a snowpack on a selected area by photogrammetric techniques and evaluate the influence of topography and vegetation on the accumulation and melting of snow. The study of different photoscales on the precision of estimate is included in the project.
(g) Preliminary results indicate that a photogrammetric technique is very promising as a means for determining snow volume on areas up to a few hundred acres.

(4835) LEAF AND CROWN AREA OF ARTEMESIA TRIDENTATA.

(b) Laboratory project.
(c) Mr. F. M. Smith, Range Conservationist, P. O. Box 2724, Boise, Idaho.
(d) Experimental: basic and applied research.
(e) Develop methods of determining total leaf area for a given size-vigor classification of A. tridentata. Determine the capacity of these leaves to store precipitation, intercept precipitation and to transpire. Evaluate the effect of immediate vegetation structure on leaf area of individual plants. Since vegetation and soils on watersheds act as reservoirs which receive, store and discharge water, an understanding of their individual performance in these capacities is tantamount to an understanding of watershed hydrology.

(4836) WATER BUDGET OF A UNIT SOURCE AREA.

(b) Laboratory project.
(c) Mr. Joel E. Fletcher, Soil Scientist, P. O. Box 2724, Boise, Idaho.
(d) Experimental; basic and applied research.
(e) Determine as fully as possible the fate of water falling on a small representative watershed throughout the year and estimate evaporation and transpiration from readily obtained instrumental and climatological data. Such a general understanding of the disposition of precipitation on an area is basic to an understanding of the effects of soils, geology, vegetation and climate.

(4837) FACTORS AFFECTING SNOW ACCUMULATION AND MELT ON UNIT SOURCE AREAS.

(b) Laboratory project.
(c) Mr. Charles F. Cooper, Botanist, P. O. Box 2724, Boise, Idaho.
(d) Experimental; basic and applied research.
(e) Determine physical and meteorological factors contributing to non-uniformity of snow accumulation and melt in a shrub covered unit source area in the sagebrush zone of Owyhee County, Idaho.
Any improvement in the quantity or timing of flow from snow fed streams by manipulation of vegetation or other practices requires a thorough understanding of the behavior of snow under these conditions. Such information must be derived from research.
(g) Instrumentation just partially installed.

(4838) A STUDY OF SURFACE WATER DIVERSIONS AND RETURN FLOW IN REYNOLDS VALLEY.

(b) Laboratory project.
(c) Mr. Clifton W. Johnson, Hydraulic Engineer, P. O. Box 2724, Boise, Idaho.
(d) Experimental; basic and applied research.
(e) This investigation is designed to find the consumptive use of water by an upstream irrigated area as it affects downstream water supplies. All of the inflow to Reynolds Valley is measured as is the outflow and general ground water levels.

(4839) GEOLOGIC CONTROL OF SUBSURFACE STORAGE AND FLOW CHARACTERISTICS OF BASALT TERRANE.

(b) Laboratory project.
(c) Mr. Gordon R. Stephenson, Geologist, P. O. Box 2724, Boise, Idaho.
(d) Experimental; basic and applied research.
(e) The purpose of this project is to evaluate the hydrologic effects of the basalts found on Reynolds Creek Experimental Watershed,

Owyhee County, Idaho. The objective is approached by studying the water balance on a closed basaltic basin.

(g) The basalts on Reynolds Creek are much less permeable than those on the Snake River plains.

(4840) THE DEVELOPMENT OF A PORTABLE IRRIGATION SPRINKLER EVALUATION DEVICE.

(b) Laboratory project. See project 4368, page 122.

(c) Mr. Claude H. Pair, Research Engineer (Irr.) Agricultural Research Service, Box 2724, Boise, Idaho.

(d) Experimental; applied research.

(e) To design a portable device that can be used in the design and evaluation of sprinkler irrigation systems. To determine procedures for the use of this device.

(g) This equipment has been used to measure the intake rate of soil for sprinkler design.

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SOUTHERN BRANCH, University of Georgia, Athens, Georgia, Mr. Russell Woodburn, Branch Chief.

(3869) FLUVIAL MORPHOLOGY.

(b) Laboratory project, cooperative with the Univ. of Miss. and Mississippi State Univ.

(c) Dr. Neil L. Coleman, Geologist, Sedimentation Laboratory, P. O. Box 30, Oxford, Miss.

(d) A joint field and laboratory project - basic and applied research.

(e) Detailed field measurements are made on selected natural water courses and flood plains in the Yazoo River Basin and other selected locations in Mississippi to delineate the variables of stream geometry, bend and bank roughness factors, dune migration, and stream hydraulics in terms of sediment transport characteristics. Laboratory studies in both 100-foot and 50-foot long flumes are carried out to define significance of various factors under controlled conditions. Acquired data are studied for adherence to existing regime equations, tractive force concepts, resistance coefficients, and bed material transport formulae, and to develop new or improved concepts and relationships.

(g) The existence of a discontinuity in the stage-discharge relation under certain conditions in sand-bed streams has been established. Changes in channel conveyance efficiency, occasioned by changes in bed configuration have resulted in variances in water discharge of over 100 percent for given water stages. Variations in Manning's roughness coefficient from 0.015 to 0.035 during the course of a storm runoff event have occurred, and for a given water discharge on separate occasions the "n" value has been known to double. Similar variations in the Darcy-Weisbach coefficient have been noted. Froude numbers for floods over plane beds or antidunes in the field are less than Froude numbers computed from comparable flow conditions in the laboratory flumes; this difference in Froude numbers is believed to be partly a function of depth.

(h) "Observations of Resistance Coefficients in a Natural Channel," by Neil L. Coleman, Proc. of International Symposium on Continental Erosion, IUGG, Bari, Italy, September, 1962.
"DISCUSSION - Dual Channel Stream Monitor," by R. A. Stein, ASCE Proceedings, May, 1962.

(3870) AGGRADATION AND DEGRADATION AS RELATED TO CHANNEL STRUCTURES.

(b) Laboratory project, cooperative with the Univ. of Miss. and Miss. State University.

(c) Mr. C. R. Miller, Director, Sedimentation Laboratory, P. O. Box 30, Oxford, Miss.

(d) Field and laboratory investigations; basic and applied research.

(e) It is necessary for proper planning and design of agricultural watershed conservation work to have knowledge of the extent of aggradation or degradation that is likely to occur with placement of structures in alluvial channels. Studies of deposition and scour as related to actual structures at various locations in Mississippi, Georgia, Wisconsin and other selected locations to provide the needed field data are underway to develop procedures and criteria useful in predicting channel adjustments with structural installations and accompanying changes in sediment transport and flow pattern.

(g) The degree of channel scour and channel erosion rates are being determined in connection with several structural installations in Mississippi. Case histories of over 70 gully control structures in Wisconsin have been established.

(h) "Case Histories of Gully Control Structures in Southwestern Wisconsin," by David A. Woolhiser and Carl R. Miller, ARS 41-60, Agricultural Research Service, February, 1963.
"Upland Gully Sediment Production," by C. R. Miller, Russell Woodburn, and H. R. Turner, Proc. of International Symposium on Continental Erosion, IUGG, Bari, Italy, September, 1962.

(3871) LABORATORY STUDIES OF SEDIMENT TRANSPORT.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.

(c) Dr. Neil L. Coleman, Geologist, Sedimentation Laboratory, P. O. Box 30, Oxford, Miss.

(d) Experimental; basic and applied research.

(e) To better explain, by laboratory flume experiments, the relationships between stream hydraulics and sediment transport which generally occur in natural channels. Work includes the testing and development of sediment transport equations, means and methods of total transport determination in natural channels, and determination of the relationship between the measured transport by use of sediment samplers now in use and the total bed material discharge.

(g) Flume studies indicate significant errors in sand concentration are possible depending upon relative position of sampler nozzle to a dune front. Studies of various type structures installed in a sand bed channel that will permit total load measurements with minimum upstream and downstream influence suggest the use of a Parshall flume under certain conditions.

(h) "Effect of Sand Dunes on Sand Transport Determinations by Use of Standard Samplers," by Dr. N. L. Coleman, Ole Miss Engineer, Vol. 2, No. 4, May, 1962.

(4316) HYDRAULICS OF CHANNELS RELATIVE TO CHANNEL STABILITY.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.

(c) Mr. D. A. Parsons, Hydraulic Engineer, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi.

(d) Experimental, field investigations, applied and basic research.

(e) The determination of flood flow qualities in selected reaches of Pigeon Roost Creek Mississippi, and other streams in studies of the resistance to erosion of streambank and bed materials, and streambank vegetation. Measurements of the boundary shear stresses in curved channels as affected by bend radius, bed angle, and Froude number.

(4317) PRINCIPLES OF STABLE CHANNELS IN COHESIVE MATERIALS.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
(c) Dr. Earl H. Grissinger, Soil Scientist, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi.
(d) Experimental, applied and basic research.
(e) Determination of: (1) The reasons for the resisting ability of soil and streambank materials to erosion by flowing water; (2) the kinds of tests needed to measure the resistance; and (3) the quantitative values of the resistance for natural and synthetic materials.
(g) A sample of the Grenada silt loam soil was mixed with various types and amounts of clays and compacted to varying densities. The molded samples were eroded by a constant erosive force. The stability of cohesive materials was found to be dependent upon the type, amount, and orientation of the clay minerals; the bulk density and antecedent moisture of the sample; and the temperature of the eroding water.
In general stability increased with increasing clay mineral content and with increasing density. Stability was greater for the 2:1 type clay mixtures than for the 1:1 type. The influences of antecedent moisture and orientation upon stability were dependent upon the type of clay minerals present. Stability decreased with increasing temperature of the eroding water.

(4318) METHODS OF CHANNEL STABILIZATION.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
(c) Mr. D. A. Parsons, Hydraulic Engineer, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi.
(d) Experimental, field investigations, applied and basic research.
(e) Includes: (1) Determination of the speeds of motion and the requisite conditions for beginning of motion of solid particles in fluid flow for various flow, particle quality, and boundary conditions in a laboratory study; (2) field investigations on Pigeon Roost Creek, Mississippi, and other streams of the resisting abilities of bank and bed materials and bank vegetation as determined by measured flood experiences (this study is associated with the one on channel hydraulics); and (3) laboratory and field study of the behavior of non-cohesive stands and silts in a stream channel bank for the conditions of lateral seepage flow to the stream.
(g) A sand of narrow size range and median diameter of 0.13 mm assumed angles of repose of 30 degrees and 19 degrees for the conditions of submergence and non-submergence respectively, under the simulated condition of a high water table in a ditch bank.
This sand was stable for with near-vertical banks in the field, when found with as little as 5 percent clay.
Small submerged spheres rolling with the impetus of laminar sheet flow over a smooth bed, traveled at speeds equal to one-half the speeds of the water in their vicinity.

(4319) SEDIMENT YIELDS AND CORRELATION WITH WATERSHED CHARACTERISTICS.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
(c) Mr. R. F. Piest, Hydraulic Engineer, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi.
(d) Field investigation project - applied research.
(e) Analyses of hydrologic, hydraulic, land use, soils, and physiographic characteristics of agricultural watersheds (varying in size from a fraction of an acre to 100 sq. mi.) are made to establish relationships with sediment transport rates, amounts, and delivery ratios. Establishment of methodology for determining long-time average annual sediment yields from fragmental field data, correlation of characteristics of the basic runoff-sediment relation (sediment rating curve) with affecting hydraulic and hydrologic parameters, and evaluation of the role of large storms as sediment contributors are all basic objectives that will lead to better sediment yield prediction procedures.
(g) Data from Pigeon Roost Creek Basin, Miss., indicates that sediment yields are highly correlated with direct runoff. Variations in unit direct runoff (and therefore unit sediment) yields between watersheds of the basin are marked. They have to some extent been correlated with basin physiography and land use. There are significant channel transmission losses in streams of the basin.
(h) "Improved Management Reduces Soil and Water Losses," by Coy W. Doty and Farris E. Dendy, Mississippi Farm Research, Vol. 25, No. 4, April, 1962.

(4320) SEDIMENT ORIGIN AND ROUTING IN A COMPLEX WATERSHED.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
(c) Dr. L. L. McDowell, Soil Scientist, Sedimentation Lab., P. O. Box 30, Oxford, Mississippi.
(d) Experimental, basic research.
(e) To develop and apply techniques, including the use of radioisotopes and neutron activation, for the identification of sediment minerals. This information plus an evaluation of selected physical parameters in study watersheds are to be used to develop concepts of soil susceptibility to detachment and transportation.
(g) Preliminary results are being evaluated. No significant results are available.

(4321) RESERVOIR SEDIMENTATION.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
(c) Dr. J. Roger McHenry, Soil Scientist, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi.
(d) Experimental and field investigation for basic research and developmental work.
(e) To relate sediment accumulation in reservoirs to sediment yields, runoff, and physical parameters of the watersheds. The nature of the sediment, its origin, mineralogy, chemistry, and biology are studied in relation to distribution and deposition within the reservoir. Nuclear methods are used where applicable.
(g) A number of reservoirs have been periodically surveyed for sediment accumulation. Nuclear means of determining in situ densities have been employed.
(h) "Determination of densities of reservoir sediments in situ with a gamma probe," by J. Roger McHenry, ARS Research Report ARS 41-53, April, 1962.
"Determination of Sediment Density of Gamma Attenuation," by J. Roger McHenry, ARS 41-61, Agricultural Research Service, Oct., 1962.

(4322) DEVELOPMENT OF METHODS FOR UTILIZING RADIOACTIVE ISOTOPES AND RADIOACTIVE MATERIALS FOR SEDIMENTATION AND HYDROLOGY RESEARCH.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi

State University.
(c) Dr. J. Roger McHenry, Soil Scientist and Dr. L. L. McDowell, Soil Scientist, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi.
(d) Experimental basic research.
(e) To devise, develop, and utilize procedures for "tagging" sediment particles with radioisotopes and identifying same in the laboratory and in the field. Results are to be used in predicting sediment production, transport and deposition.
(g) A satisfactory method has been developed for "tagging" quartz sand particles with scandium-46, an energetic gamma emitter.
(h) "The Use of Radioactive Tracers in Sedimentation Research," by J. Roger McHenry and Leslie L. McDowell, Journal of Geophysical Research, Vol. 67, pp. 1465-1471, April, 1962.

(4323) SEDIMENT PRODUCTION AND CONTROL PRACTICES ON HIGHWAY CUTS AND FILLS.

(b) Laboratory project, in cooperation with Georgia State Highway Dept., Soil Conservation Service USDA, the University of Georgia College of Agriculture Experiment Stations, and Bartow County, Georgia.
(c) Mr. E. G. Diseker, Agricultural Engineer, P. O. Box 124, Cartersville, Georgia.
(d) Experimental, field; applied.
(e) Runoff and soil losses are measured from three pairs of bare, roadbank plots (approximately 1:1, 2:1, and 3:1) on Cecil Clay subsoil using six H-flumes and Coshocton vane samplers. Metal hub stakes are used as an adjunct in determining bank erosion, and for measuring deposition or scour from the flow channels. Over 30 different plants have been tested on 850 roadbank plots for erosion control.
(g) Bare bank losses have varied from 25 to 400 tons per year per acre for the past 5 years depending on the rainfall, frost action, bank aspect and slope. Bank aspect and frost action have been major factors in the erosion process. Banks facing northwest have lost, on an average, 2.2 times as much soil as those facing southeast. Plants which have proved satisfactory for erosion control are fescue, common Bermudagrass, lovegrass, broomsedge, Pensacola and Wilmington Bahiagrasses, crownvetch, sericea lespedeza, honeysuckle and kudzu. For the establishment of satisfactory cover on slopes 2:1 and steeper, mulches were necessary particularly for the slowly developing plants such as crownvetch and Bahiagrasses. For maintenance of most plants, especially the grasses, a timely application of fertilizer is necessary. Previously outlined procedures to determine fertility requirements for maintaining vegetation on roadside areas in the Piedmont Uplands of Georgia were put into practice in the fall of 1962. Studies to determine rates and amounts of sediment delivery for selected storms at monthly intervals and annual production and delivery from bare road banks in relation to (1) rainfall intensity (2) antecedent moisture and temperature conditions and (3) face slope length with different aspects on Cecil type soils will begin in the spring of 1963. A study will be initiated in the spring of 1963 to determine sediment productions and delivery rates from fully developed, mature stands of five different representative plant species.
(h) "Mulch Aids in the Establishment of Roadside Cover," by E. C. Richardson and E. G. Diseker, Crops and Soils Magazine, February 1961, Vol. 13, No. 5.
"Erosion Rates and Control Methods on Highway Cuts," by E. G. Diseker and E. C. Richardson, ASAE Trans., Vol. 5, No. 2.

(4324) UTILIZATION OF TRITIUM IN WATERSHED RESEARCH STUDIES.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
(c) Dr. J. Roger McHenry, Soil Scientist, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi.
(d) Experimental basic research and development.
(e) To devise, develop, test and apply tracer techniques using tritium and other radioisotopes in support of studies of soil moisture and groundwater movement.
(g) Methods of high efficiency have been developed using a liquid scintillation counter. Preliminary laboratory studies have shown the precision and accuracy of the methods are adequate. Field testing will be initiated.

(4325) RUNOFF FROM AGRICULTURAL WATERSHEDS.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
(c) Mr. W. R. Hamon, Research Agricultural Engineer, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi.
(d) Field investigations; basic and applied research.
(e) To develop procedures for predicting flood runoff, water yield and hydrograph characteristics for ungaged upstream watesheds. Runoff and precipitation are observed for the 117 square-mile Pigeon Roost Creek Watershed in Northern Mississippi including 11 sub-watersheds, and for four unit-source watersheds under 4 acres in size. These data, accumulated over the past four years, are being processed by computer and analyzed to develop synthetic unit hydrographs by incorporating antecedent soil moisture and watershed factors. The predicted hydrographs will be used to establish flow-duration curves.
(h) Hydrologic data releases are prepared yearly with summaries of monthly precipitation and runoff, tabulated annual maximum flows, and detailed data for selected runoff events.

(4326) SUBSURFACE HYDROLOGY AND HYDROGEOLOGY.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
(c) Mr. F. E. Dendy, Agricultural Engineer, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi.
(d) Experimental and field investigations; basic and applied research.
(e) To study the hydraulic characteristics of geologic strata and develop methods of predicting ground water accretion and movement; subsurface and ground water contribution to streamflow from a knowledge of geology, soils, topography, climate, land use and treatment of agricultural watersheds; and to evaluate hydrogeologic factors governing transmission gains and losses in stream channels. A portable drilling rig is utilized to obtain geologic samples, establish ground water observation wells, and conduct permeability field tests.
(g) A map of the structural and stratigraphic characteristics of Pigeon Roost Creek Watershed is in preparation and seasonal ground water contours are being developed. Design and testing of a small well point for field observations of permeability has been completed.

(4327) MOISTURE REGIMES OF AGRICULTURAL WATERSHEDS.

(b) Laboratory project, cooperative with the University of Mississippi and Mississippi State University.
(c) Mr. John Kozachyn, Soil Scientist, Sedimentation Laboratory, P. O. Box 30, Oxford, Mississippi.
(d) Field investigation; applied research.
(e) To provide soil moisture data for the

development of prediction techniques for runoff and sediment production and to relate the moisture regimes of agricultural watersheds to soil, climate and vegetative parameters. Field observations of soil moisture to depths of 10 and 20 feet are obtained by the neutron probe method for different cover, slope, and soil complexes.

(g) The superiority of the neutron probe procedure over other available methods was established from laboratory and field tests. A method of installing access tubes has been perfected.

(4328) RELATION OF CLIMATE AND SOIL MOISTURE LEVELS TO PLANT GROWTH AND WATER USE.

(b) Laboratory project, cooperating with the Central and Southern Florida Flood Control District and the Florida Agricultural Experiment Station.

(c) Mr. E. H. Stewart, Soil Scientist, P. O. Box 9087, Fort Lauderdale, Florida.

(d) Laboratory and field investigations, both basic and applied for evaluating measured environmental conditions.

(e) Laboratory and field procedures are employed to determine moisture intake, retention and transmission characteristics of mineral and organic soils. Controlled water table studies in non-weighing lysimeters are conducted to determine evapotranspiration, crop growth, and soil physical properties as influenced by various water table depths. Field and plot studies in organic soils are conducted to determine soil subsidence.

(g) Root content of the plow layer (0-9") of a St. Augustinegrass sod was much higher over a 12-inch water table than over a 24- or 36-inch water table. Organic residues of this root material markedly improved early growth of the subsequent grain sorghum crop.
Average daily evapotranspiration of grain sorghum, from November 1960 to June 1961, for 12-, 24-, and 36-inch water tables was 0.15, 0.10, and 0.09 of an inch respectively. Evapotranspiration during the spring months was about twice that of the winter months.

(h) "Installation and Operation of Non-weighing Lysimeters" by W. H. Speir, Florida Agricultural Experiment Station, Journal Series No. 1629.
"Moisture Characteristics of Some Representative Soils of Florida," by E. H. Stewart, D. P. Powell, and L. C. Hammond, USDA, ARS 41-63, 1962.

(4329) HYDROLOGIC RESEARCH ON SMALL AGRICULTURAL WATERSHEDS IN CENTRAL AND SOUTHERN FLORIDA.

(b) Laboratory project, cooperating with the Central and Southern Florida Flood Control District and The Florida Agricultural Experiment Station.

(c) Mr. E. H. Stewart, Soil Scientist, Attention: W. H. Speir, Engineering Technician, P. O. Box 9087, Fort Lauderdale, Fla.

(d) Experimental, field investigations; basic and applied research.

(e) To collect, analyze, and correlate basic hydrologic data on agricultural watersheds ranging in size from 4,000 to 63,000 acres in the Coastal Plain of Florida. To determine the influence of climate, topography, soils, geology, and land use on the rate and volume of runoff and to evaluate the water balance. To devise methods of interpreting watershed characteristics as similitudes related to physiography of other areas.

(g) For an unimproved 98-sq. mile watershed the maximum daily discharge (Oct. 1956) was 2.28 inches-over-area with an instantaneous peak rate of 70 c.f.s./sq. mile; and for the 16-sq. mile upper sub-basin the respective rates were 3.14 inches and 158 c.f.s./sq. mile. For an improved 78 square mile watershed the maximum daily discharge (Sept. 1960) was 2.37 inches-over-area with an instantaneous peak rate of 66 c.f.s./sq. mile. The ratio of runoff to rainfall has averaged 0.47 for the artesian-irrigated 78 sq. mile watershed for the past 10 years; 0.34 for the 98 sq. mile unimproved watershed; and 0.27 for the 16 square mile sub basin during the past 6 years. Total water yield varied inversely with area on the unimproved watersheds. For the 98 sq. mile watershed base flow has averaged 72, interflow 20, and overland flow 8 percent of total stream flow. For the 78 sq. mile watershed these flow components have averaged 83, 8, and 9 percent respectively. For the 16 sq. mile watershed they averaged 38, 31, and 31 percent.
Potential evapotranspiration losses for these basins were 78 percent of USWB pan rates, and annual ET losses were the most stable element in the hydrologic balance. Soil moisture conditions in the vadose zone seemed to influence base flow rates as much as ground water stages.
Observations will continue to ascertain the effects of contemplated Watershed Protection and Flood Prevention Programs.

(4330) RUNOFF AND EROSION CHARACTERIZATION OF BROWN LOAM SOILS.

(b) Laboratory project.

(c) Mr. Coy W. Doty, North Mississippi Branch Experiment Station, Holly Springs, Miss.

(d) Experimental, field; basic and applied.

(e) Rates and amounts of runoff and soil losses are measured on plots with land of five percent slope and degrees of ground cover ranging from continuous fallow to 2 years of sod and one year of corn, and with contour versus up- and down-hill tillage.

(g) Both water and soil losses are excessive on bare land, and are reduced as the degree of ground cover is increased.

(4331) HYDRAULICS OF FARM WATER CONTROL IN THE SOUTHERN PIEDMONT.

(b) Laboratory project in cooperation with the University of Georgia, College of Agriculture Experiment Stations.

(c) Mr. W. Campbell Little, Agricultural Engineer, Southern Piedmont Soil Conservation Field Station, Box 33, Watkinsville, Georgia.

(d) Experimental laboratory; basic and applied.

(e) Basic research on the mechanics of erosion and hydraulics of flow in individual crop rows and in terraced channels will be developed for both terrace systems and individual row systems for the different soils of the Piedmont.

(g) Initial studies are underway.

(4332) SURFACE DRAINAGE -- ROW LENGTHS AND GRADES FOR REMOVAL AND APPLICATION OF SURFACE WATER ON FORMED AGRICULTURAL LAND OR THE MISSISSIPPI DELTA.

(b) Laboratory project in cooperation with the Louisiana Agricultural Experiment Station.

(c) Mr. Irwin L. Saveson, Project Administrator, Agricultural Engineering Building, Louisiana, P. O. Drawer 8817, University Station.

(d) Experimental; basic and applied research.

(e) Approximately 80 acres of land have been formed with four different slopes, in two replications, of 0.1', 1.15', 0.2', and 0.25'. For each slope class, row lengths of 500', 700', 900', and 1,100' will be used to determine the maximum row length for formed land as related to slope.
Runoff, time-of-concentration, infiltration, soil temperature, and soil moisture data will be gathered and correlated with rainfall, wind humidity, and sunshine radiation.
Future studies are contemplated to evaluate flow characteristics of surface water in furrows on agricultural land. This

information will be used to develop a furrow cross-section with the best hydraulic characteristics.

(g) Established in full operation in 1962.

(4333) RUNOFF AND EROSION STUDIES FOR THE SOUTHERN PIEDMONT.

(b) Laboratory project in cooperation with the University of Georgia, College of Agriculture Experiment Stations.

(c) Mr. A. P. Barnett or Mr. J. S. Rogers, Agricultural Engineers, Southern Piedmont Soil Conservation Field Station, Box 33, Watkinsville, Georgia.

(d) Experimental field investigations, development and applied.

(e) The purpose of these studies is to determine the interrelations of climate, soil, topography, cover, management, row direction, runoff, soil movement and loss from Southern Piedmont soils. The work is conducted on fractional acre field plots under both natural and simulated rainfall.
The natural rainfall plot study includes six cover, two row direction and three slope steepness treatments on a total of 42 plots. Total amounts of runoff and soil loss are measured for individual rainstorms. Meteorological data are also secured.
The rainfall simulator designed to apply rain at 4, 2-1/2 and 1-1/4 inches per hour simultaneously to three adjacent plots is used to secure runoff and soil loss data from specific soil, slope, crop, and management complexes through the application of designed storms. These data will be used to evaluate their runoff and erosion control effectiveness.

(g) Progress is reported each year in Station annual reports.

(4334) RUNOFF AND EROSION STUDIES FOR SOUTHERN COASTAL PLAINS SOILS.

(b) Laboratory project in cooperation with the Georgia Agricultural Experiment Stations.

(c) Mr. G. N. Sparrow, Agricultural Engineer, Georgia Coastal Plain Experiment Station, Tifton, Georgia.

(d) Field investigations; applied, for design.

(e) The purpose of these studies is to determine interrelations of climate, soil, land cover, runoff and soil loss for Southern Coastal Plain soils. The work is conducted on 18 field plots, 1/20 acre in size, under natural rainfall. There are four cover treatments. Total amount of runoff and soil loss are measured for individual storms. Meteorological data are also secured.

(g) Grass-based rotations and continuous corn have been evaluated, showing protective effects of perennial grass sods and of annual crop residues.

(4841) SURFACE WATER STORAGE AND SUPPLY ON FARMS IN THE COASTAL PLAINS.

(b) Laboratory project in cooperation with the Georgia Agricultural Experiment Stations and Soil Conservation Service, USDA, in Georgia.

(c) Mr. G. N. Sparrow, Agricultural Engineer, Georgia Coastal Plain Experiment Station, Tifton, Georgia.

(d) Field investigation; applied for design and development.

(e) Purpose of the studies is to determine pond storage efficiency under various soil and topographic conditions as affected by watershed yield, pond surface evaporation, seepage into and out of the impoundment, farm use of storage, and related factors. Initial study to be on one rather typical farm pond in the coastal plain, with anticipation of extending the work to other ponds.

(g) Study initiated in early 1962; expected to be fully operative on one pond in 1963.

(4842) SHALLOW WELLS AND IRRIGATION PITS FOR IRRIGATION AND OTHER FARM WATER SUPPLY IN THE COASTAL PLAINS.

(b) Laboratory project in cooperation with the Georgia Agricultural Experiment Stations and Soil Conservation Service, USDA, in Georgia.

(c) Mr. G. N. Sparrow, Agricultural Engineer, Ga. Coastal Plain Experiment Station, Tifton, Ga.

(d) Field investigation; applied, for design and development.

(e) The purpose of the studies is to develop criteria by which engineers and soil scientists can classify sites for irrigation pits, shallow wells, or other access to shallow ground water aquifers in the coastal plains on the basis of topography and soils. Initial study is concerned with excavated irrigation pits, their adequacy of supply, the relation of recharge to rainfall and soils, and other related influences. Investigations now involve 3 pits, each under somewhat different soil and topographic situations.

(g) Studies initiated in early 1962; expected to be fully operative on 3 irrigation pits in 1963.

(4843) AN EFFICIENT DRAINAGE SYSTEM FOR SUGARCANE LAND.

(b) Laboratory project in cooperation with the Louisiana Agricultural Experiment Station.

(c) Mr. Irwin L. Saveson, Project Administrator, Agricultural Engineering Building, Louisiana State University, Baton Rouge, Louisiana, P. O. Drawer 8817, University Station.

(d) Experimental applied research.

(e) The present conventional system of sugarcane land requires considerable land occupied by ditches and is costly to maintain. Experimental work is underway to develop a more efficient drainage system which will consume less land and be more economical to maintain. This is an adaptation of the cotton drainage system to sugarcane.

(g) This system reduces the amount of land in ditches from 4 to 7 percent with a $5.22 per acre per annum savings in cost of maintenance.

(h) "An Efficient Drainage System for Sugarcane Land" by I. L. Saveson, USDA, ARS 41-72, (In Press).

U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, Soil and Water Conservation Research Division.

SOUTHERN PLAINS BRANCH, 804 Bryan Street, Amarillo, Texas, Dr. J. R. Johnston, Branch Chief.

(3876) SOIL-WATER-PLANT RELATIONSHIPS OF COTTON AS AFFECTED BY SOIL MOISTURE REGIME.

(b) Laboratory project.

(c) Mr. L. N. Namken, Soil Scientist, P. O. Box 267, Weslaco, Texas.

(d) Field investigation - applied research.

(e) This study provides information on the rate, amount and pattern of soil moisture depletion by cotton as affected by the stage of plant growth, the amount of available moisture in the profile and the soil type.

(f) Completed.

(g) The rate, amount and pattern of soil moisture depletion by cotton on two of the major irrigated soils of the Lower Rio Grande Valley (Willacy fine sandy loam and Harlingen clay), were influenced by (1) stage of plant maturity, (2) amount of available water in the profile, and (3) plant density. High rates of moisture depletion occurred during periods following irrigations or appreciable rainfall. Maximum depletion rates ranged from .16 in. per day on the nonirrigated treatment to

.45 inches per day on the high moisture level treatments.
On Harlingen clay practically all soil moisture depletion occurred from the first two feet of the profile except in the dry treatment where it was evident that plant growth stopped once the available moisture was depleted from this zone. In all treatments approximately 98 percent (by weight) of the roots were confined to the top two feet of the profile.
Frequent additions of water during the peak bloom and boll development stages of plant growth, either in the form of rainfall or supplemental irrigation, gave the most efficient production of cotton on Harlingen clay.
In the case of the Willacy fine sandy loam, moisture was depleted from the entire 5 foot profile, and most efficient production of cotton occurred when 1 to 2 supplemental irrigations were applied during the peak bloom and boll development stages of plant growth.

(h) "Effect of Irrigation Differentials and Plant Spacings on Yield of Cotton on Harlingen Clay in the Lower Rio Grande Valley," by C. J. Gerard and L. N. Namken, Texas Agricultural Experiment Station Progress Report 2216, 8 pages, Oct. 26, 1961.
"Soil Moisture Depletion by Irrigated Cotton as Influenced by Moisture Regime and Stage of Plant Development," by M. Amemiya, L. N. Namken and C. J. Gerard, Presented at the Soil Science Society of America Annual Meetings, 1961, (in press).

(3877) SOIL MOISTURE REQUIREMENTS FOR COTTON.

(b) Laboratory project.
(c) Mr. P. Earl Ross, Agricultural Engineer, P. O. Box 267, Weslaco, Texas.
(d) Field investigation; applied research.
(e) A study to determine the most effective use of a variable and limited supply of irrigation water for cotton production.
(g) From a four year study on a deep sandy clay loam soil underlain with a 6-8 foot saline water table it was concluded that soil moisture in the upper two feet may be reduced to 10-15 percent field capacity with no significant reduction in yield.

(3879) CHARACTERIZATION OF THE "HOT SPOT" PROBLEM IN THE LOWER RIO GRANDE VALLEY OF TEXAS.

(b) Laboratory project.
(c) Mr. Ronald R. Allen, Agricultural Engineer, P. O. Box 267, Weslaco, Texas.
(d) Experimental and field investigation - applied research.
(e) The purpose of the study is to determine the extent of salinity problems; characterize and correlate the water table, soil, topographic and related measurable factors associated with salinity problems in the area.
(g) Extensive water table observations show a fluctuating seasonally high saline water table beneath the area. The water table and ground surfaces slope approximately one foot per mile to the northeast in the general direction of the Gulf Coast.

(3880) THE MICRODYNAMICS OF UNSATURATED MOISTURE FLOW.

(b) Laboratory project.
(c) Dr. Craig L. Wiegand, Soil Scientist, P. O. Box 267, Weslaco, Texas.
(d) Experimental, basic research.
(e) The objectives are to obtain evidence on the generality of the parabolic moisture distribution with respect to the interface of extraction and to interpret unsaturated moisture flow in terms of molecular level mechanisms of flow. The experimental technique is that of inducing moisture flow by various techniques at a series of temperatures and measuring the flow rate. The Arrhenius equation is applied to the data and an activation energy calculated. The activation energy is then interpreted in terms of energy barriers to molecular level flow mechanisms. The soil columns are sampled at the end of the runs to determine the moisture distribution with respect to the interface of extraction.
(g) The results to date indicate that the resulting moisture distribution is a function of peculiarities of the microdynamic flow processes involved and independent of the method of extraction.
(h) "Drying Patterns of a Sandy Clay Loam in Relation to Possible Depths of Seeding," by Craig L. Wiegand, (accepted for publication in Agronomy Journal).

(3881) FACTORS AFFECTING THE EVAPORATION OF FREE WATER.

(b) Laboratory project.
(c) Dr. Craig L. Wiegand, Soil Scientist, P. O. Box 267, Weslaco, Texas.
(d) Experimental, basic research.
(e) The evaporation of free water is being studied under controlled conditions to: (1) Obtain quantitative information on the rate of evaporation of free water under controlled atmospheric conditions; (2) measure the rate of evaporation of water as a function of water temperature; and (3) correlate the rate of evaporation with (a) the saturation deficit of the atmosphere, and (b) the fugacity of the water molecules. Evaporation is being measured under all combinations of 10, 20, 30, and 40 degrees C water temperature; 10, 20, 30, and 40 degrees C air temperature; and 30, 50, 70, and 90% relative humidity. Water temperature is controlled to plus or minus .1 degrees C, ambient temperature to plus or minus 1.0 degrees C, and relative humidity to plus or minus 3%.
(g) Rates encountered range from condensation at the rate of 1.1 cm. per day to evaporation at the rate of 4.4 cm. per day. The evaporation and condensation rates correlate closely with the vapor pressure difference between the water surface and the bulk air. The data indicate that the rate of evaporation is more a function of the capacity of air to take on moisture than of the escaping tendency of the water molecules.
The evaporation rate increases faster with increasing water temperature than does the vapor pressure of water itself. The implication is that the latent heat of vaporization, the energy barrier to evaporation, does not limit the evaporation rates in this study.

(4335) THE HYDRAULICS OF STRUCTURES USED IN SOIL AND WATER CONSERVATION WORKS.

See U. S. Department of Agriculture, Agricultural Research Service, Soil and Water Conservation Research Division; Corn Belt Branch, Project 1723, and Illinois State Water Survey Division Project No. 1865.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 789, Stillwater, Oklahoma.
(d) Experimental and field investigation, applied research for design.
(e) Experiments employ small scale models as well as full size structures tested under simulated natural conditions to develop designs for structures needed for soil and water conservation. Closed conduit spillway entrances including drop inlets, hood inlets, and orifice plates are tested. Debris guards are tested using full size structures to provide verification of the small models.

(g) Recent work included the testing of full size pipe spillways with hood inlet entrances. Diameters of pipe tested ranged from 8 inches to 24 inches.

(4336) DESIGN AND CALIBRATION OF DEVICES FOR THE MEASUREMENT OF RUNOFF.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 789, Stillwater, Oklahoma.
(d) Experimental, applied research.
(e) The measuring devices tested are used in the hydrology research program of the Agricultural Research Service. Sites for runoff measuring stations are surveyed and then modeled in the laboratory. Proposed structures are placed in the model and tested to develop a satisfactory design. The final design is calibrated by model tests. All current work is on specific sites and no general experiments are done.
(g) Model calibrations were made during the past year on a super-critical flow flume for measuring discharge rates up to 6000 c.f.s.

(4337) HYDRAULICS OF FLOW IN VEGETATION LINED CHANNELS.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 789, Stillwater, Oklahoma.
(d) Experimental, applied research.
(e) Channels or portions of channels are built full size on the outdoor hydraulic laboratory grounds. These are planted to the vegetation being investigated and then tested by flowing water at selected times. Friction factors and permissible velocities (or tractive force values) are determined. In recent years the establishment phase of vegetal channels has received the greater emphasis. This has included the evaluation of temporary, fabricated liners of jute, glass fiber, and asphalt.
(g) Friction factor values and permissible velocities for vegetation lined waterways which were found by this station now appear in many publications, including the "Handbook of Channel Design for Soil and Water Conservation," SCS-TP-61.

(4338) HYDRAULICS OF UNSTEADY FLOW IN OPEN CHANNELS.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 789, Stillwater, Oklahoma.
(d) Experimental, applied research.
(e) Studies are made of unsteady flow phenomena occurring in the runoff process. Included are investigations of overland flow, spatially varied unsteady flow in channels, and flood wave movement in channels. The initial phase of the study is an analytical one utilizing existing knowledge and theory. This phase will be followed by a large scale outdoor laboratory study to test hypotheses and evaluate coefficients.
(f) In construction phase.

(4339) RUNOFF CHARACTERISTICS OF AGRICULTURAL AREAS IN THE RED PRAIRIE OF OKLAHOMA.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. W. O. Ree, Hydraulic Engineer, P. O. Box 789, Stillwater, Oklahoma.
(d) Field investigation, applied research for design.
(e) Three watersheds, 17 acres, 92 acres, and 206 acres in size and covered with native grass, are instrumented to measure rainfall and runoff. Annual water yield as well as peak flood flows are determined. Selected runoff events provide data for distribution graphs or unit hydrograph development.
(g) Data from 11 years of measurement are on hand.

(4340) SEDIMENT PRODUCTION, MOVEMENT AND DEPOSITION IN THE WASHITA RIVER BASIN, OKLAHOMA.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
(d) Field investigation, applied research.
(e) Suspended sediment sampling and total sediment transport determinations are made at selected tributary and main stream locations in the Washita River Basin. These samples are analyzed for size distribution.

(4341) STREAM CHANNEL STABILIZATION AND SEDIMENT CONTROL WORKS IN CHANNELS OF THE WASHITA RIVER BASIN.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
(d) Field investigation, applied research.
(e) Selected reaches of channels representing different geologies, soils, and flow regimes are being established for detailed studies of stream channel morphology. Information is being obtained on cross-sections, slopes, thalweg lengths, alignments, vegetation, and bed and bank materials. Any control works are completely identified as to location, orientation, shape, size, and materials. Flow history will be recorded, including both water and sediment. Changes in channel conditions, or lack of change, will be related to flow history and other controlling factors for the development of criteria for stable channel design.

(4342) PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS IN THE WASHITA RIVER BASIN, OKLAHOMA.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
(d) Field investigation, applied research.
(e) A network of 170 recording precipitation gages has been established on a 3-mile grid in an 1100-square mile area in the central portion of the Washita River Basin. The precipitation characteristics will be analyzed to determine and evaluate precipitation parameters useful in estimating runoff.

(4343) RUNOFF PRODUCTION BY UNIT SOURCE AREAS IN THE WASHITA RIVER BASIN, OKLAHOMA.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
(d) Field investigation, applied research.
(e) Small watersheds generally not exceeding 100 acres in size, each representing a single soil-cover combination are being instrumented to measure rainfall, runoff, and soil moisture. Information on the runoff producing characteristics of the unit source areas will be useful in the development of equations for predicting runoff from ungaged complex watersheds.

(4344) RELATION OF INTEGRATED CLIMATIC AND WATERSHED FACTORS TO STORM RUNOFF AND WATER YIELD OF THE WASHITA RIVER AND TRIBUTARIES, OKLA.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
(d) Field investigation, applied research.
(e) A reach of the Washita River extending from Anadarko, Oklahoma, to Alex, Oklahoma,

has been selected for study. This reach has a length of 80 river miles and a drainage area along this length of 1120 square miles. Gaging stations are being established near the mouth of 20 tributaries and at 6 sites along the main stem of the Washita River in this reach. Watershed characteristics are being measured and defined. The watershed land use and structures development will be inventoried periodically. Flood peaks, total flow and its rate-time distribution will be determined and related to climatic and land factors.

(4345) EXPLORATORY STUDY OF THE REGIMES OF WASHITA RIVER MAIN STEM FLOWS.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
(d) Analysis of record, applied research.
(e) The flow history of the Washita River, Oklahoma, for the 10-year period 1941 to 1950 is being analyzed to: (1) Determine parameters characterizing the regime flows prior to development of upstream flood abatement measures; and (2) establish a base for reference in defining any future changes in flow regimes associated with conservation and treatment programs in tributary watersheds.

(4346) AQUIFER-STREAMFLOW RELATIONS, GROUND WATER BUDGET, WASHITA RIVER BASIN, OKLAHOMA.

(b) Laboratory project, cooperative with the Oklahoma Agricultural Experiment Station.
(c) Mr. M. A. Hartman, Hydraulic Engineer, P. O. Box 684, Chickasha, Oklahoma.
(d) Field investigation, applied research.
(e) The alluvia and underground flow system of the Washita River Basin are being defined by use of drilling equipment and existing well logs. Permeability coefficients will be determined and ground water observation wells established. This is one part of a comprehensive research study of the total water budget in a portion of the Washita River Basin.

(4347) AN INVESTIGATION OF RAINFALL-RUNOFF RELATIONSHIPS IN THE COASTAL AREAS OF THE LOWER RIO GRANDE VALLEY.

(b) Laboratory project, cooperative with the Texas Agricultural Experiment Station.
(c) Mr. R. R. Allen, Agricultural Engineer, P. O. Box 267, Weslaco, Texas.
(d) Field investigation, applied research for design.
(e) The project will provide data on runoff volumes needed for the design of drainage systems for the flat, coastal areas. A 3250-acre, non-leveled, dry land tract is instrumented to measure rainfall and runoff. Data are also obtained on land and soil characteristics as well as the climatic variables.
(f) Temporarily suspended.

(4348) PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM SELECTED AREAS IN TEXAS.

(b) Laboratory project.
(c) Mr. Ralph W. Baird, Hydraulic Engineer, P. O. Box 1147, Riesel, Texas.
(d) Field investigation, applied research.
(e) Rain gage networks are established on the Blacklands Experimental Watershed near Riesel, Texas, and on the Edwards Plateau near Sonora, Texas. Information is being obtained on amounts, duration, seasonal distribution, and other characteristics of rainfall to the extent that the characteristics influence runoff from agricultural watersheds.
(f) The work at Sonora, Texas, was initiated in 1961.

(4349) RELATION OF CLIMATIC AND WATERSHED FACTORS TO STORM RUNOFF AND TO WATER YIELD FROM AGRICULTURAL WATERSHEDS IN THE BLACKLANDS OF TEXAS.

(b) Laboratory project.
(c) Mr. Ralph W. Baird, Hydraulic Engineer, P. O. Box 1147, Riesel, Texas.
(d) Field investigation, applied research.
(e) Thirty watersheds at the Blacklands Experimental Watershed near Riesel, Texas, varying in size from approximately 3 acres to 5860 acres, have been equipped with precalibrated flumes or with current meter rated weirs to measure runoff rates. Precipitation is measured by recording rain gages. The land factors are determined by periodic inventory of crops, covers, and crop systems on the land. Relationships between climatic and land factors and the runoff produced are analyzed to develop prediction methods for estimating storm peaks and water yields.
(h) Monthly summaries of rainfall and runoff, maximum volumes of flow for selected periods of time, and detailed data for selected runoff events are reported annually. Several analytical and interpretive reports have been published.

(4350) RUNOFF PRODUCTION BY UNIT SOURCE AREAS IN THE BLACKLANDS OF TEXAS.

(b) Laboratory project.
(c) Mr. Ralph W. Baird, Hydraulic Engineer, P. O. Box 1147, Riesel, Texas.
(d) Field investigation, applied research.
(e) Twelve watersheds, approximately 3 acres in size each, of single land use, crop or grass, are instrumented with H-type flumes to measure the runoff. The relationships between the runoff and the associated precipitation as influenced by the land characteristics are investigated. These relationships will facilitate the prediction of runoff from ungaged watersheds composed of combination of these single soil-cover, sub-watersheds or unit source areas.
(h) Monthly summaries of rainfall and runoff, maximum volumes of flow for selected periods of time, and detailed data for selected runoff events are reported annually.

(4351) SEDIMENT YIELD IN RELATION TO CLIMATIC AND WATERSHED CHARACTERISTICS OF AGRICULTURAL AREAS IN THE TEXAS BLACKLANDS AND THE EDWARDS PLATEAU.

(b) Laboratory project.
(c) Mr. Ralph W. Baird, Hydraulic Engineer, P. O. Box 1147, Riesel, Texas.
(d) Field investigation, applied research.
(e) At the Blacklands Experimental Watershed near Riesel, Texas, sediment yield measurements have been or are being made on twenty-four plots or watersheds varying in size from one-quarter to 5860 acres. These sediment yields are correlated with precipitation, runoff, topography, soils, land use, and conservation practices. The data are analyzed to develop techniques and procedures for estimating sediment yield and sources from ungaged watersheds. On Lowry Draw in the Edwards Plateau area near Sonora, Texas, sediment range lines have been established, in cooperation with Soil Conservation Service, at two detention reservoir sites with drainage areas of 4.38 and 16.85 square miles. In addition, arrangements have been made for sampling the flow from the reservoir spillways.

(4352) RELATION OF CLIMATIC AND WATERSHED CHARACTERISTICS TO STORM RUNOFF AND WATER YIELD IN THE EDWARDS PLATEAU AREA OF WEST CENTRAL TEXAS.

(b) Laboratory project.
(c) Mr. Ralph W. Baird, Hydraulic Engineer, P. O. Box 1147, Riesel, Texas.

(d) Field investigation, applied research.
(e) Five detention reservoirs in Lowrey Draw are equipped with water level recorders. Runoff volumes are measured by volume change in the reservoir. Rates of inflow can also be determined. The watersheds above the reservoirs range in size from 686 to 10787 acres. A current meter rated gaging station will be placed at the outlet of the Lowrey Draw watershed which has a drainage area of 48 square miles. A rain gage network will determine the precipitation over the area. In addition to the development of the rainfall-runoff relationship for this area, a study will be made of the disposition of the water temporarily stored in the reservoirs.

(4353) EVALUATION OF OPERATION AND DESIGN CRITERIA OF OLD TILE DRAIN SYSTEMS.

(b) Laboratory project.
(c) Mr. Victor I. Myers, Research Agricultural Engineer, P. O. Box 267, Weslaco, Texas.
(d) Field investigation - applied research.
(e) A study to evaluate the effectiveness of some old existing tile systems in draining and leaching soils; to evaluate the functioning of tile drains with and without filter materials; and, to evaluate the adequacy of tile drain design criteria.
(g) Additional tile lines up to 30 years old have been examined by excavating to the buried lines. Detailed studies of the salinity status of the soil between tile lines and of drainage provided by tile lines shows that most systems are only partially effective. A pitot tube air meter was fabricated and calibrated to meet a need for a device to measure flows in buried tile lines.

(4354) INFILTRATION RATES AND PROFILE CHARACTERISTICS IN RELATION TO THE OCCURRENCE OF SALINITY.

(b) Laboratory project.
(c) Mr. Leon Lyles, Research Agricultural Engineer, or Dr. Craig Wiegand, Research Soil Scientist, P. O. Box 267, Weslaco, Texas.
(d) Field investigation; applied research.
(e) The purpose of the work is to relate infiltration rates to the occurrence of salt-affected profiles. Infiltration rates are to be determined on about a dozen salt affected and adjacent non-affected profile pairs which have been chemically and physically characterized. The infiltration rates will be related statistically to the severity of salinization and to the chemical and physical properties of the profiles.
(g) The infiltration rate during the 15 minute to 5 hour time interval ranged from 0.35 to 3.96 inches per hour. Electrical conductivity of saturation extracts from the surface 3 inches of soil at these sites were 51 and 0.7 mmhos. per cm., respectively. The multiple regression analysis relating infiltration rate to the chemical and physical properties of the profile is yet to be completed.

(4355) CONCENTRATIONS OF SALTS IN RAINWATER ACROSS THE LOWER RIO GRANDE VALLEY.

(b) Laboratory project.
(c) Mr. Leon Lyles, Research Agricultural Engineer, P. O. Box 267, Weslaco, Texas.
(d) Field investigation - basic research.
(e) The project was a rain water sampling study to determine the quantity of salts present in rain water of varying storm types at the coast line and extending inland approximately 90 miles.
(f) Completed.
(g) A decrease in salt concentration of rainfall was observed with distance inland. The rate of decline is a function of the logarithm of the distance inland. The concentration of individual ions determined, except calcium, follow the logarithmic relationship.

(4356) EFFECTS OF BENCHING AND TERRACING ON MOISTURE CONSERVATION ON SLOPING HARDLANDS OF THE SOUTHERN GREAT PLAINS.

(b) Laboratory project.
(c) Mr. Victor L. Hauser, Agricultural Engineer, Southwestern Great Plains Field Station, Bushland, Texas.
(d) Field investigation, applied and design research.
(e) 1. To test the feasibility of altering the configuration of the land to intercept, spread, and infiltrate surface runoff in contour basins. 2. To determine the extent to which such intercepted runoff will add to available soil moisture supplies and how such additional soil moisture may best be utilized for crop production. 3. To determine the relative value of the three types of terrace systems, conservation benching, graded, and level closed end for moisture conservation and crop production. 4. To measure runoff from well managed contour farmed hardland soils.
(g) It has been found that graded and level terraces are equally effective in conserving runoff water under semi-arid conditions where 10 or 11 months of fallow precade planting either wheat or grain sorghum. It has been found that the conservation bench terrace system is superior to either graded or level terraces in the conservation of runoff water.
(h) "Evaluation of the Zingg Conservation Bench Terrace," by V. L. Hauser and M. B. Cox, Agricultural Engineering, Vol. 43, No. 8, pp. 462-464.
"A Comparison of Level and Graded Terraces in the Southern High Plains," by V. L. Hauser, C. E. Van Doren, and J. S. Robins, Transactions of the ASAE, Vol. 5, No. 1, pp. 75-77.

(4357) EFFECT OF CROPPING SYSTEMS AND CLIMATE ON RUNOFF, EROSION, AND CROP YIELDS UNDER BLACKLAND CONDITIONS.

(b) Laboratory project.
(c) Mr. D. W. Fryrear, Agricultural Engineer, P. O. Box 748, Temple, Texas.
(d) Experimental - applied research.
(e) Runoff and soil loss are measured from 12 field scale (1 1/2 acre) plots representing a typical cultivated slope of Blackland Prairie soils. The plots are in three cropping systems with row cropping every year, in alternate years, and every third year. By taking soil moisture and crop residue measurements, in the future the interactions of varying climatic influences with crops and management are determined as a basis for determining runoff and erosion on farms and watersheds.
(g) Soil moisture is the dominant factor influencing runoff in the Blackland soils. Erosion per unit of runoff is strongly influenced by surface residues as well as live crop growth. Early stands of grain sorghum are thick and by keeping residues on the surface erosion from grain sorghum has been about one-half as much as from corn or cotton and only slightly more than oats.

(4844) TESTING OF MATERIALS FOR IMPROVED SUBSURFACE DRAINAGE.

(b) Laboratory project.
(c) Mr. Victor I. Myers, Research Agricultural Engineer, P. O. Box 267, Weslaco, Texas.
(d) Experimental; applied research.
(e) Laboratory tank studies will be made to evaluate drainage materials with particular emphasis on filters and new drain tube materials. One or more field installations

will be made in which drainage materials will be compared and evaluated. Electric analogue studies will be made for predicting flow rates into tile lines.

(g) Data are being taken but have not yet been summarized.

(4845) SOIL-WATER-PLANT RELATIONS OF IRRIGATED COTTON AS INFLUENCED BY DEPTH TO WATER TABLE.

(b) Laboratory project.
(c) Mr. L. N. Namken, Research Soil Scientist, P. O. Box 267, Weslaco, Texas.
(d) Field investigation; applied research.
(e) A set of thirty-six lysimeters, one meter square and ten feet deep, are being utilized to study the influence of soil moisture level, water table depth and water table salt level treatments on evapotranspiration, vegetative growth and yield of cotton. The objectives of the project are: (1) To determine the contribution of a water table to the water requirement of cotton; (2) to study soil moisture use and extraction by cotton as influenced by various water table depths; and (3) to study the effect of water table salt concentration on salt movement and moisture uptake by the cotton plant.

(4846) CROPPING SYSTEMS AND TILLAGE METHODS FOR SOIL AND WATER CONSERVATION IN CONNECTION WITH WHEAT PRODUCTION.

(b) Laboratory project.
(c) Mr. M. B. Cox, Agricultural Engineer, P. O. Box 128, Cherokee, Oklahoma.
(d) Field investigation; applied research.
(e) Comparison of clean tillage versus stubble mulch tillage on continuous wheat with and without nitrogen fertilizer, and rotations of three years wheat with three years alfalfa. Plowing to 12 inches was done in 1955 to disrupt the plow pan on half of all plots. The purpose of the project is to evaluate stubble mulch tillage and deep plowing with different cultural practices for increasing water infiltration, reducing runoff, controlling erosion, and improving crop production.
(g) Deep plowing reduced runoff the first year approximately 25%, the second year about 15% and the third year about 5%, the following years there was no measurable difference. There was no measurable difference in crop production. Spring application of nitrogen has materially reduced runoff and increased wheat production. Runoff is reduced by stubble mulch during the fall season but not in the spring. Runoff is reduced and wheat production is increased the first and second years of wheat following three years of alfalfa.
(h) "Stubble Mulch and Other Cultural Practices for Moisture Conservation and Wheat Production at the Wheatland Conservation Experiment Station, Cherokee, Okla.," by Harley A. Daniel, Maurice B. Cox, and Harry M. Elwell, USDA Production Research Report No. 6, October 1956.
"Rainfall-runoff Relations on Wheatland," Maurice B. Cox, Agricultural Engineering, Vol. 37, No. 2, pp. 117-119, February 1956.
"Design of Plots Conforming to the Land for Evaluating Moisture Conservation Practices," by Harley A. Daniel, Maurice B. Cox, Billy B. Tucker, and Frank G. Viets, Soil Science Society of America Proceedings, Vol. 21, No. 3, pp. 347-350, May-June 1957.
"Effect of Land Treatment on Runoff at Cherokee, Oklahoma," by W. G. Knisel, M. B. Cox, and B. B. Tucker, Oklahoma Agricultural Experiment Station Bulletin B-583.

(4847) EFFECT OF SURFACE CROP RESIDUE MANAGEMENT ON RUNOFF, EROSION, CROP YIELDS, AND SOIL PROPERTIES.

(b) Laboratory project.
(c) Mr. D. W. Fryrear, Agricultural Engineer, P. O. Box 748, Temple, Texas.
(d) Field investigation; applied research.
(e) Eight individual terrace fields on characterized Blackland Prairie soils are managed by 2 tillage systems in a 2-year rotation of cotton-wheat with crop growth and yields and soil characteristics determined, and with rainfall and runoff gauging on 4 terraces.
(g) Nine years of data show no consistent or significant difference between the runoff from trash-mulch tillage versus clean, conventional tillage.

(4848) GRADED FURROWS FOR REDUCING WATER EROSION.

(b) Laboratory project.
(c) Mr. D. W. Fryrear, Agricultural Engineer, P. O. Box 748, Temple, Texas.
(d) Field investigation; applied research.
(e) Forty-inch furrows are planted on a 1 percent grade. The amount of runoff and soil loss from the furrows will be measured along with rainfall intensities, soil moisture, and surface residues. If the furrows carry all the water that falls in them, the recommended terrace spacing could be increased.
(f) Now being initiated.

(4849) EVALUATION OF DRAINAGE METHODS FOR THE NONIRRIGATED AREA OF THE LOWER RIO GRANDE VALLEY OF TEXAS.

(b) Laboratory project.
(c) Mr. Ronald R. Allen, Agricultural Engineer, or Mr. Victor I. Myers, Research Agricultural Engineer, P. O. Box 267, Weslaco, Texas.
(d) Experimental and field investigation; applied research.
(e) The purpose of the study is to compare the effectiveness and cost of installation operation and maintenance of three drainage methods; open drain ditches, subsurface drain tile, and drainage wells in reduction of soil salinity and control of a ground water table.

U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, Soil and Water Conservation Research Division.

SOUTHWEST BRANCH, P. O. Box 2326, Riverside, Calif., Mr. W. W. Donnan, Branch Chief.

(151) LINING OF IRRIGATION CANALS AND RESERVOIRS.

(b) Laboratory project, in cooperation with the Utah State University and Bureau of Reclamation.
(c) Dr. C. W. Lauritzen, Soil Scientist, Utah State University, Mechanic Arts, 130, Logan, Utah.
(d) Experimental; basic and applied research.
(e) Linings for irrigation canals and reservoirs are being tested to develop more effective and lower cost methods of reducing seepage losses in irrigation systems. The investigation included: (1) Evaluation of physical properties of lining materials; (2) model testing of linings in an outdoor laboratory; and (3) field testing at selected sites to determine relative durability under varying subgrade and climatic conditions.
(g) After over eight years both 8-mil vinyl and polyethylene films installed as buried linings are providing almost complete seepage control. Four-mil films are becoming somewhat less effective as seepage barriers but are still relatively watertight.

(2117) WATER REQUIREMENTS IN IRRIGATED AREAS OF SOUTHWEST.

(b) Laboratory project in cooperation with State

and Federal agencies.

(c) Mr. Dean C. Muckel, Agricultural Engineer, P. O. Box 8014, University Station, Reno, Nevada.

(d) Field experiments and office analysis. Applied research.

(e) To determine the consumptive use of water by crops, phreatophytes, and other vegetation, and net irrigation supply requirements. To develop empirical formula from climatological and other data for determining rates of consumptive use.

(h) "Determining Consumptive Use and Irrigation Requirements," by Harry F. Blaney and Wayne D. Criddle, U.S.D.A. Tech. Bul. No. 1275.

(2180) EVAPORATION LOSSES FROM RESERVOIRS AND LAKES.

(b) Laboratory project in cooperation with State of California, counties and other agencies.

(c) Mr. Dean C. Muckel, Agricultural Engineer, P. O. Box 8014, University Station, Reno, Nevada.

(d) Experimental; compilation and analysis of data. Applied research.

(e) To determine evaporation losses from reservoirs and lakes and develop empirical formulas from climatological data for computing monthly evaporation. Cooperative field measurements are being made of pan evaporation at stations in California ranging from near sea level in Santa Barbara County to 9,194 feet elevation at Kaiser Pass in the Sierra-Nevada Mountains.

(2181) ARTIFICIAL RECHARGE OF GROUND WATER FOR IRRIGATION IN CALIFORNIA.

(b) Laboratory project in cooperation with the California Department of Water Resources.

(c) Mr. Leonard Schiff, Hydraulic Engineer, 4816 East Shields Avenue, Fresno 3, Calif.

(d) Experimental; laboratory and field investigations, applied research.

(e) To efficiently store imported water underground in quantity and of a qualty needed in various locations. The objectives are: (1) To determine the physical and chemical characteristics of surface soil and substrata on selected recharge sites and to relate these characteristics to infiltration and percolation rates, and to lateral aquifer flow; (2) to determine the feasibility of recharge irrigation (deep percolation by heavy irrigation of crops) as a means of storing water underground; (3) to determine the effect on recharge of the quality of water reaching the groundwater table under selected site conditions, and on the quality of the groundwater; and (4) to prepare a recharge guide which permits the evaluation of a site for recharge, suggests methods and systems of recharge to be used and indicates the quality of groundwater that may be expected as a result of recharge.

(h) "Effect of Filtering on Model Recharge Wells," by Leonard Schiff, Proc. Amer. Soc. Civil Engrs., IR 4, Dec. 1961.
"Ground Water Recharge Methods Based on Site Characteristics and on Sediment in Flood Water," by Leonard Schiff, approved by SWCRD for 1963 Tokyo meeting International Commission on Irrigation and Drainage.
"The Hydraulic Conductivity of Selected Uniform, Stratified and Mixed Sands with Emphasis on Ground Water Recharge Problems," by Jerold J. Behnke and Leonard Schiff, in press for Dec. 1962 AGU meeting.
"Effects of Prolonged Irrigation on Cotton," by E. E. Haskell, Jr. and W. C. Bianchi, accepted for publication in Agronomy Journal.
"Ground Water Recharge Hydrology," Leonard Schiff, submitted for Agronomy Monograph, A.S.A.
"Ground Water Recharge and Storage," by D. C. Muckel and L. Schiff, submitted for Agronomy Monograph, Chapter 8.

(2650) EFFECT OF WATER TABLE DEPTH ON IRRIGATION REQUIREMENTS AND YIELD OF LAHONTAN ALFALFA.

(b) Laboratory project, in cooperation with the Nevada Agricultural Experiment Station.

(c) Mr. Rhys Tovey, Agricultural Engineer, ARS, Box 8014, University Station, Reno, Nevada.

(d) Experimental; applied research.

(e) To determine surface-irrigation requirements of Lahontan alfalfa grown on three soil textures with constant water tables at various depths, and on well-drained soil in the absence of a water table; to determine the effect of plant growth stage on the rate of water use by Lahontan alfalfa; to determine the relation between the use of water by alfalfa under various water table conditions, evaporation from porous atmometer bulbs, and evaporation from a Weather Bureau evaporation pan; and to evaluate the effects of a fluctuating water table on the yield and growth rate of alfalfa.

(g) The seasonal values indicate that: (1) The consumptive use and yield of alfalfa for the non-irrigated treatments decreased as the depth to water table increased; (2) the non-irrigated lysimeters show a lower consumptive use and yield than the irrigated lysimeters in most instances; (3) the consumptive use and yield of the drained irrigated treatments are comparable to the values measured for the eight-foot water table, non-irrigated treatment; and (4) the differences due to water table depth are less for the non-irrigated treatments. Alfalfa plants, grown on a sandy loam soil, can stand submergence for three days without a reduction in yield.

(h) "Equipment for Controlled Water Table Investigations," Rhys Tovey and W. C. Bianchi, Transactions American Society of Agricultural Engineers, Vol. 4, No. 1, pp. 126 and 127, 1961.
"Consumptive Use and Yield of Alfalfa Grown in the Presence of Static Water Tables," Rhys Tovey. Submitted for Division approval; to be published as Nevada Agric. Exp. Sta. Tech. Bul.

(2651) DRAINAGE INVESTIGATIONS IN THE NORTH SHORE AREA OF CARSON LAKE, NEVADA.

(b) Laboratory project, in cooperation with the Nevada Agricultural Experiment Station.

(c) Mr. Anthony S. Dylla, Agricultural Engineer, Box 8014, University Station, Reno, Nevada.

(d) Field and applied research.

(e) To determine the causes for drainage problems in the study area, to develop equipment and techniques suited to conditions in the study area which will permit determining qualitative and, if possible, quantitative relationships between causes for drainage problems in the study area and in other similar areas; to develop physically and economically feasible methods of correcting or alleviating problems in the study area and in other similar areas.

(g) Canal seepage measurements are being analyzed for relationship to high water table build-up. Results of investigative borings are being compiled for determination of corrective drainage measures. Hydraulic conductivity and specific yield data are being compiled for design of corrective drainage measures. Plastic lined mole drains are being studied as a possible economical drainage problem. Well, piezometer, and irrigation efficiency data are being compiled for analyzing the cause for drainage problems.

(h) "Experimental Plastic Drains in Nevada," by A. S. Dylla, Agricultural Engineer, Nev. Agri. Exp. Sta. Bul. No. 228 (2nd Press).

(3212) THE HYDRAULICS OF CYLINDER INFILTROMETERS.

(b) Laboratory project, in cooperation with the California Agricultural Experiment Station,

Davis, California.
(c) Mr. D. C. Muckel, Agricultural Engineer, P. O. Box 8014, University Station, Reno, Nevada.
(d) Experimental and basic research and developmental.
(e) This is a three dimension model study of the hydraulics of Cylinder-type infiltrometer to determine the flow regime of this device, the necessity for buffer cylinders, the effect of diameter on its function, the effect of methods and depths of placement on results, the effect of location of less permeable soil strata in relation to depth of placement of infiltrometer, and the effect of various operational techniques on reliability of results.
(f) Completed.
(h) Report in preparation.

(3556) FARM CONVEYANCE AND WATER APPLICATIONS.

(b) Laboratory project, in cooperation with the Utah State University.
(c) Dr. C. W. Lauritzen, Soil Scientist, Utah State University, Mechanic Arts, 130, Logan Utah.
(d) Experimental; basic and applied research.
(e) New methods and equipment for conveying and applying irrigation water are being developed. The hydraulic properties of lay-flat tubing are being studied and new materials are being evaluated to determine their use in conveyance structures.
(g) Work continued on the design and testing of a free-flowing hopper section for subgrade-guided slipforms. The feature of the hopper section which facilitates the flow is a half conical section. This creates a diverging flow pattern that eliminates the arching and bridging associated with flow in hoppers of conventional design.
A gate valve has been developed and found to provide an effective watertight diversion structure. This gate promises to be low in cost and simple to operate. A report on this valve is scheduled to be released in the near future.
(h) "New Slipform uses Free-Flow Hopper," by Frank W. Haws and C. W. Lauritzen, Farm & Home Science, Vol. 23, No. 3, pp. 63-65, Sept. 1962, publication of Utah State Univ., Agricultural Experiment Station.
"Standardization of Canal Cross Section," by C. W. Lauritzen, Seventh Indian Standards Convention Proceedings, Calcutta, India.
"Hydraulics and Geometrical Relationships of Lay-Flat Irrigation Tubing," by A. S. Humphreys and C. W. Lauritzen, USDA Tech. Bulletin, (In Press).

(3558) LABORATORY MODEL STUDIES OF THE SEDIMENT SEALING PROCESS.

(b) Laboratory project, in cooperation with the Nevada Agricultural Experiment Station.
(c) Mr. Myron B. Rollins, Soil Scientist, Agricultural Research Service, P. O. Box 8014, University Station, Reno, Nevada.
(d) Experimental; applied research.
(e) To determine factors influencing sediment penetration and retention involved with sealing irrigation canals or reservoirs with seepage transported bentonite, and to develop procedures to obtain effective seals. Experimentation is being done with sands placed in lucite cylinders 3 inches in diameter and 2 feet long. Bentonite is applied by dispersing it in the water, percolation carries the bentonite down into the sand profile. Numerous aspects concerning the chemical, physical and mineralogical properties of the bentonites, waters, and sands will be evaluated.
(g) Investigations, to date, suggest that effective seals can be obtained within certain unknown limitations.
(h) "The Apparent Swelling Behavior of Some Moderately Dispersed Bentonites," by Myron B. Rollins, Merrill J. Hallam, and Victor I. Myers. Soil Sci. Soc. of Amer., Vol. 25, pp. 407-409, September - October 1961.

(3560) EVAPOTRANSPIRATION OF HUMBOLDT MEADOW VEGETATION AS MEASURED WITH LYSIMETERS.

(b) Laboratory project.
(c) Mr. Anthony S. Dylla, Agricultural Engineer, P. O. Box 8014, University Station, Reno, Nevada.
(e) To measure the evapo-transpiration of meadow vegetation in the Humboldt Basin area which subsists primarily under shallow water table conditions. The data will be used to determine areal use of ground waters by native vegetation and phreatophytes and to develop methods of more efficient utilization of those water supplies.
(g) Evapo-transpirational rates are being obtained by water use measurements of meadow grasses growing in plastic lysimeters. Vegetative growth, soil moisture, water table, and weather data are being collected to which evapo-transpiration rates from tanks can be related.
(h) "Plastic Membrane Tanks for Evapotranspiration Determinations," by A. S. Dylla and Rhys Tovey, Agricultural Engineering, Vol. 43, No. 10, pp. 585, 1962.

(3868) MECHANISMS AND MATHEMATICS OF WATER MOVEMENT IN UNSATURATED SOIL.

(b) Laboratory project.
(c) Dr. W. R. Gardner, U. S. Salinity Laboratory Post Office Box 672, Riverside, California.
(d) Experimental and theoretical; basic research.
(e) Improved techniques for measuring the water transmitting properties of soils are being sought. The effect of temperature on these properties is being studied. A mathematical treatment of evaporation of water from soil is being developed and tested and the redistribution of water in soil after infiltration is being studied experimentally.
(g) Equations predicting the rate of drying from bare soil as a function of potential evaporation and soil water content have been developed and tested for nearly isothermal conditions. A relatively rapid method for measuring unsaturated conductivity in the tensiometer range has been devised.
(h) "Unsaturated Conductivity and Diffusivity Measurements by a Constant Flux Method," W. R. Gradner, and F. J. Miklich. Soil Sci. 93: 271-274, 1962.
"Note on the Separation and Solution of Diffusion Type Equations," by W. R. Gardner. Soil Sci. Soc. Am. Proc. 26: 404, 1962.
"The Relation of External Evaporative Conditions to the Drying of Soils," by W. R. Gardner and D. I. Hillel. J. Geophy. Res. 67: 4319-4325, 1962.

(3872) DYNAMIC SIMILARITY IN PIPE ELBOW FLOW METERS.

(b) Laboratory project.
(c) Mr. Lloyd E. Myers, Director, Water Conservation Laboratory, Route 2, Box 816-A, Tempe, Arizona.
(d) Experimental; applied research.
(e) The objective of the study is the development of means for obtaining dynamic similarity in pipe elbow flow meters to permit the use of standard rating curves. ASA, class 125 cast iron 90 degrees flanged, 3" long and short radius elbows made by five different manufacturers have been calibrated under normal flow conditions. Magnitude of errors caused by flow disturbances from various fittings and installations were determined. Larger diameter cast iron elbows and different type elbows are being investigated.
(g) Comparison of rating curves for the 3-inch cast iron elbows gave results within plus or minus 3 percent under normal flow conditions.

(3873) GROUND COVERS AND OTHER STRUCTURES FOR COLLECTING AND STORING PRECIPITATION.

(b) Laboratory project, in cooperation with the Utah State University.
(c) Dr. C. W. Lauritzen, Soil Scientist, Utah State University, Mechanics Art, 130, Logan, Utah.
(d) Experimental and applied research.
(e) There are areas in many regions where water for livestock and even culinary uses is scarce or nonexistent, yet considerable water in the form of precipitation falls each year. As an example, the precipitation on one acre of land in an 8-inch rainfall area amounts to 217,248 gallons. This is enough to supply water to more than 200 head of cattle for 100 days. This study includes the development and testing of materials for ground covers and storage facilities to be used for the collection and storage of water in low rainfall areas together with the design and operation of these facilities.
(g) Tests of ground cover materials have shown that butyl sheeting is highly satisfactory for this purpose. It has good aging properties, is easy to install, and requires minimum site preparation, although the material is relatively expensive. Asphalt-coated jute fabrics are less expensive but more costly to install and probably have a shorter service life. After several years of test, they are still effective and should not be overlooked. A new high molecular polymer asphalt blend structure, although evaluated for less than a year, looks promising and has the advantage of being low in cost.
Evaporation-free storage of water collected from ground covers has been provided by butyl bags at an ititial cost of less than 3 cents per gallon.
(h) "Trapping Water," by C. W. Lauritzen, Western Livestock Journal, Pacific Slope Edition, Vol. 40, No. 9, p. 24, January 1962.
"Graze More Range with New Water-Saving Idea," by C. W. Lauritzen Ford Farming, p. 22, 1962. Publication of Ford Motor Company, Dearborn, Michigan.
"Capturing Precipitation," by C. W. Lauritzen, Annual Bulletin, International Commission of Irrigation and Drainage, (In Press).

(3874) INFLUENCE OF COLORADO RIVER WATER UPON IRRIGATION AND DRAINAGE IN THE SAN JACINTO BASIN, CALIFORNIA.

(b) Laboratory project.
(c) Mr. Luther B. Grass, Soil Chemist, P. O. Box 629, Pomona, California.
(d) Experimental.
(e) A study of the use of Colorado River Water for irrigation applicable to the intermediate valley and plains areas of southern Calif. is being conducted in two ways. First, in 1954 a group of key soil sampling stations were selected and sampled annually. The soil analyses were compared with previous analyses, annual rainfall patterns and cropping practices. The second study, initiated in 1960, encompasses a plot program in which potatoes and grain are grown in a three-year rotation. One-half of the plots were presalinized. Only sufficient water to supply evapotranspiration is applied to one group of plots, while to the second an excess of 20 percent evapotranspitation demands is applied.
(g) Key salinity trend stations have revealed during the past ten years that soil salinity has increased gradually in areas irrigated with Colorado River water. Winter rainfall has a very marked influence upon this rate of accumulation. A winter of substantially above normal rainfall will do much to leach the accumulated salts from the soil. However, on an average annual basis rainfall is not a dependable means of leaching. Consequently, the farm operation must include a leaching program as part of the irrigation practice. The plot studies have, in the first season, indicated the influence of but moderate concentration of salts upon productivity.

(4358) FLOOD WAVE MOVEMENT AND ROUTING IN ALLUVIAL CHANNELS.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.
(c) Mr. R. V. Keppel, Agricultural Engineer, P. O. Box 3926, Tucson, Arizona.
(d) Experimental, field investigation.
(e) Water level recorders are located at 2,000-foot intervals in a 3-mile reach of natural channel. The reach has a gaging flume at the inlet and at the outlet, and major tributary inflow is gaged. Flood waves generated by cloudburst type thunderstorms are being studied.
(g) Only one moderately high discharge event has occurred since the channel reach has been instrumented (Q = 1,000 c.f.s.). Top-riding translatory waves moved through the reach at velocities up to 25 feet per second.

(4359) PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM SEMIARID WATERSHEDS.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.
(c) Mr. H. B. Osborn, Hydraulic Engineer, P. O. Box 3926, Tucson, Arizona.
(d) Experimental, field and laboratory; basic research.
(e) Raingage networks with densities of one recording gage per square mile are being operated on the 58-square-mile Walnut Gulch watershed in southeastern Arizona and the 67-square-mile Alamogordo Creek watershed in northeastern New Mexico. The walnut Gulch study is augmented by horizontal-search 3-cm. radar. Objectives of the study are to determine precipitation parameters of importance in predicting runoff and sediment yield, and to give particular attention to the small area, highly intense, convective summer thunderstorms typical of the region.
(g) Return frequencies on the Walnut Gulch watershed, computed from three years of record for 55 raingages, were identical with those computed from 61 years of record at a point located near the center of the watershed. This indicates the convective thunderstorms occur in a random fashion on the Walnut Gulch watershed. In consecutive years (1960 and 1961), on the Alamogordo Creek watershed, convective thunderstorms occurred that had intensities for time intervals through 20 minutes greater than any reported by first order Weather Bureau Stations in the United States. Identical volumes of 3.09 inches were recorded in a 15-minute period for each event.

(4360) RUNOFF FROM COMPLEX WATERSHEDS AS INFLUENCED BY CLIMATIC AND WATERSHED CHARACTERISTICS.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.
(c) Mr. R. V. Keppel, Agricultural Engineer, P. O. Box 3926, Tucson, Arizona.
(d) Experimental; applied research.
(e) On semiarid rangeland watersheds up to 43,000 acres in size, runoff measurements are being maintained, and an attempt is being made to relate water yield to climatic and watershed characteristics, and to evaluate the effects of a range program on rates and amounts of flood runoff and on

net water yields. A new design of critical depth flume with capacities up to 18,500 cfs is being used to gage the flashy, sediment-laden flows.

(g) On 5 Walnut Gulch watersheds ranging from 560 to 36,900 acres, water yield decreases exponentially with the 0.3 power of the watershed size. All of the water yields to date have occurred from June to September as a result of intense convective thunderstorms. On the Alamogordo Creek Watershed (43,000 acres), flow events originating on the central portion of the valley floor cause a flat-top hydrograph with a sustained peak lasting 2 to 3 hours. It is believed that this is caused by unusually large valley storage located upstream from a channel discontinuity.

(h) "Field Performance of Large Critical Depth Flumes for Measuring Runoff from Semiarid Rangelands," by Osborn, H. B., Keppel, R. V., and Renard, K. G., ARS-41-69. In press.

(4361) THE ROLE OF VALLEY AND CHANNEL MATERIALS AND VEGETATION IN THE HYDROLOGY OF SEMI-ARID WATERSHEDS.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.

(c) Mr. K. G. Renard, Hydraulic Engineer, P. O. Box 213, Tombstone, Arizona.

(d) Experimental, field investigation.

(e) Measurements from tandem gaging stations are utilized to evaluate the losses that occur as runoff traverses ephemeral stream channels. Records from shallow wells show depletion patterns of the transmission loss water.

(g) Losses up to 25 acre feet per mile of channel have been measured on one reach of channel in a single flash flood. Preliminary evidence indicates that most of the water is disposed of through evaporation or transpiration, and that little of it reaches the regional water table.

(h) "Transmission Losses in Ephemeral Stream Beds," by R. V. Keppel, and K. G. Renard, Journal of the Hydraulics Div. ASCE HY 5 p. 60-68. May 1962.
"Performance of Local Aquifers as Influenced by Stream Transmission Losses and Riprarian Vegetation," by K. G. Renard, R. V. Keppel, and J. J. Hickey, Paper No. 62-705, presented at ASAE Winter Meeting, December 1962.

(4362) THE HYDROLOGY OF SEMI-ARID WATERSHEDS AS INFLUENCED BY CHARACTERISTICS OF SOIL AND NATIVE VEGETATION.

(b) Laboratory project; cooperative with Ariz. and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.

(c) Dr. J. L. Gardner, Botanist, P. O. Box 3926, Tucson, Arizona.

(d) Experimental, field and laboratory. Basic research.

(e) Interrelations of soils and native vegetation as they influence water and sediment yield are being evaluated on rangeland watersheds of 100 to 43,000 acres in Arizona and New Mexico. Supplementary to studies on entire watersheds, infiltrometer studies on 6 x 12' plots are in progress. A primary objective of the infiltrometer studies is determination of parameters of rangeland vegetation most effective in evaluating its influences on runoff and sediment production on watersheds.

(g) On the infiltrometer plots, maximum runoff is reached in about half the time on areas supporting brush as compared to those supporting grass. On small watersheds above stock tanks, average annual sediment production -- but not runoff -- is logarithmically correlated with basal area of grass cover.

(4363) HYDROLOGIC DATA REDUCTION WITH ANALOG-TO-DIGITAL CONVERTER.

(b) Laboratory projects, cooperative with the Arizona and New Mexico Agricultural Experiment Stations.

(c) Mr. H. B. Osborn, Hydraulic Engineer, P. O. Box 3926, Tucson, Arizona.

(d) Experimental; laboratory.

(e) Hydrologic records in analog form are being reduced to digital form by means of an automatic analog to digital converter. Information is transferred primarily from rainfall charts to punched cards for future computer programs.

(h) "Use of Chart Readers for Analog to Digital Conversion of Hydrologic Data," by Herbert B. Osborn, ARS-41-81. In press.

(4364) RUNOFF AND SEDIMENT MOVEMENT ON UNIT SOURCE WATERSHEDS AS INFLUENCED BY MICRO-CLIMATE, WATER BALANCE, SOIL AND VEGETATION.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.

(c) Mr. H. B. Osborn, Hydraulic Engineer, P. O. Box 3926, Tucson, Arizona.

(d) Experimental, field and laboratory. Basic research.

(e) Runoff and sediment yields are being measured from several small, single soil-cover subwatersheds located within larger experimental watersheds having mixed soil-cover situations. Objectives are to evaluate the effects of various, soil-vegetation complexes, microclimate and water balance phases on local runoff and sediment production, and to identify and characterize unit source-areas controlling the net storm runoff and sediment yields of larger, more complex watersheds.

(g) Average annual sediment yield from small predominantly grass-covered watersheds is about 1%, by weight, of their water yield. Sediment yield measured from predominantly brush-covered watersheds ranges from around 2%, by weight, of water yield upward.

(4365) SEDIMENT MOVEMENT ON COMPLEX WATERSHEDS AS INFLUENCED BY CLIMATE AND WATERSHED CHARACTERISTICS.

(b) Laboratory project, cooperative with the Arizona and New Mexico Agricultural Experiment Stations, and the U. S. Soil Conservation Service.

(c) Mr. K. V. Keppel, Agricultural Engineer, P. O. Box 3926, Tucson, Arizona.

(d) Experimental, field and laboratory.

(e) The objectives of this study are: (1) to determine the relationship of sediment production on unit source areas to sediment yield from complex watersheds, (2) to adapt or develop methods for measuring sediment concentrations from the silt-laden ephemeral streams of the Southwest, (3) to determine the rates and influencing factors in the sedimentation of stock watering ponds and, (4) to develop methods for reducing sediment yields from complex rangeland watersheds. Laboratory investigations are being conducted using an electrical capacitance sensing element to measure sediment concentrations.

(4366) RAINFALL CONTRIBUTION TO GROUND WATER SUPPLIES AT SELECTED SITES IN SANTA BARBARA COUNTY, CALIFORNIA.

(b) Laboratory project, cooperative with Santa Barbara County Water Agency; U. S. Geological Survey; California State Department of Water Resources; and U. S. Bureau of Reclamation.

(c) Mr. G. P. Lawless, Soil Scientist, P. O.

Box E, Lompoc, California.
(d) Basic and applied research.
(e) Soil moisture measurements (made with neutron scattering moisture meters to depths of ten to twenty-eight feet) together with measurements of precipitation and other climatological factors are being made to determine how much, if any, of the rainfall in certain ground water recharge areas penetrates beyond the root zone. The thirteen sites being studied represent various cover, soil, and topographic conditions. From the data collected, evapotranspiration rates are determined. A study is made of movement of water in various soils to help determine net contribution to ground water recharge by deeply penetrating rainwater.
(f) Completed.
(g) Downward translocation of moisture has been observed to continue during the dry season following winter precipitation. This migration of moisture in unsaturated soil has been observed in all soils studied but is most pronounced in sandy soil.
(h) Summarizing report of six years of field observations is near completion.

(4367) CONSUMPTIVE USE OF WATER AS RELATED TO PACIFIC COASTAL CLIMATIC INFLUENCE.

(b) Laboratory project, cooperative with Santa Barbara County Water Agency; U. S. Geological Survey; California State Department of Water Resources; and U. S. Bureau of Reclamation.
(c) Mr. P. R. Nixon, Agricultural Engineer, P. O. Box E, Lompoc, California.
(d) Basic and applied research.
(e) Soil moisture and soil suction measurements are made on land in native vegetation and agricultural crops under central California coastal and nearby environments. From these and other data, evapotranspiration is computed. Evapotranspiration values are compared with observations made at five climate stations of USWB Class A type. Objectives include basic information and refinement of present methods of computing evapotranspiration, for development of improved management techniques for agricultural watersheds and associated ground water basins along the coast.
(f) Completed.
(g) Rather marked increase in evapotranspiration rates have been observed as distance increases from four to twenty-eight miles from the ocean. These rates are noticeably related to measurable climatic factors.
(h) Summarizing report of six years of field observations is near completion.

(4368) DEVELOPMENT OF A PORTABLE IRRIGATION SPRINKLER EVALUATION DEVICE.

(b) U. S. Dept. of Agriculture, Agricultural Research Service, Soil and Water Conservation Research Division.
(c) Mr. Rhys Tovey, Agricultural Engineer, ARS, Box 8014, University Station, Reno, Nevada.
(d) Experimental; applied research.
(e) (1) To develop a portable device that can be used in the design and evaluation of sprinkler irrigation systems and (2) to determine procedures for the use of the portable irrigation sprinkler evaluation device in measuring soil intake rates, sprinkler application rates and other factors pertinent to the efficient design of sprinkler irrigation systems.
(g) A portable irrigation sprinkler evaluation device has been designed and constructed. Tests show that the device works satisfactorily.
(h) "A Portable Irrigation Sprinkler Evaluation Device," Rhys Tovey, paper presented at the winter meeting of American Society of Agricultural Engineers, Dec. 1961 and submitted for publication in ASAE Journal or Transactions. (Article based on ASAE paper, published in March issue of Irrigation Engineering and Maintenance magazine).

(4850) WATERSHED RELATIONS TO RECHARGE OF DIRECTLY ASSOCIATED GROUND WATER BASINS.

(b) Laboratory project, cooperative with Calif. Dept. of Water Resources, California Agric. Experiment Station, and the U. S. Soil Conservation Service.
(c) Mr. Paul R. Nixon, Agricultural Engineer, P. O. Box E, Lompoc, California.
(d) Basic and applied research.
(e) Soil moisture measurements (made with neutron scattering moisture meters to depths of ten to twenty-eight feet) together with measurements of precipitation and other climatological factors are being made on a watershed near Lompoc, California, to determine how much, if any, of the rainfall in certain areas penetrates beyond the root zone to recharge groundwater. The thirteen sites now being studied represent various cover, soil, and topographic conditions. A study is made of movement of water in various soils to help determine net contribution to ground water recharge by deeply penetrating rainwater. A technique for predicting ground water recharge by deep penetration of rainwater is being developed which will provide probability estimates of seasonal recharge based site conditions and climatological records.
(f) New project extending from No. 4366 (completed).
(g) Downward translocation of moisture has been observed to continue during the dry season following winter precipitation. The magnitude of this migration is predictable and amount of downward movement of moisture through the root zone can be estimated fairly accurately without the benefit of periodic moisture determinations; provided monthly precipitation data are available and the range of available moisture in the root zone is known.

(4851) WATERSHED EVAPOTRANSPIRATION LOSSES IN CENTRAL AND SOUTHERN CALIFORNIA.

(b) Laboratory project, cooperative with Calif. Dept. of Water Resources, California Agric. Experiment Station, and the U. S. Soil Conservation Service.
(c) Mr. G. Paul Lawless, Soil Scientist, P. O. Box E, Lompoc, California.
(d) Experimental and field investigation, basic and applied research.
(e) Measurements of soil moisture content are being made at 13 neutron scatter metering sites on a watershed near Lompoc, Calif. Soil suction is measured at one site by tensiometers. Precipitation is measured within a complex of four of the soil moisture sites. Outside of the watershed, in a plot (approx. one acre) of perennial ryegrass, soil moisture data are obtained by an electronically weighing lysimeter, neutron scatter meter, tensiometers and moisture blocks. Soil temperature, soil heat flux, drainage from the lysimeter, wind velocity and direction, solar, total hemispherical, and net radiation, albedo, air temperature and humidity are measured in or near the lysimeter. Most of this data is automatically recorded. Data is also obtained from an adjoining USWB class A type climate station, which contains extra instruments consisting of a hygrothermograph, spherical atmometers, and recording rain gage. Purpose of this work is to determine the relationship between evapotranspiration and various climatic, soil, and plant influences as these relationships affect watershed performance with respect to net water yield.
(f) New project extending from No. 4367 (completed).
(g) During the long dry season, brush oak trees,

and grassweed ground cover use practically all of the avialable soil moisture in their root zones. This is to 20 feet or more in the cases of brush and oak trees, and about 8 feet for grass-weed. Evapotranspiration rates are highest in the spring following the winter rains, because much of the available water is quickly used, decrease by midsummer to very low rates. The electronic lysimeter was only recently installed, and no results are available at this time.

(4852) SEDIMENT SOURCES AND DELIVERY CHARACTERISTICS OF AGRICULTURAL WATERSHEDS IN CENTRAL & SOUTHERN CALIFORNIA.

(b) Laboratory project in cooperation with the U. S. SCS, Calif. Water Resources Dept., and the Calif. Agric. Experiment Station.
(c) Mr. Fred J. Libby, Geologist, P. O. Box E, Lompoc, California.
(d) Basic and applied research.
(e) To determine sediment producing characteristics of agricultural watershed lands as related to their geology, climate, soils, land use and treatment; their stream sediment movement and depositional characteristics as related to hydraulic and hydrologic influences; and to develop therefrom methods for prediction of sediment deposition on agricultural flood plain areas and carried into streams and reservoirs in central and southern California.

(4853) SALINITY BALANCE INVESTIGATION OF CITRUS IRRIGATION ON RESIDUAL SOILS, USING COLORADO RIVER WATER.

(b) Laboratory project, in cooperation with the U. S. Soil Conservation Service, and Riverside County (California) Flood Control Dist.
(c) Mr. Sterling Davis, Drainage Engineer, P. O. Box 629, Pomona, California.
(d) Experimental.
(e) The salinity of the soil and drainage water from this watershed is compared with total Colorado River water irrigation application plus rainfall to determine the salinity trends within a 1,000 acre watershed planted primarily to citrus orchards. Granodiorite rock underlying these soils minimizes loss of effluent to deep percolation. Bi-annual soil samplings are taken of selected sites within the watershed. Intensive investigations including flow recorders, flumes, and recording rain gages, were activated in May 1961. The program was expanded in 1962 to include sufficiently large flumes to measure winter storm runoff. The project was established as a five-year program.
(g) Preliminary observations have demonstrated the capabilities of this research technique in securing information on salinity trends on a watershed-wide basis.

(4854) EFFECT ON TILE DRAINS OF MANGANESE AND IRON SOLUBILITY IN SOILS.

(b) Laboratory project, in cooperation with the U. S. Soil Conservation Service.
(c) Mr. Luther Grass, Soil Chemist, P. O. Box 629, Pomona, Calif.
(d) Experimental.
(e) A study to determine the ability of various soils to yield ferrous or amanganous ions in drainage effluent under varying conditions of reduction and pH and to develop an index for classifying soils as to their reduction potential. Tile line deposits of manganese and ferric oxide now represent a serious threat to irrigated agriculture, particularly in the Coachella and Imperial Valleys of California. SCS and ARS technicians have collected and forwarded soil samples from 11 locations throughout the United States where this problem has been observed in agricultural drain lines. Apparatus has been set up in the laboratory to subject these reduced conditions.

(4855) THE CHARACTERISTICS OF FIBERGLASS MAT MATERIALS AS FILTERS FOR SUBSURFACE DRAINAGE SYSTEMS.

(b) Laboratory project in cooperation with the U. S. Soil Conservation Service.
(c) Mr. Hollis Shull, Agri. Engr., Southwestern Irrigation Field Station, Brawley, Calif.
(d) Experimental.
(e) A study is being conducted in the laboratory to determine the water permeability of fiberglass mat materials and to determine their filtering characteristics. Sand and gravel filter materials have been used for many years as an envelope around agricultural drain tile lines. The purpose is to prevent silting of the lines and to provide stability of tile alignment. In many irrigated areas where the drainage is needed, sand and gravel materials are difficult to obtain. The use of fiberglass mat materials offer an economical substitute.
(g) A laboratory device has been developed for use in testing all types and thicknesses of fiberglass mat materials. Tests have been run on a wide variety of materials.
(h) "An Electric Analog for Computing Agricultural Tube Drain Spacing," by Hollis Shull. Instrument News Dept. Ag. Engineering Journal - (In press).
"Self-propelled Agricultural Drain Line Camera," by Hollis Shull. Agricultural Research Magazine, October 1962.
"Hydraulic Characteristics of Glass Fiber Mat Material," by Hollis Shull. Mimeographed progress report, November 1962.

(4856) STUDY OF PLASTIC LINED MOLE DRAINS.

(b) Laboratory project, in cooperation with Utah State University, and the U. S. Soil Conservation Service.
(c) Mr. Lyman Willardson, Agri. Engr., ARS, Utah State University, Logan, Utah.
(d) Experimental and applied field tests.
(e) A study to determine the applicability of shallow depth lined and unlined mole drains, to develop methods of installation and to determine their durability and efficiency. This project is part of a Branch wide study of plastic lined mole drains. Field installations were completed in 1959 at sites in Calif., Nev. and Utah. At Logan, Utah, 20 mole drains using several different types of plastic liners have been under field observation. An additional 10,000 ft of plastic has been purchased for installation in 1963. Studies of the bearing strength and allowable bearing loads have been conducted in the laboratory at Logan, Utah.
(g) Observations of plastic lined mole drains reveal that they will remain open and function as drains if installed in fine textured soils and if careful management is practical after installation. In coarse textured soils, such as sands, fine sands, and silts, the surrounding earth particles migrate into the lines causing clogging or collapse.
(h) "Field and Laboratory Tests of Low Cost Plastic Drains," by W. W. Donnan and V. S. Aronovici. Journal Irrigation and Drainage Division, ASCE, January 1963.
"Plastic Lined Mole Drains," by J. L. Fouss and W. W. Donnan, Ag. Engineering Journal, ASAE, Vol. 43, No. 9, pp. 512-515, Sept. 1962.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Central States Forest Experiment Station.

Inquiries concerning the following projects should be addressed to R. D. Lane, Director, 111 Old Federal Bldg., Columbus 15, Ohio.

(3563) SUBSURFACE WATER MANAGEMENT ON NORTHERN HARDWOOD FOREST AREAS.

(g) Preliminary analyses of stormflow measurements on a forested watershed in east central Ohio show that 50 to 90 percent of the water falling on the surface of a 22 by 30 foot plot flowed out from the subsurface layers within 4 to 6 hours after artificial sprinkling. Rates and quantities of flow from individual depths and from the entire profile varied with intensity and duration of simulated storms and with antecedent soil-moisture tension. Flow was most uniform from the 24 to 36-inch zone, ranging from 0.22 to 0.30 inches per hour. Flow was only slightly less uniform from the somewhat more permeable 16 to 24-inch zone. However, flow from the highly permeable, upper 16 inches was quite erratic. Since soil-moisture tension was zero at the 16-in. depth, flow from depths lower than this was probably through a saturated medium.
Where soil-moisture tension was relatively high before and during sprinklings, the greatest quantities of flow were recorded from the deeper zones, and little to no flow occurred from the intermediate depths. This indicates that the lowest zone overlying a water-impeding stratum must be wetted before flow will occur in the upper soil zones. It appears that the impeding layer is a controlling factor and that flow from the shallower soil layers depends upon the degree of wetness in the layers just above the impeding stratum. No flow was recorded below 36-inches, probably because of a layer of dense clay at that depth.
Flow recession from the deepest zone followed somewhat the same exponential type flow pattern for all storms of 1 to 4-inches per hour, but the flow from storms of 0.5-inch per hour followed a different exponential curve. For example, average recession of subsurface stormflow from the 36-inch depth during eleven storms in the 1 to 4-inch per hour intensity class was described by the exponential curve $Q = 0.247(e)^{-0.0205t}$. For seven storms in the 0.5-inch per hour intensity class the average recession curve from the 36-inch depth was of the form $Q = 0.155(e)^{-0.0t}$.
These preliminary analyses showed that in most of the storms the antecedent hydraulic head readings were relatively high. Therefore, antecedent soil-moisture tensions were relatively low. In those few sprinklings where hydraulic head readings were low, outflow was delayed and total outflow was less than for those storms having moist antecedent conditions.
Hydraulic head distribution graphs taken from the multiple tensiometer readings during and after sprinklings showed a rapid increase in hydraulic head (with decreasing moisture tension) throughout each storm. These patterns of change in hydraulic head with change in depth give an indication of the direction of flow during the storm. For example, a hydraulic gradient larger than unity and accompanying a small depth change indicates a great suction gradient. In relatively dry soils this might represent the location of the wetting front.
During the two storms in the 1-inch per hour class where sprinkling lasted 120 to 150 minutes, hydraulic gradients from the 4 to 16-inch depth dropped to zero. This indicates a lack of a vertical driving force in that range of depths because a zero hydraulic gradient represents hydrostatic equilibrium as well as pressure head increasing with depth. Therefore, it is less likely that the flow here will be predominantly vertical. Since flow will occur against a pressure gradient if elevation head is present, flow lines in this area may be more or less lateral or somewhat parallel to the plane of the flow-impeding layer.
The two storms in the 1-inch per hour intensity class, where sprinkling lasted 120 to 150 minutes, showed a long drainage period in which the hydraulic gradient from the 4 to 16-inch depth was zero. Therefore, lateral flow probably took place in this zone during these two storms.

(4373) USE OF NUCLEAR RADIATION EQUIPMENT FOR MEASURING FOREST SOIL MOISTURE AND DENSITY.

(b) Laboratory project.
(d) Experimental and field investigations; basic and applied research.
(e) Some newly developed equipment, operating on the principle of nuclear radiation, facilitates the measurement of soil moisture and the soil's closely allied property--bulk density. We now have a five-piece set of this nuclear radiation equipment. We are investigating principles that will guide us in the use of this equipment.
(g) Most of the information now available on the subject of the sample size that is necessary for determining a nuclear soil-moisture meter's impulse rate has been devoted almost entirely to a purely theoretical development of the sampling error of radioactive decay measurements. A rather strong departure of some of our empirical results from certain of the assumptions necessary in such a theoretical treatment have caused us to reexamine the error structure associated with our subsurface nuclear moisture meter observations.
The observations treated herein were taken at one point in a clay-loam soil that contained about 20 percent moisture by volume. We made 20 observations for each of nine different time periods: 1, 2, 5, 10, 20, 40, 60, 120, and 300-seconds. The probe was a Model P-19 manufactured by the Nuclear-Chicago Corporation. The results may or may not apply to other similar probes made by this or any other manufacturer.
The length of observation, measured with a stop watch, introduced a reaction-time error that increased rapidly in magnitude of impulses per minute (i.p.m.) as the observation time dropped below 60-seconds. The practical use of the standard deviation - time relation was found to be limited here to the durations between 10 and 300-seconds. With two or more observations the relation can be used to determine the minimum length of observation required to obtain an acceptably precise estimate of i.p.m.
Suppose: 1. From experience, i.p.m. is expected to be in the neighborhood of 5,500 for the soil at hand. (The i.p.m. in this study averaged about 5,500. Applicability of the results to much higher or lower averages is not yet known). 2. That an allowable error or "half-confidence" interval (0.5 c.i.) of 10 percent, or 550 i.p.m., is deemed sufficiently precise for the soil-moisture estimate that is to be made. 3. That a sample size of two observations (n=2) is being considered and that measurement probability theory is applicable to impulse - rate observations of large magnitude. (The "t" value for n-1=1 degree of freedom is 12.706 at the 5 percent level of probability):
Then, expressing the standard deviation (s) as a function of length of observation in seconds (X) we can substitute this function for (s) in a basic statistical equation in order to arrive at an estimate of the minimum length of observation period required.
$0.5\ C.I. = t\ s/\sqrt{n} = t(35 + 1860/X)/\sqrt{n}.$
(The expression 35 + 1860 X approximates the empirical (s) distribution within the crucial range of 10 to 300 seconds. Now,

$$X = 1860\ t/\left[\sqrt{n}\ (0.5\ C.I.) - 35\ t\right]$$

$$= 1860\ (12.706)/\left[\sqrt{2}\ (550) - 35\ (12.706)\right]$$

$$= 71 \text{ seconds.}$$

Thus with two successive and independent observations at each depth in the soil, each observation would have to be 71 seconds long in order to meet the 10 percent error limitation imposed. Considering the cost of each observation, it may be more efficient to take three or four shorter observations at each depth rather than two longer ones. Using appropriate (n) and (t) values in the above equations we obtain:

n	2	3	4
x	71	10	6

Then, three observations of 10 seconds each would total about one-fifth of the time required for two of 71 seconds each, and yet would meet the precision goal of 10 percent. The advantage of 4 over 3 is less. It is also outside the usable range of the function, $s = 35 + 1860/X$. Therefore, an (n) of 3 instead of 1 should be used even though it increases the recording and computation time.
Note that X turns negative under certain combinations of formula input, indicating that the precision goal cannot be met under the circumstances imposed. Independence of sequential observations at one point is assumed here although it is probably violated to a limited extent.

(4752) THE CHARACTERISTICS OF A CONIFEROUS PLANTATION THAT ARE MOST CLOSELY RELATED TO TREE GROWTH AND TO WATER AVAILABLE FOR STREAMFLOW.

(b) Laboratory project.
(d) Experimental and field investigations; basic and applied research.
(e) This is an intensive soil-moisture study initiated to discover some basic tree stand characteristics that are closely related to tree growth and to water available for stream flow and to develop guides for field use in managing forest plantations to obtain optimum production of wood and water.
(g) In an attempt to bracket the minimum soil-moisture value occurring in a pine plantation in late autumn, seven sets of nuclear soil-moisture meter readings were made between September 12 and November 22, 1961 on 14 plots located in a pine plantation approximately 17 years old and located in east central Ohio. Preliminary analyses showed no meaningful difference between the totals of the seven sets of readings. Differences between sets separated by only 2 or 3 days were extremely small. Readings made near October 1 and 30 were lowest, those near September 15 were intermediate, and those on November 21-22 were highest. This suggests that soil-moisture depletion was still in progress when sampling started, that depletion continued until at least October 1, and that soil-moisture recharge began before November 20.
Cursory observations of the individual measurements indicate that the bottoms of the 9-foot 7-inch deep nuclear meter access tubes are 3 to 4-feet below maximum root depth. Complete verification of this, however, must await analyses that reveal which depths show relatively little moisture fluctuation.

(4753) FOREST RESTORATION AND WATERSHED MANAGEMENT ON STRIP MINED LANDS.

(b) Laboratory project.
(d) Experimental and field investigations; basic and applied research.
(e) Surface runoff on spoil banks, freshly formed during strip mining in the Appalachian coal fields, has a high soil erosion and sediment transport potential. This seriously affects water quality and has other deleterious effects on watersheds in which coal is harvested. It is highly desirable to establish a vegetative cover as quickly as possible after mining disturbance in order to minimize erosion and maintain water quality. The purpose of this project is to develop practical surface mining methods for the rugged, forested watersheds of the Appalachian coal field that will result in a minimum of damage to soil, water, and other resources and that will leave the mined areas in the best possible condition for restoration of these resources.
(g) Field work on the first phase of our initial study, the determination of fluff (expansion) factor of overburden, overlying coal seams in the Harlan (Kentucky) area is approximately 75 percent complete but the results are not yet available.
A second study, strip mining effects upon chemical characteristics of water in Forester's Creek Watershed, Harlan County, Kentucky, was initiated in June 1962. The objectives of this exploratory study are: (1) determine the chemical characteristics of water in the stream of non-flood stage for a one year period; and (2) show possible changes in water quality for a period of time after strip mining. Processing preliminary water samples for selected amions and cations revealed some substances not previously reported. $NaHCO_3$, for example, made up nearly 80 percent of the total dissolved solids.
A third study, evaluation of some plant species for late summer and fall seeding to give a quick cover on strip mine spoil banks, was initiated in Aug. 1962. Kentucky 31 Fescue, Balbo Rye, Italian Ryegrass, and Hairy Winter Vetch were selected for sowing at two-week intervals through August, Sept., and October on spoil banks from the Harlan coal seam near Cawood, Kentucky.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Intermountain Forest and Range Experiment Station, Ogden, Utah.

Inquiries concerning projects should be addressed to Mr. Joseph F. Pechanec, Director, Intermountain Forest and Range Experiment Station, Ogden, Utah.

(4754) FACTORS AFFECTING MAXIMUM SNOWPACK WATER CONTENT IN A WESTERN WHITE PINE FOREST.

(b) Laboratory project.
(d) Experimental and field investigations; basic and applied research.
(e) A study of 4-years' data on snow accumulation to determine effects of elevation, aspect, and forest canopy density on the maximum snowpack water content.
(f) Completed.
(g) Maximum snowpack water content in a small white pine-forested watershed in northern Idaho during four winters was related to elevation, aspect, and density of forest canopy. Distribution of maximum snow water content can be accurately described by an equation containing the first three power functions of elevation, the first three power functions of aspect, a linear function of forest canopy density, a linear interaction between magnitude of snowfall from year to year and elevation, and a linear interaction between aspect and elevation. These nine variables account for 91.6 % of the variance in snow water content with a standard error of estimate of 2.8 inches. Throughout its range from 2,700 to 5,500 feet, elevation accounted for an increase of 30.1 inches of water content in the average snowfall year. The effects of aspect varied with elevation. The aspects on which minimum and maximum water contents occurred were, respectively, 165 and 11 degrees, measured as azimuths from the north. At 2,700 feet, a change of aspect from 165 to 11 degrees resulted in an increase in snow water content of 4.3 inches, but at 5,500

feet the same shift in aspect effected an 18.8-inch increase in snowpack water. Snow water content was affected uniformly by changes in the forest canopy regardless of elevation, aspect, or magnitude of snowfall. It increased 4.2 inches with a change in canopy density from a completely closed canopy (100-percent density) to a completely open condition (zero canopy) such as would occur by clear cutting the timber. The forest effect on snowpack water content was related to known cumulative diameter and basal area characteristics of white pine stands. These relations showed that the largest increases in snow water content occurred with diameter and basal area reductions in the densest forest stands and became smaller with comparable diameter and basal area reductions in more open stands.

(h) "Elevation, Aspect, and Cover Effects on Maximum Snowpack Water Content in a Western White Pine Forest," Paul E. Packer, Forest Sci. 8(3): 225-235, 1962. Copies available upon request to Station Director.

(4755) CRITERIA FOR LOCATING AND CONSTRUCTING ROADS ON FOREST WATERSHEDS TO CONTROL EROSION AND PREVENT SEDIMENTATION.

(b) Laboratory project.
(d) Experimental and field investigations; basic and applied research.
(e) Objectives of this study are: To develop mathematical functional expressions of site factors which represent or describe forces that influence erosive cutting and sediment movement which can be determined in the field; determine which factors or forces significantly influence erosive cutting and sediment movement; establish quantitative relations for site variables influencing erosion and based upon these relations, determine road location and design standards necessary to prevent sediment from reaching streams, adjacent roads, or other areas critical for producing high-quality water.
(g) Field work has been completed on 720 plots located on six major soil groups, important because of their instability or wide areal extent, to determine which natural watershed characteristics and which logging road characteristics influence erosion and sediment movement. The soil groups include soils derived from basalt, hard sediments (slates and shales), andesite, granite, glacial silt, and loess.
Distances that water flows down road surfaces before causing erosion were found to depend upon: (a) Two controllable road characteristics: (1) Proportion of road surface material consisting of waterstable soil aggregates larger than 2 mm. in diameter; (2) steepness of road surface gradient. (b) Three unalterable watershed characteristics: (1) Topographic position - whether a road is on the upper, middle, or lower portion of a sidehill slope; (2) aspect; (3) steepness of slope above the road cut.
Distances that sediment moves down slopes below the outlets of road cross-drains were used as a basis for defining the widths of protective strips that are needed below logging roads to prevent sediment from reaching stream channels and other lower-lying developments that require protection. These distances and hence the protective strip widths required for sediment control depend upon: (a) Four manageable watershed characteristics: (1) Kind of obstruction to sediment movement; (2) spacing between obstructions; (3) distance from cross-drain outlet to the first obstruction, and (4) fill slope ground cover density. (b) One unalterable watershed characteristic: a proportion of water-stable aggregates larger than 2 mm. in diameter on slopes below roads. (c) One controllable road characteristic: cross-drain spacing. (d) Age of roads.
From these relations, a series of graphs and tables from which cross-drain spacings and protective strip requirements can be obtained are being developed. These criteria are applicable to locating logging roads prior to construction to prevent sediment production, and to the control of sediment from previously constructed roads.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Lake States Forest Experiment Station.

Inquiries concerning the following projects should be addressed to the Director, Lake States Forest Experiment Station, St. Paul Campus, University of Minnesota, St. Paul 1, Minn., unless indicated otherwise for a specific project.

(3887) WATERSHED MANAGEMENT RESEARCH IN NORTHERN MINNESOTA.

(b) Laboratory project.
(d) Experimental and field investigations; basic and applied research.
(e) Tests the influence of forested bogs on streamflow and groundwater behavior. Three major projects have been undertaken to date: 1) Studies of the effect of forest cover conditions on individual hydrologic processes. This has included the impact of soil-cover types on snow accumulation and melt, soil freezing, and moisture regime. 2) Studies of forest bog hydrology on five small forested swamp watersheds. Present instrumentation includes a recording well and a series of 9 to 12 nonrecording wells in each of 5 bogs, plus several upland wells in adjacent mineral soil. Four swamp watersheds have been equipped with stream-gaging stations, involving two 120 degree V-notch weirs and three type "H" flumes. (3) Laboratory and field studies to evaluate the hydrologic and physical characteristics of peat soils. Moisture characteristics of undisturbed peat cores have been determined with specially built pressure cells. The hydraulic conductivity of several peat materials is being tested using field piezometer and laboratory techniques.
(g) An analysis of the water content of the snowpack in various types of forest and logging practices indicates that there is prospect of a modest gain in early spring water yield through forest cover manipulation, including cutting, thinning, and type conversion.
A wide range of moisture contents has been observed in different peat types. These ranged from 332 to 3,529 percent on an ovendry basis, and from 83 to 99 percent by volume. Bulk density of the peats studied to date range from 0.028 to 0.249 grams per c.c.
Preliminary studies of ground-water characteristics in northern bogs shows two distinct conditions. Some bogs have two distinct water tables: (1) The water table in the bog is perched on the surface, and (2) The true water table is at a greater depth. In other bogs the bog water table and the true water table are the same. The shallow bog water table continues into the mineral upland soils.
(h) "Where and How Will There be Water?" Sidney Weitzman. Minnesota Conservation Volunteer 25 (145): 1-7, illus. 1962.

(3889) WATERSHED MANAGEMENT RESEARCH IN THE DRIFTLESS AREA OF SOUTHWESTERN WISCONSIN.

(b) Laboratory project, with some aspects in cooperation with Wisconsin Conservation Dept.
(d) Field investigations; basic and applied research.
(e) Major emphasis is given to methods of controlling runoff and erosion, including

gully stabilization through reforestation, and other land-use treatments. Studies of infiltration, soil-moisture movement and storage on loessal soils under the impact of grazing and other uses are planned. The effect of land use and land treatments on springflow is also being investigated. In connection with this, ground-water divides are being mapped by subsurface exploration. A total of 28 water-measuring devices have been installed on watersheds ranging from about 2 to 55 acres in area. The devices include 90 V-notch weirs, modified 2-foot San Dimas flumes, and several sizes of H-flumes. All are equipped with recording instruments. Of the above devices, six are at springs with permanent flow. A total of 30 wells up to 100 feet deep have been drilled above one spring in an attempt to locate the water table divide.

(g) A study of springs on the Coulee Experimental Forest near La Crosse, Wis., shows these exist in two distinct elevation levels. The upper level springs (approximate elevation 1,030 feet) appear at a contact zone of sandstone and an impermeable silt stone and their hydrographs show rather uniform flow throughout the year. The lower level springs (approximate elevation 900 feet) appear on sides of hills or points of ridges with no apparent relationship of water-table divide to topographic features. These springs show much more fluctuation in their hydrographs and have marked changes related to precipitation, and inversely to atmospheric pressure and with seasonal variations quite pronounced. Currently an attempt is being made to delineate drainage areas feeding springs by a series of wells drilled above a spring. In essence, it involves finding the high points of water tables and which do not conform very well with surface topography.

(h) "Field Transport for the Neutron Soil-Moisture Meter," Richard S. Sartz, Jour. Soil and Water Conserv. 17(1):27, illus. 1962.
"The Coulee Experimental Forest -- a New Field Laboratory for Southwestern Wisconsin," Richard S. Sartz. Wis. Academy Review. Vol. 9. No. 1, Winter 1962.

(3890) WATERSHED MANAGEMENT RESEARCH IN LOWER MICHIGAN.

(b) Cooperative project with Fish Division, Michigan Dept. of Conservation, Lansing, Mich.

(d) Field investigation; basic and applied research.

(e) Two major projects have been undertaken to date: 1) A major study is designed to determine the hydrology of ground-water recharge and consumption in deep sandy soils of the Udell Hills area in Michigan. Installations to date include a series of 108 ground-water wells in deep morainal areas and adjoining outwash plains; of these, 8 have automatic recorders. There are also soil-moisture measurement stations with five to seven levels of sampling. After the calibration period, the effect of cover manipulation -- especially plantation establishment and harvesting methods -- on ground-water recharge and use will be established. (2) A second major study is concerned with streambank stabilization and the sediment problem in streams flowing through these sandy areas. Major objectives of this study are (a) to determine the influence of land use upon sediment production, and (b) to evaluate the effect of streambank stabilization measures upon suspended sediment loads. A total of 20 sampling stations have been established on 11 streams.

(g) Early results from (1) were previously reported. Additional analyses are underway. Results from (2) indicate the loss from unstabilized sandy streambanks averaged 12 inches of soil depth during spring 1961, while on unstabilized claybanks it was 1 inch of soil depth in the same period. A comparison of sediment catch using the automatic single-stage sampler and the integrated depth sampler was made at 20 sampling stations on small streams. There was considerable variation between individual pairs of observations. But on the average both the automatic sample and the integrated depth sample were close to the mean sediment concentration. For the single depth integrated samples, the mean was 8 p.p.m. higher than the mean sediment concentrations. For the single-stage samples, it was 9 p.p.m. below mean sediment concentrations. A chi-square test shows that single depth-integrated samples and single-stage automatic samples are satisfactory measures of stream-sediment concentration for the stream's sample, if the allowable error is set at 45 p.p.m. and 50 p.p.m. respectively.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Northeastern Forest Experiment Station.

Inquiries concerning the following projects should be addressed to Dr. Ralph W. Marquis, Director, Northeastern Forest Experiment Station, 102 Motors Avenue, Upper Darby, Pennsylvania.

(1188) WATERSHED MANAGEMENT RESEARCH, FERNOW EXPERIMENTAL FOREST, WEST VIRGINIA.

(b) Laboratory project.

(d) Field investigation; basic and applied research.

(e) Studies were started in 1951 on the Fernow Experimental Forest, Tucker County, W. Va., to determine the effect of different levels of cutting practices, different logging methods, and different forest uses upon water quantity and quality. Nine watersheds have been equipped with streamgaging stations and rain-gages.

(g) Following six years of record taking, and analysis for calibration, treatment of one group of five watersheds was started in May 1957 and completed in 1958. Analysis of records of the first three after treatment showed increases in annual flow -- as much as 5 inches in the Clearcut watershed the year after treatment -- and increases were in relation to the amount of material cut. Most of the increases came in the growing season From May to October 1959 they were as follows:

Type of cutting	Material removed Mbd.-ft per acre	Increase in flow (inches)	(percentage)
Commercial clearcut	8.5	3.0	111
Diameter limit	4.2	1.8	53
Extensive selection	3.7	1.4	33
Intensive selection	1.7	.3	9

Peak flow changes were small except on the clearcut watershed where, on the average, instantaneous peaks during the growing season were increased by 21 percent. The average dormant-season peak flow was not affected. Increases in low flow were marked and were related to the amount of timber cut. Care in the logging operation was clearly reflected in water quality: maximum turbidities ranged from 56,000 ppm on the clearcut watershed, with unplanned skidroads and without provisions for drainage, to 25 ppm on the intensive selection watershed with carefully planned skidroads.

(h) "Effect on Streamflow of Four Different Forest Practices in the Allegheny Mountains," K. G. Reinhart, and A. R. Eschner. Jour. Geophys. Res. 67: 2433-2445. 1962.

(2419) WATERSHED MANAGEMENT RESEARCH, HUBBARD BROOK

EXPERIMENTAL FOREST, NEW HAMPSHIRE.

(b) Laboratory project.
(d) Field investigation; basic and applied research.
(e) The objective is to determine the effect of forest type, condition, and treatment on quantity and quality of streamflow. Studies are conducted in plots and experimental watersheds on the 7500-acre experimental forest in the White Mountains at West Thornton, New Hampshire.
(g) Six weirs have been built and climatic stations established.
(h) "Leaf Fall, Humus depth, and Soil Frost in a Northern Hardwood Forest," by George Hart, Raymond E. Leonard, and Robert S. Pierce. Northeastern Forest Expt. Sta. Research Note 131, 3 pp. 1962.

(2910) WATERSHED MANAGEMENT RESEARCH, LEADING RIDGE WATERSHED, PENNSYLVANIA.

(b) Laboratory project, in cooperation with the School of Forestry, Pa. State Univ. and the Pennsylvania Dept. of Forests and Waters.
(d) Field investigation; basic and applied research.
(e) A cooperative study was started in 1957 to determine the effect of forest cover and treatment on quantity and quality of streamflow in the oak-hickory type in Pennsylvania, and to study associated and basic soil-water relationships.
(g) Six experimental watersheds have been selected weirs have been constructed, and climatic stations established.

(3567) WATERSHED MANAGEMENT RESEARCH, BALTIMORE WATERSHEDS, BALTIMORE, MARYLAND.

(b) Laboratory project in cooperation with the Baltimore Bureau of Water Supply.
(d) Field investigation; basic and applied research.
(e) A cooperative study started in 1958 to determine effect of growth of loblolly and white pine in plantations on streamflow, and to compare streamflow from watersheds in conifer plantations with streamflow from a hardwood-forest watershed.
(g) Streamflow of three experimental watersheds is being measured and a climatic station has been established.

(3568) WATERSHED MANAGEMENT RESEARCH, NEWARK WATERSHEDS, NEWFOUNDLAND, N.J.

(b) Laboratory project in cooperation with the Division of Water Supply of the City of Newark, N. J.., Newfoundland, N. J.
(d) Field investigation; basic and applied research.
(e) A cooperative study to determine the influence of selected treatments of forested municipal watersheds on water supply.
(g) Weirs on 3 experimental watersheds were built in the fall of 1958 and stream gaging and climatic measurements were started in the spring of 1959.

(4756) WATERSHED MANAGEMENT RESEARCH, SYRACUSE UNIVERSITY, NEW YORK.

(b) Laboratory project, in cooperation with the State University College of Forestry at Syracuse University, Syracuse, New York.
(d) Field investigation; basic and applied research.
(e) This cooperative project was started in 1961 to determine quantitative relationships of forest types and stand conditions to the amount, timing, and quality of streamflow in the Adirondacks, the glaciated Appalachian Plateau, and the Catskills.
(g) A problem analysis has been completed and 2 studies initiated: a study of snow deposition and melt under different forest types and densities in the Appalachian Plateau, and a study of long-time trends in water yield from an Adirondack watershed to forest conditions.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Northern Forest Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. Richard M. Hurd, Director, Northern Forest Experiment Station, Box 740, Juneau, Alaska.

(2654) EFFECT OF LOGGING ON PHYSICAL CHARACTERISTICS OF SALMON STREAMS IN SOUTHEAST ALASKA.

(b) Laboratory.
(d) Field investigation, applied.
(e) This work is concerned with the relationships between salmon spawning streams and timber harvesting in Southeast Alaska. Work is concentrated on 3 streams lying 40 miles west of Ketchikan. Two of the watersheds have been logged. The third watershed will ramain unlogged.
Study is concentrated on factors which can exert a major influence on pink and chum salmon development and survival in a logged stream. During 1962 measurements or samples were taken of: 1) stream discharges; 2) stream temperatures; 3) stream channel shift; 4) stream debris occurrence and movement; 5) suspended sediment levels in streams.
Items 3) and 4) above were rephotographed from the air during 1962.
(g) Low elevation (1,000 ft.), vertical photographs taken from a helicopter prove to be useful tools in examining the stream bed for structural changes. The two years of comparative photos (1961 vs. 1962) showed numerous gross changes in the stream bed. Many areas of major change contained concentrations of debris or log jams. Seasons of especially high stream flow (such as fall 1961) probably introduce the major stream bed changes, making them periodic rather than continuous.

(4377) HISTORY OF SUSPENDED SEDIMENT IN A SALMON STREAM IN SOUTHEAST ALASKA AND EFFECT ON SALMON REPRODUCING ENVIRONMENT IN RIFFLE GRAVELS.

(b) Laboratory project.
(d) Experimental, basic and applied aspects.
(e) This is a study of some features of suspended sediment behavior in salmon streams. Areas of chief concern are sediment dropout from the stream and possible subsequent flush-out from the stream bed. Four stream riffles, each considered a potential chum salmon spawning area, were selected for study. One area is above a sector suitable for hydraulic mining sediment into the stream; the other 3 areas are downstream from the sediment source. The latter were treatment areas while the upstream area served as a control. The sediment entering the stream was sampled immediately upstream from the first treated riffle.
Stream bed gravels for each riffle were sampled for composition and for dissolved O_2 in the intra-gravel water. This was done immediately before artificial siltation (July 1961) and immediately after the siltation was stopped (August 1961). Gravel composition was re-samples in July 1962 to determine if previous fall-winter freshets flushed the gravels, returning them to the pre-sedimentation condition.
(f) Completed.

(4378) EFFECTS OF LOG JAMS ON A STREAMBED.

(b) Laboratory project.
(d) Experimental, with both basic and applied aspects.

(e) Study in cooperation with the Fisheries Research Institute of the University of Washington to determine the effects of log jams on pink and chum salmon spawning beds. Log jams were installed at two locations on a study stream. In addition to being mapped in planimetric and topographic detail, the stream bed areas were sampled to determine gravel composition and dissolved oxygen level before jam construction. Perforated ping-pong balls were also buried at 4 depths at a number of points in each area to determine the depth of bedload scouring. In May 1962 all features of study were re-measured or resampled.
(f) Completed.
(g) Fall high flows of 1961 reworked the stream bed regions of the two log jams. Unusually high stream flows of October 1961 washed both jams out, leaving the stream beds in a reworked condition. The jams have acted to clean the stream bed gravels in their vicinity. This may be due to increased local velocities which stimulate stream bed movement in the area. Clean gravels indicate a better salmon producing environment. However, the advantage of gravel cleanness to salmon eggs, larvae, or fry is thought to be outweighed by the danger of salmon mortality due to stream bed instability associated with log jams.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Pacific Northwest Forest and Range Expt. Station.

Inquiries concerning the following projects should be addressed to Mr. R. W. Cowlin, Director, Pacific Northwest Forest and Range Expt. Sta., P. O. Box 3141, Portland 8, Oregon.

(4757) WATER YIELD AND EROSION, WENATCHEE, WASH.

(b) Laboratory project.
(d) Field investigations; basic and applied research.
(e) Field studies in ponderosa pine and mixed-conifer forests and forest-ranges on the east slopes of the Cascade Range in Oregon and Washington: Erosion in forests and ranges: (1) Sediment production from Swauk sandstone-ponderosa pine; (2) sediment production from grazed pine-fir-larch ranges, Blue Mountains; (3) stimulation of seeded and natural grass cover by fertilization - Swauk sandstone soils; (4) relation of parent material and vegetative cover to organic matter, aggregation, pH, and bulk density of forest-range soils - eastern Washington; (5) effect of climate on development of soils from identical parent rock. Evapotranspitation: Includes studies with the overall objective of measuring factors which affect distribution and use of water in forests and related ranges: (1) Measurement of solar energy in a pine forest; (2) seasonal changes in soil moisture under a lodgepole pine forest; (3) measurements of moisture use by plants; (4) effect of removing brush and tree growth in three experimental watersheds on water yield (Entiat watershed study, in calibration stage -- no treatment yet applied); (5) water-holding capacity and drying rates for humus types characteristic of ponderosa pine-Douglas-fir forests - east side of the Cascade Range.
(g) In Mission Creek near Wenatchee, Wash., measurements on three small drainages have shown that Swauk sandstone soils have eroded at the rate of 1.5 to 2.0 tons per acre per year over a 4-year period. Stimulating the development of an adequate cover of vegetation on bare areas seems to be one of the most promising means of controlling such rapid soil movement. Broadcast application of nitrogen, potassium, and phosphorous has resulted in significant increases in growth of native vegetation on depleted Swauk sandstone sites. Six years after establishment, plots fertilized in spring 1957 still show a 155-percent increase in production of air-dry vegetative material. A study of the characteristics of soils from basalts, granodiorite and Swauk sandstone shows a pattern of increasing erosion hazard with increasing depth for soils from all three parent materials. Increasing erosion hazard is inversely related to organic matter content. Land treatment appears to have a greater influence on the stability of all three soils than inherent characteristics derived from their parent materials.
Measurements of streamflow from three experimental watersheds in the Entiat River drainage indicate that small tributary river systems on the east side of the Cascade Range may provide a greater part of total annual yield than at first thought. Flow of all three watersheds is well sustained during dry summer periods.
(h) "Lodgepole Pine Rooting Habits in the Blue Mountains of Northeastern Oregon," by Daniel M. Bishop, Ecology Vol. 43(1): 140-142.

(4758) WATERSHED LOGGING METHODS AND STREAMFLOW.

(b) Laboratory project with some phases in cooperation with City of Portland, Bureau of Water Works and Oregon State University.
(d) Field investigations; basic and applied research.
(e) Research is conducted at three field locations in the Cascade Range of western Oregon: Bull Run watershed (domestic supply area for Portland), H. J. Andrews Experimental Forest, and South Umpqua Experimental Forest. Studies are confined to two forest types representing major segments of the remaining old-growth forests of the Pacific Northwest: (1) Douglas-fir, western hemlock, western redcedar, and (2) Douglas-fir, sugar pine. Investigations represent an initial effort to study precipitation runoff, erosion, and soil moisture in undisturbed stands, and to follow changes caused by several methods of logging. Included are studies in four categories: (1) Soil movement on logged land and an evaluation of effectiveness of grass seeding on roadbanks; (2) changes in water quality resulting from roadbuilding, two methods of cable logging, two degrees of forest removal -- 25 percent and 100 percent -- and slash burning; (3) changes in streamflow caused by clear cutting and partial cutting in groups of varying size on matched watersheds in old-growth Douglas-fir and sugar pine-fir. Pretreatment measurements are still being made to provide statistical basis for treatment evaluation; (4) soil moisture movement and disposition and the role of vegetation in evapotranspiration, including measure of seasonal changes in soil moisture under a Douglas-fir stand, vertical movement of water in Douglas-fir soils, rainfall interception by crowns of old-growth Douglas-fir soils, rainfall interception by crowns of old-growth Douglas-fir, and changes in plant succession following logging and slash burning.
(g) Roads constructed in 1959 in one of the experimental watersheds (250 acres) at H. J. Andrews Experimental Forest continue to affect streamflow and runoff. For three consecutive years since construction, late-summer flows have been increased in measurable amounts. Analytical methods used so far have failed to indicate changes in peak flows. Sediment movement caused by road construction still exceeds that of adjacent control watersheds, although the roads are not being used. A study of the effect of grass seeding on road cuts shows that this measure will curtail erosion from bank

surfaces. Soil washed from the test plot decreased from a rate of 12.7 tons per acre to 2.3 tons per acre annually after a stand of grass covered the soil. Surface runoff, however, showed an increase, evidently caused by the thatched-roof effect of the matted grass cover. Water contained in the top 4 feet of soil under mature Douglas-fir forests varies considerably with season of the year. During the first 45 days of the growing season of 1961, water was removed from the top 4 feet of soil at an average rate of 0.10 inch per day. This rate dropped to 0.02 inch per day as the reservoir of available water dwindled. Samples taken below 4 feet suggest that a considerable part of the water used by vegetation during the late summer comes from depths below 4 feet. Samples also show the soil to be exceptionally porous. Mean bulk densities from 0.66 to 0.71 gms/cc indicate that approximately 75 percent of the total volume is pore space. Under dense stands of old-growth Douglas-fir and associated species, throughfall averages 76 percent of gross summer precipitation. A relationship of throughfall(T) to storm size (P), expressed by the formula

$$T = 0.8318 - 0.0466$$

accounts for 95 percent of the variation in throughfall. In application, this relationship indicates that more throughfall results from one large storm than from an equal amount of precipitation received from several small storms. Throughfall in winter months increases to an average of 86 percent, compared with 76 percent in summer months. Stemflow does not result in significant increases in the net precipitation received on the forest floor in a mature Douglas-fir forest.

(h) "First Year Effects of Timber Removal on Soil Moisture," by Nedavia Bethlahmy. Internatl. Assoc. Sci. Hydrol. Vol. VII(2), pp. 34-39, illus. June 1962.
"Logging Methods in Relation to Streamflow and Erosion," by E. G. Dunford. Fifth World Forestry Congress Proc. Vol. 3, pp. 1703-1708. (August 29-Sept. 10, 1960) 1962.
"Grass Seeding as a Control for Roadbank Erosion," by A. G. Wollum II. Pac. NW. Forest & Range Expt. Sta. Res. Note 218, 5 pp., illus. June 1962.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Pacific Southwest Forest and Range Experiment Station.

(261) WATERSHED MANAGEMENT RESEARCH, SOUTHERN CALIFORNIA.

(b) Laboratory project.
(c) Dr. R. Keith Arnold, Director, Pacific Southwest Forest and Range Experiment Station, P. O. Box 245, Berkeley 1, California.
(d) Experimental; field investigations; basic and applied research.
(e) Purposes are 1) to determine how watersheds function: what happens to the precipitation, and how water and soil movement are influenced by conditions of vegetation, soil, geology, and topography; and 2) to develop methods of watershed management, including treatment of areas denuded by fire, to insure maximum yield of usable water and satisfactory flood runoff and soil erosion control.
Principal work center is the 17,000-acre San Dimas Experimental Forest situated in the San Gabriel Mountains. A fire started by lightning in July 1960 consumed the vegetation, mostly brush, on 90 percent of the area and destroyed or damaged many of the research installations. Immediately after the fire a major emergency research program was started to test the effectivene of various measures used to reduce flood runoff and erosion on the denuded watersheds. These rehabilitation measures include seeding grasses and mustard singly and in combination with physical treatments such as wattling, channel barriers and contour terraces. The tests are being made on 38 watersheds of 2 to 90 acres each, equipped to measure rainfall intensity, peak discharge and suspended sediment. Twenty-five have basins to measure bedload. Studies of hydrologic processes and tests of applied management methods to increase water yield through vegetative type conversion in progress before the fire are being continued.
(g) A study of the interception losses of rainfall on annual grasses was conducted during the hydrologic years '60, '61, and '62. Twenty-five storms totaling 9.80 inches of precipitation were measured. We found that, in nature, a good proportion of the annual precipitation falls on grass in its lower stages of development. For a year with an average distribution of storms the interception loss on a grass cover would be 6.5 percent while 11.1 percent would be lost from a chaparral cover.
Data were collected from four major storms in the study of methods aimed at reducing post-fire erosion and flood peaks. The regression analysis used explained about 80 percent of the variation in the data. Highest flood peaks were observed in watersheds which had no physical treatment. Peaks from the watersheds with channel barriers were almost as high as the untreated watersheds. Peaks from the watersheds with contour trenches and side slope stabilization with barley wattling were about half as high as those mentioned above. Watersheds seeded to a low density of perennial grasses had consistently higher flood peaks than watersheds with other vegetative treatments or unseeded. Debris yields from watersheds without physical erosion control measures averaged 36 cubic yards per acre. The side slope stabilized watersheds yielded about 29 percent of this amount, the contour trenched watersheds - 36 percent and the channel stabilized watersheds - 67 percent. The high level annual grass seeding watersheds also showed substantially lower yields than the watersheds with other vegetative treatments. The contour trenches which were necessarily under-designed because of the steepness of our watersheds were overtopped in two storms. This resulted in considerable erosion and increased the height of flood peaks.
(h) "What's Happening at San Dimas?" R. P. Crouse and L. W. Hill, Pacific Southwest Forest and Range Experiment Station. Misc. Paper No. 68, 4 pp., illus. 1962.

(2415) WATERSHED MANAGEMENT RESEARCH, NORTHERN CALIFORNIA.

(b) Laboratory project.
(c) Dr. Keith Arnold, Director, Pacific Southwest Forest and Range Experiment Station, P. O. Box 245, Berkeley 1, California.
(d) Experimental; field investigations; basic and applied research.
(e) The aim is to develop a hydrologic base for land management decisions. The hydrologic effects of wild fires, attempts of conversion of brush lands to grass, and logging and other land uses are to be evaluated. Regional analyses of sources of water yield, floods, and sedimentation for California wildlands are being studied. Present studies emphasize development of methods for management of high elevation snow packs for yield and control of water, and methods for watershed management in California's Lower

Conifer Zone.
Major works are centered in Berkeley with 25 studies being conducted throughout northern California in the headwaters of the Kings, American, Yuba, Truckee, and Feather Rivers, and in Casper Creek Basin near Ft. Bragg. At the Teakettle watersheds in the headwaters of the Kings River Basin, five small watersheds have been under calibration for six years; road construction as a watershed treatment is being installed. In the Onion Creek watersheds in the headwaters of the American River Basin, five streams are being gaged and sediment is being measured. In the headwaters of the Yuba River, Castle Creek itself and two small tributaries are being gaged and sediment measurements taken. In the Donner Ridge burn in the Truckee Basin, 21 small tributaries are being studied -- maximum discharges measured and sediment and water quality sampled. In the Miller Creek watershed in the headwaters of the Feather River a practical sized test of logging for water production has been applied. At most of the above, concomitant measures of snow accumulation and melt and soil moisture depletion are being taken.
In the area of the Central Sierra Snow Laboratory studies include the tests of the applicability of gamma and neutron probes in measuring the hydrologic characteristics of snow, the use of suppressants in retarding evaporation from snow and soil, and evapotranspiration from brush and tree sites. Basic studies include those of microclimate and heat budget of forest stands.

(g) In forest openings created by logging, soil moisture savings are likely to continue for 16 years. This is the main conclusion from the study in the sub-alpine forest near the Central Sierra Snow Laboratory. Soil moisture depletion in openings created by logging in 1948, 1950, 1955, and 1959 were measured, together with moisture losses in the surrounding forest. At the period of maximum soil moisture depletion, 1-year-old openings had 7 inches more soil moisture per 4-foot soil depth than did the surrounding forest. These 7 inches of water represent the moisture saving for stream flow as a result of logging. In openings five years old, the savings had dropped to 2.9 inches; after ten years, to 1.2 inches and after 12 years to 0.7 inches. The projection of the regression indicates that summer soil moisture savings will reach zero, 16 years after logging.
Rapid measurement of hydrologic characteristics of snow pack which may permit more accurate appraisal and prediction of delivery of snow-melt water may be possible using gamma and neutron probes. Commercially available probes with gamma and neutron sources (Nuclear-Chicago, P-20 and P-19 probes) were tested for the ability to measure snow density, ice lenses, and the thermal quality (free water) of the individual layers in the snow pack. Usable regressions of snow density (D) at each depth, measured gravimetrically and with neutron counts (Cn) and gamma counts (Cg) in CPM in the snow pack were obtained. Snow density ranged from 12 to 60 percent. Improvement in regressions were obtained by using the counts 6 inches above (Cna or Cga) and the counts 6 inches below (Cnb or Cgb) as well as the counts at the points. The relationship of snow density (D) in percent to gamma and neutron counts are given by these equations. For gamma probe at depths $\geq$ 18 inches, $D = 11.8 + 0.022\ Cg^2 - 0.722\ (Cga - Cg) - 1.03\ (Cgb - Cg)$; for depth of 12 inches, $D = -2.7 + 1.25\ Cg + 0.50\ (Cgb - Cg)$; and for depth of 6 inches, $D = -2.6 + 1.33\ Cg + 1.39\ (Cgb - Cg)$. Standard errors of estimates were 3.4, 2.3, and 3.4 percent. For the neutron probe at depth $\geq$ 12 inches, $D = 9.1 + 6.25\ Cn - 0.052\ Cn^2$; and for depth of 6 inches, $D = 2.2 + 12.3\ Cn - 1.00\ Cn^2 + 2.9\ (Cna - Cn) + 11.2\ (Cnb - Cn)$. Standard error of estimates were 3.6 and 2.2 percent. Counts in water for these probes, with aluminum access tubes were 15,900 and 44,400 CPM for the neutron and gamma probes, respectively. In measuring surface snow density with the gamma probe we found it essential to extend the aluminum access tube at least 12 inches above the snow. Ice lenses in the snow were readily detectable by shifts in the neutron probe counts; neutron counts would increase markedly at the occurrence of ice; gamma counts were only slightly affected. In a study of changes in the thermal quality of snow pack throughout the day and from day to day, neutron counts were directly related to the percentage of ice in the snow, as contrasted with free water. The ratio of gamma to neutron counts reflects differences in thermal quality for two successive days with identical average snow density (56 percent) but with thermal qualities of 82 and 95 percent.
Summer soil moisture losses and winter surface evaporation from snow pack at high elevation sites were reduced by the addition of the suppressant hexadecanol. Hexadecanol was applied to the soil surface of 1/15 acre plots of bare soil, brush, and red fir forest. The hexadecanol was applied to 17 natural sites, the applications being at rates of 35, 130, and 680 pounds per acre. In fully vegetated sites of red fir and natural brush, indicated reductions in the loss were small, ranging from 0.2 to 0.3 inches for the total summer. At sites where vegetation had been removed by bulldozing or in which natural bare ground occurred, reductions in evaporation of treated sites was 0.3 to 1.0 inch. Application of hexadecanol to the snow surface decreased evaporation by as much as 50 percent. Without the hexadecanol, the evaporation rates ranged from 0.012 to 0.039 inch per day; with 20 to 30 pounds per acre of hexadecanol, the rates were 0.006 to 0.016 per day.
Measurements of evaporation from snow under various topographic and forest conditions for the years 1958-1960, were summarized and evaporation for the Castle Creek watershed, elevation 7,500 feet, was computed. Evaporation ranged from 0.5 inch under dense forest on the valley floor to 3.1 inches in large openings on exposed ridges. Average evaporation for the four square mile Castle Creek Basin was computed as 2.0 inches depth. Average annual precipitation for Castle Creek is 74 inches per year, so snow evaporation is about 2.7 percent of total precipitation.

(h) "Progress Report, 1961-62, Cooperative Watershed Management Research in the Lower Conifer Zone of California," by Walt Hopkins and K. R. Bowden. Pac. SW For. and Range Expt. Sta. 10 pp. 1962.
"Snow Evaporation from a Forested Watershed in the Central Sierra, Nevada," by Allan J. West, Jour. For. 60(7):481-484, 1962.
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Probes," by R. A. Merriam and K. R. Knoerr. Soil Sci. 92(6):394-95, 1961.
"A Model for Evaluating Wildland Management for Flood Prevention," by Henry W. Anderson. Pac. Sw For. and Range Expt. Sta. Tech. paper 69, 19 pp. 1962.
"How a Logging Operation can Affect Streamflow," by R. M. Rice and J. R. Wallis. For. Industries 89 (11):38-40, 1962.
"Current Research on Sedimentation and Erosion in California Wildlands," by Henry W. Anderson. Internat. Assoc. Sci. Hydrol. Publ. No. 59:173-182, 1962.
"Fourth Progress Report, 1960-1961, Cooperative Snow Management Research," by Henry W. Anderson and L. G. Richards. Pac. SW For. and Range Expt. Sta. pp. 141-204, 1961.
"Measures of Streamflow Timing," by Arnold Court, Jour. Geophy. Res. 67(11):4335-4340, 1962.
"Measurement of Snow Pack Profiles with Radioactive Sources," by LLoyd W. Gay. 30th Annual West. Snow Conf. Proc. pp. 14-19, 1962.
"Snow in Trees -- Where does it go?" by David H. Miller, 30th Annual West. Snow Conf. Proc. pp. 21-27, 1962.

(4759) WATERSHED MANAGEMENT RESEARCH, HAWAII.

(b) Laboratory project.
(c) Dr. Keith Arnold, Director, Pacific Southwest Forest and Range Experiment Station, P. O. Box 245, Berkeley 1, California.
(d) Experimental field investigations; basic and applied research.
(e) The aim is to develop a hydrologic and meteorological base for making land management decisions in Hawaii which may effect water yield, water quality and floods. Hydrologic effects of conversion of native vegetation to urban areas, to grass land, to commercial timber stands, and to cultivated lands are to be evaluated. Present studies emphasize appraisal of the hydrologic characteristics of the island soils, including soil erodibility and soil moisture storage and losses.
Major work center is in Honolulu with three studies actively underway. Field measurements of soil moisture, and physical analysis of soil to determine soil moisture constants, have been made for soils representing 10 great soil groups in the state of Hawaii. Samples were obtained from the surface 12 inches of soil at 34 sites distributed in the islands of Hawaii, Kauai, and Oahu. Periodic sampling of soil moisture under stands of various tree, brush, and grass species has been made at two sites near Honolulu and at one site in the Waianae range, all on Oahu.
Rainfall runoff relations in two small watersheds are being studied using data collected by the State Division of Forestry in the years 1951 to 1955. Differences involving watershed covers of Uluhi fern, planted trees, and burned-over fern are being evaluated.
(g) Difference in soil properties among great soil groups were found to be associated with forest cover, cultivation, pasture, and idle grass land. Soils in Hawaii were found to be fine textured and composed mostly of colloidal clay and organic particles. Forest soils, as contrasted to the soils in cultivated and in idle lands, had soil structure which favored infiltration and percolation of water. Forest soils were found to have highest average total pore volume, available water capacity, and volume of large pores. Pasture and forest soils have the highest average organic matter content. Sampling of erodibility of soils of Hawaii shows wide variation in the erodibility of soils developed under a single geologic rock type (basalt).
Frequent rainfall in Hawaii minimizes the opportunity for determining evapotranspiration by soil moisture measurements. However, studies at six sites in the dryer part of Oahu have shown differences in soil moisture deficit associated with various tree, grass and brush species. In a five month period mid-April to mid-September, 1962, soil moisture deficits from 6 1/2 to 8 1/2 inches developed under tree species despite the occurrence of 7 1/2 to 10 inches of rain in the period. Deficits under brush were greater than under grass; soil moisture loss for the three month period mid-July to mid-September, 1962, was from 2 to 5 inches greater under brush than grass. Runoff measured as streamflow from experimental watersheds on Oahu was rather small and variable. Average runoff for the period 1951 to 1955 for tree covered watershed was only on inch per year. Year to year variation in runoff was found to be high. For an Uluhi fern-covered watershed, for example, yearly runoff ranged from as little as 0.3 inch to as much as 3.0 inches per year, in the short period 1951 to 1955.
(h) "Watershed Management Research in Hawaii's Wildlands," by Henry W. Anderson, Walt Hopkins, and Robert E. Nelson, Pac. SW For. and Range Expt. Sta., Tech. Paper No. 75, 15 pp., illustrated, 1962.
"Soil Moisture and Soil Strength Characteristics of Five Hawaiian Soils," Pac. SW For. and Range Expt. Sta. Res. Note No. 184, 8 pp. illus.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Rocky Mountain Forest and Range Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. Raymond Price, Director, Rocky Mountain Forest and Range Experiment Station, Room 221 Forestry Building, Fort Collins, Colorado.

(377) WATERSHED MANAGEMENT RESEARCH, FRASER HYDROLOGIC LABORATORY.

(b) Laboratory project.
(d) Field investigations; applied research.
(e) To determine influence of lodgepole pine and spruce-fir forests and of the management of these forests for wood products on factors associated with the yield of water, largely from stored snow. The purpose is to solve problems in the management of forested watersheds of the high altitude zone of the Rocky Mountains for maximum yields of usable water.
(g) The following table summarizes water yields from the Fool Creek watershed since timber harvesting:

Year	Period of Record	Predicted Yield	Actual Yield	Increase
		acre feet		
1956	5/3 - 10/12	668	922	254
1957	5/23 - 9/30	1158	1358	200
1958	5/8 - 9/30	673	798	125
1959	5/8 - 9/30	620	806	186
1960	4/23 - 8/24	656	882	226
1961	5/6 - 9/30	520	640	120
1962	4/19 - 9/5	1020	1130	110

(h) "Watershed Management in the Rocky Mountain Alpine and Subalpine Zones," M. Martinelli, Jr., Arid Land Symposium, AAAS Proc. Dec. 1962. (In preparation).

(657) WATERSHED MANAGEMENT RESEARCH, TEMPE,ARIZONA.

(b) Laboratory project.
(d) Experimental; basic and applied research.
(e) To study the disposition of rainfall as influenced by waterhed vegetation; to determine the influence of various types of forest and grassland vegetation as well as vegetation modified by cultural treatment such as grazing and timber harvest, on

streamflow, water use, water loss, and erosion and sediment yield; and to determine for phreatophytic vegetation (water-loving plants) the amount of water used, methods for reducing water use by phreatophytes or for replacing them with more useful plants; and for mixed conifer and chaparral types of vegetation to determine the hydrologic characteristics of natural watersheds and the effect of cover modification upon water yields, soil stability and other resource values. At Sierra Ancha Experimental Watersheds in central Arizona, rainfall, runoff, and erosion are measured on three watersheds in the pine-fir vegetation type at high elevation, on two watersheds in the ponderosa-chaparral type, and from four watersheds in the grassland-chaparral type at intermediate elevations, and on nine small watersheds in the semidesert-chaparral type at low elevations. Water use by different types of plants in various soils is studied on eleven large lysimeters. Three watersheds have been established on the ponderosa pine type, three in the mixed-conifer type, and two watersheds in the high (9300-foot elevation) grassland type (measuring weirs currently under construction). Effect of frost on water yields (surface runoff and soil moisture accretion) is studied on small grass, aspen and mixed conifer plots. Soils from grass, aspen and mixed conifer plots are being laboratory tested for hydrologic characteristics. Soil moisture is followed with a neutron probe. Gaging stations for four watersheds in the pure chaparral type are also available to evaluate watershed-game interrelations. One cluster of two watersheds and and another cluster of three watersheds are available for testing the effect of manipulating chaparral cover. Supplemental studies are determining the proper use of chemicals, fire, and mechanical treatment for manipulating shrub in the type. Interception, moisture use, and factors affecting water yield are being tested in Utah and alligator juniper forests on the Beaver Creek Project, south of Flagstaff, Arizona. Ecology of Tamarix pentandra and other phreatophytes is under investigation. Germination, seedling survival, sprouting ability, and rate of spread studies were continued. A field apparatus employing plastic tents, a ventilating system, and a wet-dry bulb hygrometer has been developed and used for detailed measurements of evapotranspiration of phreatophytes.

(g) In pine-fir watersheds at Workman Creek, elevations 6590 to 7724 feet, two timber-harvest treatments have been completed. Test of individual tree selection resulted in no significant change in water yield, but clear cutting of one-third of a watershed and planting to grass resulted in a significant increase in water yields the second year after treatment during an above average water yield year. The third year's data almost exactly duplicated the first year's data. Both these years were dry and streamflow of 1.4 inches compared to an estimated streamflow of .9 inches were not large enough for statistical significance for individual events. Preliminary data for the fourth year indicates near average water yield, and increases due to treatment consistent with previous years.
During February 1962, temperatures were higher than average and runoff from snow melt occurred on experimental watersheds below about 8500-foot elevation. In spite of significant runoff, 100% snow cover on north slopes was maintained throughout February. On south slopes, however, snow cover decreased to about 30% on grass-covered areas and 50% on timbered areas which seems to indicate that south slopes were important contributors to water yields. During this February runoff, a recorder equipped water-table well at 9300-foot elevation showed a good rise and diurnal fluctuations were similar to the temperature curve, highest in the afternoon and lowest near midnight. The effect of clipping treatments on Tamarix pentandra was tested during the 1962 growing season. Sprouts from previously cut plants clipped every 2-, 4-, and 8-week intervals and control plants clipped only in Sept. resulted in survivals of 14, 44, 42, and 92%, respectively, at the end of the growing season. Increase in unit water yield of a burned and sprayed over a burned but unsprayed chaparral watershed about 5 months after the second annual chemical treatment. By the first full water year following the second treatment, a significant increase (4.30 inches) in runoff occurred compared to the unsprayed control watershed. A controlled fall chaparral burn following chemical dessication of foliage resulted in 92.6% reduction in crown canopy cover but only a 28.7% reduction in litter. Post-fire litter was 4.85 tons per acre air dry basis.

(h) "A Simple Device for Measuring Fluctuations in Shallow Ground-Water Wells," by Howard L. Gary, Research Note 68, 2 pp., (Processed)
"Measuring transpiration of undisturbed tamarisk shrubs," John P. Decker, William G. Gaylor and Frank D. Cole, Plant Physiology 37: 393-397, May 1962.
"Water Relations of Plant Communities as a Management Factor in Western Watersheds," John P. Decker, Science 138, (3539): 532-533. October 26, 1962.
"Taxonomic notes on Tamarix pentandra in Arizona," Jerome S. Horton and John E. Flood, Southwestern Naturalist 7(1): 23-28, June 1962.
"Preliminary Results of Effect of Forest Tree Removal on Water Yields and Sedimentation -- Workman Creek Experimental Watersheds, In Watershed and Related Management Problems," Lowell R. Rich, Ariz. Watershed Symposium Proc. 4: 13-16, illus. (Processed.)
"Surface Runoff and Erosion in the Lower Chaparral Zone - Arizona," Station Paper 66, 35 pp., illus. (Processed.)
"The Workman Creek Experimental Watershed," H. G. Reynolds and J. A. West, Station Paper 65, 18 pp. illus.
"Preliminary Hydrologic effects of Wildfire in Chaparral," G. E. Glendening, C. P. Pase and P. Ingebo, Fifth Ann. Ariz. Watershed Symp. Proc. September 1961.

(1969) WATERSHED MANAGEMENT RESEARCH, ALBUQUERQUE, NEW MEXICO.

(b) Laboratory project. Some work in cooperation with Bureau of Land Management and Geological Survey.

(d) Applied research.

(e) Evaluation of range-watershed conditions on small watersheds in the San Luis drainage of the Rio Puerco. Three contiguous watersheds, ranging from 338 to 555 acres located about 8 miles north of the San Luis community and west of the Rio Puerco main channel provide the study area. Water and sediment inflow are measured in small reservoirs formed by earthen dams. Precipitation rates and amounts of vegetation changes are periodically measured over the watersheds. Ten years of data have been collected under cattle grazing during a 5 1/2-6 month overwinter period (November 1 to April 30).
Evaluation of soil ripping (Jayhawker) on surface runoff, erosion, and vegetation. Surface runoff plots (64), 10' x 31', are installed on a north and south aspect and upper and lower slopes representing different soil conditions in the Rio Jemez drainage. Precipitation, runoff, and sediment are measured.
To obtain information on factors effecting rates of snowpack ablation and correlation to relative water yields from several vegetation zones in high altitude watersheds

in New Mexico. Plastic membrane lysimeters 50 square feet in size and in batteries of three were installed in open areas and in spruce-fir forests on north and south slopes.

(g) Grazing use by cattle has averaged 54% on the key species alkali sacaton and only 34% on the less preferred galleta species. Fencing and variation in class of cattle have had a pronounced effect on the grazing pattern.
Soil ripping with the Jayhawker resulted in about 96-97% reduction in surface runoff during the first rainy season. By the end of the third year of study this reduction had declined to 81-87%.

(2658) WATERSHED MANAGEMENT RESEARCH, RAPID CITY, SOUTH DAKOTA.

(b) Laboratory project.
(d) Experimental; basic and applied research.
(e) (1) Soil moisture effects of thinning dense ponderosa pine. (2) Control of runoff and soil erosion by seeded and native vegetation of the 1959 Deadwood Burn. (3) Development of a diversion type sampler for continuous measurement of sediment and runoff in small streams. (4) Runoff from grazed and protected Kentucky bluegrass range in relation to soil compaction. (5) Water yield and sediment production in relation to standard forest management practices.
(f) Items 1, 2, 3, and 5 active; item 4 temporarily suspended.
(g) Due to soil moisture carryover from a wet year, thinned pine (post-pole size) on a deep soil, used more water in each of three successively drier years than did dense unthinned pine. Difference in total use, about 2 inches the first year, had dropped to about 0.2 inch in the third due to reduction in year-to-year carryover. The trend reversed in the wet year just passed. The thinned pine has used less moisture than the unthinned and there is substantially greater amount of stored moisture for carryover into next year under the thinned than the unthinned pine.
Increasing density of seeded and native vegetation on the 1959 Deadwood Burn is effectively controlling runoff and soil erosion. Plots continue to produce more runoff from snowmelt on frozen ground than summer storm runoff. Amounts of summer storm runoff and sediment are much more closely related to total amount of precipitation per storm in excess of 0.03 inch per five minutes than total precipitation depth.

(2913) BEAVER CREEK WATERSHED PROJECT.

(b) Laboratory project, cooperative with Coconino National Forest, Flagstaff, Ariz.
(d) Field investigation; basic research.
(e) Calibration of watersheds prior to treatment. Additional small watersheds have been gaged, making a total of 12 in the ponderosa pine type, 3 in the alligator juniper type, and 3 in the Utah juniper type -- all under 2,000 acres. Two large pine watersheds (about 10,000 acres) are also being calibrated. One of the Utah juniper watersheds will be treated in 1963; treatment will consist of juniper eradication followed by seeding to grass. Calibration units are "flow periods" which are flows from individual storms.
(g) Intensive sediment measurements have been started on one small pine watershed and one small Utah juniper watershed. Total sediment yield will be estimated for flow periods, seasons and years. Large sediment sizes will be caught in an artificial impoundment and small sizes will be caught in a series of splitters which sample outflow through the impoundment spillway. In a test installation on a 1,100 acre pine watershed the spring runoff in 1962 deposited only 638 pounds of sediment in the impoundment; most of the outflow carried less than 100 p.p.m. of suspended sediment. Sediment in the impoundment was 80% organic (pine needles, leaves, etc.) and 20% mineral (14% sand, 47%silt, 39% clay).

(3569) WATERSHED MANAGEMENT RESEARCH, LARAMIE, WYOMING.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) The objectives of the study are to determine the effects of big sagebrush on total runoff from snowmelt, snow accumulation and storage pattern. Three high elevation sagebrush watersheds, 60 to 106 acres, in western Wyoming provide the study area. V-notch we gage the runoff, and suspended sediment samples are taken periodically. Snowpack is sampled along permanent transects and at random points. Precipitation is sampled by a network of recording and non-recording gages.
The objective of this study is to determine the soil moisture withdrawal pattern under natural stands of big sagebrush, and the effect of sagebrush eradication on moisture withdrawal. Four 0.1 acre plots on an east and a west exposure have been established within high elevation sagebrush type in western Wyoming. Sagebrush on two of the plots on each exposure has been eradicated spraying. Soil moisture samples are taken periodically to trace moisture withdrawal under each condition. Study to evaluate the comparative efficiencies, in terms of water stored in accumulated snow, of tandem 4-foot slatted snow fences erected at different spacing intervals on open windswept slopes in southeast Wyoming. Study to evaluate the effects of inducing snow accumulation on a watershed through use of artificial barriers. Three experimental grassland-type drainages, 88 to 144 acres, have been selected for the study area in southeastern Wyoming where snow transport by wind commonly occurs. V-notch weirs are installed to measure water yield. Snowpack is sampled in areas of natural accumulation along permanent transects. Summer precipitation is sampled by a network of recording and nonrecording gages.
(g) Peak snowpack in the spring of 1962 was 150 percent greater than the 1961 snowpack. Snowmelt was rapid with peak flows being reached approximately 10 days after melt began. Maximum observed suspended sediment load, near peak flow, was 109 p.p.m. Coarse sediment data indicate bed load movement at a rate of 0.0021 ac. ft./sq. mi. of experimental drainage area.
1962 was the first year following spraying on the treated plots. On six sampling dates no significant differences were found in the moisture levels of the 0-6 foot soil layer on treated and untreated plots. On the eastern exposure treated plots withdrew 2.74 inches of moisture compared to 3.78 inches on the untreated plots. While no significant difference in total herbage production was found, grass production on the treated plots increased 48% while forb production decreased markedly. During the winter 1961-62, eight slatted snow fences placed on upland areas in tandem at intervals of 325 feet saturated. Resultant snowdrifts were 4.5 feet high, extended an average of 106 feet downwind from the fence, and contained about 110 cubic feet of water, snowpack equivalent, per lineal foot of fence. Trials for efficient snow fence spacings in small natural drainages are continuing. Installations necessary to the study were completed during the summer of 1962 and calibration began. Peak snowpack data collected in the spring of 1962 show that an average of only 1.1 inches of water,

snowpack equivalent, accumulates naturally on the experimental drainages.

(3895) WATERSHED MANAGEMENT RESEARCH, ALPINE HYDROLOGIC LABORATORY.

(b) Laboratory project.
(d) Field investigations; basic research.
(e) The purpose is: 1) To correlate snowdrift intensity with meteorological and terrain features; 2) to measure the amount and vertical distribution of snow carried by the wind in an area of moderately rough terrain; 3) To determine important features associated with the deposition of snow; 4) to determine the effect of slat and wire fencing on the accumulation of snow in selected natural catchments in the alpine portion of Loveland Basin, Colorado, and to test the relative effectiveness of this type of fence at two locations in the same general area; and 5) to test several types of wind barriers in alpine conditions.
(g) Data have been taken on the effect of slat and wire snow fencing on the accumulation of snow in six selected natural alpine catchments. One catchment along the main ridge showed a very large increase in snow due to the fence. At the other catchments, one showed an increase, two showed little net change, and two were used as control areas.

(3896) WATERSHED MANAGEMENT RESEARCH, FORT COLLINS, COLORADO.

(b) Laboratory project.
(d) Field investigations; applied research.
(e) Field plot to observe the adaptability and growth characteristics of twenty-three tree shrub and twenty-six grass and forb species for further testing on critical erosion sites.
Research to find the influences of mechanical watershed rehabilitation measures on the microclimate and other site factors in the southern Rocky Mountains. To determine the effect of range conditions and related factors on sediment production and runoff on three mountain grassland watersheds in western Colorado. Range condition is being measured by means of 20 or more 3-step transects on each watershed. Ninety degree V-notch weirs are used to gage the watersheds which vary in size from 86 to 272 acres. Water samples are taken several times daily during snowmelt and periods of storm runoff for determination of suspended sediment; bedload is measured in the weir ponds.
(g) This year, as in 1961, moisture was favorable for plant growth at the plot. This resulted in only minor increases in mortality over 1961. The outstanding shrub was Sambucus neomexicana which grew to heights of 7 feet and diameters of 6 feet from basal shoots and produced by far the greatest weight of litter. Annual forbs did poorly this second season while the biennial Melilotus clovers were the superior species at the grass and forb plot. Agropyron trachycaulum was observed to be one of the best perennial grasses in regard to growth and litter produced.
Ground cover index shows a strong correlation with both peak suspended sediment concentration (parts per million) and peak discharge (cubic feet per second per square mile). Suspended sediment concentrations have been as high as 6820 p.p.m., and peak discharge has been as high as 96 c.s.m.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Southeastern Forest Experiment Station.

(380) WATER RESOURCE AND WATERSHED MANAGEMENT RESEARCH.

(b) Laboratory project. For general public use and information.
(c) Dr. Thomas F. McLintock, Director, Southeastern Forest Experiment Station, U. S. Forest Service, P. O. Box 2570, Asheville, North Carolina.
(d) General investigations of forest influences in the southeastern United States, with primary emphasis on fundamental hydrologic research on watershed processes and related application in watershed management.
(e) Basic research into forest hydrologic processes from the precipitation of water over an area until it leaves the watershed as streamflow or evapotranspiration. Demonstrations of several cover types and land management practices and their effect upon water yield, quality and flow characteristics. Development of watershed management methods pertinent to the region and cooperative trials and demonstrations of these methods. Most of the experimental and hydrologic data are collected on the 5600-acre Coweeta Hydrologic Laboratory, located in the zone of maximum precipitation for the eastern United States (Nantahala Range of the southern Applachians). The basic hydrologic gaging network at the Coweeta Hydrologic Laboratory, near Franklin, N. C., includes 1 multiple and 11 unit watersheds currently active and 19 standby watersheds on which up to 27 years of continuous streamflow records and a cumulative total of more than 670 years are available on drainages ranging from 4 acres to 8 square miles, 12 recording and 23 standard rain gages, 1 recording hygrothermograph, 1 metering anemometer, 2 recording anemometers and wind vanes, 1 evaporation pan, and 2 recording pyrheliometers. An additional 44 rain gages of various types are currently being used for special studies. Occasional water samples are collected from selected watersheds for quality analysis on a storm period basis. Soil moisture is measured in the field with tensiometers and 2 neutron scattering devices servicing a network of some 60 access tubes. A small laboratory equipped for soil and plant physical analysis and instrument repair is on the area. Most recording devices are of the chart-trace type with exception of one analog-to-digital streamflow recorder. Much of the data is being reduced from chart traces to punch cards by an Oscar-K chart reader with subsequent computation and analysis by computers at the National Weather Records Center in Asheville, N. C. Supplementing the plant-soil-water studies at Coweeta is a research unit located in the piedmont at Union, S. C. Current soil moisture studies include development of field measurement techniques for moisture investigations by the neutron method, comparative water use requirements of cover types, moisture recharge and depletion investigations, and depth of moisture withdrawal by representative cover types. Research facilities are largely inactive at the present time but include 4 unit watersheds, a rain gage network, and a standard Weather Bureau weather station plus a neutron scattering device and numerous plots for soil moisture study (now active). All projects are to be carried to completion through analysis of data, preparation of reports, and publication of technical articles. Research studies (Coweeta and Union) include: 1) evapotranspiration from forest land, hydrologic effects of reducing basal area; 2) evapotranspiration and water yield from different types of forest cover; 3) soil-water balance as related to recharge, drainage, and evapotranspiration; 4) source, volume, and timing of stormflows from small mountain watersheds; 5) energy balance, precipitation, and evapotranspiration on

slopes and how modified by cover and physiography; 6) soil moisture depletion by drainage and transpiration from deep forest plots covered with plastic film; 7) internal water balance of forest trees under natural and induced drought conditions; 8) interception by forest litter cover; 9) soil moisture storage and movement on steep slopes; and 10) a pilot study testing multiple uses such as water, timber recreation, and wildlife on a 360-acre watershed. Wetland research, recently inaugurated at Charleston, South Carolina, involves studies of the effects of drainage and other management practices on the water regime and timber growth and survival. Planned work will attempt to classify wetland forest sites as regards hydrologic characteristics and management potential, identify the factors affecting coastal plain hydrology, and evaluate changes in wildlife habitat resulting from modification of water regimes.

(g) Past cutting experiments at Coweeta have resulted in 6 to 16 inches of increased water yield the first year following 100% reduction in basal area of the hardwood forest cover. As the forest vegetation recovered after cutting, these increases in yield dropped off at a rate approximately linear with the logarithm of time, indicating that as the coppice forest matured evapotranspiration returned to precutting levels. A 23-acre watershed was recently converted from forest to grass in an attempt to compare evapotranspiration from these two cover types. After 3 growing seasons no significant differences in water use have been detected. The study continues to determine if grass is actually using as much water as forest or if some watershed factor is complicating results. Mature forest trees on two 50-foot square plastic covered plots were defoliated late in June. At that time drainage from the covered soil had virtually ceased and trees were fully leaved out. No further loss of soil moisture occurred on the defoliated plots, but on an adjacent control plot losses continued until leaf fall in September. Methods for measuring leaf-water deficits and leaf-water potential in the forest were improved. Forest vegetation in the southern Appalachian highlands was shown to exhibit as a rule only minor deficits in the internal water balance. Average noontime diffusion pressure deficits of forest leaves during the summer of 1961 was only about 5 atmospheres. Interception of rainfall by litter under a hardwood forest accounted for about 2 to 4 inches of water per year. Litter interception appears greater during the leafless dormant season than during the growing season. A 3 x 3 x 45-foot column of soil inclined at 40 percent in concrete box drained after soaking for 145 days before outflow became so low that it could no longer be measured. After the first 5 days, outflow was entirely from unsaturated soil. These results strongly support the theory that baseflow at Coweeta is largely from unsaturated soil moisture draining slowly from slopes above stream channels.

(h) "The Annual Range of Soil Moisture under High Rainfall in the Southern Appalachians," by J. D. Helvey and John D. Hewlett, J. of Forestry 60(7): 485-486, July 1962.
"Variance of Nuclear Moisture Measurements," by James E. Douglass, Station Paper No. 143, Southeastern Forest Experiment Station, Asheville, N. C.
"A Method for Determining the Slope of Neutron Moisture Meter Calibration Curves," by James E. Douglass, Station Paper No. 154 Southeastern Forest Experiment Station, Asheville, N. C.
"Moisture and Energy Conditions within a Sloping Soil Mass During Drainage," by John D. Hewlett and Alden R. Hibbert, to be published in Journal of Geophysical Research February 1963.
"Instrumental and Soil Moisture Variance using the Neutron Scattering Method," by John D. Hewlett, James E. Douglass, and Jerome L. Clutter, to be published in Soil Science.
"The Measurement of Water Deficits in Broadleaf Plants," by John D. Hewlett and Paul J. Kramer, to be published in Protoplasma.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Southern Forest Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. P. A. Briegleb, Director, Southern Forest Experiment Station, T-10210 Federal Bldg., 701 Loyola Avenue, New Orleans 12, Louisiana.

(2914) WATERSHED MANAGEMENT RESEARCH, OXFORD RESEARCH CENTER, OXFORD, MISSISSIPPI.

(b) Laboratory project, in cooperation with Soil Conservation Service, Agricultural Research Service, and University of Mississippi.
(d) Field investigation of runoff and erosion from small experimental watersheds on forest and potential forest lands; basic and applied research.
(e) Twelve small natural headwater catchments, two to four acres each, were installed in batteries of three to determine runoff and erosion from old fields, depleted upland hardwoods, pine plantations, and mature upland pine-hardwoods. Treatments are deferred until after a suitable calibration period. Related studies include restoration of depleted watersheds and plant-soil-water relationships.
(g) Data collection on all watersheds was continued. Indications of continuing improvement in effectiveness of some watershed covers have necessitated further deferment of planned watershed treatments. Runoff and sediment production continues to be related to cover type.

(3225) WATERSHED MANAGEMENT RESEARCH, HARRISON RESEARCH CENTER, HARRISON, ARKANSAS.

(b) Laboratory project.
(d) Field investigations on effects of forest type and condition on timing of flows in streams of the Ozark-Ouachita uplands; basic and applied research.
(e) Runoff and sediment from three small mountain watersheds are measured currently. Cover conditions will be changed after an adequate calibration period. Related studies of soil moisture and erosion are continuing.
(g) A guage was devised for detailed measurement of erosion from watershed lands.
(h) "Soil Erosion Gauge," C. Mesavage and J. L. Smith. Jour. Soil and Water Conserv. 17(2): 71, 1962.

U. S. ARMY, CORPS OF ENGINEERS, Beach Erosion Board.

Inquiries concerning the following projects should be addressed to the President, Beach Erosion Board, 5201 Little Falls Road, N.W., Wash. 16, D. C.

(181) EQUILIBRIUM PROFILE OF BEACHES AND STUDY OF MODEL SCALE EFFECTS.

(b) Laboratory project.
(d) Experimental; basic research.
(e) Equilibrium beach profiles will be determined experimentally for waves up to 6 feet in height in a prototype tank; the waves will be modeled at a 1 to 10 scale in small laboratory tanks (to determine scale effects)

for various median diameter and specific gravity sediments.

(g) Additional tests were made using crushed coal of average specific gravity 1.5 (modeled by the settling velocity relationship to give corresponding characteristics of material tested in the large tank). Observed material movement and profile changes corresponded basically to the large scale results in the prototype tank, although the coal slope deteriorated somewhat faster. A partial explanation for differences is the wide range of specific gravities of individual coal particles. Tests for a few selected storm waves were made in the large tank with waves from 2 to 5.5 feet in height using a sand of 0.4-mm. median diameter. The profiles obtained in these tests may be compared with those obtained earlier with 0.2-mm. sand to indicate differences in rates of scour and degree of protection with different sized material.

(660) OBSERVED WAVE CHARACTERISTICS.

(b) Laboratory and field project.
(d) Field investigation; basic research.
(e) To secure a more thorough knowledge of the characteristics of ocean waves, a number of electrical recording wave gages have been installed in coastal waters and these records are analyzed for significant height and period, and wave spectra.
(g) The new relay type wave gage has proved to be superior to the parallel and series types of step resistance wave gages. This type gage has been installed for the Beach Erosion Board at Virginia Beach, Va., Buzzards Bay, Mass. (Coast Guard Tower), and Atlantic City, N. J. Plans are in progress for replacing the wave gages at Naples, Fla., and Huntington Beach, Calif. with relay type gages. Reinstallation of the wave recording station at Palm Beach, Fla. is also planned for 1963. Additional gages on other Coast Guard light towers are planned for installation in 1963. Magnetic tape recorders for recording ocean waves have been installed on all Beach Erosion Board wave gages. These records are being analyzed on a wave spectrum analyzer in the Board's laboratory. Certain improvements were made in interpreting the record for average height, energy, and peak height.

(975) METHODS OF BY-PASSING SAND PAST INLETS.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) To study methods and requirements for pumping sand past inlets and to determine the applicability of the methods in stabilization of beaches adjacent to inlets. Data are being procured on the effect to the shoreline of sand by-passing operations at Port Hueneme, California and Lake Worth Inlet, Fla. and on the effect to the shoreline of a new harbor constructed at Ventura, California. This latter harbor involves an offshore detached breakwater along with entrance jetties to the new harbor. Data at the three locations include periodic hydrographic surveys south and north of the inlet, wave data, sand samples, detailed records of pumping operations, and detailed records of entrance channel maintenance. A general study is being made of the possibility of adapting commercial instruments utilizing a radioactive source to the discharge line to measure quantity of material pumped in by-passing operations.

(976) ESTABLISHMENT OF CRITERIA FOR CONSTRUCTION OF ARTIFICIAL BEACHES.

(b) Laboratory project.
(d) Theoretical; applied research.
(e) To develop criteria for construction of beaches by artificial means. The present continuing phase of this general study involves the measurement of a natural beach slope and attempts to determine its response to the forces normally incident upon the shore such as wave height and period, angle of wave approach, tide, and direction and magnitude of littoral current. By statistical methods the relative importance of the forces or combinations of forces may be evaluated.
(g) Computing machine techniques have been applied to the statistical evaluation of the importance of the forces and of the parameters. Preliminary results indicate that wave height and wave period are more important although, in general, the data used in the analyses were too sparse and too statistically noisy to achieve definite results.

(977) DEVELOPMENT OF WAVE HEIGHT AND WAVE DIRECTION GAGES.

(b) Laboratory project.
(d) Experimental; development.
(e) To develop wave height and wave direction gages for use in securing accurate records of wave characteristics. (See also Project 660).
(g) Two relay type wave gages were fabricated for use by the Walla Walla District, Corps of Engineers. These gages are unique in that they include an automatic wave height controlled programmer. This programmer activates the wave recording apparatus only when waves of two previously selected heights are present, thus precluding the recording of waves with low or negligible heights. The height selectors are adjustable in height and also in length of recording period for each height. A long period wave recording station (100-seconds thru 15-minute wave periods) was fabricated for use in Hilo, Hawaii. This gage was designed to obtain wave data on waves and surges causing ship and port damage in Hilo Harbor. Four wave gages and magnetic tape recorders were furnished the Los Angeles District, Corps of Engineers, for use in the Playa Del Rey Boat Basin. The gages are needed to obtain information relative to boats and dock installation damage caused by waves entering the basin from the Pacific Ocean. A wave gage was furnished (loaned to) the City of Detroit, Michigan, for measurement of waves in small boat harbors caused by large ocean vessels underway in adjacent channel areas. Three staff type wave gages were installed at Port Hueneme, Calif., replacing pressure type gages. Magnetic tape recorders are used with these wave gages.

(2190) STUDY OF EFFECT OF A GROIN ON THE RATE OF LITTORAL MOVEMENT.

(b) Laboratory project.
(d) Experimental; basic research.
(e) To study the effect of groins on the rate of littoral drift passing a groin system. Initial tests consist of waves generated at a 30-degree angle to the sand beach with measurement of material movement being made at the downdrift end. The tests planned for the immediate future, as have the current season tests, will continue to emphasize the task of collecting and establishing reliable calibration data on the relationship between the littoral transport rate and the wave characteristics. These generalized (not to specific model scale) studies are being made in the Shore Processes Test Basin of the Beach Erosion Board. They will include tests of waves up to about 1 foot in height and wave periods of 1.25 to 4.00 seconds.
(g) A total of seven littoral transport tests have been completed this year. These tests may be conveniently grouped into the following four categories: (1) sand feeder

calibration tests - intended to determine the optimum position (vertical and horizontal) of the sand feeder; (2) transverse or parasite wave tests designed to eliminate transverse waves which possibly have adverse effects on the littoral transport test results; (3) radioactive feasibility, tests to determine the feasibility of measuring the littoral transport by monitoring the progress of an initial injection of radioactive sand as it is displaced from the injection area by the action of waves, and (4) miscellaneous or liaison data collection and testing, using SPTB facility and equipment.
Results from the sand feeder calibration tests shows that the magnitude of the vertical spacing between the still water level and the sand feeder mouth affects the amount of sand fed in the presence of waves. Sand feeding curves, in general, showed that the higher the feeder was placed above the still water level, the greater was the amount of sand fed. This test result does not of itself select a specific or optimum feeder elevation for a given wave condition, but it does provide useful data which may aid a particular selection of feeder elevation. The variability of wave heights measured along the toe of the beach slope confirm the presence of a transverse wave, or basin oscillation. Installation of a splitter wall 1/4 basin width upbeach of the down-beach training wall reduced the magnitude and increased the frequency of wave height variability as measured along the wave crest. Results from the tracer feasibility tests were confined mainly to the development of methods, techniques, and procedures. The information gained will guide the design of a more sophisticated test having the specific purpose and a definite plan for measuring (estimating) by use of radioactive or fluorescent tracers the magnitude of the littoral transport rate. Additional work included the measurement and tabulation of wave height, wave period, and eccentric setting for use in preparing calibration curves for the Shore Processes Testing Basin wave machines.

(h) "Laboratory Determination of Littoral Transport Rates" by R. P. Savage, Proceedings Separate No. 3128, Journal Waterways and Harbors Division, American Society of Civil Engineers, WW2, May 1962.

(2192) REGIONAL STUDIES OF THE ATLANTIC COAST OF NEW JERSEY; AND THE DELAWARE-MARYLAND-VIRGINIA SHORE LINE FROM CAPE HENLOPEN TO CAPE CHARLES.

(b) Laboratory project.
(d) Field investigations; basic research.
(e) To compile all existing data pertinent to shore processes on a regional scale. Reports to consist of three chapters: geomorphology and shoreline histories, littoral forces, and littoral materials. Subject matter to include physiography, geological development of the shore region, sources of littoral material, waves, tides or water level fluctuations, current physical characteristics of the littoral materials, interrelation of sedimentary properties, relation of properties of littoral materials to position in the littoral zone, and changes in shoreline configuration.
(g) The Delaware-Maryland-Virginia shoreline from Cape Henlopen to Cape Charles is currently under study. Data compilation for this reach is essentially completed and the report is under preparation.

(2193) SHORE PROTECTION PLANNING AND DESIGN.

(b) Laboratory project.
(d) Design.
(e) To supplement and revise the Beach Erosion Board's Technical Report No. 4, "Shore Protection Planning and Design" as new data and techniques are developed for use in the solution of coastal engineering problems.
(g) This report was reprinted in October 1961.

(2195) RE-EXAMINATION OF ARTIFICALLY NOURISHED AND CONSTRUCTED BEACHES.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) To study the behavior of beach fills placed to restore or nourish a beach sector and the effect of the fill on adjacent shores. A selected number of beach fills are being re-examined.
(g) Study is underway of data collected at Seaside Park, Sherwood Island State Park, and Hammonasset, Conn.; Key West, Fla.; and Presque Isle, Pa.

(2659) LARGE SCALE TESTS OF WAVE FORCES ON PILING.

(b) Laboratory project.
(d) Experimental; applied research, design.
(e) To determine nature and magnitude of forces on piles.
(f) Suspended.
(h) A report on some of the data was presented at the ASCE meeting at Houston in February 1962.

(2660) WAVE TANK STUDY OF QUANTITY OF SEDIMENT IN SUSPENSION IN THE SURF ZONE (INCLUDING TEMPERATURE EFFECTS).

(b) Laboratory project.
(d) Experimental; basic research.
(e) To determine the relationship between wave, water, and sand characteristics, and the amount of material maintained in suspension and, hence, available for longshore transport by currents.
(g) A vacuum pump-type suspended sediment sampler has been used to collect suspended sand samples under various laboratory conditions of waves, water temperature, and sand. A pump type sampler has been used to collect suspended sediment samples in the Beach Erosion Board large wave tank in conjunction with other tests (Items 181 and 4764 - last item). Some of these samples have been analyzed and compiled. Tests using an eductor to collect suspended sediment samples were also carried out and showed that the eductor could be used in place of a pump to make suspended sediment collections in the large wave tank. The advantage of the eductor is that only the intake nozzle and piping need be placed in the water. All other equipment (filter, case, meter etc.) can be positioned above and completely out of the water. Modifications to the vacuum pump suspended sampling apparatus for use in laboratory wave tanks are continuing. Fabrication of six cylindrical receptacles (3 bronze, 3 plexiglass) for use in suspended sediment collection have been completed. These receptacles replace a square cross-section receptacle formerly used. The new receptacle provides greater efficiency in sample collection and extraction, and a saving in replacement costs.

(2661) WAVE RUN-UP ON SHORE STRUCTURES.

(b) Laboratory project.
(d) Experimental; design.
(e) Wave run-up is determined experimentally for various waves for different types of shore structures. Effect of both structure roughness and permeability is being investigated.
(g) Relatively large scale data (wave heights about 3 feet) have been taken on a 1 on 1 1/2 slope rubble mound structure, with a cover layer of (75-lb.) quadripods. Some data using waves 2 to 5.5 feet high have also been obtained on smooth 1 on 15 beach slopes, the beach material having a median diameter of 0.4 milimeters. Curves

presenting run-up data for use in deep inland reservoirs have been prepared, embodying within them an average scale correction factor, and published by ASCE. The joint distribution of wave height and wave period, for a fully developed sea, as developed by Bretschneider, has been used to obtain the distribution of relative wave run-ups in a sea condition, and also the distribution of actual run-up. This latter distribution turns out to be essentially identical with the wave height distribution as developed by Putts, Longuet-Higgins, and others (at least for conditions examined). As such, it appears that about 13% of the run-ups exceed the run-up of the significant wave, about 1% of run-ups will be 1.5 times $R_{1/3}$ and that about 1 in 1,000 will be 2 times $R_{1/3}$. This analysis has been made only for the case of relatively deep water fronting a structure (i.e., d/H_o greater than 3) and for a fully developed sea, though it has been extended to include normal generating areas. A graphical method was developed for checking the design height of protective dunes or beach fills which are to be constructed along an existing shoreline. The method involves computing a "critical profile" which, when plotted on transparent paper, can be overlaid on field profile plots to determine if run-up from expected waves will exceed the structure height.

(h) "Freeboard Allowances for Waves in Inland Reservoirs" by Thorndike Saville, Jr., E. W. McClendon, and A. L. Cochran; Proc. of the American Society of Civil Engineers, Journal of the Waterways and Harbors Div., WW2, Separate No. 3138, May 1962.
"An Approximation of the Wave Run-up Frequency Distribution" by Thorndike Saville, Jr.; Proc. of the Eighth International Conference on Coastal Engineering, Council on Wave Research, Engineering Foundation (in press).
"A Graphical Method for Checking the Design Height of Structures Subjected to Wave Run-up" by R. P. Savage, Bulletin of the Beach Erosion Board, Vol. 16, 1962.

(3228) MODEL TESTS OF WAVE SETUP ON BEACHES.

(b) Laboratory project.
(d) Experimental; basic research.
(e) To relate increase in water level at the shore due to wave action alone, to the incident wave characteristics and shore hydrography.
(g) Additional tests have been made on a 1 on 10 slope and a 1 on 6 slope. Tests in general indicate a wave set-up at the shoreline of about 10% to 20% of the wave height for profiles. The earlier indication of reduced set-up for slopes 1 on 6 or steeper may be in error and may have resulted from insufficient measurements near the still water line.

(3897) RADIOACTIVE TRACERS FOR BEACH STUDIES.

(b) Laboratory project.
(d) Experimental; research.
(e) A natural or simulated sediment on or in which a radioisotope has been incorporated was placed in a strip across a sandy beach in the Shore Processes Test Basin. Waves and wave induced currents transported the labelled particles, and periodically the beach and offshore zone was monitored with appropriate detection instruments. In this manner a time-space of the labelled particles was determined. From this history and other data it is hoped to develop further information concerning the mechanics of particles and littoral movement. Experience gained from the laboratory testing program will be utilized when field testing is undertaken.
(g) Two laboratory tests were completed during the late summer of 1962. It was found that the sediments moved alongshore and also toward deeper water. The transport may have been pulsating in character. A possible onshore-offshore oscillatory motion was also noted.
(h) "Laboratory Applications of Radioisotopic Tracers to Follow Beach Sediments," by Norman E. Taney, Proceedings of the Eighth International Conference on Coastal Engrg., Council on Wave Research, Engineering Foundation (in press).

(3898) SCOUR CAUSED BY WAVES STRIKING SEAWALLS OR BULKHEADS.

(b) Laboratory project.
(d) Experimental; basic research.
(e) To study the effect of waves acting against a vertical bulkhead on a sand beach in eroding or building up a beach.
(g) Work has been continued on analysis of the data obtained last year.

(4760) EXPERIMENTAL STUDY OF DUNE BUILDING WITH SAND FENCES.

(b) Laboratory project.
(d) Experimental; design.
(e) The experimental study consists of the construction of various types and arrangements of sand fences to determine the fence type and arrangement most effective in building a dune by trapping and holding wind-blown sand. Slat-type snow fencing and locally constructed brush fencing have been used in straight, straight-with-side spurs, and zigzag configurations. The study is being conducted on the Outer Banks of North Carolina between Cape Hatteras and Cape Lookout.
(g) The study indicates that brush fencing of sufficient density traps about 5% more sand than slat-type fencing, and that the straignt fencing configuration traps and holds as much, or more, sand than either the straight-with-side spurs or zigzag configuration.
(h) "Experimental Dune Building on the Outer Banks of North Carolina" by Rudolph P. Savage, Shore and Beach, Vol. 30, No. 2, October 1962.
"Experimental Study of Dune Building with Sand Fences," by Rudolph P. Savage, Proc. of the Eighth Conference on Coastal Engrg., Mexico City, 1962 (in press).

(4761) EVALUATION OF A STREAM OUTLET STRUCTURE (SAND PLUG OPENING DEVICE).

(b) Soil Conservation Service, U. S. Dept. of Agriculture.
(d) Experimental; applied research.
(e) A laboratory study was made on the effectiveness of a sand plug opening device. The device was designed to aid stream floods in breaking through ocean formed sand plugs in the seaward exits of streams before the stream floods reach an elevation high enough to cause flooding damage inland of the sand plug. In general, the stream flood cannot be allowed to ride high enough to overtop the plug.
(f) Completed.
(g) A 1 to 20 scale model of the proposed structure was made and tested. The structure worked as predicted; however, the study left some doubt as to whether the structure would cause the sand plug to erode quickly enough to prevent flooding when the stream flood rose from plus 2 ft. MSL to plus 6 ft. MSL in 13 minutes. Flooding was assumed to occur at stream elevations greater than plus 6 ft. MSL.
(h) Report submitted to the Soil Conservation Service.

(4762) CORRELATION OF STORM WAVE ATTACK AND BEACH EROSION.

(b) Corps of Engineers.

(d) Field and office investigation to develop quantitative correlation between storm violence and shore erosion.
(e) Repetitive profiles are taken at selected beach areas. The storm wave action between surveys is analyzed and correlations between the wave action and observed profile changes are established.
Repetitive profile lines were established in November 1962 at nine locations between Delaware Bay and Cape Cod. These profiles are resurveyed at weekly or bi-weekly intervals. Storm wave action is measured by the Beach Erosion Board Ocean Wave gages, and storm surges by U.S.C. & G.S. tide gages.

(4763) OFFSHORE SAND SOURCES.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) To develop data on offshore deposits of material along the U. S. coasts that could be used in beach fill or nourishment projects.
(g) Map study has been made to locate possible source areas. A pilot operation utilizing a "sparker" type sounder to indicate depth of deposit was carried out off the Florida coast. Plans for a dredging operation using a dredge with pump-out capability are underway to study feasibility and costs.

(4764) MODEL TESTS - PROPOSED LOS ANGELES - SANTA MONICA CAUSEWAY.

(b) Los Angeles District, Corps of Engineers, U. S. Army (for State of California).
(d) Experimental; basic research.
(e) An offshore sand barrier has been proposed for a causeway across a portion of Santa Monica Bay. One proposal involves a rock barrier, submerged perhaps 15 feet (to prevent damage to swimmers and small craft) to hold the seaward end of the sand barrier. It thus eliminates the large quantity of sand otherwise necessary to form the toe of the sand barrier. A few large scale (waves 3-6 feet in height) tests have been made to give an indication of possible quantity of scour shoreward of the rock barrier induced by it, and the relative proportion of this scour material which might be moved seaward across the rock barrier crest and become unavailable for further nourishment and protection of the sand barrier.
(f) Essentially completed.
(h) Final report to the Los Angeles District is underway.

U. S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS, PORTLAND, Bonneville Hydraulic Laboratory.

Inquiries concerning Projects Nos. 2662, 3577, 3578, 3899, 4379, 4503, 4504, and 4505 should be addressed to the District Engineer, U. S. Army Engineer Dist., Walla Walla, Building 602, City-County Airport, Walla Walla, Washington.

(403) MODEL STUDY OF LOOKOUT POINT SPILLWAY, MIDDLE FORK WILLAMETTE RIVER, OREGON.

(b) U. S. Army Engineer District, Portland, Corps of Engineers, 628 Pittock Block, Portland 5, Oregon.
(c) District Engineer, U. S. Army Engineer District, Portland, 628 Pittock Block, Portland 5, Oregon.
(d) Experimental; for design.
(e) Approximately 2000 ft. of forebay area upstream from the dam, a 2200-ft. section of 250-ft.-high earth embankment, the 1900-ft.-long, uncontrolled side-channel spillway with 725-ft.-long ogee and 150-ft.-wide stilling basin, and 2400 ft. of downstream river bed were reproduced in a 1:72-scale model. Later a gravity spillway 149 ft. wide having 5 tainter-type crest gates was tested in the model.
(f) Tests have been completed.
(g) Suitable designs were developed for all elements of the spillway and stilling basin.
(h) "Spillway and Stilling Basin for Lookout Point Dam, Middle Fork Williamette River, Oregon," U. S. Army Engineer Bonneville Hydraulic Laboratory Tech. Report No. 42-1, December 1962. (Available on loan.) Final report covering tests on the gravity spillway and regulating outlets.

(2662) GENERAL MODEL STUDY OF JOHN DAY LOCK AND DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) U. S. Army Engineering District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
(d) Experimental; for design.
(e) A fixed-bed model constructed to an undistorted scale of 1:80 reproduces the Columbia River bed from Mile 213.7 to 216.8. The dam axis is at Mile 215.6. The original structures layout consists of a straight, 20-bay, gravity-type spillway controlled by 50- by 58.5-ft. tainter gates, a powerhouse for 20 Kaplan turbines (initial installation 10 units), an 86- by 675-ft. navigation lock having a maximum lift of 113 ft., a concrete nonoverflow section, rock-fill abutments, and facilities for passing anadromous fish over the dam. Cofferdams having steel cells in the river legs and earth-and-rock shore connections are designed to withstand river flows to 700,000 cfs during first- and second-stage construction periods and 300,000 cfs during third-stage diversion. Purposes of the model study are to check the structures alinement and flow conditions affecting power generation, cofferdam placement, and fish passage.
(f) Tests have been completed.
(g) Satisfactory designs were developed for both the first- and second-step cofferdams as a result of tests made in the model. Although flow patterns adjacent to the main structures were fairly satisfactory, realignment of the downstream approach channel improved conditions for navigation, and extension of a training wall between the spillway and powerhouse reduced a possible hazard for fish migrating upstream. Detailed studies of powerhouse tailrace alignments, south fishway entrance, and a pumphouse to provide auxiliary attraction water for the powerhouse fish collection system were made. Additional tests with a revised second-step cofferdam, right bank fills adjacent to and upstream from the navigation lock, highway detour fill, and extended river side downstream lock guard wall indicated that flow conditions adjacent to these elements would be satisfactory. Alternative methods for effecting the transition between the first and second-step cofferdams, and various proposals for constructing portions of the second-step cofferdam in successive low-water seasons were investigated during 1962.
(h) Final report is in preparation.

(3577) GENERAL MODEL STUDY OF LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
(d) Experimental; for design.
(e) An undistorted, fixed-bed, 1:100-scale model reproduced approximately 2.4 miles of Snake River bed and overbank topography at the dam site. The dam axis is 41.5 river miles upstream from the confluence of the Snake and Columbia Rivers and about 60 miles from the city of Pasco, Washington. Studies were made to determine flow conditions during various construction stages and after completion of the project.
(g) After verification of the model, studies of successive construction stages were made. It was found that proposed limits for

cavation along the right bank were inadequate, revisions in alignment and height of first-step cofferdam cells were needed, and problems concerning fish passage would arise during each phase of construction. Numerous conferences and demonstrations held on the model helped solve problems regarding fish migrations. Final designs for all features of the project were developed. Operational tests of the final design are in progress.

(3578) MODEL STUDY OF FISH LADDERS FOR JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
(d) Experimental; for design.
(e) An existing 1:10-scale fish ladder model is being used for tests of the 24-ft-wide, 1-on-10 sloped fish ladders for John Day Dam.
(g) Velocities, flow patterns, and surge characteristics were determined for typical fixed weirs of several alternative designs. A design was developed for a 1-on-10 fishway in which flow conditions will be comparable to those in a 24-ft-wide fish ladder sloped 1 on 16. Then the model was revised to include the north fishway exit, orifice control section, fish counting station, and eight typical weirs. Orifice sizes for non-overflow bulkheads in the orifice control section (two orifices per bulkhead) were adjusted to provide a uniform drop between successive pools for an 11-ft variation in forebay level. Flow conditions with a third orifice on the center line of each typical weir (adopted design) were investigated. Tests of the counting station for the south shore fish ladder are in progress.

(3899) MODEL STUDY OF SPILLWAY FOR LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
(d) Experimental; for design.
(e) The 1:42.47-scale model includes a 3-bay section of the 8-bay spillway and stilling basin. Tests were made to evaluate hydraulic performance of the proposed spillway and to develop revisions in design that would increase performance or reduce construction and maintenance costs.
(f) Tests have been completed.
(g) Satisfactory designs for spillway crest, piers, abutments, and stilling basin were derived; pressure data and discharge rating curves for free and gated flows were determined with and without a simulated powerhouse structure in place. With a maximum head of approximately 65 ft, an abutment coefficient of 0.0335 was indicated for a half pier adjacent to the powerhouse, whereas a value of 0.0365 was derived for the opposite abutment.
(h) Final report is in preparation.

(3900) MODEL STUDY OF DOWNPULL FORCES ON EMERGENCY CLOSURE GATES.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
(c) District Engineer, U. S. Army Engineer District, Portland, 628 Pittock Block, Portland 5, Oregon.
(d) Experimental; applied research.
(e) This is a general study of various sluice coaster gate bottom and lip shapes, and includes downpull and discharge measurements as affected by angle of gate bottom, length of gate lip extension, control valve opening, number of control valves operated, and condition of air vents (open or closed). A 1:25-scale model reproduces a level approach to an intake tower with vertical headwall normal to intake center line, two three-sided bellmouth intakes, a 20-ft.-wide by 22-ft.-high emergency gate (tractor type), two 10-ft.-wide by 15-ft.-high control valves (tainter), and a 22-ft.-diam. outlet tunnel. Hydraulic downpull forces are computed from pressures at 21 critical locations on the emergency gate.
(f) Tests have been completed.
(g) Downpull forces were measured on a tractor-type emergency closure gate with bottom beam sloped 30, 37.5, and 45 degrees and with lip extensions of 0, 3.5, 8, and 12 in. under heads between 50 and 300 ft. Downpull forces were highest with the 30-degree bottom and lowest with the 45-degree bottom. Although lip extensions reduced the downpull, their effectiveness decreased as the bottom slope was increased.
(h) Final report is scheduled for publication in 1963.

(4379) MODEL STUDY OF LOWER MONUMENTAL NAVIGATION LOCK, SNAKE RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
(d) Experimental; for design.
(e) A 1:25-scale model reproduces a typical 86- by 675-ft. lock chamber, split lateral filling and emptying system, river outlet for emptying system, and portions of the upstream and downstream approach channels. The model forebay includes the short nonoverflow section between spillway and navigation lock, and two adjacent spillway bays to permit investigation of vortex action over the staggered intake manifolds when filling the lock with or without spillway flow.
(f) Tests have been completed.
(g) Studies indicated that vortex action occurred over the right intake of original design (Plan A) during a portion of the filling operation, whereas eddy currents along the left guard wall were dissipated before they could join into a vortex. Additional tests led to the development of a satisfactory intake design (Plan I). No vortices formed under any method of operation with steady flow into the lock chamber. No dimples which indicated incipient vortex formation in the model were apparent during filling operation at an initial head of 117 ft (maximum lock inflow increased 10 percent) when the spillway was closed, when both intakes were open, or when the river wall intake was closed. Intermittent dimples formed when the spillway flow averaged 10,000 cfs per bay and when the land wall intake was closed.
(h) Final report is in preparation.

(4380) MODEL STUDY OF SPILLWAY FOR GREEN PETER DAM, MIDDLE SANTIAM RIVER, OREGON.

(b) U. S. Army Engineer District, Portland, Corps of Engineers, 628 Pittock Block, Portland 5, Oregon.
(c) District Engineer, U. S. Army Engineer District, Portland, 628 Pittock Block, Portland 5, Oregon.
(d) Experimental; for design.
(e) A 1:50-scale model includes 1540 ft. of the forebay area, the 2-bay spillway and flanking abutments, outlet conduits, stilling basin, powerhouse tailrace, and approximately 1620 ft. of river channel downstream from the project. The spillway model will be used to determine the adequacy of the stilling basin design, the spillway crest, pier, and abutment details, the location of tainter gate trunnions and outlet eyebrows, and will provide data needed for design of a training wall between the powerhouse tailrace and the stilling basin.
(g) Improved designs for the abutments, training walls, and stilling basin were developed. Model tests of the fish ladder auxiliary water pump intake locations, fish ladder entrance, and flow conditions in the powerhouse tailrace were made with minimum and maximum powerhouse discharges of 950 and 4200 cfs, respectively. Studies to determine

the best method for coordinated operation of the project (spillway, powerhouse, and fish facilities) will be completed in 1963.

(4381) TESTS OF RUBBER MITER GATE BOTTOM SEALS FOR PANAMA CANAL.

(b) U. S. Army Engineer District, Seattle, Corps of Engineers, Seattle Washington.
(c) District Engineer, U. S. Army Engineer Dist., Seattle, 1519 South Alaskan Way, Seattle 4, Washington.
(d) Experimental; for design.
(e) The Panama Canal miter gates vary in height from 47.3 to 82.0 ft., and the head on closed gates ranges from 0 to 80.0 ft. The miter gate sills were originally built of timber beams supported continuously on iron angles in the concrete. The gate leaves carried a timber bumper that fitted closely against the timber sill to form a bottom seal. It is proposed that the timber bumpers will be replaced by butting-type rubber seals attached along a bottom girder on the downstream side of each miter gate. The proposed rubber seal "floats" between a continuous upper seal plate and 1-ft.-long lower angle brackets spaced 2 ft. apart. The rubber seal is retained by 1-in. bolts through 4-in.-diam holes spaced on 4-ft. centers in the seal web. Five-ft-long sections of three types of proposed rubber seals were tested in a pressure tank to determine: (a) the head differential required to seat the seal against the sill plate; (b) leakage of seal at various heads from just seating to a maximum of 80 ft; (c) effect of changing 1/4-in. clearance between the proposed angle-bracket seal supports; (d) effect of irregularities in straightness of rubber seal and sill plate, and of simulated debris between seal and sill; (e) head required to cause "blow by" between gate leaf and sill; and (f) effect of increasing rubber seal flotation by adding polyvinyl chloride unicellular foam to the rubber seal core holes.
(f) Tests have been completed.
(g) The head required to move an unrestrained seal into seating position against the upper seal plate and downstream miter gate sill varied from 0.2 to 0.5 ft. All the seal specimens tested were satisfactory when free of surface irregularities along the sealing surfaces. For a differential head of 5 ft, leakage varied from 0.003 cfs per lineal ft of straight seal to 0.030 cfs when the center of an unstressed seal was warped 3/8 in. from a taut line between opposite ends of the 5-ft-long test section. Although leakage past all seals in a seated position was negligible when the head exceeded 25 ft, surface imperfections increased leakage approximately eight times at the higher heads.
(h) "Miter Gate Seals, Panama Canal Locks," U. S. Army Engineer Bonneville Hydraulic Laboratory Technical Report No. 111-1, December 1962, (Available on loan.)

(4503) MODEL STUDY OF FISH LADDERS FOR LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
(d) Experimental; for design.
(e) Data were obtained on a 1:10-scale model of the 16-ft-wide, 1-on-10 sloped south fish ladder for Lower Monumental Dam. The model included a 55-pool tangent with 10-ft-long pools, 6-ft-high weirs with two 18- by 18-in. orifices spaced 3 ft from the walls, and John Day-type weir crests. A 6-ft-long nonoverflow baffle with fins projecting 1.5 ft upstream from each end was centered in the ladder on top of each weir. The general purposes of the study were to determine surge characteristics, to establish a discharge rating curve, and to measure velocities in the typical pools.
(f) Tests have been completed.
(g) There was no visual or measurable surge action in the fish ladder for simulated heads of from 3.2 to 18.0 in. Flow was stable and no unsatisfactory condition was noted except through the transition from plunging to full shooting flow (83.0 to 95.5 cfs). Flow patterns within the typical pools were satisfactory and reasonably symmetrical from pool to pool.
(h) Final report is in preparation.

(4504) GENERAL MODEL STUDY OF LITTLE GOOSE LOCK AND DAM, SNAKE RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Walla, Corps of Engineers, Walla Walla, Washington.
(d) Experimental; for design.
(e) A fixed-bed model constructed to an undistorted scale ratio of 1:100 reproduces the Snake River bed and pertinent overbank topography between river miles 68.3 and 71.6. The dam axis is at mile 70.3. The original layout consists of a straight, 8-bay, gravity-type spillway controlled by 50- by 59-ft tainter gates, a powerhouse for six Kaplan turbines (initial installation three units), an 86- by 675-ft navigation lock having a maximum lift of 101 ft, concrete nonoverflow sections, rockfill abutments, and facilities for passing migratory fish over the dam. The initial power installation will produce 405,000 kilowatts. Purposes of the model are to check the structures layout and flow conditions affecting cofferdam placement, power generation, navigation, and fish passage.
(g) The model was constructed and verification studies were completed during 1962.

(4505) MODEL STUDY OF FISHWAY DIFFUSERS FOR LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.
(d) Experimental; for design.
(e) An existing 1:8-scale fishway diffuser model was revised so that two diffusion chambers were supplied by a single riser from the conduit. Included in the model were diffusers 3 and 4 and the common distribution well, the supply conduit, and a portion of the 16-ft-wide south shore fish ladder that carried all flow which passed through the diffusion chambers. In the original design, a 7-in.-wide control orifice was located 3.5 ft above the diffuser well floor, and 1.5-ft-high ports admitted flow into the respective diffusion chambers. The information desired from this model include: the orifice size required to provide 48 cfs through each diffuser with a head of 2 ft (supply conduit grade line minus tailwater elevation), a submergence of 4 ft (supply conduit grade line minus elevation of downstream weir adjacent to diffuser 3), and a conduit flow of 500 cfs; a family of rating curves for heads of from 0.5 ft to 6.0 ft and various submergences; and the effect on diffuser discharge of varying the conduit flow from about 50 cfs (only one diffuser) to 750 cfs while a constant head is maintained on the test diffuser.
(g) Two diffuser floor plans and 12 orifice arrangements have been tested in an effort to obtain uniform distribution of diffuser flow into the fish ladder.

(4506) MODEL STUDY OF FINGERLING COLLECTOR FOR GREEN PETER DAM, MIDDLE SANTIAM RIVER, ORE.

(b) U. S. Army Engineer District, Portland, Corps of Engineers Portland, Oregon.
(c) District Engineer, U. S. Army Engineer Dist. Portland, 628 Pittock Block, Portland 5, Oregon.
(d) Experimental; for design.
(e) Two undistorted hydraulic models are being used for studies of facilities for downstream

migrant fingerling salmon and steelhead trout at Green Peter Dam. The proposed facility is composed of an entrance horn, vertical adjustable-height riser, separator, flow distribution control device, trough, flexible hose, transverse pipe system, and outlet pipe followed by a flume into the tailwater. The collector will be located on the upstream face of the dam at the focal point of reservoir discharge. Its 20-ft-high horn will collect fish near the water surface with a minimum submergence over its top of 5 ft and a maximum submergence at its bottom of 40 ft. About 200 cfs will enter the horn and carry migrating fish inward, upward, and across a separator screen (a 10- by 20-ft perforated plate) covering the compartmented flow distribution device through which from 190 to 194 cfs will pass vertically into a collector well and then be pumped back to the reservoir. Fish in the remaining 6 to 10 cfs will be carried from the separator screen through a flexible hose attached to laterals through the dam and thence by open channel flow to the tailrace. A trash boom at the upstream face of the dam will prevent small floating and suspended debris from entering the fingerling collector. Two-ft-wide sections of prototype and model separator plates were tested in a flume model as the first step in determining model-prototype similitude relationships. The model perforated plate that reproduced flow conditions over the prototype plate in the most satisfactory manner was used in a 1:4-scale model of the entire fingerling collector. Tests of different distributor bar spacings, trough floor designs, deflector locations, and separator slopes are progressing in the 1:4-scale model.

U. S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS, St. Paul.

(194) A STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS.

U. S. Army Engineer District, St. Paul and U. S. Geological Survey, in cooperation with St. Anthony Falls Hydraulic Laboratory. See St. Anthony Falls Hydraulic Laboratory, page 70.

U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS.

Inquiries concerning the following projects should be addressed to the Director, U. S. Army Engineer Waterways Experiment Station, Corps of Engineers, P. O. Box 631, Vicksburg, Miss.

(236) MISSISSIPPI BASIN MODEL.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
(d) Experimental; for design.
(e) The project provides for construction and operation of a model of the Mississippi River watershed including the Missouri, Ohio, Tennessee, Cumberland, and Arkansas Rivers and their principal tributaries. The model area comprises 200 acres and reproduces 1,250,000 square miles of the Mississippi Basin. The topography of the streams and flood plains is being reproduced to a horizontal scale of 1:2,000 and vertical scale of 1:100. All existing and proposed flood-control reservoirs, dikes, floodwalls, and other pertinent works will be reproduced in the portion constructed of concrete. The completed construction in concrete consists of the Upper Mississippi River from Hannibal, Missouri, to Baton Rouge, Louisiana; the Missouri River from Sioux City, Iowa, to the mouth; the Ohio River from Louisville, Kentucky, to the mouth; the Tennessee River from Pickwick Dam, Tennessee, to the mouth; the Cumberland River from Old Hickory Dam, Tennessee, to the mouth; and the Arkansas River from Blackburn Dam Site, Oklahoma, to the mouth. Water-surface elevations are measured by electrically operated stage devices with the recorders located in central control buildings. Streamflow is introduced and controlled by automatic instruments called inflow controllers. The model was designed to aid in the development of coordinated basinwide plans for flood control and operation of flood-control structures.
(g) The extent of model operation each year is determined by the testing programs directed by the Mississippi Basin Model Board and Chief of Engineers and requested by Divisions and Districts that have operable sections on the model. The model was operated as an integrated unit for comprehensive (basinwide) tests: tests were conducted of the 1937, 1943, 1945, and 1950 floods using the actual floods with present-day conditions and the same floods without reservoir modification and with modification by the existing reservoirs and those scheduled for completion in the near future (approximately 1970), and with ultimate reservoir modification. Tests were conducted to verify the Memphis, Tenn., to Vicksburg, Mississippi, reach to the 1945 and 1950 floods. Tests were completed for the U. S. Army Engineer Division, Ohio River, to assist in determining the roughness conditions that will exist in the Barkley and Cheatham Reservoirs after completion of Barkley Dam. Tests of the 1937 and Standard Project Floods with and without reservoir modification and the 1962 flood were conducted on the Cumberland River for the Nashville District of the Ohio River Division.
(h) "The Ohio River Hypothetical Flood OR-1," Mississippi Basin Model Report 43-1, Feb. 1962.
"Verification of Sioux City-to-Mouth Reach, Missouri River and Tributaries, 1952 and 1951 Floods," Mississippi Basin Model Report 12-2, June 1962.
"Mississippi River Hypothetical Flood 52A," Mississippi Basin Model Report 31-4, Sept. 1962, U. S. Army Engineer Waterways Experiment Station. (Available on loan.)

(993) CAVITATION RESEARCH.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
(d) Experimental; applied research.
(e) The cavitation characteristics of such eleme as baffle piers, steps in stilling basins, spillway and conduit gate slots, and offset joints are studied in either a vacuum tank or a variable-pressure, closed-jet water tunnel. The investigation includes a review of literature to evaluate the many variables that affect cavitation results. A high-velocity water facility is being used to study resistance of concrete and protective coatings to cavitation.
(g) The degree of cavitation damage to concrete specimens is related directly to the compressive strength of the concrete. Variables investigated include water-cement ratio and type of aggregate.

(994) EFFECTS OF MODEL DISTORTION.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
(d) Experimental; applied research.
(e) This is a general study to determine the hydraulic effects of various types and degrees of model scale distortion on velocity distribution and other hydraulic conditions, with the ultimate aim of establishing limits of permissible distortion for the various types of models. Tests are in progress of a rectangular flume having a 90-degree bend

with provisions for changing the vertical scale to provide a distortion of 0 to 10.

(999) STABILITY OF RUBBLE-MOUND BREAKWATERS.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
(d) Experimental; applied research.
(e) Rubble-mound structures are studied in a 5- by 4- by 119-foot and 12.5- by 4- by 119-foot wave flumes to develop formulas, supported by experimental data, from which the design of safe and economical breakwaters can be determined. In addition to quarrystone, tetrapods, tetrahedrons, tribars, and other specially molded armor units are being studied.

(1002) EFFECTS OF SCALE AND OPERATING TECHNIQUES ON HARBOR WAVE ACTION MODELS.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
(d) Experimental; applied research.
(e) Tests are conducted in flumes and harbor model basins to obtain information that will allow more accurate determination of optimum scales for wave models, and the effects of different scales and operating techniques on the accuracy of model results. The efficiency of flexible-element wave filters is being investigated to facilitate continuous operation of wave flumes. Resonant chambers for harbor entrances and attenuation of waves in a three-dimensional model are being studied.

(1004) INSTRUMENTATION.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
(d) Experimental; development.
(e) Various types of measurement and control equipment for use in hydraulic studies are being developed. These include equipment for measuring subsurface currents, for operation of a model boat by remote control and for measuring model lock tow hawser forces. The development of miscellaneous model and field measuring instruments was continued as the need arose.

(1211) MODEL STUDY OF HOOSIC RIVER, NORTH ADAMS, MASSACHUSETTS.

(b) District Engineer, U. S. Army Engineer Dist., New York, Corps of Engineers, New York, N.Y.
(d) Experimental; for design.
(e) A 1:30 model was used to verify the hydraulic design for improvement of certain sections of the North and South Branches of Hoosic River in North Adams, Massachusetts, and to determine whether changes should be made for safety, increased efficiency, or economy. The flow in the major portion of these channels will be below critical depth. The model was used to check such design features as channel alinement, transitions, superelevation in bends, characteristics of weirs, stilling basins, drop structures, the treatment of intakes and outlets, wall heights, and elevations of bridges.
(f) Completed.
(g) Improvements in flow conditions were effected by several changes in the design of the overall project. A serious problem occurred at the junction of the North and South Branches because of unequal distribution of energy in the flow entering the stilling basin below the junction. A dividing wall was installed in the stilling basin to form two basins, each designed for the flow that would pass through it. Various alterations were made to permit the capacity discharge to pass under several bridges. Of particular interest was verification of the procedure used for determining superelevation in bends. The maximum velocity of the flow entering a bend was found to be the controlling factor in determining optimum superelevation.
(h) "Flood-Control Project, Hoosic River, North Adams, Massachusetts; Hydraulic Model Investigation." U. S. Army Engineer Waterways Experiment Station Technical Report No. 2-338, Report 2, June 1962. (Available on loan.)

(1467) DEVELOPMENT OF HYDRAULIC DESIGN CRITERIA.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.
(d) Analytical (model and prototype); for design.
(e) A general study to develop, analyze, and disseminate to Army Corps of Engineers establishments hydraulic design criteria to ensure adequate capacity, economy of design and construction, and safe and satisfactory operation of large hydraulic structures. Criteria are developed from model and prototype tests relating to the design of spillways, outlet works, gates and valves, channels, and navigation structures.
(g) An analytical study of flow in open channels resulted in a graphical solution for subcritical, supercritical, and pulsating flow. A single chart permits determination of channel capacity and identifies the type of flow. Studies of river diversion methods, outlet tunnel gate transitions, and spillway energy losses resulted in design data pertinent to the development of Hydraulic Design Criteria charts.
(h) "Types of Flow in Open Channels," U. S. Army Engineer Waterways Experiment Station Misc. Paper No. 2-498, June 1962, in cooperation with the U. S. Army Engineer District, Mobile, Alabama. (Available on loan).

(1474) OPERATING FORCES OF MITER-TYPE LOCK GATES.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
(d) Experimental; applied research.
(e) A general study to collect basic data on operating forces of miter-type lock gates and to determine the effect of various elements upon these forces was conducted in a 1:20 model. A lock chamber 110 feet wide was reproduced with provisions for varying the length up to 600 feet on each side of the gate. Forces required for operation of miter gates were measured for variations of the following elements: gate leaves, speeds and accelerations of operation, submerged depths, recess shapes, bottom clearances, chamber lengths, and nonsynchronous operation of gate leaves. Variations in the type linkage driving the gate were also investigated.
(h) Final report in preparation.

(1475) SIPHON ACTION AT PUMPING PLANTS.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
(d) Experimental; applied research.
(e) This study was conducted to aid in developing design criteria for pumping plants that depend on development of siphonic action in the discharge side of the pumps in order to yield the required discharge. Full-size models of a 6-inch and 12-inch plastic discharge line were tested. Variables investigated during the tests were: rates of flow, water levels in the discharge side of the pumps, slope and length of the riverward leg, and venting conditions at the crown.
(g) The tests indicated that for each plan tested there was a minimum flow below which siphonic action would not fully develop. This minimum flow appeared to be dependent upon the diameter, length, and slope of the riverward leg. The priming time was divided into two intervals based on pressures at the crown. The positive phase (during which crown pressures were above atmospheric) depended upon the discharge, tailwater, crown venting condition, length of line and diameter as well as the characteristics of the pump. The negative phase (period

during which crown pressures were less than atmospheric) depended on the velocity of flow during the priming period, head, length, slope and diameter of the riverward leg. Only the sloping portion of the riverward leg was effective in determining the minimum initial priming velocity and length of the negative phase; vertical extensions had no effect. The equation developed from the model data to determine the minimum initial velocity required to achieve a full prime is:

$$V_{min} = 0.362 \left(\frac{L/D}{\sin \theta}\right)^{0.161}$$

Field data obtained on discharge lines for 21 pumping plants with diamteres ranging from 12 to 72 inches indicate satisfactory verification of the minimum initial velocities computed by this formula.

(h) Final report in preparation.

(1986) SALT WATER INTRUSION AND RELATED PHENOMENA.

(b) Committee on Tidal Hydraulics, Corps of Engineers (correspondence should be addressed to Mr. J.B. Tiffany, Chairman, Committee on Tidal Hydraulics, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.).

(d) Experimental; applied research.

(e) To determine the effects of salinity and related phenomena on the vertical distribution of currents and shoaling characteristics in estuaries, tests are being made in a lucite flume 327 feet long, 1.5 feet deep, and 0.75 foot wide. One end of the flume is connected to a 25-foot-square tidal basin in which any desired tide can be produced and in which the salinity can be controlled. The opposite end is connected to a fresh-water source. Combinations of flume roughness, tidal range, tidal period, source salinity, mean depth, and fresh-water inflow are studied. Additional tests to define diffusion characteristics were completed and the results are being analyzed.

(1987) RIPRAP PROTECTION AT HYDRAULIC STRUCTURES.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.

(d) Experimental; applied research.

(e) The study of erosion characteristics of various sizes of riprap and gravel material is being performed with a view to securing adequate protection at minimum cost. Measurements of velocity and depth at which movement of material begins will be made. At present, tests are being conducted on various sizes of riprap below a high structure, a low navigation-type structure, and the crown of a rock embankment to determine the flow characteristics at which movement occurs.

(g) Test results indicate that relations between upper pool elevation, gate opening, tailwater elevation, and unit discharge may be used in relating the conditions where the various sizes of riprap fail. Data are being analyzed in an effort to generalize the test results.

(1988) WATER TEMPERATURE EFFECTS ON BED FORMS AND ROUGHNESS.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.

(d) Experimental; applied research.

(e) A laboratory flume, in which water temperatures can be varied to simulate normally experienced summer and winter temperatures, is being used to investigate the effects of water temperature on streambed forms and roughness of various types of bed materials. Preliminary tests with fine sand have been completed and tests with crushed coal undertaken.

(2428) MODEL STUDY OF SAVANNAH HARBOR, GEORGIA.

(b) District Engineer, U. S. Army Engineer District, Savannah, Corps of Engineers, Savannah, Georgia.

(d) Experimental; for design.

(e) The investigation was conducted in a model which reproduced the following: 1) that portion of the Atlantic Ocean, adjacent to the harbor entrance, from Calibogue Sound on the north to Wassaw Sound on the south; 2) the Savannah River and its flood plain to the head of tide at Ebenezer Landing; and 3) that portion of the Intracoastal Waterway which crosses the area included in the model. The model was of fixed-bed construction with scale ratios, model to prototype, of 1:800 horizontally and 1:80 vertically. Automatic tide generators were used to reproduce tides and tidal currents throughout the harbor, and salt water was used in the model ocean to reproduce the effects of density difference on current velocities and distributions. Shoaling studies were made by injecting finely ground gilsonite into the model to reproduce the patterns of shoaling as observed in the prototype, following which the effects of proposed improvement plans on shoaling patterns were observed and evaluated. Studies were also made of the effects of proposed improvement plans on dispersion and dilution of contaminants discharged into the harbor. Refinements of plans for reducing and localizing shoaling were tested. The results of recently completed tests are being analyzed.

(f) Tests resumed; preparation of Section 3 of final report in progress.

(2673) MODEL STUDIES OF BARKLEY LOCK AND DAM, CUMBERLAND RIVER, TENNESSEE.

(b) District Engineer, U.S. Army Engineer District, Nashville, Corps of Engineers, Nashville, Tennessee.

(d) Experimental; for design.

(e) A 1:120 model, reproducing the Cumberland River from mile 29.4 to 32.2, the lock, dam, and powerhouse, was used to investigate flow characteristics in the approaches to the lock. A 1:36 model, reproducing the riverward downstream lock wall including the culvert manifold which discharges into the spillway stilling basin, five spillway bays, 324 feet of approach channel, and 596 feet of exit channel, was used to investigate flow characteristics in the stilling basin and exit channel. The emergency lock gate was studied in a 1:25 model which reproduced the gate,gate sill, and portions of the upstream lock approach and the lock chamber downstream from the gate. This model was used to determine: 1) hydraulic forces on and stability of the emergency gate under various flows including free flow over the lock miter sill; 2) hydrostatic forces on the gate in various positions; 3) gate wheel reactions and sill roller reactions at given positions; and 4) head loss through the bridge decking.

(h) Final report in preparation.

(2678) MODEL STUDY OF NAVIGATION CONDITIONS, McALPINE LOCKS AND DAM, OHIO RIVER.

(b) District Engineer, U. S. Army Engineer District, Louisville, Corps of Engineers, Louisville, Kentucky.

(d) Experimental; for design.

(e) A fixed-bed, 1:120 model reproduced a six-mile reach of the Ohio River including adjacent overbank areas, the locks and dam structures, and all bridges and other structures that might affect flow conditions. Purposes of the model study were to: determine the effects of location, size, and alinement of the dam on stages and currents in the upper pool; determine the effects of location, size, and alinement of a new approach channel on navigation and surge conditions; determine the best location for a new navigable span on the Pennsylvania Railroad bridge; determine a method of operating the dam for optimum navigation conditions; study navigation conditions in the lower approach as affected by flow through dam, powerhouse,

and lock-emptying system; and provide a means for navigation interests to satisfy themselves as to the acceptability of the proposed plan by observing the model in operation.

(h) Final report in preparation.

(2680) MODEL STUDY OF HURRICANE TIDES IN NARRAGANSETT BAY, RHODE ISLAND.

(b) Division Engineer, U. S. Army Engineer Division, New England, Corps of Engineers, Boston, Massachusetts.

(d) Experimental; for design.

(e) A fixed-bed model, 1:1,000 horizontally and 1:100 vertically, reproduces all of Narragansett Bay and an adjacent portion of the Atlantic Ocean. An automatic tide generator reproduces normal tides throughout the model, and a separate, manually operated generator reproduces hurricane tides of the desired characteristics at the bay entrance. Numerous barrier plans for prevention of hurricane-tide damage have been proposed. The relative and absolute effectiveness of these plans in reducing hurricane-tide elevations throughout the bay system were determined and the effects of the best plan on such important factors as tidal circulation, pollution, salinity, and shoaling for normal conditions were investigated. Fresh water only is used in the model during tests of the proposed barrier plans, but both salt and fresh water are used in tests to determine the effects of barrier plans on all significant factors for normal conditions. Model appurtenances consist of automatic tide gages to record both hurricane-tide and normal-tide elevations at critical points, recording salinity meters, recording dye meters for observing pollution and/or flushing characteristics, current velocity meters, and equipment for simulating shoaling of the channels and other navigation facilities.

(g) The results of supplemental tests indicate that a lower bay barrier plan can be dsigned which is acceptable to the Navy and which will afford most of the desired protection from hurricane surges. However the results of the study to date indicate that some further modification to the structure may be necessary in the interest of safe navigation by small boats.

(2681) SCALE-EFFECT TESTS OF RUBBLE-MOUND BREAKWATERS.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.

(d) Experimental; applied research.

(e) Tests are being conducted by the Beach Erosion Board, under the supervision of the Waterways Experiment Station, to investigate the effects of model scale on the results of experimentally determined criteria for the design of rubble-mound breakwaters. Stability tests are being made of a breakwater slope of 1 on 1-1/2 using wave periods of 2.61, 3.75, 7.87, and 11.33 seconds. Tests in the Beach Erosion Board wave flume (15 feet by 20 feet by 635 feet) are being conducted using a linear scale of 7.5 to 1 based on the tests conducted in the Waterways Experiment Station 5- by 4- by 119-foot wave flume. Stability tests have also been conducted in the Waterways Experiment Station small wave flume (1 foot by 1.5 feet by 94 feet) using a scale of 0.5 to 1 based on tests conducted in the 5- by 4- by 119-foot wave flume. Therefore, data on the stability of rubble-mound breakwaters will be available for three different linear scales, 0.5 to 1, 1 to 1, and 7.5 to 1. Test data from the Beach Erosion Board wave flume will be correlated with data from the Waterways Experiment Station flumes. Tests are being conducted using rough quarrystone and concrete quadripods.

(2685) MODEL STUDY OF WAVE ACTION, SUPERIOR ENTRY, DULUTH-SUPERIOR HARBOR, LAKE SUPERIOR.

(b) District Engineer, U. S. Army Engineer District, St. Paul, Corps of Engineers, St. Paul Minnesota.

(d) Experimental; for design.

(e) A 1:150 fixed-bed model was used that reproduced all the navigation approach channel and harbor breakwater structures as well as the inner-harbor dock area serving Superior, Wisconsin, and also included sufficient adjacent lake and shoreline areas to permit reproduction of storm waves from all critical directions. Investigations were made: to evaluate the wind-wave problems that cause ship damage in the vicinity of Superior Entry, and to develop the most effective remedy for navigation and docking hazards now experienced.

(f) Completed.

(g) Final analysis of test results indicates that a detached breakwater 900 feet long, the out limit of which is 300 feet southeast of the center line of the navigation approach channe 2,100 feet lakeward of the navigation entranc will provide adequate protection to the inner harbor against wave action.

(h) "Wave Action and Breakwater Location, Duluth-Superior Harbor," U. S. Army Engineer Waterways Experiment Station Technical Report, in publication. (Available on loan.)

(2925) ULTRASONIC FLOW MEASUREMENT.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.

(d) Experimental; development.

(e) Various types of acoustic flowmeter equipment for discharge measurement in closed rectangular and circular conduits are being investigated for proposed field application in large conduits and tunnels. Both line and point transducers are being evaluated.

(2931) MODEL STUDY OF SOUTHWEST PASS, MISSISSIPPI RIVER.

(b) District Engineer, U. S. Army Engineer District, New Orleans, Corps of Engineers, New Orleans, Louisana.

(d) Experimental; for design.

(e) To determine the effectiveness of proposed improvement works (jetty extensions, channel realinements, and contraction works) in eliminating or reducing the periodic maintenance now required in order for deep-draft vessels to navigate the jetty and bar channels of Southwest Pass, the lower 12 miles of the Pass and the adjacent area of the Gulf of Mexico were reproduced in a fixed-bed model to scale ratios of 1:500 horizontally and 1:100 vertically. Tides, tidal currents, littoral currents, and wave action in the Gulf of Mexico, and saltwater and freshwater flows in Southwest Pass and the bar channel were reproduced in the model. Shoaling studies were made by introducing various mixtures of plastic materials into the model to simulate prototype shoaling materials and thus reproduce in the model the patterns and distribution of shoaling that occur in the prototype.

(h) Final report in preparation.

(3236) MODEL STUDY OF MAXWELL LOCKS AND DAM, MONONGAHELA RIVER, PENNSYLVANIA.

(b) District Engineer, U. S. Army Engineer Dist., Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.

(d) Experimental; for desigh.

(e) A 1:120 fixed-bed type, comprehensive model, reproducing about 2.5 miles of the Monongahela River and the locks and dam structures, was used to study approach conditions under various river flows and methods of operation of control gates; to determine effects of design modifications; to develop modifications required to overcome any

undesirable conditions; and to demonstrate to navigation interests the acceptability of the proposed design from a navigation standpoint.

(h) Final report in preparation.

(3241) STUDY OF SEICHE ACTION, DULUTH-SUPERIOR HARBOR, LAKE SUPERIOR.

(b) District Engineer, U.S. Army Engineer District, St. Paul, Corps of Engineers, St. Paul, Minnesota.

(d) Analytical; for design.

(e) Water-stage and current-velocity records obtained from gages in Duluth-Superior Harbor were analyzed to determine whether seiches are the cause of strong, unpredictable currents in the entrances to the harbor which have caused hazardous navigation conditions in the area, and to provide information needed to design a hydraulic model if use of a model to study the problem is indicated.

(f) Completed.

(g) It was concluded that: (1) Hazardous currents in the entrance channels are caused by Lake Superior seiches with periods greater than the fundamental resonant period of a free oscillation in the harbor. (2) No independent seiche oscillations occurred in the harbor during the period of record. (3) The current-velocity indicators in use during the period of record did not reflect reliably the mean, midchannel velocity. (4) It was impossible to determine whether a correlation exists between current magnitude and direction in the entrance channels and ship-maneuvering difficulties because of lack of data.

(h) "Seiches and Currents in Duluth-Superior Harbor, June-November 1958; Analytical Investigation." U. S. Army Engineer Waterways Experiment Station, Miscellaneous Paper No. 2-502, June 1962. (Available on loan.)

(3242) MODEL STUDY OF CONNEAUT HARBOR, LAKE ERIE, OHIO.

(b) District Engineer, U.S. Army Engineer District, Buffalo, Corps of Engineers, Buffalo, New York.

(d) Experimental; for design.

(e) Conneaut Harbor consists of a triangular-shaped outer harbor protected by east and west breakwaters which converge to form a 600-foot-wide navigation opening, and a rectangular-shaped inner harbor with a 200-foot-wide entrance formed by east and west piers. A 1:125 model was used to determine the optimum length of east breakwater extension and optimum alignment and length of the east pier required to provide better navigation conditions at the inner-harbor entrance without increasing wave action in the inner harbor, and optimum length of detached breakwater needed to protect the outer-harbor entrance and satisfy anchorage requirements at the inner-harbor docks. The model was equipped with a wave generator that produced storm waves from all critical directions, and a circulating system that permitted simulation of currents through and past the harbor caused by seiches.

(f) Completed.

(g) Results of the investigation show that (1) the east breakwater should be extended to shore to reduce currents at the entrance to the inner harbor to an acceptable level, (2) the east pier should either be removed or shortened and realigned parallel to the west pier to provide a satisfactory width of navigation entrance without permitting increased wave action in the inner harbor, (3) a detached breakwater 900 feet long is necessary if the wave criterion for good anchorage at the docks is to be met.

(h) "Improvement of Navigation Conditions, Conneaut Harbor, Ohio; Hydraulic Model Investigation." U. S. Army Engineer Waterways Experiment Station Technical Report, in publication. (Available on loan.)

(3243) MODEL STUDY OF LOCKS AND DAM NO. 4, MONONGAHELA RIVER.

(b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.

(d) Experimental; for design.

(e) A 1:120 fixed-bed, comprehensive model, reproducing about 2.5 miles of the Monongahela River and the locks and dam structures was used to determine the effects of modifications to the existing locks and dam on navigation conditions, and to develop modifications required to overcome any undesirable conditions.

(f) Additional tests completed; final report in preparation.

(g) The last series of tests showed that additions of concrete cells at the end of the upper guard wall would tend to improve navigation conditions with the existing locks and reconstructed dam.

(3581) MODEL STUDY OF LAKE PONTCHARTRAIN, LOUISIANA.

(b) District Engineer, U.S. Army Engineer District, New Orleans, Corps of Engineers, New Orleans, Louisiana.

(d) Experimental; for design.

(e) The investigation was conducted in a fixed-bed model that reproduced to scales of 1:2,000 horizontally and 1:100 vertically, Mississippi Sound west of Grand Island, and Lakes Borgne, Pontchartrain, and Maurepas, together with significant tributaries. The model reproduced the tides, tidal currents, salinities, and freshwater discharges of the prototype. The purpose of the study was to determine the effect of proposed hurricane-surge control structures across the connections between Lake Borgne and Lake Pontchartrain upon the hydraulic and salinity regimens of the area landward from the structures.

(f) Tests completed; final report in preparation.

(g) Test results indicate that the proposed gated control structures in the Rigolets and Chef Menteur Passes, which would reduce the existing cross-sectional area of the passes by about 75 percent, would have no significant effects on the present salinity regimen of the lakes or on the passage of floods when the Bonnet Carre Spillway is in operation.

(3582) ARKANSAS RIVER CHANNEL MODEL.

(b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.

(d) Experimental; for design.

(e) The Arkansas River project has as one of its major aims the development of river navigation from the Mississippi River to the general area of Tulsa, Oklahoma. The Arkansas River channel model was of the movable-bed type with a horizontal scale of 1:150 and a vertical scale of 1:36, and reproduced a typical reach of the Arkansas River between miles 140.0 and 151.1. The model study constituted an idealized experimental approach to the solution of sedimentation problems involved in the canalization of the Arkansas River and was designed to investigate problems typical of, and to provide results generally applicable to the development and maintenance of a navigable channel on the river.

(f) Completed.

(g) Principal conclusions derived from the study were: (1) A dredged cut without an appreciable reduction in the river's sediment load or the addition of regulatory works would only temporarily affect channel conditions. (2) Regulating structures to increase the radius of curvature of bends would tend to provide a more uniform channel cross section

and improve channel alignment over crossings. (3) Controlling depths and the alignment of the channel over a crossing could be improved by the proper design of the lower reach of the upstream bend. (4) Longitudinal groins would be effective in fixing the location and alignment of the channel over crossings, and would produce some deepening of the channel over the crossings.

(h) "Development and Maintenance of Navigation Channel, Arkansas River, Arkansas and Oklahoma; Hydraulic Model Investigation." U. S. Army Engineer Waterways Experiment Station Technical Report No. 2-608, August 1962. (Available on loan.)

(3584) MODEL STUDIES OF RED ROCK DAM, DES MOINES RIVER, IOWA.

(b) District Engineer, U. S. Army Engineer Disrict, Rock Island, Corps of Engineers, Rock Island, Illinois.

(d) Experimental; for design.

(e) A 1:50 model that reproduced 900 feet of the approach channel above the spillway, an 825-foot-wide section along the dam, the spillway, conduits, stilling basin, and 575 feet of the outlet channel, and a 1:16 model that reproduced one conduit and a 16-foot-wide portion of the spillway and stilling basin were used to study flow conditions in the approach, particularly at the abutments, to verify stilling basin and training wall design, to evaluate reduction in conduit flow during combined operation, to determine the need for armor plate at the outlet portal, and to study the effects of deflectors above the conduit outlet portals.

(g) The general model provided information on spillway capacity as affected by abutment changes; velocities in the approach, particularly against the dam; optimum basin elevation consistent with safety and economy; basin elements of minimum size; and bottom velocities in the exit channel.

(h) Final report in preparation.

(3586) MODEL STUDY OF HOPPER DRAGHEAD.

(b) District Engineer, U.S. Army Engineer District, Philadelphia, Corps of Engineers, Philadelphia, Pennsylvania,

(d) Experimental; for design.

(e) To develop improved dragheads designed to attain a greater rate of intake of solids when dredging mud and silt mixtures (soft materials) and dredging densely packed, fine sand (hard material), an investigation is being conducted in a 60- by 10-foot flume containing various types of bed material. The draghead and suction line, constructed to a scale of 1:6, are connected to a suction pump mounted on a double carriage that provides travel, both longitudinally and transversely, along the top of the flume.

(g) For dredging in sand, it was concluded that: (1) no correlation can be made between the performance of a draghead pumping water and dredging a sand-water mixture; (2) the length and shape of the grate perimeter are of prime importance since the primary "digging" capability results from the relatively high-velocity flow entering around the perimeter; (3) the grate area, formerly considered important, is relatively unimportant since it was found to be larger than required on all dragheads in use as well as on those of a practicable type tested; and (4) dragheads should be rectangular in plan, as wide as possible and only about 3 feet long, with a relatively thin grate perimeter held 1 to 3 inches off the sand bed.

(3587) MODEL STUDIES OF JOHN REDMOND DAM, GRAND RIVER, KANSAS.

(b) District Engineer, U.S. Army Engineer District, Tulsa, Corps of Engineers, Tulsa, Oklahoma.

(d) Experimental; for design.

(e) A 1:100 model that reproduced 2,900 feet of the approach channel above the spillway, the spillway, stilling basin, and 2,450 feet of the outlet channel, and a 1:36 model that reproduced one full bay and two half bays of the spillway and the stilling basin were used to study flow conditions in the shallow, curved spillway approach channel; to verify capacity of the structure and adequacy of the stilling basin and exit channel; and to determine minimum requirements for training walls.

(f) Completed.

(g) The model study showed that the desired spillway capacity could be obtained by deepening the approach channel 15 feet for 200 feet upstream of the weir, revising the weir profile, and installing a stub dike at the right abutment. A satisfactory stilling basin was developed at the desired elevation, consisting of a horizontal apron with two rows of baffle piers and an end sill. At the design discharge, natural tailwater provided 87 percent of the optimum depth for a hydraulic jump. Exit channel excavation was reduced by contracting the channel width beginning 250 feet below the end sill. The tops of the stilling basin training walls were lower than required to contain the design discharge; however, the only harmful effect from flow overtopping the training walls was eddy action along the left spillway embankment toe. A 250-foot-long stub dike set back from the left training wall satisfactorily reduced velocities along the embankment and would be less costly than higher training walls.

(h) "Spillway for John Redmond Dam, Grand (Neosho) River, Kansas; Hydraulic Model Investigation." U. S. Army Engineer Waterways Experiment Station Technical Report No. 2-611, Nov. 1962. (Available on loan.)

(3588) MODEL STUDY OF SPILLWAY, BIG BEND RESERVOIR, MISSOURI RIVER, SOUTH DAKOTA.

(b) District Engineer, U.S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Nebraska.

(d) Experimental; for design.

(e) A 1:60 model, reproducing 2,400 feet of the curved approach channel, the spillway and stilling basin, and 1,000 feet of the exit channel, was used to determine: (1) velocity and flow characteristics in the approach channel and chute on weir discharges; and (3) stilling basin behavior with tailwater depths insufficient for ideal performance of a hydraulic jump-type basin, and exit channel velocity and scour data.

(f) Completed.

(g) In the spillway approach, realignment of a spur dike and installation of elliptical abutment walls corrected turbulent flow conditions in the spillway bays adjacent to the right abutment. Also minimum excavation in the approach area was determined. The spillway weir and chute were satisfactory. A stilling basin was developed in which 12-foot-high baffle piers eliminated spray action and resulted in satisfactory flow in the basin. Return walls of two different designs were developed that improved flow conditions below the stilling basin.

(h) "Spillway for Big Bend Dam, Missouri River, South Dakota; Hydraulic Model Investigation." U. S. Army Engineer Waterways Experiment Station Technical Report No. 2-605, June 1962. (Available on loan.)

(3590) EFFECTS OF HURRICANE BARRIER ON NAVIGATION CONDITIONS IN EAST PASSAGE, NARRAGANSETT BAY, RHODE ISLAND.

(b) Division Engineer, U.S. Army Engineer Division, New England, Corps of Engineers, Waltham, Massachusetts.

(d) Experimental; for design.
(e) A 1:150 model is being used to determine the effects of tidal and hurricane surge currents, waves, and winds on the operation of an aircraft carrier in East Passage. A barrier across East Passage has been proposed to limit the quantity of water entering Narragansett Bay from hurricane surge, and the model study will examine ship navigation conditions with respect to barrier location and its navigation opening. A self-propelled, radio-controlled, model aircraft carrier, dynamically similar to its prototype, is being used in the tests.
(g) Flume tests are being conducted to determine the design of a barrier opening which would have the desired flow characteristics. Tests are being conducted to establish the current patterns and magnitudes which would affect navigation. Tests showed that an aircraft carrier can satisfactorily maneuver in all storm conditions up to and including the 1938 hurricane, with hurricane tide currents up to 12 knots, if the barrier is constructed. The currents resulting from astronomical tides are being studied.

(3592) MODEL STUDY OF TYPICAL NAVIGATION DAM, ARKANSAS RIVER.

(b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.
(d) Experimental; for design.
(e) The Arkansas River multipurpose project includes the development of river navigation from the Mississippi River to the general area of Tulsa. Present plans for navigation include construction of several navigation locks and dams. The purposes of the model study were to investigate various problems that occur in the vicinity of the structures. The investigation was conducted on a movable-bed model constructed to linear scales of 1:120 horizontally and 1:40 vertically, reproducing a 5-mile reach of a typical stream having characteristics generally similar to reaches of the Arkansas River, including a typical Arkansas River lock and dam structure.
(h) Preparation of final report in progress.

(3596) HYDRAULIC STUDIES FOR IMPACT ENERGY DISSIPATOR DESIGN.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
(d) Experimental; applied research.
(e) A general investigation to determine the energy loss coefficient of an impact energy dissipator of variable height and depth for varying slopes, diameters, and energy of flows of the incoming pipe was conducted on a 1.0-foot-diameter impact energy dissipator. The dissipator consisted of a vertical section of circular pipe affixed to the outlet end of a storm drainage outfall, termed a stilling well. The energy of the influx was determined from measurements of the discharge and the hydraulic gradient, and the energy of the efflux from measurements of the water surface above the top of the well. The slope and size of the incoming pipe were varied to determine the effect of each upon the energy dissipated. For a particular slope and diameter of the incoming pipe and a particular height and depth of the dissipator above the invert of the incoming pipe, the relative energy content of the efflux to the influx was determined for a range of Reynolds numbers to ascertain the effect of Reynolds number upon the energy loss in the dissipator.
(f) Tests completed.
(g) Test results indicate that there is an optimum depth of the stilling well below the invert of the incoming pipe, dependent on the slope of the incoming pipe. Limited tests indicated that there is also an optimum height of the well above the pipe invert for each given set of conditions. In regard to energy dissipation, test results show that the smaller the ratio of the diameter of the incoming pipe to that of the stilling well and the flatter the slope of the incoming pipe, the greater the value of the energy loss coefficient. The energy loss coefficient is less for full pipe flow than for partial pipe flow.
(h) Final report in preparation.

(3597) CORRUGATED PIPE ROUGHNESS STUDY.

(b) Office of the Chief of Engineers, Department of the Army, and Bureau of Public Roads, Department of Commerce, Washington, D.C.
(d) Experimental; applied research.
(e) This is a general investigation to determine a resistance coefficient and the law of velocity distribution for flow in structural-plate corrugated pipe. A fiber-glass test section reproducing a 5-foot-diameter standard corrugated pipe at a scale of 1:4 was tested in order to obtain additional data on the resistance coefficient and velocity distribution and to correlate model work with full-scale tests. Fiber-glass test sections reproducing a 5-foot-, 10-foot-, and 20-foot-diameter structural-plate pipe at scales of 1:2.2, 1:8, and 1:16, respectively, were tested to determine the effect of relative roughness upon the resistance coefficient and velocity distribution. The hydraulic gradient and the energy loss through 20- to 80-diameter lengths of test section were established by piezometers located at 5-foot intervals. These piezometers were 1/8 inch in diameter, on center of the crests of the corrugations, and four in number around the periphery of the pipe. Velocity traverses were made by means of calibrated pitot tubes at several locations along the test section for determination of the velocity distribution.
(f) Tests completed.
(g) Tests conducted on the model reproducing standard corrugations at a scale of 1:4 have been completed and the results of tests for a range of Reynolds numbers from 4×10^4 to 2×10^6 agree favorably with results of full-scale studies made at Bonneville Hydraulic Laboratory. Results of tests on the models simulating 5-foot-, 10-foot-, and 20-foot-diameter structural-plate pipes indicate maximum Manning's "n" of 0.033, 0.032, and 0.030, respectively. Velocity distribution data in an overlapping range of wall Reynolds numbers in the models of a 5-foot- and 10-foot-diameter pipe yielded a mean flow equation or law of velocity distribution from which the roughness factor for any size structural plate pipe can be computed.
(h) Final report in preparation.

(3598) MODEL STUDIES OF CONTAMINATION DISPERSION IN ESTUARIES.

(b) Nuclear Projects Office, Maritime Administration, U.S. Department of Commerce.
(d) Experimental: applied research.
(e) The increasing use of nuclear reactors in the production of automotive power, both on land and sea, presents new problems pertaining to the dispersal of radioactive waste released either accidentally or purposely into rivers, estuaries, and harbors. The Maritime Administration is concerned with the probable dispersion patterns of radioactive matter that might be released in accidents involving nuclear-powered ships. A series of tests was made on several existing models of important estuaries, including the Delaware River, Narragansett Bay, New York Harbor, and San Francisco Bay, in order to obtain data from which dispersion effects could be computed. Tides, tidal currents, salinities, and fresh-water flow were reproduced for all

tests. Methylene blue chloride dye was used to simulate contamination, and the dye releases were generally made at the most adverse time of tide in relation to the potential upstream spread of the contaminant. Water samples were obtained periodically throughout contaminated area for spectrophotometer analysis, and in addition, meters which automatically measured and recorded dye concentrations were in continuous operation at strategic locations. Results obtained are expressed as percentages of the initial concentration.

(f) Completed.

(h) "Contamination Dispersion in Estuaries, San Francisco Bay; Hydraulic Model Investigation." U. S. Army Engineer Waterways Experiment Station Miscellaneous Paper No. 2-332, Report 4, August 1962. (Available on loan.)

(3902) RADIOACTIVE TRACER TESTS OF SEDIMENT, GALVESTON BAY, TEXAS.

(b) District Engineer, U.S. Army Engineer District, Galveston, Corps of Engineers, Galveston, Texas.

(d) Experimental; field investigation.

(e) The movement of sediment in the vicinity of the Galveston Bay jetty was investigated by use of radioactive gold-impregnated glass. The glass was ground to the particle size of the natural sediment. In the first series of tests, the activated, gold-impregnated glass was deposited at three locations on the north side of the jetty, and the paths of the particles were traced by instruments from a small boat. Readings were procured over a period of about one week. It was expected that the tidal action, littoral current, and wind waves would move the material around the end of the jetty and/or through the jetty. In a second series of tests, the tracer material was deposited at five additional locations north of the north jetty. These locations extended the area under study beyond the end of the jetty.

(g) In the first series of tests, some of the radioactive material passed through a small boat opening in the jetty, and further tests were needed to determine whether any material passes around the end of the jetty. In the second series of tests, the bulk of material deposited near the end of the jetty swept around the end into the ship channel and was randomly distributed over the area between the jetties.

(3903) MODEL STUDY OF TSUNAMIS AT HILO HARBOR, HAWAII.

(b) District Engineer, U.S. Army Engineer District, Honolulu, Corps of Engineers, Honolulu, Hawaii.

(d) Experimental; for design.

(e) A fixed-bed hydraulic model is proposed to determine the optimum plan of protection for Hilo Harbor from attack by tsunamis. This model will be used to investigate the effects of different plans of construction on the reduction of damage to the city of Hilo from tsunamis, and to determine the stability of the proposed breakwater under tsunami attack. The model will also be used to investigate surge action and damaging ship motion in the vicinity of the piers.

(g) Design of model is in progress. A pilot model study to investigate model distortion and scale effects is being conducted.

(3905) KELLEYS ISLAND HARBOR STUDY, LAKE ERIE, OHIO.

(b) State of Ohio.

(d) Analytical; for design.

(e) An analytical study was conducted to determine the characteristics of short-period wind waves which occur at the site of the proposed Kelleys Island harbor of refuge. Deepwater waves were charted into the position of the harbor entrance by use of refraction diagrams. The resulting data were used to determine the optimum alinement of the navigation opening, and the need for, and approximate length of a protecting breakwater.

(f) Final report in preparation.

(3906) POWER PLANT TRANSIENTS TESTS, GARRISON AND OAHE DAMS, MISSOURI RIVER, NORTH DAKOTA.

(b) Division Engineer, U.S. Army Engineer Division, Missouri River, and District Engineer, U.S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Nebraska.

(d) Field investigations; applied research and design.

(e) Hydraulic prototype measurements of power plant transients at Garrison Dam have been made to evaluate results of a comprehensive digital computer study made by the sponsoring offices, and to determine extent to which operation corresponds to design in order to develop a solution of the entire problem of power plant transients, with primary emphasis on governing stability. For different plant loadings, instantaneous pressure values at a number of locations in the power tunnel, the surge tank system, turbine scroll case, and draft tube were obtained simultaneously with instantaneous values of tunnel velocity, reservoir and tailwater elevations, turbine speed and gate opening, power output and other elements (including governor system). Pressure and water level were measured with electrical pressure transducers, velocities with pressure transducers mounted in probes projecting into the flow, and mechanical and electrical values with appropriate transducers. Measurements were recorded on about 90 channels of oscillograph and magnetic tape recorders. Tests at Oahe Dam will be made in the spring of 1963.

(g) Approximately 150,000 data points have been digitized from about 10 miles of multichannel oscillograph charts. These data are being analyzed by the sponsoring offices.

(3907) SHOALING PROCESSES.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.

(d) Experimental; for design.

(e) The annual cost to the Federal Government of maintaining navigable channels in tidal waterways is estimated to be of the order of $60,000,000. The Corps of Engineers Committee on Tidal Hydraulics has concluded that a thorough study of shoaling processes in tidal waterways would lead to improvements in channel design, dredging, and spoiling practices, and other maintenance techniques which would reduce this large expenditure. The Committee concludes that the following program of research is essential in arriving at the objective of reducing maintenance cost: (1) Flume studies to determine the basic laws involved in the movement and deposition of muddy sediments; (2) flume studies to determine effects of repetitive scour and deposition on sedimentation; (3) the development of techniques for using radioactive tracers for observing the movement and deposition of sediments in nature; (4) the development of a simple and accurate instrument for in-place measurement of turbidity; (5) a study of the physical, chemical, and hydraulic factors involved in the stabilization of deposits in navigable channels; (6) determination of the effects of flocculation on shoaling; (7) prototype studies aimed at correlation of sedimentation phenomena in tidal waterways with physical, chemical, hydraulic, salinity, and other significant factors; and (8) classification of the sediments which constitute all major repetitive shoals in tidal waterways. Item (1) was completed under terms of a contract between the University of California and the U. S. Army Engineer District, San Francisco, and

all pertinent reports have been published; item (2) is presently inactive; item (3) is in active status by the U. S. Army Engineer Waterways Experiment Station and U. S. Army Engineer Districts, Galveston and Wilmington; item (4) is presently inactive; item (5) is being investigated under terms of a contract between the University of Calif. and the U. S. Army Engineer Waterways Experiment Station; item (6) is under study by the Committee on Tidal Hydraulics and the U. S. Army Engineer Waterways Experiment Station; and items (7) and (8) are in progress by the U. S. Army Engineer Waterways Experiment Station. No definite conclusions have yet been reached as a result of these studies.

(3908) ARKANSAS RIVER NAVIGATION MODEL.

(b) District Engineer, U.S. Army Engineer District, Vicksburg, Corps of Engineers, Vicksburg, Mississippi.
(d) Experimental; for design.
(e) A fixed-bed model reproducing to scales of 1:600 horizontally and 1:100 vertically about 33 miles of the Mississippi River near the mouths of the White and Arkansas Rivers, 57 miles of the lower Arkansas River, 12 miles of the lower White River, and the major portion of the White-Arkansas River backwater area was used for the investigation. The model was used to demonstrate alternate routes for the entrance to the Arkansas River navigation project, flow patterns, nature of overbank flow, effect of Arkansas-White Cutoff, and problems related to the location and alighment of the navigation entrance to the Arkansas River from the Mississippi River.
(h) Final report in preparation.

(3911) MODEL STUDY OF MATAGORDA SHIP CHANNEL, TEXAS.

(b) District Engineer, U.S. Army Engineer District, Galveston, Corps of Engineers, Galveston, Texas.
(d) Experimental; for design.
(e) The fixed-bed model, constructed to scale ratios of 1:1,000 horizontally and 1:100 vertically, reproduces about 800 square miles of prototype area, including all of Matagorda Bay, part of the connecting bay system, and a portion of the Gulf of Mexico adjacent to Pass Cavallo. Tides and tidal currents are reproduced by one primary tide generator and one secondary tide generator, and fresh-water discharges of tributaries, together with the rainfall over the area, are introduced by means of weirs and flowmeters. Salt water is used in the model gulf to reproduce the prototype salinity regimen, and provisions have been made for the injection of silt in the model for measurements of deposits on the bed of the model. Studies will be made to determine: (1) The best location for the entrance channel; (2) the best route for the channel from the entrance to Point Comfort; (3) such protective works as may be required in the interests of navigation and maintenance of the channel; and (4) the effects of the deep-draft navigation channel on the salinity regimen of the bay system.
(g) Test results indicate that proposed channel route C is superior to any of the other channel routes tested. Tests to determine the optimum jetty arrangement at the channel entrance have been completed; the optimum arrangement of spoil disposal areas inside the bay has been developed on the basis of model tests, and the effects of the project on the hydraulic and salinity regimens of the bay have been determined.

(3912) MODEL STUDY OF GALVESTON BAY, TEXAS.

(b) District Engineer, U.S. Army Engineer District, Galveston, Corps of Engineers, Galveston, Texas.
(d) Experimental; for design.
(e) A movable-bed model, with scale ratios of 1:500 horizontally and 1:100 vertically, reproduces about 174.5 square miles of prototype area, including a small portion of Galveston Bay and a portion of the Gulf of Mexico extending 8 miles north of the north jetty, 6-1/2 miles south of the south jetty, and offshore to about the 50-foot contour of depth. Tides, tidal currents, littoral currents, and wave action in the Gulf of Mexico are reproduced. Studies are being made to determine: (1) Plans for relocation and stabilization of the jetty channel on an alinement and depth suitable for navigation of supertankers; (2) means of protecting the north jetty from undermining action of tidal currents; (3) shoaling characteristics of the relocated and deepened jetty (inner bar) channel and plans for minimizing shoaling; and (4) shoaling characteristics of the deepened outer bar channel. Verification of bed movement and deposition has been accomplished, and the model is ready for testing proposed improvement plans.

(3913) MODEL STUDY OF GULF OUTLET CHANNEL, LOUISIANA.

(b) District Egineer, U.S. Army Engineer District, New Orleans, Corps of Engineers, New Orleans, Louisiana.
(d) Experimental; for design.
(e) The investigation is being conducted in a fixed-bed extension of the Lake Pontchartrain model and in conjunction with that model study. Reproduced is that area eastward of New Orleans to Breton Sound and south of Lakes Pontchartrain and Borgne to include the connecting waterways between those lakes and the Gulf Outlet Channel, now under construction. Scales are 1:2,000 horizontal and 1:100 vertical. Tides, tidal currents, salinities, and water exchange through the connecting waterways are simulated. Purpose of the study was to determine the effect of the channel on the salinity regimens of Lakes Pontchartrain and Borgne, which will be connected to the channel by existing waterways.
(h) Final report in preparation.

(3914) MODEL STUDY FOR MODERNIZATION OF EXISTING LOCK, McALPINE LOCKS, OHIO RIVER.

(b) District Engineer, U.S. Army Engineer District, Louisville, Corps of Engineers, Louisville, Kentucky.
(d) Experimental; for design.
(e) A 1:25 model which reproduced the filling and emptying system was used to develop feasible modifications which will improve prototype performance.
(h) Final report in preparation.

(3915) MODEL STUDY OF DROP STRUCTURE, GERING VALLEY PROJECT, GERING VALLEY, NEBRASKA.

(b) District Engineer, U.S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Nebraska.
(d) Experimental; for design.
(e) A 1:12 model reproducing successively three typical drop structures, adjacent overbank areas, and 300 feet of the approach and exit areas was used to examine the hydraulic performance of the drop structures, which will vary in width from 6 to 33 feet and have drop heights of 5 and 10 feet.
(f) Tests completed.
(g) Families of curves were developed to permit selection of drop structure design based on drop and discharge conditions. A satisfactory plan for the placement of riprap material in the vicinity of the structure was developed.
(h) Final report in preparation.

(3916) MODEL STUDY OF OAHE RESERVOIR SPILLWAY,

MISSOURI RIVER, SOUTH DAKOTA.

(b) District Engineer, U.S. Army Engineer District, Omaha, Corps of Engineers, Omaha Nebraska.
(d) Experimental; for design.
(e) A 1:50 model reproduced the remote, gated control structure which will serve as the spillway, along with approximately 3,000 feet of approach and exit channel. The model study was intended to: (1) indicate head losses through structure and in channel, and provide data on flow patterns and velocities; (2) verify discharge data for gate bays; and (3) develop design of stilling basin, and of transition from stilling basin to sloped sides of exit channel.
(h) Final report in preparation.

(3917) GENERAL SPILLWAY MODEL TESTS.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D.C.
(d) Experimental; for design.
(e) Tests are made on various elements of spillways to develop improved designs and to better define values of coefficients used in design formulas. A series of tests is being conducted on low weirs to determine optimum shape from a consideration of discharge coefficients and pressures.
(g) The desirability of a weir crest shape tangent to the upstream face of the weir was established. This applies to weirs with sloping or vertical upstream faces. A design procedure for developing the shape for the upstream quadrant of the crest of a weir with a vertical upstream face was developed. This procedure results in an elliptical shape with axes depending on height of weir and expected head.

(3918) MODEL TESTS FOR TYPICAL FLOOD- AND WATER-CONTROL STRUCTURE.

(b) District Engineer, U.S. Army Engineer District, Jacksonville, Corps of Engineers, Jacksonville, Florida.
(d) Experimental; for design.
(e) A 1:16 model, reproducing 384 feet of the approach channel, an 81.33-foot-wide 3-bay structure, the spillway, stilling basin, and 192 feet of the outlet channel, was used to determine the discharge coefficient and flow conditions of similar project structures having various approach and exit channel elevations for both controlled and uncontrolled flows.
(f) Final report in preparation.
(g) As expected, results indicated that the greater the depth of approach and/or difference in elevation between weir crest and exit channel, the greater the discharge coefficient for all flow conditions. The effects of both on the discharge coefficients are shown by means of graphical plots. Expressions describing free and submerged controlled and uncontrolled flow conditions and parameters that will define the limits of each of the four possible flow conditions were determined.

(3919) MODEL STUDY OF ALLEGHENY DAM, ALLEGHENY RIVER, PENNSYLVANIA.

(b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
(d) Experimental; for design.
(e) A 1:36 model reproduced a 375-foot-wide section of the approach, the entire spillway and portions of each abutment, the six low-level sluices and two high-level sluices, the stilling basin, and a 425-foot-wide section of the exit channel. The model provided a means for determining sluice design, spray wall heights, and stilling basin design. Weir calibration data and pressures were determined.
(f) Completed.
(g) Tests indicated that the maximum expected discharge (140,000 cfs) would be satisfactorily passed by the spillway and six low-level sluices at a head of 29 feet. The high-level sluices (to be used to draw warm water off top of reservoir in summer), discharging through the spillway spray walls with their major axes parallel to the spillway slope, effectively spread flow across the spillway weir. A horizontal low-level sluice with flared exit and tetrahedral deflector provided good flow distribution in the basin. The stilling basin effected satisfactory energy dissipation with the apron raised 3 feet and the height of the baffle piers decreased 3 feet.
(h) "Spillway and Sluices, Allegheny Dam, Allegheny River, Pennsylvania and New York; Hydraulic Model Investigation," U. S. Army Engineer Waterways Experiment Station Technical Report, in publication. (Available on loan.)

(4382) HYDRAULIC PROTOTYPE TESTS.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
(d) Field investigations for applied research and design.
(e) The hydraulic prototype testing program of the Corps of Engineers is coordinated for complete coverage of needed testing, prevention of unnecessary duplication of testing facilities and tests, recommendations of installations at projects where physical and hydraulic conditions will be suitable for obtaining data, and investigation of prototype hydraulic performance. Personnel and equipment are made available to Corps of Engineers Districts conducting hydraulic field tests. Assistance also is given in planning test facilities, analyzing data, and preparing reports.
(g) Surface profiles and vertical velocity profiles were measured in the chute spillway at Fort Randall Dam for discharges giving uniform flow depths of 2.2 to 3.4 feet and velocities of 35 to 45 feet per second, piezometric pressures were obtained along a tunnel approximately 19 feet in diameter at Oahe Dam for average velocities between 10 and 60 feet per second, and lock hawser stresses for a 9,300-ton tow were measured during filling and emptying operations at Jackson Lock. (See also item 4397 on McAlpine Lock emergency gate, item 3906 on power plant transients tests, and item 2925 on ultrasonic flow measurement.)
(h) "Flow Characteristics in Flood-Control Tunnel 10, Fort Randall Dam, Missouri River, South Dakota; Hydraulic Prototype Tests," U. S. Army Engineer Waterways Experiment Station Technical Report, in publication. (Available on loan.)

(4383) MODEL STUDY OF TURTLE CREEK CHANNEL IMPROVEMENT, PENNSYLVANIA.

(b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
(d) Experimental; for design.
(e) To evaluate proposed channel improvements and determine the necessity for raising bridges and modifying piers and abutments, a 1:50 model reproducing the lower 7,700 feet of Turtle Creek channel was used. The model included provisions for testing plans with the existing and improved channels in the lower, 1,500-foot reach of the channel.
(h) Final report in preparation.

(4384) MODEL STUDY OF SPILLWAY, PROCTOR RESERVOIR, LEON RIVER, TEXAS.

(b) District Engineer, U.S. Army Engineer District, Fort Worth, Corps of Engineers, Fort Worth, Texas.

(d) Experimental; for design.
(e) A 1:40 model reproducing a center bay and adjacent half bays of the spillway and stilling basin, and 400 feet of approach and exit areas, was used to verify the weir coefficients by means of head-discharge relations and pressure measurements on the spillway, and to determine the effect of varying the depth of approach and the weir shape on these conditions. Results will be used for other projects with similar weir shapes.
(g) Decreasing depth of approach increased weir coefficients slightly; however, pier contraction coefficients were also increased. Making crest shape tangent to upstream face of weir increased weir coefficients. Cover plates were used over the bulkhead slots to reduce negative pressures in this area.
(h) Final report in preparation.

(4385) MODEL STUDY OF BELLEVILLE LOCKS AND DAM, OHIO RIVER, OHIO AND WEST VIRGINIA.

(b) District Engineer, U.S. Army Engineer District, Huntington, Corps of Engineers, Huntington, West Virginia.
(d) Experimental; for design.
(e) The project involves construction of a nonnavigable-type dam with parallel locks; the main lock will be 1,200 feet by 110 feet and the auxiliary lock 600 feet by 110 feet. A 1:120 fixed-bed model reproducing about 3 miles of the river was used to study navigation conditions in the lock approaches and the effects of the structures on flood stages.
(f) Suspended.
(g) With the original design, currents hazardous to navigation formed in the upper approach to the locks. Shifting of the locks landward and increasing the number of gate bays in the dam tended to improve navigation conditions in the upper approach. No serious navigation difficulties were indicated in the lower approach to the locks.

(4386) MODEL STUDY OF HOLT LOCK AND DAM, WARRIOR RIVER, ALABAMA.

(b) District Engineer, U.S. Army Engineer District, Mobile, Corps of Engineers, Mobile, Alabama.
(d) Experimental; for design.
(e) A 1:80 model, reproducing the structures, 4,800 feet of the approach channel and 4,800 feet of the exit channel, was used to study flow conditions in the lock approaches and in the approach and exit channels for all arrangements of the structures. A 1:36 section model reproducing one full bay and two adjacent half bays of the spillway and stilling basin was utilized for studies of the adequacy of the weir and stilling basin design. A 1:25 model reproducing 800 feet of the lock approach channel, intake manifolds, the 670-foot lock chamber, culverts, bottom laterals, outlet stilling basin, and 730 feet of the downstream exit channel was used to study various types of filling and emptying systems to determine the most advantageous system from the standpoints of rate of operations, degree of turbulence, and economy. A 1:15 model of a culvert valve was used to study proposed valve designs.
(f) Tests completed.
(g) The 1:80 general model indicated the overall arrangement and location of the structures to be generally satisfactory; installation of a 300-foot-long dike in the downstream river channel afforded some improvement in flow conditions in the lower lock approach. Tests on the 1:36 section model indicated that the 80-foot-long apron-type basin can be replaced with a small 20-foot-radius bucket. In the 1:25 lock model the original design laterals were revised for better flow distribution between the 12 ports. The bottom middle-third lateral system was found to be feasible. Increasing the spacing between the laterals in this system improved its performance. The final design middle-third system consisted of 12 laterals spaced on 17-foot centers with the first lateral 237 feet below the upstream miter gate pintle. A satisfactory split lateral filling system was also developed, consisting of 12 laterals divided into two groups of six each at 17-foot centers. The land-wall group began 177 feet from the upstream miter gate pintle and river-wall group began 401 feet from the upper miter gate pintle. A vertically framed culvert valve was developed in 1:15 valve model.
(h) Final report in preparation.

(4387) MODEL STUDY OF WILLOW SPRINGS AND SAG JUNCTION DIVERSIONS, CHICAGO SANITARY AND SHIP CANAL, ILLINOIS.

(b) Metropolitan Sanitary District of Greater Chicago, Chicago, Illinois.
(d) Experimental; for design.
(e) Tests were conducted on two 1:60 models, reproducing the diversion channels and a portion of the Sanitary and Ship Canal at each location, to determine the effect of crosscurrents on navigation and to verify or further develop the hydraulic design of the diversion channels and appurtenant hydraulic structures. A 1:16 section model was used for study of control structures.
(f) Tests completed.
(g) Strong crosscurrents in the canal adjacent to the Willow Springs diversion were improved by adjusting the heights of the curtain walls in the bridge bays to obtain equal distribution of flow through the bridge. Design capacity of the Willow Springs diversion can be met with only seven gate bays while ten are provided. Design capacity of the Sag Junction diversion can be met with the seven gate bays provided in the original design. Satisfactory flow distribution obtained through the diversion bridge and control structure at Sag Junction as well as satisfactory navigation conditions in the Sanitary Canal. Operation data were obtained for a full range of hydraulic conditions on both diversion studies. Single gate hydraulic conditions and stilling basin action below the control gates were studied in the section model.
(h) Final report in preparation.

(4388) SECTION MODEL STUDY OF LOCK AND DAM NO. 6, ARKANSAS RIVER, ARKANSAS.

(b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.
(d) Experimental; for design.
(e) A 1:25 section model, reproducing a 5-foot depth of approach channel, one 60-foot gate bay and two adjacent half bays, the spillway stilling basin, and outlet channel, is being used to determine the optimum parabolic shape of the downstream face of the gate sill, the dimensions and elevation of the stilling basin, the shape of the gate piers, the spillway rating curves with full and partially opened gates, and the minimum riprap requirements for various elevations of the exit channel.
(f) Tests completed; final report in preparation.
(g) Tests regarding shape of the gate piers indicated that either the semicircular or ogival pier nose was satisfactory; however, the ogival pier nose yielded a slightly greater value of the discharge coefficient. Tests on the parabolic gate sill shape based on the trajectory of a free jet showed that a parabola based on a 10-foot head rather than the original 24-foot head would result

in desirable basin action under all expected conditions. This allows a 13.5-foot reduction in length of gate sill without serious negative pressures. Tests indicated that the apron elevation, within the limits investigated, had no effect on the discharge characteristics of the structure. Expressions describing free and submerged controlled and uncontrolled flow conditions were determined. Tests of stilling basin performance were conducted for a wide range of pool and tailwater elevations. The optimum slope of scour below the stilling basin was indicated to be 1 on 6. In tests to determine the stability of 18-, 24-, and 36-inch maximum size riprap, the relations between tailwater elevation and gate opening at which each of the protective stone sizes failed for heads of 15 and 30 feet were determined.

(h) Final report in preparation.

(4389) MODEL STUDY OF WAVE ACTION, LORAIN HARBOR, OHIO.

(b) District Engineer, U.S. Army Engineer District, Buffalo, Corps of Engineers, Buffalo, New York.
(d) Experimental; for design.
(e) A 1:125 fixed-bed model was used to determine the influence of storm wave action and attendant currents in causing navigation hazards at Lorain Harbor which is located at the mouth of Black River on the south shore of Lake Erie. The model reproduced about 8.3 square miles including all the area within the harbor and sufficient adjacent lake area to permit reproduction of waves from all critical directions. Waves are generated in the model by a 60-foot-long plunger-type wave machine and wave heights were measured electrically by an oscillograph.
(f) Completed.
(g) Five of the ten improvement plans tested met the wave-height and current-velocity criteria selected for the navigation entrance and mooring area of the harbor. The recommended plan, selected from these five on the basis of economy, provides for a 2,250-foot-long detached breakwater and the removal of 300 feet of the existing east breakwater.
(h) "Detached Breakwater and Improved Navigation Entrance, Lorain Harbor, Lorain, Ohio," U. S. Army Engineer Waterways Experiment Station Technical Report, in publication. (Available on loan.)

(4390) MODEL STUDY OF CANNELTON LOCKS AND DAM, OHIO RIVER, INDIANA AND KENTUCKY.

(b) District Engineer, U.S. Army Engineer District, Louisville, Corps of Engineers, Louisville, Kentucky.
(d) Experimental; for design.
(e) The project involves the construction of a nonnavigable dam with parallel locks, the main lock to have clear dimensions of 1270 by 110 feet and an auxiliary lock, 600 by 110 feet. A 1:120 model reproducing about 9 miles of the river is used for investigation of navigation conditions in the lock approaches, effects of the structures on flood stages, to obtain data for development of rating curves, and to determine the effect of powerhouse installation on flow and navigation conditions. A 1:25 model, reproducing 500 feet of the lock approach channel, intake manifolds, the 1270-foot lock chamber, culvert, sidewall port manifolds, outlets, and 200 feet of the downstream exit channel is being used to determine the suitability of a sidewall port filling system under heads and submergences which will obtain at the Cannelton and Belleville Locks, Ohio River.
(g) Tests on the 1:120 general model indicated that velocities in the upper lock approach would tend to be high and downbound tows would experience difficulty in approaching the locks because of the velocity and alignment of currents in the approach. Plans were developed which would reduce velocities in the upper approach and minimize the tendency for tows to be moved riverward of the guard wall. A submergible-type gate placed next to the locks would tend to pass little drift and ice since most of the flow through the ports tends to move over the gate. Lock emptying outlets without stilling basins would tend to produce a strong eddy in the lower lock approach which would be objectionable to navigation during low flows. Initial tests in the 1:25 model indicate that a feasible sidewall port arrangement can be developed.

(4391) MODEL STUDY OF LOCK AND DAM NO. 3, ARKANSAS RIVER, ARKANSAS.

(b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.
(d) Experimental; for design.
(e) A movable-bed model reproducing about 13 miles of the Arkansas River and adjacent overbank area, constructed to a scale of 1 to 120 horizontally and 1 to 80 vertically, is being used to determine the suitability of the proposed site for the lock and dam structure, the effects of proposed regulating works in the vicinity including a cutoff, and modifications which might be required to provide adequate channel depths in the lock approaches and safe navigation conditions with minimum maintenance.
(g) Results indicate that the regulating structures as originally designed with the cutoff downstream would not eliminate the tendency for the channel to meander at the proposed lock and dam site. Installation of the lock and dam in a long straight reach would produce considerable shoaling upstream and tend to develop a wide shallow channel. The channel in the lower lock approach would tend to shoal rapidly and might require continuous maintenance; this tendency would be reduced appreciably with a wing dike at the end of the lower guard wall.

(4392) EXTENSION OF LA GUARDIA FIELD RUNWAY, NEW YORK.

(b) Port of New York Authority.
(d) Experimental; for design.
(e) The existing New York Harbor model is being used for tests to determine the effects of certain proposed fills in East River, for the purpose of extending the North-South runway at La Guardia Airport, on the hydraulic and flushing characteristics of the surrounding areas.
(g) Preliminary tests indicate that a solution satisfactory to all interests has not been found; supplemental tests have been planned and will be undertaken in the near future.

(4393) MODEL STUDY OF STABILITY OF SOUTH JETTY, SIUSLAW RIVER, OREGON.

(b) District Engineer, U.S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.
(d) Experimental; for design.
(e) Stability tests were conducted in two wave flumes 119 feet long, 5 feet deep, and 4 feet wide on section models of the jetty constructed to a linear scale of 1:50 to determine experimental coefficients (K_Δ) in the Waterways Experiment Station breakwater stability equation for design of repairs of the south jetty at the river mouth. Design criteria were also desired for both the head and trunk of the structure for the conditions of (1) waves breaking directly on the structure, (2) special placement by crane of selected long-axis stones above low tide, (3) angles of wave attack of 0 and 90 degrees, and (4) pell-mell placement by crane of cover-layer stones from toe of jetty to

crest.
(h) Final report in preparation.

(4395) DISPERSION STUDIES IN NEW YORK HARBOR MODEL.

(b) Interstate Sanitation Committee.
(d) Experimental; for design.
(e) The existing New York model is being used for a comprehensive study of the diffusion patterns from most of the major sewer outfalls in New York Harbor. Model tests are conducted using conservative fluorescent dyes as tracers, and the results will be used for planning the construction of additional sewage treatment facilities. Results are being analyzed by the Interstate Sanitation Commission.

(4396) MODEL STUDY OF COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) District Engineer, U.S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.
(d) Experimental; for design.
(e) The model reproduces the lower 52 miles of the Columbia River and pertinent offshore areas to linear scales of 1:500 horizontally and 1:100 vertically. Tides and tidal currents, density currents, waves, and other phenomena significant to the movement and deposition of sediments are reproduced and studied. Some portions of the model are of the fixed-bed type, while other portions are of the movable-bed type. Hydraulic adjustment of the model has been accomplished and preliminary tests have just been undertaken.

(4397) McALPINE LOCKS EMERGENCY GATE PROTOTYPE TESTS.

(b) District Engineer, U.S. Army Engineer Dist., Louisville, Corps of Engrs., Louisville, Ky.
(d) Experimental; for design.
(e) Prototype measurements of the forces acting on the downstream leaf of a two-leaf, vertical-lift emergency gate (531 kips dry weight) were made to determine acceptability of the gate under flowing water conditions. Measurements included tension in the dead end of the hoist fall lines, gate-end elevations, and gate vibration. The prototype downpull and gate vibration were compared with the results of a model study.
(f) Data analysis completed.
(g) A maximum hydraulic downpull force of 310 kips was measured in the prototype as compared with 225 kips in the model study of a similar installation. Structural differences between the model and prototype may account for the difference in downpull. Maximum prototype vibration was about 0.1g with about 0.1-inch displacement.
(h) Final report in preparation.

(4398) MODEL STUDY OF AMISTAD DAM SPILLWAY, RIO GRANDE.

(b) District Engineer, U.S. Army Engineer District, Fort Worth, Corps of Engineers, Fort Worth, Texas.
(d) Experimental; for design.
(e) A 1:70 model reproducing one-half of the river for a distance of 1,500 feet upstream and 2,500 feet downstream, one powerhouse, and one-half of the 975-foot-wide, 16-bay structure including the spillway and stilling basin is being used to determine spillway rating curves, flow conditions at the abutments and training walls, pressures on weir crest, lateral pressures on pier subjected to unbalanced flow, and stilling basin action. A 1:20 section model reproducing two of the irrigation conduits and the portion of the stilling basin into which they discharge, one powerhouse and tailrace, and about 500 feet of exit channel is being used to investigate the adequacy of the stilling basin for releases from the conduits and the flow conditions in the power tailrace.
(g) Test results verify the adequacy of the spillway to pass the design flood of 1,550,000 cubic feet per second. Spillway rating curves have been compiled and lateral pressures on the gate piers subjected to unbalanced flows determined. Hydrostatic pressures on the spillway crest have been determined and indicate that no serious cavitation damage should occur. Satisfactory designs for both a conventional, horizontal apron and a double-stage-type stilling basin have been determined. A design incorporating intakes in several gate piers, penstocks and power generating facilities in the structure, and conduits discharging onto the downstream portion of the spillway is being considered.

(4399) MODEL STUDY OF STABILITY OF BREAKWATER, TSOYING HARBOR, TAIWAN.

(b) District Engineer, U.S. Army Engineer District, Okinawa, Corps of Engineers, San Francisco, California.
(d) Experimental; for design.
(e) Stability tests were conducted in a concrete wave flume 119 feet long, 12.5 feet wide, and 4 feet deep on section models of the breakwater constructed to linear scales of 1:47.6 and 1:58.6 and to obtain data from which alternate designs could be developed for construction of the proposed breakwater. Design criteria for both the head and trunk of the breakwater were desired. Cover layers of both quarrystones and quadripod armor units were tested. Tests were also conducted to show the effects of roughness of quarrystones, and the effects on stability of placing the quarrystones by hand as compared to placing them pell-mell.
(f) Tests completed.
(g) Test results indicated that the stability of breakwater sections constructed of quarrystone cover layers is more dependent upon the roughness and shape of the stone used than upon the method of placing the stones in the cover layers. Breakwater head and trunk sections constructed of 25- to 35-ton quarrystones would be stable for the 27-foot design wave height. For these conditions the slopes of the head and trunk sections were 1:4.5 and 1:3.5, respectively. Breakwater head and trunk sections, constructed of 32-ton quadripods, would be stable for the design wave height of 27 feet. For these conditions, variable width berms were used in the design, and the effective side slope of the trunk and the head section was 1:6.
(h) Final report in preparation.

(4593) MODEL STUDIES OF MILLERS FERRY LOCK AND DAM, ALABAMA RIVER, ALABAMA.

(b) District Engineer, U. S. Army Engineer Dist., Mobile, Corps of Engineers, Mobile, Ala.
(d) Experimental; for design.
(e) The project will include a nonnavigable dam with a gated and an overflow section, a lock on the left bank having clear dimensions of 600 by 84 feet, and a powerhouse. A 1:100 model, reproducing about 3.1 miles of river, will be used to investigate navigation conditions through an existing bridge and in the lock approaches, the effects of the structures on flood stages, and the effects of powerhouse operations on navigation conditions. A 1:50 model of a section of the gated portion of the dam, reproducing 600 feet of the approach channel, a 50-foot-wide gate bay with piers and 28.5 feet of each adjacent gate bay, a 125-foot-wide section of the stilling basin, and 700 feet of the exit area, is being used to determine flow characteristics over the spillway and verify the adequacy of the stilling basin design.

(4594) MODEL STUDY OF SPILLWAY, SHELBYVILLE DAM, KASKASKIA RIVER, ILLINOIS.

(b) District Engineer, U. S. Army Engineer Dist., St. Louis, Corps of Engineers, St. Louis, Missouri.
(d) Experimental; for design.
(e) A 1:40 model that reproduces the spillway and allied structures, a portion of the earth embankment on each side of the spillway, 1,550 feet of the approach channel, and 1,150 feet of the exit channel is being used to study flow conditions at the spillway, to study the overall hydraulic performance of the spillway and outlets to the sluices, and to verify chute and stilling basin designs.
(g) The high unit discharge combined with lateral flow at the abutments caused severe surging at the abutments and reduction in capacity. The surging at the abutments was eliminated and capacity increased by revising the abutment nose shape, and installing spur dikes on the upstream embankment near the abutments.

(4595) MODEL STUDY OF COLUMBIA LOCK AND DAM, OUACHITA RIVER, LOUISIANA.

(b) District Engineer, U. S. Army Engineer Dist., Vicksburg, Corps of Engineers, Vicksburg, Mississippi.
(d) Experimental; for design.
(e) The project involves construction of a cutoff channel about 5,600 feet long with a bottom width of 582 feet, a gated structure (consisting of five tainter gates each 50 feet wide and 26 feet high) located about midway of the cutoff, a 150-foot-wide navigable pass on the right of the dam, and a 600- by 84-foot lock on the left. A 1:100 model, reproducing about 2.6 miles of the river, was used to investigate navigation conditions in the approaches to the lock and navigable pass, and the effects of the structures on flood stages.
(f) Suspended.
(g) Tests indicated that the width of the navigable pass should be increased to eliminate the danger of tows hitting the abutment pier of the gated structure, and that the number of dam gates could be reduced to four without affecting navigation conditions or producing excessive backwater effect.

(4596) MODEL STUDY OF OVERFLOW EMBANKMENTS FOR LOW HEAD DAM ON ARKANSAS RIVER, ARKANSAS.

(b) District Engineer, U. S. Army Engineer Dist., Little Rock, Corps of Engineers, Little Rock, Arkansas.
(d) Experimental; for design.
(e) A 1:4 model reproducing a 40-foot-wide section including 90 feet of approach channel, an embankment with upstream and downstream slopes of 1 on 3 and 1 on 4, respectively, and crown widths of 20 and 35 feet, and 100 feet of exit channel was used to verify the adequacy of proposed designs utilizing four gradations of riprap on the downstream slope of both an access and nonaccess type overflow embankment for unit discharges ranging from 10 to 60 cubic feet per second per foot width.
(f) Tests completed.
(g) Relations between headwater and tailwater elevations, with respect to the crown, where each of the four types of protective stone failed for the range of unit discharges investigated were determined. Data are being analyzed in an effort to generalize the test results.
(h) Final report in preparation.

(4597) MODEL STUDY OF ENERGY DISSIPATOR FOR OUTLET CONDUIT, MISSISSINEWA DAM, MISSISSINEWA RIVER, INDIANA.

(b) District Engineer, U. S. Army Engineer Dist., Louisville, Corps of Engineers, Louisville, Kentucky.
(d) Experimental; for design.
(e) Tests were conducted on a 1:24 model, reproducing 125 feet of the downstream end of the 16-foot-diameter outlet conduit, the outlet portal, energy dissipator, and 250 feet of the exit channel, to study the adequacy of the proposed impact device in dissipating the energy of flows ranging from 500 to 9,000 cfs. An impact device was selected for study because it would require minimum rock excavation and sidewall protection for the conduit and downstream slope of dam.
(f) Completed.
(g) Tests were conducted of the original and six other basin designs; the letter involved the use of impact sills, baffle piers, and an end sill. The original impact device could not be made to perform satisfactorily. A two-stage hydraulic jump-type basin which provided adequate energy dissipation was developed. This basin is recommended for use only if economic studies clearly indicate it to be preferable to a single-stage conventional hydraulic jump-type basin.
(h) "Energy Dissipator, Mississinewa Dam Outlet Conduit, Mississinewa River, Indiana; Hydraulic Model Investigation." U. S. Army Engineer Waterways Experiment Station Miscellaneous Paper No. 2-536, October 1962. (Available on loan.)

(4598) MODEL STUDY OF DROP STRUCTURE, CAYUGA INLET, ITHACA, NEW YORK.

(b) District Engineer, U. S. Army Engineer Dist., Buffalo, Corps of Engineers, Buffalo, N. Y.
(d) Experimental; for design.
(e) A 1:20 model, reproducing 300 feet of the approach channel, the drop structure, and about 400 feet of the exit channel, is being used to confirm the suitability of the drop structure, and if indicated, to develop advantageous modifications thereto. Of particular concern is the magnitude of channel velocities below the structure.
(g) Tests indicate that the length of the structure can be reduced and baffle piers will not be required in the basin. A 3-foot sill was added to the weir crest to prevent critical head loss in the upstream channel.

(4599) MODEL STUDY OF CONTROL STRUCTURES, LITTLE SIOUX RIVER, LITTLE SIOUX, IOWA.

(b) District Engineer, U. S. Army Engineer Dist., Omaha, Corps of Engineers, Omaha, Nebraska.
(d) Experimental; for design.
(e) A 1:30 model, reproducing about 600 feet of the approach channel, the control structure, and 1,000 feet of the exit channel, is being used to study the placement of riprap materials in the vicinity of the structure. Tests are also concerned with the discharge capacity of the proposed structure.
(g) Tests indicate that stone sizes in the original riprap plan were larger than necessary and smaller sizes could be used with a resulting saving in construction costs. The capacity of the control structure was found to be adequate.

(4600) RADIOACTIVE TRACER TESTS OF SEDIMENT, CAPE FEAR RIVER, NORTH CAROLINA.

(b) District Engineer, U. S. Army Engineer Dist., Wilmington, Corps of Engineers, Wilmington, North Carolina.
(d) Experimental; field investigation.
(e) The movement of material from dredge spoil areas was investigated using labeled sediment to determine if spoil material moves into the wharf areas at Sunny Point Army Terminal. The sediment was labeled using auric chloride (Gold-198) solution adsorbed on existing sediment. Material was placed at four locations under two extreme tide conditions. Movement of sediments was observed for two weeks using instruments on a small boat.

(f) Tests completed.
(g) Evidences of labeled sediments were found in the problem area after each of the four placements, indicating the need for remedial measures.
(h) Final report in preparation.

(4601) MODEL STUDY OF POLLUTION, CONEY ISLAND CREEK, NEW YORK.

(b) New York City Department of Health, New York, New York.
(d) Experimental; for design.
(e) An existing model of New York Harbor is being used to investigate diffusion patterns from sewage treatment plant outfalls and combination sewer and storm outfalls with special attention to contamination of bathing beaches and other recreational facilities. Plans for diverting pollution away from certain critical areas are also being investigated.

(4602) LOCK FILLING AND EMPTYING SYSTEM.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.
(d) Experimental; applied research.
(e) A 1:15 valve model used to develop the vertically framed Holt Lock valve was utilized to compare the performance of this valve with that of the McNary type valve. The Holt valve was 12.5 by 12.5 feet and the McNary valve was 11 feet wide by 12 feet high. Therefore, for tests of the McNary valve the valve was expanded to 12.5 by 12.5 feet by additions of 1.5 feet in width and 0.5 foot in height to the center portions of the valve.
(g) The Holt valve, which allows free circulation along the upstream side of the skin plate, performed best. The range of total hoist loads for the Holt valve was about half those of the McNary valve. Hoist loads for the McNary valves were less that the dry weight of the valve throughout the entire range of valve openings; thus, the hydraulic forces acting on the valve tended to open it. These uplift forces are considered high. Loading the interior of the McNary valve with water (between the double skin plates) indicated that the hydraulic forces are independent of the valve being filled with water. Variations in total hoist load for the McNary and Holt valves were not more than 6 kips throughout the range of opening. Maximum variations in the total hoist load for the McNary valve were improved at valve openings between 7 and 12 feet by filling the interior of the valve and trunnion arms with water.

(4603) MODEL STUDY OF FILLING AND EMPTYING SYSTEM FOR LOW-LIFT LOCKS, ARKANSAS RIVER, ARKANSAS.

(b) District Engineer, U. S. Army Engineer Dist., Little Rock, Corps of Engineers, Little Rock, Arkansas, and other interested Corps of Engineers offices.
(d) Experimental; for design.
(e) A 1:25 model, reproducing 700 feet of lock approach channel, intake manifolds, a 670-foot-long lock chamber, culvert, sidewall port manifolds, outlet manifold, and 700 feet of downstream channel is being used to determine an optimum port arrangement for the filling and emptying system for low-lift locks. An intake is to be developed for use in all tests. Then optimum shape, size, number, spacing, and location of the ports in the lock chamber as related to culvert size will be determined for a full range of heads and submergences. The Little Rock District is sponsoring the first phase of the tests in which a 12- by 12-foot culvert will be used. Tests of other size culverts will be sponsored by interested Corps of Engineers offices for the purpose of standardizing lock design for 600- by 110-foot locks.
(g) Tests with a satisfactory port design installed at 24-, 26-, 28-, and 32-foot cent in the lock chamber walls indicated that with 28-foot spacing turbulence appears to be well distributed across the lock chamber. A location at least 70 feet below the filling valves was selected for positioning the first port of the culvert manifold due to pressure conditions and low tailwater accompanying head conditions.

(4604) MODEL STUDY OF INTAKE AND FLOOD-CONTROL OUTLET, DEGRAY DAM, CADDO RIVER, ARKANSAS.

(b) District Engineer, U. S. Army Engineer Dist., Vicksburg, Corps of Engineers, Vicksburg, Mississippi.
(d) Experimental; for design.
(e) A 1:23 model that will reproduce the intake tower and a portion of the reservoir, the diversion tunnel, stilling basin, and 240 feet of the exit channel will be used to develop a conventional hydraulic jump-type stilling basin. At the conclusion of the diversion tests, the flood-control and power tunnels will be installed and flow through the intake tower, elbow, tunnels, junction, and at the flow-control device at the end of the flood-control tunnel will be studied.

(4605) MODEL STUDY OF BREAKWATER, KAHULUI HARBOR, HAWAII.

(b) District Engineer, U. S. Army Engineer Dist., Honolulu, Corps of Engineers, Honolulu, Hawaii.
(d) Experimental; for design.
(e) Stability tests were conducted in a concrete wave flume 119 feet long, 12.5 feet wide, and 4 feet deep, on section models of both the east and west breakwater heads, and sections of the trunk of the east breakwater constructed to a linear scale of 1:68.5 to develop designs for repair of the damaged breakwater heads and trunks. Tests conducted were concerned with the stability of 35- and 50-ton tribars.
(f) Tests completed.
(g) Stability tests indicated that a repair section consisting of a cover layer of 30-ton tribars placed pell-mell over the existing slopes of the trunk of the east breakwater would be adequate to withstand the attack of waves 34 feet in height. It was found that a repair section consisting of a cover layer of 50-ton tribars from plus 20 feet mllw down to -20 feet mllw, and 35-ton tribars from -20 feet mllw down to the toe of the slope, would be adequate to withstand the attack of the 34-foot-high waves on the heads of both the east and west breakwaters. For these conditions the slope of the repaired head sections was about 1:3.
(h) Final report in preparation.

U. S. DEPARTMENT OF COMMERCE, BUREAU OF PUBLIC ROADS.

(856) HYDROLOGY OF STORM DRAINAGE SYSTEMS IN URBAN AREAS.

Cooperative with Johns Hopkins University. See page 42.

(1591) DETERMINATION OF WATERWAY AREAS.

Cooperative with University of Illinois. See page 35.

(2435) HYDRAULICS OF PIPE CULVERTS.

Cooperative with National Bureau of Standards. See page 158.

(2839) HYDRAULICS OF RIVER FLOW UNDER ARCH BRIDGES.

Cooperative with Purdue University. See page 63.

(3597) CORRUGATED PIPE ROUGHNESS STUDY.

Cooperative with U. S. Army Engineer Waterways Experiment Station. See page 149.

(3805) INVESTIGATION OF SUPERCRITICAL FLOW CHANNEL JUNCTIONS.

Cooperative with Oregon State College. See page 59.

(4101) UNSTEADY FREE SURFACE FLOW IN A LARGE STORM DRAIN.

Cooperative with Colorado State University. See page 19.

(4617) MECHANICS OF LOCAL SCOUR.

Cooperative with Colorado State University. See page 22.

U. S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, Fluid Mechanics Section.

(1478) WIND WAVES.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental and theoretical; basic research.
(e) Includes mathematical and experimental studies of (1) wind tides (setup), (2) growth of wind waves, and (3) surface traction of wind on wavy surfaces.
(h) Report in preparation.

(2435) HYDRAULICS OF PIPE CULVERTS.

(b) Bureau of Public Roads.
(d) Experimental; applied research.
(e) To determine hydraulic characteristics of various types of culvert entrances and to develop inlets of improved design.

(2436) FLOW OVER HYDROPHOBIC MATERIALS.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental; applied research.
(e) To determine augmented dissipation of hydrophobic disks and plates oscillated in various fluids.
(h) "Friction at Menisci on Hydrophobic Surfaces," by G. H. Keulegan and M. R. Brockman, (In press).

(3250) INERTIAL FORCES IN UNSTEADY FLOW.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental; basic research.
(e) Determination of inertia and drag coefficients of cylinders and plates when subjected to a varying monotonically varying flow.
(h) Report in preparation.

(4400) MOTION AROUND A BODY IN A STRATIFIED FLUID.

(b) Office of Naval Research, Dept. of the Navy.
(d) Theoretical and experimental; basic and applied research.
(e) A study is made of the internal waves produced by the horizontal motion of three-dimensional objects of revolution through a stably stratified liquid.

(4891) WAVE PROPAGATION IN A TURBULENT LIQUID.

(b) Office of Naval Research, Dept. of the Navy.
(c) Dr. G. Kulin, Hydraulic Engineer.
(d) Experimental; basic research.
(e) A study is being made of additional gravity wave damping due to turbulence.

(4892) TURBULENT SHEAR FLOW THROUGH COMPLIANT WALLED TUBES.

(b) Office of Naval Research, Dept. of the Navy.
(c) Dr. G. Kulin, Hydraulic Engineer.
(d) Experimental; basic research.
(e) Investigation of effect of compliancy of boundaries on a turbulent flow with a view toward possible damping of turbulence and potential reduction in wall shear stress.

U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU.

Inquiries concerning the following projects, except as indicated, should be addressed to Mr. William E. Hiatt, Chief, Hydrologic Services Division, Weather Bureau, U. S. Dept. of Commerce, Washington 25, D.C.

(1015) MEASUREMENT OF EVAPORATION.

(b) Laboratory project.
(d) Theoretical and field investigation; applied research.
(e) Studies are directed toward the derivation of reliable procedures for estimating evaporation from reservoirs (existing and proposed) and land surfaces, utilizing readily available meteorological data and pan evaporation observations.
(g) Major emphasis during Fiscal Year 1963 will be devoted to the evapotranspiration study to develop a basic accounting method for estimating soil moisture deficiency. It is proposed to compute potential evapotranspiration from meteorological factors for a number of first-order Weather Bureau stations to facilitate field testing of the technique to river forecasting. The computations of potential evapotranspiration and the accounting are accomplished by IBM -1620 computer.
The Commission for Instruments and Methods of Observations of the World Meteorological Organization has recommended that comparisons between several types of evaporation pans be conducted by Member Nations to assist in selection of an internationally standard evaporation instrument. It is planned to conduct tests of several pans (including Russian GGI-3000) AT at 3 or 4 climatological different locations in the United States. The installation of the fourteen Class A pan evaporation stations at various elevations (4800 to 8900 feet) on the windward and lee side of the Wasatch Range near Farmington, Utah was completed in June of 1962. Radiation and humidity observations will be made at several of the pan sites. The purpose of the project is to study the effect of elevation, aspect and exposure on evaporation. Analysis will be initiated when 1963 data become available.

(1744) DEVELOPMENT OF RIVER FORECASTING METHODS.

(b) River Forecast Centers for: Lower Ohio River Basin, Cincinnati, Ohio, Upper Ohio River Basin, Pittsburgh, Pa.; Susquehanna and Delaware River Basins, Harrisburg, Pa.; Missouri River Basin, Kansas City, Mo.; Columbia River Basin, Portland, Oreg.; Middle and Upper Mississippi River Basin, St. Louis, Mo.; Arkansas and Red River Basins, Tulsa, Okla.; New England and Hudson River Basins, Hartford, Conn.; South Atlantic and East Gulf River Basins, Augusta, Ga.; West Gulf Drainage Basins, Ft. Worth, Tex.; and Middle Atlantic River Basins, Washington, D.C.
(d) Theoretical and field investigation; operation and applied research.
(e) The purpose of these investigations is to develop modern river forecast procedures for all ranges of flow for various streams of each basin. Procedures include: (1) Rainfall-runoff relations involving consideration of the physics of soil moisture, vegetative reception, transpiration, evaporation and geological features of the basins; (2) snowmelt forecasting relations involving consideration of the physics of snow and heat

transfer; (3) unit hydrographs; and (4) streamflow routing procedures, based upon adaptations of basic hydraulic principles, using electronic or mechanical analogues. Studies have been initiated at several of the Centers to develop procedures for forecasting the formation and breakup of ice on rivers.

(g) Forecasting procedures have been developed for key points. Refinement and modification of procedures due to reservoir construction and channel improvements are a continuing project. Results of the first year's operation of the Fort Worth River Forecast Center have been most encouraging for the application of high speed electronic computer (IBM 1610) for river forecast procedure development and in forecasting operations. It is planned to equip the new River Forecast Center at Sacramento, Calif. with an IBM-1620 computer.

(h) "Weather and Water Resources," by M. A. Kohler, presented at Water Resources Symposium, University of Alabama, October 1962.

(1745) WATER SUPPLY FORECASTS FOR WESTERN UNITED STATES.

(b) Work being conducted in following field offices: River Forecast Center - Portland, Oreg., Water Supply Forecast Unit - Salt Lake City, Utah, River Forecast Center - Kansas City, Mo., River Forecast Center - Sacramento, Calif., River Forecast Center - Windsor Locks, Connecticut.

(d) Theoretical and field investigation; operation and applied research.

(e) The purpose of these investigations is the development of precipitation-runoff relations for water supply forecasting utilizing statistical methods to correlate precipitation during the winter with runoff during the melting season.

(g) Water Supply Forecasts are prepared for nearly 400 points in the United States. These forecasts of water-year and residual flow are released in Monthly Water Supply Forecast Bulletins, January through May. This research program is of a continuing nature designed to improve and extend the present forecasting service.

(1751) MAXIMUM STATION PRECIPITATION.

(b) Corps of Engineers, Department of the Army.
(d) Analysis of data.
(e) Tabulations of maximum recorded 1-, 2-, 3-, 6-, 12-, and 24-hour precipitation, for automatic recording rain-gage stations, by states.
(f) Discontinued.
(h) Twenty-seven states completed and published as parts of Weather Bureau Technical Paper No. 15.

(2437) UNITED STATES STORM CHARACTERISTICS PROJECT.

(b) Soil Conservation Service, Department of Agriculture.

(d) Theoretical and field investigation; applied research and design.

(e) Studies to provide rainfall data for design criteria in estimating required capacities of hydraulic structures. Work includes: (1) Development of a generalized relationship between depth, area, duration and frequency for areas up to 400 square miles, durations of 20 minutes to 24 hours, and return periods from 1 to 100 years; (2) development of a generalized portrayal of the probable maximum precipitation for areas up to 400 square miles, and durations up to 24 hours in the United States; and (3) combination of (1) and (2) for Hawaiian Islands and Alaska.

(h) "A General Relation between Frequency and Duration of Precipitation," by L. L. Weiss, Monthly Weather Review, vol. 90, no. 3, pp. 87-88, U. S. Weather Bureau, March 1962.
"An Empirical Comparison of the Predictive Value of Three Extreme Value Procedures," by D. M. Hershfield, Journal of Geophysical Research, vol. 67, no. 4, pp. 1535-1542, April 1962.
"Rainfall-Frequency Atlas of the Hawiian Islands for Areas to 200 Square Miles, Durations to 24 Hours, and Return Periods from 1 to 100 years," Technical Paper No. 43, U. S. Weather Bureau (in press).

(2438) STORM TIDE PREDICTIONS.

(b) Laboratory projects.
(c) Mr. D. Lee Harris, Office of Meteorological Research, U. S. Weather Bureau, Washington 25, D. C.

(d) Theoretical and field investigation; basic and applied research.

(e) The differences between the observed and predicted tides during storms are being studied with the goal of improving the accuracy of storm tide forecasting.

(g) Empirical methods of forecasting these inundations are being developed and used in the Weather Bureau's hurricane and storm warning service. Continued improvement in these forecasts is expected to result from this research.

(h) "The Equivalence between Certain Statistical Prediction Methods and Linearized Dynamical Methods," by D. Lee Harris, Monthly Weather Review, vol. 90, No. 8, pp. 331-340, Aug. 1962.
"Wave Patterns in Tropical Cyclones," by D. Lee Harris, Mariners Weather Log, vol. 6, No. 5, pp. 156-160, Sept. 1962.
"A Regression Model for the Prediction of Storm Surges on Lake Erie," by D. Lee Harris and Aldo Angelo, Proceedings of the Fifth Conference on Great Lakes Research, Great Lakes Research Division University of Michigan, Ann Arbor, Mich. (in press).
"Characteristics of the Hurricane Storm Surge," by D. Lee Harris, Weather Bureau Technical Paper, (in preparation, 1962).

(2943) METEOROLOGICAL RADAR TRANSPONDER (MRT) FOR REPORTING RAINFALL.

(b) Laboratory project.
(d) Field investigation; development and operation.

(e) A compact device, consisting of a tipping bucket rain gage and transponder, that can be installed in relatively remote areas at an average distance of 70 miles from the radar and up to 140 miles with a mountain-top installation. Activated by a signal from the radar, the MRT transmits a pulsed signal which appears in Binary code on the radar scope indicating the accrued amounts of precipitation. Investigations are continuing for application to reporting of river and tide stage, and snow water-equivalent data.

(g) MRT-1 now operational, 30 MRT-2's being installed within range of Weather Bureau weather search radars.

(3251) PRECIPITATION DISTRIBUTION AS DETERMINED BY WSR-57 RADAR.

(b) Laboratory project at Weather Bureau Office in Sacramento, Calif.

(d) Theoretical and field investigation, operation and applied research.

(e) Studies are being made to relate, within 100 N.M. of the radar, the intensity and duration of weather echoes with observed rainfall. Estimates of rainfall can be determined by use of the calibrated attenuators on the radar and converting these db values to theoretical rainfall rates by means of a rainfall rate-echo intensity graph. This use of radar has application to flood forecasting, water supply forecasting and will also be used to determine a radar range correction value.

(g) Data being collected.

(3601) STUDY OF TECHNIQUES FOR MEASURING RAINFALL BY REFERENCE TO RADAR ATTENUATION.

(b) Laboratory project in cooperation with Stanford Research Institute, Menlo Park, Calif.
(d) Experimental; development and applied research.
(e) By measuring the attenuation of short wave length radar signals over a fixed course and relating it to the measured precipitation along the path of the radar beam, a relationship can be established enabling an instrument (specifications being written) to monitor areas above damsites and small headwaters for the purpose of averting downstream interests to heavy rainfall.
(g) Over a path of 3.25 KM radar attenuation has been successfully correlated with observed rainfall. Incremental measurements of .10 inch/hour were made the radar attenuation determinations of rainfall varying an average of plus or minus .10 with extremes of plus .25 in 10 minute periods.
(h) "Study of Techniques for Measuring Rainfall by Reference to Radar Attenuation," by Ronald T. H. Collis, under Weather Bureau Contract 10271, Stanford Research Inst. (Project 3367), Menlo Park, Calif., June 1962.

(3602) EXTENSION OF RATING CURVES.

(b) Laboratory project.
(d) Field investigation; operation and applied research.
(e) The flood forecasting procedures used by the Weather Bureau are primarily based on discharge. However, the flood warnings to be of any value must be in terms of stage (or elevation). This is accomplished by use of U. S. Geological Survey rating curves relating discharge to stage. Rating curves are defined only to the maximum observed stage of record. Therefore, it is imperative to devise a reliable method of extending rating curves in order to issue accurate stage predictions for the record breaking flood.
(g) Progress is slow due to the difficulty in obtaining the required stream cross-section data.

(3920) FLOAT-TYPE RESISTANCE RIVER GAGE.

(b) Laboratory project.
(d) Experimental; development.
(e) A device employing a Helipot (multi-turn potentiometer) operated by a float or connected to an existing river gage and linked by wire or radio to an observation point (up to 3 miles by wire and 50 miles by radio). A reading is obtained by balancing the resistance in the system with a similar unit at the observation point. May be operated on AC or DC power.
(g) Initial field installations of units linked by land lines now operational; radio link still under development.

(3921) PUNCHED-TAPE RECORDING, WEIGHING-TYPE PRECIPITATION GAGE WITH TELEMETERING CAPABILITY.

(b) Laboratory project.
(d) Experimental; development.
(e) A twenty-inch capacity, weighing-type battery-operated precipitation gage providing a punched tape record which can be machine processed, capable of over one month's unattended operation. Gage so designated that data can be telemetered through use of a "black box" attached to recording mechanism.
(g) Initial gage built and undergoing laboratory tests. Additional gages for testing being procured. Installation and field testing to begin early 1963.

(4401) BINARY-DECIMAL TRANSMITTER FOR USE WITH ANALOG-DIGITAL RECORDER.

(b) Laboratory project in cooperation with Fischer & Porter Co.
(d) Experimental; design development.
(e) Black-box attachment for Analog-Digital Recorder (ADR) permitting interrogation by telephone or radio of river stage data.
(g) Initial installations undergoing field test.

(4402) RADAR PRECIPITATION INTEGRATOR.

(b) Laboratory project in cooperation with Stanford Research Institute, Menlo Park, Calif.
(d) Experimental and field investigation, applied research and development.
(e) A system for reporting accrued precipitation, using six levels of intensity of the log receiver of the weather search radar, by quantizing and recording the received signal from a preselected grid to provide a pulsed digital readout. The presentation is made on a series of electro-mechanical counters, set in a map corresponding to the 140 grid locations, in units of depth. Because of the pulsed digital nature of the readout, it is possible to transmit it by narrow bandwidth links. An evaluation of the system is scheduled for 1963 over a dense network of recording rain gages operated by the Agricultural Research Service near Norman, Okla. The operational capability of the system will also be tested at the Weather Bureau's recently established Radar Research Lab., University of Oklahoma Research Park, Norman, Oklahoma.
(h) "Monthly Status Reports 1-6, Construction of Prototype," by Ronald T. H. Collis, under Weather Bureau contract 10282, Stanford Research Inst., August 1962.

(4403) PROBABLE MAXIMUM PRECIPITATION AND SNOWMELT CRITERIA FOR SELECTED WATER SHEDS IN ALASKA.

(b) Corps of Engineers, Department of Army.
(d) Applied research and design.
(e) Estimates of probable maximum precipitation, maximum snowpack, and maximum snowmelt factors including temperature, dew point, wind and solar radiation.
(h) Completed preliminary estimates for Yukon River above Rampart dam site and two smaller basins. Reports unpublished.

(4765) THE ANARCTIC CIRCUMPOLAR CURRENT.

(b) Laboratory project (supported by National Science Foundation).
(c) Mr. F. Ostapoff, Polar Meteorological Research Project, U. S. Weather Bureau, Wash. 25, D. C.
(d) Theoretical and field investigation; basic and applied.
(e) Attempts have been made to assess quantitatively the meridional and vertical velocity components of the Antarctic Circumpolar Current, an important problem in the study of oceanic circulation around Antartica and its interaction with the atmosphere.
(g) Transverse and vertical velocity components were computed from hydrographic data along meridional cross-sections through the Antarctic Circumpolar Current. Results indicate the existence of a well-defined convergence zone lying north of the primary polar front.
(h) "On Frictionally Induced Transverse Velocity Components in the Antarctic Circumpolar Current," by F. Ostapoff, unpublished manuscript, U. S. Weather Bureau, 1962.

(4766) OCEAN-ATMOSPHERE INTERACTION.

(b) Laboratory Project.
(c) Dr. Kirk Bryan, General Circulation Research

Laboratory, U. S. Weather Bureau, Wash. 25, D. C.
(d) Experimental, theoretical; basic.
(e) As part of the fundamental investigation of atmospheric processes by the General Circulation Research Laboratory, work has been initiated to study the large-scale aspects of the interaction of the ocean with the atmosphere. The problem of the response of a simplified ocean model to wind stress was chosen as a starting point. Numerical solutions for this problem incorporate a much more detailed treatment of the non-linear terms than has been possible in previous studies. Model and boundary refinements will be made to check whether the results could be explained by aspects other than the pattern of wind stress.
(g) Preliminary conclusions drawn from calculations indicate that details of the observed pattern of wind stress are very important for explaining many features of the Gulf Stream and Kuroshio Systems.
(h) "Measurements of Meridional Heat Transport by Ocean Currents," by K. Bryan, Journal of Geophysical Research, vol. 67, No. 9, pp. 3403-3414, Aug. 1962.

(4767) PROBABLE MAXIMUM PRECIPITATION IN THE HAWAIIAN ISLANDS.

(b) Corps of Engineers, Department of the Army.
(d) Applied research and design.
(e) Estimates of probable maximum precipitation for durations up to 24 hours for the Hawaiian Islands.
(f) Completed.
(h) "Probable Maximum Precipitation in the Hawaiian Islands," U. S. Weather Bureau, Hydrometeorological Report No. 39, in preparation.

(4768) STORM WINDFLOW OVER CALIFORNIA.

(b) Corps of Engineers, Department of the Army.
(d) Applied research.
(e) Determine windflow in precipitation storms for purposes of estimating design storms and forecasting precipitation.
(f) Completed.
(h) "Airflow on the Windward Side of a Large Ridge," Vance A. Myers, Journal of Geophysical Research, Vol. 67:11, pp.4267-4291, October 1962.
"Three-Dimensional Windflow and Resulting Precipitation in a Northern California Storm," Vance A. Myers and George A. Lott, in preparation.

U. S. DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY.

(1221) STEADY STATE ELECTRIC FLOW NET MODELS.

(b) Laboratory project.
(c) Mr. R. R. Bennett, U. S. Geol. Surv., Wash. 25, D.C.
(d) Applied research.
(e) Preparation of electric flow net models using graphite paper, conductive paints, resistor grids, etc.

(2444) REDESIGN OF PRICE CURRENT METER.

(b) Laboratory project.
(c) Mr. E.G. Barron, U.S. Geol. Surv., Columbus 12, Ohio.
(d) Experimental; development.
(e) Purpose is to design a vane-type rotor that is little affected by vertical velocity components or proximity to the water surface.
(f) Completed.
(g) Rotors made from different metals were tested in calibration flume. Berylium-copper selected as best. Several meters prepared for field use.

(2688) MECHANICS OF AQUIFERS.

(b) Laboratory project.
(c) Mr. J.F. Poland, U.S. Geological Survey, Sacramento, California.
(d) Field investigation; basic and applied research
(e) To determine the principles and factors involved in the strain, deformation, and compaction of water-bearing rocks resulting chiefly from changes in hydrologic environment.
(h) "X-ray Diffractometer Method for Measuring Preferred Orientation in Clays," by R. H. Meade, in Geological Survey Research 1961: U. S. Geol. Survey Prof. Paper 424-B, pp. 273-276.
"Compaction of Montorillonite-rich Sediments in Western Fresno County, California," by R. H. Meade, in Geological Survey Research 1961: U. S. Geological Survey Prof. Paper 424-D, pp. 89-92.
"Compaction of an Aquifer System Computed from Consolidation Tests and Decline in Artesian Head," by R. E. Miller, in Geol. Survey Research 1961: U. S. Geol. Survey Prof. Paper 424-B, pp. 54-58.
"The Coefficient of Storage in a Region of Major Subsidence Caused by Compaction of an Aquifer System," by J. F. Poland, in Geol. Survey Research 1961: U. S. Geol. Survey Prof. Paper 424-B, pp. 52-54.
"Relation of Volumetric Shrinkage to Clay Content of Sediments from the San Joaquin Valley, California;" by A. I. Johnson and D. A. Morris: U. S. Geol. Survey Prof. Paper 450-B, p. B43-B44.
"Hydrologic and Physical Properties of Water-Bearing Deposits from Core Holes in the Tulare Wasco Area, Calfornia," by A. I. Johnson and R. P. Moston, (in final review).
"Hydrologic and Physical Properties of Water-Bearing Deposits from Core Holes in the Santa Clara Valley, California," by R. P. Moston and A. I. Johnson, (in review).

(2689) DIFFUSIONAL PROCESSES AND HYDRODYNAMICS OF SALT-FRESH WATER INTERFACE IN AQUIFERS.

(b) Laboratory project.
(c) Mr. H. H. Cooper, Jr., U.S. Geol. Surv., Tallahassee, Florida.
(d) Field and laboratory investigation; basic and applied research.
(e) To determine the factors affecting the distribution of salt water in coastal aquifers subject to salt water encroachment.
(h) "Transitory Movements of the Salt-Water Front in an Extensive Artesian Aquifer," by H. R. Henry, in Geological Survey Research 1962: U. S. Geol. Survey Prof. Paper 450-B, pp. 87-89.

(2694) FLOW OF WATER OVER WEIRS AND SPILLWAYS.

(b) Laboratory project.
(c) Prof. C.E. Kindsvater, Georgia Institute of Technology, Atlanta, Georgia.
(d) Library search, re-analysis and correlation of published data, and original research.
(e) A comprehensive study of the discharge characteristics of practical forms of weirs and spillways. Objectives include the publication, in generalized form, of available experimental data.
(h) "Discharge Characteristics of Round Crested Weirs," by D. B. Jones, U. S. Geological Survey Water-Supply Paper (in preparation).

(2695) CONTINUOUS DISCHARGE RECORDS IN TIDAL STREAMS.

(b) Laboratory project.
(c) Dr. Chintu Lai, USGS, Washington 25, D. C.
(e) Purpose is to develop a mathematical system that describes the flow pattern and related channel characteristics for a tidal stream, and to develop methods for determining the discharge in the reach.
(g) Basic partial differential equations for tidal flow were derived. These equations were transformed into characteristics equations and then organized into difference equations suitable for electronic digital

computer. Trial runs have indicated satisfactory results.

(2699) UNIFORM FLOW IN OPEN CHANNELS.

(b) Laboratory project.
(c) Mr. H.J. Tracy, U.S. Geol. Surv., Atlanta 8,Ga.
(d) Theoretical and experimental; basic research.
(e) A comprehensive laboratory study of uniform flow in open channels.
(f) Completed.
(h) "Resistance Coefficients and Velocity Distribution - Smooth Prismatic Channels," by C. M. Lester and W. W. Emmett, U. S. Geological Survey Water-Supply Paper (in preparation).

(2702) ROUGHNESS AND WATER SEDIMENT MOVEMENT IN ALLUVIAL CHANNELS.

(b) Laboratory project.
(c) Dr. D. B. Simons, Geological Survey, Colorado State University, Fort Collins, Colorado.
(d) Basic and applied research.
(e) A study of mechanics of flow in alluvial channels using a large recirculating laboratory flume. Based upon a laboratory study and field studies, relationships which describe flow in alluvial channels are being developed. The study has been completed for six (6) bed materials. Regimes of flow, forms of bed roughness, resistance to flow relations, and sediment transport relations have been developed for the six sizes of sand investigated.
(g) The grain roughness of sands investigated was found to equal d_{86}. A uniform bed material having a given median diameter will develop a rougher boundary and will be less susceptible to transport than a nonuniform bed material having the same median diameter. The gradation coefficient ($\sigma = 1/2 \sqrt{d_{85}/d_{50} + d_{50}/d_{15}}$) of bed material in sand channel streams has an average value of 1.60. This value is approached in flumes also. The presence of fine-grained material in pipes or channels affects sediment transport and resistance to flow by a factor not entirely explained by consideration of conventional viscosity effects.
(h) "The Effect of Bed Roughness on Depth-Discharge Relations in Alluvial Channels," by D. B. Simons and E. V. Richardson, U. S. Geological Survey Water-Supply Paper 1498-E, 1962.
"The Variable Depth Discharge Relation in Alluvial Channels," by D. B. Simons, E. V. Richardson, and W. L. Haushild, U. S. Geol. Survey Professional Paper 424-C, pp. 45-47, 1961.
"The Significance of the Fall Velocity and the Effective Fall Diameter of Bed Materials," by W. L. Haushild, D. B. Simons, and E. V. Richardson, U. S. Geological Survey Prof. Paper 424-D, pp. 17-20, 1961.
"Qualitative Effects of Temperature on Flow Phenomena in Alluvial Channels," by D. W. Hubbell and Khalid Al-Shaikh Ali, U. S. Geological Survey Prof. Paper 424-D, pp. 21-23, 1961.
"Boundary Form and Resistance to Flow in Alluvial Channels," by E. V. Richardson, D. B. Simons, and W. L. Haushild, Bulletin of the International Association of Scientific Hydrology. VII Annee, No. 1, pp. 48-52, 1962.

(2703) EVAPORATION SUPPRESSION.

(b) Cooperative with Bureau of Reclamation and Texas A. and M. College.
(c) Mr. G. E. Koberg, U. S. Geol. Surv., Denver, Colorado.
(d) Field investigation continued during the year.
(h) "Relationships for Computing Long-Wave Radiation from a Water Surface," by G. E. Koberg, U. S. Geological Survey Water-Supply Paper (in preparation).

(2948) ANALOG MODEL ANALYZER FOR STEADY-STATE GROUND-WATER FLOW PROBLEMS.

(b) Laboratory project.
(c) Mr. R. W. Stallman, U.S. Geol. Surv., Denver, Colo.
(d) Theoretical study and instrument development.
(e) Use of a variable-resistance gird analyzer in analyzing steady-state ground-water flow problems in which the transmissibility varies in space.
(h) "An Electric Analog of Three-Dimensional Flow to Wells and its Application to Unconfined Aquifers," by R. W. Stallman, U. S. Geol. Survey Water-Supply Paper 1536-H (in press).
"Calculation of Resistance and Error in an Electric Analog of Steady Flow hrough Non-homogeneous Aquifers," by R. W. Stallman, U. S. Geol. Survey Water-Supply Paper 1544-G (in press).

(2949) ULTRASONIC FLOW METER.

(b) Laboratory project.
(c) Mr. E. G. Barron, U. S. Geological Survey, Columbus 12, Ohio.
(d) Experimental; instrument development.
(e) The objective is to measure the average velocity in a natural channel by acoustic means.
(g) Further testing of instruments in the field being done.

(2950) SEDIMENT TRANSPORT AND CHANNEL ROUGHNESS IN NATURAL AND ARTIFICIAL CHANNELS.

(b) Laboratory project.
(c) Mr. Thomas Maddock, Jr., U. S. Geological Survey, Washington 25, D.C.
(d) Basic research.
(e) Field and laboratory studies, original and other investigations will be analyzed in terms of sediment movement, channel roughness, shear distribution in channel prism and other effects on shape of natural channels.
(g) Sand channel reach with controlled flow on the Rio Grande below El Paso selected for concentrated study.

(3253) CHANNEL STABILITY IN AN EPHEMERAL STREAM.

(b) Laboratory project.
(c) Dr. Luna B. Leopold, U. S. Geological Survey, Washington 25, D. C.
(d) Field investigation; basic research.
(e) In an ephemeral stream (arroya), measurements are being made on the following: Stress on rocks during a flow; movement and location of rocks after flow; extent of scour and fill; movement of bars; changes in cross sections at certain locations; erosion on slopes; mass movement of soils; and soil wash.
(g) Report in preparation. Paper on downstream scour and fill to be presented at Second National Conference on Sedimentation in Jan. 1963.

(3254) DISPERSION IN NATURAL STREAMS.

(b) Atomic Energy Commission.
(c) Dr. N. Yotsukura, USGS, Washington 25, D. C.
(d) Theoretical and field investigation; basic research.
(e) To measure dispersion and relate dispersal patterns to stream-channel geometry, fluid properties, and flow characteristics.
(g) Numerical solution for turbulent dispersion equations obtained for short distances downstream from injection point. Analog simulation was investigated. Background study of dispersion in a steady non-uniform flow yielded a one-dimensional dispersion equation which can be solved numerically.
(h) "Turbulent Dispersion in a Steady Uniform Flow - Allenspark Flume," by N. Yotsukura, is in review.

(3255) ELECTROMAGNETIC FLOW METER.

(b) Laboratory project.
(c) Mr. E. G. Barron, U. S. Geological Survey, Columbus 12, Ohio.
(d) Experimental; instrument design.
(e) To redesign, adapt, and repackage the electromagnetic flow meter now used by the U. S. Navy to measure velocity in open channels.
(f) Discontinued.

(3256) EFFECT OF ROUGHNESS CONCENTRATION ON OPEN CHANNEL FLOW.

(b) Laboratory project.
(c) Mr. J. Davidian, U. S. Geological Survey, Washington 25, D. C.
(d) Experimental; applied research.
(e) To determine the effect of bed roughness on open channel flow by increasing the concentrations of 3/16-inch cubes cemented to the flume floors.
(f) Completed.
(h) "Roughness Concentration Effects on Flow over Hydrodynamical Rough Surfaces," by H. J. Koloseus and J. Davidian, U. S. Geol. Survey Water-Supply Paper (in preparation). "Free Surface Instability Correlations," by H. J. Koloseus and J. Davidian, U. S. Geol. Survey Water-Supply Paper (in Preparation).

(3257) MEASUREMENT OF TOTAL SEDIMENT DISCHARGE OF COARSE SEDIMENTS.

(b) Laboratory project.
(c) D. W. Hubbell, U. S. Geological Survey, Colorado State University, Fort Collins, Colorado.
(d) Analytical; applied research.
(e) A review of the types of equipment currently used to measure sediment moving as bed load and the preparation of a report covering criteria for sampler design and use.
(f) Completed.
(h) "Apparatus and Techniques for Measuring Bed-Load," by D. W. Hubbell, U. S. Geol. Survey, Water-Supply Paper 1748 (to be released in 1963).

(3260) SOIL-MOISTURE EQUIPMENT.

(b) Laboratory project.
(c) Mr. A. I. Johnson, Chief, Hydrologic Laboratory, U.S. Geological Survey, Denver, Colo.
(d) Laboratory and field investigation; applied research.
(e) Laboratory model and field comparative study of techniques and of various commercially available instruments for measuring soil moisture. New equipment may also be designed as result of study.
(g) Field and laboratory calibrations of neutron meter, tensiometers, moisture blocks and sampling equipment. Evaluation of neutron meter. Design of small-diameter fast-response tensiometer. Library research.
(h) "Measurement of Soil Moisture Under Field Conditions," by A. I. Johnson, U.S. Geol. Survey Water-Supply Paper 1619-U.

(3261) MODEL STUDY FOR SALT WATER DIFFUSION.

(b) Laboratory study.
(c) Mr. A. I. Johnson, Chief, Hydrologic Laboratory, U. S. Geological Survey, Denver, Colo., or Mr. H. H. Cooper, Jr., Research Engineer, U.S. Geological Survey, Tallahassee, Floria.
(d) Experimental; applied research.
(e) Model study is being used to study diffusion at the interface between fresh and salt water. Variable movement of interface simulates effects of various amplitudes and periods of tidal action.
(f) Completed.
(g) Design and construct plastic model and conductivity - recording equipment; one test run with fine-sand-size glass beads and two test runs on medium sand completed.
(h) "Dispersion with Oscillating Flow in a Granular Material" by W. K. Kulp; U. S. Geol. Survey Prof. Paper 424-D, p. D25-D28.

(3263) PERMEABILITY.

(b) Cooperative with the State of California.
(c) Mr. A. I. Johnson, Chief, Hydrologic Laboratory, U.S. Geological Survey, Denver, Colo. or Mr. Fred Kunkel, District Geologist, U. S. Geological Survey, Sacramento, Calif.
(d) Laboratory and field investigation; basic and applied research.
(e) Theoretical, laboratory and field study of permeability and related properties such as transmissibility, capillary conductivity, relative permeability, unsaturated flow and flow-drainage relationships, as related to soil moisture and ground-water movement. Evaluation of existing, and possible development of new methods for determining these properties.
(g) Library research in progress.

(3264) SUBSURFACE EXPLORATION EQUIPMENT AND TECHNIQUES.

(b) Laboratory project.
(c) Mr. A. I. Johnson, Chief, Hydrologic Laboratory, U. S. Geological Survey, Denver, Colo.
(d) Laboratory and field investigation; applied research.
(e) Evaluate and adapt subsurface exploration equipment and techniques, such as gamma ray and electric loggers, fluid velocity and conductivity loggers, temperature loggers, power augers and core samplers, for solving ground water occurrence problems
(g) Portable temperature logger nearly completed; core samplers designed and commercial models procured and compared under field conditions; power augering equipment and techniques evaluated; evaluation in progress of gamma-ray conductivity and temperature logging equipment for salt-water encroachment and waste disposal problems. Library research in progress.
(h) "Selected References on Laboratory and Field Methods in Ground-Water Hydrology," by A. I. Johnson, (in review).
"Use of Inflatable Packers in Multiple-Zone Testing of Water Wells," by F. C. Koopman, J. H. Irwin, and E. D. Jenkins: U. S. Geol. Survey Prof. Paper 450-B, p. B108-B109.

(3265) INVESTIGATION OF VADOSE FLOW THROUGH HOMOGENEOUS ISOTROPIC MEDIA.

(b) Laboratory project.
(c) Mr. A. I. Johnson, Chief, Hydrologic Laboratory, U. S. Geological Survey, Denver, Colo.
(d) Experimental; basic and applied research.
(e) Laboratory model study of infiltration of fluids from surface pits into a thick unsaturated zone above the water table.
(f) Completed.
(g) Model tank designed and constructed; several test runs with beads of different particle size completed; library research; test runs photographed by slide and movie.
(h) Silent, color, lapse-time movie on second, third and fourth phase of model study completed.
"Model study of Infiltration into layer Materials," by W. N. Palmquist, Jr., and A. I. Johnson: U. S. Geol. Survey open-file report (1960).
"Vadose Flow in Layered and Nonlayered Materials," by W. N. Palmquist, Jr., and A. I. Johnson; U. S. Geol. Survey Prof. Paper 450-C p. C142-C143.
"Model Study of Vadose Flow Through Porous Media," by W. K. Kulp and others: U. S. Geol. Survey (in review).

(3603) SURFACE FOLLOWER.

(b) Laboratory project.
(c) Mr. E. G. Barron, U. S. Geological Survey,

Columbus 12, Ohio.
(d) Experimental; design.
(e) The surface follower is designed to operate a recorder while following the level of the water in a 2-inch vertical pipe. A switch in a "float" closes either the up or down circuit which rotates a drum raising or lowering the float. A shaft input recorder is coupled to the drum.
(f) Completed.
(g) Units produced for field operation.

(3604) TRANSPORT OF RADIONUCLIDES BY FLUVIAL SEDIMENT.

(b) Atomic Energy Commission.
(c) Mr. D. W. Hubbell, U. S. Geological Survey, Colorado State University, Fort Collins, Colorado.
(d) Field investigation; basic research.
(e) Study of dispersion, transportation, and concentration of radionuclides by stream sediments for representative hydrologic and geologic environments.
(g) Statistical theory of homogeneous turbulence appears to have useful application in the study of lateral turbulent diffusion in alluvial channels. The scale and intensity of lateral turbulence components at the surface of an alluvial channel can be estimated using small polyethylene particles floating on the surface. Usability of radioactive tracer techniques for the study of the dispersion and transport of contaminated bed-material particles was studied further and appears entirely feasible.
(h) "Uptake and Transport of Radionuclides by Stream Sediments," by W. W. Sayre, H. P. Guy, and A. R. Chamberlain, U. S. Geol. Survey Professional Paper 433-A (to be released early 1963).

(3605) MINERALOGY OF FLUVIAL SEDIMENTS.

(b) Atomic Energy Commission.
(c) Mr. V. C. Kennedy, U. S. Geol. Surv., Denver, Colo.
(d) Laboratory and field investigations.
(e) Study of the mineralogy and cation-exchange capacity of fluvial sediments for typical hydrologic and geologic environments.
(f) Completed.
(g) Project report in preparation.

(3923) DISTRIBUTION OF BOUNDARY SHEAR IN OPEN CHANNEL FLOW.

(b) Laboratory project.
(c) Mr. R. W. Carter, U. S. Geol. Survey, Wash. 25, D.C.
(d) Experimental; applied research.
(e) Shear plates will be used in a flume to measure boundary shear in open-channel flow. If an accurate measure is obtained, the indirect methods of shear determination will be evaluated.
(g) Series of runs in flume have been made at various Froude number and depths of flow. Data being analyzed and report in preparation.

(3924) GAGING FLOW THROUGH TURBINES.

(b) Atomic Energy Commission.
(c) Mr. R. W. Carter, U. S. Geol. Survey, Washington 25, D. C.
(d) Experimental; applied research.
(e) To develop a method of rating turbines with use of radioisotopes as a tracer similar to "salt dilution" method.
(f) Completed.
(g) Final report in preparation.

(3929) USE OF AERIAL PHOTOGRAPHS AND MAPS IN HYDROLOGIC STUDIES.

(b) Laboratory project.
(c) Mr. W. J. Schneider, USGS, Wash. 25, D.C.
(d) Field investigations; applied research.
(e) Objective is to determine possible relationships between basin characteristics and low stream flow for areal studies; and establish criteria for depicting streams on topographic maps to meet needs in hydrologic investigations.
(f) Completed.
(h) "Portrayal of Drainage and Vegetation on Topographic Maps" by W. J. Schneider and J. C. Goodlett, U. S. Geological Survey Open-File Report, June 1962.

(3930) FLOODS FROM SMALL AREAS.

(b) Laboratory project.
(c) Mr. W. D. Mitchell, USGS, Champaign, Ill.
(d) Field investigation; applied research.
(e) Purpose is to provide information and develop methods to solve small basin drainage structure design problems.

(3931) SOURCE OF BASE FLOW OF STREAMS.

(b) Laboratory project.
(c) Mr. A. N. Cameron, U. S. Geological Survey, Atlanta, Ga.
(d) Field investigation; applied research.
(e) Purpose is to define the source, amount and distribution of base flow of streams.
(g) Geologic and hydrologic data collected in Yellow River Basin in Georgia is being analyzed and a report is in preparation.

(3933) EVALUATION OF STATISTICAL PROCEDURES IN HYDROLOGY.

(b) Laboratory project.
(c) Dr. N. C. Matalas, USGS, Wash. 25, D.C.
(d) Experimental; basic and applied research.
(e) (1) To define the spectral properties between tree ring series from Western North America, and (2) to define the relations among the moments of transformed and untransformed random variables in the case of fractional power and logarithmic transforms.
(f) Completed.
(g) (1) Power spectra analyses showed that the generating process of tree ring series can be approximated by a second order autoregressive process. Cross-power spectra analyses showed that the coherence between the series was uniform over all frequencies. The cross-correlation between tree ring series decreases exponentially with distance. This decrease also occurs with temperature and precipitation series. The precipitation and tree ring correlations decrease at approximately the same rate with an increase in distance; however, the temperature correlation decreases at a slower rate.
(2) By means of Taylor series expansions, the moments of transformed random variables (fractional power and logarithmic transforms) were related to the moments of the untransformed random variables. The moments of each order for the transformed random variables were shown to be functions of the sum of the moments of all orders of the untransformed random variables.
(h) "Probability Distribution of Low-Flows," by N. C. Matalas, 1962, U. S. Geological Survey Professional Paper 434-A (in press).
"Autocorrelation of Rainfall and Streamflow Minimums," by N. C. Matalas, 1962, U. S. Geological Survey Professional Paper 434-B (in press).
"Statistics of a Runoff-Precipitation Relation," by N. C. Matalas, 1963, U. S. Geol. Survey Professional Paper 434-D.
"Information Content of the Mean," by N. C. Matalas and W. B. Langbein, 1962, Journal of Geophysical Research, Vol. 67, No. 9, Aug. 1962.
"Statistical Properties of Tree Ring Data," by N. C. Matalas, 1962, International Assoc. of Scientific Hydrology, No. 2, June 1962.
"Spectra Analyses of Tree Ring Series from Western North America," 1962, by N. C. Matalas (in preparation).
"Relation Between Moments of Transformed

Random Variables, for both the Fractional Power and the Logarithmic Transform," 1962, by N. C. Matalas (in preparation).

(3935) FLOOD PLAIN ZONING IN SUBURBAN AREAS.

(b) Laboratory project.
(c) Mr. D. G. Anderson, USGS, 300 South Payne St., Fairfax, Virginia.
(d) Field investigation; applied research.
(e) To determine magnitude and frequency of flood discharges from records of short duration and develop a method to describe the water-surface profile for a flood of a given frequency at all points along the stream channel.
(g) Field data being evaluated; report in preparation.

(3939) STUDY OF RADIOACTIVE WASTES, CLINCH RIVER, TENNESSEE.

(b) Atomic Energy Commission.
(c) Mr. P.H. Carrigan, U. S. Geological Survey, Oak Ridge, Tennessee.
(d) Field investigation; applied research.
(e) Purpose is to undertake a comprehensive study of the entry, movement, location and fate of radioactive wastes discharged into the Clinch River by the Oak Ridge National Laboratory.
(g) Laboratory flume study conducted in addition to field investigations.

(3943) USE OF PRECIPITATION RECORDS IN EXTENDING STREAMFLOW DATA.

(b) Laboratory project.
(c) Mr. R. O. R. Martin, USGS, Wash. 25, D. C.
(d) Field investigation; applied research.
(e) Objective is to develop a practicable method of using the precipitation records to augment short-term streamflow records and to test the extent of the improvement in reliability.
(f) Completed.
(h) Open-file report being processed.

(3944) AUTOMATIC COMPUTATION OF DAILY DISCHARGE RECORDS.

(b) Laboratory project.
(c) Mr. W. L. Isherwood, USGS, Wash. 25, D. C.
(d) Experimental; operation systems.
(e) To develop a practical system of collecting records of river stages in a form suitable for automatic computation through a high speed computer with print out acceptable for offset reproduction.
(g) Digital recorder program operational for 260 gaging sites; records processed routinely on magnetic tape, suitable for offset reproduction.

(3946) MORPHOLOGICAL ANALYSES OF GROUND-WATER DISCHARGE AREAS.

(b) Laboratory project.
(c) Mr. H. B. LeGrand, U. S. Geological Survey, Washington 25, D. C.
(d) Basic research.
(e) Through geologic and hydrologic observations and inferences hypothetical piezometric maps are to be prepared in the environs of stream valleys. Various types of hydrogeology settings are being studied so that a specific stream can be compared with its prototype.

(3947) PROBLEMS OF CONTRASTING GROUND-WATER MEDIA IN CONSOLIDATED ROCKS.

(b) Laboratory project.
(c) Mr. H. E. LeGrand, USGS Survey, Wash. 25, D.C.
(d) Basic research.
(e) Porous granular material overlies jointed consolidated rock in many parts of the earth, resulting in two contrasting types of media through which water moves. Description of media and hydrologic ramifications with variable geologic conditions and with variable head changes in the piezometric surface are considered for the composite frame work.
(h) "Perspective on Problems of Hydrogeology," by H. E. LeGrand, Geological Society of America Bulletin, V. 73, pp. 1147-1152, Sept. 1962.

(3948) SEDIMENT TRANSPORT PARAMETERS IN SAND BED STREAMS.

(b) Laboratory project.
(c) Mr. Carl F. Nordin, Jr., U. S. Geological Survey, Albuquerque, New Mexico.
(d) Field and office research.
(e) Field and theoretical investigation of sediment transportation in sand bed streams. Specifically included are hydraulic and sediment data for the Rio Grande.
(h) "Particle-Size Distribution of Stream-Bed Material in the Middle Rio Grande Basin, New Mexico," by C. F. Nordin, Jr. and J. K. Culbertson, U. S. Geological Survey Professional Paper 424-C, pp. 323-326, 1961.

(3949) FACTORS AFFECTING BED-MATERIAL DISCHARGE OF SAND BED STREAMS.

(b) Laboratory project.
(c) Mr. B. R. Colby, USGS, Lincoln, Nebr.
(d) Field and office research.
(e) Field and theoretical investigation of bed-material discharge of sand bed streams utilizing available sediment-load data for a range of width/depth ratios.
(g) Concentration differences calculated by a velocity-weighted method and by a method involving the ratio of the weight of sediment in motion above a unit area of the bed to the weight of the water-sediment mixture above the same unit area, are usually large. The depth of sand deposited instantaneously on a stream bed, even from high flows, is usually very small. Scour and fill in reaches or at cross sections of sand-bed streams are basically related to continuity of discharge of sediment of particle sizes in the stream-bed.

(3952) STUDY OF MECHANICS OF HILLSLOPE EROSION.

(b) Laboratory project.
(c) Dr. S. A. Schumm, USGS, Denver, Colo.
(d) Field investigation.
(e) The purpose of this project is to study the mechanics of the erosion of hillslopes under various physical conditions, and to appraise the relative influence of each factor involved in hillslope erosion in semiarid and arid environments. Studies include quantitative measurements of hillslope erosion, and to the extent possible, measurements of the contributing or related factors. Such information is needed to determine the amount of sediment derived from hillslopes and to provide guidance in planning erosion control measures. Studies are in progress in several areas in eastern and western Colorado and western Utah.
(g) The study has been expanded to cover areas of different geology and topography.
(h) "Erosion on Miniature Pediments in Badlands National Monument, South Dakota," by S. A. Schumm, Geological Society of America Bulletin v. 73, pp. 719-724, June 1962.
"Disparity Between Modern Rates of Denudation and Orogeny," by S. A. Schumm, U. S. Geol. Survey Professional Paper 454-H, in process of publication.

(3953) BASIC RESEARCH IN VEGETATION AND HYDROLOGY.

(b) Laboratory project.
(c) Dr. R. S. Sigafoos, USGS, Arlington, Va.
(d) Field investigation.
(e) The purpose of this project is to study the interrelationship between vegetation and geomorphic processes by comparing qualitative

differences in distribution and form of plants with selected geologic and hydrologic variables. This comparison is prerequisite to establishment of methods to measure botanical parameters quantitatively. The immediate objectives will be to identify and map species limited to flood plains, to adjoining uplands, to alluvial fans, terraces, coves and ridges; to study relationship between forest development and flood frequency, and to determine the effect of land use upon changes in vegetation.

(g) Four reports in preparation or scheduled.

(h) "Vegetation in Relation to Flood Frequency near Washington, D. C.," by R. S. Sigafoos, In Geological Survey Research, 1961, U. S. Geological Survey Professional Paper 424-C, pp. 248-250.
"Influence of Strip Mining on the Hydrologic Environment of Parts of Beaver Creek Basin, Kentucky 1955-59," by R. S. Sigafoos, In Forest and Forest Development, by C. R. Collier and others, U. S. Geological Survey Professional Paper 427-B, in process of publication.

(3954) CHARACTERISTICS OF GLACIER-FED STREAMS.

(b) Laboratory project.

(c) Dr. R. K. Fahnestock, USGS, Fort Collins, Colo.

(d) Field investigation.

(e) The purpose of this project is to study the channel characteristics of streams below active glaciers, especially those carrying substantial amounts of debris which is sorted and transported by meltwater. It should assist developing an understanding of glacial outwash deposits, both present and past, in other areas. This study should also add to both the knowledge of the influence of diurnal fluctuations in flow on the characteristics of alluvial channels and to the knowledge of long term response of stream channels to glacier fluctuations. The project is carried on at White River below Emmons Glacier, Mt. Rainier, Wash., flume studies are carried out at Colorado State University.

(3955) DOWNSTREAM EFFECT OF DAMS, DIVERSIONS AND IRRIGATION DRAINS ON ALLUVIAL CHANNELS.

(b) Laboratory project.

(c) Dr. M.G. Wolman, Johns Hopkins University, Baltimore, Md.

(d) Field investigation.

(e) The purpose of the project is to determine the downstream effect the above types of structures exert on alluvial channels. All available data are to be gathered and summarized on channel surveys before and after construction. This will be accomplished insofar as possible by correspondence with State, Federal, and local agencies.

(g) Report in preparation.

(3956) LONG-TERM HYDROLOGIC TRENDS AS INDICATED BY GLACIERS.

(b) Laboratory project.

(c) Dr. M.F. Meier, USGS, Tacoma, Washington.

(d) Field investigation.

(e) The purpose of this project is to learn more of the mechanics of glaciers and to relate ice thickness, velocity, slope, surface water flow, streamline inclination, and ablation. The hydrology of alpine basins, including snow fields and ice-covered areas, is important because of the relation of climate, precipitation, snow melt and storage effects on the water resources of northern and high-elevation areas. The project consists of a basic research study in fundamental problems of glacier regime, studies of long-term fluctuations in hydrologic factors, and relations between climatic and hydrologic factors. Comparisons will be made between the regime nourishment factors and activity of two similar valley glaciers located in different climatic environments. Primary study area: South Cascade Glacier, Washington.

(g) Several reports in preparation.

(h) "Glaciological Investigations on South Cascade Glacier," by W. V. Tangborn, The Mountaineer, Vol. 55, No. 4, 1962.
"Recent Variations in Mass Net Budgets of Glaciers in Western North America," by M. F. Meier and A. S. Post, In Commission of Snow and Ice, International Association of Scientific Hydrology Publication No. 58, pp. 63-77, 1962.

(3957) THE HYDROLOGY OF A PORTION OF THE HUMBOLDT RIVER VALLEY.

(b) State of Nevada and U. S. Bureau of Reclamation.

(c) Mr. T.W. Robinson, USGS, Menlo Park, Calif.

(d) Field investigation.

(e) The purpose of this project is to determine how the available water in Humboldt River valley might better be utilized. The following hydrologic data will be collected and studied: (1) Runoff characteristics and magnitude of use of surface waters; (2) the specific yield of sediments in the flood plain and the magnitude and extent of water-level fluctuations in the groundwater reservoir; (3) the use of water by greasewood and willows; (4) variations in chemical quality of the water in the flood plain; (5) amount of underflow at Comus and Rose Creek to be determined by means of pumping tests of exploratory holes; and (6) amount of ground water from tributary valleys, to be determined on the basis of chemical analyses and low-flow measurements. The General Hydrology Branch has furnished the project leader and will determine the amount of water used by greasewood and willows by use of tanks (lysimeters) similar to those used in the Buckeye project. Site is near Winnemucca, Nevada, in the Humboldt River Valley.

(g) Eight evapotranspirometers were installed during the 1961 season. These will be used for measuring water use as follows: two for greasewood, three for willow, and three for rabbitbrush.

(3958) THE EFFECT OF EXPOSURE ON SLOPE MORPHOLOGY.

(b) Laboratory project.

(c) Mr. R. F. Hadley, USGS, Denver, Colo.

(d) Field investigation.

(e) The purpose of this project is to determine the morphologic and hydrologic differences existing among slopes of various exposures and to measure the resulting effects on erosion, soil moisture, and vegetational cover. Also, the effect of differential exposure on drainage-basin evolution will be investigated. Sites for study are several selected small areas in Wyoming, Colorado, and New Mexico.

(g) A report on certain phases of project in preparation.

(3959) LONG-TERM CHRONOLOGIES ON HYDROLOGIC EVENTS.

(b) Laboratory project.

(c) Mr. W. D. Simons, USGS, Tacoma, Washington.

(e) The purpose of this project is to provide information on flood and drought frequencies and other critical hydrologic events from the history of major river basins. Data will be sought to evaluate long-term fluctuation in water supply to determine whether or not there has been either an upward or downward trend during the last 2 or 3 centuries. Such data will include crop records, news items, historical records, tree-ring data and lake levels. Efforts will be made to obtain useful data from anthropological research studies in the Pacific Northwest. This study would provide additional knowlege on probable frequency and duration of critical hydrologic

events especially droughts for each major river basin. The first investigation would be in the Columbia River basin.

(3961) USE OF WATER BY SALTCEDAR.

(b) Bureau of Reclamation.
(c) Dr. T. E. A. vanHylckama, USGS, Phoenix, Arizona.
(e) The purpose of this project is to measure the use of ground water by saltcedar in evapotranspirometers and to evaluate these data against those obtained by energy budget and mass transfer methods. Estimates can then be made of the quantity of water salvageable by control or eradication of saltcedar. Large evapotranspirometers have been constructed in an environment of saltcedar and planted at the same density as in the surrounding area. The use of water from these tanks will be measured and the effect of maintaining ground water at different levels studied.
(g) Preliminary data on water use were presented at the Pacific S. W. regional meeting of the American Geophysical Union in Tucson, Arizona, in January 1962. It is expected that preliminary data on mass transfer and energy budget methodology can be published at the end of the calendar year 1962. A report on growth and development of saltcedar as affected by access to soil moisture is in preparation.

(3962) RESEARCH IN PHREATOPHYTES.

(b) Laboratory project.
(c) Mr. T. W. Robinson, USGS, Menlo Park, Calif.
(d) Field investigation.
(e) The purpose of this project is to estimate with reasonable accuracy the quantity and quality of the ground water consumptively wasted and to evaluate the quantity and quality of the water that can be salvaged by control or eradication of the phreatophyte. The fields of study involved in attaining these objectives are: (1) A knowledge of the habitats and life-cycle characteristics of problem phreatophytes; (2) the factors that control their growth, development, and occurrence; (3) the factors that affect their use of ground water; and (4) ecomonic methods for effecting salvage of the water consumptively wasted by phreatophytes. Among others, data are needed on occurrence, which requires mapping of areas and density of growth; relations of occurrence to the quality of the ground water; depth of root penetration; effects of phreatophytes on flood-plain erosion and sedimentary processes; and the annual water consumption for different depths to the water table under different climatic conditions, by species.
(h) "Introduction, Spread and Areal Extent of Saltcedar in Western United States," by T. W. Robinson, to be published as U. S. Geol. Survey Hydrologic Atlas.

(3963) EVAPOTRANSPIRATION THEORY AND MEASUREMENT.

(b) Laboratory project.
(c) Mr. O. E. Leppanen, USGS, Phoenix, Arizona.
(d) Field investigation.
(e) The purpose of this project is to study the physical processes involved in evapotranspiration and to develop techniques and equipment for measuring evapotranspiration. The studies encompass an analysis of the physical forces and differential equations describing the transport of momentum, latent heat of evaporation, energy, water vapor, and possibly carbon dioxide in the earth's surface in order to develop practical techniques and instruments for the measurement of evapotranspiration.
(g) Final report in preparation.

(3965) HYDROLOGIC EFFECT OF VEGETATION MODIFICATION.

(b) Laboratory project.
(c) Mr. R. M. Myrick, USGS, Tuscon, Arizona.
(d) Field investigation.
(e) The purpose of this project is to evaluate the change in water yield produced by the vegetation modification and to develop a more comprehensible understanding of the function of vegetation, within the hydrologic regime, under semiarid conditions. Substitution of short-rooted grass for deep-rooted trees is the basis for this study. The study has been divided into two parts; (1) The determination of the changes in water yield produced by a pinon-juniper eradication program on a drainage area of 200 square miles; and (2) the intensive study of 2 pairs of small watersheds to evaluate the hydrologic processes involved and alterations that occur as a result of vegetation modification. Correlations of runoff, using precipitation will be used for (1). In part (2) an attempt will be made to evaluate the major portions of the hydrologic cycle and to define the interrelationships. Study site is Carrizo and Corduroy Creek basins in the Fort Apache Indian Reservation, Arizona.
(g) Soil moisture, soil tension, precipitation, and surface-water data have been collected. Data being analyzed and reports in preparation.

(3966) EFFECTS OF SEDIMENT CHARACTERISTIC OF FLUVIAL MORPHOLOGY AND HYDRAULICS.

(b) Laboratory project.
(c) Dr. S. A. Schumm, USGS, Denver, Colo.
(d) Field investigation.
(e) The purpose of this project is to collect data on the physical properties of sediments forming the perimeter of alluvial channels, and to determine the effect of sediment type on fluvial morphology and hydraulics. The physical and chemical properties of alluvial materials and their relations to and effects upon fluvial morphology are not well enough understood and require considerable research. Basic data are collected at about 200 cross-sectional sites on as many as possible of the following: channel shape, dimensions, gradient, pattern, and roughness; channel and bank vegetation; stream discharge; velocity of flow; suspended and bed sediment loads; and the types of sediment forming the cross-sectional perimeter of the channels.
(h) "Recent Flood-Plain Formation along the Cimarron River in Kansas," by S. A. Schumm, U. S. Geological Survey Professional Paper 424-B, pp. 112-114, 1961.
"The Sinuosity of Alluvial Rivers on the Great Plains," by S. A. Schumm, to be published in the Geological Society of America Bulletin.

(3968) STUDY OF CHANNEL CHARACTERISTICS AND FLOOD-PLAIN AGGRADATION, TUSAYAN WASHES, ARIZONA.

(b) Laboratory project.
(c) Mr. R.F. Hadley, USGS, Denver, Colo.
(d) Field investigation.
(e) The purpose of this project is to determine the physical and hydraulic factors that control channel characteristics in aggrading and degrading alluvial channels in the semiarid and arid Southwest. An understanding of these processes is needed in order to plan conservation practices in a logical and economic fashion. The project includes study of aggradation occurring naturally as well as aggradation induced by channel structures. Studies are in the drainage basins of Polacca, Oraibi, Jeddito, Dinnebito Washes, all tributary to Little Colorado River near Winslow in northeastern Arizona.
(g) Report in preparation.

(3969) GENERAL STUDIES OF EROSION AND SEDIMENTATION.

(b) Laboratory project.
(c) Mr. R. F. Hadley and Mr. N. J. King, USGS, Denver, Colo.
(d) Field investigation.
(e) The purpose of this project is to investigate the basic processes of erosion in a semiarid and arid environment. Studies fall into three general groups: (1) Quantitative measurements of gully growth, channel widening, and channel erosion; (2) measurements of rates of upland erosion; and (3) detailed studies of a particular erosion process in a selected area. The quantitative measurements will be utilized to aid in design of soil and water conservation measures. Studies are being made in several areas in Montana, Wyoming, Utah, New Mexico, and Arizona.

(3970) HYDROLOGIC EFFECTS OF URBANIZATION.

(b) Laboratory project.
(c) Mr. A. O. Waananen, USGS, Menlo Park, Calif.
(d) Field investigation.
(e) The purpose of this project is to evaluate the hydrologic effects of changes in land use associated with development of suburban, industrial and urban communities; also included is a study of hydrologic problems in storm drainage in urban areas. Changes in land use associated with urban development affect local hydrologic factors such as runoff, flood frequency, recharge, channel stability, sediment production and the interrelationship between surface and ground water. Data on stream flow, precipitation, soil moisture and related hydrologic and climatologic data, topographic effects, and geologic, soils, and ecologic information, together with documentation of changes in land use as they occur, are needed for proper evaluation. The study area, San Francisquito Basin at Stanford University, Palo Alto, California.

(3971) THE HYDROLOGY OF PRAIRIE POTHOLES, NORTH DAKOTA.

(b) Research Section of Bureau of Sport Fisheries and Wildlife.
(c) Mr. Wm. S. Eisenlohr, Jr., U.S.G.S., Denver, Colo.
(g) Collection of data continued on the original group of potholes and several others were selected and instrumented.
(h) "A Description of the Hydrologic Investigations of Prairie Potholes," by J. B. Shjeflo, U. S. Geological Survey Circular 472, in process of publication.

(3972) STUDY OF WATER APPLICATION AND USE ON A RANGE WATERSPREADER IN NORTHEASTERN MONTANA.

(b) Laboratory project.
(c) Dr. F. A. Branson, Mr. I. S. McQueen, and Mr. R. F. Miller, USGS, Denver, Colo.
(d) Field investigation.
(e) The purpose of this project is to evaluate the use of a waterspreader on forage yields. Little information is available on amounts of water applied to and used by waterspreaders or on the amounts of water needed for successful waterspreaders. As water becomes more in demand, information on the efficiency of water used by waterspreaders becomes increasingly important. Water applied to the spreader is measured by means of a water-stage recorder which determines the duration of flow through a pipe into the spreader and by means of a rain gage. Plant measurements are being made by the Montana Agricultural Experiment Station. Study site is the Willow Creek area near Fort Peck, Mont.
(g) Data on soil moisture storage and use have been obtained for three years (1959-61) when water was applied to the spreader. Analyses are being made of the differences in storage and use on the three major soil-vegetation types included in the spreader.
(h) Report in preparation.

(3975) STUDY OF EFFECTS OF GRAZING IN BADGER WASH AREA, COLORADO.

(b) U. S. Bureau of Land Management, Reclamation, Forest Service, and Fish and Wildlife Service.
(c) Mr. G. C. Lusby, USGS, Denver, Colo.
(d) Field investigation.
(e) The purpose of this project is to determine the effects of grazing exclusion in regard to improving vegetation, and reducing damaging floods, upstream erosion and downstream sedimentation. This study was planned and started in 1953 as a cooperative undertaking between the Bureau of Land Management, Forest Service, Bureau of Reclamation, and the Survey. Studies by the Fish and Wildlife Service started a year later. The study by agreement is to run for 20 years. Twenty reservoirs were constructed and records of runoff and sediment are collected on each. The study area is divided into four pairs of areas each with a dam and reservoir. One of each pair is fenced to exclude grazing and the other is left open. Study area is about 8 miles northwest of Mack, Mesa County, Colorado.
(h) "Hydrologic and Biotic Characteristics of Grazed and Ungrazed Watersheds of the Badger Wash Basin in Western Colorado, 1953-58," by G. C. Lusby, G. T. Turner, J. R. Tompson and V. H. Reid, U. S. Geological Survey Water-Supply Paper 1532-B, in process of publication.

(3976) EVALUATION OF SEDIMENT BARRIER ON SHEEP CREEK, NEAR TROPIC, UTAH.

(b) Laboratory project.
(c) Mr. G. C. Lusby, USGS, Denver, Colo.
(d) Field investigation.
(e) The purpose of this study is to test the effectiveness of treatment methods to reduce the high sediment contribution of the Paria River and similar streams. In addition to land-treatment practices, which will be carried out by the Forest Service, National Park Service, Bureau of Land Management and Soil Conservation Service, the Bureau of Reclamation has constructed a small barrier on Sheep Creek. The Survey is to measure the effect of this barrier on runoff and sediment at a site about 7 miles southwest of Tropic, Utah.
(g) A dam was constructed on Sheep Creek in 1960 and sediment samplers were installed in the channel upstream from the dam and in the spillway. Runoff during the 1960 water year was very low, but in 1961 runoff occurred several times in relatively large amounts. Sediment deposition in the reservoir and channel upstream in 1961 was appreciable.
(h) Report in preparation.

(3977) HYDROLOGIC EFFECTS OF SMALL RESERVOIRS.

(b) Laboratory project.
(c) Mr. F. W. Kennon and Mr. R. W. Stallman, USGS, Oklahoma City 2, Oklahoma.
(d) Field investigation.
(e) During recent years there has been a great increase in the number of small reservoirs being constructed for stock water supply, irrigation, flood control, recreation, and other uses. The purpose of this project is to evaluate this type of construction in terms of its effect on the hydrology of the area. Similar work has been done in other parts of the West.

(3978) EFFECTS OF MECHANICAL TREATMENTS ON ARID LANDS IN WESTERN UNITED STATES.

(b) Laboratory project.
(c) Mr. A. Branson, Mr. I. S. McQueen, and Mr. R. F. Miller, USGS, Denver, Colo.
(d) Field investigation.
(e) The purpose of this project is to determine the effects of different mechanical treatments on arid lands. Several small basins on land administered by the Bureau of Land Management in central Montana, eastern New Mexico, and western Colorado, are the study sites. Some reservoirs have been, and others are to be constructed in each of these basins, and runoff and sediment yield is being and has been determined before treatments are applied. Among the treatments applied after precalibration are the following: spike-tooth pitting, eccentric-disc pitting, and contour furrowing (with furrow intervals determined on the basis of computed furrow water-storage capacity). Other measurements made would include: vegetation kinds and quantities before and after treatment, soil-moisture storage and seasonal and annual changes.
(g) Reports have been submitted for publication in the Journal of Range Management.

(3979) GENERAL EVALUATION OF SOIL AND MOISTURE TREATMENT PRACTICES.

(b) Laboratory investigation.
(c) Mr. K. R. Melin, U. S. Geological Survey, Denver, Colorado.
(d) Field investigation.
(e) The purpose of this project is to appraise the structures and treatment practices used in soil moisture conservation to determine their effectiveness in accomplishing the purposes for which they were designed. The field studies include maintenance of records on runoff, erosion and sedimentation to determine the effects of the structures or practices at several areas in Colorado, Utah, Arizona, Wyoming, Montana, and New Mexico.

(3980) HYDROLOGY OF DEATH VALLEY.

(b) Laboratory project.
(c) Mr. T. W. Robinson and Mr. C. B. Hunt, U. S. Geological Survey, Denver, Colorado.
(d) Field investigation.
(e) The purpose of this report is to study the various phases of the hydrology of Death Valley. Data on evaporation, wind movement, humidity and temperature are being obtained under informal agreement with the National Park Service. Relations of plants to salinity and effects of salinity on evapotranspiration also are being investigated.
(g) Report on the hydrology of Death Valley in preparation.

(3981) PLEISTOCENE LAKES OF THE GREAT BASIN.

(b) Nevada State Engineers.
(c) Mr. C. T. Snyder, U. S. Geological Survey, Menlo Park, California.
(d) Field investigation.
(e) The purpose of this project is to prepare a map based on data gathered during Soil and Moisture Conservation investigations showing the Pleistocene Lakes in the Great Basin area. Further refinements can now be made to Lakes Lahounta and Bonneville and the associated smaller lakes that existed concurrently. An additional large Pleistocene lake recently discovered is included.
(g) Map and report in preparation.
(h) "The Pleistocene Lake in Spring Valley, Nevada, and Its Climatic Implications," by C. T. Synder and W. B. Langbein, Journal of Geophysical Research, Vol. 57, No. 6, pp. 2385 - 2394, June 1962.
"A Hydrologic Classification of Valleys in the Great Basin Western United States," by C. T. Snyder, Bulletin of the International Association of Scientific Hydrology VII Annee, No. 3, pp. 53-59, 1962.

(3982) INTERRELATIONSHIPS BETWEEN ION DISTRIBUTION AND WATER MOVEMENT IN SOILS AND THE ASSOCIATED VEGETATION.

(b) Laboratory project.
(c) Mr. R. F. Miller, USGS, Denver, Colo.
(d) Field investigation.
(e) The purpose of this study is to obtain information basic to improvement of water use and vegetation yields on arid lands. These data are needed to evaluate the potential of treatment practices proposed on an extensive scale on the public domain. This study emphasizes the investigation of soil chemistry as it affects the swelling or shrinkage of soils and may have as great an effect of hydrologic characteristics as texture. Study areas are in several locations on public lands in several western states.
(f) Completed.
(g) Field work on this project largely completed; laboratory work partially completed; data evaluation and preparation of reports in progress.

(3983) DEVELOPMENT OF FIELD CRITERIA FOR EVALUATING SITES FOR FLOOD WATER SPREADING.

(b) Laboratory project.
(c) Mr. R. F. Miller, USGS, Denver, Colo.
(d) Field investigation.
(e) The purpose of this project is to determine field criteria with which to evaluate potential sites before making relatively large expenditures for further developments. Examinations made to date on spreaders in several localities suggest that in addition to adequacy of water available the infiltration characteristics and moisture-holding capacity of the soils are important factors. The kinds and quantities of vegetation growing where water collects naturally on similar soils on or near proposed sites may be a useful indicator of the potentiality of the site after water is applied.
(f) Completed.
(g) Report in preparation.

(3984) WATER AND SOIL RELATIONSHIPS AS INDICATED BY PLANT SPECIES OR PLANT COMMUNITIES.

(b) Laboratory project.
(c) Dr. F. A. Branson, Mr. I. S. McQueen and Mr. R. F. Miller, U. S. Geological Survey, Denver, Colorado.
(d) Field investigation.
(e) The purpose of this project is to determine whether or not phonological development of vegetation differs for communities having the same macroclimate but different soils. Plants have been used as indicators of conditions, processes and uses for many years. Where plants can be used as indicators of soil conditions, expensive measurements of physical and chemical properties can be reduced. Plant species or communities may be used as indicators of potential production to be expected from land management and treatment practices. Research sites are near Golden, Colorado. Other sites will be selected.
(g) Preliminary work and some mapping has been accomplished.
(h) "Soil Moisture Under Juniper and Pinyon Compared with Moisture under Grasslands in Arizona," by R. F. Miller, F. A. Branson, I. S. McQueen, and R. C. Culler, U. S. Geol. Survey Professional Paper 424-B, pp. 233-235, 1961.

(4404) EROSION, SEDIMENTATION, AND LAND-FORM DEVELOPMENT IN ARID AND SEMIARID REGIONS.

(b) Laboratory project.
(c) Messrs, Garald G. Parker, Reuben C. Miller, and Irel S. McQueen, U. S. Geological Survey, Denver, Colo.
(d) Field investigation; both basic and applied

research.

(e) Purpose is to ascertain the causes and forces that separate soil and/or rock particles from their sources, and to study the resultant land forms for geomorphic analyses. Field study areas have been selected in several western States, and a primary field research station has been established at the Warbonnet Ranch, 13 miles north of Harrison, Nebr., where all factors relating to erosion and sedimentation are being measured both automatically by specialized recording instruments and manually. The Warbonnet research station has been established for a minimum 10-year project life.

(4405) PIPING, AN EROSIONAL PHENOMENON IN CERTAIN SILTY SOILS OF ARID AND SEMIARID REGIONS.

(b) Laboratory project.
(c) Messrs. Garald G. Parker, Reuben C. Miller, and Irel S. McQueen, USGS, Denver, Colo.
(d) Field investigation; both basic and applied research.
(e) Purpose is to ascertain the causes of piping and thus enable field engineers and geologists to control this form of destructive erosion. Soils chemistry and physiology will be thoroughly investigated, the atmospheric and other environmental factors related to piping will be determined, and long-term (10 years, at least) observational records will be kept on several areas where piping is a prominent form of erosion. Primary study areas are near Chinle and Cameron in Arizona; Cuba, New Mexico; and Panquitch, Utah.

(4406) TECHNIQUES FOR UTILIZATION OF SEDIMENT RECONNAISSANCE DATA.

(b) Laboratory project.
(c) Mr. H. P. Guy, USGS, Washington 25, D.C.
(d) Theoretical analyses; applied research.
(e) Examination of quantitative relationships between sediment yield and environment for basin and regions in eastern United States and development of techniques for translating minimum, pertinent sediment observations into an adequate quantitative description of sediment behavior in selected basins.
(f) Suspended.
(g) Water discharge is the most important independent variable for explaining storm-to-storm variation in sediment concentration.
(h) "Sediment in Small Reservoirs Due to Urbanization," by H. P. Guy and G. E. Ferguson, Jour. of Hydr. Div., Proc. ASCE, HY2, pp. 27-37, 1962.

(4408) ANALOG MODELS OF HYDROLOGIC PHENOMENA.

(b) Laboratory project.
(c) Mr. John Shen, USGS, Phoenix, Arizona.
(d) Basic and applied research.
(e) Investigation of applicability of analog computer technique to solve problems involving either hydrologic data in general or surface-water flow in particular.
(g) Results to date indicate concept and approach are valid. Additional methods and instrumentation being investigated.
(h) "A Method of Determining the Storage-Outflow Characteristics for Nonlinear Reservoirs," by John Shen; U. S. Geol. Survey Prof. Paper 450-E, article 232, 1962.
"An Analog Solution to Turbulent Diffusion Equation in Open Channel," by John Shen; U. S. Geol. Survey Prof. Paper 450-E, article 233, 1962.

(4409) TURBULENT DIFFUSION IN OPEN CHANNELS.

(b) Laboratory project.
(c) Mr. R. W. Carter, USGS, Washington 25, D.C.
(d) Experimental, theoretical; basic research.
(e) Develop necessary instrumentation; compare Eulerian and Lagraugian methods of expressing the flow field; observe effects of boundary roughness, channel geometry, and flow conditions on turbulent field; and define the relations of the turbulence spectrum and diffusion patterns.
(g) Laboratory evaluation of instrumentation underway.

(4410) BANK SEEPAGE DURING FLOOD FLOWS.

(b) Laboratory project.
(c) Mr. M. E. C. Pogge, U. S. Geological Survey, Iowa City, Iowa.
(d) Field investigation; applied research for doctoral thesis.
(e) Purpose is to understand the mechanics of seepage flow into and from bank storage along a channel in response to movement of flood waves through a channel reach.
(g) Program expanded to include study of origin of base flow. Objective now to determine interrelationships between ground and surface water for understanding hydrologic characteristics of streams. Observation well and stream gaging stations installed in small study basin in Central Iowa. Additional wells installed in Missouri Valley for pump-test determination of hydraulic characteristics of outwash aquifer.

(4411) LIQUID MOVEMENT IN CLAYS.

(b) Laboratory project.
(c) Dr. H. W. Olsen, USGS, Washington 25, D.C.
(d) Experimental and theoretical study; basic research.
(e) To study the nature of liquid movement through clays in response to gradients of electrical potential, ionic concentration, and temperature; and to relate the movement to such factors as the mineralogical and chemical composition of the clay and pore liquid.

(4769) INSTRUMENTATION FOR EVAPORATION STUDIES.

(b) Laboratory project.
(c) Mr. C. R. Daum, USGS, Denver, Colorado.
(d) Experimental; instrument design.
(e) Primary purpose is to develop instrumentation for measuring components of the energy budget.
(g) Heat-flow and radiation equipment have been developed and are being tested in the field in conjunction with evaporation and evaporation suppression studies.

(4770) EROSION CHARACTERISTICS OF CLAY.

(b) Laboratory project.
(c) Mr. A. V. Jopling, Harvard University, Cambridge, Massachusetts.
(d) Basic and applied research.
(e) Purpose is to study erodibility characteristics of cohesive materials under a fluid shearing stress and correlate them with physio-chemical properties of the material.
(g) Literature research undertaken and laboratory facilities established.

(4771) FLOW THROUGH SPUR DIKES.

(b) Laboratory project.
(c) Mr. R. R. Wright, USGS, Atlanta, Georgia.
(d) Model study; applied research.
(e) Purpose is to study discharge coefficients and velocity distribution for flow through man-made constrictions with spur dikes.

(4772) MODEL T RECORDER.

(b) Laboratory project.
(c) Mr. E. G. Barron, USGS, Columbus, Ohio.
(d) Experimental instrument development.
(e) Purpose was to develop an instrument easy and quick to install that would provide picture of stream recession.
(f) Completed.
(g) Self contained unit designed that fits on a

3 inch pipe. Number produced for field use.

(4773) TYPE "A" RECORDER (CREST STAGE GAGE).

(b) Laboratory project.
(c) Mr. E. G. Barron, USGS, Columbus, Ohio.
(d) Experimental; instrument development.
(e) Purpose was to design an inexpensive recorder to provide a supplementary record during peak stages.
(f) Completed.
(g) Self contained unit designed for installation on 3 inch pipe. Has a disk that completes one revolution per day and has 2 ranges (10' or 20'). It is accurate to within plus or minus 0.05'. Number fabricated for field use.

(4774) ADAPTATION OF DIGITAL RECORDER FOR MEASURING HYDROLOGIC PARAMETERS.

(b) Laboratory project.
(c) Mr. E. G. Barron, USGS, Columbus, Ohio.
(d) Experimental; instrument design.
(e) The purpose is to obtain hydrologic data in a form suitable for automatic computation.
(g) Recorder has been adapted for use on a rain gage. Several rain collectors have been produced and completed. Set-ups are being tested in the field.

(4775) LVDT - MANOMETERS.

(b) Laboratory project.
(c) Mr. E. G. Barron, USGS, Columbus, Ohio.
(d) Experimental; instrument development.
(e) This instrument was designed to measure very low velocity heads.
(f) Completed.
(g) LVDT (linear variable differential transformers) was adapted for use with the differential manometer to measure small changes in pressure. Several prepared for field evaluation.

(4776) OPTICAL CURRENT METER.

(b) Laboratory project.
(c) Mr. Winchell Smith, U. S. Geological Survey, Menlo Park, Calif.
(d) Field investigation; instrument development.
(e) To measure surface velocities in swift or debris-laden streams without immersing equipment. The meter works on the stroboscopic principle whereby the rotation of a series of mirrors may be varied to apparently stop the surface motion of a stream.
(f) Completed.
(g) Meter has been field tested successfully.
(h) "Optical current meter," by Winchell Smith, U. S. Geological Survey and G. F. Bailey, Agricultural Research Service, J. of the Hydraulics Division, American Society of Civil Engineers, Volume 88, no HY 5, pages 13-22, September 1962.

(4777) NATURAL WATER LOSS IN SOUTHERN CALIFORNIA.

(b) Laboratory project.
(c) Mr. J. R. Crippen, U. S. Geological Survey, Los Angeles, Calif.
(d) Field investigation; applied research.
(e) To relate average annual natural water loss to climatological and geological factors. The parameters used are potential evapotranspiration (as determined from evaporation pan data), annual precipitation, and surficial rock types.
(f) Completed.
(h) Final report in preparation.

(4778) LOW-FLOW FREQUENCY OF ILLINOIS STREAMS.

(b) Laboratory project.
(c) Mr. William D. Mitchell, District Engineer, SW, 605 Neil St., Champaign, Ill.
(d) Field investigation; development, and applied research.
(e) An analysis of streamflow data to determine low-flow characteristics of Illinois streams on a frequency basis. Regional curves applicable to short term or intermittent records will be developed.
(g) Techniques have been developed and curves are being applied to test data.

(4779) LARGE-SCALE ROUGHNESS.

(b) Laboratory project.
(c) Mr. J. Davidian, USGS, Washington 25, D. C.
(d) Field investigation; applied research.
(e) Purpose is to study energy losses produced by large-scale roughness resulting from channel alignment and configuration.
(g) Available data compiled and background literature searched.

(4780) SNOWMELT HYDROLOGY OF A SIERRA NEVADA STREAM.

(b) Laboratory project.
(c) Mr. S. E. Rantz, U. S. Geological Survey, Menlo Park, Calif.
(d) Field investigation; applied research.
(e) To use physical laws of heat transfer and hydrologic routing procedures to predict daily snowmelt runoff from a mountain watershed. Daily amounts of radiation melt, convection melt, condensation melt, rain melt, and ground melt are first computed from hydrometeorological observations. These melt components are then totalled and routed to the gaging station.
(f) Completed.
(g) Method was tested successfully by reconstructing the daily discharge hydrographs for the North Yuba River during 3 snowmelt seasons. Final report in preparation.

(4781) THERMAL CHARACTERISTICS OF LAKES.

(b) Laboratory project.
(c) Mr. M. D. Hale, USGS, Indianapolis, Ind.
(d) Field investigation; applied research.
(e) Purpose is to study (1) lake temperatures and their relations with hydrometeorologic conditions, (2) energy required to maintain isothermal conditions, (3) methods of eliminating temperature stratification, (4) changes in water quality (BOD), biota, and evaporation as a result of elimination of thermocline.
(g) Small lake in Northeastern Indiana selected for study. Instrumentation of study now underway.

(4782) WATER MANAGEMENT.

(b) Laboratory project.
(c) Mr. C. W. Reck, USGS, Washington 25, D. C.
(d) Experimental; applied research.
(e) Purpose is to develop hydrologic principles and methods of water-resources appraisal that can be used for water management.
(g) Initial concepts and controlling factors have been evolved. Field sites are being investigated for testing of concepts.

(4783) APPLICATION OF THE THEORY OF MULTIPHASE FLOW.

(b) Laboratory project.
(c) Mr. R. W. Stallman, U. S. Geological Survey, Denver, Colo.
(d) Applied research in the measurement of moisture movement in unsaturated materials.
(e) Includes study of methods for measuring, in the field significant parameters related to flow in unsaturated material; and determining the nature of flow by laboratory models.
(h) "Multiphase Fluids in Porous Media - A Review and Discussion of Selected Literature Pertinent to Hydrologic Studies," by R. W. Stallman, U. S. Geol. Survey Prof. Paper 411-E (in press).
"Relation Between Storage Changes at the Water Table and Observed Water-level Changes," by R. W. Stallman, in Geological Survey Research 1961: U. S. Geol. Survey Prof.

Paper 424-B, p. 39-40.
"Preliminary Design of an Electric Analog of Liquid Flow in the Unsaturated Zone," by R. W. Stallman, in Geological Survey Research 1961: U. S. Geol. Survey Prof. Paper 424-B, p 60-63.
"New Equipment for Measurements in the Unsaturated Zone," by R. W. Stallman, and R. P. Moston, in Geological Survey Research 1961: U. S. Geol. Survey Prof. Paper 424-C, p. 363-365.

(4784) FLOW LOSSES IN EPHEMERAL STREAM CHANNELS.

(b) Cooperating Agent - Bureau of Land Management.
(c) Mr. R. F. Hadley, U.S.G.S., Denver, Colo.
(d) Field investigation, basic research.
(e) Measurement of surface flow losses in an ephemeral stream channel and determination of whether or not the absorbed water reaches a ground-water reservor will be evaluated on the San Ysidro Wash in Sandoval County, New Mexico. Secondly, these studies will furnish an opportunity to determine changes in channel and hydraulic geometry in a "losing" reach of channel.
(g) Construction is now in progress on two gaging stations and channel controls.

(4785) THE VIGIL NETWORK.

(b) Laboratory project.
(c) Dr. L. B. Leopold, U.S.G.S., Washington 25, D. C.
(d) Field investigation; basic research.
(e) To determine the changes with time on a number of small watersheds (from 1 to 10 square miles) in the vegetation, the channels, the biota, and the overall landscape.
(g) Progress has been made on choossing a series of small watersheds along a line or transect stretching in an east-west direction between the major mountain masses on the North American continent. Later it is hoped to have a similar series of watersheds in a north-south line through the central part of the United States where the topography is relatively flat. The north-south transect, then would give a representation of the effect of latitude uninfluenced by major differences in Topography.

(4786) EVALUATION OF HYDROLOGIC FEATURES CONCERNING GROUND-WATER CONTAMINATION.

(b) Laboratory project.
(c) Mr. H. E. LeGrand, U.S.G.S., Washington 25, D. C.
(d) Field investigation; basic research.
(e) To put into hydrologic perspective the various problems of ground-water contamination. To identify and classify both the contamination problems and their major geologic settings.
(g) Progress is being made on classifying the hydrogeologic framework in which contamination occurs.
(h) "Graphic Evaluation of Hydrogeologic Factors in the Management of Radioactive Waste," Proceeding Second A.E.C. Working Meeting - Ground Disposal of Radioactive Wastes - Chalk River, Canada, U.S. Dept. Commerce TZD 7628, pp. 67-76, 1962.

(4787) MECHANICS OF FLUID FLOW IN POROUS MEDIA.

(b) Laboratory project.
(c) Dr. Akio Ogata, U. S. Geological Survey, Honolulu, Hawaii.
(d) Experimental and theoretical study; basic research.
(e) Theoretical and laboratory study of microscopic and macroscopic aspects of flow through porous media.
(h) "Transverse Diffusion in Saturated Isotropic Granular Media," by Akio Ogata, 1961, U. S. Geological Survey Prof. Paper 411-B, 8 p.
"A Solution of the Differential Equation of Longitudinal Dispersion in Porous Media," by Akio Ogata, and R. B. Banks, 1961, U.S. Geol. Survey Prof. Paper 411-A, 7 p.

(4788) FLOW PHENOMENA AND SEDIMENT TRANSPORT IN STREAMS WITH HIGH CONCENTRATIONS OF FINE MATERIAL.

(b) Graduate project in cooperation with U. S. Geol. Survey.
(c) Mr. Carl F. Nordin, Jr., University of New Mexico, Albuquerque, New Mexico.
(d) Field investigation; applied research.
(e) Study of transport parameters in ephemeral streams transporting high concentrations of fine sediment.
(g) Velocity varies logarithmically with distance from the stream bed. Concentration distribution for several size classes of sand can be described by a conventional distribution equation if the fall velocity of the sand is corrected for the influence of the fine sediment. "Armoring" of the stream bed with clay affects the availability of sand.
(h) "Formation and Deposition of Clay Balls, Rio Puerco, New Mexico," by C. F. Nordin, Jr., and W. F. Curtis, U. S. Geological Survey Professional Paper 450-B, pp. 37-40. Report on sediment transport parameters in review.

(4789) THE EFFECT OF PHREATOPHYTE CLEARING, MIDDLE GILA RIVER VALLEY, SAN CARLOS INDIAN RESERVATION, ARIZONA.

(b) Laboratory.
(c) Mr. R. C. Culler, U.S. Geological Survey, Tucson, Arizona.
(d) Field investigation, basic research.
(e) To evaluate the change in evapotranspiration produced by the eradication of phreatophytes and the substitution of a beneficial vegetation. A water budget evaluation will be made of 16 miles of the flood plain of the Gila River, within the San Carlos Indian Reservation, Arizona. The water budget will be kept with the phreatophytes undisturbed for the calendar years 1963 to 1966. In 1967 the phreatophytes will be removed and a suitable replacement vegetation will be established. From 1967 to 1970 the water budget will be evaluated for the replacement vegetation.
(g) Four gaging stations were installed on the Gila River in 1962. Installation of observation wells and soil moisture meter access pipes was started.

U. S. DEPARTMENT OF THE INTERIOR, BUREAU OF MINES, Morgantown Coal Research Center.

(4436) FLOW PROPERTIES OF COAL-WATER SLURRIES.

(b) Laboratory project--information for general public use.
(c) Dr. L. L. Hirst, Research Director, Morgantown Coal Research Center, Morgantown, West Virginia.
(d) Experimental; applied research.
(e) The object of the project is to establish friction factor-Reynolds number relationships for coal-water slurries of various concentrations with coals of different ranks and size analyses. Work is being done with 1/2 inch, 3/4 inch, and 1 inch pipes. Data are processed on an IBM-1620 computer.
(g) Preliminary results show a change in rheological classification at or above 45 percent coal concentrations.
(h) "Aqueous Slurries of Coal and Granular Materials; A Bibliography," by L. F. Wilmot, W. R. Huff and W. E. Crockett, Bureau of Mines Inf. Circ. (in process of publication, 1963).

(4790) DIELECTRIC SEPARATION OF PARTICLES FROM SUSPENSIONS OF FINE COAL IN OIL.

(b) Laboratory project.
(c) Dr. L. L. Hirst, Research Director, Morgantown, Coal Research Center, Morgantown, W. Va.
(d) Experimental; applied research for a M.S. thesis at West Virginia University.
(e) The purpose of the project is to explore the feasibility of separating solid particles in nonpolar liquids by the application on a nonuniform electric field to a flowing stream of the suspension and in particular the separation in an oil vehicle of fine coal from its ash constituents.
(g) Capacitance cells have been constructed for determining the dielectric constants of the solids fractions and the oils in the suspensions.

U. S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION.

Inquiries concerning the following projects should be addressed to Assistant Commissioner and Chief Engineer, Bureau of Reclamation, Denver Federal Center, Denver 25, Colorado.

(2457) EROSION AND TRACTIVE FORCE STUDY OF UNLINED AND EARTH-LINED CANALS.

(e) Three field test reaches have been selected for study and for verification of laboratory studies in order to establish critical tractive force criteria for design of canals. A laboratory flume is being calibrated for determining tractive forces that erode soil in terms of standard soil properties.
(h) "Tractive Force Studies of Cohesive Soils for Design of Earth Canals," by E. J. Carlson and P. "F." Enger -- Paper presented at Eleventh Hydraulics Division Conference of the ASCE, Davis, California, August 15-17, 1962.

(2719) GLEN CANYON DAM SPILLWAY.

(f) Tests completed.
(h) Report in preparation.

(2953) STUDIES OF WIND WAVES ON CANALS.

(e) A soil classified as a fine silt having practically no cohesive qualities was subjected to surface water waves generated in a laboratory flume to determine its resistance to erosion.
(f) Tests completed.
(g) The relationship of bank erosion to wave length, wave period, wave height, and time of exposure to waves was determined.
(h) Report in preparation.

(2959) STILLING BASINS FOR SLIDE GATE CONTROLLED OUTLET WORKS.

(f) Tests in progress.
(h) Report to be prepared.

(2960) FLAMING GORGE DAM SPILLWAY.

(f) Tests completed.
(h) Report in preparation.

(3267) CANAL INLET AND OUTLET TRANSITION STUDIES.

(f) Present phase completed.
(g) Losses for a variety of conventional, open, broken-back transitions were found to be 0.6 to 0.7 for outlet service and 0.4 for inlet service. Scour was slightly reduced with the closed conduit transitions.
(h) "Progress Report 1 -- Research Studies on Inlet and Outlet Transitions for Small Canals," by W. P. Simmons, Hydraulics Branch Report No. Hyd-492, July 1962.

(3270) SAN ACACIA DIVERSION--HEADWORKS AND SLUICEWAY.

(d) Experimental; for design.
(e) A 1:20 movable bed hydraulic model was used to determine a satisfactory method for reducing the quantity of coarse sediments entering a canal headworks. A partial verification with the prototype was obtained, then various discharges were tested.
(f) Tests completed.
(g) Three systems were found which resulted in satisfactory conditions. The three methods found included guide vanes, an inverted siphon, and a flume containing a sluicing arrangement. The model indicated that at certain discharges approximately 90 percent of the coarse sediments could be prevented from entering the canal.
(h) "Hydraulic Model Study to Determine a Sediment Control Arrangement for Socorro Main Canal Headworks, San Acacia Diversion Dam--Middle Rio Grande Project, New Mexico," by P. "F." Enger, Hydraulics Branch Report No. Hyd-479, March 1962.

(3271) CHANNELIZATION IN ALLUVIAL RIVERS USING STEEL JACKS AND JETTIES.

(f) Laboratory tests completed, field data to be analyzed progressively as obtained.
(h) "Control of Alluvial Rivers by Steel Jetties," by E. J. Carlson and R. A. Dodge, Jr., proceedings of the ASCE, Journal of the Waterways and Harbors Division, Volume 88, No. WW4, November 1962.

(3274) CONSTANT HEAD ORIFICE TURNOUT.

(f) Tests completed.
(h) Report in preparation.

(3275) FRICTION FACTOR TESTS IN LARGE PRESSURE CONDUITS--EKLUTNA TUNNEL, ALASKA.

(f) Tests and data analyses completed.
(h) Results to be presented in revised editions of Bureau of Reclamation Engineering Monograph No. 7, "Friction Factors for Large Conduits Flowing Full," by J. N. Bradley and L. R. Thompson (report in preparation).

(3278) CAVITATION OF CONCRETE SURFACE IRREGULARITIES.

(h) Additional reports to be prepared.

(3609) TWIN BUTTES OUTLET WORKS INTAKE STRUCTURES.

(f) Completed.
(h) "Aerodynamic Model Studies of the Outlet Works Intake Structures for Twin Buttes Dam -- San Angelo Project, Texas," by D. Colgate, Hydraulics Branch Report No. Hyd-470, August 1962.

(3611) ADJUSTABLE WEIR.

(f) Single weir investigation completed.
(h) Report in preparation.

(3612) DISCHARGE COEFFICIENTS FOR RADIAL GATES.

(b) Laboratory project.
(d) Experimental, laboratory and field investigations; applied research.
(e) Radial gates are used extensively in irrigation systems for discharge and water surface level control. Intelligent operation of the systems requires that the rate of flow passing the gated structure be known. Literature research resulted in an analytical approach and adjusted equation for the gate capacity with unsubmerged flow.
(g) Extensive model and prototype radial gate data were obtained from the TVA Hydraulic Laboratory. The data are being analyzed to verify the proposed discharge formula and to extend the scope of presently available information.

(3613) COMPOUND WEIR STUDIES.

(f) Tests completed.

(g) Head-discharge relationships are presented for compound weirs. All compound weirs had a common 1-foot-deep 90 degree V-notch with following combinations; Sides vertical from top of notch, 1-foot and 2-foot horizontal extensions from top of notch to vertical sides, and 1-foot and 2-foot 15 degree upward sloping extensions from top of notch to vertical sides. Certain generalizations were drawn from the analysis of the test data but these should be confirmed by further testing before weirs other than those investigated are used in critical situations.
(h) "Compound Weir Study," by J. M. Bergmann, Hydraulics Branch Report No. Hyd-505, March 1962.

(3614) EXPERIMENTAL STUDY OF SUBCRITICAL FLOW IN CURVED CHANNELS.

(b) Laboratory project.
(d) Experimental; applied research and design.
(e) A fixed-bed, hydraulic model has been constructed to determine the possibility of reduction in scour and deposition in unlined channels due to secondary currents. A Preston Tube has been constructed and is being used to measure boundary shear along the curved portion of the trapezoidal model channel.
(f) Tests in progress.

(3985) DISCHARGE CAPACITY OF LARGE CONCRETE-LINED CANALS.

(b) Laboratory project.
(d) Experimental, laboratory and field investigations; applied research and design.
(e) This study is for the purpose of exploring the effects on the hydraulic gradient of the relationship of boundary surface resistance to the cumulative resistance of crossings, inlets, turnouts, checks, and other local items in concrete-lined canals of different sizes, shapes, and grades. This study is part of a program to explain why design procedures used successfully for small and medium sizes of canals may not be adequate for large concrete-lined canals on flat slopes.
(h) Report on field investigations in preparation.

(3988) YELLOWTAIL DAM OUTLET WORKS.

(f) Completed.
(g) A satisfactory structure was developed that provided good operation over the full range of extreme tailwater variations.
(h) "Hydraulic Model Studies of Yellowtail Dam Outlet Works," (Final Studies) by T. J. Rhone, Hydraulics Branch Report No. Hyd-482, February 1962.

(3989) YELLOWTAIL DAM SPILLWAY.

(f) Completed.
(g) The following were developed during the study: width and alinement of the approach channel; length and shape of the pier at the gate section; discharge calibration; curvature of the tunnel trajectory approaching the combination flip bucket stilling basin; length, depth, and shape of the flip bucket basin; and riprap requirements downstream from basin.
(h) Report in preparation.

(3990) BAFFLED APRON FOR GRAVITY FLOW BYPASS--WILLARD CANAL PUMPING PLANT NO. 1.

(f) Completed.
(g) Previous tests have shown that for satisfactory operation of an apron on a 2:1 slope with baffle piers 3 feet high, the spacing of the rows should be 6 feet measured along the slopes. Tests conducted on drops with slopes of 3:1 and 4-1/2:1 showed that the vertical fall distance between rows of baffle piers is constant, thus allowing greater spacing between rows of piers for aprons on flatter slopes.
(h) "Hydraulic Model Studies of Baffled Apron Drops, Willard Canal Pumping Plant No. 1, Weber Basin Project, Utah," by T. J. Rhone, Hydraulics Branch Report No. Hyd-490, July 1962.

(3991) SEDIMENT TESTS ON PROTOTYPE DIVERSION DAMS--KANSAS RIVER BASIN--NEBRASKA-KANSAS.

(f) Data obtained in the field have been partiall analyzed.
(h) Report in preparation.

(3994) HYDRAULIC JUMP CHUTE BLOCK AND BAFFLE BLOCK PRESSURES.

(b) Laboratory project.
(f) Tests in progress.
(g) The minimum subatmospheric pressures on a square-edge chute block, whose height and width are equal to the depth of the approaching flow, are related to tailwater depth for a range of approach velocities. Also, minimum pressures on a baffle pier will be related to tailwater depth for a range of approach velocities.
(h) Progress report in preparation.

(3995) LABORATORY STUDY TO DETERMINE THE EQUILIBRIUM BEACH PROFILE FOR FIGARDEN RESERVOIR SITE--CENTRAL VALLEY PROJECT, CALIFORNIA.

(e) A sloping beach composed of sand (mean diameter 0.57 mm, similar to Figarden Reservoir material) was placed in the wave channel. This test section was subjected to wave action and the equilibrium beach slope determined. The purpose of this study was to obtain information helpful in determining the amount of right-of-way required for Figarden Reservoir.
(f) Completed.
(g) The equilibrium beach slope was approximately 1:10. Interrelationship of dimensionless parameters was determined for this soil and is useful in predicting beach encroachment by waves.
(h) "Laboratory Study to Determine the Equilibrium Beach Profile for Figarden Reservoir--Central Valley Project, Calif.," by R. A. Dodge, Jr., Hydraulics Branch Report No. Hyd-475, July 1962.

(3996) HIGH HEAD ORIFICE STUDIES.

(f) Tests in progress.
(h) Progress report in preparation.

(4412) OROVILLE DAM DIVERSION TUNNELS AND TAILRACE.

(b) California Department of Water Resources.
(d) Experimental; for design.
(e) A 1:54.63 scale hydraulic model was used to study complex, high-velocity diversion flows in the two 36-foot-diameter, 4,500-foot-long tunnels and to study surge characteristics of the underground power house whose draft tubes connect to the downstream portion of the tunnels to form the tailrace. A 1:46.6 scale air model was used to evaluate various passage configurations for connecting the draft tubes to the tunnels to obtain minimum losses.
(f) Completed.
(g) Flow and pressure conditions were satisfactory in the bellmouth inlets, tunnels, and outlet portals for diversion flows. Better river channel flow conditions were obtained with a higher guide wall on the right side of Outlet Portal 1, and with the channel upstream from the portals filled to the downstream face of the dam. Other improvements in the river, such as guide walls and the removal of rock outcrops, were not necessary or economically feasible. The design of the complex tail-race system for the underground powerhouse satisfactorily

controlled surging for all possible load acceptance or load rejection cycles.
(h) Reports in preparation.

(4413) OROVILLE DAM TUNNEL PLUG OUTLET WORKS.

(b) California Department of Water Resources.
(d) Experimental; for design.
(e) A 1:18 scale model of the tunnel plug outlet works was used to determine the appurtenant structures necessary in the 35-foot-diameter tunnel to adequately dissipate the high energy flow from two 54-inch Howell-Bunger valves discharging under a 670-foot head.
(f) Completed.
(g) A design was developed which adequately dissipates the high energy flows from two 54-inch Howell-Bunger valves, each discharging 2,700 cfs under a head of 670 feet. The valves are placed 3 feet above the tunnel centerline, and the appurtenances consist of a deflector ring around the inside of the tunnel and two rows of baffle piers on the invert downstream.
(h) Report in preparation.

(4414) WANSHIP DAM VERTICAL STILLING WELLS.

(b) Laboratory project.
(d) Experimental; applied research and design.
(e) Laboratory tests were made to determine the required depth of two vertical stilling wells having corner fillets and a sleeve-type valve which seats on a pedestal in the center of the well floor.
(f) Completed.
(g) A water depth of 9.3 feet is sufficient to produce a smooth water surface in a well 6 by 6 feet, operating at a maximum design discharge of 16.7 cubic feet per second under total design heads up to 118 feet. A water depth of 11.8 feet is required in the same size well without corner fillets. Water depths and heads are measured from the top of the pedestal.
(h) "Hydraulic Model Studies of the Wanship Dam Vertical Stilling Wells, Weber Basin Project, Utah," by H. T. Falvey, Hydraulics Branch Report No. Hyd-481, January 1962.

(4415) FISH PROTECTIVE FACILITIES--TRACY PUMPING PLANT.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:6.3 scale model was used to determine modifications for the existing secondary fish screen structure to eliminate the large-scale turbulences and eddies which produced unnecessary fish mortalities.
(f) Completed.
(g) An effective closed-conduit type expanding section was created in the structure by divider walls and a top cover so that smooth eddyless flow occurred without regions where fish could be entrapped.
(h) "Hydraulic Model Studies of the Secondary Louver Structure -- Fish Protective Facilities -- Tracy Pumping Plant -- Central Valley Project, California," by W. P. Simmons, Hydraulics Branch Report No Hyd-480, September 1961.

(4416) BLUE MESA DAM SPILLWAY.

(d) Experimental; for design.
(e) A 1:32.78 scale model was used to study the radial gate controlled intake, inclined tunnel, and the flip bucket for flows up to 33,650 cfs discharging at a velocity of 113 feet per second at the outlet portal.
(f) Tests completed.
(g) The approach channel shape, tunnel transition section at the intake, inclined tunnel, vertical bend in tunnel, and flip bucket were developed.
(h) Report in preparation.

(4417) FONTENELLE DAM OUTLET WORKS.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:24.7 scale model was used to investigate the flow from three 11-foot-diameter circular conduits discharging through top-seal radial gates into three 14-foot-diameter horseshoe conduits leading to a common stilling basin. Eventually, a 10-foot-diameter power penstock will be installed in the right horseshoe conduit with a bifurcation and slide-gate controlled bypass located at the start of the stilling basin chute. Studies were made to develop the bypass structure so that the stilling basin derived for the original structure would be equally satisfactory for the modified structure.
(f) Completed.
(g) Satisfactory flow conditions were obtained in the original structure and the most favorable alinement for the bypass structure was determined. Pressure distribution and head loss measurements were also obtained in the bifurcation structure.
(h) "Hydraulic Model Studies of the Fontanelle Dam Outlet Works, Seedskadee Project, Wyoming," by T. J. Rhone, Hydraulics Branch Report No. Hyd-487, August 1962.

(4418) SANFORD DAM SPILLWAY AND FLOOD CONTROL OUTLET WORKS.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:46.42 scale model was used to study hydraulic characteristics for two features, the morning-glory spillway and flood control outlet works. Hydraulic characteristics of the entrances, chutes, and stilling basins were studied. Also, the influence one feature has upon the other during simultaneous operation was investigated for various flow conditions.
(f) Completed.
(g) Tapered dividing piers, at the outlet portal of the flood control outlet works, were modified to eliminate overtopping of the side walls and improve poor flow distribution on the chute during asymmetrical gate operation. Combination crest piers and guide vanes were developed for the morning-glory spillway entrance to reduce the size of the vortex and improve the tunnel flow conditions. No changes or additions were necessary for the remaining features of the design.
(h) "Hydraulic Model Studies of Sanford Dam Spillway and Flood Control Outlet Works," by D. L. King, Hydraulics Branch Report No. Hyd-491, December 1962.

(4419) WHISKEYTOWN DAM SPILLWAY.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:32.78 scale model was constructed to study the morning-glory intake, the vertical tunnel bend, the straight tunnel, the flip bucket, and the downstream river channel for flows up to 28,450 cfs discharging with a maximum velocity of 96 feet per second at the outlet portal.
(f) Completed.
(g) The following were developed during the study: Guide vanes for the crest, a deflector and air vent for the vertical bend, shape of the flip bucket, discharge channel alinement, and head discharge relationships for the spillway.
(h) "Hydraulic Model Studies of Whiskeytown Dam Spillway," by G. L. Beichley, Hydraulics Branch Report No. Hyd-498, January 1963.

(4420) FONTANELLE DAM SPILLWAY.

(b) Laboratory project.
(d) Experimental; for design.

(e) A 1:30 scale model was used to investigate the design of a double side-channel spillway discharging into a sloping chute and hysraulic jump stilling basin.
(f) Completed.
(g) Minor modifications were made to the sloping chute between the spillway and stilling basin, otherwise the design was found to be satisfactory.
(h) "Hydraulic Model Studies of Fontanelle Dam Spillway, Seedskadee Project, Wyoming," by T. J. Rhone, Hydraulics Branch Report No. Hyd-486, February 1962.

(4421) SEDIMENT CONTROL AT DIVERSIONS.

(b) Laboratory project.
(d) Experimental; for design.
(e) Various devices are being studied to develop ways of reducing the amount of bed sediment entering canals.
(f) Continuing.
(g) Several arrangements of bottom and surface guide vanes were tested, and their effectiveness in reducing sediment intake into a canal diverted from a large river was compared.
(h) "Hydraulic Model Tests of Bottom and Surface Guide Vanes to Control Sediment Inflow Into a Canal Headworks," by P. "F" Enger, Hydraulics Branch Report No. Hyd-499, August 1962.

(4423) RELATION OF SEDIMENT SUSPENSION AND SCOUR TO CHANNEL HYDRAULIC CHARACTERISTICS.

(f) Suspended.

(4424) EQUILIBRIUM BEACH PROFILES.

(b) Laboratory project.
(d) Experimental; for design.
(e) To determine equilibrium beach profile in terms of soil properties and in terms of waves expected at a reservoir site.
(f) Model has been constructed.

(4425) WATER-COLUMN SEPARATION.

(b) Division of Design Project.
(d) Theoretical and field investigation; applied research.
(e) Field tests are being used to check theoretical developments designed to predict completely the hydraulic transient conditions occurring during separation and rejoining of water columns occurring during separation and rejoining of water columns in pump discharge lines.
(g) Peak pressures higher than predicted were measured in the field.
(h) Report in preparation.

(4791) HIGH-VELOCITY JET ON PROTECTIVE COATINGS.

(b) Laboratory study.
(d) Experimental; for operation and maintenance.
(e) A 100-fps, 1-inch-diameter jet was impinged at 45 degrees on protective coverings proposed for application on concrete surfaces to be subjected to high-velocity flow with sediment laden water.
(f) Completed.
(g) All protective coatings tested, in which the surface was unbroken, withstood the jet for 4 hours. All coatings tested in which a broken or cut surface extended to the concrete were ripped from the concrete test blocks in less than 5 minutes.
(h) Report in preparation.

(4792) CANADIAN RIVER AQUEDUCT CHECK TOWERS.

(b) Laboratory project.
(d) Experimental; for design.
(e) Laboratory tests are being made to determine the hydraulic losses and air-entrainment potential of check towers to be installed in the 125-mile-long Canadian River Aqueduct. The towers and aqueduct are to be so designed that the tops of each tower are slightly below the hydraulic gradient. Preliminary studies are with a 90 degree vertical bend from the conduit alinement, a rising leg, a 180 degree return bend, a descending leg, and a 90 degree vertical bend to return the conduit to the main conduit alinement. The inside diameter of the check tower is the same as the conduit.
(f) Tests in progress.

(4793) ROTATING DISK--PAINT TEST APPARATUS.

(b) Laboratory project.
(d) Experimental; development.
(e) A test apparatus consisting of four disks, each rotating in a separate chamber, was constructed and tested. Protective coatings will be applied to the disks and to the walls of each chamber, to evaluate the coating's resistance to flowing water.
(f) Completed.
(g) Water velocity and path charts have been prepared for both the rotating disks and the chamber walls.
(h) Report in preparation.

(4794) VERTICAL STILLING WELL.

(b) Laboratory project.
(d) Applied research.
(e) The purpose is to obtain the optimum size, depth, and internal configuration of vertical stilling wells for high-head discharges. The test installation is a model with a 4- by 4-foot-square well 6 feet deep, followed by a canal with a 4-foot bottom width and 1:1.5 side slopes. One-quarter of the symmetrical floor is equipped with piezometers to measure changes in pressure distribution with changes in internal well configuration or with downspout length to well depth ratios.
(f) Initial testing presently underway.

(4795) SUCTION ELBOWS FOR LARGE PUMPING PLANTS.

(b) Laboratory project.
(d) Experimental; research and design.
(e) The purpose is to make a comparative analysis of two suction elbows involving 135 degrees of turn rather than the usual 90 degrees. Tests are being made with 1:9.187 scale model elbows having 8-inch outlet diameters. One elbow is based on the concept of RV being constant, and the other is based on the concept of a constant radius centerline. The cross sectional areas of both elbows decrease in the downstream direction. Use of elbows with 135 degrees of turning results in a shallower forebay with cost saving due to decreased excavation. The shallower forebay prevents "pooling" of water in the forebay and provides a more efficient design because the kinetic energy of the canal flow is maintained. Sediment deposits which often occur in the forebay will also be decreased.
(g) Both elbows show a high degree of efficiency; however, design simplicity dictates the use of the elbow based on a constant radius centerline. The velocity distribution at the location of the pump impeller is excellent and the energy loss from forebay to impeller station is 0.01 h_{v2}.
(h) Report in preparation.

(4796) CULVERT HYDRAULICS.

(b) Library research project.
(d) Research; for design.
(e) A library study was conducted to determine present knowledge of culvert hydraulics, to compile an annotated bibliography of publications on the subject, and to prepare a summary of research still needed in specific areas.
(f) Completed.
(g) Considerable data are presently available,

but many areas still need further study. On the basis of present information, a comprehensive design manual could be prepared. During this preparation, areas where additional study is needed would become clearly delineated.

(h) "Culvert Hydraulics--A Library Study," by H. T. Falvey, Hydraulics Branch Report No. Hyd-489, April 1962.

(4797) HYDRAULIC STUDIES OF A 3-INCH QUICK-OPENING SLOW-CLOSING AIR VALVE.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 3-inch prototype valve was tested to determine its hydraulic characteristics and the effects of design modifications on its speed of closure under low-line pressures.
(f) Completed.
(g) The speed of closure under very low-line pressure was increased by adding a standpipe to the valve waste line. The speed of closure under normal operating heads remained unchanged. Counterweights of more appropriate size would help in adjusting the opening and closing characteristics of the valves.
(h) "Hydraulic Studies of a 3-inch Quick-opening Slow-closing Air Valve," by H. T. Falvey, Hydraulics Branch Report No. Hyd-488, June 1962.

(4798) DOWNPULL STUDIES OF FIXED-WHEEL GATE FOR RED BLUFF DIVERSION DAM.

(b) Laboratory project.
(d) Experimental; for design.
(e) 1:18.6 model studies were conducted to determine downpull forces on 18- by 60-foot, upstream seal, fixed-wheel gates for free and submerged flow conditions.
(f) Tests completed.
(g) To reduce downpull during submerged operation the conventional solid-web beams on the downstream face of the gate were replaced with open bow trusses. A combination of weighing and pressure techniques was used to measure total downpull and to separate it into the forces acting on certain parts of the gate.
(h) Report in preparation.

(4799) SAN LUIS DAM SPILLWAY.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:14.83 scale model was used to study the morning-glory spillway intake, vertical shaft, and vertical bend for flows up to 3,000 cfs, dropping approximately 100 feet through the inlet and vertical shaft.
(f) Tests completed.
(g) A deflector, with air vent and guide vanes, was developed for the vertical bend.
(h) Report in preparation.

(4800) SAN LUIS DAM FOREBAY.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:21.91 scale model is being constructed to study the morning-glory inlet, vertical bend, and stilling basin for flows up to 3,600 cfs flowing at approximately 50 feet per second at the tunnel exit portal.

(4801) NORTON DAM SPILLWAY.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:42 scale model was used to investigate hydraulic features of the spillway structure. This included size and shape of spillway piers and approach walls, placement of radial gates, flow distribution on the chute, and stilling basin performance.
(f) Tests completed.
(g) Satisfactory flow conditions in the crest section were obtained by modifying the approach walls and spillway piers. Counterweight arms of the radial gates were modified to prevent flow from impinging on the counterweights. Sidewalls of the spillway chute were slightly modified to prevent overtopping during unsymmetrical gate operations. Performance of the stilling basin was found to be satisfactory for all operating conditions.
(h) "Hydraulic Model Studies on Norton Dam Spillway, Missouri River Basin Project, Kansas," by W. P. Meyer and T. J. Rhone, Hydraulics Branch Report No. Hyd-493, Nov. 1962.

(4802) STUDIES ON ORIFICES FOR AUTOMATIC RADIAL GATE CONTROLS.

(b) Laboratory project.
(d) Experimental; for design.
(e) A study to determine flow characteristics and coefficient of discharge of 1-inch and 3-inch orifices in floatwell intakes of automatic radial-gate controls. Studies will be made with orifices in horizontal and vertical planes, in nonstandard settings, with different approach and exit conditions at heads from 1 to 100 feet.
(f) Tests in progress.

(4803) BULLY CREEK DAM--BULLY CREEK OUTLET WORKS.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:6.75 scale model was used to determine the energy-dissipating efficiency of the hydraulic jump stilling basin and to observe the flow conditions, on the chute downstream from the high-pressure slide gate, in the stilling basin, and in the channel downstream.
(f) Completed.
(g) All features of the design were found to be acceptable. Hydraulic jump data for other than design head and discharge were recorded for use in future designs.
(h) "Hydraulic Model Studies of Bully Creek Dam—Bully Creek Outlet Works," by D. L. King, Hydraulics Branch Report No. Hyd-494, Jan. 1963.

(4804) BULLY CREEK DAM -- CANAL OUTLET WORKS.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:9.75 scale model was used to study the hydraulic operating characteristics of the slide gate controlled canal outlet works including the chute, hydraulic jump stilling basin, and a portion of the canal.
(f) Completed.
(g) All features of the design were found to be acceptable. Hydraulic jump research data were recorded for use in future designs.
(h) "Hydraulic Model Studies of Bully Creek Dam Canal Outlet Works," by D. L. King, Hydraulics Branch Report No. Hyd-495, January 1963.

(4805) CAUSEY DAM OUTLET WORKS.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:11 scale model was used to observe hydraulic performance of the slide gate controlled outlet works. The features included: Symmetrical wye branch upstream from gates, chute, hydraulic jump stilling basin, and a portion of the downstream river channel.
(f) Completed.
(g) All features of the design were found to be acceptable. Pressures and head losses in the wye branch were determined and hydraulic jump data were taken for use in future designs.
(h) Report in preparation.

(4806) NORTON DAM OUTLET WORKS.

(b) Laboratory project.

(d) Experimental; for design.
(e) A 1:8.75 scale model is being constructed to study the hydraulic characteristics of the chute and stilling basin for the slide gate controlled outlet works.

(4807) MORROW POINT DAM SPILLWAY AND OUTLET WORKS.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:24 scale model was constructed to aid in the development of the unusual design of the spillway and outlet works for the thin-arch concrete dam. The original design, consisting of a free overfall spillway and an outlet works located near the bottom of the dam, was abandoned because of undesirable flow conditions in the artificially formed stilling pool at the base of the dam. The present design includes four fixed-wheel gate controlled conduits near the top of the dam which pass the combined spillway and outlet works discharge of 38,100 cfs, allowing it to fall approximately 400 feet to the stilling pool.
(f) Tests in progress.

(4808) JOES VALLEY DAM SPILLWAY.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:20.29 scale model is being constructed to study hydraulic features of the morning-glory spillway. The model will include the spillway entrance, a portion of the reservoir topography surrounding the entrance, vertical bends, and a portion of the horizontal tunnel.

U. S. DEPARTMENT OF THE NAVY, DAVID TAYLOR MODEL BASIN.

Inquiries concerning the following projects should be addressed to the Commanding Officer and Director, David Taylor Model Basin, Washington 7, D.C.

(710) RESEARCH ON MAIN INJECTION SCOOPS AND OVERBOARD DISCHARGES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical; applied research.
(e) Investigations to determine the characteristics of injection scoops and discharges to provide design data for use in design of future ships in both high and low speed ranges.
(f) Discontinued.

(711) CAVITATION RESEARCH.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental; applied research.
(e) Research is being conducted on the mechanism and effects of cavitation phenomena in real and ideal fluids. (1) Linearized theory is being applied to determine cavity shapes and forces in steady flows. (2) Experimental studies of the growth of cavities on hydrofoils are to be made in both steady and unsteady flows (see project #3284).
(g) A better correlation between theoretically and experimentally determined cavity shape has been achieved by modifying linearized cavitation theory to include surface tension effects.
(h) "Surface Tension and Free Surface Effects in Steady Two-Dimensional Cavity Flow About Slender Bodies," by S. H. Schot, TMB Report 1566 (January 1962).

(1778) HYDRODYNAMIC NOISE.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Hydrodynamic research.
(e) Investigations of the characteristics of underwater noise associated with various hydrodynamic phenomena such as cavitation, bubble oscillation, turbulence and splashing. Particular attention is now being given to measurement of spectra and space-time correlations of pressure fluctuations on walls adjacent to turbulent flows, such as flat plate boundary layer flows and fully turbulent pipe flows.
(g) Experimental and theoretical studies have been made of noise produced by cavitation, splashing, oscillating air bubbles, and turbulence.

(1783) MATHEMATICAL SHIP LINES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical research.
(e) Development of a suitable method for the mathematical determination of ship lines which can be applied to a wide variety of ship forms especially to those of modern design.
(g) A method has been developed for the mathematical fairing of graphical lines. This is a first step toward the development of a flexible system of mathematical ship lines. Future work is directed toward the development of a system of mathematical lines which will permit the derivation of a hull form for a given set of parameters.

(1786) STUDIES OF THE SLAMMING OF SHIPS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical basic research.
(e) Computations and measurements of the pressure distribution and impact forces on the bottoms of slamming ships for the purpose of developing design criteria to effect their reduction.
(g) A theory which is applicable to almost any practical ship forebody section has been developed for determining impact force and pressures on a ship's bottom during slamming. The theory was applied to three different ship forms ranging from extreme U to extreme V and pressures, forces and impulse were compared. A comparison of the theory with two dimensional drop tests using the V-form was also included.
(h) "Hydrodynamic Impact With Application to Ship Slamming," by K. M. Ochi and M. D. Bledsoe, presented at the Fourth Symposium on Naval Hydrodynamics, August 1962.

(2019) SERIES 60 - PROPELLER EXCITED VIBRATION.

(b) David Taylor Model Basin and Society of Naval Architects and Marine Engineers.
(d) Experimental basic research.
(e) Measurement of propeller induced vibratory forces on a series of models with variations in stern shape.
(g) The instrumentation and test techniques for measuring the propeller induced vibratory forces on a single screw ship model has been developed sufficiently to obtain repetitive results. Although there is insufficient information available to permit extrapolation to full scale forces, comparison of test results of models of similar type and dimensions appears valid. During the past year tests were conducted of a series of 3 models, based on the 0.70 C_B series 60 parent form, with variations in stern section shape from U to V. Measurement of instantaneous pressure has been made on the hull of the USS TIMMERMAN and on the hull of a 30-foot model of that vessel. Preliminary data indicates that the model measurements when similarly extrapolated also produce higher values than were measured on board ship.

(2229) NEAR SURFACE EFFECTS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Hydrodynamic research.

(e) A mathematical study of the forces and moments acting on bodies due to the proximity of a free surface. The studies include both the case in which the surface is initially undisturbed and the case in which there are disturbances originating at a distance. Experiments are being conducted to verify the theoretical developments.

(g) Methods were developed for computing the forces and moments acting on bodies of revolution, both due to waves generated by the body itself and to regular trains of waves. Experiments with a spheroid moving under waves largely confirmed the theory except in following seas. The damping forces on a submerged translating ellipsoid which is oscillating in any of its six degrees of freedom have been developed theoretically. The effect of tank walls has been evaluated theoretically as well.

(h) "Wave Resistance of a Moving Pressure Distribution in a Canal", by J. N. Newman and F. A. Poole, Schiffstechnik Band 9, Heft 45, Jan. 1962, Reprinted as TMB Report 1619.
"The Coupled Damping Coefficients of a Symmetric Ship," by R. Tinman and J. N. Newman, Journal of Ship Research, Vol. 5, No. 4, March 1962.

(2230) THEORY OF SEAWORTHINESS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Hydrodynamic research.
(e) A theoretical and experimental study of factors affecting the seaworthiness of ships, for the purpose of developing procedures for predicting their motion. The work is oriented in four directions: (1) Finding the equations of motion of a ship in a seaway, with the forces obtained from solutions of the boundary value potential problem. This approach will provide equations which are valid for transient as well as steady-state oscillatory conditions. (2) Validification of the more common technique of assuming that the longitudinal plane motions can be described by a system of linear second order differential equations with constant frequency dependent coefficients. The coefficients in the equations of motion are determined experimentally, as well as the forces on restrained models in regular waves. The motions of a free model can then be computed and compared with experiments to determine the validity of the theory. (3) Analytical and experimental studies of the damping of ship motions by free surface effects. (4) Determination of the form of a set of equations for the motions of a ship which are more reasonable physically than the second order constant-coefficient equations. Such equations will be derived in a heuristic manner, and certain parameters will be determined experimentally. The resulting equations should be valid for transient and steady-state sinisoidal motions.

(g) A restrained ship model has been towed in regular waves and the force and moment induced by the waves has been measured. Comparison of these data with calculations based on the Froude-Krylov hypothesis shows only qualitative agreement. Calculation of damping coefficients has been completed for Series 60 model, yielding generally excellent agreement with forced oscillation experiments. A mathematically defined model has been oscillated in pitch and in heave over a range of frequencies and forward speeds, to determine the coefficients for the assumed second order equations of motion. Equations of motion for the oscillating ship have been obtained which remove the necessity for frequency dependent coefficients. These equations include convolution integrals over the past history of the motion, and are completely general.

(h) "The Impulse Response Function and Ship Motion," by W. E. Cummins, Schiffstechnik, 9 Band, 47 Heft, June 1962.
"Polynomial Representation and Damping of Series 60 Hull Forms," by J. Gerritsma, J. E. Kerwin, J. N. Newman, International Shipbuilding Progress, July 1962.

(2231) HYDRODYNAMIC ROUGHNESS STUDIES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental; basic and applied research.
(e) Research on methods for analyzing and predicting the frictional resistance of arbitrarily rough surfaces such as the painted surfaces of ship hulls. The geometrical characteristics are to be correlated with the hydrodynamic characteristics.
(g) A new roughness profilometer has been built for use in curved surfaces and which is integrated into a magnetic tape recording system. A theoretical method has been devised for predicting the full scale resistance of arbitrarily rough surfaces from tests if model plates with the actual roughness. A high speed towing rig is under design and construction for these tests.
(h) "The Frictional Resistance and Turbulent Boundary Layer of Rough Surfaces," by P. S. Granville, Journal of Ship Research, Vol. 2, No. 3, December 1958.

(2235) LIBERTY SHIP SEAWORTHINESS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental.
(e) Thorough seaworthiness investigations of a Liberty Ship and a modified Liberty Ship hull. Full scale trials were conducted during several crossings of the North Atlantic. Speed reduction, ship motion stresses and slamming pressures were investigated.
(f) Completed.
(g) The motion and stress data obtained for special maneuvers conducted on each of the ships in approximately a State 5 sea have been analyzed and a comparative evaluation made for this particular oceanographic condition. Data obtained in all sea conditions have been analyzed and a final report comparing the two ships has been completed and is in review.

(2237) LIFTING SURFACE THEORY OF PROPELLERS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical; applied research.
(e) Studies of the corrections on lifting line theory which arise from the finite extent of the blades.
(g) The available results are being applied to propeller design methods.

(2462) PITCH REDUCTION STUDIES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical.
(e) To determine the mechanism of occurrence and basic properties of horizontal hull vibrations induced by anti-pitching fins.
(f) Completed.
(g) To clarify the mechanism whereby the transverse vibrations are induced, a fiberglass model of the Mariner was tested and the fin loading, model motions and hull vibrations recorded. The effect of position of the fin along the hull on the vibration was studied. It was found that the vibrations are the result of an impact on the fin and/or bow due to collapse of a cavity and/or slamming. A 22 foot model was also tested on which the pressure distribution on the bow was measured along with the other variables mentioned above.
(h) "Model Experiments with Bow Anti-Pitching Fins," by G. P. Stefun, TMB Report 1118.

(2463) STUDIES OF LOW ASPECT-RATIO CONTROL SURFACES.

(b) David Taylor Model Basin; laboratory project.
(d) Experimental investigation; basic research.
(e) Determine the aerodynamic characteristics of a family of low aspect-ratio control surfaces which can be used by the designer of submarines and surface ships. Phase I is an investigation of a family of all movable control surfaces. Phase II is an investigation of the same family with plain flaps of different chord length.
(f) Phase I, Completed: Phase II, Completed.
(g) The results of Phase I indicate that many of the aerodynamic characteristics of low aspect ratio surfaces can be accurately predicted from lifting surface theory. The aerodynamic characteristics for an NACA 0015, aspect-ratio 2, movable control surface with 30, 40 and 50 percent flaps were obtained at the University of Maryland Wind Tunnel. The tests were conducted for the David Taylor Model Basin under U. S. Navy contract. Forces and moments for the complete control surfaces were obtained in the first part of the test. Forces and moments for the flap portion of the control surfaces were obtained in the second part of the test.
(h) The results of Phase I and comparisons with lifting surface theory are presented in TMB Report 933.
The results of the Phase II tests are presented in University of Maryland Wind Tunnel Report No. 268, December 1959.

(2470) CAVITY RESONANCE.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical investigation of the excitations of cavity resonance by fluid flow.
(e) Studies to determine the mechanism of excitation of the cavity resonance by fluid flow past orifice will be undertaken. The experimental investigation will employ the low turbulence wind tunnel and circulating water channel. The amplitude of pressure fluctuations in the cavity will be investigated as function of the size, shape and number of orifices, as well as the turbulence characteristics in the boundary layer flow.
(f) Discontinued.
(h) "Flow-Induced Cavity Resonance in Viscous Compressible and Incompressible Fluids," by W. H. Dunham, presented at the Fourth Symposium on Naval Hydrodynamics, Ship Propulsion and Hydroelasticity, Washington, D. C. August 1962. Published in ONR Preprint ARC-73, Vol. 3.

(2471) THEORY OF CONTRAROTATING PROPELLERS.

(b) Cooperative with the Bureau of Ships.
(d) Experimental and theoretical; applied research.
(e) Studies of the theory of contrarotating propellers without assumptions regarding the orientation of the resultant induced velocity. Open water and water tunnel tests to determine, experimentally, the effect of various propeller parameters.
(f) Inactive.
(g) Application to open water and wake adapted propellers. Latest experiments have shown the performance to be insensitive to spacing between propellers so long as they are operated at their design spacing.
(h) "The Design of Contrarotating Propellers Using Lerbs' Theory," by W. B. Morgan, SNAME Trans., Vol. 68-1960.

(2472) COOPERATIVE TESTS ON A VICTORY SHIP DESIGN.

(b) David Taylor Model Basin: Skin Friction Committee of the International Towing Tank Conference.
(d) Experimental testing; basic research.
(e) The investigation was authorized by the International Committee on "Scale Effect on Propellers," and on "Self-Propulsion Factors," as part of the international cooperative test program in ship basins. The International Committee will compare the results from the various basins and present a report to the coming International Conference. The tests will be carried out with a wax model of scale 1:23 equipped with different kinds of stimulators. The friction corrections will be calculated by the various basins according to their methods.
(g) The specified program of model testing has been completed. The required calculation for the power predictions have to be done before the evaluation work can proceed.
(h) Results have been reported to the International Towing Conference. A TMB Report is being prepared comparing TMB results with those of other basins.

(2729) HULL FORM RESEARCH WITH A FLEXIBLE MODEL.

(b) David Taylor Model Basin.
(d) Development and experimental work.
(e) A flexible model which can be quickly changed to have any fullness and any shape of section area curve is to be developed first. The effect of section area curve parameters, such as t_F, t_A, C_{PF}, C_{PA}, L_E, L_X, X_F, X_A, etc., upon resistance will be systematically investigated by using this flexible model.
(f) Inactive.
(g) The flexible model has been built and experimental test work begun. Thirty resistance tests have been conducted during the past fiscal year. Preliminary work with this flexible model indicates its adaptability for this work is satisfactory. An analysis of the test results has not been completed.

(2730) MOLECULAR - PHYSICAL SKIN EFFECT.

(b) David Taylor Model Basin.
(d) Experimental; applied research.
(e) The frictional resistance of a "new" plate consisting of a special molecular coating will be compared with the frictional resistance of a hydraulically smooth brass plate and of a mirror smooth glass plate. The test equipment will be designed and constructed to study wave and spray formation for the determination of the true wetted surface. The plate will be tested with maximum speed of 15.0 knots and with various stimulation devices.
(g) The Nikuradsi coated plates have been tested. Significant resistance differences between coated and non-coated plates have been measured on a coated brass plate and an uncoated aluminum plate. Since the contours of the leading and trailing edges of the two plates vary considerably doubt is raised at whether the coating or the difference in the contours caused the resistance differences. A stainless steel plate having the same contours and the coated brass plate has been constructed and tested.

(2970) STUDIES OF HYDRODYNAMIC LOADING ON BARE AND FAIRED CABLES.

(b) David Taylor Model Basin.
(d) Experimental investigation; basic research.
(e) Measure the tangential and normal hydrodynamic forces acting on a long cylinder towed at various angles to the stream over a range of Reynolds numbers. Tests will be made with various degrees of roughness simulating stranded cable, and various trailing-type fairing designs.
(f) Discontinued.

(2971) FULL SCALE TRIALS AND MODEL PREDICTION CORRELATION.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Experimental testing and re-evaluation of existing test data.
(e) The accuracy of full scale power predictions from model test results depends upon the selection of the proper correlation allowance (ΔC_F) to be used in model calculations. Model tests have been conducted and past correlations have been re-analyzed such that a total of 54 correlations have been completed. An analysis of this data has begun.
(g) Analysis of the completed correlations on the basis of SHP has been done. Further analysis on the basis of other parameters is progressing.
(h) A paper entitled, "Ship Standardization Trial Performance and Correlation with Model Predictions," by J. B. Hadler, C. J. Wilson and A. L. Beal was presented to the Chesapeake Section of the Society of Naval Architects and Marine Engineers on 7 December 1961. This paper was selected for publication in the Transactions of the Society in Volume 70, 1962. A classified report supplementing the data in this paper will be prepared.

(3284) UNSTEADY HYDROFOILS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical applied research.
(e) The purpose of this work is to provide hydrofoil design criteria to the Bureau of Ships to be used in designing high speed, seagoing hydrofoil craft. The objective is to determine the steady and unsteady forces on hydrofoils due to heaving and pitching oscillations of the foil and due to encounters with regular head and following waves on the foil when operated in proximity to the free water surface. Both fully wetted and cavitating foil conditions are being studied. This work is related to Hydroelasticity (Reference No. 3285) and Cavitation (Reference No. 711) studies.
(g) Two large hydrofoil models with internal dynamometers in midspan stations, a large pitch-heave oscillator to drive the foils and a digital data recording system are being assembled to experimentally measure the unsteady loads on the oscillating foils. An IBM 7090 program was written to compute the unsteady lift and pitching moment on an oscillating, fully-wetted hydrofoil based on the classical aerodynamic theory. Dimensional loads on the model foil were calculated as well as the dimensionless loads for a wide range of reduced frequency, amplitude and pitch axis location. Another IBM 7090 program has been written to predict unsteady loads on supercavitating foils based on the theory of I. C. Woods.
(h) "The Unsteady Lift Force on a Restrained Hydrofoil in Regular Waves," by J. M. Steele, Jr., and D. A. Jewell, TMB Report 1408 (in preparation)
"Calculated Hydrodynamic Loads on an Oscillating Hydrofoil," by T. J Langan and D. Coder, TMB Report 1695 (in review).

(3285) HYDROELASTICITY PROBLEMS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and Theoretical Applied Research.
(e) Investigations to determine the conditions which produce hydroelastic instability of oscillatory hydrofoil systems. The effects of speed, frequencies, mass distribution, cavitation, free surface and waves on the system stability will be studied. This work is related to Unsteady Hydrofoils (Reference No. 3284 and Cavitation Studies, Reference No. 711).
(g) Critical flutter speeds and frequencies of a two-dimensional, two-degree-of-freedom hydrofoil with cavitation and near the water surface will be found experimentally by use of a flutter dynamometer, which is under construction.
(h) "Hydroelastic Instability of a Control Surface," by D. A. Jewell and M. E. McCormick, TMB Report 1442, December 1961.
"A Simplified Analysis of the Hydroelastic Instability of a Three-Dimensional Hydrofoil," by M. E. McCormick, TMB Report 1555 (in review).

(3286) SUPERCAVITATING PROPELLER DEVELOPMENT.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental; applied research.
(e) Studies and design of propellers designed to operate at high speeds including improved section shapes for good operating characteristics and better strength capability.
(g) Theoretical series for preliminary design purposes have been computed and published. Crashback and windmilling performance has been experimentally obtained. Experiments with a controllable pitch supercavitating propeller have confirmed the feasibility of this type of propulsion device.
(h) "Backing Characteristics of Supercavitating Propellers," by R. Hecker, and N. McDonald, TMB Report 1604.
"Windmilling and Locked Shaft Performance of Supercavitating Propellers," by R. Hecker, TMB Report 1625.
"Steady-State Tests for the Determination of the Crashback and Crashahead Performance of Supercavitating Propellers," by N. McDonald and R. Hecker, TMB Report 1629.
"Supercavitating Propeller Performance," by E. Venning, Jr., LCDR USN and W. L. Haberman, Paper to annual meeting of SNAME, November 1962.
"TMB 2, 3 and 4-Bladed Supercavitating Propeller Series," by E. Caster, TMB Report 1637, December 1962.

(3287) EFFECT OF STERN MODIFICATION TO A SERIES 60 VESSEL, RESISTANCE, POWERING, WAKE DISTRIBUTION AND PROPELLER INDUCED VIBRATION.

(b) David Taylor Model Basin; Maritime Administration.
(d) Experimental testing and evaluation of data for basic research.
(e) Models representing specific variations in stern shapes and designed for special instrumentation installation will be built. The basic design will be the Series 60, 0.70 Block Coefficient Parent. Six other forms will be derived having systematic changes in section shapes (from V to extreme U) and for variation in waterline endings (from fine to blunt). An attempt will be made to develop formulation to mathematically express the stern variations from the parent.
(g) The basic model has been constructed and powering data has been obtained.
(h) "Effect of Hull Modifications on Resistance and Propulsion Characteristics of a Series 60 Stern,

(3292) EXPLORATORY STUDIES AND PLANS AT DTMB FOR MODEL TESTS IN 3-DIMENSIONS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental; basic research.
(e) A new seakeeping test facility is now in operation. Techniques for generating irregular short-crested seas and measuring the response of ship models at oblique headings is under development.
(g) Segmented wave generators provide the ability to produce oblique waves. Programming to individual wavemakers results in generation of confused seas of almost any nature. The rectangular basin offers opportunity to test in any relative heading to the waves and even in cross seas. Problems in analysis involve determination of the seaway (in the tank) as a function of frequency and direction. Ship motions in confused seas will be random in nature

and will be analyzed by spectrum methods.

(h) "SPLASHNIK The David Taylor Model Basin Disposable Wave Buoy," by W. Marks and R. G. Tuckerman, TMB Report 1423.

(3617) VENTILATED PROPELLER DEVELOPMENT.

(b) David Taylor Model Basin.
(d) Theoretical and experimental; applied research.
(e) Studies and design of ventilated propellers for operation at intermediate speeds.
(g) Experiments on the use of tripping wedge and tripping wire have been performed. The wedge appears to be no better than the wire and causes a loss in performance. Work on measurements of ventilated cavities is progressing.
(h) "Performance of a Ventilated Propeller," by W. B. Morgan, Paper presented at American Towing Tank Conference, Berkeley, Calif., August 1959.

(3619) VERTICAL AXIS PROPELLER.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical; applied research.
(e) Theoretical and experimental studies of performance characteristics of various types of vertical axis propellers.
(g) Experimental work has been completed for cycloidal blade motion over a range of pitch ratios with 2, 3, and 6 blades and with blades of various types, for ahead thrust. Future work will deal with measurement of steering forces, determination of cavitation performance and performance with pitch ratios greater than pi.
(h) "Performance of Vertical Axis (Cycloidal) Propellers Calculated by Taniguchi's Method," by W. Haberman and E. E. Harley, TMB Report 1564, November 1961.

(3621) STUDY OF BENDING MOMENTS OF A SHIP MODEL MOVING IN WAVES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental; basic research.
(e) To provide ship designers with more exact information concerning the magnitude of bending moment and shear forces in a ship moving in waves.
(f) Completed.
(g) Bending moment about the transverse axis and vertical shear forces were measured experimentally in regular head seas and results compared with analytical calculations of motions bending moments and shear forces. The above work was supplemented by additional tests in regular following waves.
(h) "Experimental Determination of Bending Moments and Shear Forces in a Multi-Segmented Ship Model Moving in Waves," by Z. George Wachnik and Frank M. Schwartz.

(3622) FLUCTUATING FLOWS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical; basic research.
(e) Investigations are being made of the fluctuating hydrodynamic forces on a body in a moving stream. The nature of the vortex shedding will be studied by obtaining a frequency spectrum of the transverse forces.
(f) Suspended.

(3999) SHIP WAKE CHARACTERISTICS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental; applied research.
(e) Development of instrumentation for measuring turbulent velocities and thermal microstructure in ship wakes. Measurements will be made to determine the rate of decay and dispersion of wakes.
(f) Discontinued.

(4000) DRAG REDUCTION BY BOUNDARY LAYER CONTROL.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental; basic and applied research.
(e) Investigations into feasibility of achieving drag reduction by boundary layer control in applications to naval hydrodynamics. Tests are to be made on flat plates with flexible coatings which delay transition to turbulent flow. Other methods are also being studied.
(g) Towing rig under design and construction.
(h) "The Boundary Layer and Frictional Resistance of Flat Plates in Non-Newtonian Fluids," by P. S. Granville, Journal of Ship Research, Vol. 6, No. 2, October 1962.

(4426) DEVELOPMENT OF A LOW WAVE DRAG HULL FORM - SERIES 64.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Basic research.
(e) To establish a series of basic hull forms which can be used as a guide to evaluate the merit of future high speed ship designs. The basic test work has been completed. Thirty three models were tested for resistance including 4 defining the parent form and 2 catamarans. The basic series covers the following range of coefficients C_B from 0.35 to 0.55 at constant C_P of 0.63, B/H from 2 to 4, $\Delta/(L/100)^3$ from 15 to 55. Analysis of data has begun.
(g) Basic models have been constructed and tested for resistance. It is planned to expand this series to obtain data as to the effect of LCB position and C_P variation.
(h) A paper to be presented to the Society of Naval Architects and Marine Engineers is contemplated. An unclassified report will also be published.

(4427) A METHOD OF CALCULATING SPINDLE TORQUE OF CONTROLLABLE PITCH PROPELLERS.

(b) David Taylor Model Basin.
(d) Theoretical; applied research.
(e) A method of calculating the spindle torque of a controllable pitch propeller over the complete range of operating conditions and a theoretical investigation of the effect of various design parameters upon spindle torque In order to calculate spindle torque at off design conditions, the off design performance of the controllable pitch propeller must first be determined.
(g) A method of calculating the spindle torque at design conditions has been completed. The geometric problem of determing the effective distortion of blade sections at off design pitch settings has been solved. The solution has been programmed for the 7090 Computer.

(4428) COMPUTER SOLUTIONS OF FREE SURFACE FORCES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Hydrodynamic research.
(e) The potential problem of a translating body oscillating on the free surface will be solved directly on a digital computer by distributing pulsating sources over the surface of the body and calculating the required source density. The individual source potentials are chosen to satisfy the free surface boundary condition.
(g) The integral equations for source density have been formulated for the case of two-dimensional bodies with no forward speed. The numerical analysis and programming have been largely completed for this case.

(4429) LATERAL FORCES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Hydrodynamic research.
(e) The lateral force on a translating body which vertically cuts the free surface is being formulated theoretically. Two special cases are included: (a) If the draft is large compared to the length, the body is a strut with angle of attack. (b) If the draft is

very small, the body corresponds to a yawed thin ship.

(g) An integral equation has been derived for the density of a surface distribution of dipoles, such that the boundary conditons are satisfied.

(4809) TURBULENT BOUNDARY LAYERS IN PRESSURE GRADIENTS ON ROUGH SURFACES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental; basic and applied research.
(e) Research in behavior of turbulent boundary layers in pressure gradients leading to separation. Initial roughnesses will be screens of various gages fastened to wall of wind tunnel. Velocity surveys and turbulence measurements will be performed.
(g) Equipment and apparatus being assembled and readied.

(4810) SHIP WAKE SIMULATION STUDIES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical; applied research.
(e) To produce ship wake distributions in a variable pressure water tunnel in order to determine the performance of propellers in non-uniform wake flows.
(g) A theoretical method has been obtained for determining the wire grid geometry necessary to produce arbitrary, steady, three-dimensional flows. Simple experimental confirmation of the method has been obtained.
(h) "Steady, Moderately Sheared, Three-Dimensional Flow Past Nonuniform Wire Grids in a Duct," by J. H. McCarthy to be published in 1963.

(4811) STEADY-STATE FORCES ON SUPERCAVITATING AND VENTILATED HYDROFOILS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental; applied research.
(e) To study the steady-state lift and drag characteristics of supercavitating hydrofoil configurations for application to hydrofoil craft and supercavitating propeller design.
(g) Experimental determination of the lift and drag of various three-dimensional supercavitating hydrofoils is in progress. These include foils with 2-term, 5-term and flat-faced sections. The effects of aspect-ratio and taper are being investigated. Ventilation by blowing air through holes in the suction surface of the foil is used to extend the range of cavitation number. Future research includes the determination of two-dimensional lift and drag, studies of flap configurations and measurement of the interaction of tandem and cascade foils.
(h) "Experimental Determination of the Forces on Supercavitating Hydrofoils with Internal Ventilation," by N. L. Ficken, Jr. and G. F. Dobay, Proc. of National Meeting of IAS on Hydrofoils and Aerospace Sciences, Sept. 1962.

(4812) PROPELLER-AND BODY INTERACTION.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental; applied research.
(e) Study and development of design criteria for determining propulsion characteristics of submerged bodies and hydrofoil-supported craft.
(g) Axial clearance between a submerged body of revolution and a stern propeller has been optimized on the basis of propulsive coefficient. A method has been developed for computing thrust deduction for submerged hydrofoil-propeller arrangements.
(h) "Thrust Deduction Due to a Propeller Behind a Hydrofoil," by John L. Beveridge, TMB Report 1603, October 1962.

(4813) INVESTIGATION OF DUCTED PROPELLERS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental; applied research.
(e) To develop a design method for ducted propellers and to conduct a parametric study of ducted propeller performance.
(g) A theory of the ducted propeller with finite number of blades has been developed. From this theory a design method will be developed and then a parametric study of ducted propeller performance will be conducted.
(h) "Theory of the Annular Airfoil and Ducted Propellers," by W. B. Morgan, Fourth Symposium on Naval Hydrodynamics, Office of Naval Research, 1962.

(4814) POWERING IN WAVES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental.
(e) To determine the powering characteristics and speed loss of ships in waves by conducting model tests in regular and irregular waves. Limitations of present procedures for predicting power and speed loss in a seaway from tests in regular waves will be determined and new techniques will be developed where necessary.

(4815) PARAMETRIC STUDIES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental.
(e) To provide basic information from which the most suitable destroyer form for high sustained sea speeds in a seaway can be established. Model tests will be conducted in regular and irregular seas using a series of models for which the significant geometric parameters are systematically varied. Motions and powering increase in waves will be studied.

(4816) FUNDAMENTAL PROPERTIES OF SHIP ROLLING.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical.
(e) Though extensive studies of rolling have been made in recent years, a great deal remains to be learned concerning the fundamental properties of rolling for both surface ships and submarines. Areas which require additional research are (1) applicability of superposition principle for rolling motion especially in short crested waves, (2) unstable rolling motion in oblique regular and in irregular waves, (3) nonlinear roll behavior in rough seas, etc. In order to clarify the fundamental nature of rolling, model tests will be conducted in regular and irregular waves at various heading angles. Parameters significant for roll will be investigated.

For sponsored projects see the following:

U. S. DEPARTMENT OF THE NAVY, NAVAL BOILER AND TURBINE LABORATORY.

(3623) HIGH PRESSURE-TEMPERATURE WATER FLOW METER CALIBRATION.

(b) Bureau of Ships; Philadelphia Naval Shipyard (Naval Boiler and Turbine Laboratory).
(c) Mr. J. W. Murdock, Associate Technical Director for Applied Physics Division, Naval Boiler and Turbine Laboratory, Phila. Naval Shipyard, Phila. 12, Pennsylvania.
(d) Experimental; applied research.
(e) A facility is available for calibrating with water at pressures and temperatures up to 2500 psi and 600 F respectively. Capacity is 100 gpm at maximum pressure and temperature and greater at lower pressures and temperatures. After flowing through the metering section the water is cooled and weighed. The facility is also used to investigate and verify orifice meter coefficients at pressures and temperatures above those at which the coefficients in use were established. A number of flow meters which measure the flow in nuclear reactor loops have been calibrated.
(g) A limited amount of test data indicate good agreement between orifice flow rates obtained by calibration at high pressures and temperatures and those obtained by extrapolating from cold water calibrations. Other meter tests show the need to include suitable corrections for change in shape, size, density, etc.

(3624) INVESTIGATION OF ELBOW FLOW METERS.

(b) Bureau of Ships; Philadelphia Naval Shipyard; (Naval Boiler and Turbine Laboratory).
(c) Mr. J. W. Murdock, Head, Applied Physics Division, Naval Boiler and Turbine Lab., Phila. Naval Shipyard, Phila. 12, Pa.
(d) Experimental, applied research.
(e) The 90 degree elbow has been proposed for metering flow in shipboard systems. This type meter is attractive since the use of an existing elbow would not require any changes to the piping and would impose no additional pressure drop on the system. In addition, the elbow can meter reverse flow. The chief drawbacks are large variation in elbows and the lack of an exact relationship between flow and differential pressure. Testing was limited to the long turn 90 degree, type A elbows of Specification MIL-F-1183 to establish criteria for their installation and use.
(g) When certain standards are imposed on the fabrication and measurement of the elbows and a specified means of computing flow is used, a measurement tolerance of 4 percent can be expected. In control applications the elbow meter was found to have a square root transfer function and a repeatability of 0.2%.

(4001) HIGH PRESSURE STEAM AND WATER FLOW TESTS.

(b) American Society of Mechanical Engineers.
(c) Research Committee on Fluid Meters, American Society of Mechanical Engineers, 345 East Forty-Seventh Street, New York 17, New York.
(d) Experimental; applied research.
(e) Although the ASME Research Committee on Fluid Meters has sponsored many fundamental research programs dealing with the development of basic constants used with primary elements, hardly any of this work has been done on steam flow at high pressures and temperatures. Neither has research been done on high temperature water flow. Analysis of many tests indicate that the basic calibrations obtained with low temperature water (air and gas) could be extrapolated with high accuracy to the measurement of high pressure and temperature steam and water flow provided suitable corrections were made for the change in the shape and size of the primary element, the pipe and the fluid. This procedure has been experimentally verified for steam up to 2000 psi and 1050 F and for water to 2500 psi and 600 F.
(f) Completed.
(g) Nozzles and orifices were calibrated with water at 240 F, 2200 psia, and with steam at 1050 F, 2000 psia. Pipe Reynolds numbers averaged 600,000 for the water and 4,000,000. for the steam. Coefficients were generally in agreement with ASME predicted coefficients Two and a quarter percent (2 1/4%) chrome-molybdenum steel proved unsatisfactory for the steam nozzles showing rusting and pitting after less than 10 hours. Type 430 stainless steel was substituted and was satisfactory.
(h) Test results reported to ASME as: "Flow Meter Calibrations for the American Society of Mechanical Engineers Research Committee on Fluid Meters," by C. Gregory, 31 Oct. 1962. ASME has not published results.

U. S. NAVAL ORDNANCE LABORATORY.

(4867) THE HYDROBALLISTICS OF WATER ENTRY.

(b) Bureau of Naval Weapons, Department of the Navy.
(c) Commander, U. S. Naval Ordnance Laboratory White Oak, Silver Spring, Maryland.
(d) Experimental, theoretical, basic and applied research.
(e) The purpose is to study high velocity water entry as related directly or indirectly to the behavior of missiles. The study includes the stability and forces during the entry, cavity development and pressure, and the missile trajectory. A wide range of developmental and research configurations and of esperimental conditions are investigated. Guns are used to launch models into a tank equipped for operation at various pressures.

U. S. NAVAL ORDNANCE TEST STATION.

(3295) FORCED VENTILATION OF HYDROFOILS.

(b) Bureau of Naval Weapons, Department of the Navy.
(c) Commander, U. S. Naval Ordance Test Station, Attn: T. G. Lang or A. G. Fabula, Code P5006, 3202 E. Foothill Boulevard, Pasadena 8, California.
(d) Experimental and theoretical; basic research.
(e) The hydrodynamic lift, drag, pitching moment and pressure distribution are studied on hydrofoils of various cross-sections from which gas is exhausted through ports of varying shape and location. The results are applicable to torpedoes as a simple means of varying control forces on stabilizing fins and a new type of propeller blade cross-section.
(g) To minimize tunnel blockage effect which restricts the cavity number to higher values than can be obtained in unbounded flow, tests have been made in the Free-Surface Water Tunnel at Caltech. Theory has been developed to consider the blockage effects in the closed test section of the High-Speed Water Tunnel, and a previous disagreement of theory and experiment has been found to be mainly due to the manner of determining the experimental cavity number.
(h) "Water Tunnel Tests of Three Vented Hydrofoils in Two-Dimensional Flow," by T. G. Lang and D. A. Daybell, J. Ship Res. 5, 3, pp 1-15 (1961).
"Thin Airfoil Theory Applied to Hydrofoils with a Single Finite Cavity and Arbitrary Free-Streamline Detachment," by A. G. Fabula J. Fluid Mech. 12, 2, pp 227-240 (1962).
"Free-Surface Water Tunnel Tests of an Uncambered Base-Vented Parabolic Hydrofoil of Aspect Ratio One," by T. G. Lang and D. A. Daybell, NAVWEPS Report 7920, Sept. 1962.
"Comparison of Theory and Experiment for Vented Hydrofoils, Part 1: Analysis; Part 2, Tables," by A. G. Fabula, NAVWEPS Report 7941 (in two parts separately bound), in press.
"Choked Flow About Vented or Cavitating Hydrofoils," by A. G. Fabula, submitted to the Annual Meeting of the ASME, November 1963.

(4002) MISSILE BEHAVIOR DURING WATER EXIT.

(b) Bureau of Naval Weapons, Navy Department.
(c) Commander, U. S. Naval Ordnance Test Station, Attn: Dr. John G. Waugh, Code P8074, 3202 E. Foothill Blvd., Pasadena, California.
(d) Experimental; basic research.
(e) The purpose of this study is to evaluate qualitatively the inherent value of slender body theory in predicting the underwater and water exit behavior of an underwater launched missile in the presence of various sea states.
(g) The experimental fully-wetted flight and water-exit behavior of a blunt-based axisymmetric missile traveling in a standing wave are simulated on an analogue computer using motion equations derived from slender body theory. The analytical approach is supplemented by introducing experimental hydrodynamic coefficients and transverse drag terms. The results of the simulation are compared graphically with the experimental behavior to illustrate an upper limit of the accuracy to be expected of slender body theory.

(4430) ROTATING CYLINDER CONTROL.

(b) Laboratory project.
(c) Commander, U. S. Naval Ordnance Test Station, Attn: John D. Brooks, Code P8040, 3202 E. Foothill Blvd., Pasadena, Calif.
(d) Experimental; applied research.
(e) The purpose of the study was to investigate the effect on the hydrodynamic forces of a rotating cylinder placed at the leading or trailing edge of a hydrofoil. A model was constructed and tested in a water tunnel.
(f) Completed.
(g) It was found that lift equivalent to about 1/2 degree angle of attack was obtained with the cylinder in the forward position, and lift equivalent to 9 degrees angle of attack with the cylinder in the rear position.
(h) "The Effect of a Rotating Cylinder at the Leading and Trailing edges of a Hydrofoil," by J. D. Brooks, NAVWEPS 8042, (in publication).

(4434) DUCTED PROPELLER DESIGN.

(b) Bureau of Naval Weapons, Navy Department.
(c) Commander, U. S. Naval Ordnance Test Sta., Attn: Mr. J. F. Reynolds, Code P8074, 3202 East Foothill Blvd., Pasadena, Calif.
(d) Theoretical; applied research.
(e) An improved ducted propeller design method includes an application of Lerb's method, used in propeller design, to account for non-uniformity of flow due to the boundary layer. The influence of a tapered afterbody on the ring wing boundary condition is also being investigated.
A propeller program using Lerb's method is available on an IBM 7090 computer which will account for the non-uniformity of flow in a ducted propeller system. By means of an iterative process the program gives the ducted propeller inflow velocities corresponding to the boundary layer and pitch angle variations across the propeller-shed vortex sheet.
Future efforts will concern the various aspects of ducted propeller programming for an IBM 7090 computer. It is hoped that this will ultimately lead to the availability of a complete computer program for a specific ducted propeller design method.

(4868) NON-NEWTONIAN FLUIDS.

(b) Bureau of Naval Weapons, Department of the Navy.
(c) Commander, U.S. Naval Ordnance Test Station, Attn: A. G. Fabula, P5006, 3202 E. Foothill Boulevard, Pasadena 8, California.
(d) Experimental; basic research.
(e) The turbulent flow characteristics of dilute solutions of various high polymers are being studied to understand why they often display anomalous flow behavior, apparently related to turbulence suppression by long molecules.
(g) The anomalous behavior has been found to occur also at very low concentrations, if mechanical degradation is avoided. Tests of homologous polymers of different molecular weight at high Reynolds numbers suggest a dependence of the turbulence suppression upon molecular dimensions in a manner similar to the dependence upon molecular weight of intrinsic viscosity and critical concentration, which are measured at low Reynolds numbers.
(h) "Turbulent Flow Properties of Dilute Solutions of Linear Polymers," by A. G. Fabula, Research Note submitted to the Physics of Fluids.

(4869) FLUID AMPLIFIERS.

(b) Laboratory project.
(c) Commander, U. S. Naval Ordnance Test Station, Attn: J. D. Brooks, Code P8040, 3202 E. Foothill Boulevard, Pasadena, California.
(d) Experimental, applied research.
(e) Studies are being conducted of the performance of a model fluid amplifier, which is so constructed that the physical dimensions, orifice sizes, etc., can be varied over a wide range. The amplification and efficiency are being optimized as a function of these physical parameters for this particular amplifier design.

(4870) DETERMINATION OF POTENTIAL STREAM FUNCTION VALUES.

(b) Bureau of Naval Weapons, Navy Department.
(c) Commander, U.S. Naval Ordnance Test Station, Attn: Mr. William A. Middleton, Code P8074, 3202 E. Foothill Blvd., Pasadena 8, Calif.
(d) Theoretical; applied research.
(e) The perturbation stream function value is found for an arbitrary point in space due to an arbitrary body in axisymmetric flow. This is accomplished by utilizing a ring-source distribution to describe the body. The perturbation values are found by solving a line integral numerically which has an integrand involving complete elliptic integrals of the first and third kinds.
(g) The results of the theoretical analysis is being compared with the exact solution of the prolate spheroid.

(4871) BASE-VENTED PROPELLER.

(b) Bureau of Naval Weapons, Navy Department.
(c) Commander, U. S. Naval Ordnance Test Station, Attn: Mr. Gerald G. Mosteller, Code P8074, 3202 E. Foothill Blvd., Pasadena 8, Calif.
(d) Experimental; applied research.
(e) The purpose of this project is to develop a wake adapted propeller to operate silently and efficiently at rpm's and forward velocities where conventional propellers would cavitate.
To avoid cavitation noise under these conditions and at inherent off design angles of attack caused by circumferential velocity variations, the local cavitation number along the blade sections had to be low and the leading edge radius large. The basic blade section which filled these requirements was a semi-ellipse for 2/3 of the chord followed by a parallel section cut-off perpendicular to the mean chord. Lift was developed by camber. The form drag of the blade was minimized by ejecting air into the base cavity. The propeller was tested in the ORL water tunnel at Pennsylvania State Univ. Its maximum efficiency was 86% when operating at an advance ratio of 1.18. The cavitation number based on free stream velocity was 1.05 and the base gas flow ratio (volume flow/volume swept out by trailing edge) was 0.066.
(h) A NAVWEPS Report is in preparation.

(4872) A METHOD FOR COMPUTING TURBULENT BOUNDARY LAYERS BASED ON THE LAW OF THE WALL AND THE LAW OF THE WAKE.

(b) Bureau of Naval Weapons, Navy Department.
(c) Commander, U. S. Naval Ordnance Test Station Attn: Mr. David M. Nelson, Code P8074, 3202 E. Foothill Boulevard, Pasadena 8, California.
(d) Theoretical; applied research.
(e) A method for computing turbulent boundary layers based on the law of the wall and Coles' law of wake is under development. This method is applicable to two dimensional bodies and to bodies of revolution in axial-symmetric flow where the boundary layer thickness is not necessarily small compared to the body radius. A simultaneous solution of the momentum integral equation and the energy integral equation is carried out assuming the mean velocity profiles are given by a universal, two-parameter representation as suggested by Coles. The computational procedure will be programmed for an IBM 7090 computer.

(4873) RING WING LOADINGS.

(b) Bureau of Naval Weapons, Navy Department.
(c) Commander, U. S. Naval Ordnance Test Station, Attn: J. F. Reynolds, Code P8074, 3202 East Foothill Blvd., Pasadena 8, Calif.
(d) Theoretical; applied research.
(e) A survey of loadings on ring wings at an angle of attack with cross flow central body effects revealed significant work by J. Weissinger. Application of Weissinger's basic techniques in addition to a development of the moment due to axial forces resulting from an arbitrary symmetric ring wing camber line, in contrast to Weissinger's circular arc, gave significant results for the effective wing moment and position of the aerodynamic center.
For a ring wing used as a control surface it is useful to know the effective position of the aerodynamic center. A specific three-dimensional ring wing shape with a half cone angle of 6 degrees and a central body wing radius ratio of 0.58 locates the effective aerodynamic center one tenth of a chord length from the leading edge as compared to an aerodynamic center one quarter of chord length from the leading edge for two-dimensional thin airfoils.
A current area of investigation involves the influence of a tapered afterbody, with a doublet representation, on wing loadings for non-axisymmetric flow. A tapered afterbody, with a line source representation, is also being studied to determine its possible influence on the axial suction force. If the change in the value of the suction force term appears to have significance, there may be significant change in the wing's effective moment and aerodynamic center.

U. S. DEPT. OF THE NAVY, OFFICE OF NAVAL RESEARCH.

For sponsored projects see the following:

TENNESSEE VALLEY AUTHORITY, Engineering Laboratory.

Inquiries concerning the following projects should be addressed to Mr. Rex A. Elder, Director, TVA Engineering Laboratory, P. O. Box 37, Norris, Tenn.

(3629) LOW POWER VHF RADIO GAGES FOR REPORTING RAINFALL AND STREAM LEVEL DATA.

(d) Development.
(e) Transistorized radio components operating from nickel cadmium batteries charged by solar cells will be used. Data in binary coded decimal form will be transmitted by audio tone pulses. Long-term, unattended operation is a primary consideration in design.
(g) Design work continued with emphasis being placed on rain and stream gage digital transducers and associated electronics. Two types of transducers are being considered: (1) a direct pressure to digital unit, and (2) a shaft position to digital encoder.

(4439) DENSITY UNDERFLOW WITHDRAWAL STRUCTURES.

(d) Experimental; applied research.
(e) A three-dimensional model was used to develop the basic relationship involved in the design of skimmer wall structures used to insure the withdrawal of the bottom layer in a two-layered, density stratified reservoir.
(f) Laboratory study completed.
(g) Design curves were developed which will permit design of structures which will insure withdrawal of only the bottom layer or of withdrawal of the bottom layer plus 1 percent, 2 percent or 5 percent of the flow from the top layer.
(h) Report in preparation.

(4440) INTERNAL DENSITY CURRENTS CREATED BY WITHDRAWAL FROM A STRATIFIED RESERVOIR.

(b) This was a cooperative study with the U.S. Corps of Engineers, U. S. Army District, Walla Walla, Engineering Division, Planning and Reports Branch, Walla Walla, Washington.
(d) Theoretical evaluation of field data.
(e) A study of several years of temperature soundings taken in TVA's Fontana Reservoir was made in an attempt to determine the thickness of the withdrawal layer when water is withdrawn from a deep, thermally stratified reservoir at an intermediate elevation.
(f) Study completed.
(g) A plausible curve was developed, based on a theoretical analysis and established from the field data.
(h) "Internal Density Currents Created by Withdrawal From a Stratified Reservoir," TVA Engineering Laboratory, 1962, Norris, Tenn.

(4441) MEASUREMENT OF KAPLAN TURBINE DISCHARGES USIN OTT COMPONENT CURRENT METERS.

(d) Equipment development and field measurement operation.
(e) A measuring technique is being developed with which the flows through Kaplan type turbines can be accurately measured by use of Ott component type current meters which can vertically traverse the flow at the turbine intake gate slots. These measurements, made at several fixed discharges, will be used to calibrate Winter-Kennedy scroll case pressure taps. The Winter-Kennedy taps will then be used, with suitable measuring equipment, to determine the discharge for any turbine loading.
(g) The carriage framework upon which the Ott component type current meters will be mounted along with their associated lifting devices, and the necessary recording instrumentation has been designed, constructed and field tested. Development of the actual measuring techniques is now in progress.

(4442) NEW WHEELER LOCK CULVERT ENTRANCE MODEL.

(d) Experimental; for design.
(e) 1:25 scale model studies are being conducted to develop acceptable flow conditions in the area of the new Wheeler lock culvert entranc A prior study has been outmoded by the failure of the Wheeler auxiliary lock and subsequent design revisions.
(f) Laboratory study completed.
(h) Internal reports issued.

(4874) WIDOWS CREEK STEAM PLANT UNIT 8, AIR DUCT STUDIES.

(d) Experimental; for design.
(e) Velocity distribution and pressure loss studies were conducted on a 1:16 scale model of the air ducts from the air inlet to the forced draft fans.
(f) Model testing completed.
(g) Tests on the original duct design disclosed that without bend vaning there was very poor velocity distribution with attendant poor operation of the air flow meter and pulsations in the intakes to the two forced draft fans. Vaning of the original duct design resulted in elimination of the adverse effects but increased the draft losses to nearly double those used in determining the fan capacity. The undesirable flow conditions and excessive draft losses were eliminated by the removal of the 90 degree inlet bend, the replacement of the 90 degree elbow immediately upstream from the fan distribution section with two 45 degree meter bends, and development of proper vaning for each bend.
(h) Report in preparation.

(4875) WIDOWS CREEK STEAM PLANT UNIT 8, GAS DUCT STUDIES.

(d) Experimental; for design.
(e) Model studies were conducted on a 1;:16 scale model of the section of the gas duct running from the air pre-heater through the electrostatic precipitator.
(f) Model testing completed.
(g) A base test with no vaning in the duct indicated excessive head-loss and poor velocity distribution throughout the test reach. The studies disclosed that the poor operation stemed directly from the geometric

configuration of the duct work upstream and downstream from the precipitator. Conditions were improved by development of proper vaning and installing a perforated plate upstream from the precipitator.

(h) Internal reports issued.

(4876) BULL RUN STEAM PLANT, SMOKE STACK CONFIGURATION.

(d) Experimental; for design.
(e) A study was made to determine the effects on the effective stack discharge height of two proposed designs for the top of an 800 foot stack. Two different configurations were studied; a straight cylindrical exit section and a quasi-venturi exit section. Both configurations represented the top 140 feet of the stack. Model studies were conducted utilizing a 1:8 scale model. The results were obtained by comparison of the diffusion characteristics of the two outlet configurations. Related studies to determine the effect of reducing the stack exit diameter from 28 feet to 22.5 feet while maintaining the same stack discharge and to develop a computational procedure for computing the internal pressure at the base of the stack were also carried out.
(f) Laboratory work completed.
(g) Results of the tests showed the cylindrical exit section as compared to the quasi-venturi exit section was considerably more effective in carrying the gases to a higher altitude. The reduced diameter stack was only slightly more effective in delivering the effluent stack gases to a higher elevation above the stack top.
(h) Internal reports in preparation.

(4877) JOHNSONVILLE STEAM PLANT, AIR DUCT TESTS.

(d) Experimental; for design.
(e) Studies were made on a 1:14 scale model to determine the cause of excessive head losses which were occurring in the air ducts for the 1,100,000 lb/hr boilers and to develop the modifications required to minimize the head losses in the system. An improvement in the velocity distribution of air through the pre-heater was also required.
(f) Laboratory model studies completed.
(g) Head loss was reduced by the use of vanes and by internal modifications to the duct shapes. A loss equal to the reduction attainable by vaning was caused by internal struts. The velocity distribution in the air pre-heater was greatly improved by internal duct modifications to the duct immediately upstream from the pre-heater.
(h) Internal report issued.

(4878) PARADISE STEAM PLANT, AIR DUCT STUDIES.

(d) Experimental; for design.
(e) Model studies were conducted on a 1:8 scale model of the forced draft blower and the appurtenent duct work beginning with the fan silencers and extending through the first pass of a four pass tubular pre-heater to: (1) obtain uniform velocity distribution into the pre-heater, and (2) reduce head loss in the duct system.

(4879) EFFECT OF INTAKE DESIGN ON CONDENSING WATER RECIRCULATION.

(d) Experimental; applied research for master's thesis.
(e) Laboratory tests were conducted to establish the relationships which control recirculation in an industrial cooling water system in which water is withdrawn from a river or canal, heated and then returned to the river. The studies presupposed the existance of a skimmer wall structure across the intake canal and an underwater dam immediately downstream from the intake canal. The intake and discharge canals were at right angles to the river.
(f) Study completed.
(g) The results show the limitations within which the recirculation through a stream plant located on a river can be satisfactorily controlled by properly designed skimmer wall and underwater dam control structures.
(h) "The Effect of Intake Design on Cooling Water Recirculation for Steam Plants," by Jack M. Garrison, S.M. Thesis, 1962, Mass. Inst. of Technology Library, Cambridge, Mass.

(4880) VIBRATION STUDIES OF STEAM PLANT AIR AND GAS DUCTS.

(d) Experimental; for basic and applied research.
(e) Studies are being made to extend our knowledge relating to flow induced duct vibrations and to apply the findings to present and future installations. Duct vibrations which are believed to stem from the highly turbulent flows created by the forced draft fans and by the various duct configurations have been experienced in the duct work of some plants. These turbulent conditions create pressure fluctuations which could lead to wall vibrations.

(4881) DIFFUSION AND EXCHANGE OF HEAT DISCHARGED INTO RIVERS AND LAKES.

(d) Experimental; for basic and applied research.
(e) Studies are now underway to establish the laws governing heat diffusion and heat energy exchange with the surroundings in river reaches downstream from steam plant outlets. The study will consist of field and laboratory tests and analytical analyses using the heat energy budget method to correlate the pertinent hydraulic and heat parameters with the field and laboratory data.

(4882) GUNTERSVILLE MAIN LOCK INTAKE DESIGN.

(d) Experimental; for design.
(e) The intake facilities for the 100 foot wide x 600 foot long, 45 foot lift, new lock are of the multiple opening type located in an extension of the two lock walls. The design is being studied by means of a 1:24 scale model to determine (1) if each entrance opening carries its share of the discharge, and (2) that no objectionable vortices occur.

(4883) GUNTERSVILLE MAIN LOCK DISCHARGE STRUCTURES.

(d) Experimental; for design.
(e) The discharge structures for the 110 foot wide x 600 foot long, 45 foot lift, new lock are to be located immediately below the downstream miter gate and will consist of multiple horizontal openings across the width of the approach channel at river bed level. Each culvert will have its own discharge system. The 1:24 scale model tests are to determine the actual outlet configuration required to furnish satisfactory navigation conditions near the outlet area.

TENNESSEE VALLEY AUTHORITY, Hydraulic Data Branch.

Inquiries concerning projects should be addressed to Mr. James Smallshaw, Chief, Hydraulic Data Branch, Tennessee Valley Authority, Knoxville, Tennessee.

(765) EVAPORATION IN THE TENNESSEE BASIN.

(d) Field investigation; applied research.
(e) To provide data for estimating reservoir losses and derive a general rule, applicable to the Basin, permitting computation of evaporation from pans at six locations in Basin, together with standard meteorological readings.
(h) Results published in monthly and annual bulletins, "Precipitation in Tennessee River Basin" (Project 768).

(768) PRECIPITATION IN TENNESSEE RIVER BASIN.

(d) Field investigation; basic research.
(e) A comprehensive study of rainfall and other weather phenomena for purposes of water dispatching and improvements in water control; storm studies as related to maximum precipitation, rainfall-runoff, spillway design and operation, etc.
(h) Monthly and annual bulletins, "Precipitation in Tennessee River Basin."

(769) RESERVOIR AND STREAM TEMPERATURES.

(d) Field investigation; basic research.
(e) Study of water utilization and water movement as concerns industrial plant locations and stream pollution. Variations in temperature from surface to bottom in reservoirs throughout the year are determined by soundings, and by continuous recording gages in natural streams.

(771) GALLERY DRAINAGE IN LARGE DAMS.

(d) Field investigations; design.
(e) Weirs are placed in main galleries and drainage measured as check on tightness and stability.

(779) MAXIMUM POSSIBLE PRECIPITATION IN TENNESSEE VALLEY.

(b) Cooperative with U. S. Weather Bureau.
(d) Theoretical; applied research.
(e) Hydrometeorological analysis of large storms with upward adjustments of controlling factors to maximum limits as applied to the Tennessee Valley and subdivisions.
(g) Results to be published as one of current series of hydrometeorological reports by the U.S.W.B. and cooperating agencies.

(780) PERIODIC EVALUATION OF GROUND-WATER STORAGE.

(d) Theoretical; operation.
(e) By analysis of current records of stream discharge, the volumes of runoff in ground-water and channel storage are determined for use in operation of multi-purpose reservoirs.
(g) Results reported monthly and weekly within the orgainzation.

(785) SEDIMENTATION OF EXISTING RESERVOIRS.

(d) Field investigation; basic research.
(e) Selected ranges in reservoirs are probed and sounded, volumetric samples are collected and analyzed, quantity and distribution of sediment are computed to determine deposition by stream, probable life of reservoir, effect of sediment storage on navigation channels and sedimentation of down-stream reservoirs, and probable sedimentation in future reservoirs.

(3306) COOPERATIVE RESEARCH PROJECT IN WESTERN NORTH CAROLINA.

(b) Project conducted in cooperation with North Carolina State College of Agriculture and Engineering.
(d) To determine water-land relationships for some of the principal soils used for agricultural purposes in western North Carolina under important vegetative covers. Observations include rainfall, runoff, soil-moisture, potential evapotranspiration, and actual evapotranspiration.
(e) A statistically designed rotation of four covers on four small watersheds and a separate evaluation of deep-rooted crop on a fifth watershed.
(f) Field studies of the deep-rooted crop, alfalfa, have been discontinued.
(g) Results to date are summarized in annual reports on the project.
(h) "Effects of Single Crop Covers on Runoff," by C. B. England and E. H. Lesesne, Journal of Soil and Water Conservation, Volume 17, No. 1, pp. 11-12, January-February 1962. "Evapotranspiration Research in Western North Carolina," by C. B. England and E. H. Lesesne, Agricultural Engineering, pp. 526-528, September 1962.

(3307) PARKER BRANCH PILOT WATERSHED RESEARCH PROJECT.

(b) Project conducted in cooperation with North Carolina State College of Agriculture and Engineering.
(d) To determine the effects upon the hydrology of the watershed of an intensive farm development program designed to give the optimum economic well-being of the people using the land. Rainfall, runoff, suspended and deposited sediment are observed, periodic soils-land-use and inventories are made and records of income summaries and public and private investments are maintained.
(e) Project activities are divided into calibration, action, and evaluation phases.
(f) Agricultural economics portion of project terminated June 30, 1962; hydrologic portion terminated September 30, 1962.
(g) Results are summarized in annual reports on the project. A final comprehensive report is in preparation.

(3308) WHITE HOLLOW WATERSHED.

(d) To study the effect of changes in the vegetal cover on a watershed taken out of cultivation on the hydrologic factors of runoff and soil erosion.
(e) Continuous record from 1935 of rainfall, runoff, and suspended sediment, and periodic determination of vegetal cover indexes.
(f) Trees have been marked for selective cutting which will be accomplished in 1963.
(g) During the 24-year period 1935-1958, the forest cover improvement in the watershed resulted in greater watershed protection with no measurable change in water yield, no change in volume of either surface runoff or ground-water runoff, marked reduction in summer peak rates of discharge with lesser reduction in winter rates, a prolongation of the period of draining of surface runoff from the channel system, and a 96 percent reduction in the sediment load.

(3309) PINE TREE BRANCH WATERSHED.

(d) To determine the effects upon the hydrology of the watershed by reforestation and erosion control measures.
(e) Continuous record from 1941 of rainfall, runoff, ground water, and sediment loads.
(f) Trees have been marked for selective cutting which will be accomplished in 1963.
(g) During the 20-year period 1941-1960, the cover improvement and erosion control in the watershed resulted in a decrease in surface runoff volumes and an increase in ground-water discharges, marked reductions in summer and winter peak flood discharges, a reduction in overland surface velocities, a prolongation of the period of draining of surface runoff from the channel system, an appreciable decrease in water yield, and a 96 percent reduction in sediment load.
(h) "Reforestation and Erosion Control Influences upon the Hydrology of the Pine Tree Branch Watershed, 1941-1960," TVA Report.

(4011) NORTH FORK CITICO CREEK RESEARCH WATERSHED.

(b) Project conducted in cooperation with U.S. Forest Service.
(d) Field investigation; basic research.
(e) To determine the effects of normal, high-standard National Forest Multiple-use management upon the hydrology of the area. Observations include rainfall, runoff, air and water temperature, and humidity. Timber inventories, soil surveys, wildlife

inventories, and evaluations of soil disturbances will be made. Project activities are divided into calibration, development, and evaluation phases.

(g) Results will be published in annual reports. A report covering the period June 1960 through September 1961 was published in April 1962 for distribution to cooperating agencies.

(4884) UPPER BEAR CREEK EXPERIMENTAL PROJECT.

(b) TVA Tributary Area Development project cooperative with U. S. Forest Service and Auburn University.

(d) Quantitative determination of the effect of soil type, slope, and vegetative cover upon runoff, peak discharge, and erosion on small watersheds progressing to large watersheds. Development of procedures to make data usable in projecting effects from small watersheds to larger drainage areas and to transfer results of the study to ungaged areas.

(e) Four general types of land cover and use will be considered in the study of the watersheds that progress downstream from areas of several hundred acres through intermediate-sized watersheds to a drainage area of 143 square miles.

(f) Approximately half of the stream gaging stations, sediment samplers, and raingages were installed by November 1962. The remaining installations will be completed over a period of several years.

(g) Results will be published in annual reports.

H. G. ACRES & COMPANY LIMITED, Hydraulic Laboratory.

Inquiries concerning the following projects should be addressed to Mr. F. H. Jonker, Head, Hydraulic Department, H. G. Acres and Company Limited, Consulting Engineers, Niagara Falls, Canada.

(4446) DIVERSION TUNNEL MODEL TESTS FOR MANICOUAGAN NO. 2, HYDRO ELECTRIC DEVELOPMENT.

(b) Quebec Hydro-Electric Commission.
(d) Experimental; design.
(e) Tests were continued on the 1:110 scale model of the diversion tunnels, to determine the most suitable shape and alignment of the conduits to ensure free flowing tunnels for a wide range of discharges. The two tunnels are required to pass 500,000 cords of logs in a three-month period. Extensive tests were carried out to study both the formation and the removal of log jams in these tunnels.
(f) Tests completed.
(g) The test results indicated that log jams are likely to occur during low flows in locations where the velocity is extremely low or where the velocity is reversed. It was found that the intake and the bends in the alignment of the tunnel were potentially dangerous and that logs should be passed only when the flow exceeds a certain critical value.
(h) Reports in process of preparation.

(4552) FEASIBILITY STUDY OF DIVERSION TUNNEL CLOSURE BY BLASTING A ROCK PLUG INSIDE THE TUNNEL.

(b) Quebec Hydro-Electric Commission.
(d) Experimental; design.
(e) The feasibility of diversion tunnel closure by blasting a section of the tunnel roof was investigated in a 1:50 scale model.
(f) Completed.
(g) The model tests indicated that the erosion on the downstream slope prevented the formation of a stable rockfill section. This erosion was caused by both the seepage through rockfill and by the back surge of the flowing water in the tunnel.
(h) Report in preparation.

(4553) MODEL TESTS OF A TWO-STAGE STILLING BASIN.

(b) Metropolitan Toronto and Region Conservation Authority.
(d) Experimental; design.
(e) The outflow from a flood control dam is discharged by means of pipes or culverts. The energy of the high-velocity jets must be dissipated to prevent scour of the river valley downstream. Tests were performed on a 1:57.6 scale model to determine the dimensions of a two-stage stilling basin.
(f) Completed.
(g) The model test indicated the importance of providing suitable piers between the individual culverts discharging into the primary stilling basin. The dimensions of both the primary and the secondary stilling basins were determined experimentally in the model. The model test indicated that all major dimensions of the stilling basin were determined by the asymmetrical flow conditions which occur when only one or two of the culverts were operating.
(h) Report submitted to client.

(4554) MODEL TESTS OF A SUBMERSIBLE SECTOR GATE.

(b) Manitoba Department of Agriculture and Conservation.
(d) Experimental; design.
(e) A submersible sector gate with a diameter of 42 feet was tested in a 1:50 scale model to determine the relative merits of submersible gates of this size using upstream or downstream hinges. The test program included the determination of the discharge characteristics, the location of zones of low pressure, the magnitude and frequency of pressure fluctuations on the downstream skin plate and the design of the downstream bucket to give optimum energy dissipation.
(g) The results to date indicate the feasibility of a submersible sector gate with upstream hinges. The maximum pressure fluctuation on the downstream skin plate was found to be approximately eight feet. This fluctuation can be decreased substantially by rounding the top section of the gate. This rounding however resulted in large negative pressures which were found to be low enough to cause both cavitation and lifting of the gate.

(4555) MODEL TESTS OF A SUBMERSIBLE CONTROL GATE.

(b) Dominion Bridge Company Limited.
(d) Experimental; design.
(e) Model tests were carried out on a 1:24 scale model of a submersible, fish belly type, control gate to determine: (1) The torque for various operating conditions; (2) the nappe form; (3) the effectiveness of nappe aerations; (4) the magnitude and frequency of pressure fluctuations; and (5) the discharge rating curve of the final design.
(f) Completed.
(h) Report submitted to client.

UNIVERSITY OF ALBERTA, Hydraulics Laboratory.

(4885) PIPE LINE TRANSPORT OF FLUIDIZED SOLIDS.

(b) University of Alberta.
(c) Mr. R. W. Ansley, Department of Civil Engrg., University of Alberta.
(d) Laboratory experiments in 1" and 2" diameter pipes carrying solids water slurries.
(e) Study the effect of particle size on the pipe line transport of fluidized solids.
(f) Laboratory experiments continuing.
(g) Homogeneous slurries of fine mineral matter and water effectively decrease the critical velocity (the velocity at which solids settle on the pipe walls) for sand transport.
(h) "The Effect of Fines on the Pipeline Flow of Sand-Water Mixtures," C. D. D. Howard. M.Sc. Thesis, 1962.

(4886) ACTIVE BED-LOAD PARTICLE SIZE DISTRIBUTION AND REGIME SLOPE ANALYSIS IN A GRAVEL RIVER.

(b) Alberta Government Dept. of Water Resources and University of Alberta.
(c) Mr. R. E. Bailey, Chief Engineer, Dept. of Water Resources, Government of Alberta.
(d) Field experiments; basic and applied research master's thesis. Minor supplementary lab. experiments.
(e) Study stone size distribution in active portion of river bed gravel. Verify practical applicability of regime slope formula analysis to steep reaches of gravel river during low flow. Test utility of such analysis for future geomorphic surveys. Regime analyses to be extended as routine to other rivers.
(g) Active gravel bed found to have logarithmic normal grain size distribution. Tentative rule suggested for determining median size of active portion of total gravel. Approximate relation obtained between bed factor at vanishingly small bed-load charge and median size of active gravel portion. Regime slope analysis at low discharge found satisfactory under certain limitations of slope and discharge and size of gravel relative to depth.
(h) "Regime Relations in a Gravel Reach of the Red Deer River, Alberta," by M. A. Qureshi, M.Sc. thesis 1962. Copies obtainable from item (c).

UNIVERSITY OF BRITISH COLUMBIA, Hydraulics Lab.

(4451) HEAD LOSS IN SPHERICAL WYES.

(b) Laboratory project.

(c) Dr. E. Ruus, Dept. of Civil Engineering, University of British Columbia.
(d) Applied research.
(e) The spherical wye due to its small dimensions is particularly suitable as a wye-branch in large penstocks under high head. A Lucite model was constructed to measure the head losses in the spherical wye. The inside diameters of the main pipe, the sphere and the branch pipes were 5 1/4, 5.85 and 3 3/4 inch respectively. The angle between branches was 90 degrees. Several modifications of the wye, such as tapered outlets and rounded corners were tested.
(g) Report in preparation.

(4507) NEW HIGHWAY BRIDGE OVER THE COLUMBIA RIVER AT KINNAIRD, BRITISH COLUMBIA.

(b) Hydraulic laboratory studies cooperative with Choukalos, Woodburn and Mckenzie, Ltd., Consulting Engineers, Vancouver, B.C., for the Department of Highways, Province of British Columbia.
(c) Prof. E. S. Pretious, Dept. of Civil Engrg., Univ. of British Columbia, Canada.
(d) Experimental project to aid in the design of the pier foundations and the rock protection for the river bed around the piers.
(e) A model of one of the piers was investigated. It was proposed to support the pier pedestals on a pile grillage driven into the river bed. Special features in the geometry of the proposed piers, combined with their skewness with the flow, made it necessary to investigate flow patterns along with potential river-bed scour. The model pier (scale 1:100) was installed in the large concrete flume in the hydraulic laboratory, and rested on a bed of sand of suitable grade. Various flows, and corresponding water depths, including a flood having a probable recurrence interval of 1,000 years, were imposed.
(f) Completed.
(g) The study provided the consulting engineers with the information they required.
(h) A report was submitted to the Consulting Engineers, and copies were forwarded to the Bridge Engineer's Office, Department of Highways, Province of British Columbia.

ECOLE POLYTECHNIQUE, Department of Civil Engineering.

(4043) STUDY OF THE RELIABILITY AND OPERATION OF BACK-WATER VALVES ON PLUMBING SYSTEMS AGAINST FLOODING BY PUBLIC SEWERS.

(b) City of Montreal, City Planning Department, Inspection Division.
(c) Professor Raymond Boucher, Director, Hydrodynamics Laboratory, Ecole Polytechnique, 2500 Marie-Guyard Avenue, Montreal 26, Quebec, Canada.
(d) Experimental; applied research.
(e) A full scale three-story plumbing system has been erected in the Hydrodynamics Laboratory of Ecole Polytechnique. The diameter of the pluvial column, the soil stack and the drain is 4 inches. The drain has many sections of pyrex glass to permit observations at critical points. A system of valves and of cross-connections on the vents lends to various combinations of tests. The back-water valves have a transparent lucite cover to enable visual observations. As air entrainment seems to have a great importance on the venting capacity, the rate of air entrained in the vertical columns is measured at the inlet by means of a hot-wire air-meter. Various flooding conditions of the public sewers are simulated by a tank in which the water level can be controlled by gate valves. This research is aimed at determining whether back-water valves can offer home dwellers a reliable protection against flooding due to any overload of combined sewers. If this method is not satisfactory, an improved design of plumbing system may be suggested.
(f) Temporarily suspended.
(g) The mechanism of air entrainment has been studied and tests have revealed the best position for some of the vents.
(h) Interim report to be submitted in February 1963.

THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO, Hydraulic Model Laboratory.

Inquiries concerning the following projects should be addressed to Mr. J. B. Bryce, Hydraulic Engineer, Hydraulic Generation Department, 620 University Avenue, Toronto 2, Ontario, Canada.

(3324) ST. LAWRENCE RIVER MODEL - OGDENSBURG TO LEISHMAN'S POINT.

(b) Ontario Hydro and the Power Authority of the State of New York.
(d) Experimental; for design, development and operation.
(e) A 1:500 x 1:100 scale model of St. Lawrence River between Ogdensburg and Leishman's Point, a distance of 16.1 miles, was constructed to determine the design of channel enlargements, the location of the Iroquois Control Dam and a plan of river control during construction of the St. Lawrence Power Project. The locations and conditions for a series of six ice booms for ice control were determined.
(f) Work is essentially completed but model is still active.
(g) Channel enlargements were developed which met the criteria stipulated by the International Joint Commission with respect to navigation and ice-forming velocities and the seaway navigation channel was located. The optimum arrangements and location for the Iroquois Control Dam was determined. A plan of river control during construction was developed. Log booms for ice control have been successful since their installation in the prototype.

(3325) ST. LAWRENCE RIVER MODEL - OGDEN ISLAND REACH.

(b) Ontario Hydro and the Power Authority of the State of New York.
(d) Experimental; for design, development and operation.
(e) A 1:500 x 1:100 scale model of the St. Lawrence River reproducing 7.9 miles of the river between the towns of Iroquois and Morrisburg, was constructed to determine the design of channel enlargements and a plan of river control during construction of the St. Lawrence Power Project.
(f) Work is completed and model removed.
(g) Channel enlargements were developed which met the ice-forming criteria stipulated by International Joint Commission and a satisfactory Seaway Navigation channel was located. A plan of river control during construction was developed.

(3326) ST. LAWRENCE RIVER MODEL - DEWATERING AND CLOSURE AREA.

(b) Ontario Hydro and the Power Authority of the State of New York.
(d) Experimental; for design, development, and operation.
(e) A 1:500 x 1:100 scale model of the St. Lawrence River reproducing 13.8 miles from Cat Island to below the powerhouses was constructed to develop plans for dewatering the Long Sault Dam and the powerhouse and to investigate conditions during the various stages of their construction.
(f) Work is completed and model removed.
(g) Dewatering diversion channels were designed in detail and a plan of construction developed to preserve the necessary water levels for existing navigation and ensure adequate

discharge capacity in the various stages of construction. Velocities in the Seaway Channel were also investigated. The Power Pool filling operation was investigated in detail.

(3333) ST. LAWRENCE RIVER MODEL - TAILRACE AREA.

(b) Ontario Hydro and the Power Authority of the State of New York.
(d) Experimental; for design.
(e) A 1:160 x 1:80 scale model reproducing 2.5 miles of the St. Lawrence River from above the powerhouses to below Polly's Gut, has been constructed to develop the design of an economic tailrace improvement and a suitable dewatering scheme.
(f) Work is completed and model removed.
(g) An economic tailrace enlargement was developed in the model. A cofferdamming plan to dewater much of the enlargement area was devised and the velocities at various stages observed. A plan for disposal of dredged material behind a dyke adjacent to the work area was developed.

(3643) HEADGATE MODEL.

(b) Ontario Hydro.
(d) Experimental; as applied research.
(e) A 1:24 scale model of the St. Lawrence powerhouse headgate and inlet water passage was built to investigate the hydraulic forces on gates with upstream and downstream skin plates under conditions of horizontal and sloping floors and submerged and free discharge conditions.
(f) Work is completed and model removed.
(g) A series of curves was developed from which hydraulic downpull forces may be determined for several types of gates and gate installations for use in preliminary designs.

(3644) OTTER RAPIDS GENERATING STATION MODEL.

(b) Ontario Hydro.
(d) Experimental; for design.
(e) A 1:72 scale comprehensive model of the sluiceways, powerhouse and upstream and downstream river channels has been constructed to determine the dewatering arrangement for construction, velocities at and along cofferdams, height location and slope of high water channel sluiceway training walls, the rating of the diversion ports and the sluiceways and the tailrace channel enlargement.
(f) Work is completed and model removed.
(g) The dewatering plans were developed and tested in the model. The calibration and performance of the four tunnel diversion ports for use during construction were determined. The design and operational use of the sluiceways in the high water channel were tested.

(4026) NIAGARA RIVER MODEL.

(b) Ontario Hydro.
(d) Experimental; for design and operation.
(e) An existing 1:250 x 1:50 scale model reproducing five miles of the Niagara River from Buckhorn Island to below the Cataracts is being used to determine the operational characteristics of the Niagara River Control Structure under developed conditions. This model was previously used to investigate the remedial works necessary for the Preservation and Enhancement of Niagara Falls and for the location of the intakes and necessary river improvements of both Ontario Hydro and the Power Authority of the State of New York. To fully realize the terms of the 1950 Niagara Treaty, additional remedial works have been designed. These include a five-gate extension to the existing 13-gate control structure as well as a system containing an upstream accelerating wall, a downstream training wall and overflow weir for the safe passage of ice past the various intakes along the Canadian shore of the river above the Falls. The sequence of construction of these works and the conditions during their construction were determined in the model. Rating of the structure under cofferdammed conditions was obtained. An echo-sounding survey with electronic fixing was made in the field in 1962 and portions of the model re-contoured. Certain river improvements were designed and executed to assist in the passage of ice floes.

(4453) LITTLE LONG GENERATING STATION INTAKE MODEL.

(b) Ontario Hydro.
(d) Experimental; for design.
(e) A 1:36 scale model of a bell-mouthed water passage from the dam to the circular penstock and scroll case was built. The configuration of the bell mouth was determined and the design of the bay-window type trash racks upstream of the dam face. Piezometer tap locations were investigated for future prototype Gibson test efficiency tests.
(f) Work is completed and model removed.

(4454) ONTARIO POWER GENERATING STATION - INTAKE AND WEIR MODEL.

(b) Ontario Hydro.
(d) Experimental; for design and operation.
(e) A 1:50 scale model was built of the Ontario Power outer forebay intake wall and a portion of the downstream training wall and overflow weir, which are a part of the extension to the Niagara River additional remedial works. The design of the weir and wall as developed in the distorted Niagara Model was checked in this natural scale model
(f) Work is completed but model is still active.

(4455) ARROW LAKES DAM - COLUMBIA RIVER.

(b) British Columbia Power Commission.
(d) Experimental; for design and operation.
(e) An 1:80 scale model of the Arrow Lakes and dam and environs was built to determine the detailed location and adequacy of the water passages in a concrete structure and the energy-dissipating works necessary to ensure the protection of an associated earth dam. A 1:50 scale model was tested in a flume to determine the hydraulic design of the tunnel ports in the concrete structure and to develop the associated energy-dissipating work. Rating of these ports was obtained as well as the hydraulic loadings on the port gates. A 1:60 scale model of one of the four sluiceways is being tested in the flume to determi the rating of the sluice and the hydraulic loadings on the sluice gate. Piezometers are being used to determine under varying conditions of flow, the rollway pressures as well as the pressures at selected locations in the energy-dissipating bucket and associated tooth-like projections of the dissipator.

(4508) LITTLE LONG MAIN DAM MODEL.

(b) Ontario Hydro.
(d) Experimental; for design and operation.
(e) A 1:80 natural scale model was constructed of the main dam containing two submerged tunnel ports and five sluiceways with staggered sill elevations. Discharge capacities of these components were determined as well as several schemes of closure in raising the head pond. Conditions downstream of the structure at several access bridge piers were studied.
(f) Work is essentially completed, but model is still active.

(4509) HARMON GENERATING STATION MODEL.

(b) Ontario Hydro.
(d) Experimental; for design and operation.
(e) A 1:80 natural scale model was constructed of the main dam, two submerged ports and two sluiceways. A diversion channel was

designed with associated cofferdams for use during construction. Capacities of ports and sluices were determined. Location of downstream access bridge piers was determined. A ski-jump type energy dissipator for the sluiceways was also designed.
(f) Model is still active.

(4510) DOUGLAS POINT CIRCULATION MODEL.

(b) Atomic Energy of Canada Limited.
(d) Experimental; for operation.
(e) A 1:100 vertically and 1:500 horizontally scale model was constructed of an area one-and-a-half miles by three miles of Lake Huron in the vicinity of the Douglas Point nuclear plant intake and outfall. The circulation of the cooling water from the outfall with respect to the intake was investigated with littoral drifts of different velocities and opposite directions, as well as no drift.

(4511) CLAIREVILLE DAM MODEL.

(b) Metropolitan Toronto and Region Conservation Authority.
(d) Experimental; for design
(e) A 1:40 natural scale model of the dam and its environs was built and the capacity and rating of the five sluiceways determined. Schemes of various energy dissipators were investigated and a design recommended.
(f) Work is complete, but model is still active.
(g) Sluiceway capacity was determined and a scheme of energy dissipation developed.

(4512) WESTERLY WATER PURIFICATION PLANT MODEL.

(b) The municipality of Metropolitan Toronto.
(d) Experimental; for design.
(e) A 1:8 plastic model of one of the bays of a water purification plant is being constructed. It contains the main manifold with its associated laterals and the filter and backwash cycles will be checked to ensure as uniform a distribution of flow as possible through the lateral beds. This will be accomplished by experimenting with the size of the openings in the main manifold.
(f) Model is under construction.

LASALLE HYDRAULIC LABORATORY LTD.

(4456) VELOCITY AND DIRECTION OF CURRENT RECORDER.

(b) Laboratory Project.
(d) Experimental - development of instrument for hydrographic and oceanographic research for acquisition of datum in computable form (punched tape).
(e) Recording of velocity by impulse counter for propeller type current-meter. Recording of direction by reading an encoder monitorized by a marine compass. Instrument must be: 1) rugged, 2) simple and easy to maintain, 3) very low power drain for long periods. (recording up to 6 months under ice).
(g) Prototype routine tests equivalent to 2 years without failure have been carried out. Tests at sea expected to be carried out in 1963. Depth up to 2000 feet. Patent pending.

(4458) PEACE RIVER - PORTAGE MOUNTAIN DEVELOPMENT.

(b) British Columbia Electric and I.P.E.C.
(d) Theoretical and experimental; design.
(e) A 1/100 scale model was constructed to determine the practicability of the hydraulic design of the three diversion tunnels proposed.
Studies include: approach channel, intake tunnels, discharge capacity, energy dissipating works with movable bed and cofferdamming of the river.
(f) Completed.
(h) Reports submitted to sponsor.

(4459) DUNCAN LAKE PROJECT.

(b) Montreal Engineering and B.C.P.C.
(d) Experimental; design.
(e) A 1/48 scale model used to study the best design of the outlet works for the diversion tunnels and of the downstream discharge channel in order to minimize erosion, ensure stability of the structures and prevent deposition of material near the tailrace of the powerhouse.
(f) Completed.
(h) Report submitted to sponsor.

(4513) MEILLEUR - ATLANTIQUE. SEWAGE REGULATOR.

(b) City of Montreal.
(d) Theoretical; design.
(e) Study of a flow meter for domestic and flood waters combined with an automatic sewage regulator.
The regulator includes upstream and downstream water level controls.
(f) Completed.
(h) Report submitted to sponsor.

(4514) DRAINAGE OF THE SOUTH WATERSHED OF THE CITY OF MONTREAL.

(b) City of Montreal.
(d) Theoretical; design.
(e) Hydraulic study of a new sewer network draining the domestic and flood waters of the southern watershed of the Town of Montreal.
Provision has been made for the future purification of domestic water.
(f) Completed.
(h) Report submitted to sponsor.

(4515) ANTHES - IMPERIAL PIPE.

(b) Anthes Imperial.
(d) Experimental.
(e) Full scale measurements of the friction coefficient of a 6-inch pipe coated with special paint intended to protect the pipe.
Results were extrapolated to include larger and smaller pipe sizes.
(f) Completed.
(h) Report submitted to sponsor.

(4516) GROS CACOUNA HARBOUR.

(b) Public Works Department.
(d) Theoretical and experimental: design.
(e) A study of the arrival of waves in the harbour was carried out by using wave diagrams. Then a 1/100 scale model was built to study the protection of the harbour against penetration of swell.
(f) Completed.
(h) Report submitted to sponsor.

(4517) MONTREAL - SOREL SHIP CHANNEL.

(b) Department of Transport.
(d) Theoretical and experimental: design.
(e) Two models representing a section of the St. Lawrence River from Laprairie Basin including Montreal Harbour to Sorel Islands were built at a scale 1/150 vertically and 1/600 horizontally.
The purpose of the model was to study the improvement of navigation in this section of the St. Lawrence River.

(4518) BAY OF FUNDY.

(b) New Brunswick Government.
(d) Theoretical: design.
(e) Study carried out in collaboration with H. G. Acres and The Foundation Engineering of Canada.
The aim of this study was to appraise the possibilities of tidal power in the Bay of Fundy.
(f) Completed.
(g) Report submitted to sponsor.

(4519) SWIFT RAPIDS LOCK.

(b) Department of Transport.
(d) Theoretical and experimental; design.
(e) A 1/20 scale model of this lock, which forms part of the Trent River navigation facilities, was used to determine filling and emptying conditions, intake and outlet flow characteristics as well as the hydraulic flow conditions along the whole water conducting circuit.

(4520) MANICOUAGAN POWER PLANT - SITE 5 BOTTOM OUTLETS.

(b) Quebec Hydroelectric Commission.
(d) Theoretical; design.
(e) Hydraulic design of the bottom outlet intended to work under a maximum head of 500 feet. The major design criterion was to avoid cavitation.

(4521) MANICOUAGAN POWER PLANT - SITE 5 BOTTOM OUTLETS.

(b) Quebec Hydroelectric Commission.
(d) Experimental; design.
(e) A 1/60 scale model was built to study the best design of the bottom outlet with regard to the erosion downstream of the structures. This model is also used for pressure measurements on the structures.

(4522) BRAZEAU OUTLET WORKS.

(b) Dominion Bridge.
(d) Experimental; design.
(e) Study on a 1/36 scale model of the hydraulic forces and possibility of vibration of the gate during the starting operations of the turbine - pump.
Forces and vibrations are directly measured by force transducers.

(4523) PERFORATED BREAKWATERS.

(b) Laboratory project.
(d) Basic research.
(e) Theoretical and model study of swell reflexion against vertical perforated breakwaters. Comparison with Clapotis and Rubble Mound breakwaters reflective action.

(4524) CARILLON POWER PLANT - SCOURS DOWNSTREAM OF THE SPILLWAY.

(b) Quebec Hydroelectric Commission.
(d) Experimental; operation.
(e) Tests on the 1/110 scale general model have been carried out to reproduce scours found downstream of the prototype spillway and which seemed to be due to a geological fault in the rock.
An operating programme has to be recommended in order to avoid further scours.

UNIVERSITY OF MANITOBA, Hydraulics Laboratory.

Inquiries concerning the following projects should be addressed to Professor E. Kuiper, Department of Civil Engineering, University of Manitoba, Fort Carry, Manitoba, Canada.

(4547) FAIRFORD RIVER CHANNEL IMPROVEMENTS.

(b) Water Control Branch, Province of Manitoba.
(d) Experimental project to aid in the design of the most economical channel improvements.
(e) The channel excavation at the Fairford River, where it drains Lake Manitoba, is part of an engineering project to control the levels of Lake Manitoba. The purpose of the model study was to determine how the hydraulic effectiveness of the channel design could be improved. The model had a horizontal scale of 1:1200 and a vertical scale of 1:36 and included approximately 5000 feet of river channel.
(f) Completed.
(g) It was found from the model study that the originally proposed excavation could be reduced by 55,000 cubic yards, without reducing the hydraulic effectiveness of the channel improvements.
(h) "Fairford River Channel Improvements" Report No. 1, Hydraulics Laboratory, University of Manitoba.

(4548) SOUTH SASKATCHEWAN RESERVOIR SEDIMENTATION.

(b) Prairie Farm Rehabilitation Administration, Regina.
(d) Experimental project to determine nature of deposition of sediment.
(e) The upper 80 miles of the South Saskatchewan Reservoir were reproduced as a length ratio of 1:15,000; a width ratio of 1:1500; and a depth ratio of 1:40; resulting in a model that was 30 feet long, 4 feet wide and 3 feet deep. The model was operated in accordance with the prototype fluctuations in discharge, sediment transport and reservoir level. The purpose of the tests was to study the pattern of deposition in longitudinal direction.
(f) Testing is completed on deposition of sand. The model is now being used for tests in the deposition pattern of sand and silt, which are simulated in the model by sand and grains of plastic.
(g) It was found that the slope of the delta surface between the upper and lower reservoir levels approximates the slope of the river bed. The slope below is substantially steeper. The slope above follows the backwater curve towards normal depth.
(h) "South Saskatchewan River Reservoir Sedimentation," by R. W. Newbury. Part requirement for degree of M.Sc. from University of Manitoba.

(4549) RED RIVER FLOODWAY OUTLET MODEL.

(b) Water Control Branch, Province of Manitoba and H. G. Acres and Company, Niagara Falls.
(d) Experimental project to aid in the design of the outlet structure of the Red River Floodway.
(e) The lower end of the Floodway, the fixed-crest drop structure and the junction with the Red River channel were reproduced at a horizontal scale of 1:100 and a vertical scale of 1:100, resulting in a model of 30 x 60 feet. Different designs of the drop structure and different plans of excavation were investigated for different discharges in order to find the most economical design that would keep velocities below erosive capacity. The bed material was uniform sand with a diameter of approximately 1 mm.
(f) Test completed.
(g) Test indicated that the drop structure could be designed much simpler than was originally proposed. The tail race channel between the drop-structure and the Red River will be of approximately the same dimensions as the Floodway, while the side slopes will be protected by rip rap.
(h) Report under preparation.

(4550) RED RIVER FLOODWAY INLET MODEL.

(b) Water Control Branch, Province of Manitoba.
(d) Experimental project to aid in the design of the inlet works of the Red River Floodway.
(e) The upper end of the Floodway, the control dam with drum gates, and two miles of Red River Channel were reproduced at a horizontal scale of 1:120 and a vertical scale of 1:60, resulting in a model of 40 x 160 feet. Different designs of the floodway inlet and different plans of rip rap protection were investigated for different discharges. Tests were also conducted with surface ice (cakes of wax) to determine the likelihood of an ice jam at the point of intake.
(f) Tests completed.
(g) Tests indicated the most satisfactory elevation and width of the floodway entrance; and the extent of rip rap required downstream of

the control dam.
(h) Report under preparation.

(4551) MEANDERING OF ALLUVIAL RIVERS.

(b) University of Manitoba.
(d) Basic research in the hydraulics laboratory towards a masters degree.
(e) Collecting pertinent information from the literature and foreign hydraulic laboratories. Verifying some of this information under the presently available laboratory conditions. Pursuing the investigation into areas that are ill understood such as the helicoidal movement of water and sediment in riverbends.
(f) Recently started.

MCGILL UNIVERSITY, Department of Civil Engineering and Applied Mechanics.

(4545) BREAKUP OF SOLITARY WAVE.

(b) Laboratory project.
(c) Dr. A. J. Reynolds, Dept. of Civil Engineering and Applied Mechanics, McGill University, Montreal 2, P.Q., Canada.
(d) Experimental; basic research.
(e) Examination of disintegration of a solitary wave in shallow water on encountering deep water.

(4546) CAVITATION AT HIGH-HEAD SLUICE GATES.

(b) Laboratory project.
(c) Dr. A. J. Reynolds, Dept. of Civil Engrg. and Applied Mechanics, McGill Univ., Montreal 2, P. Q., Canada.
(d) Experimental; applied research, for Master's degree.
(e) Study of pressure fluctuations on wall behind an obstruction which produces cavitation.

NATIONAL RESEARCH COUNCIL, Division of Mechanical Engineering.

Inquiries concerning the following projects should be addressed to Dr. D. C. MacPhail, Director, Division of Mechanical Engineering, National Research Council, Montreal Road, Ottawa, Ontario, Canada.

(4047) BAIE COMEAU, PROVINCE OF QUEBEC.

(b) Department of Public Works, Canada.
(d) Experimental; for design.
(e) This harbour is located on the north shore of the Gulf of St. Lawrence where it is exposed to strong wave action. A new design of perforated vertical-wall breakwater, developed in the laboratory, is being constructed as a 1000-ft. extension to an existing wharf. Field data on waves and stresses in the perforated wall are being obtained in co-operation with the Division of Building Research.
(g) The breakwater extension is nearing completion and wave recording equipment is being installed.
(h) A report will be prepared when wave and stress data are available.

(4464) RUSTICO HARBOUR, PRINCE EDWARD ISLAND.

(b) Department of Public Works, Canada.
(d) Experimental for design.
(e) This harbour is located in an area of strong littoral drift and, as a result, the entrance is subject to shoaling. The main problem is to stabilize the width and increase the depth of the approach channel. A 1:150 by 1:30 tidal wave model, using crushed bakelite as a bed material, has been constructed to study remedial measures.
(g) A preliminary design of control structure has been made and tests are continuing to study the final details.

(4465) SPILLWAY.

(b) Shawinigan Engineering Co., Ltd., Montreal.
(d) Experimental; for design data.
(e) A 1/60 scale model of a side channel spillway, designed to pass flood water about a proposed power plant, was used to verify the spillway capacity and study flow conditions downstream of the powerhouse. A number of modifications were made to reduce turbulence.
(f) Completed.
(h) A report has been issued to the sponsor.

(4466) AIR BUBBLERS.

(b) Laboratory project.
(d) Experimental; field investigations.
(e) Laboratory experiments have been performed to determine the circulation induced by air bubblers in homogeneous and stratified water. Field measurements have been made in two Arctic inlets in which air bubblers were operating.
(g) Additional field measurements with improved equipment will be taken during the freeze-up period in the Fall of 1962 to obtain a better understanding of the dynamics and energy budget in an Artic inlet.
(h) "Winter Regime of a Tidal Inlet in the Artic and the Use of Air Bubbler for the Protection of Dock Structures", by S. Ince. Paper was presented to the Eighth Conference on Coastal Engineering in Mexico City, November 5-9, 1962.

(4525) FORMATION OF ICE IN RIVERS.

(b) Laboratory project.
(d) Experimental; field investigations.
(e) Temperature measurements were taken at a number of locations in the St. Lawrence River below Kingston, during the Winter and early Spring of 1961-62, to obtain information on the heat losses.
(g) Improved temperature measuring equipment has been installed at 15 locations in the St. Lawrence River between Kingston and Sorel, and water temperatures will be obtained at approximately bi-weekly intervals during the winter of 1962-63.
(h) "A Preliminary Temperature Survey of the St. Lawrence River from Kingston to Beauharnois, February 22-24, 1961" Internal Memoranda HY-8 and HY-42 "A Note on the Density Structure of the St. Lawrence River at Kingston," by S. Ince, have been prepared.

(4526) CHANDLER HARBOUR WHARF.

(b) Department of Public Works, Canada.
(d) Experimental; for design data.
(e) A scale model of a wharf, protected by a rock-filled breakwater, was tested in a wave flume to determine the stability in waves. The tests showed that some modifications to the original design were desirable.
(f) Completed.
(g) A new control was made for a flap-type wavemaker so that waves of constant height but random frequency could be generated. The effect of random frequency waves on the breakwater was different from groups of waves of constant frequency.
(h) Design data have been issued to the sponsor.

(4527) TIDE PROPAGATION IN AN ESTUARY.

(b) Laboratory project.
(d) Theoretical and experimental.
(e) A study of the tide range in the lower Fraser River indicated that it was greatly influenced by a number of restrictions, many of which had been constructed to increase local depths. It has been proposed that it would be preferable to remove a number of these restrictions and rely on the increased flushing action of the tides to maintain the channels. A 1:1440 by 1:144 fixed-bed model of the entire tidal area is being constructed to study the effect

of removing certain restrictions and making other improvements.
(g) The model is nearing completion.

(4528) EFFECT OF EARTH'S ROTATION ON RIVER FLOW.

(b) Laboratory project.
(d) Theoretical and experimental.
(e) Considerations of gravity and Coriolis forces acting in fast-flowing, straight rivers of small slope indicate that considerable spiral flow is possible. Measurements with directional current meters in a section of the St. Lawrence River confirmed this. A small rotating table is being constructed to study flow in channels in a rotating system.

ONTARIO AGRICULTURAL COLLEGE.

(2492) RUNOFF FROM SMALL WATERSHEDS.

(b) Laboratory project.
(c) Prof. D. F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Experimental; applied research.
(e) The relationship of precipitation and snowmelt to runoff characteristics on four watersheds of 20 acres each, under various land use practices, is being evaluated.
(g) Winter surface runoff from watersheds with good grass-legume cover is greater than from watersheds plowed during the winter season. Negligible surface runoff from watershed in trees and pasture.
(h) Discussion by D. F. Witherspoon "Hydrologic Design of Culverts" by Ven T. Chow. Journ. of Hydraulics Paper No. 3071, March 1962, published in Proc. ASCE Vol. 88 HY5, Sept. 1962.

(2740) MAIN TILE DRAIN SIZES FOR COMPOSITE DRAINAGE OF BROOKSTON CLAY SOIL.

(b) Laboratory project.
(c) Prof. F. R. Hore, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Field investigation; applied research.
(e) Discharge measurements from lateral tile drains in Brookston clay soil are being made to determine the proper drainage coefficient to use in the design of main tile drains and to determine the effect of lateral tile drain spacing on the drainage rate. Two additional lateral drains were installed in the fall of 1960.
(g) Preliminary frequency analyses have been made on runoff data collected over a 5-year period.

(3363) HYDROLOGIC CHARACTERISTICS OF ORGANIC SOIL.

(b) Laboratory project.
(c) Prof. R. W. Irwin, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Field investigation; applied research.
(e) The study is being carried out to establish criteria to be used in the development and operation of a water control program for organic soils. In the investigation, an attempt will be made to establish a hydrologic water balance for the field area by measuring, recording, and analyzing so far as possible the evaporation, seepage, transpiration, precipitation, water table elevation and ground water discharge through tile drains.
(g) Data collection continuing.
(h) Thesis in preparation.

(3658) THE RESISTIVITY METHOD OF GROUND WATER PROSPECTING.

(b) Laboratory project.
(c) Prof. D. F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Field investigation; applied research.
(e) The objective is to investigate the application of the resistivity method to subsurface exploration for ground water under the geological conditions found in southern Ontario.
(g) The resistivity method was successfully used in investigation of a pre-glacial valley as a possible source of ground water.
(h) "Resistivity Survey of the Twelve and Sixteen Mile Creek Watersheds" by G. Wessels. M.S.A. thesis on file in Massey Library, Ontario Agricultural College.

(3660) RAINFALL-DEPTH-AREA-INTENSITY RELATIONSHIPS IN CENTRAL ONTARIO.

(b) Laboratory project.
(c) Prof. D. F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Field investigation; applied research.
(e) A dense network of standard and recording rain gages has been established in the Guelph area with the cooperation of the Meteorological Branch, Department of Transport. The network is over an area of approximately 12 square miles with an average gage density of 1 per square mile. The purpose of this study is to obtain detailed information on summer precipitation characteristics for use in the hydrologic design for small drainage basins.
(g) Analysis of data shows that for 8 years intensity-frequency relationships are different from nearby stations with longer record.

(3662) POTENTIAL EVAPOTRANSPIRATION AND CONSUMPTIVE USE OF WATER BY CROPS.

(b) Laboratory project.
(c) Dr. K. M. King, Department of Soils, Ontario Agricultural College, Guelph, Ontario, Can.
(d) Field investigations; basic research.
(e) The purpose of this investigation is to evaluate the factors influencing evapotranspiration by the use of a specially designed floating lysimeter. Study is being conducted on the effect of soil moisture on the heat budget and evapotranspiration for crops.
(g) Data analysis is continuing.

(4052) COVER MATERIALS FOR TILE DRAINS.

(b) Laboratory project.
(c) Prof. F. R. Hore, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Experimental and field investigation; applied research.
(e) This study is being made to determine the effect of several cover materials on soil movement and water discharged into a tile drain. Laboratory studies of some relatively new glass fiber materials have been completed and a field experiment based on those results was installed in the fall of 1960.
(g) Yearly sampling of sediment from drains at the field experimental site are being continued but no conclusions can be drawn as yet.
(h) "Cover Materials for Tile Drains," by F. R. Hore and H. C. Tiwari. Can. Agric. Eng. Vol. 4 No. 1, Jan. 1962.

(4053) THE WATER YIELD OF SWAMP AREAS.

(b) Laboratory project.
(c) Prof. D. F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Field investigation; Master's thesis.
(e) A watershed of approximately 900 acres containing a swamp area is being studied to determine the relationship between watershed characteristics and water yield.
(f) Discontinued.
(g) Analysis of three years data of rainfall runoff and water levels in the study watershed shows the swamp to be a result of a ground water outcrop.
(h) "Relationship of Ground Water Levels to Streamflow from a Swamp" by R. K. Rai. M.S.A. thesis on file in Massey Library, Ontario Agricultural College.

(4054) RUNOFF FROM FLAT LAND.

(b) Laboratory project in cooperation with Water

Resources Division, Department of Northern Affairs and National Resources.
(c) Prof. F. R. Hore, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Field investigation; applied research.
(e) Several 2 to 10 square mile flat watersheds of fine-textured soils are to be studied to determine the relationship between precipitation, snowmelt, watershed characterisitcs and runoff. Hydrologic data on this type of watershed is being sought for the establishment of criteria for the design of hydraulic structures. The installation of gaging stations and the survey of watershed boundaries is continuing.

(4055) EVAPORATION FROM A SNOW SURFACE.

(b) Laboratory project.
(c) Prof. D. F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Field investigation; applied research.
(e) Snow evaporation will be measured from a floating lysimeter and basic equations for the heat budget over a snow surface will be developed for estimating snow evaporation and snowmelt. These data will be used in a water balance for experimental watersheds in the Guelph area.
(g) Equipment has been designed and constructed. Data will be collected during 1962-63.

(4467) DRAIN FLOW STUDIES.

(b) Laboratory project.
(c) Prof. F. R. Hore, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Experimental; basic research and development.
(e) The object of this research is to study the fundamental nature of flow through multiple openings in an underdrain with the view towards development of satisfactory design criteria for the openings.
(f) Inactive.
(g) A review of literature has been made and a few preliminary investigations have been made in the laboratory.

QUEEN'S UNIVERSITY AT KINGSTON, Hydraulic Laboratories.

(3364) LITTORAL DRIFT AND ITS EFFECT ON THE HARBOURS ON THE NORTH SHORE OF LAKE ONTARIO.

(b) The National Research Council of Canada.
(c) Dr. A. Brebner, Ellis Hall, Queen's Univ., Kingston, Ontario, Canada.
(d) Experimental and field; basic and applied.
(e) Field and laboratory: 3-dimensional model of Cobourg Harbour.
(h) "A Model Investigation of Cobourg Harbour," by B. Le Mehaute and J. I. Collins, Queen's Civil Engineering Report No. 17.
"Wind and Waves at Cobourg, Lake Ontario," by A. Brebner and B. Le Mehaute, Queen's Civil Engineering Report No. 19 (Available from (c).)
"On the Accuracy of Various Methods of Predicting Wave Climates for Limited Fetches," by Dr. A. Brebner, Queen's Civil Engineering Report No. 22. (Available from (c).)

(3666) CRITICAL MASS-TRANSPORT VELOCITIES FOR PARTICLES OF VARIOUS SIZES.

(b) The National Research Council of Canada.
(c) Dr. A. Brebner, Ellis Hall, Queen's Univ., Kingston, Ontario, Canada.
(d) Experimental laboratory investigation for doctoral thesis by J. I. Collins.
(e) Work extended in an attempt to uncover relationships for superposed currents on mass transport characteristics.
(f) Inactive.

(4057) THE TRANSPORT OF LOGS OR SUSPENDED SOLIDS THROUGH PIPELINES.

(b) The National Research Council of Canada.
(c) Dr. A. Brebner, Ellis Hall, Queen's Univ., Kingston, Ont., Canada.
(d) Laboratory investigation but to almost full-size scale.
(e) The head losses associated with two-phase flow of wood-chips and water.
(g) Wood-chips pumped through 400 ft. of 4" line with good success.
(h) "An Introduction to Aqueous Hydraulic Conveyance of Solids in Pipe-lines," by Dr. A. Brebner, Queen's Civil Engineering Report No. 21. (Available from (c).)

(4468) CRITERIA FOR THE INCIDENCE OF TURBULENCE.

(b) National Research Council.
(c) Prof. R. J. Kennedy, Queen's Univ., Kinston, Ont., Canada.
(d) Basic research.
(e) An apparatus to produce plane Couette flow is used. Both shear intensity and distance between boundaries are independently variable

(4529) THE STABILITY OF RUBBLE MOUND FOUNDATIONS FOR VERTICAL BREAKWATERS.

(b) National Research Council of Canada.
(c) Dr. A. Brebner, Ellis Hall, Queen's Univ., Ontario, Canada.
(d) Applied research to model scales.
(e) To establish criteria for the stability of rubble mound foundation subjected to wave action.
(f) Discontinued.
(h) 8th International Congress on Coastal Engrg., Mexico City, November 1962, or Queen's Civil Engineering Report No. 23. (Available from (c).)

(4530) THE VERTICAL PUMPING OF MINE PRODUCTS.

(b) Ontario Mining Association.
(c) Dr. A. Brebner, Ellis Hall, Queen's Univ., Kingston, Ontario, Canada.
(d) Applied research in laboratory.
(e) To establish co-relation between head losses in vertical pumping and particle size, specific gravity, concentration, etc.
(g) Work commencing.

UNIVERSITY OF TORONTO, Department of Mechanical Engineering.

(1298) DISCHARGE CHARACTERISTICS OF WEIR-TYPE SPILLWAYS.

(b) Laboratory project.
(c) Prof. L. E. Jones, University of Toronto, Toronto 5, Canada.
(d) Experimental; applied research for master's theses.
(e) A long-term research carried out with a view to systematizing discharge characteristics for spillways having various pier spacings and proportions.
(f) A computer project is being undertaken to review all numerical work and to utilize appropriate statistical procedures in the function-fitting.
(g) Significant correlations obtained via special plotting techniques.
(h) Report in preparation.

(3003) ROUGHNESS PHENOMENA IN OPEN CHANNEL FLOW.

(b) Laboratory project.
(c) Prof. L. E. Jones, University of Toronto, Toronto 5, Canada.
(d) Experimental and analytical; basic research for doctoral thesis.
(e) Critical analysis of the hydraulic radius concept and the effect of cross-section geometry on the resistance to flow in conduits. Detailed evaluation of mean flow parameters such as friction coefficients, static pressures, velocities, and wall shear stresses. The channel under study was 70 feet long and had a variable rectangular cross-section of 3 x 1, 3, 9 inches,

respectively, and used air as the fluid medium.

(f) First project completed.

(g) Friction coefficients plotted as function of bulk Reynolds number exhibit a trend similar to but not identical with the circular pipe resistance law. The local velocities correlate well in the form of the inner law provided the local shear velocity is used. The appropriate velocity scale for the outer law correlation is the average shear velocity, but this correlation is not established for Reynolds numbers below 10^5. Static pressures increase toward the center of the ducts.

(h) "The Effect of Cross-Section Geometry upon the Resistance to Flow in Conduits," by H. J. Leutheusser, Ph.D. thesis, University of Toronto, October 1961.
"Turbulent Flow in Rectangular Ducts," by H. J. Leutheusser, Journal of Hyd. Div., May, 1963.

(3368) DIFFUSION OF GASEOUS PLUMES.

(b) Laboratory project.

(c) Prof. W. D. Baines, University of Toronto, Toronto 5, Canada.

(d) Experimental and analytical; basic research for Master's thesis.

(e) A jet of air is injected at various angles into a uniform cross-flow. From photographs of the jet containing smoke, and velocities determined with a hot-wire anemometer the shape of the jet and the pattern of dispersion are being studied.

(g) Momentum equations yield parametric relationships for the shape of the jet which have been used to define the path of a jet injected at 90 degrees to the cross-flow. Experiments are in progress with jets entering at other angles.

(h) "The Round Turbulent Jet in a Cross-Wind," by J. F. Keffer, Ph. D. thesis, University of Toronto, April, 1962.

(4064) EFFECT OF GROINS ON LITTORAL TRANSPORT.

(b) Laboratory project.

(c) Prof. G. Ross Lord, University of Toronto, Toronto 5, Canada.

(d) Experimental and analytical; applied research for master's thesis.

(e) The motions of individual sediment particles of various sizes and densities were studied on a solid plane beach of 1:10 slope at 45 degrees to the wave direction. Direction and magnitude of the particle velocities and the effect of groins upon particle motion were studied.

(g) Wave induced currents have been analyzed and compared with experimental results. After minimizing the effects of nearshore circulation, equations are derived for littoral transport velocities of spherical particles for the given beach and wave configuration. Modification of existing refraction theories is proposed.

(h) Report in preparation.

(4065) EFFECTS OF VELOCITY DISTRIBUTION ON WIND LOADS ON BUILDINGS.

(b) Division of Building Research, National Research Council of Canada.

(c) Prof. W. D. Baines, University of Toronto, Toronto 5, Canada.

(d) Experimental; applied research for design information.

(e) A velocity distribution similar to that in the atmosphere has been created in a wind tunnel. Pressure distributions and flow patterns around typical building shapes have been measured.

(g) For tall buildings the pressure distribution on frontal surfaces reflects the distribution of stagnation pressure but the wake pressure is uniform. On low buildings an upstream separation zone is formed and as a result the pressure on all surfaces is relatively uniform.

(h) "Pressure Distribution on a Cube Immersed in a Boundary Layer," by G. H. Robertson, M.A.Sc. thesis, University of Toronto, May 1962.
"Effect of Velocity Distribution on Wind Load on a Tall Building," by W. D. Baines, Dept. of Mechanical Engineering Technical Publication, TP6203, June 1962.
"Measurements of Pressure Fluctuation on a Cube in Constant and Boundary-Layer Velocity Fields," by J. F. Keffer and W. D. Baines, Department of Mechanical Engineering Technical Publication, TP6204, October 1962.
"Effect of Velocity Distribution on Wind Loads on Walls and Low Buildings," by G. F. Hamilton, Department of Mechanical Engrg. Technical Publication, TP6205, November 1962.

(4469) DIFFUSION OF MOMENTUM AND ENERGY IN NON-CIRCULAR DUCTS.

(b) Laboratory project.

(c) Prof. W. D. Baines, University of Toronto, Toronto 5, Canada.

(d) Experimental and analytical; basic research for doctoral thesis.

(e) The origin of secondary currents in turbulent flow in square, rectangular and elliptical ducts have been studied by experimental determination of the local rates of production, diffusion and convection of longitudinal vorticity. The role of the currents in the convection of mean flow momentum and heat are being studied.

(g) The secondary flows are the result of steep Reynolds stress gradients near the bisectors of the corners in angular ducts and lines of minimum radius of curvature in an elliptical duct. The circulation is limited by the viscous stresses close to the wall surfaces.

(h) "The Production and Diffusion of Vorticity in Channel Flow," by E. Brundrett, Ph.D. thesis, University of Toronto, April 1963.

(4470) CHARACTERISTICS OF TURBULENT WALL JETS.

(b) Laboratory project.

(c) Prof. W. D. Baines, University of Toronto, Toronto 5, Canada.

(d) Experimental; applied research for master's thesis.

(e) The flow in a two-dimensional wall jet is being studied to determine the conditions under which flow similarity is maintained at successive stations.

(g) A jet impinging on a wall at inclination up to 15 degrees from tangency has been found to have similar characteristics to the simple jet. Only the position of the virtual origin changes. A jet moving along a porous wall has markedly different characteristics.

(h) "The Two-Dimensional Turbulent Wall Jet on an Inclined Plane," by K. McIlroy, M.A.Sc. thesis, University of Toronto, October 1962.

(4471) WIND-INDUCED CURRENTS IN SHALLOW WATER.

(b) Laboratory project.

(c) Prof. W. D. Baines, University of Toronto, Toronto 5, Canada.

(d) Experimental; applied research for master's thesis.

(e) The mean flow and turbulent field induced by an air flow over a shallow tank of water have been measured. Three cases have been studied: constant depth, shoaling depth, and contracted width.

(g) The mean and turbulent velocities are proportional to the shear velocity imposed by the air flow.

(h) "Wind Induced Water Currents," by D. J. Knapp, M.A.Sc. thesis, University of Toronto, May 1962.

(4472) SURGES IN AIR VENTS.

(b) Laboratory project.

(c) Prof. L. E. Jones, University of Toronto, Toronto 5, Canada.

(d) Experimental; applied research for M.S. thesis.
(e) Investigation of mixed regime conditions due to sudden discharge changes in a horizontal conduit equipped with air vent and surge tank.
(g) Experimental, photographic and computer data have been assembled in the mixed-regime analysis for head-gate closure and for conduit refilling. Significant data have been established on the surge front profile and the phenomenon of air-entrapment.
(h) "Transient Hydraulic Phenomena in a Horizontal Conduit -- Air Vent -- Surge Tank Supply System," by R. Abel, M.A.Sc. thesis, University of Toronto, September 1962.

(4473) OUTLET STRUCTURE OF PROPOSED WILDWOOD DAM NEAR ST. MARYS, ONTARIO.

(b) M. M. Dillon and Co., London, Ontario, for Upper Thames River Conservation Authority.
(c) Prof. H. J. Leutheusser, University of Toronto, Toronto 5, Canada.
(d) Experimental; applied research for design.
(e) Model investigation of optimum discharge capacity and energy dissipation. Evaluation of scouring tendencies at toe of dam.
(f) Completed.

(4887) WOODBRIDGE CHANNEL IMPROVEMENTS.

(b) J. F. MacLaren Associates, Toronto, Ontario, for Metropolitan Toronto and Region Conservation Authority.
(c) Prof. H. J. Leutheusser, University of Toronto, Toronto 5, Canada..
(d) Experimental, applied research for design.
(e) Model investigation of two drop structures.
(f) Completed.

(4888) HYDRAULIC TRANSIENTS IN AN AIR VENT - SURGE TANK ASSEMBLY.

(b) Laboratory project.
(c) Prof. H. J. Leutheusser, University of Toronto, Toronto 5, Canada.
(d) Experimental, basic research for master's thesis.
(e) Using an existing small-scale replica of a schematic penstock-inlet, air entrainment and pressure conditions due to various modes of gate and valve closure are being investigated.

(4889) UNSTEADY LAMINAR FLOW IN SHORT, CLOSED CONDUITS.

(b) Laboratory project.
(c) Prof. H. J. Leutheusser, University of Toronto, Toronto 5, Canada.
(d) Experimental and analytical, basic research for master's thesis.
(e) Various cases of unsteady (oscillating) laminar flow as encountered in typical viscous damping devices are being investigated.

(4890) CHARACTERISTICS OF FLOW OF FLUID-SEDIMENT MIXTURES.

(b) Laboratory project.
(c) Prof. H. J. Leutheusser, University of Toronto, Toronto 5, Canada.
(d) Experimental, basic research.
(e) Evaluation of mean flow parameters such as friction coefficients, static pressures, velocities and wall shear stresses in closed conduits.

U.S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
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The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

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Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage. Absolute Electrical Measurements.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Volume.

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Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

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Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING LABORATORY

Cryogenic Processes. Cryogenic Properties of Solids. Cryogenic Technical Services. Properties of Cryogenic Fluids.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Tropospheric and Space Telecommunications. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Spectrum Utilization Research. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Frequency Utilization. Modulation Research. Antenna Research. Radiodetermination.

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Radio Standards Engineering. High Frequency Electrical Standards. High Frequency Calibration Services. High Frequency Impedance Standards. Microwave Calibration Services. Microwave Circuit Standards. Low Frequency Calibration Services.

Joint Institute for Laboratory Astrophysics-NBS Group (Univ. of Colo.).

Hydraulic Research in the United States

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