Reference No. VI-6/INH-655-C

U. S. DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
Lyman J. Briggs, Director.

CURRENT HYDRAULIC LABORATORY RESEARCH IN THE UNITED STATES.

REPORT NO. I-3
October 1, 1933.

WASHINGTON.

A D D E N D A

TO

HYDRAULIC LABORATORIES
IN THE UNITED STATES
July 1, 1933.

<u>THE UNIVERSITY OF KANSAS, Department of Applied Mechanics, Lawrence, Kansas.</u>

1. Hydraulics Laboratory, University of Kansas.
2. Established 1923.
3. Especially fitted for instruction of engineering students.
4. Head and quantity of water available for tests:
   (a) Gravity -
   (b) Pumping, 5000 g.p.m. (11.1 c.f.s.), 40 ft. head.
   150 g.p.m.(0.33 c.f.s.), 150 ft. head.
5. Principal equipment:
   (a) Weir channel, 4 ft. wide, 4 ft. deep, 50 ft. long;
   (b) Two tanks, 350 cu. ft. capacity for measuring discharge, as well as a number of smaller tanks for the same purpose;
   (c) One Worthington 12" x 12" Centrifugal pump, single stage double suction direct connected to induction motor; One Dayton-Dowd 8" x 8" single stage double suction centrifugal pump, directly connected to induction motor;
   (d) Two Builders Iron Foundry Venturi meters, 1 1/2" x 3" and 3" x 6"; one Simplex Venturi meter, 6 1/2" x 10";
   (e) One 6-inch Trump reaction turbine; one laboratory model Pelton wheel, 12-inch;
   (f) Hook-gages, manometers, and other small equipment.
6. Unusual equipment, none.
7. Possibilities for work by outside persons or companies and charge therefor: each case handled separately.
8. Two miles from railroad station.
9. Head of laboratory: J.O.Jones, Professor of Hydraulics.
10. Number on regular staff, one.
11. Description: First floor 50 ft. by 50 ft., contains all machinery and measuring tanks; second floor (mezzanine) 20 ft. by 60 ft. contains the weir channel. Out of doors is a 30 ft. by 30 ft. by 6 ft. deep sump from which water is pumped and to which the water returns when emptied from the measuring tanks or waste channels.
12. Only one set of experiments has been completed. This was a measurement of loss of head in small rubber lined hose. The experimental work and computations have been completed but not published. There is under way a set of experiments to determine the effect upon the coefficient of discharge and upon the loss of head in a Venturi meter due to changing the angle of divergence of the downstream end of the meter.

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AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS, College Station, Texas.

1. Hydraulic Laboratory, Civil Engineering Department, Texas Agricultural and Mechanical College.
2. Established 1910.
3. Laboratory fitted for general instruction and tests of small weirs, orifices, nozzles, Venturi meter, Pitometer, water meters, pressure gages, pipe friction, small Pelton water wheel, hydraulic ram, centrifugal pumps, stream flow with electric current meters, rainfall and run-off relations, etc.
4. Head and quantity of water available for tests:
   (a) Gravity: Brazos River and nearby tributaries. No head available. Discharge variable from a small dry weather flow to several thousand cubic feet per second during highwater periods. Outside work available at all seasons of the year.
   (b) Pumping: 250 g.p.m. (0.55 c.f.s.) 100 ft. head.
   (c) City mains: 140 ft. head.
5. Principal equipment:
   (a) Weir flume 3 ft. wide by 2.5. ft. deep with weirs and hook gages for accurate measurement of water.
   (b) Circular weighing tank 6 ft. diameter by 2.5 ft. deep provided with hook gages and mounted on platform scales.
   (c) Rectangular concrete pump pit 9 x 12 ft.
   (d) 1½-inch single stage centrifugal pump.
   1½-inch two stage centrifugal pump.
   2-inch single stage centrifugal pump.
   (e) 25 h.p. electric motor with wattmeter to run pumps.
   (f) 18-inch Pelton water wheel.
   (g) System of pipe layout with 2-inch Venturi meter, Collins flow meter and Pitometer. Pressure regulating tank.
   (h) Numerous water meters varying in sizes of 2-inches and under with scales and tanks for calibration.
   (i) Small orifice tank and two inch nozzles.
   (j) Two electric current meters and one acoustic meter.
   (k) Standard rain gages and water stage recorders.
6. Unusual equipment: None.
7. Possibilities for work for or by outside persons or companies: Very little work has been done for or by outside persons, and consequently there are no definite arrangements. Cooperative investigations may be carried on by special arrangement.
8. Approximately ¼ mile from railroad station or siding.
9. Head of laboratory: J. J. Richey, Professor of Civil Engineering, is head of the Department of Civil Engineering. T. A. Munson, Professor of Hydraulic Engineering is in direct charge of the hydraulic laboratory.
10. Different members of the civil engineering department give instruction in the hydraulics course.
11. Brief general description: The indoors laboratory is located in a basement room of the civil engineering building with a floor space of 1200 sq. ft. Outside work is conducted on streams and watershed areas near the College.
12. Research: Preliminary data gathered with brief results relating to rainfall, run-off and stream flow for a stream draining about 900 sq. mi.

ADDENDA (Page 3.)

NEWPORT NEWS SHIPBUILDING AND DRY DOCK COMPANY, Newport News, Virginia.

1. Newport News Hydraulic Laboratory.
2. Established 1923 - Built new laboratory 1933.
3. Especially fitted for testing hydraulic turbines, centrifugal and propeller type pumps, horizontal or vertical models. Vertical turbine models may be tested complete with intake and penstock. Facilities for cavitation studies on turbine and pump models. Towing apparatus for obtaining resistance of ship models or other structures.
4. Head and quantity of water available for tests.
   - (a) Gravity - none.
   - (b) Pumping - 7,500 g.p.m. (16.5 c.f.s.) at 50 ft. head.
     18,000 g.p.m. (40 c.f.s.) at 30 ft. head.
     1,000 g.p.m. (2.5 c.f.s.) at 4 ft. head.
5. Principal equipment:
   - (a) 5 ton traveling crane.
   - (b) 200 H.P. motor generator set.
   - (c) 65 H.P. Vertical electrical dynamometer - 3000 R.P.M.
   - (d) 65 H.P. Horizontal electric dynamometer - 3000 R.P.M.
   - (e) 2500 ft. lb. Woodward type H.R. governor.
   - (f) 18" Alden dynamometer.
   - (g) 7500 g.p.m. at 50 ft. head circulating pump.
   - (h) 18000 g.p.m. at 30 ft. head circulating pump.
   - (i) Head and tail race tanks - 12 ft. diameter.
   - (j) Head race 6 ft. wide, 7 ft. deep by 20 ft. long.
   - (k) Tail race 6 ft. wide, 8 ft. deep by 22ft. long.
   - (l) Two 6 ft. suppressed weirs.
   - (m) 6" x 4" venturi-meter, capacity 3.4 c.f.s.
   - (n) 10" x 6-1/2" Venturi-meter, capacity 9.0 c.f.s.
   - (o) 16" x 9-1/4" venturi-meter, capacity 17.5 c.f.s.
   - (p) Test bed for pumps up to 24" discharge diameter.
   - (q) 24" penstock leading to vertical flume.
   - (r) Air compressor.
   - (s) Small flume for testing draft tube and other models under 4 ft. head with pump capacity of 1000 g.p.m.
   - (t) 18" needle valve.
   - (u) 12" rotary valve.
   - (v) Miscellaneous turbine and pump casings.
   - (w) 14" turbine pressure regulator.
6. Very unusual equipment and facilities:
   - (a) Ashdown Rotoscope for observing turbine and pump models while in operation through glass windows.
   - (b) Special apparatus for studying cavitation of turbine models under heads up to 50 ft. and static suction heads up to 20 ft.
   - (c) Regulation tests with governor.
   - (d) Photo-electric apparatus.
   - (e) Equipped to test combination turbine and pump models by reversing the rotation and flow.
7. Work done for outside firms or persons by arrangement.

8. Ample facilities for handling equipment from railroad up to five tons per piece. Two miles from railroad siding.
9. Head of Laboratory: Address the company at Newport News, Va.
10. Number of persons on regular staff: Four.
11. General description of laboratory: The building is 60'-0" by 36'-6" inside, three stories high including basement. The main flume, of welded steel plate construction, occupies one side of the building, the head race being immediately above the tail race, and each provided with a 6 ft. suppressed weir.
    - The general sump occupies one third of the basement. The main circulating pumps and horizontal pump models are installed in the basement, taking suction from a 36" suction header. By opening a cross connecting valve both pumps may be used to discharge up to 40 c.f.s. into the main flume head race or direct to the model through a 24" diameter penstock.
    - Any vertical model may be tested either as a turbine or pump in open or closed flume. Any horizontal model may be tested as a turbine or pump in closed flume.
    - The turbine cavitation apparatus is located on the second floor approximately 25 ft. above the sump to which it connects by a tail pipe equipped with butterfly valve to regulate the suction head.
12. Research and other work completed:
    (a) Development of reaction turbine models for heads from 8 to 1000 ft.
    (b) Development of best proportions for elbow and concentric type draft tubes.
    (c) Development of centrifugal and propeller type pumps.
    (d) Development of adjustable vane type propeller runners in which vanes are moved by the natural flow of water through the model. Determination of forces and moments acting on vanes.
    (e) Studies on 14" pressure regulator model to determine discharge coefficients, unbalanced forces, etc.
    (f) Development of water ejectors.
    (g) Development of best shape for centrifugal pump casings.
    (i) Determination of hydraulic thrust for hydraulic turbines.

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THE UNIVERSITY OF ROCHESTER, Rochester, N. Y.

1. The Hydraulic Laboratory of the Department of Mechanical Engineering.
2. Established 1914.
3. Laboratory especially designed to give instruction to undergraduates in the fundamental principles of hydraulics.
4. Head and quantity of water available for tests.
    (a) Gravity: 360 g.p.m. (0.8 c.f.s.) at 25 ft. head through 4" pipe connected to city mains.
    (b) Pumping: 100 g.p.m. (0.22 c.f.s.) at 250 ft. head.
    700 g.p.m. (1.55 c.f.s.) at 50 ft. head.
    220 g.p.m. (0.5 c.f.s.) at 25 ft. head.
5. Principal Equipment:
    (a) Set up to run simultaneous experiments on nozzles, weirs and orifices. Equipment consists of 4 standard 1/2" nozzles-conical, cap, short tube and diverging; one contracted weir .728 ft. long; 3 sharp edged orifices

1.008" diam., 1.502" diam. and 2.124" diam., max. discharge head 1.35 ft., weighing tank holding 1875 lbs. water (30 cu. ft.)

(b) 2" Venturi Meter.
(c) 90 degree triangular weir, max. head .5 ft.
(d) 4" Venturi meter.
(e) Rectangular contracted weir 1" long, max. head .3 ft.
(f) 12" Pelton Wheel with prony brake and magneto tachometer.
(g) 4" Francis Turbine with prony brake and magneto tachometer.
(h) Cochrane Flow meter with 2" and 4" orifices. Electrical clock driving chart one complete revolution in three hours.
(i) 3" Three Stage AC motor driven centrifugal pump delivering 100 gpm at 250 ft. head.
6" Single stage, double suction AC motor driven centrifugal pump delivering 700 gpm at 50 ft. head.
3" Single stage, DC variable speed motor driven centrifugal pump for test and supply delivering 220 gpm at 25 ft. head.
(j) Pipe friction test set, consisting of 15 ft. each of 1/2", 3/4" and 1" pipe with special gage connections for pressure measurement.
(k) Hydraulic Ram 1 1/4" inlet, 3/4" outlet, variable lifts for ram tests and water hammer experiments.
(l) Two concrete sumps in floor of 60 cu. ft. and 300 cu. ft. capacity respectively.

6. The Department of Engineering has at its disposal, if and when funds are available and the demand arises, an unused building of the Rochester Gas and Electric Corp. which was formerly a hydro-electric plant. Practically the entire flow of the Genesee River is available for large scale test purposes. Tests on model dams were at one time conducted in this building by the Rochester Gas and Electric Corp.
7. Possibilities for work, for or by outside persons or companies: A limited amount of such work may be carried on under terms to be agreed upon.
8. About 700 ft. from railroad siding on the Campus.
9. Head of laboratory: Prof. J. W. Gavett, Jr., Head of Department of Engineering.
10. One person teaching Hydraulics and Hydraulics Laboratory, although three others of the department staff are competent to do work in this laboratory.
11. Brief description of laboratory: The laboratory occupies three 20 ft. bays in the main shop building which is 240 ft. long and 60 ft. wide. The equipment is of such size and capacity as to be economical to operate and yet to give the student thorough training in the fundamental principles governing the flow of water. Practically all of the tests are run recirculating, water being drawn by centrifugal pumps from sumps in the laboratory and returned there after being weighed.
12. Research of unusual importance: None as yet.

REPORT ON CURRENT HYDRAULIC LABORATORY RESEARCH IN THE UNITED STATES.

Compiled by the Bureau of Standards
U. S. Department of Commerce
Washington, D. C.

Vol. I, No. 3. October 1, 1933.

International exchange of information on hydraulic research.

In its preliminary report to the International Executive Council of the World Power Conference in 1932, the Swedish National Committee had proposed the creation of "a provisional Commission, having as their object the organization of the exchange of experiences as well as collaboration in other ways, between the hydraulic laboratories"; it also proposed that "after preliminary correspondence those interested should be invited to a meeting in Stockholm at the time of the 1933 Sectional Meeting with the object of drawing up proposals for the collaboration suggested, and of nominating a permanent Commission under the auspices of the World Power Conference."

In conformity with these proposals, the Swedish National Committee, following the Council meeting, appointed a sub-committee consisting of Professor Wolmar Fellenius, Chairman, Major Mauritz Serrander and Mr. Ely Velander. This sub-committee, through its chairman, entered into correspondence with certain individuals engaged in hydraulic engineering research for the purpose of developing a plan for subsequent submission through the Swedish National Committee to the World Power Conference. As the immediate result of the correspondence, a meeting was called in Berlin in January which was attended by Professor C. Camichel, University of Toulouse; Professor Th. Rehbock of the Technische Hochschule, Karlsruhe; Professor Fr. Schaffernak of the Technische Hochschule, Vienna; Professor R. Seifert, Director of the Research Institute for Hydraulic Structures and Shipbuilding, Berlin; Professor G. de Thierry, Berlin, Oberingenieur J. Th. Thijsse, Director of the Research Institute for Hydraulic Structures, Delft; Professor Wolmar Fellenius, of the Technische Hochschule, Stockholm, and Mr. Erik Lindquist representing the Swedish National Committee.

Although the function of the Sub-committee was to prepare a report for submission by the Swedish National Committee to the International Executive Council for its approval, modification, or rejection, the Berlin meeting constituted itself a "Provisional Commission" and designated as additional members the following individuals not at the meeting: J. Blockman, Ingenieur principal des Ponts et Chaussées, Antwerp; H. N. Eaton, Acting Chief, National Hydraulic Laboratory, Washington; A. Genthial, Secrétaire Général de la Commission Internationale des Grands Barrages, Paris; Professor A. H. Gibson, Victoria University, Manchester; Professor E. Meyer-Peter, Eidgenössische Technische Hochschule, Zurich; and Professor A. Smrcek, Bohmische Technische Hochschule, Brünn.

After two days of discussion, the "Provisional Commission" adopted a "Proposal for the Organization of an International Commission on Hydraulic Research", and decided to call a meeting of the Commission (later fixed as June 29) in Stockholm at the time of the Sectional Meeting. This proposal of the "Provisional Commission", without change of any consequence, was subsequently submitted by the Swedish National Committee as its final report to the International Executive Council.

The proposal was as follows:

"The International Commission for Hydraulic Research is composed of Corresponding Members, who, in each Member-Country of the World Power Conference and the Permanent International Association of Navigation Congresses, shall be nominated by:-

1. The Individual National Committees of the World Power Conference.
2. The National Delegates of the Permanent International Association of Navigation Congresses.

The Governing Body of the Commission is composed of Delegates nominated in equal numbers by:-

1. The International Executive Council of the World Power Conference.
2. The Permanent International Association of Navigation Congresses.

The National Committees of the World Power Conference and the National Delegates of the Permanent International Association of Navigation Congresses shall be entitled to nominate an unlimited number of Corresponding Members of the Commission, active in their respective countries in Hydraulic Research. The Corresponding Members shall be nominated for five years. They may also propose one or two candidates for membership of the Governing Body. Of course, in both cases candidates may be proposed jointly by the National Bodies of both international organizations.

From the number of candidates proposed in this way by the separate countries, the International Executive Council of the World Power Conference and the Permanent International Association of Navigation Congresses shall each nominate seven members of the Governing Body of the International Commission for Hydraulic Research.

The Governing Body so appointed shall elect:-

1. A Chairman of the Commission.
2. An Executive Committee of three, one of whom must be the Chairman of the Commission.

The Commission will adopt its own Constitution, subject to the approval of the International Executive Council of the World Power Conference and of the Permanent International Association of Navigation Congresses. It shall, however, be able to give consideration to means for improving its own organization.

The duties of the Executive Committee shall include:-

1. Keeping in touch with institutions and individuals engaged in Hydraulic Research in the separate countries, chiefly through the medium of the Corresponding Members nominated for the countries in question.
2. Drawing up a list of interested institutions and individuals throughout the world.

3. Publication of periodical papers or pamphlets on the work and achievements of the Hydraulic Laboratories.
4. Arrangement of Meetings of the Commission (including the Corresponding Members), as a rule in conjunction with the Meetings of the World Power Conference or of the Permanent International Association of Navigation Congresses.
5. Proposing questions relating to Hydraulic Research to be dealt with at Meetings of the World Power Conference and of the Permanent International Association of Navigation Congresses.
6. Financing the work by:-
   (a) The collection of donations and annual subscriptions from interested organizations and individuals.
   (b) Obtaining contributions from interested International Organizations; in the first instance, the World Power Conference and the Permanent International Association of Navigation Congresses.
   (c) The sale of publications.

Pending the election of the Governing Body of the International Commission for Hydraulic Research, the Provisional Committee shall deal with the proposals here submitted, and convene a Meeting in Stockholm at the time of the Sectional Meeting of the World Power Conference, 1933.

After the election of the Governing Body the first Meeting of the Members will be called by the Chairman of the Provisional Committee."

The report of the Swedish National Committee came before the International Executive Council at its first meeting in Stockholm on June 28. Objections were made that the elaborate machinery proposed was unnecessary for the purpose of exchange of information; that the creation of a new international organization, unless the need therefor could be much more clearly shown, was distinctly undesirable; that the alliance of the new organization with two independent international organizations would be undesirable, since it would leave both of the latter without effective authority or responsibility; and that the World Power Conference should not, either alone or in association with the Navigation Congress, assume financial sponsorship for the proposed organization. The views of the Council were explained at the meeting of the "Provisional Commission" on June 29. The latter voted, however, to make no change in its recommendations. The Council, accordingly, rejected the proposals in the forms submitted, but agreed for the time being to assist through its National Committees in establishing an interchange of data between hydraulic laboratories in different countries and to permit, if desired, the use of its Central Office as a clearing house for such purpose.

The Provisional Commission discussed at a later meeting this action of the Council, without taking any definite action. An attempt may be made to obtain from other sources the funds necessary to carry on the work of the Commission. At present, however, no arrangements for collecting and distributing information as to current hydraulic research, or the results of such research, in Europe have been made.

A.S.M.E. Committee on Hydraulic Research.

In the first quarterly report, a brief statement was made as to other attempts which had been made to exchange information on hydraulic research prior to the establishment of the present service. At that time, the fact was overlooked that the Hydraulic Division of the American Society of Mechanical Engineers several years ago had organized a Committee on Survey of Hydraulic Research under the chairmanship of Professor Charles M. Allen. This committee rendered a report (Transactions A.S.M.E., Vol. 52, No. 14, HYD-52-6, 1930) in which it suggested hydraulic problems on which research was needed, listed references to hydraulic research in Europe, reported on research in the United States by water-power companies, by consulting engineers and by hydraulic laboratories, and made recommendations. According to recent information received from the American Society of Mechanical Engineers, this committee no longer exists.

Report of Committee on Dynamics of Streams.

For the benefit of those investigators who are interested in the study of streams, reference is made to the report of the Committee on Dynamics of Streams of the Section of Hydrology, American Geophysical Union. (Trans. American Geophysical Union, National Research Council, Washington, D. C., 1933, pp. 379-388 inclusive). This report lists for the entire world:

(a) hydraulic laboratories having facilities for research in open-channel flow and river hydraulics,
(b) organizations whose work is related to that of the Committee on Dynamics of Streams, and
(c) investigators on the dynamics of streams.

Other investigators may be interested in the list of organizations in the United States which are studying problems of ground-water hydrology which is included in the report of the Committee on Underground Water of the Section of Hydrology. This is given on pp. 371-373 of the Transactions noted above.

Bibliography.

Attention is called to the "Bibliography on the Subject of Transportation of Solids by Flowing Water in Open Channels" by the Bureau of Reclamation of the U. S. Department of the Interior, Denver, Colorado, March, 1933. (Price $1.25 for Part I and Part II, mimeographed). Part I (108 pp.) lists over 1000 titles alphabetically under authors. Part II (8 pp.) is a subject index.

Translations.

A correspondent who is interested in a translation of Boussinesq's "Eaux Courantes" has inquired whether this work has ever been translated into English, and, if not, whether there are any persons who would be willing to undertake jointly such a project. He suggests also the desirability of avoiding duplication of effort in the translation of scientific literature. As this suggestion has been brought up a number of times, a new section is added to this report which will be continued in the future if the results appear to be of sufficient value. This section on "Translations" will include "(a) Translations in Progress", and"(b) Translations Completed". Under (b) will be given, in general, only recent translations or those difficult of access. Correspondents are requested to send in reports suitable for inclusion under these headings. For completed translations, a full reference to publication is desired, and if not published, a notation as to conditions under which the translation may be borrowed.

Frequency of Research Reports.

Several correspondents have suggested that these research reports need only be issued semi-annually. Experience in preparing three quarterly reports indicates that the normal changes in listings in the course of three months are not sufficient to justify the expense of such frequent service. The heads of several university laboratories have proposed that semi-annual reports be issued in April and October. Your opinions as to frequency and dates of publication will be appreciated. A form on which to register your choice is inclosed for your convenience. At the same time, any suggestion for improving the manner of reporting projects will be welcomed.

CALIFORNIA INSTITUTE OF TECHNOLOGY.

(100) (a) MODEL INVESTIGATIONS OF SILTING PROBLEMS AT SEAL BEACH.

(d) Dr. Robert T. Knapp and V. A. Vanoni with Major Charles T. Leeds as consultant.

(e) Professor R. L. Daugherty.

(f) To determine the probable effect of a change in the channel of the San Gabriel River, which now discharges into Alamitos Bay some distance from the point where the bay is connected with the ocean. This causes the bay to silt up. The Flood Control engineers propose to cut a new river channel so that it will discharge into the channel connecting the bay with the ocean. But the Seal Beach steam plant of the Los Angeles Gas & Electric Corporation is located along this channel and draws condensing water from it. It is feared that the change will cause this channel to silt up and thus interfere with the supply of condensing water.

See Report I-2 for (b), (c), (g), (h) and (i).

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(101) (a) THE CHARACTERISTICS OF A CENTRIFUGAL PUMP WHEN OPERATED UNDER ABNORMAL CONDITIONS.

(d) Dr. R. T. Knapp and B. C. Haynes, and others as assistants.

(e) Professor R. L. Daugherty.

(f) To investigate characteristics when a centrifugal runs in both directions, with water being pumped and also with water flowing down backwards through the pump. This study is of interest for cases where the power suddenly fails for a centrifugal pump with a high lift and a long discharge line in which the flow will reverse. See Report I-2 for (b), (c), (g) and (h).

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(102) (a) INVESTIGATION OF VELOCITY DISTRIBUTION IN THE VOLUTE OF A CENTRIFUGAL PUMP IN THE NEIGHBORHOOD OF THE IMPELLER.

(d) R. C. Binder.

(e) Professor R. L. Daugherty.

(f) By a special instrument the magnitude and direction of the velocity of the water is measured at a number of points within the volute, thus supplying experimental information that has long been desired.

See Report I-2 for (b), (c), (g) and (h).

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(103) (a) EFFECT ON EFFICIENCY OF A CENTRIFUGAL PUMP THROUGH REDUCING ITS CAPACITY BY BLOCKING OFF CERTAIN OF THE IMPELLER PASSAGES.

(d) Keith Murdock.

(e) Professor R. L. Daugherty.

(f) Purpose is indicated by the title, except that there is a practical application when the overall efficiency may be better if a reduced discharge is desired by blocking off passages rather than by throttling the discharge.

See Report I-2 for (b), (c), (g) and (h).

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(104) (a) FURTHER MODIFICATION OF THE THEORY OF CENTRIFUGAL PUMP DESIGN.
(d) George F. Wislicenus.
(e) Professor R. L. Daugherty.
(f) To place the method of design on a sounder basis.
See Report I-2 for (b), (c), (g) and (h).

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(105) (a) INVESTIGATION OF TRANSPORTING VELOCITIES OF SAND FOR USE IN MODELS.
(d) W. F. Prudon and J. Sheffet.
(e) Professor R. L. Daugherty.
See Report I-2 for (b), (c), (g) and (h).

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UNIVERSITY OF CALIFORNIA.

(12) (a) JET PUMPS.
(c) Laboratory project.
(d) Ledgett and Folsom.
(e) Professor M. P. O'Brien.
(f) Continuation of project on water jet pumps, by O'Brien and Gosline reported at Pacific Coast Applied Mechanics meeting of the A.S.M.E., January 20-21, 1933.
(g) Studies are being made on an air jet pumping air. The mixing process is receiving particular study in a special model.

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(13) (a) AIR-LIFT AND GAS-LIFT.
(c) Laboratory project.
(d) O'Brien and Gosline.
(e) Professor M. P. O'Brien.
(f) Velocity of rise of bubbles as a function of viscosity and surface tension; theoretical and experimental investigation of lifts for water and oil.
(h) Investigation completed and reported on in Doctor's thesis by Gosline.
(i) Thesis may be borrowed from laboratory director. See "Abstracts and references".

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(14) (a) STREAMLINE AND TURBULENT FLOW THROUGH GRANULAR MATERIALS.
(c) Laboratory project.
(d) Given and Hickox.
(e) Professor M. P. O'Brien.
(f) Determination of laws of flow through soils, sands and gravels.
(h) Preliminary study of (1) flow through lead shot and (2) effect of size of container, has been completed by Given.
(i) Report may be borrowed from laboratory director.

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(16) (a) EFFECT ON EVAPORATION FROM STANDARD PANS DUE TO CHARACTER OF SURFACE OF PAN.
(c) Laboratory project.
(d) Hickox.
(e) Professor M. P. O'Brien.

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(17) (a) TRANSPORTATION OF BED LOAD BY STREAMS.
(c) Laboratory project.
(d) Rindlaub.
(e) Professor M.P.O'Brien.
(f) Continuation of work begun by Cothran, Rindlaub, Wilson, Kurilow.
(h) Preliminary report on method of obtaining and representing data completed in May, 1933.
(i) Report may be borrowed from laboratory director. See "Abstracts and References."

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(20) (a) VORTEX MOTION ON THE SURFACE OF FLUIDS.
(d) Carter.
(e) Professor M. P. O'Brien.
(h) To be completed in May, 1933. See "Abstracts and References".
See Report I-1 for (c) and (i).

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(21) (a) CAPILLARY POTENTIAL AND CAPILLARY FLOW IN SOILS.
(d) Colby.
(e) Professor M. P. O'Brien.
(h) See "Abstracts and References".
See Report I-1 for (c) and (i)

....

(23) (a) STIRRING CHEMICALS FOR WATER TREATMENT BY DISC FRICTION.
(d) Gayner.
(e) Professor M. P. O'Brien.
(h) To be completed in May, 1933. See "Abstracts and References".
See Report I-1 for (c) and (i)

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(172)(a) HYDRAULIC JUMP.
(c) Laboratory project.
(d) Hickox and Rose,
(e) Professor M. P. O'Brien.
(f) Experiments on circular and trapezoidal channels, rectangular channels with flaring sides or with sloping bottoms.

....

(173)(a) RATING A MODIFIED PARSHALL FLUME.
(c) Undergraduate thesis.
(d) Gilden and Taylor.
(e) Professor M. P. O'Brien.
(f) Determination of rating of modified Parshall flume for use where standard flume fills with sediment. In cooperation with U. S. Forest Service.
(h) To be completed in May, 1934.

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(174) (a) AERATION OF SHARP-CRESTED WEIRS.
(c) Graduate thesis.
(d) Johnson.
(e) Professor M. P. O'Brien.
(f) Determine supply of air necessary to insure complete aeration of nappe. Effect of incomplete aeration on discharge.
(h) To be completed in May, 1934.

....

(175) (a) COMPARISON OF MODELS AND PROTOTYPES.
(c) Laboratory project.
(d) Jameson.
(e) Professor M. P. O'Brien.
(f) To determine the limits of correspondence of model and prototype.
(g) Tests are being made on models of dams, tunnels and river bends. The model scale is being reduced until the model fails to correspond to the prototype.

....

HARVARD UNIVERSITY.

(106) (a) A STUDY OF THE FLOW OF WATER THROUGH SAND.
(d) Gordon M. Fair and Loranus P. Hatch, Associate Professor of Sanitary Engineering and Research Fellow in Sanitary Engineering, respectively.
(e) Professor Gordon M. Fair.
(f) To determine the filtration and expansion characteristics of sands used in purification and, if possible, to aid in the study of the flow of water through the soil.
See Report I-2 for (b), (c), (g) and (h).

....

HYDROLOGICAL LABORATORY, U. S. GEOLOGICAL SURVEY, WATER RESOURCES BRANCH, DEPARTMENT OF THE INTERIOR.

(26) (a) PERMEABILITY TESTS CONDUCTED UNDER VERY LOW HYDRAULIC GRADIENTS.
(d) O. E. Meinzer, V. C. Fishel.
(e) O. E. Meinzer.
(f) The purpose of this experiment is to find out if there is a flow of liquids through porous materials with hydraulic gradients as low as one foot per mile or less, and if there is a flow at such low gradients, to ascertain if it follows Darcy's law which states that the flow of ground water through a given material varies directly as the hydraulic gradient.
(h) The results of the tests with the former apparatus are given in U. S. Geological Survey Water-Supply Paper 596 by N. D. Stearns. The new apparatus has just recently been started and no satisfactory results can yet be given out.
See Report I-1 for (b), (c), (g).

....

(27) (a) THIEM'S METHOD FOR DETERMINING PERMEABILITY OF WATER-BEARING MATERIALS.
(d) Under the supervision of L. K. Wenzel.
(e) L. K. Wenzel, U. S. Geological Survey, Washington, D. C.
(f) Pumping tests were conducted near Grand Island, Nebraska, during the summer of 1931, to attempt to determine the practicability of Thiem's method for determining permeability of water-bearing materials as a part of a cooperative investigation of the ground-water resources of the Platt Valley, Nebraska.
See Report I-1 for (b), (c) and part of (f).

....

IOWA INSTITUTE OF HYDRAULIC RESEARCH.

(107) (a) HYDRAULIC TEST ON MODEL OF MISSISSIPPI RIVER BELOW KEOKUK DAM.
(b) U. S. Engineer Department, Rock Island District.
(c) Institute project.
(d) U. S. Engineer Department Staff.
(e) Martin E. Nelson, Associate Engineer.
(f) To determine remedy for diagonal currents below lock and effect of wing dams and old cofferdam on tail water of Keokuk plant.
(g) Investigation on model of river built to scale of 125 to 1.
(h) Progress report on first part completed, model recently extended to investigate second part of investigation.
(i) Will be completed Sept. 1, 1933.

....

(108) (a) HYDRAULIC INVESTIGATION OF GENERAL MODEL OF LOCK AND DAM NO. 4, MISSISSIPPI RIVER AT ALMA, WISCONSIN.
(b) U. S. Engineer Department, St. Paul District.
(c) Institute project.
(d) U. S. Engineer Department Staff.
(e) Martin E. Nelson, Associate Engineer.
(f) To determine discharge and navigation conditions.
(g) Investigation on model of river to horizontal scale of 300 to 1 and vertical scale of 100 to 1.
(h) Cross sections ready for model construction.
(i) Will be completed in 1934.

....

(109) (a) HYDRAULIC STUDIES TO IMPROVE INTAKE AND OUTLET CONDUITS FOR STANDARD LOCKS.
(b) U. S. Engineer Department, Upper Mississippi Valley Division.
(c) Institute Project and Graduate Thesis.
(d) U. S. Engineer Department Staff.
(e) Martin E. Nelson, Associate Engineer.
(f) To determine better design for emptying and filling of locks.
(g) Investigation on lock model on scale of 15 to 1 with many adjustable and variable features under control.
(h) Model under observation for six months.
(i) Investigation will continue for several years.

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(110) (a) HYDRAULIC STUDY OF MODEL OF LOCK AND DAM NO. 26, MISSISSIPPI RIVER AT ALTON, ILLINOIS.
(b) U. S. Engineer Department, Mississippi Valley Division.
(c) Institute project.
(d) U. S. Engineer Department Staff.
(e) Martin E. Nelson, Associate Engineer.
(f) To determine current effects and conditions downstream from proposed dam below mouth of Illinois River.
(g) Investigation conducted on model with movable bed with horizontal scale of 250 to 1 and vertical scale of 60 to 1.
(h) Model now under observation.
(i) Observations will be completed October 1.

....

(112) (a) FLOW OF WATER AROUND BENDS IN OPEN AND CLOSED CHANNELS.
(b) Bureau of Agricultural Engineering, U. S. Department of Agriculture.
(c) Institute project.
(d) U. S. Department of Agriculture Staff.
(e) David L. Yarnell, Senior Engineer.
(f) To determine losses, changes in pressure, velocity and direction of current flowing around both open and closed bends of various curvatures and central angles.
(g) Investigation now being conducted with transparent pyralin pipe and bends 6 inch diameter standard curvature through angles of 45, 90, 180 and 270 degrees and bends of irregular sections.
(h) General study in progress since 1926; report completed on transparent conduits of square and rectangular section. Present set-up of 6-inch pyralin pipe under observation since March 1.

....

(113) (a) CALIBRATION OF SILT MEASURING APPARATUS.
(b) Bureau of Agricultural Engineering, U. S. Department of Agriculture.
(c) Institute project.
(d) U. S. Department of Agriculture Staff.
(e) David L. Yarnell, Senior Engineer.
(f) To calibrate various devices for use in measuring the quantity of silt removed by surface runoff from agricultural lands.
(g) Investigations have been made on several types of apparatus.
(h) Separate reports prepared on devices tested.

....

(114) (a) PILE TRESTLES AS CHANNEL OBSTRUCTIONS.
(b) Bureau of Agricultural Engineering, U. S. Department of Agriculture.
(c) Institute project.
(d) U.S.Department of Agriculture Staff.
(e) David L. Yarnell, Senior Engineer.
(f) To test head loss caused by pile trestles.
(g) Results of 1100 tests of full-size pile trestles and models of same.
(h) Report by Yarnell, Nagler and Woodward ready for publication.

....

(115) (a) BRIDGE PIERS AS CHANNEL OBSTRUCTIONS.
(b) Bureau of Agricultural Engineering, U. S. Department of Agriculture.
(c) Institute project.
(d) U. S. Department of Agriculture Staff.
(e) David L. Yarnell, Senior Engineer.
(f) To measure obstruction and erosion caused by bridge piers of various shapes.
(g) Results of 2600 tests on larger pier operating under more extensive range of conditions than has hitherto been attempted.
(h) Report being edited for publication.

....

(116) (a) RUN-OFF STUDIES OF RALSTON CREEK.
(b) U. S. Department of Agriculture and University of Iowa.
(c) Institute project.
(d) G. Marston and H. Evans.
(e) Professor Floyd A. Nagler.
(f) To determine factors affecting runoff from small midwestern watersheds.
(g) Intensive study of runoff factors on 3 square mile water-shed near Iowa City, from which runoff is continuously measured by weir, rainfall at 8 stations including recording gage, and ground water

(116) (g) (continued)
observed at 18 points. Other studies include soil moisture, crops, etc.
(h) In continuous progress since 1924.

....

(117) (a) TRANSPORTATION OF SEDIMENT BY FLOWING WATER.
(c) Graduate theses.
(d) Chitty Ho, Roland A. Kampmeier, Y.C.Tu.
(e) Professor S. M. Woodward.
(f) To determine the relation of sediment movement to bottom and mean velocity.
(g) Experiments in glass walled flume upon movement of sediments of various size, shape and weight. Also revision of Gilbert's studies.
(h) Progress reports completed, July 1, 1933.

....

(118) (a) RELATION OF TAIL RACE FLOOR TO BOTTOM OF DRAFT TUBES.
(c) Graduate Thesis.
(d) A. Luksch.
(e) Professor Floyd A. Nagler.
(f) To determine effect of location of tail race floor upon draft tube efficiency with and without spiral flow.
(g) Tests made on small model of vertical tube with movable flow plate, variable entrance vanes to induce helical flow of various angles. Photographic study of resulting stream lines by using transparent tube and tank with aluminum powder in circulation.
(h) Report completed July, 1933. Photographic studies being continued.

....

(119) (a) STUDY OF MIXTURES OF STREAM FILAMENTS OF VARYING VELOCITY.
(c) Graduate thesis.
(d) J. S. Meyers.
(e) Professor Floyd A. Nagler.
(f) To investigate phenomenon of pressure recovery and loss in the alternation of velocity distribution in conduits.
(g) Study is being conducted in rectangular transparent conduit 3 inches x 6 inches x 40 feet long, in which divided currents of any amount and cross section may be introduced and observed until thorough mixture has resulted.
(h) First progress report will be completed February, 1934.

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(120) (a) FLOW IN BENDS OF QUARTER TURN DRAFT TUBES.
(c) Graduate thesis.
(d) C. A. Mockmore.
(e) Professor Floyd A. Nagler.
(f) Study of flow phenomena with and without spiral discharge of types of 90-degree bends.
(g) Investigation being conducted in transparent pyralin bends of various shape, observing velocity distribution and losses.
(h) In progress since 1932; thesis report on bend of circular cross section available; present study will be completed in August, 1934.

....

(121) (a) CHARACTERISTICS OF SIDE CONTRACTION METER.
(c) Graduate thesis.
(d) R. G. Poston and H. Evans.
(e) Professor Floyd A. Nagler.
(f) Study of a Venturi meter formed by contracting only the sides of a circular pipe.
(g) Experiments upon pyralin meter in pipe 6 inches diameter and steel meter in pipe 4 feet in diameter determining constants, loss of head and throat pressure phenomena for various contraction ratios.
(h) Report on one 6 inch meter, 1 - 2 area contraction available. Investigation will be completed August, 1933.

....

(122) (a) LATERAL SPREADING OF CONCENTRATED SPILLWAY DISCHARGE.
(c) Graduate thesis.
(d) Fred S. Witzigman.
(e) Professor Floyd A. Nagler.
(f) Model study of type of sill which will effectively spread the flow of a narrow spillway over the entire width of the river.
(g) Experiments in small scale model designed sill that will accomplish lateral spreading of flow. Final tests on full scale spillway making velocity measurements of effectiveness of sill and apron.
(h) Report completed July 1, 1933.

....

(123) (a) DEVELOPMENT OF PITOT TUBE FOR USE IN MEASURING VELOCITY OF SEWAGE.
(c) Graduate thesis.
(d) Frank A. Kulas.
(e) Professor Floyd A. Nagler.
(f) To develop a Pitot tube that will successfully measure the velocity of water carrying a large quantity of foreign matter that would clog the ordinary Pitot tube.
(g) A Pitot tube is being developed using high velocity jet that gives promise of successful use in dirty water.
(h) Progress report completed August, 1933.

....

(124) (a) CALIBRATION OF PADDLE WHEEL METER FOR SURFACE VELOCITIES.
(b) Chicago Sanitary District.
(c) Institute project.
(d) Frank A. Kulas.
(e) Professor Floyd A. Nagler.
(f) To determine coefficients for paddle wheel type of current meter used by Chicago Sanitary District for measuring flow in large sewers.
(g) Paddle wheel meter floated in river canal and channels of various section and depth to determine discharge coefficients.
(h) Will be completed in 1934.

....

(125) (a) STUDY OF PULSATIONS OF PIEZOMETERS.
(c) Graduate thesis.
(d) O. J. Baldwin, G. Shafer.
(e) Professor Floyd A. Nagler.
(f) To determine causes, amplitude and period of pulsations in piezometer columns.

(125) (continued)
(g) Photographic records of pulsations in piezometers attached at different points in a conduit are being studied to determine cause, effect of length of rubber hose, glass column, and methods of damping.
(h) In progress.

....

(126) (a) CALIBRATION OF SUBMERGED TRIANGULAR WEIR.
(b) Graduate thesis.
(d) R. E. Johnson.
(e) Professor Floyd A. Nagler.
(f) To determine effect of submergence of flow through 90-degree triangular weir.
(h) Theoretical calculation of effect of submergence completed.

....

(127) (a) CURTIS BEND IN IOWA RIVER.
(b) Graduate thesis.
(d) R. L. Lancefield, F. L. Blue, J. K. Herbert.
(e) Professor Floyd A. Nagler.
(f) To determine hydraulic phenomena in sharp 110 degree river bend near Iowa City.
(g) Measurements are being made of cross-section, velocity and current direction at five cross-sections, above, below and at the bend.
(h) Progress report completed, July, 1933.

....

(159) (a) TAINTER GATE COEFFICIENTS.
(c) Graduate thesis.
(d) S. Guha, Ross Brudenell.
(e) Professor Floyd A. Nagler.
(f) To determine discharge coefficients for Tainter Gates of various radii and elevations of axes, upon various types of crests.
(g) Measurements being made on 1 to 14 scale model of 30 foot gate.
(h) Progress report in manuscript form. Experiments being conducted through greater variety of conditions.

....

(160) (a) HEAD LOSS IN CHECK VALVES.
(c) Institute project.
(d) J. W. Howe.
(e) Professor Floyd A. Nagler.
(f) To decrease head losses in standard design of check valve by prominent manufacturer.
(g) Investigation on valves 4 inches and 6 inches in diameter.
(h) Experimental work completed.
(i) Report available August 10, 1933.

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LOUISIANA STATE UNIVERSITY AND AGRICULTURAL AND MECHANICAL COLLEGE.

(28) (a) HYDROLOGICAL STUDY OF CITY PARK LAKE DRAINAGE AREA.
(d) T. Smart and A. Lambert.
(e) Dr. Glen N. Cox, Associate Professor of Mechanics and Hydraulics.
(f) Study of rainfall, runoff, and evaporation.
See Report I-1 for (b), (c), (g) and (h).

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

(29) (a) EXPERIMENTAL STUDY OF SEA-WALL DESIGN.
(d) Professor K. C. Reynolds.
(e) Professor K. C. Reynolds.
(f) Improvement of sea wall design.
(g) A plunger at one end of a concrete basin 6 ft. x 20 ft. creates waves which run the length of the basin, break on a sandy beach and strike a vertical sea wall.
(h) Preliminary observations of the sand and water carried over the wall indicate that a possible criterion of the relative effectiveness of various types of sea walls may be judged by measuring the amount of sand carried over the wall in a minute. The effect of the height of wall, and of the height and slope of beach on this amount is now under investigation to determine the conditions for maximum sand movement. Paper entitled "Investigation of Wave Action on Sea Walls by the Use of Models" published in Transactions of the American Geophysical Union, National Research Council, Washington, D. C., June, 1933, pp. 512-516.
See Report I-1 for (b) and (c).

....

(30) (a) EXPERIMENTAL INVESTIGATION OF THE TRANSPORTATION OF SAND BY RUNNING WATER.
(d) C. H. MacDougall of laboratory staff.
(e) C. H. MacDougall.
(f) To investigate the factors which influence the movement of sand and the attendant phenomena.
(h) Paper entitled "Bed-Sediment Transportation in Open Channels" published in Transactions of the American Geophysical Union, National Research Council, Washington, D. C., June, 1933, pp. 491-495. A comprehensive paper will be available soon.
See Report I-1 for (b), (c), (g).

....

(31) (a) INVESTIGATION OF WAVE PHENOMENA IN CHANNELS.
(d) J. B. Drisko of laboratory staff.
(e) J. B. Drisko.
(f) To determine characteristics of wave phenomena in channels. This includes tidal waves, waves of translation and flood waves.
(h) Various types of waves have been studied. A paper entitled "Wave Motion in a Channel" was published in Transactions of the American Geophysical Union, National Research Council, Washington, D. C., June, 1933, pp. 516-518. The experimental work has been completed and a report is on file which may be borrowed on application.
See Report I-1 for (b), (c), (g).

....

(32) (a) DYNAMICS OF SUPPRESSED WEIR DISCHARGE.
(d) Hunter Rouse.
(e) Professor K. C. Reynolds.
(f) To show relation between pressure distribution in nappe and (a) shape of nappe; (b) ratio of head on crest to depth of approach. To determine progression of contraction and velocity-of-approach coefficients as height of weir decreases to zero.
(h) Experimental work completed.
See Report I-1 for (b), (c), (g).

....

(33) (a) EFFECT OF ANGULARITY AND DEPTH OF APPROACH ON SPILLWAY DISCHARGE.
(d) R. Eliassen and H. Farney.
(e) Professor K. C. Reynolds.
(f) To determine variation in spillway coefficient as angle of approach and depth of approach are varied.
(h) Angles of 30, 45, 60 and 90 degrees have been investigated. Work reported in 1932 Master's thesis by Messrs. G. R. Lord and T. A. Fearnside, "An Experimental Investigation to Determine the Effect of Angularity and Depth of Approach on the Discharge over Spillways", and in 1933 Master's theses by Messrs. Eliassen and Farney, "An Experimental Investigation to Determine the Comparative Effect of Angularity and Depth of Approach of Flow over Vertical Sharp-crested Weirs and Spillways". Both theses may be borrowed for not over three weeks.
See Report I-1 for (b), (c), (g).

....

(34) (a) EXPERIMENTAL INVESTIGATION OF THE HOLDING ABILITY OF ANCHORS.
(d) Lieut. R. K. James, U.S.N., and Lieut. W. E. Howard, U.S.N.
(e) Professor H. E. Rossell, Commander, U.S.N.
(f) To determine the variation in holding ability of an anchor as the angle of pull varies. To investigate the effect of changes in design.
(h) Experimental work completed, M.I.T. Master's thesis (1933) entitled "Investigation of Anchor Characteristics by Means of Models". Thesis may be borrowed for not over three weeks.
See Report I-1 for (b), (c), (g).

....

(35) (a) EXPERIMENTAL STUDY OF FLOW OVER TYPICAL SPILLWAY SECTIONS.
(d) L. Reid.
(e) Professor K. C. Reynolds.
(f) To improve spillway design and put it on an analytical rather than an empirical basis.
(h) Experimental work completed and Master's thesis available for loan.
See Report I-1 for (b), (c), (g).

....

(36) (a) EXPERIMENTAL INVESTIGATION OF THE CAVITATION PHENOMENA.
(d) Hydraulic Machinery Laboratory, under direction of Professor Spannhake.
(e) Professor W. Spannhake.
(f) An experimental study in a systematic way of the fundamental theory of cavitation and the pitting caused by cavitation.
(h) Air-foils have recently been tested with different angles of attack. The distribution of pressure along the air-foil and the deflecting effect has been investigated when the pressure level approached the cavitation region. Also the influence of changes in the leading and

trailing edges on the tendency for cavitation to occur is to be measured.

See Report I-1 for (b), (c), (g).

(38) (a) LATERAL SPILLWAY CHANNELS.
(d) D. M. Stewart and H. W. Taul.
(e) Professor T. R. Camp.
(f) The purpose of these experimental studies is to determine the hydraulic conditions of flow in rectangular channels such as are used for the effluent flumes of settling tanks, to develop the theory from the fundamental differential equations, and to correlate the theoretical results with experimental measurements.
(h) Present studies completed and reported in 1933 thesis, "Experimental Studies of the Hydraulics of Lateral Spillway Channels". This thesis is a continuation of previous work reported in 1930 thesis by Engler and LaPointe and 1932 thesis by Hunter and Hough. These theses may be borrowed for not over three weeks.

See Report I-1 for (b), (c), (g).

(40) (a) STUDY OF HYDRAULICS OF SEDIMENTATION BASINS.
(d) C. Chayabongse and S. D. Miller.
(e) Professor T. R. Camp.
(f) The purpose of this work is to develop as result of experimental measurements a rational theory for estimating the removal by sedimentation of suspended solids.
(h) Present studies completed and reported in 1933 thesis "An Experimental Study of Velocity Distribution in a Model Settling Tank" by Messrs. Chayabongse and Miller.

See Report I-1 for (b), (c), (g).

UNIVERSITY OF MINNESOTA.

(94) (a) TRANSPORTATION OF SEDIMENT.
(e) Prof. Lorenz G. Straub.
(f) Investigations of the transportation of bed sediment in alluvial rivers and the effect of contraction works on the river channel.
(g) In progress.

(95) (a) BROAD-CRESTED WEIRS.
(e) Prof. Lorenz G. Straub.
(f) Characteristics of broad-crested weirs, experimentally establishing the pressure-momentum relations.
(h) In progress.

(96) (a) EXPERIMENTAL DESIGN OF DROP-CULVERT SPILLWAYS.
(e) Prof. Lorenz G. Straub.
(h) In progress.

(97) (a) MODEL TESTS OF SAND DAMS.
(e) Professor Lorenz G. Straub.
(h) In progress.

(98) (a) PERMEABILITY OF GRANULAR MATERIALS.
(e) Professor Lorenz G. Straub.
(f) Investigation of the permeability of granular materials when subjected to high liquid pressures.
(h) In progress.

....

(99) (a) LAWS OF HYDRAULIC SIMILITUDE.
(e) Professor Lorenz G. Straub.
(f) Investigation of the limitations of the laws of hydraulic similitude.
(h) In progress.

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MICHIGAN STATE COLLEGE OF AGRICULTURE AND APPLIED SCIENCE.

(128) (a) INVESTIGATION OF THE HEAT CONDUCTIVITY OF THE BOUNDARY FILM SURROUNDING HOT BODIES.
(d) William G. Keck.
(e) William G. Keck.
(f) To determine heat transfer from solids to gases, especially surface resistance. Air flow incidental to problem but proved to be a major problem.
See Report I-2 for (b), (c), (g) and (h).

....

NATIONAL HYDRAULIC LABORATORY, BUREAU OF STANDARDS, WASHINGTON, D. C.

(42) (a) INVESTIGATION OF THE PHYSICS OF PLUMBING.
(d) R. B. Hunter.
(e) The Director, U. S. Bureau of Standards.
(f) To obtain data on which to base logical estimates of the capacities of various sizes of drain pipes, vertical and sloping, in plumbing systems.
(h) An installation of 6" pipe, which for a part of the work will be of glass, has been made for continuing the study, and several runs have been made. Work has been suspended temporarily on this project.
See Report I-1 for (b), (c), (g), and part of (h).

....

(43) (a) INVESTIGATION OF PIPE BENDS.
(d) K. H. Beij, G. H. Keulegan.
(e) The Director, U. S. Bureau of Standards.
(f) To obtain the general laws of head loss in pipe bends; to correlate, insofar as possible, all available results of previous investigations; to obtain practicable formulas for use of engineers; and to extend the results to include flow of other fluids such as oils, steam, etc.
(h) A set-up for tests on 3/8 inch brass tubing is practically completed.
See Report I-1 for (b), (c) and (g).

....

(44) (a) STUDY OF "DEEP WELL" CURRENT METERS.
(d) R. B. Hunter, W. F. Stutz.
(e) The Director, U. S. Bureau of Standards.
(f) To study the characteristics of current meters developed by the U. S. Geological Survey for explorations in artesian wells; to calibrate these meters in various sizes of well casings from 3" to 15" diameters and to examine their reliability for detecting the location and extent of leaks in the casing.
(h) Tests have been made with 1.5 inch meter in 2, 3 and 4-inch casings, and with two 3-inch meters in 3, 4, 6, 8 and 12-inch casings, and complete calibration data obtained for all meters in each size of casing. Vertical and horizontal traverses of the 6, 8-inch casings have been made to determine the variation in calibration due to position of the meter in the casings. Vertical traverses in 4, 6 and 8-inch casings with artificial leaks have been made.

See Report I-1 for (b), (c) and (g).

....

(129) (a) TRANSPORTATION OF SEDIMENT.
(d) C. A. Wright.
(e) The Director, U. S. Bureau of Standards.
(f) To determine the relative scouring action on a bed of fine sand of clear water and of water containing a considerable amount of fine silt.
(h) Equipment for this project is nearly complete. It consists of a separate circulation system comprising a storage basin, constant level tank, wooden flume about 18 inches wide and 40 feet long, and a settling basin.

See Report I-2 for (b), (c), and (g).

....

(171) (a) INVESTIGATION OF THE PRESSURE VARIATION IN THE UPSTREAM AND DOWNSTREAM SIDES OF AN ORIFICE PLATE.
(b) Scientific Data, Bureau of Standards.
(c) Bureau of Standards research.
(d) H. S. Bean, E. Buckingham, C. D. Shepard.
(e) The Director, U. S. Bureau of Standards.
(f) To obtain more complete data than is now at hand on the variations of pressure in the vicinity of an orifice plate, which will assist in better correlation of orifice coefficient data.
(g) Water from a constant head tank will be discharged through the orifice section of the line into either a weighing or calibrated tank. Simultaneous readings will be made of the pressure at 48 pressure openings extending from the orifice plate face to about 4 pipe diameters upstream and 10 pipe diameters downstream. It is planned to vary the ratio of orifice to pipe diameter from about 0.05 to over 0.8, and to vary the Reynolds number over at least a 1 to 10 range for each orifice.
(h) Set-up in progress of erection.
(i) It is possible the same set-up will be used later for similar tests using air in place of water.

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NEW YORK UNIVERSITY.

(130)(a) DURATION CURVES OF STREAM FLOW.
(e) Professor Thorndike Saville.
(f) To determine regional characteristics of stream flow and the applicability of statistical methods to its analysis.
(h) Study of five North Carolina streams completed and published: "An investigation of the flow duration curves of North Carolina streams", by Thorndike Saville and John D. Watson, Trans. American Geophysical Union, National Research Council, Washington, D. C., 1933, pp.406-425. Studies in progress covering streams in New Jersey, New York, Tennessee and North Carolina. See Report I-1 for (c),(g) and (i).

(131)(a) ESTIMATING FLOOD FLOWS.
(b) General scientific research and for Master's theses.
(d) Thorndike Saville, graduate students, and assistants.
(e) Professor Thorndike Saville,
(f) (g) To compare all the various methods which have been proposed by applying them to streams having long records of flow, and to develop, if found desirable, improved methods.
(h) Comparison of several methods to 57 year daily record of Tennessee River in Master's thesis (1933) by H. Thielheim. Results indicate marked diversity.

(132)(a) RAINFALL, RUNOFF, EVAPORATION, SILTING ON FLAT RIVER, N.C.
(d) Thorndike Saville and Charles E. Ray, Jr.
(e) Professor Thorndike Saville.
(f) To determine hydrological characteristics of Flat River drainage basin. See Report I-2 for (b), (c), (g) and (h).

(133)(a) COASTAL EROSION IN NORTH CAROLINA.
(d) Thorndike Saville and Charles E. Ray, Jr.
(e) Professor Thorndike Saville.
(f) To determine nature and extent of coastal erosion at selected points and propose control measures. See Report I-2 for (b),(c),(g) & (h).

OHIO STATE UNIVERSITY, ROBINSON LABORATORY.

(134)(a) A DETERMINATION OF THE COEFFICIENTS OF COMMERCIAL METERING ELEMENTS FOR STEAM AND WATER.
(d) S.R.Beitler and T.C.Barnes.
(e) S.R.Beitler.
(f) To determine the effect of temperature, viscosity, and expansibility of commercial metering elements (orifices, nozzles, and Venturi tubes.) See Report I-2 for (b),(c),(g) and (h).

(135)(a) A STUDY OF THE FLOW OF WATER THROUGH ORIFICES IN VARIOUS SIZED PIPES.
(d) S.R.Beitler.
(e) S.R.Beitler.
(f) To determine the variation of orifice coefficients with pipe size and orifice size and to get comparative values for the various location of pressure taps at present used. See Report I-2 for (b),(c),(g) and (h).

(136) (a) AN INVESTIGATION OF THE EFFECT OF FLANGE FORM ON ORIFICE COEFFICIENTS.
(d) S. R. Beitler, S. E. Overbeck.
(e) S. R. Beitler.
(f) To determine the effect of the various commercial orifice flanges now in use with the gas industry upon the coefficient of discharge of the orifice.
See Report I-2 for (b), (c), (g) and (h).

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PACIFIC HYDROLOGIC LABORATORY.

(45) (a) RELATION OF PERMEABILITY OF GRANULAR MATERIALS TO PARTICLE SIZE.
(d) Charles H. Lee.
(e) Charles H. Lee, Consulting Engineer, 58 Sutter Street, San Francisco, California.
(f) To provide a more accurate basis for preliminary classification of soil and earth materials as to permeability.
(h) No progress report.
See Report I-1 for (b), (c) and (g).

. . . .

(46) (a) RELATION OF HEAD TO FLOW OF WATER THROUGH PARTIALLY SATURATED GRANULAR MATERIALS.
(d) Charles H. Lee.
(e) Charles H. Lee, Consulting Engineer, 58 Sutter Street, San Francisco, California.
(f) To ascertain more definitely the relation of flood flow in streams to seepage from their beds.
(h) No progress report.
See Report I-1 for (c) and (g).

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THE PENNSYLVANIA STATE COLLEGE.

(137) (a) A STUDY OF VARIOUS TYPES AND KINDS OF STILLING DEVICES FOR USE IN CHANNELS OF APPROACH TO WEIRS AND FOR OTHER PURPOSES.
(d) Professors Elton D. Walker and H. K. Kistler.
(e) Either of above.
(f) The development of a standard stilling device, or possibly more than one device.
See Report I-2 for (b), (c), (g) and (h).

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PRINCETON UNIVERSITY.

(138) (a) LOSS DUE TO SUDDEN ENLARGEMENTS IN OPEN CHANNELS.
(d) Lieut. J. A. Ostrand Jr., U.S.A.,
(e) Professor L. F. Moody.
(f), (g) To compare actual results with theoretical calculation following a rational method based on the impulse-reaction principle or momentum principle. Applied to flow in a glass flume of 12" x 12" section, with two ratios of sudden enlargement in addition to uniform section. Results show good agreement with theory.
See Report I-2, for (b), (c) and (h).

. . . .

(139)(a) INVESTIGATION OF A "FREE" and "DROWNED" HYDRAULIC JUMP, Or COMPARISON OF FREE JUMP WITH SUBMERGED DISCHARGE.
(d) Lieut. P. E. Ruestow, U.S.A.
(e) Professor L. F. Moody.
(f) (g) To compare actual results with theoretical calculation following a rational method based on the "momentum principle". Particularly directed to the "drowned" or partially submerged jump, or the transition stage between the complete or free jump and completely submerged discharge from an orifice. Applied to experiments in a 12" x 12" glass-sided flume about 8 ft. long. Results show good agreement with theory. See Report I-2 for (b), (c) and (h).

....

(140)(a) INVESTIGATION OF RAINFALL AND RUNOFF IN CERTAIN WATERSHEDS.
(d) Lieut. C. Van B. Sawin, U.S.A.
(e) Professor L. F. Moody.
(f) An analytical and statistical investigation of typical eastern watersheds. A comparison of different methods of graphical analysis of runoff-duration curves, using "probability scales", or scales based on the probability integral. Also analysis of functional effect of certain variables on mean-annual runoff. See Report I-2 for (b),(c),(g) & (h)

....

(141)(a) EFFECT OF TURBULENCE ON CURRENT METER MEASUREMENTS.
(d) Lewis F. Moody, Jr.
(e) Professor L. F. Moody.
(f) To investigate experimentally the error due to turbulence in applying still-water ratings to moving water measurements. Comparison of actual results with calculations by the two-meter "angular method, based on oblique still-water ratings, to determine whether this method is reliable with a particular kind and degree of turbulence.
See Report I-2 for (b),(c),(g),(h) and (i).

....

(142)(a) EFFECT OF LONGITUDINAL VELOCITY OSCILLATIONS ON CURRENT METER PERFORMANCE.
(d) Robert S. Hackett.
(e) Professor L. F. Moody.
(f) To determine whether, or to what degree, variations or pulsations in the magnitude of velocity affect the recording of a current meter. Involves the effect of that factor in ordinary flowing water which results in variations of magnitude of velocity, as a result of turbulence or eddies, as separated from variations in direction or angularity. See Report I-2 for (b),(c),(g),(h) and (i).

....

(143)(a) INVESTIGATION OF TRIANGULAR WEIRS OF VARIOUS VERTEX ANGLES.
(d) John Campbell, Jr.
(e) Professor L. F. Moody.
(f) Continuation of program of previous years, extending measurements from 90 degree to 30 degree vertex angle, and covering a coordination and partial formulation of results.
See Report I-2 for (b),(c),(g),(h) and (i).

PURDUE UNIVERSITY.

(47)(a) FLOW OF FLUIDS THROUGH CIRCULAR ORIFICES.
(b) Purdue Engineering Experiment Station.
(c) General scientific research.
(d) F.W.Greve and graduate students.
(e) Professor F.W.Greve, School of Civil Engineering, Purdue University, West Lafayette, Indiana.
(f) To determine experimentally the effects of density, surface tension, viscosity, and temperature upon the rate of discharge through small circular orifices.
(g) The liquids under investigation were water, three sucrose solutions of different densities, furnace oil, engine oil, and a mixture of furnace and engine oil. Flow was maintained by a small pumping unit discharging directly into an open orifice tank that was approximately 15 in. in its three dimensions. The nominal diameters of the thin-edge orifices, cut in 1/4 in. brass plates, were 1/4, 3/8, 1/2, 5/8, 3/4 and 7/8 in. respectively. The discharge from each orifice was directed into either a weighing tank or into the reservoir which supplied the pump. The discharge was weighed to within one ounce. A telescope and micrometer scale attached to a piezometer of 2-in. diameter permitted readings of the head to be noted to within 1/1000 in. Time was indicated on a stop-watch. The tests were made at room temperature. An Engler viscometer, a Cenco-de Novay tensiometer, and a Jolly balance were employed to measure the respective viscosities, surface tensions, and densities.
(h) The investigation to date has been in the nature of a preliminary survey, the results being indicative rather than qualitative. Larger and more extensive equipment is being installed to permit greater ranges in head, discharge and temperature. Actual tests will probably not be resumed for several months.

....

STANFORD UNIVERSITY, SCHOOL OF ENGINEERING.

(144)(a) DETERMINATION OF THE COEFFICIENTS FOR DISCHARGE OVER MODELS OF SOME DAM CRESTS NOW IN USE ON THE WESTERN RIVERS OF THE UNITED STATES OF AMERICA.
(b) Self.
(c) Investigation for thesis for the advanced degree of Engineer in Civil Engineering.
(d) Allan J. Meadowcroft and Niel F. Meadowcroft.
(e) A. J. Meadowcroft.
(f) See title.
(g) Tests on models of various scales and crest lengths in channels of different widths.
(h) The work has been completed, and the report was submitted as a thesis. (See (c) in July, 1933.)

....

STEVENS INSTITUTE OF TECHNOLOGY.

(145)(a) GEOMETRICALLY SIMILAR SHIP MODELS IN MIXED FLOW.
(d) Albert Shields.
(e) Professor Kenneth Davidson.
(f) Effects of model size in the region of Reynold's numbers in which transition from laminar to turbulent flow occurs. Effects on boundary layer and eddy formation. See Report I-2 for (b), (g) and (h).

....

(146) (a) CORRELATION BETWEEN SMALL MODEL RESISTANCE AND RESISTANCE OF FULL SIZE RACING SAILING YACHT.
(d) Professor Kenneth Davidson.
(e) Professor Kenneth Davidson.
(f) A check on the variations of skin friction, wave-making and eddy making with change in size between full size and a model ordinarily running in the transition region.
See Report I-2 for (c), (g) and (h).

....

TEXAS ENGINEERING EXPERIMENT STATION.

(147) (a) THE LOSS OF HEAD IN CAST IRON TEES.
(d) F. E. Giesecke, W. H. Badgett, and J. R. D. Eddy.
(e) The Director, Texas Engineering Experiment Station, A. and M. College of Texas, College Station, Texas.
(f) To determine a means of calculating the loss of head for the flow of water through cast iron tees.
See Report I-2 for (b), (c), (g), (h) and (i).

....

U.S. BUREAU OF RECLAMATION.

(48) (a) HYDRAULIC MODEL EXPERIMENTS FOR THE DESIGN OF BOULDER DAM.
(d) Research Division, U. S. Bureau of Reclamation.
(e) U. S. Bureau of Reclamation, Denver, Colorado.
(f) These experiments are being carried out for the design of the spillways, gate towers, penstocks and needle valve outlets at Boulder Dam.
(h) The experimental work and preparation of the report on these studies is still under way, and will continue for some time. When the results of these studies are in shape for giving to the public, it is expected that technical reports for general distribution will be issued.
See Report I-1 for (b), (c) and (g). See "Abstracts and References."

....

(161) (a) SPILLWAY DESIGN COLUMBIA RIVER DAM.
(b) U. S. Bureau of Reclamation.
(c) General scientific research.
(d) Under direction of E. W. Lane.
(e) U. S. Bureau of Reclamation, Denver.
(f) For design of spillway dam.
(g) Tests of model of ogee and multiple arch types to determine the best method of preventing scour from overfalling water.
(h) Model testing just started.

....

(162) (a) STABLE CHANNELS FOR IRRIGATION CANALS.
(b) U. S. Bureau of Reclamation.
(c) General scientific research.
(d) Under direction of E. W. Lane.

(162) (continued)
(e) U. S. Bureau of Reclamation, Denver.
(f) To determine the stable channel shape for a canal of 15,000 sec.ft. capacity.
(g) Research in literature from all parts of the world and an analysis of the data to determine factors controlling stable channel shapes and quantitative relations existing.
(h) Tentative conclusions regarding fundamental relations were reached and further studies being made to determine quantitative relations.

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U. S. WATERWAYS EXPERIMENT STATION.

(51) (a) SUSPENDED LOAD INVESTIGATIONS.
(b) Mississippi river and tributaries.
(c) All experiments are prosecuted to the end of aiding in the development of plans for flood control, harbor improvement, navigation, etc. All have a direct practical application to the work of the Corps of Engineers, U. S. Army, in its administration of the Rivers and Harbors of the Nation. The U. S. Waterways Experiment Station holds as an unvarying principle the maintenance of the closest contact with the field in all experimental work. This contact is kept both by Station personnel visiting the prototype and by engineers from the field visiting the Station while any particular model study is in progress.
(d) All experiments are conducted at the U. S. Waterways Experiment Station, by personnel of the Station under the direction of Lt. H. D. Vogel, Director of the Station. Further information and data covering any particular experiment may be obtained from the Director, U. S. Waterways Experiment Station.
(e) Study of suspended load carried by the Mississippi River and its tributaries - silting of reservoirs.
See Report I-2 for (f) and (g). See also p. 35 of Report I-2 for reference to publications.

. . . .

(52) (a) SOILS INVESTIGATIONS.
(b) Navigable Waterways, U.S.A.
(c) and (d) See (51).
(e) Study physical properties of soils, especially as they pertain to levee building.
(f) Mechanical analyses, compression tests, shear tests of samples taken undisturbed or otherwise under supervision of the Station. Study of subsidences and slides by use of pre-set plates.
(g) Studies in progress continually.

. . . .

(59) (a) LEVEE SEEPAGE.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Locate hydraulic gradient and seepage lines in levees of standard section and of varying materials.
See Report I-2 for (f) and (g).

. . . .

(70) (a) RALEIGH BAR.
(b) District Engineer, Louisville, Ky.
(c) and (d) See (51).
(e) Development system to improve navigability of Raleigh Bar (and other bars) Ohio River.
(f) Model scales of 1 to 720 and 1 to 72, with movable bed.
(g) Completed. See "Abstracts and References".

....

(74) (a) TRACTIVE FORCE.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Critical depths and slopes to cause movement of any given bed load.
(f) Tests in special tilting flumes checked by special runs in models.
(g) In progress.

....

(77) (a) ISLAND NO. 35, MISSISSIPPI RIVER.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Develop methods of improving navigation.
(f) Model scale 1 to 600 and 1 to 150, movable bed.
(g) Nearing completion.

....

(80) (a) HOTCHKISS BEND, MISSISSIPPI RIVER.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Develop dikes upstream to improve navigation conditions.
(f) Model scales 1 to 600 and 1 to 150; movable bed.
(g) Complete.

....

(81) (a) ST. CLAIR RIVER COMPENSATING WEIRS.
(b) Great Lakes Division.
(c) and (d) See (51).
(e) Determine kind, number and placing of weirs to raise level of Lake Huron.
(f) Model scales 1 to 100 undistorted and 1 to 100 against 1 to 30, also flume tests of individual weirs.
(g) In progress.

....

(83) (a) FORT CHARTRES, MISSISSIPPI RIVER.
(b) District Engineer, St. Louis, Mo.
(c) and (d) See (51).
(e) Develop dike system to improve depths over crossings.
(f) Model scales 1 to 1000 and 1 to 100; movable bed.
(g) Complete.

....

(84) (a) BROOKS POINT, MISSISSIPPI RIVER.
(b) District Engineer, St. Louis, Mo.
(c) and (d) See (51).
(e) Develop dike system to improve depths over crossings.
(f) Model scales 1 to 1000 and 1 to 100; movable bed.
(g) Complete.

....

(85) (a) ACTION OF BED LOAD AT A STREAM FORK.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Characteristics of a Bifurcated Flume.
(f) Flumes with divided channels; movable beds.
(g) 1st and 2nd phases complete, more to come. See "Abstracts and References".

....

(87) (a) BRAZOS SANTIAGO PASS, GULF OF MEXICO.
(b) Gulf of Mexico Division.
(c) and (d) See (51).
(e) Effects of jetties on present channel.
(f) Model scales 1 to 300 and 1 to 150.
(g) In progress.

....

(88) (a) FITLER BEND, MISSISSIPPI RIVER.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Effects of Point Bar dredging.
(f) Model scales 1 to 800 and 1 to 125; movable bed.
(g) Complete.

....

(90) (a) POINT PLEASANT, MISSISSIPPI RIVER.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Develop dike system to improve conditions for navigation.
(f) Model scale 1 to 1000 and 1 to 100; movable bed.
(g) Complete.

....

(91) (a) MISSISSIPPI RIVER MODEL No. 4 - INCLUDING THE RIVER FROM MILE 560 TO MILE 655 BELOW CAIRO.
(b) Mississippi River Commission
(c) and (d) See (51).
(e) Miscellaneous problems involving the river between the limits specified in (a).
(f) Model scales 1 to 1000 and 1 to 100; movable bed.
(g) In progress.

....

(92) (a) MISSISSIPPI RIVER MODEL NO. 5 - INCLUDING THE RIVER FROM MILE 650 TO MILE 740 BELOW CAIRO.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Miscellaneous problems involving the river within the limits specified in (a).
(f) Model scales 1 to 1000 and 1 to 100; movable bed.
(g) In progress.

....

(93) (a) LAKE LONG BIFURCATION, ATCHAFALAYA RIVER.
(b) Mississippi River Commission.
(c) Study of bed load movement at this stream fork, and study of dredge cut above.
(d) See (51).

(93) Continued.
(e) Study of bed load movement at this stream fork.
(f) Model scales 1 to 200 and 1 to 50; movable bed.
(g) Complete.

....

(148) (a) WINYAH BAY, SOUTH CAROLINA COAST.
(b) Division Engineer, South Atlantic Division.
(c) and (d) See (51).
(e) Study of means of increasing navigable depths in the harbor.
(f) Model scales 1 to 500 and 1 to 100, tidal study.
(g) In progress.

....

(149) (a) COW ISLAND CUT-OFF, ATCHAFALAYA RIVER.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Study of bed load and current direction after this cut-off is effected.
(f) Model scales 1 to 400 and 1 to 75.
(g) Complete.

....

(150) (a) ISLAND NO. 20, MISSISSIPPI RIVER.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Study of effects of regulating works on channel location and depths.
(f) Model scales 1 to 1000 and 1 to 125; movable bed.
(g) In progress.

....

(151) (a) ATCHAFALAYA RIVER BASIN.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Study of the effects of changes in the regimen of the effluents of the Atchafalaya.
(f) Model scales 1 to 1500 and 1 to 100; fixed bed.
(g) In progress.

....

(152) (a) ROBINSON CRUSOE ISLAND, MISSISSIPPI RIVER.
(b) District Engineer, Memphis, Tenn.
(c) and (d) See (51).
(e) Study of proposed regulating works.
(f) Model scales 1 to 1000 and 1 to 125; movable bed.
(g) In progress.

....

(153) (a) ARTICULATED CONCRETE MATTRESS STUDY.
(b) District Engineer, Memphis, Tenn.
(c) and (d) See (51).
(e) Study of the causes of leaching of subsoil from under concrete materials.
(f) Full scale; small scale models supplementing.
(g) In progress.

....

(163) (a) MISSISSIPPI RIVER MODEL No. 1 - INCLUDING THE RIVER FROM MILE 390 TO MILE 810 BELOW CAIRO, AND THE ATCHAFALAYA RIVER TO MILE 35 BELOW BARBRE LANDING.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Miscellaneous problems affecting water surface elevations within the limits specified in (a).
(f) Model scales 1 to 2400 and 1 to 120; fixed bed.
(g) In progress.

....

(164) (a) TURBULENCE INDEX STUDIES.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Studies to determine a criterion for the critical point of turbulent flow in model channels.
(f) Special flumes and existing models used in study.
(g) In progress.

....

(165) (a) MISSISSIPPI RIVER BED LOAD SURVEY.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Mechanical analyses of samples taken from bed of Mississippi River, half-mile intervals, Cairo to New Orleans; also includes the Atchafalaya River survey.
(f) Analyses equipment.
(g) In progress.

....

(166) (a) U. S. INTRA-COASTAL WATERWAYS CROSSING BRAZOS RIVER NEAR FREEPORT, TEXAS.
(b) District Engineer, Galveston, Texas.
(c) and (d) See (51).
(e) Study to end of eliminating silting of canal by Brazos River.
(f) Model scales 1 to 25 undistorted; movable bed.
(g) In progress.

....

(167) (a) ST. JOHNS RIVER, JACKSONVILLE, FLORIDA.
(b) District Engineer, Jacksonville, Florida.
(c) and (d) See (51).
(e) Study to determine effects of blocking off one entrance to tidal area in order to improve channel conditions in other entrance.
(f) Model scales 1 to 1000 and 1 to 125; fixed bed.
(g) In progress.

....

(168) (a) HEAD OF PASSES, MISSISSIPPI RIVER.
(b) District Engineer, 1st New Orleans District, New Orleans, La.
(c) and (d) See (51).
(e) Determine methods of improving navigation conditions at Head of Passes.
(f) Model scales 1 to 600 and 1 to 125; movable bed.
(g) In progress.

....

(169) (a) SOUTHWEST PASS, MISSISSIPPI RIVER.
(b) District Engineer, 1st New Orleans District, New Orleans, La,
(c) and (d) See (51).
(e) Determine methods of improving channel conditions in Southwest Pass.
(f) Model scales 1 to 1000 and 1 to 125; movable bed.
(g) In progress.

....

(170) (a) MISSISSIPPI RIVER MODEL NO. 2 - INCLUDING THE MISSISSIPPI RIVER FROM MILE 370 TO MILE 445 BELOW CAIRO, AND 60 MILES OF THE ARKANSAS RIVER, AND 20 MILES OF THE WHITE RIVER.
(b) Mississippi River Commission.
(c) and (d) See (51).
(e) Determine effects of separating mouths of Arkansas and White Rivers; also effects of cut-offs on the rivers upstream from mouth.
(f) Model scales 1 to 1000 and 1 to 100; movable bed.
(g) In progress.

....

WEST VIRGINIA UNIVERSITY.

(49) (a) SEDIMENTATION OF SMALL PARTICLES SUSPENDED IN WATER.
(d) H. W. Speiden and L. V. Carpenter.
(e) L. V. Carpenter, College of Engineering, West Virginia University, Morgantown, W. Va.
(f) To study the laws governing the rate of settling of small particles in model basins.
(h) Experimental work has been started on a basin 4 ft. by 6 ft. in cross section and 10 ft. long. Other basins will be constructed in the near future.

See Report I-1 for (b), (c) and (g).

....

(50) (a) DISCHARGE THROUGH THIN PLATE ORIFICES IN PIPE LINES.
(d) L. V. Carpenter, assisted by students.
(e) L. V. Carpenter, College of Engineering, West Virginia University, Morgantown, W. Va.
(f) To study coefficients of various sizes of circular thin plate orifices in pipe lines with a view to the determination of the relations existing between the coefficients of large and small orifices by principles of similarity.
(h) Experiments on the 2-inch pipe lines are completed, and preparations are being made to start experimental work on the 3-inch pipe line.

See Report I-1 for (b), (c) and (g).

....

UNIVERSITY OF WISCONSIN.

(154) (a) EXPERIMENTAL STUDY OF THE HYDRAULICS AND PNEUMATICS OF THE PLUMBING SYSTEM.
(b) Laboratory project.
(d) F. M. Dawson, L. H. Kessler, H. Ruf, H. Pommerenck, S. E. Kotz.
(f) To determine by experimental study and show by apparatus the following features:
(1) Friction loss in small house water supply installations, including losses in copper, lead, iron pipes, valves, water meters, and in hot and cold water fixtures.
(2) Water hammer developed in piping layouts and methods of relief of this pressure in the plumbing water supply system.
(3) Proper venting of vertical stacks and horizontal waste and soil pipes.
(4) Self-siphonage of various types of traps.
(5) Heating of hot water by oil and gas and increase of pressure due to expansion of water and best method of control of this pressure.
(6) Construction of brazed, wiped, and soldered joints in copper and lead piping, and strength of these joints.
(7) Adequate water supply to a battery of closets operated by flushometer valves.
(8) Chemical solvents for cleaning of stoppages in waste pipes.
(9) Experimental investigation of grease traps.
(h) Most of the work was completed in June, 1933.

....

(155) (a) STUDY OF FLOW OVER TRIANGULAR OR V-NOTCH WEIRS.
(b) Laboratory project.
(c) F. M. Dawson and A. T. Lenz.
(f) To collect data already published and make new tests on the triangular weir for the purpose of producing working tables for triangular weirs good for any viscosity and angle of notch.
(h) Material collected and studies made. Should be ready for publication within a year.

....

(156) (a) DISCHARGE OVER WEIRS IN SIDE OF CHANNEL.
(b) Laboratory project.
(f) To determine the discharge over a rectangular weir which is placed in the side of a flowing channel.

....

(157) (a) DISCHARGE THROUGH ORIFICES ON END OF PIPE LINE.
(b) Laboratory project.
(f) To determine the coefficient of discharge for orifice openings having various ratios of area to that of approach pipe. Velocity of approach and partial suppression of contraction affects discharge from these orifices.

....

(158) (a) RESISTANCE TO FLOW THROUGH LOCOMOTIVE WATER HYDRANTS AND RELIEF FROM WATER HAMMER PRESSURES DUE TO THE CLOSURE OF CYLINDRICAL VALVES.

(b) Laboratory project.

(d) L. H. Kessler.

(f) To determine the loss of head in valve, riser in spout of locomotive water column, and study relief valves, and regulation of valve travel and the effects on the control of water hammer pressures within limits that are not destructive to water service installations.

....

COMPLETED PROJECTS.
Abstracts and References.

UNIVERSITY OF CALIFORNIA.

(13) "Air-Lift and Gas-Lift".

Abstract. Experimentally it is shown that single air bubbles in ascending through viscous liquids exhibit three modes of motion. The mean velocity of rise, the physical properties of the liquids, and the size of the tube are related to the nature of the motion. Spherical bubbles in rising through liquids contained in relatively large tubes obey Stokes Law approximately; however, the effects of surface tension and the size of the tube cause deviation from this law.

On the basis of experiments on air-liquid mixtures in a vertical glass pipe it is shown that data for single bubble motion cannot be used to predict the slip velocity in the flow string of a gas lift. For the range of liquids used the results also indicate that the slip velocity does not depend upon the physical properties of the liquids. Observation of these mixtures showed them to be extremely non-homogeneous and highly turbulent.

A series of experiments on a glass gas lift indicate that the manner of gas injection into the bottom of the flow string of an oil gas lift has no effect upon the operation. Viscosity, however, is an important factor, as the efficiency declines rapidly with an increase in magnitude of this property. Viscosity has no effect upon the submergence ratio for maximum efficiency.

Two distinct modes of admixture of gas and fluid were found to occur in the experimental lift; first, a non-homogeneous, highly turbulent mixture and secondly, an annular ring condition in which the fluid adhered to the wall of the pipe with the air passing up through the central portion. This latter type is believed to occur in oil field installations and therefore, a method of design of an efficient flow string for this condition is presented.

The energy losses in a gas lift arise from two sources; first, from the losses inherent to the motion of the fluid and secondly, from a wastage of gas. These losses are computed for the annular ring condition experiments and the results indicate that the losses are proportional to the fluid velocities at the top of the flow string and that the gas losses increase rapidly with the weight of air per second. The liquid losses are small in comparison to the gas losses.

(17) "Transportation of Bed Load by Streams".

Abstract. The investigation of the transportation of bed load by streams was undertaken to determine, if possible, the relations between the variables controlling the flow of water in open channels and the rate of transportation of the material forming the bottom. Four types of sand dredged from different parts of the San Francisco Bar were used. The following table gives an indication of the size of material in each type:

"Transportation of Bed Load by Streams". (continued)

TABLE.

Accumulative Retention on U. S. Standard Sieves.

Sieve No.	Sand "A"	Sand "B"	Sand "C"	Sand "D"
30	0.1	0.2	63.7	61.3
50	0.5	47.8	92.6	92.5
80	1.9	85.4	97.3	97.1
100	19.0	97.3	99.5	99.5
150	84.6	99.5	99.9	99.8
200	96.6	99.7	99.9	99.9
325	99.9	99.8	99.9	

The observations were made in a glass channel twenty-four feet long, one foot high, and six inches wide. Water was piped from a constant head tank and was measured with a circular orifice attached to a tilting mercury manometer. Measurements of water and bed surfaces were made with three, and later with four, point gages spaced at intervals along the channel. Depth of water was controlled by an adjustable gate in the downstream stilling tank.

Sand was fed on a plate in the upstream stilling tank from which it was gradually washed into the channel. A bucket which could be quickly rolled into place at the downstream end of the channel was used to collect the sand for measurement.

Velocities were observed by means of a very small current meter having blades about 0.04 feet long. The vertical velocity curve at the middle of the channel near the downstream end was found for most of the runs.

An attempt was made to relate the transportation of bed load to the following: First, the average velocity of the stream, the slope of the water surface, and the depth of the water; and second, to the unit shear on the bottom of the stream.

At the present time the investigation is incomplete. Sand "A" was too fine to allow any observations at velocities higher than those which just started motion. Some runs have been made on the next coarser sand, type "B", but calculations are not at this time complete.

Curves of transportation plotted against the observed velocities at 0.1 feet above the bottom and at nine tenths depth have been determined for sands "C" and "D". Curves showing transportation against shear for the same sands have also been plotted.

Work on this experiment is being continued. Observations are being studied with a view to comparing the results with those of other investigators and evolving, if possible, more exact relations between the quantities involved.

(20) "Vortex Motion on the Surface of Liquids".

Abstract. This study was used as an experimental verification of von Karman's theory of the stability of vortex arrangements behind solid objects moved through a viscous liquid.

The apparatus used was patterned after that used by Ahlborn. It consists of a water tank 18" x 18" x 144". A moving carriage tows a model through the water in the tank and also carries a camera to photograph the vortex motion behind the model. Aluminum powder was sprinkled on the surface of the water and time exposures of 1/10 and 1/15 second were made with the camera in order to obtain visible pictures of the liquid motion.

The model consisted of a flat plate fastened at right angles to a wall plate, the longitudinal axis of which was parallel to the direction of motion. The outer edge was chamfered to eliminate any effects of plate thickness.

The flow of vortices from this projecting plate was photographed and by application of the method of images (assuming the same flow from an imaginary plate on the other side of the wall plate), the flow from a hypothetical full plate was obtained from the actual half flat plate. Ignoring the boundary layer effects of the wall plate, the photographs obtained were printed directly and in reverse and the two prints joined together.

These assembled photographs showed that the pairwise arrangement (vortices from the two edges breaking away together and remaining directly opposite each other) is unstable as was theoretically shown by von Karman. From a large number of photographs, the average position of the vortices, at any distance behind the plate, was obtained.

(21) "Capillary Potential and Capillary Flow in Soils".

Abstract. The object of the study was to investigate the theory of capillary potentials and to measure some of the quantities involved in its application.

Three kinds of apparatus were used. The first was a capillary potentiometer consisting of a porous clay cup connected to a mercury manometer. The manometer reading could be changed by means of a piston. Soil was packed around the porous cup, and the piston was moved until the mercury column gave a negative pressure which was close to that of the water in the soil. Then the piston was fixed in place and water moved inward or outward through the porous cup till equilibrium was reached.

In the second type of apparatus, columns were built to different heights using galvanized steel rings 4 inches in diameter. Rings 1/2 inch and 1-1/2 inches long were alternated in the column. Friction tape held the rings together. When the rate at which moisture passed into the soil became nearly steady, the moisture contents of the soil in the shorter rings was found. These columns were kept at constant temperature.

The third kind of apparatus was a battery of potentiometers placed at 2-inch intervals in a vertical column of soil held in a wooden container 6 inches square and 24 inches tall. A water table was maintained near the bottom of the column. At the end of this experiment the moisture content was determined at the level of each potentiometer.

Results are reported for only one soil. It was a fine sandy loam from an orchard near Lodi, California. Two samples were taken at different times but from points close together. The average moisture equivalent of one sample was 6.30 and of the other 6.70.

The most recent explanations of the capillary theory have been given by Israelsen[1] and by Richards[2,3]. During this study equations similar to those given by Richards[3] were derived on a different basis.

The principal results and conclusions are as follows:

The two samples gave almost identical results. In general the capillary potential of this soil changed slowly with changes in the moisture content between saturation and about 10% moisture. This change was more rapid from 10% moisture to the moisture equivalent and was much more rapid as the moisture content decreased below the moisture equivalent. The capillary potentiometer fitted with a piston can be used to measure capillary potentials rapidly.

All the columns showed a region of saturation or approximate saturation extending from 4 to 10 inches above the water table. Neither the capillary potential measurements made on this soil nor the published measurements of capillary potentials made on other soils indicate this region of almost constant moisture content.

The experiment using the battery of potentiometers showed that the resistance to flow of water through a solid changed greatly with a change in the moisture content. Near the top of the column the potential gradient necessary to cause a given rate of discharge through unit area was more than a thousand times the potential gradient required just above the water table.

Under certain conditions the equations derived for capillary flow supply a means of computing the flow.

Moisture in a soil at a height greater than 100 to 800 centimeters above a water table, depending on the characteristics of the soil, will not be at equilibrium with the water table.

The capillary potential theory has field applications; the limitations of each application must be tested in the field.

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1 Israelsen, O.W. 1927 The application of hydrodynamics to irrigation and drainage problems. Hilgardia 2: 479-528.

2 Richards, L.A. 1928 The usefulness of capillary potential to soil moisture and plant investigation. Jour. Agr. Research 37:719-742.

3 Richards, L.A. 1932 Capillary conduction of liquids through porous mediums. Physics 1:318-333.

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(23) "Stirring Chemicals for Water Treatment by Disc Friction".

Abstract.

General Recapitulation.

Aeration Experiments. The tests made with the aeration apparatus included observations of air distribution, bubble fineness, and velocity distribution. The experiments were carried on in a four foot section of twenty four inch woodstave pipe which was fitted with a reinforced concrete floor. A center shaft of one inch pipe extended through the center of the tank, resting in a thrust bearing set in the floor. A thin disc of galvanized iron was attached with a clearance to the tank floor of thirteen inches. A uniform water depth of three feet was used throughout. Observations were made with shaft speeds of from 200 to 1000 rev. per min. with

compressed air bubbling through a filtrose inlet set on the floor near the edge, and later from a separate pipe inlet placed directly under the disc. Both a six inch and a twelve inch disc were used during the course of the experiments, and in an effort to retard the upward flow, in one test a wooden baffle was used with the twelve inch disc, being inserted across the tank at about the elevation of the disc, with a circular center hole of twelve inch diameter.

Velocity distribution measurements were completed with the aid of a calibrated pitometer. Traverses at four cross-sections of the pipe were taken and the position of the velocity contours determined for both the six and the twelve inch discs with speed ranges of from 200 to 1000 rev. per min.

Disc Friction Experiments. Disc friction measurements were made with the aeration apparatus for both the six and twelve inch disc, using the thirteen inch floor clearance and speed ranges up to 1000 rev. per min.

A more concentrated study of disc friction was made on a special piece of apparatus similar in general design to the aeration apparatus described above, but of small dimensions. A twelve inch glass jar was used as the tank and was mounted on a pivot stand which turned freely. A solid 0.875 inch steel shaft extended down into the jar from a motor which was supported on a frame extending over the jar, a brass disc of six inch diameter was attached to the flange with a slip collar, so that the bottom clearance of the disc could be varied at will.

Determinations of the disc friction power in the aeration apparatus were limited to electrical measurements of the motor armature output, but in the special disc friction apparatus were supplemented by mechanical measurements of the torque transmitted to the jar which tended to turn on the pivot support. The rotating force was transferred to a torsion balance and the torque then determined. Tests were made with a six inch disc, using bottom clearances varying from one-quarter inch to six inches, and with water depths of nine and eighteen inches.

Suggestions. As a result of the observations on the aeration apparatus, the following suggestions are made with a view to increasing the general efficiency thereof:

1. Use a greater diameter of disc, preferably eighteen to twenty inches.
2. Place the disc closer to the floor of the tank with a clearance of from five to eight inches.
3. Increase the number of air inlets to three or four, placed well under the disc.
4. Revise the design completely, providing an air inlet on the disc which will be changed to a thin, hollow shell.

The results of the disc friction apparatus should be extended to tests with other sizes of disc and other depths of water. The method of measuring the torque, used in these experiments, was unsatisfactory, and could possibly be improved upon by substituting a piano wire attachment to the horizontal arm, running it over a pulley to a weight resting on the balance.

Conclusions. The experimental data obtained from the experiments pointed to the following general conclusions:

1. That aeration apparatus would show greatest efficiency when a disc diameter of approximately .75 that of the enclosing tank was used.
2. That air distribution would be most satisfactory when the disc is placed near the bottom of the tank.
3. That an air inlet provided in the disc should prove advantageous.
4. That baffles are inefficient and unsatisfactory as a means of retarding upward air flow.
5. That, at least for tanks of similar proportions, disc friction varied approximately with the fifth power of the disc radius and the cube of the disc speed, the exact equation being

$$F \propto V^{3.1} \; r^{4.9}$$

6. That disc friction was a maximum for a ratio of disc bottom clearance to water depth of 0.15 to 0.20.
7. That the velocity lag - the ratio of disc velocity to water velocity - remained constant for any disc.
8. That velocity lag varies inversely as the .75 power of the radius of the disc.

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U. S. BUREAU OF RECLAMATION.

(48) "Hydraulic Model Experiments for the Design of Boulder Dam". Three mimeographed reports issued. "Hydraulic Capacity of the Diversion Tunnels of the Hoover Dam", by B. W. Steele and S. P. Wing, Denver, Colorado, Sept. 1, 1931.
Technical Memorandum No. 335, "Hydraulic Model Experiments for the Design of the Hoover Dam", Book 2, "Results of visual tests on semi-final and final designs," by E. W. Lane, Denver, Colorad, May 12, 1933.
Technical Memorandum No. 347. "Hydraulic Model Experiments for the Design of the Boulder Dam", Book 3, "Qauntitative Results of the Flow in the Spillway Channels and Spillway Tunnels", by E. W. Lane, Denver, Colorado, Sept. 7, 1933. Price $5.35.

....

U. S. WATERWAYS EXPERIMENT STATION.

(54) "Cut-offs, Greenville Bends". Paper I of the U. S. Waterways Experiment Station, "Experiment to Determine the Effects of proposed Dredged Cut-offs in the Mississippi River", April 15, 1932, with bibliography. Price 50 cents.
(68) "Railroad Embankment". Paper 12 of the U.S.Waterways Experiment Station, Investigations of Certain Proposed Methods of Bank and Embankment Protection", July, 1933. Price 20 cents.
(69) "Morrison Towhead". Paper 11 of the U. S. Waterways Experiment Station, "Model Studies of Dike Location", June, 1933. Price 50 cents.
(70) "Raleigh Bar". Paper 11, as given in (69).
(71) "Stewart Bar". Paper 11, as given in (69).

(73) "Concrete and Gravel Revetments". Paper 12, as given in (68).
(75) "Island No. 9, Mississippi River". Paper 11, as given in (69).
(79) "Racetrack Towhead". Paper 11, as given in (69).
(85) "Action of Bed Load at a Stream Fork". See paper by Gerard H. Matthes, Mississippi River Commission, Vicksburg, Miss., "Diversion of Sediment at Branching Channels", Trans. American Geophysical Union, National Research Council, Washington, D. C., June, 1933, pages 506-509.

TRANSLATIONS

(a) <u>In progress</u>: By A. S. M. E., 29 West 39th Street, New York, N. Y.

Mitteilungen des Hydraulischen Instituts des Technischen Hochschule München, Heft 3, 1929.

(b) <u>Completed</u>: Technical Memorandums, National Advisory Committee for Aeronautics, Washington, D.C.

No. 343, December 1925. "Potential Flow in Engine Valves", Bruno Eck, Zeit. f. ang. Math. u. Mech., Vol. IV, 1924.

No. 350, February 1926. "Change of 180 degrees in the Direction of a Uniform Current of Air", Contribution by the Aerodynamic Laboratory of the Warsaw Polytechnic Institute, Przegladu Technicznego, Vol. LXIII, 1925.

No. 388, November 1926. "Experiments with a Sphere from which the Boundary Layer is removed by Suction", Oskar Schrenk, Z.F.M., Sept. 14, 1926.

No. 395, January 1927. "Removing Boundary Layer by Suction", J. Ackeret, Zeit. V.D.I., Aug. 28, 1926.

No. 435, October 1927. "Turbulent Flow",L. Prandtl, International Congress for Applied Mathematics, Zurich, 1926.

No. 474, August 1928. "Windmills in the Light of Modern Research" A. Betz, Die Naturwissenschaften, Vol. XV, No. 46, 1927.

No. 475, August 1928. "Recent Researches on the Resistance of Spheres", D. Flachsbart, Phys. Zeit., Vol. 28, 1927.

No. 491, December 1928. "Propeller Problems", D. Betz, Zeit. f. ang. Math. u. Mech., Vol. VII, 1927.

No. 542, "Contributions to the Aileron Theory", A. Betz and E. Petersohn, Zeit. f. ang. Math. u. Mech., Vol. VIII, 1928.

No. 549, "Coefficients of Flow of Standard Nozzles", H. Mueller, and H. Peters, Zeit. V.D.I., No. 27, 1929.

No. 576, July 1930. "The Vortex Theory and its Significance in Aviation", A. Betz, Unterrichtsblaetter f. Math. u. Naturwissenschaften, Vol. 34, No. 12, 1928.

No. 585, October 1930. "Velocity Distribution in the Boundary Layer of a Submerged Plate", M. Hansen, Abh. aus dem Aerodyn. Inst. an der Techn. Hochs. Aachen, No. 8, 1928.

No. 653, January 1932. "Turbulence and Mechanism of Resistance on Spheres and Cylinders", Fr. Ahlborn, Zeit. f. Tech. Phys., Vol. 12, No. 10, 1931.

No. 659, February 1932. "Disintegration of a Liquid Jet", A. Haenlein, Forschung a. d. Geb. d. Ing., Vol.2, No.4, April 1931.

No. 657, April 1932. "Application of the Theory of Free Jets", A. Betz and E. Petersohn, Ingenieur-Archiv, May 1931.

No. 683, October 1932. "Speed and Pressure Recording in Three-dimensional Flow", F. Krisam, Z.F.M., July 14, 1932.

No. 699, February 1933. "The Process of Separation in the Turbulent Friction Layer", E. Gruschwitz, Z.F.M., June 14, 1932.

No. 713, June 1933. "Behavior of Vortex Systems", A.Betz, Zeit. f. ang. Math. u. Mech., Vol. 12, No. 3, June 1932.

No. 715, July 1933. "Pressure and Frictional Resistance of a Cylinder at Reynolds Numbers 5,000 to 40,000", L. Schiller and W. Linke, Z.F.M., April 13, 1933.

No. 720, August 1933. "Recent Studies in Turbulence Research", L. Prandtl, Zeit. V.D.I., Vol. 7, No. 5, Feb. 4, 1933.

No. 722, September 1933. "Guide Vanes for Deflecting Fluid Currents with small loss of Energy", G. Kröber, Ingenieur-Archiv, Vol. 3, 1932.

U.S. Department of the Interior, Bureau of Reclamation, Technical Memorandum

No. 325, Feb. 1, 1933. "Hydraulic Losses in Pipe Fittings - Report on some Experiments made by the Hydraulic Institute of the Technical College at Munich", D. Thoma.

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