NATIONAL BUREAU OF STANDARDS REPORT

6580

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period July 1 to September 30, 1959

By
Photometry and Colorimetry Section
Optics and Metrology Division

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers. These papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($1.50), available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

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NBS REPORT
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Development, Testing, and Evaluation of
Visual Landing Aids

Consolidated Progress Report
to
Ship Installations Division
and
Aerology Division
Bureau of Aeronautics
Department of the Navy
Washington 25, D. C.

For the Period
July 1 to September 30, 1959

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Development, Testing, and Evaluation of Visual Landing Aids
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I. REPORTS ISSUED

Report No.	Title
6501	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period April 1 to June 30, 1959
6518	Development of Taxi Guidance Wands for Carrier Deck Personnel
21P-34/59	Life Tests of 500-Watt, 20-Ampere, PAR-56 Approach-Light Lamps
Memorandum Report	Problems in the Design of Flush Runway Lights
Letter Report	Roundels for PAR-56 Lights

II. VISIBILITY METERS AND THEIR APPLICATION

Visibility Meter for Shipboard Use. Study of the design details has been continued. Construction of a feasibility model will be started next quarter.

Measurements of Runway Illumination and Sky Brightness. Tests of the effect of high-intensity runway and approach lights on the horizon sky brightness and illumination on a horizontal surface from the runway and in the approach zone were virtually suspended during this period as the approach lights were being changed from the slopeline system to the centerrow system. After the centerrow installation was completed, one set of measurements was made from a point 2300 feet from threshold on the extended centerline of the runway at near runway elevation, which was about 15 feet above the centerrow barrettes at that point. With the approach lights on intensity setting of step 5 and measuring at a spot about one degree above the threshold, a brightness of 18 footlamberts was obtained. The brightness just above the centerrow lights was three times that at one degree above the lights. Because of this very high sky brightness and because it is not feasible to make measurements from positions near the glide path, some check measurements will be made from a position to one side of the lights to obtain some idea of the brightnesses as observed on final approach. These tests should be completed and the report issued during the next quarter.

Measurements of Natural Illumination and Horizon Sky Brightness. Data relating illumination on horizontal and vertical surfaces and horizon-sky brightness are now nearly complete. The data are being reduced prior to the preparation of a report which will complete this task.

Slant Visibility Meter. In an effort to improve lamp and compressor life, the size of the lamp jet orifices was reduced, the crankcase of the compressor was vented, and the speed of the compressor was reduced. The air pressure regulator was removed from the unit. The overall performance of this part of the slant visibility meter appears to be satisfactory. Relieving the crankcase has reduced the oil consumption markedly. No addition of oil was required in a two-month period whereas previously approximately a pint of oil per week was required. By reducing the speed of the compressor, a steady flow of air at 13-15 p.s.i. is maintained without a weighted pressure regulator. Lamp life seems to be stabilized except, of course, for the random lamps that fail almost immediately after being placed in service. Due to a faulty ball bearing in the motor, the motor locked and was burned out. The motor will be replaced.

Plans are being made for the validation of this instrument. Use will be made of the extensible towers and kytoons of the Atmospheric Research Group.

Transmissometers.

Non-linear Indicator. A transmissometer indicator modified to provide the non-linear output described in the Progress Report for last quarter has been operated on the National Bureau of Standards transmissometer range simultaneously with a standard indicator. Operation of this non-linear indicator has been very satisfactory. Figure 1 shows records obtained from the two indicators during a period of rather dense fog. Note the differences in the detail of the records at the low transmittances. Additional varistors have been obtained for testing to determine if the characteristics of these elements are sufficiently similar so they can be adjusted to the same scale. A report summarizing the work and giving the details of the circuit changes will be prepared next quarter.

Errors in Transmissometer Measurements Resulting From Scattered Light. The first draft of a report giving the results of the work on this task is almost completed. However, there is still a need for data relating the error at low visibility conditions to the angular size of the field of view. The data obtained from the standard transmissometer have been reduced and seem to fit the following empirical

equation, within limits of measurements:

$$\frac{\Delta T}{T} = T^{-1/2} (1-T)(1-e^{C\theta^2})$$

where ΔT, equivalent transmission due to scattered light, is the difference between the regular transmission, T, and the transmission including scattered light; θ is the half angle field of view in minutes. C was found to be approximately 1.5×10^{-4} minutes^{-2}.

Data will be taken in fog using an unshielded lamp to see if the beam spread has very much effect on the error due to scattered light in the transmissometer.

Transmissometer Instruction Book. Arrangements are being made to re-run NBS Report 2588, Instruction Book for Transmissometer Set AN/GMQ-10. Three hundred copies will be supplied to the Bureau of Aeronautics and one hundred copies will be supplied to the Weather Bureau.

III. DEVELOPMENT OF AIRFIELD LIGHTING AND MARKING COMPONENTS

Flush-Type Lights. A memorandum report exploring some of the optical and geometric limitations in the design of flush lights has been prepared. The conclusion of this study is that insofar as operational conditions permit, the aperture of the light should be brought above the runway surface.

Runway Distance Markers. Several tests of the Cecil Field runway distance markers were made in various fog conditions. For some of these observations the four 120-volt, 150-watt lamps were energized at 115 volts. This gave an intensity suitable for very thick weather but glaring in clearer conditions. When these lamps were energized from a 200-watt, series-series, isolating transformer in the runway lighting circuit, the markers could be read at 1600 feet or greater in clear nighttime conditions although the intensity at all intensity settings appeared somewhat lower than desired. By using four 75-watt lamps instead of the four 150-watt lamps on a single 200-watt series transformer, the brightness of the marker was increased at the low intensity settings and remained about the same for the high intensity settings. Still higher brightnesses of the markers may be desirable, especially for conditions requiring high intensity settings of the runway lights at night. Tests using higher efficiency lamps to increase the brightness of the markers will be made. The brightness could also be increased by using two 200-watt isolating transformers with a load of three 100-watt or four 75-watt 120-volt lamps as the load for each transformer.

The Cecil Field markers are a definite improvement over the externally illuminated markers for nighttime use and are only slightly less effective in daytime than the markers with white numerals on an international orange background. These tests should be completed and the report issued during the next quarter.

Taxiway Lighting and Marking. (TED NBS SI-5007) The study of the requirements of taxiway lighting and markings is continuing. Scale drawings of each intersection of the Miramar Naval Air Station, showing the proposed location of each light and the position and information of each taxiway guidance sign, have been completed and reviewed. After revisions and approval, these drawings will be issued for use at the Miramar installation. Priorities for these signs will be indicated but notes will accompany the drawings to indicate possible operational priorities. One major change to be recommended will be the installation of a lighted and marked taxiway on the ramp side of the refueling lanes which may replace the present taxiway through the middle of the ramp. A rough draft of the "Standard for Lighting, Guidance Signs, and Markings of Taxiways for Naval Air Stations" was prepared.

Approach Beacons. The FAA flight-check pilots reported on their observations of the approach beacons during the flight check of the centerrow approach-light installation. They were very favorably impressed with the performance of the approach-beacon system for circling approaches and guidance on the downwind leg of the approach pattern and as an addition to the centerrow approach-light system which does not have the high-intensity flashing units. They requested the details on our approach-beacon system.

Characteristics of Series-Series Transformers with Multiple Lamps as Loads. Additional 60- and 75-volt lamps were received and tested in the runway-lighting circuits at Arcata using 200-watt series-series transformers. These tests show curve characteristics similar to those of the 120-volt lamps. 30-45 watt series-series transformers were received from two manufacturers and tests were made using 120-volt lamps as loads. Difficulty was encountered in making measurements at low rated loads because the internal resistance of the ammeter, which was an appreciable part of the load, affected the data. Low internal resistance meters will be obtained from the National Bureau of Standards in Washington and additional tests will be conducted on these transformers.

Cable-Fault Locating. Several field tests have been made using the TSM-11 Cable Test-Detecting Set, both by National Bureau of Standards personnel and the Arcata Airport Maintenance Electrician. Because of low soil conductivity in the area, some difficulty has been encountered in locating grounds in cables which are buried close to their neutral conductor. Two instances occurred in which the signal was as strong past the point where the "hot" conductor had grounded to the neutral conductor as

it was previously. In these instances the only assistance of the TSM-11 was in determining the routing of the cable and the faults were located by sectionalizing. One ground was located where the conductor-to-ground resistance was 2000 ohms. In this case the indication was that similar to a change in cable depth, but since it was the only location along the cable route which gave any indication of a fault, the cable was dug up in that area and the fault located. Four faults have occurred in one direct burial 5000-volt cable on the airport. This cable is buried without the neutral conductor in the same trench. Each of these faults has been located without any difficulty whatsoever. In one instance, two faults developed at the same time. During the locating procedure, the fault nearest the signal source was intentionally passed over because of the small amount of signal change. The fault farthest away from the signal source was located and cleared and then the other fault was located. One experimental test was conducted on open circuit faults. The TSM-11 indicator was used to trace the cable before the cable was spliced after a fault was located. The cable could be traced to within 50 feet of the open end on 1000, 2000, and 4000 foot lengths of cable. Where an ungrounded open fault occurs, a reduction of the digging required to locate this type of fault can be accomplished by applying the signal generator to each end of the cable and tracing to the point of signal loss from each end. The fault will probably be found near the midpoint between these points. This method should reduce the search time considerably. Extreme care must be exercised when using the fault locator on open faults, as it is very easy to follow the wrong cable. As experience is gained, more uses will be found for this equipment.

Over-Current Protector for Type NC-3 Regulators. This device has been installed in the runway-light circuit at the Arcata Airport for more than a year and has not operated during this period. This was expected since the conditions tending to produce an over-current were not present. Therefore, tests were conducted whereby lamps were removed from the circuit (leaving their isolating transformers open-circuited) until the protector functioned. Tests were also made by increasing the input voltage until the protector functioned. In both of these tests the protector functioned at the designed over-current (6.7 amperes). The device is considered satisfactory for use. A report will be issued during the next quarter.

Automatic Intensity Control. (TED NBS SI-5004) Construction of feasibility models of two automatic intensity control devices, one using the non-linear transmissometer indicator and the other a simple servo mechanism will be started next quarter.

IV. DEVELOPMENT OF SEADROME LIGHTING COMPONENTS

Battery-Operated Buoy-Mounted Channel-Marker Lights. The drawings of the redesigned type FMF-6 light and the new wet-battery-operated, photoelectrically controlled light designed by the Naval Air Engineering Facility (Ship Installations) were reviewed. Revisions and corrections were discussed with personnel of that organization.

Channel Identification Lights. Technical assistance has been given to the contractor manufacturing channel (runway) identification lights on several occasions. It appears that the design of these lights will follow in detail the design developed by the NBS Shops.

Norfolk Installation. The contract specifications for the seadrome installation at Norfolk Naval Air Station were reviewed. Suggestions and comments were reported for consideration.

V. DEVELOPMENT OF CARRIER LIGHTING AND MARKING COMPONENTS

Lights for Carrier Deck Personnel. (TED NBS SI-5001)

A report summarizing the development of improved taxi guidance wands has been prepared and released. (NBS Report 6518) These wands are a substantial improvement over the wands now being used by the Navy. They are lighter and unbreakable. The average luminance of the improved C-size flashlight wand is 20 times that of the present wand and considerably more uniform. Twenty additional C-size flashlights have been equipped with wands as part of task TED NBS SI-5008.

The design of goggle (eye-ball) lights has been completed and twenty sets of goggles are being equipped with these lights. Each set of goggles has two lights mounted on the top of the goggles above the nose piece. These lights use 2-volt, 0.06-ampere lamps and are supplied by two A-size flashlight cells connected in series and mounted on either side of the lights. A switch is located in the mount of the lights.

LSE Suit. (TED NBS SI-5008) Two LSE suits are being modified for use in directing helicopter landings during the forthcoming Landing Personnel Helicopter (LPH) operations. Since the position of the flight director is not fixed, the suits must be battery powered. Therefore, the number of lights on a suit will be reduced to 60, about one-third the number used on the LSO suits. In addition, the lamps used will be 2-volt, 0.06-ampere lamps instead of 28-volt, 0.04-ampere lamps. As the viewing distances will be short, the resulting reduction in intensity is expected to be permissible.

VI. PHOTOMETRIC AND ELECTRICAL TESTS OF AIRFIELD AND SEADROME LIGHTING EQUIPMENT (TED NBS SI-5003)

Filters for PAR-56 Approach-Light Lamps. Tests have been completed of the use of tempered-glass roundels for use as filters for approach-light lamps. These roundels withstood temperature shocks of 150°C and simulated rough service conditions satisfactorily. Changes in the specification requirements for these filters have been recommended (and have been incorporated in drawing MS 24489 by the Air Force.)

Life Test of 500-Watt, 20-Ampere, PAR-56 Lamps. A study has been made of the intensity - life characteristics of 500-watt, 20-ampere, PAR-56 lamps to obtain data for use in modifying the life-test requirements of Specification MIL-L-6363B. This study indicated that the rated life of these lamps could be 125 hours based on the maintenance of 70% of the initial intensity measured at the angle of elevation at which the peak intensity occurs initially. The data obtained from the study have been released in NBS Test 21P-34/59.

"Night-Vision" Floodlights. The data obtained from photometric intensity distribution measurements of a production-run L. C. Doane "night-vision" floodlight have been used to compute the illumination that would be obtained on the horizontal surface of a 200-foot-wide runway if these lights were placed on both sides of the runway, 25 feet from the runway edge, with a spacing of 10 feet between the lights. Illumination as a function of distance across the runway has been computed for several mounting heights, for lights equipped with the standard 14-inch-long hood, and for a special 24-inch-long hood fabricated at the National Bureau of Standards. This latter hood was used in order to increase the intensity at angles of elevation near the horizontal to increase the illumination in the center of the runway. If the lights were mounted 4-3/4 feet above the edge of the runway, the horizontal footcandles incident on the runway would vary from 0.35 footcandle near the edges of the runway to 0.2 footcandle in the center of the runway. This variation in illumination would be nearly imperceptible. The report on this test is being prepared and will be released in the next quarter.

Tests have been made of the use of lamps with higher current filaments in a "night-vision" floodlight. The peak intensity of the light when a 100-watt, 6.5-volt (16-ampere) lamp was used was 65% of the peak reported in NBS Test 21P-13/58 in which a 200-watt, 6.6-ampere lamp was used. Since the light uses a horizontal spread lens, the intensity of a 200-watt, 20-ampere lamp would be about twice that of the 100-watt lamp. Thus a gain of 30% in peak intensity is indicated. The light would also have a slightly smaller vertical beam spread. This would improve the uniformity of the illumination across the runway.

Runway Marking Materials. Daytime and nighttime tests were made of the runway marking materials installed at Washington National Airport, as part of a terminated Air Force project. The data from these measurements and the photographs were studied and assembled with the previous data for inclusion in the report which was written during this quarter. This report presents the results of the measurements of the performance of the materials during the seventeen months of exposure.

Tests of Direct-Burial Cable. Tests have been made on a sample of No. 6 direct-burial cable, which has been in stock for a number of years, to determine the serviceability of the cable. A report giving the results of the tests is being drafted.

Tests of Airfield Lighting Connectors. Because of the low soil conductivity during the prevailing dry weather at Arcata, no insulation resistance tests were made of the buried connectors during this period. A method was developed for using a sensitive electrometer in place of the microammeter in the high-voltage insulation tester and will be used for future measurements. This will permit a more accurate measurement of very high insulation resistances.

Samples of "Scotch-Cast" connectors have been fabricated using "Stakon" and "Scotch-Lok" wire connectors. These samples have been submitted to accelerated service tests, and the millivolt drop across the connectors has been measured to compare effects of the two types of wire connectors. The samples are at present undergoing a weather exposure test after which further measurements of the millivolt drop across the connectors will be made.

VII. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

Kinorama. Arrangements were coordinated for the transfer of the kinorama from the School of Aviation Medicine to the Institute for Vision Research, Ohio State University.

Standards for Runway Lighting and Marking. Technical assistance has been given Technical Group No. 14 ACC/AGA National Standards Section in the preparation of revised drafts of the National Standards for runway lighting and marking.

VIII. MISCELLANEOUS

Fog Dispersal. The tests of fog dispersal equipment at the Arcata Airport by the Cambridge Research Center and the Atmospheric Research Group in "Operation Pea Soup" have been hampered by a fog season which had very few low visibility conditions. Also the particle spectrum counters have not operated satisfactorily. For this reason there will be no opportunity for correlation of our test measurements with particle size and distribution for this fog season. This group plans further tests at Arcata next year. Efforts will be made to correlate our data with the data taken by them at that time.

October 1959

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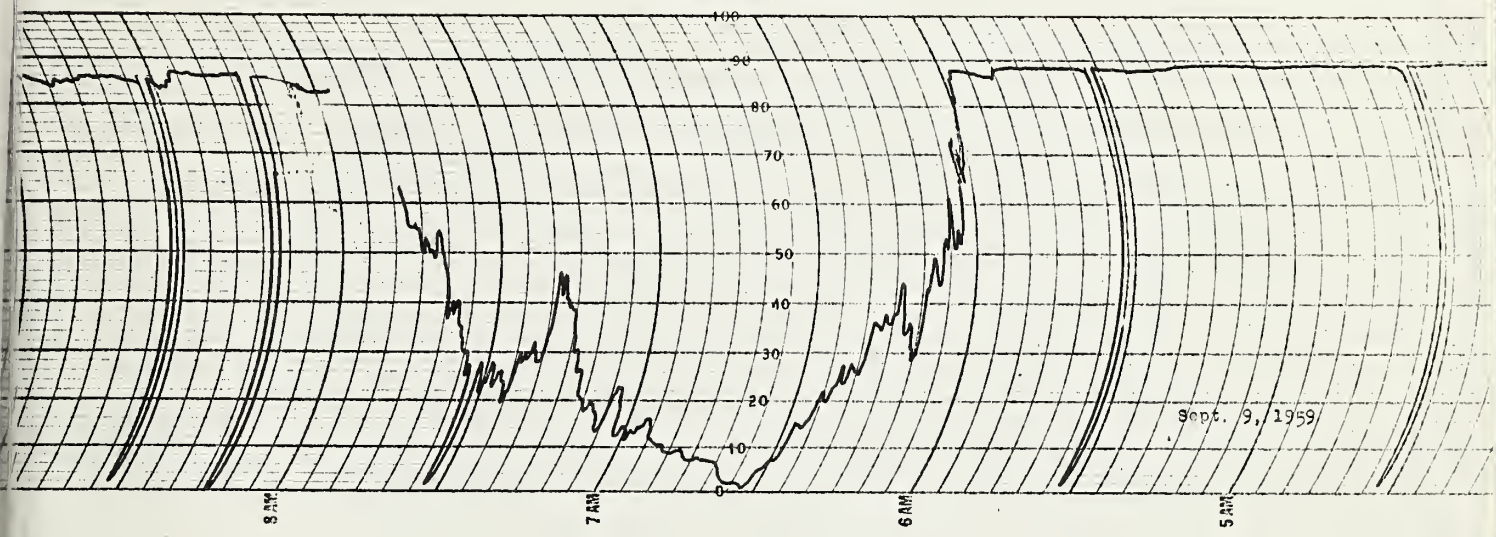
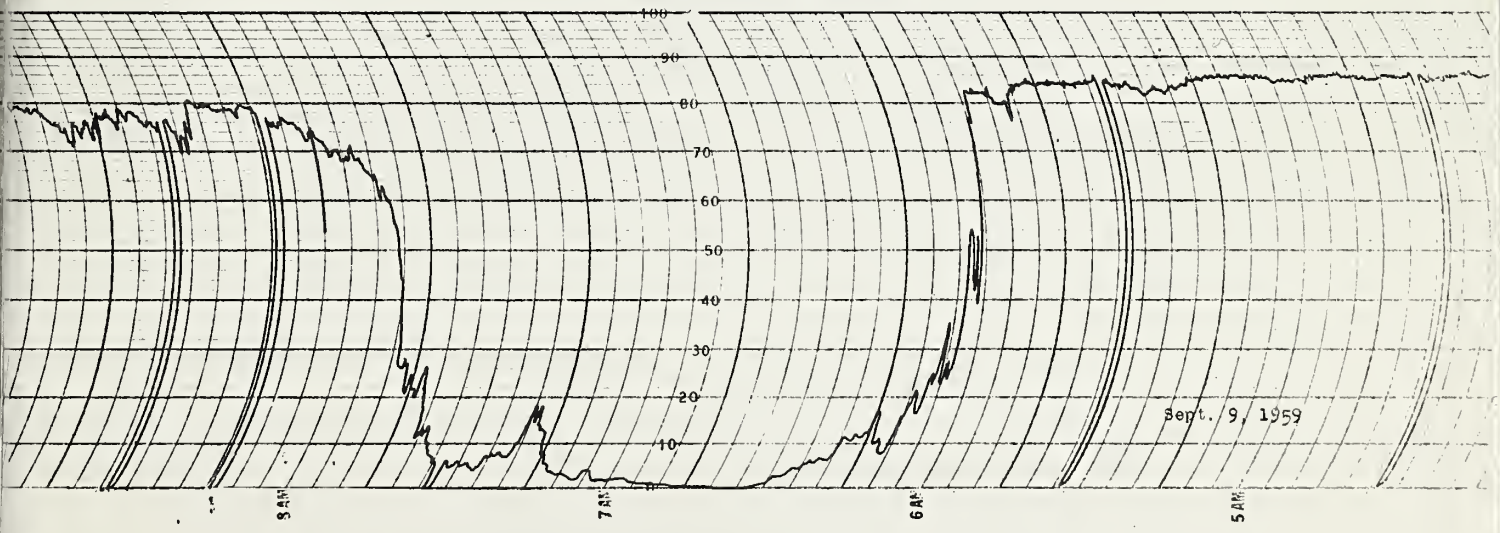
NBS Non-Linear Indicator



Standard Linear Indicator



SIMULTANEOUS TRANSMISSOMETER RECORDS MADE WITH NON-LINEAR AND LINEAR INDICATORS

Figure 1

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, *Secretary*

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

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer. Concreting Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation.

• Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research. Radio Warning Services. Airglow and Aurora. Radio Astronomy and Arctic Propagation.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Research. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation Obstacles Engineering. Radio-Meteorology. Lower Atmosphere Physics.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

Radio Communication and Systems. Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Ultra High Frequency and Super High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.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