Hydraulic Research in the United States

1960

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Miscellaneous Publication 231

AUTHENTICATED
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UNITED STATES DEPARTMENT OF COMMERCE • Frederick H. Mueller, *Secretary*
NATIONAL BUREAU OF STANDARDS • A. V. Astin, *Director*

Hydraulic Research in the United States

1960

(Including Contributions from Canadian Laboratories)

Edited by Helen K. Middleton

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FOREWORD

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

Projects are numbered chronologically, and the number once assigned is repeated for identification purposes until a project is completed. Numbers commencing with 3373 refer to projects which are reported for the first time. All projects are in active state, unless otherwise noted under (f).

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

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

A. V. Astin, Director

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Key to Projects

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

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QUEEN'S UNIVERSITY 179
Hydraulics Laboratory, Kingston, Ontario, Canada
Prof. R. J. Kennedy, Directing Head

UNIVERSITY OF ARKANSAS, Agricultural Experiment Station.

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

(b) Arkansas Agricultural Experiment Station cooperative with U. S. Geological Survey and U. S. Corps of Engineers.
(c) Prof. Kyle Engler, Head of Agricultural Engineering Dept., University of Arkansas, Fayetteville, Arkansas.
(d) Basic and applied research.
(e) A 16-inch vertical recharge well is surrounded by test wells for the purpose of observing hydraulic information and for sampling chemical quality and bacterial analyses. A series of tests of short duration have been run using treated surface water as recharge media. This water has been copper sulphated to kill plankton, treated with alum to flock out collodial materials, chlorinated to kill bacteria, and aerated to remove free air. This treated water has given satisfactory results in the tests. A straight 26-inch, sand packed recharge well has been completed and is still under test. The next step will be using injection water under pressure to eliminate any possibility of air contamination and probably the use of Separan AP-30 as a means of clarifying injection water.
(g) The project is not developed to a point for satisfactory reporting.

UNIVERSITY OF ARKANSAS, Civil Engineering Dept.

(2741) ROCKEFELLER FILTRATION PROJECT.

(b) Laboratory project.
(c) Prof. L. R. Heiple, Head, Civil Engineering Dept., Univ. of Ark., Fayetteville, Arkansas.
(d) Experimental and field investigation; applied research; has been used for three masters theses to date.
(e) Involves a study of the removal of turbidity and bacteria from surface water supplies using coarse grained media (1/4 in. to 1 in.). The variables investigated included (1) Depth of bed; (2) size of media; (3) shape and nature of media; (4) effect of head of water on filter bed; and (5) rate of filtration. Laboratory model investigations are complete with long range field study underway for the past year.
(f) Completed.
(g) Field studies have disclosed that turbidity from normal surface waters may be substantially reduced by filtration, without prior treatment through a coarse grained material such as pea gravel. With a 16 in. bed of 1/4 to 1/2-inch gravel as a filter media and operation at a rate of 1/10 gallon per sq ft per minute the average efficiency of turbidity removal is well in excess of 50 percent and has achieved 90 percent efficiency on occasions. Such a filter has a capacity for effective long range operation without development of appreciable head loss or the need for cleaning and with minimum attention. Such filtration will also remove at least 50% of total bacteria present in normal waters. Filtration efficiency is most effective in low turbidity waters where particle size is predominately colloidal.
(h) "Effectiveness of Coarse-Grained Media for Filtration", by Loren R. Heiple, Jour. Am. Water Works Assn., Vol. 51, No. 6, June 1959.

THE BALDWIN-LIMA-HAMILTON CORPORATION, Hydraulic Turbine Laboratory.

Inquiries concerning Projects Nos. 271, 2050, 2500, 3007, 3373, and 3374 should be addressed to Mr. W. R. MacNamee, Chief Engineer, Hydraulic Turbines and Marine Products Division, or Mr. A. W. Madora, Supervisor, Hydraulic Research Laboratory, Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pennsylvania.

(271) ADJUSTABLE AND FIXED BLADE PROPELLER-TYPE HYDRAULIC TURBINE MODELS.

(b) Laboratory project.
(d) Experimental; applied research for design.
(e) To improve performance of present designs, and to extend the range of application of this type turbine. Propeller runners of various designs in combination with modified turbine settings are methodically tested in the 11-inch cavitation flume. Efficiency output, cavitation, runaway speed, hydraulic thrust, and hydraulic blade torque are measured.
(g) Results provide data for improvement of existing design and information for designs which extend the range of application.

(2050) PUMP TURBINE LABORATORY.

(b) Laboratory project.
(d) Experimental; applied research.
(e) Pump-turbines, of various specific speeds, have been designed and tested in settings hydraulically similar to proposed field installations. The performance characteristics of efficiency, discharge, runaway speeds, horsepower, cavitation, thrust data for thrust bearing, and wicket gate torques.
(g) Results provide data for the design of future proposed installations and modifications to existing designs.

(2500) AXIAL FLOW PUMP LABORATORY.

(b) Laboratory project.
(d) Experimental; applied research.
(e) Axial flow pumps of various specific speeds have been designed and tested. Investigations pertaining to the number of impeller blades, proper diffuser vane

angle and intake conditions, have been completed. Performance characteristics of efficiency, discharge, horsepower, runaway speeds and blade torques have been obtained.

(g) Results provide data for the design of future proposed installations, and modifications to existing designs.

(3007) AIR TEST FLUME.

(b) Laboratory project.
(d) Basic research.
(e) The purpose of constructing an air test flume is for expediency in obtaining basic information pertaining to flow patterns of model pumps, turbines, and pump turbines at both inflow and outflow and for other component parts. The information obtained will be utilized in determining blade shapes and contours, suitable angles at entry and exit of model runners and pumps.

(3373) WHEELER DAM HYDRO PROJECT.

(b) Tennessee Valley Authority.
(d) Official contract acceptance tests.
(e) A complete homologous model of a fixed blade propeller is currently being tested, encompassing the operating conditions expected in the field.
(g) Results obtained thus far meet all guarantees as set forth in the specifications.

(3374) GREERS FERRY DAM AND RESERVOIR, LITTLE RED RIVER, ARKANSAS.

(b) Corps of Engineers, Little Rock District.
(d) Official contract acceptance tests.
(e) A complete homologous model of a Francis turbine was tested, encompassing the operating conditions expected in the field.
(f) Completed.
(g) Results obtained generously exceed all guaranteed conditions as requested by the Corps of Engineers in the specifications.

POLYTECHNIC INSTITUTE OF BROOKLYN.

(3375) FLOOD PLAIN ZONING.

(b) Laboratory project.
(c) Prof. Matthew W. Stewart, Assoc. Prof. of Civil Engineering, Polytechnic Inst. of Brooklyn, 333 Jay Street, Brooklyn 1, N. Y.
(d) Theoretical for masters thesis.
(e) A study to determine the economic feasibility of flood plain zoning.

(3376) FLOW THROUGH CULVERTS.

(b) Laboratory project.
(c) Prof. Matthew W. Stewart, Assoc. Prof. of Civil Engrg., Polytechnic Inst. of Brooklyn, 333 Jay Street, Brooklyn 1, New York.
(d) Experimental for masters thesis.
(e) Experimental study to determine the nature of flow through culverts.
(g) Apparatus under construction.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Engineering Division.

(1548) SPECIAL PROBLEMS IN HYDRODYNAMICS.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. Milton S. Plesset, Calif. Inst. of Technology, Pasadena, California.
(d) Theoretical and experimental; basic research.
(e) Studies of cavitating and noncavitating flow; dynamic behavior of cavitation bubbles; theoretical and experimental studies of cavitation damage.
(h) "Unsteady Supercavitating Flows," by T. Y. Wu, Calif. Inst. of Tech., Engineering Div., Report No. 85-11, July 1959.
"On Cathodic Protection in Cavitation Damage," by Milton S. Plesset, Calif. Inst. of Tech., Engrg, Div., Rep. No. 85-12, July 1959.
"Growth of Vapor Bubbles in a Rapidly Heated Liquid," by S. A. Zwick, Calif. Inst. of Tech., Engrg. Div., Rep. No. 85-13, September 1959.
"Water Waves Generated by Thin Ships," by M. S. Plesset and T. Y. Wu, Calif. Inst. of Tech., Engrg. Div. Rep. No. 85-14, Oct.1959.

(1816) FORCE CHARACTERISTICS OF SUBMERGED HYDROFOILS UNDER CAVITATING CONDITIONS.

(b) Bureau of Ships, Dept. of the Navy.
(c) Prof. Milton S. Plesset, Calif. Inst. of Technology, Pasadena, California.
(d) Theoretical and experimental; basic research.
(e) Studies of hydrofoils.
(h) "Numerical Evaluation of the Force Coefficients for Supercavitating Hydrofoils," by Z. M. Lindberg, California Inst. of Tech., Engineering Div., in preparation.
"Experimental Investigations of Three-Dimensional Effects on Supercavitating Hydrofoils," by R. W. Kermeen, Calif. Inst. of Tech., Engrg. Div., in preparation.
"Supercavitating Flow with a Slender, Pointed Hydrofoil," by E. Cumberbatch and T. Y. Wu, California Inst. of Tech., Engineering Division, in preparation.
"Cavitating Flow with a Large Aspect Ratio Hydrofoil," by E. Cumberbath, Calif. Inst. of Tech., Engineering Div., in preparation.

(2258) THE RESUSPENSION OF FLOCCULENT SOLIDS IN SEDIMENTATION BASINS.

(b) National Institutes of Health, U. S. Public Health Service.
(c) Dr. J. E. McKee, California Inst. of Tech., Pasadena, California.
(d) Experimental, directed from theoretical considerations. Applied research, as to performance of laboratory settling tank. Basic research on settling properties of suspensions was subject of Ph.D. thesis for Dr. R. T. McLaughlin (see publication listed below).
(e) The purpose of the project is (a) to investigate the resuspension of flocculent settled material from the sludege bed in

settling tanks, (b) to minimize this resuspension, thereby improving the efficiency of settling tanks, and (c) to test the methods evolved from theory in laboratory models and full-scale settling tanks.

(f) Completed.

(g) This investigation has been conducted in three parts, (a) tests of removal performance in primary sewage settling tanks, (b) tests of resuspension and removal of non-flocculent suspensions in 15-inch wide laboratory flume, and (c) similar tests utilizing a flocculent suspension introduced continuously. The laboratory flume is equipped with an endless chain-belt type of sludge removal equipment. The full-scale plant tests indicated that removal efficiencies are greatly affected (favorably) by flocculation. A critical velocity for resuspension of settleable solids was found to be about 8.5 ft per min. In the laboratory tests utilizing gilsonite (spec. gr. of 1.04) particles, it was found that water velocities greater than 12 times the settling velocity caused appreciable entrainment (when sludge scrapers were running). Studies with continuous injection of alum floc in the laboratory flume at 0.75 ft depth reveal a sharp decrease in removal between flow velocities of 0.035 and 0.06 ft per sec, indicating a range of critical velocities. The installation of transverse baffles, spaced 2 inches apart, and sloping (with the upper end) downstream, occupying approximately the lower half of the tank depth, did not appreciably improve removal efficiency either in the laboratory or field tests.

(h) "Resuspension of Solids in Sedimentation Basins", by R. T. McLaughlin and A. C. Ingersoll, PUBLIC WORKS, Vol. 89, No. 12, pp. 108-109, December 1958.
"The Settling Properties of Suspensions", by Ronald T. McLaughlin, Jr., Jour. of Hydraulics Div., Vol. 85 No. HY12 Proc. ASCE, pp. 9-39 December 1959.

(3377) THEORETICAL STUDIES IN HYDRODYNAMICS.

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

(c) Prof. T. Y. Wu, Calif. Inst. of Tech., Pasadena, California.

(d) Theoretical; basic research.

(e) Studies of hydrodynamic flows with free surface phenomena; steady and unsteady cavity flows; principle of fish propulsion.

(h) "Some Features of Unsteady Cavity Flows", by T. Y. Wu and D. P. Wang, Calif. Inst. of Tech., Engineering Div., Report No. 97-1, in press.
"A Modified Wake Hodograph for Free-Streamline Flows", by T. Y. Wu, Calif. Inst. of Tech., Engineering Div., Report No. 97-2, in preparation.
"A Preliminary Study of the Principle of Fish Propulsion", by T. Y. Wu, Calif. Inst. of Tech., Engineering Div., Report No. 97-3, in preparation.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Hydrodynamics Laboratory.

(2502) MECHANICS OF CAVITATION DAMAGE.

(b) National Science Foundation.

(c) Dr. A. T. Ellis. Assoc. Prof. of Applied Mechanics, Calif. Inst. of Tech., Pasadena, Calif.

(d) Project is both experimental and theoretical. It is primarily basic research, but it is anticipated that it will also have applications. The work will be the basis of two doctoral theses.

(e) The purpose of the project is to determine the detailed mechanism of mechanical damage by cavitation, and to attempt to correlate this with field results. The collapse of a cavitation bubble of arbitrary shape close to, or in contact with a solid boundary is being considered. Mechanical damage from bubbles not in contact with the boundary can result only from shock waves in the liquid. Preliminary work showed that these shock waves existed, but that they were too weak to be considered as a damaging mechanism. Bubbles in contact with the boundary were next considered. Experiments showed that for all but the hemispherical cavities perfect fluid theory with constant cavity pressure would yield good results concerning the change of shape of the bubble during collapse and the pressure at collapse. The high pressure is in this case generated by water hammer. It is anticipated that the infinite collapse velocities which are encountered in theoretical treatment of hemispherical cavities can be eliminated by taking into account the compression of permanent gas, and the partial compression of vapor at very high compression rates. Very little is known about this last subject, and it is anticipated that an attempt will be made to obtain some data in this field.

(g) The perfect fluid theory for collapse of a non-hemispherical cavity in contact with a solid boundary has been worked out and checked experimentally.

(2746) HYDRODYNAMICS OF UNDERWATER BODIES.

(b) Bureau of Ordnance, Dept. of the Navy.

(c) Dr. Vito A. Vanoni, Hydrodynamics Lab., Calif. Inst. of Tech., Pasadena, Calif.

(d) Experimental and theoretical investigations.

(e) Investigations of the mechanics of hydrodynamic phenomena involved in the motion of underwater bodies, including (1) studies of forces on such bodies in cavitating and non-cavitating conditions; (2) investigations of the detailed mechanics of the fluid motions giving rise to the above forces.

(3009) CAVITATION SIMILITUDE.

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

(c) Prof. A. J. Acosta, Calif. Inst. of Tech., Pasadena, Calif.

(d) Experimental program of basic unclassified work.

(e) To determine the effect of the various

thermal properties on cavitation in a venturi tube. It is known that cavitation similitude parameters based upon the vapor pressure of the liquid at the bulk temperature are misleading since the pressure in the cavity may be less or may exceed this value depending on air content, speed, size, thermal conductivity, etc. To investigate this question, a simple test loop with a venturi-section made with glass windows has been constructed and run with water. In the future, other fluids will be used. Measurements of cavity pressure, air content, temperature, are being made.

(g) Results in water ranging in temperature from 70° to 200° show that the cavity pressure can depart appreciably from the value at the bulk temperature. The results are still incomplete and inconclusive.

(h) "Remarks on Cavitation in Turbo Machines", A. J. Acosta, A. Hollander, Report E 79.3 Div. of Eng., Calif. Inst. of Technology, October 1959.

(3010) FULLY CAVITATED HYDROFOIL NEAR A FREE SURFACE.

(b) Bureau of Ordnance, Dept. of the Navy.

(c) Prof. A. J. Acosta, Calif. Inst. of Tech., Pasadena, Calif.

(d) Unclassified basic research.

(e) Experimental investigation of the lift and moment of a fully cavitating two-dimensional flat plate hydrofoil near a free surface. Pressure distributions and cavity proportions for various angles of attack, cavitation numbers and depth in chords are being found. Basic research, part of which is being done as the thesis for an advanced degree.

(f) Completed.

(g) The results at the deepest submergence tested (2.2 chords) nearly agree with the results of exact potential flow calculations in a free stream. The effect predicted for the proximity of the free surface was not realized, however, due to the combination of relatively low Froude number and finite bottom.

(h) "An Experimental Investigation of a Fully Cavitating Two-Dimensional Flat Plate Hydrofoil near a Free Surface", thesis for Aeronautical Engineering Degree by Thomas E. Dawson, June 1959 Div. of Eng. Calif. Inst. of Technology.

(3378) CAVITATION IN CASCADES.

(b) Office of Naval Research Dept. of the Navy.

(c) Prof. A. J. Acosta, Calif. Inst. of Tech., Pasadena, Calif.

(d) Theoretical basic unclassified research.

(e) Study of flow through a cascade of cavitating circular arc hydrofoils. Linearized theory is used to get lift and drag coefficients, cavitation numbers and burning for the case of infinitely long cavities.

(h) "Cavitating Flow Past a Cascade of Circular Arc Hydrofoils", A. J. Acosta, Rep. E-79.2, Calif. Inst. of Tech., Div. of Engineering, (in preparation).

(3379) EXPERIMENTAL INVESTIGATION OF CAVITY COLLAPSE PRESSURES.

(b) Bureau of Ordnance, Dept. of the Navy.

(c) Dr. Albert T. Ellis, Hydrodynamics Laboratory, Calif. Inst. of Tech., Pasadena, Calif.

(d) Experimental program of basic research.

(e) The purpose of the project is to experimentally investigate the pressure developed at the site of collapse of a transient cavity. Single, hemispherical spark cavities are created in water at the pressure end of a composite dural--flint glass--lead pressure bar. At the collapse of such a cavity, a transient stress pulse is propagated along the bar which is detected by an x-cut circular disk of quartz of the same diameter as the bar and which is recorded photographically from an oscillograph. These photographic records yield information regarding the total lifetime of the cavity and the maximum amplitude and time variation of the force developed during its collapse. An ultra-high speed photographic technique permits an estimate of the peak pressure developed at the site of collapse of the cavity to be made.

(g) Cavities having maximum diameters up to $\frac{1}{2}$ inch have been studied during the course of these experiments and collapse pressures of at least 10,000 atmospheres have been observed.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Sedimentation Laboratory.

(2747) STUDY OF THE DESIGN OF LOW DROPS AND THEIR EFFECT ON THE CAPACITY OF FLOOD CHANNELS.

(b) U. S. Dept. of Agriculture, Soil Conservation Service, Berkeley, Calif.

(c) Prof. Vito A. Vanoni, Sedimentation Lab., Calif. Inst. of Technology, Pasadena, Calif.

(d) Experimental investigation carried on by graduate students.

(e) The work is carried out in a specially designed tilted flume to obtain information for use in connection with the design of flood control channels.

(g) Tests have been completed and the final report prepared. The report gives design dimensions for rectangular drops with heights equal to 0.3 and 0.5 times the critical depths for flows with Froude numbers ranging as high as 1.5.

(h) "Experimental Design of Low Rectangular Drops for Alluvial Flood Channels", by Vito A. Vanoni and Robert E. Pollak, Sedimentation Laboratory Report No. E 82, September 1959.

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

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

(c) Prof. Vito A. Vanoni, Prof. Norman H. Brooks, John F. Kennedy, California Institute of

Technology, Pasadena, California.
(d) Experimental and analytical basic research.
(e) This work, the experimental part of which will be carried on in laboratory flumes, is an extension of the program of sedimentation research which has been carried on by the Sedimentation Laboratory for some time. The program is devoted primarily to a study of the roughness and sediment transport in alluvial streams with anti-dunes and standing surface waves, which are usually associated with Froude numbers in the vicinity of one or slightly greater.
(g) No reports are available. The project is about 90 percent complete.

UNIVERSITY OF CALIFORNIA, College of Agriculture, Department of Irrigation.

(21) STUDY OF HYDRAULICS OF SPRINKLING SYSTEMS.

(b) California Agricultural Experiment Station.
(c) Prof. J. R. Davis, Dept. of Irrigation, Univ. of California, Davis, Calif.
(d). Experimental; theoretical and field investigation.
(e) Investigations to evaluate sprinkler irrigation vs surface irrigation with respect to water application, relative production, effect of fertilizers, and production are continuing. Laboratory studies are continuing on sprinkler nozzles to evaluate (1) present methods of measuring discharge from sprinkler nozzles, (2) the effect of nozzle geometry on the coefficient of discharge, and (3) the influence of impinging jets on the uniformity of distribution of water.
(h) "Field Comparison of Sprinkler Irrigation With Surface Irrigation for Production of Mountain Hay", J. A. Corry and W. A. Fry, Jan. Mimeo. 1959.
"Spray Characteristics of Converging Sprinkler Nozzles", by John M. Langa and John R. Davis, Agr. Engin. 40(8):447-449, 1959.

(23) HYDROLOGY OF IRRIGATION SUPPLIES IN CALIF.

(b) California Agricultural Experiment Station.
(c) Prof. R. H. Burgy, Dept. of Irrigation, Univ. of California, Davis, Calif.
(d) Experimental and field investigation; applied research and operation.
(e) Studies were continued on the hydrologic effects of various watershed practices. Work is continuing on a new electrical control system which provides timing synchronization for rainfall and runoff measurement on a series of major watersheds. Core boring equipment has been assembled for the purpose of sampling rocky watersheds. Samples will be used to calculate permeabilities in order to account for subsurface flow.
(h) "Costs and Benefits of Converting Chaparral and Chaparral Woodlands in California", by R. H. Burgy. Proc. of Second Annual Meeting, Arizonz Water Resources Committee and Watershed Management Div., State Land Dept., State of Arizona, pp. 49-58, Sept. 1958.
"Watershed Management Progress and Prospects", by R. H. Burgy. Minutes of the Irrigation Districts Assoc. of California Annual Convention, p. 57-60, 1958.
"Watershed Management Research", by R. H. Burgy. Report presented at the 12th Nevada Water Conference, Carson City, Nev. Mimeo. 17 pages, 1958.
"Water Yields as Influenced by Vegetation Management on Watersheds Below Snowline, by R. H. Burgy. Proc. First Intersociety Conf. on Irrigation and Drainage, San Francisco, 1957, pp. 19-23 1959.

(24) MEASUREMENT OF IRRIGATION WATER AND IMPROVEMENT IN FARM IRRIGATION STRUCTURES.

(b) California Agricultural Experiment Station.
(c) Prof. V. H. Scott, Prof. W. A. Hall, and Prof. J. R. Davis, Dept. of Irrigation, Univ. of California, Davis, Calif.
(d) Experimental; design.
(e) Attempts were made to devise an inexpensive totalizing meter for use on pump discharge pipes by the use of a small by-pass meter. Investigations of plastic ditch liners were also continued during 1959. A study was initiated on the use of plastics for levees and borders. A comprehensive study on the hydraulics of furrow irrigation systems is continuing in the field and laboratory. Tracer techniques are being developed.
(h) "Polyethylene Film for Ditch Linings", by J. A. Corry and Verne H. Scott, Irrigation Engineering and Maintenance 8(10):12-13, 1958.
"Installation of a Vinyl Film Reservoir Liner in the Coachella Valley,"by Jack A. Corry, Mimeo. 1958.
"Plastic Film Ditch Liners", by J. A. Corry, and D. R. Fox, Univ. of California Agr. Extension Service, pp. 1-5, 1959.
"Measuring Irrigation Water", by V. H. Scott and C. E. Houston, California Agr. Exp. Sta. Cir. 473, 1959.
"Farm Irrigation Structures--Hatrack Irrigation Pipe Trailer", by J. A. Corry and M. O'Brien, Univ. of California Agr. Ext. Service unnumbered leaflet, 1959.
"Polyethylene Film for Water Conservation", by J. A. Corry and V. H. Scott, Ger-Pak Agri-News, News Bull. No. 9, pp. 3-6, 1959.

(25) PHYSICAL AND CHEMICAL FACTORS AFFECTING SOIL INFILTRATION RATES.

(b) California Agricultural Experiment Station.
(c) Prof. L. D. Doneen, Prof. D. W. Henderson and J. W. Biggar, Univ. of California, Davis, Calif.
(d) Experimental and field; basic and applied research.
(e) Investigations on soil and water management practices have been continued in the field and laboratory.
(g) Results of the investigation concerned with the effect of changing from one water quality to another show that these changes in water quality often impair infiltration.
(h) "Soil Subsidence in the San Joaquin Valley", by D. W. Henderson. Presented at the 37th

Annual Meeting, Amer. Soc. Agr. Engin., Feb.4-5, 1959.
"Evaluating the Quality of Irrigation Waters in Ventura County," L. D. Doneen, In Water Quality and Water Quality Problems, Ventura County, State of Calif. Dept. of Water Resources Bul. No. 75, 1959.
"Some Effects of Organic Additives on Compressibility of Yolo Silt Loam Soil," Howard M. Taylor and Delbert W. Henderson, Soil Sci. 88(2): 101-106, 1959.
"Factors Affecting Irrigation Practice and Water-use Efficiency," D. W. Henderson, In Advances in Agronomy 11:98-104, 1959.

(1819) DRAINAGE IN RELATION TO IRRIGATION.

(b) Calif. Agricultural Experiment Station.
(c) Prof. J. N. Luthin and Prof. V. H. Scott, Department of Irrigation, Univ. of Calif., Davis Calif.
(d) Experimental and field investigation; basic and applied research.
(e) Analytical studies on basic flow problems are continuing. Electrical analogs are being used to check theories on flow into and around tile lines as influenced by the presence of impermeable layers. A new study on developing criteria for the selection and use of wells in controlling the water table was initiated.
(h) "Investigation of an Artesian Well Adjacent to a River," V. H. Scott and J. N. Luthin, ASCE Jour. of the Irrig. and Drainage Div., 85, No. IR1, Pt. 1, pp. 45-62, 1959.
"Area-wide Drainage," Jewell L. Meyer and Clyde E. Houston, Calif. Agr. 13(7):11, 1959.

(2055) THE PHYSICS OF SOIL MOISTURE MOVEMENT.

(b) California Agricultural Experiment Station.
(c) Prof. J. N. Luthin, Dept. of Irrigation, Univ. of Calif., Davis, Calif.
(d) Laboratory and theoretical studies; basic research.
(e) Analog studies were continued to determine the optimum depth for drains in stratified soils under ponded water conditions. The resistance network analog has been used to study the water table shape and rate of drop.
(h) "The Falling Water Table in Tile Drainage II," James N. Luthin, Proposed criteria for spacing tile drains, ASAE Trans. 2(1):44-47, 51, 1959.
"A Resistance Network Analog for Studying Seepage Problems," Robert V. Worstell and James N. Luthin, Soil Sci. 88(5):267-269, 1959.

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

Inquiries concerning the following projects should be addressed to Prof. A. F. Pillsbury, Dept. of Irrigation and Soil Science, Univ. of California, Los Angeles 24, Calif.

(26) DRAINAGE INVESTIGATION IN COACHELLA VALLEY, CALIFORNIA.

(b) Cooperative between the Coachella Valley County Water District, Coachella, Calif., U. S. Salinity Laboratory, Riverside, Calif., U.S. Bureau of Reclamation, Boulder City, Nevada, and this laboratory.
(d) Field investigations; applied research and design.
(e) Work now concentrated on studies of drainage adequacy and of drainage yield. Change in salinity status of soil is index of drainage adequacy. Information being obtained on fluctuations of water table following irrigation, and on effect thereon of mechanically affecting soil stratification. Where drainage yield is being metered will seek to establish relationship to factors such as surface soil, crop, irrigation slope, etc.

(27) HYDROLOGY OF WATER SUPPLIES IN CALIFORNIA.

(b) Laboratory project cooperative with Pacific Southwest Forest and Range Experiment Sta., USFS, and with College of Engrg., Univ. of Calif. Los Angeles 24; coordinated with work of Dept. of Irrigation, Univ. of Calif., Davis, Calif.
(d) Experimental; applied research.
(e) Work now concerned with (1) Subsurface movement of moisture; (2) surface treatments affecting infiltration of precipitation; and (3) detention of precipitation by surface litter and effect upon infiltration.

(1058) SOIL PHYSICAL CONDITIONS IN RELATION TO IRRIGATION.

(b) Laboratory project, coordinated with work of Dept. of Soils and Plant Nutrition, Univ. of Calif., Riverside.
(d) Continuing laboratory and field studies.
(e) Present work involves (1) Evaluation of use of neutron moisture probe in following the downward movement of the wetting front and use of rate of that movement to evaluate changes in soil texture and structure with depth; (2) effects of surface tension and fluid viscosity on hydraulic conductivity of soil; and (3) effects of salt crystals per se on water movement into soil.
(f) Recently reactivated.

(1303) HYDRAULIC CHARACTERISTICS OF IRRIGATION DISTRIBUTION SYSTEMS.

(b) Laboratory project, cooperative with College of Engrg., Univ. of Calif., Los Angeles 24, Calif.
(d) Basic and applied research.
(e) Graduate student now working with model low pressure pipe system to study hydraulic transients occurring with automatic operation.

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

(b) Laboratory project, cooperative with College of Engineering, Univ. of California,

Los Angeles 24, Calif.
(d) Experimental; applied research.
(e) Solution by mathematical models on digital computers of midpoint water table recession rates between tile lines.
(h) "Shallow Ground Water and Tile Drainage in the Oxnard Plain," J. D. Isherwood and A. F. Pillsbury, Trans. Amer. Geophys. Union 39: 1101-1110, 1958.
"Water Table Recession in Tile-Drained Land," J. D. Isherwood. Discussion in Journal of Geophy. Res. 64:855-860, 1959.

UNIVERSITY OF CALIFORNIA, College of Engineering, Hydraulic Laboratory.

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

(40) FLOW AND HEAT TRANSFER CHARACTERISTICS OF GAS-SOLIDS MIXTURES.

(b) Laboratory project.
(d) Experimental; basic and applied research, design.
(e) The flow characteristics of a gas-solids mixture (Alumina catalyst and air) have been investigated in a 17 mm I. D. glass conduit for various gas flow and solids flow rates. Pressure drops across test sections have been accurately measured for a series of air flow rates in which the solids to air ratio is varied from zero to 11.0 pounds of solids per pound of air. The solids are introduced into the flow system through a mixing nozzle fed by a slide valve controlled weighing tank, and have a size distribution varying from particles less than 10 microns to particles greater than 220 microns. Investigation on the metering of solids-gas mixtures by nozzle and Venturi-tubes has been carried out. Studies on the heat transfer to flowing gas-solids mixtures have been carried out and are being continued. Metering and heat transfer studies are now being continued using fixed size glass spheres.
(g) Results on several different particle sizes indicate a pronounced influence on the flow and heat transfer characteristics of the mixtures used. The larger spherical glass particles have relatively no effect in increasing heat transfer rates when compared to the increases obtained from the smaller sized particles.
(h) "Heat Transfer to Flowing Gas-Solids Mixtures in a Circular Tube," by Leonard Farbar and Morgan J. Morley, Industrial Engineering Chemistry, Vol. 49, p. 1143, July, 1957.
"Heat Transfer to Flowing Gas-Solids Mixtures Using Solid Spherical Particles of Fixed Size," by C. A. Depew, M. S. Thesis, 1957, Univ. of Calif. Library, Berkeley, Calif.

(280) SEDIMENT TRANSPORT.

(b) Laboratory project and U. S. Corps of Engrs.
(d) Experimental and theoretical.
(e) Various fundamental problems in relation to sediment transport have been studied, and efforts have been made to apply the results of research to solve practical problems.
(f) Experimental work concluded.
(g) The changes in the bed-load relationships are studied as they result from high sediment concentrations near the bed. No results are available as yet.
(h) "Effects of Heavy Sediment Concentration Near the Bed on the Velocity and Sediment Distribution," H. A. Einstein and Ning Chien, Corps of Engineers Missouri River Div., Sediment Series No. 8.

(529) LITTORAL SEDIMENT FLOW UPON A BEACH.

(b) Beach Erosion Board, Dept. of the Army, Washington, D. C.
(d) Field, laboratory experimental and theoretical research.
(e) The object of this investigation is to study littoral transport upon beaches in the vicinity of San Francisco, California. For several years samples have been taken and beach profiles measured upon 18 beaches both north and south of the Golden Gate. The main purpose has been to measure the periodic amount of cut and fill upon the beaches and the variations in size and size distribution of the sediments on these beaches. During the current year these beaches have been occupied as in previous years, but the interval of occupation has averaged about four months instead of 6 weeks as in previous years. The change in character of the beaches has been essentially the same as in previous years except that Point Reyes Beach, 50 miles northwest of the Golden Gate eroded very badly at the site measured during the winter of 1958-1959, with all the sand back to the sea cliff being cut away as well as some 15 to 20 feet of the cliff itself. Also the beach at the extreme north end of the Great Beach on the coast south of the Golden Gate near the Cliff house eroded severely during the winter, and in the spring of 1959 was at its lowest position in several years. The pattern of grain size variation was essentially the same during the current year as in previous years.
During the year an effort was made to trace sand movement by means of measurement of the Thorium content in the sands with aid of a gamma ray spectrometer. Preliminary studies show considerable variation in the thorum concentration in the sands, which with the aid of more detailed surveys to be made during the coming year should give information as to pattern of movement of sand on some of the beaches near San Francisco.
(h) "Beaches Near San Francisco, California, 1956-1957," Parker D. Trask, Beach Erosion Board Tech. Memo 110, 89 pages, April 1959.
"Mechanical Analyses of Beach Sands near San Francisco, California," Parker D. Trask, Sigrid Snider, and Henry Klehn, Jr.,Univ.

of Calif. Institute of Engrg. Research Report, Series 14, Issue 22, 71 pages, January 1960.

(1554) SEA WATER CONVERSION RESEARCH.

(b) State of California.
(c) Professor Everett D. Howe, Director, Sea Water Conversion Laboratory, 177 Richmond Field Station, Univ. of Calif., Richmond, California.
(d) Experimental, theoretical, field investigation, and pilot plant; basic research, applied research, design, and operation.
(e) The purpose of this investigation is to discover whether there is available any method for the large-scale, low-cost demineralization of sea water. The project includes a number of investigations, of which the following have been active during 1958-59: (1) Solar distillation, (2) low temperature difference method, (3) use of high liquid pressures in combination with appropriate permeable membranes (osmotic pressures), (4) thermodynamic analyses of separation methods, (5) ion exchange using heat for regeneration, (6) vapor compression distillation measurements, (7) freezing as a means of separation, (8) electrodialysis tests, (9) tests on magnetic scale control unit, (10) multiple effect centrifugal evaporator project, (11) nuclear reactor studies, (12) biological conversion of saline waters, and (13) underground nuclear explosions as a possible source of heat energy for the distillation of sea water. Investigations are being carried on both at Berkeley and at Los Angeles. Work on the Los Angeles campus has emphasized Items 3 and 4.
(g) Detailed results may be obtained from the progress reports and publications listed under (h) below. This project has been active since 1951-52 and previous summaries have listed all reports prior to November 1958.
(h) The following reports and publications have been issued during the period since July 1958 and summarize the work to date:
UNIVERSITY OF CALIFORNIA AT LOS ANGELES:*
Progress Report April 1959.
Summary Report for period ending June 30, 1959.
Quarterly Progress Report March 1 - May 31, 1959, Report 59-46.
"Thermodynamic and Economic Considerations in the Preparation of Fresh Water from the Sea," Myron Tribus et al June 1959, Report 59-34.

UNIVERSITY OF CALIFORNIA AT BERKELEY:**
"Progress in Saline Water Conversion," Everett D. Howe, Journal American Water Works Association, Vol. 51, No. 10, Oct. 1959, pp. 1191-1201.
"Visitation of Research and Operating Plants concerned with the Demineralizing of Water in Europe, the Middle East and Africa," by Everett D. Howe, IER Series 75, Issue 10, February 1959, 14 pp.
"Exploratory Studies on Paraffin Wax as a Storage Medium for Solar Energy," by Leonard Farbar, IER Series 75, Issue 11, November 1958, 32 pp.
"The Costs of Demineralizing Water," by Everett D. Howe, IER Series 75, Issue 12, February 1959, 16 pp.
"How to Build a Solar Still," L. Edson, H. McCracken, and J. Weldy, IER Series 75, Issue 13, April 1959, 7 pp.
"Preliminary Economic Study of Sea Water Demineralization by Ion Exchange with Energy Regeneration of Exchangers," by Paul B. Stewart, IER Series 75, Issue 14, May 1959, 19 pp.
"Progress Report for the Year Ending June 30, 1959," IER Series 75, Issue 15, July 24, 1959, 28 pp.
"Performance Characteristics of Vacuum Deaeration Equipment," Series 75, Issue 16, John T. Chambers, September 1959, 28 pp.
"A Study of the Feasibility of Using an Underground Nuclear Explosion as a Source of Heat Energy for the Distillation of Sea Water," by I. Fatt, IER Series 75, Issue 17, September 1959, 31 pp.
"Sea Water Demineralization by Ammonium Salts Ion Exchange," by Paul B. Stewart, IER Series 75, Issue 18, September 1959, 64 pp.

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* Requests for copies should be directed to: Department of Engineering, University of California, Los Angeles, Calif.

**Requests for copies should be directed to: Sea Water Conversion Laboratory, 177 Richmond Field Station, University of California, Richmond, Calif.

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

(b) Beach Erosion Board.
(d) Experimental; basic research.
(e) To obtain experimental information on the criterion for initial and general movement of bottom sediment by wave action. Prototype conditions of the relative motion of water and bed were simulated by use of an oscillating plate in still water.
(g) A theoretical solution has been found for the turbulent boundary layer flow along an oscillating surface and was empirically checked for the smooth bottom. A solution has been found for the rough wall, but must be checked for various different types of roughness.

(1829) STUDY OF INCLINED GAS-LIQUID FLOW IN TUBES.

(b) Laboratory research project.
(c) Prof. A. D. K. Laird, 109 Mechanics Bldg., Univ. of Calif., Berkeley 4, Calif.
(d) Experimental and theoretical; basic research.
(e) Collection and correlation of data on several diameters of tubing at inclinations from horizontal to vertical.
(f) Completed.

(2059) STUDY OF BED-LOAD MOTION IN A FLOW SUBJECTED TO COMPOSITE FRICTION.

(b) Laboratory project, thesis study.

(d) Experimental.
(e) A granular bed is developed between a system of obstructions such as piles. It is attempted to determine the part of the flow resistence which determines the rate of sediment motion.
(f) Completed.
(g) In a thesis study limitations are investigated to the independence of frictional drag forces.
(h) "The Effect of Obstructions on Sediment Transport," K. Ieleja Aters Thesis M.S.C.E. 1959, Berkeley, Calif.

(2062) STRESS-STRAIN RELATIONSHIPS FOR SHEAR IN A SAND-WATER MIXTURE.

(b) Laboratory project.
(d) Experimental; basic research.
(e) The relationship is determined in an especially constructed rotating shear device for various normal pressures.
(f) Experimental work concluded.
(g) Results have been obtained. Work is now concentrating on the analysis of the results.

(2063) METHODS OF DETECTING AND TRACING THE MOVEMENT OF GROUND WATER.

(b) U. S. Bureau of Reclamation.
(d) Experimental; applied research.
(e) This study has as its objectives study of velocity variations observed in tracing the flow of liquids through porous media, development of methods and tracers for field determination of water movement underground, and application of these methods to location and measurement of seepage from canals.
(g) Experimental and analytic studies of dispersion in a radial flow pattern have been conducted. A report is in preparation. Field studies now underway consist of measurements of seepage from a ponded section of unlined canal. Tritium and chloride are being used to trace the movement of seepage from the canal.

(2261) WAVE REFRACTION RESEARCH.

(b) Beach Erosion Board, Dept. of the Army, Washington, D. C.
(e) In shallow water the velocity of a water gravity wave depends upon the depth of water as well as upon the length of the wave. When it travels in shoaling water it bends. This refraction changes the wave height and direction. Powerful graphical and analytical tools are available for use by the engineers; however, there is an almost complete lack of evidence as to their accuracy. The purpose of this contract has been to perform laboratory experiments to check the validity of the techniques used in practice. The first series of tests were performed in a ripple tank; these showed that the techniques were fairly reliable from a practical standpoint. A series of tests have been made in a model basin 150 feet by 64 feet by 2 1/2 feet deep. The results of these tests have been published. Tests have been conducted on the formation of secondary wave crests as periodic waves pass into shoal water, and the results have been found to compare favorably with theory. Studies are being made of the non-reflecting characteristics of waves incident to a steep slope, large plane angle shore.
(h) "Secondary Wave Crest Formation," Kiyoshi Hovikawa and R. L. Wiegel, Univ. of Calif., IER, Tech. Report 89-4, 23 pp. Feb. 1959. "The Propagation of Tidal Waves into Channels of Gradually Varying Cross-section (Effect of a Frictional Resistance over the Bed" by Paul Perroud, Tech. Memo. No. 112, Beach Erosion Board, Corps of Engineers, U. S. Army, 27 pp., May 1959.

(2262) ANCHORING FORCES RESEARCH.

(b) Shell Development Company.
(e) Model studies are being made of the forces in mooring lines of specially designed anchored vessels at sea. Tests are being made with uniform wave conditions.
(f) Completed.

(2265) FORCES ON ACCELERATED CYLINDERS.

(b) Engineering Foundation and laboratory project.
(d) Experimental; basic research.
(e) Measurement of drag coefficients and flow configurations about cylinders during accelerated motion in fluids as related to wave forces as cylinders.
(h) "Water Forces on Accelerated Cylinders." A.D.K. Laird, C.A. Johnson, and R.W. Walker, Journal Waterways and Harbors Div., Proc. Am. Soc. of Civil Engr., Vol. 85, No. WW1, Mar. 1959.

(2505) EFFECT OF SEDIMENT DISTRIBUTION IN STREAM CHANNELS.

(b) University project.
(d) Experimental; basic research.
(e) Alluvial flows in channels with artificially secured banks are studied systematically for their tendency to meander as expressed by the development of alternate bars. It is the aim of this study to develop criteria for stability.
(f) Experimental work concluded.
(g) The important parameters seem to be the Froude's number, the depth-width ratio and the size and uniformity of the bed sediment.

(2506) SEDIMENT MOTION IN SILT CARRYING STREAMS.

(b) National Science Foundation.
(d) Experimental; basic research.
(e) An alluvial stream with a bed material in the sand sizes or coarser follows relationships generally called bed-load formulas. This study tries to find what the corresponding laws are if the bed sediment consists mainly of particles in the silt sizes as fines.
(f) Experimental work concluded.
(g) The transport of silts coarser than 5 microns seem to follow laws very similar to those for fine sand.

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(2507) SAND DEPOSITS IN CANALS.

(b) U. S. Bureau of Reclamation.
(d) Experimental; basic research.
(e) The relationships are sought governing the deposit of various sediment sizes and types in lined canals under various flow conditions. Of particular interest is any resulting change of the effective channel roughness and of its flow capacity.
(f) Concluded.
(g) The case of fine sediment on a rough bottom has been solved. The case of coarse sediment on a smooth bottom follows the same laws as the first case.
(h) "Sand Deposits in Canals," H. A. Einstein and G. Kalkanis. Project report to the U.S. Bureau of Reclamation. Univ. of Calif., Berkeley IER series No. 93, Issue No. 6.

(2509) NON-STEADY FLOW ANALOGY.

(b) Department of Water Resources, State of California.
(d) Experimental; applied research.
(e) By means of an electric analog model of the San Francisco Bay and the Sacramento-San Joaquin Delta Region, the feasibility of barriers and channel works is being investigated, with the purpose of providing a greater flow of fresh water southward in the Central Valley.
(f) Completed.
(g) The tidal amplitude changes which should be expected due to the imposition of each of several proposed salinity barriers have been predicted, and are in accordance with analytic results where these are available. Prototype tidal amplitudes, phases, and currents were duplicated in the analog model within three to five percent at all major points. A new type of square-law resistor has been developed which takes into account changes in the water depth.
(h) "An Electric Analog Model of a Tidal Estuary," H. A. Einstein and J. A. Harder, Proceedings ASCE, Vol. 85, No. WW3, Sept. 1959.

(2751) DEVELOPMENT OF A TRASH RACK AND INTAKE STRUCTURE TO BARREL TYPE SPILLWAYS.

(b) U. S. Department of Agriculture.
(d) Experimental; developmental.
(e) Barrel type spillways can highly increase the effectiveness of small flood control retaining basins, if they can be prevented from plugging by floating trash. An effective intake and trash rack is developed from the viewpoint of clogging.
(f) Completed.
(g) A syphon-type intake with low intake velocity appears to provide for the most desirable hydraulic and trash conditions.
(h) "Model Studies of Spillways," P.F. Ruff, ES - 6079, Issue 1.

(2753) HYDRAULIC BREAKWATER.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental; applied research.
(e) Determination by model tests of the mechanisms by which hydraulic breakwaters dampen water gravity waves.
(g) Three dimensional tests in a model basin show that the effect of wave refraction due to the currents generated by the hydraulic breakwater is of primary importance. For certain conditions the area in the lee of the breakwater can be made to be almost free of waves, while for other conditions the waves behind the breakwater will be higher than if there were no hydraulic breakwater in operation. A series of model sizes have been used and a definite scale effect observed. Tests are being continued with the purpose of measuring the currents generated by the jets and then the effect of the currents on the waves, the purpose being to find out in which portion of the mechanism the scale effect occurs, or perhaps in both portions.
(h) "Shipboard Hydraulic Breakwater," by R. A. Dilley, Jour. Waterways and Harbors Div., ASCE, Vol. 84, No. WW2, Paper No. 1569, 21 pp. March 1958.
"Model Study of a Hydraulic Breakwater Over a Reef," C. M. Snyder, Jour. Waterways and Harbors Div., ASCE, Vol. 85, No. WW1, Paper No. 1979, pp. 41-68, March 1959.
"Scale Effects of Models of Hydraulic Breakwaters," John A. Williams, Univ. of Calif., IER, Tech. Report 104-7, 40 pp., Oct. 1958.
"Three-dimensional Model Studies of Hydraulic Breakwaters," K. Horikawa, Univ. of Calif., IER, Tech. Report 104-8, 43 pp. Oct. 1958.
"Pneumatic Breakwater (I), (II), and (III)," by Michinori Kurihara, Univ. of Calif., IER Reports 104-4, 5, and 6. Translations made by K. Horikawa.

(2755) DEVELOPMENT OF METHODS TO TRACE SEDIMENTS USING RADIOACTIVE MATERIALS.

(b) U. S. Corps of Engineers.
(d) Experimental; theoretical and field.
(e) Radioactive materials are sought which can be permanently attached to sediment grains from the sand to the clay sizes. The instrumentation is to be developed by which these tagged sediments can be observed in prototype water courses, particularly in the San Francisco Bay.
(g) Scandium-46 and gold-198 have been found to be the best suited materials. The instrumentation for field detection of radio activity has been developed. Three field tests in San Francisco Bay have been completed and analyzed. These tests have shown that claggy sediments are transported in salt water only in general suspension and are deposited in stable form from water flowing at less than two feet per second average velocities.
(h) "Second Annual Program Report on the Silt Transport Studies Utilizing Radioisotopes," 122 pp.

(3012) RADIAL FORCES IN A RADIAL FLOW CENTRIFUGAL PUMP.

(b) Laboratory project.

(d) Theoretical and experimental; basic and applied research.
(g) Radial forces on the impeller of a radial flow centrifugal pump were measured and were correlated with forces evaluated from the measured pressure distribution in the volute of the pump. A mixing analysis was made of the flow conditions in the volute. The volute pressure distributions and resulting radial forces were predicted. The analysis was extended to show the influence of the mixing in the volute on the pump performance.
(h) "Volute Pressure Distribution, Radial Force on the Impeller, and Volute Mixing Losses of a Radial Flow Centrifugal Pump," H. W. Iversen, R.G. Rolling, and J.J. Carlson. ASME Paper No. 59-HYD-10.

(3013) ARTIFICIAL INCREASE OF FRICTION IN ALLUVIAL CHANNELS.

(b) U. S. Department of Agriculture.
(d) Experimental.
(e) Decrease of flow velocities and consequently prevention of erosion in alluvial channel with limited capacity can be effected by increasing artificially the friction.
(f) Concluded.
(g) Low sills placed on the banks at properly determined intervals, result to a uniform dissipation of the excess energy along the channel.
(h) "Energy Dissipation by Bank Structures," G. Kalkanis and Z.I.A. Hashmi, ES-6150 Issue No. 1.

(3015) EDDY DIFFUSION IN OPEN CHANNEL FLOW.

(b) Water Resources Center and Sanitary Engineering Research Laboratory, Univ. of Calif., Berkeley, Calif.
(c) Prof. G.T. Orlob, 412F Hesse Hall, Univ. of California, Berkeley, Calif.
(d) Experimental verification of theories of eddy diffusion in statistically homogeneous flow. Basic research for doctoral thesis.
(e) Objectives of investigation included development of technique of determining scale of eddies and turbulence intensity and the experimental verification of the Kolmogoroff von Weizsacher similarity principle and the Richardson "Four-thirds Law." The theory of eddy diffusion by continuous movements as originally derived by Taylor provided the basis for the experimental determination of scale and turbulence intensity. A broad open channel with a rough bottom served to produce a turbulence which was statistically homogeneous in two dimensions. Dispersion patterns of floating polyethylene discs were analyzed in relation to scale, turbulence intensity, energy dissipation, Reynolds number, and Schmidt number. The coefficient of eddy diffusion was related to each of these factors.
(f) Completed.
(g) A simple method of determining eddy scale and turbulence intensity from particle dispersion patterns was developed. The Kolmogoroff von Weizsacher similarity principle was verified experimentally.
(h) "Eddy Diffusion in Homogeneous Turbulence," J. Hydraulics Div. ASCE, Vol. 85 No. HY9, pp. 75-101, Sept. 1959.

(3017) HELIUM AS A GROUND WATER TRACER.

(b) Laboratory project.
(d) Experimental and field; applied research.
(e) The purpose of this work is to determine the feasibility of helium as a ground water tracer. Included in the study have been methods of adding helium to water, methods of recovery and analysis, and rate of loss of helium from ground water.
(f) Completed.
(g) Laboratory and field experiments were conducted with helium as a ground-water tracer. Techniques were developed for the addition and extraction of helium from water. A mass spectrometer and a pressure-volume apparatus were used for helium measurements at concentrations in water ranging from 1.5 to 5.5 x 10^{-4} milligrams per liter. In the field investigations, flow was traced through a confined aquifer for a distance of 188 ft. Both laboratory and field experiments showed that helium traveled at a slightly lower velocity than chloride. Disadvantages of helium as a tracer are the relatively large errors in analysis, difficulties of maintaining a constant recharge rate, time required to develop equilibrium conditions in unconfined aquifers and possible loss to the atmosphere in unconfined aquifers.
(h) "Measurement of Helium in Ground Water Tracing," by R.C. Carter, D.K. Todd, G.T. Orlob, and W.J. Kaufman, Water Resources Center Contribution No. 21, Univ. of Calif., Berkeley, 56 pp., 1959.
"Helium as a Ground-Water Tracer," by R. C. Carter, W. J. Kaufman, G.T. Orlob, and D.K. Todd, Jour. Geophysical Research (in press).

(3018) GROUND WATER INFLOW.

(b) Laboratory project.
(d) Experimental; applied research.
(e) Seepage from leveed rivers into low-lying adjoining agricultural lands is studied by an electric analogy model. A variety of geologic cross-sections were selected to cover effects of layered anisotropic strata.
(f) Completed.
(g) Results of the model tests furnished flow nets and seepage rates and distributions for the cross-sections studied. Effects of two subsurface layers of different permeabilities and anisotropies, layer arrangements and thicknesses, channel depth and width, levee base width, and water table slope were evaluated. Flows were expressed dimensionlessly so that results can be applied to any given permeability and river stage. Furthermore, by means of a dimensionless scaling factor, the results can be modified to furnish estimates of seepage rate and distribution for many other cross-sections which only approximate the test conditions.

(h) "River Seepage Investigation," by D.K. Todd and J. Bear, Water Resources Center Contribution No. 20, University of California, Berkeley, 163 pp., 1959.

(3019) ANALOG MODELS FOR HYDRAULIC SYSTEMS.

(b) Laboratory project.
(d) Experimental and theoretical; design and development.
(e) Electric analog elements to represent all major hydraulic features of a flood control project are being designed and constructed, with the purpose of devising a tool enabling hydraulic engineers to optimize the design and operation of flood control systems.

(3020) BOUNDARY LAYER FRICTION IN THE DOLPHIN.

(b) Laboratory project.
(d) Experimental; basic research.
(e) Purpose is to elicit whether there is an anomaly in skin friction of dolphins.
(f) Suspended.

(3021) A HYDRAULIC STUDY OF SUSPENSION ON TRANSPORT OF ORGANIC SEDIMENTS SUCH AS ALGAE.

(b) Laboratory project.
(d) Field investigation; design and operations.
(e) Flow velocity sufficient to maintain suspension of algae is essential in the high-rate pond process and in streams receiving effluents from algal ponds. Observations were made of alga suspension as a function of flow velocity.
(f) Completed.
(g) Suspended algae remain in suspension at a mean flow velocity of 0.5 foot per second. A velocity of 1.0 foot per second will resuspend settled algae unless clumped. If algae are clumped velocities of 1.5 feet per second are required to resuspend all of the clumped material.
(h) "Waste Water Reclamation Through Production of Algae," William J. Oswald, C.G. Golueke and Henry K. Gee. Contribution No. 22, Water Resources Center, University of Calif., Berkeley.

(3022) FLOATING BREAKWATER.

(b) U. S. Navy Civil Engineering Laboratory.
(d) Analytical and experimental; applied research.
(e) Analytical and experimental studies of new concepts of floating breakwaters.
(g) Several new concepts have been investigated. One of these systems consisted of a series of long plastic tubes (slightly buoyant) connected side by side and filled with water. The effectiveness of the system was remarkable for wave lengths of the order of one-half the tube length, or less. Additional work has been done with large plastic bags filled with water with the same results.
(h) "Rigid Vertical Thin Barrier," R.L. Wiegel, Univ. of Calif., IER, Tech. Report 140-1, 16 pp., June 1959.

(3023) PRESSURE GENERATED WATER WAVES.

(b) National Science Foundation.
(d) Experimental; basic research.
(e) This is a study of the coupled waves generated by a pressure area moving over the water surface, both two dimensional and three dimensional; in addition, analytical studies are being made of long waves.
(g) The cnoidal wave theory has been reduced to the form that rapid calculations can be made with it, using curves and tables. Laboratory tests in three dimensions have been made to determine the limit of the effect of surface. Tension. Tests are now being conducted well within the gravity wave regime.
(h) "Presentation of Cnoidal Wave Theory for Practical Application," R.L. Wiegel, accepted for publication in Journal of Fluid Mechanics.
"Model Study of Water Gravity Waves Generated by Moving Circular Low Pressure Area," G. Abraham, University of Calif., IER, Tech. Report 99-5, 122 pp., May 1959.

(3380) SANTA ROSA CREEK STRUCTURES.

(b) U. S. Soil Conservation Service.
(d) Experimental.
(e) Model tests of structures designed to regulate the flood flows and sediment loads in Santa Rosa Creek.
(f) Experimental work completed.
(g) The combination of a flow regulating orifice with a diversion dam and a sediment carrying tube provides a satisfactory solution.

(3381) DISCHARGE COEFFICIENT OF BANCROFT DAM.

(b) Contra Costa County Flood Control and Water Conservation District.
(d) Experimental.
(e) Model tests of existing structure to establish flow characteristics.
(f) Completed.
(g) The performance of the structure under varying degree of submergence is described by means of a graph.
(h) "Discharge Coefficient of Bancroft Dam," by G. Kalkanis, ES - 6291, 1959.

(3382) FLUME STUDY ON THE TRANSPORT OF ESTUARIAL SEDIMENT.

(b) Corps of Engineers.
(d) Experimental.
(e) The motion in saline water of estuarial sediments is studied under controlled laboratory conditions. Both flumes and settling vessels are used. The viscosity, settling and composition of sediment-water mixtures are also studied to understand the relationships between the flow and the deposit.

(3383) EFFECT OF SURFACE ROUGHNESS ON THE FLOW OF WATER OVER ROCK SILLS.

(b) Thesis study.
(d) Experimental.

(e) Smooth and rough rock sills are compared in a 1 foot wide flume. The discharge coefficient is determined for free and submerged flows.
(g) Discharge coefficient is determined for a sill with 6-inch crest width, 6 inches high and 1:4 slopes upstream and downstream. This discharge coefficient is somewhat lower than that for a smooth dam of the same geometry. The downstream velocity distribution with 0.1 foot rock is very different from that on a smooth structure. The scour pattern downstream is much more favorable than for the smooth structure.
(h) Thesis in preparation.

(3384) SAND MOVEMENT BY WIND.

(b) Beach Erosion Board.
(d) Experimental.
(e) To develop a trap and auxiliary equipment for field measurements of the rate of sand movement by wind action. Tests on various types of traps were made in a wind tunnel to determine the trap efficiency as a function of the wind characteristics.
(h) "Sand Movement by Wind Action on the Characteristics of Sand Traps," K. Horikawa, Univ. of Calif. Inst. of Engin. Research Series 72, Issue 4.

(3385) ELECTRIC FLOOD MODEL.

(b) U. S. Corps Engineers, Kansas City District.
(d) Experimental; design and development.
(e) Using analog model techniques a simulator for the Kansas River and its tributaries is being developed. Purpose is to provide a rapid and convenient means of estimating the effects of reservoir operation and rainfall distribution on flood stages. All pertinent hydraulic variables will be under operator's control, and a flood routing procedure completed each 1/60 second.

(3386) SUBSURFACE SALINITY.

(b) Laboratory project.
(d) Analytical and experimental; basic research.
(e) This investigation is concerned with the dynamics of the fresh-salt water interface in flow through porous media. Effects of non-steady flows and dispersion will be considered.
(g) A new analytic technique has been developed which permits the two-fluid problem to be reduced to a single fluid potential problem with the introduction of vortices along the interface. Corollary experimental studies are now underway.
(h) "Vortex Theory for Multiple Phase Flow Through Porous Media," G. de Josselin de Jong, Water Resources Center Contribution No. 23, Univ. of Calif., Berkeley, 80 pp., 1959.

UNIVERSITY OF CALIFORNIA, Department of Naval Architecture.

(3026) SHIP RESISTANCE IN UNIFORM WAVES AS A FUNCTION OF WAVE STEEPNESS AND BEAM OF THE SHIP.

(b) David Taylor Model Basin, Dept. of the Navy.
(c) Mr. O.J. Sibul, Room 224, Bldg. T-3, Univ. of California, Berkeley, Calif.
(d) Experimental (laboratory).
(e) A series of experiments were performed to study the effect of width (beam) of the ship and the wave steepness on the added resistance of a ship in uniform waves. A 5-foot model of Series 60, block coefficient 0.60, was used as the parent form. Two additional models were similar to the parent except for the beam, which was 0.75 of parent for one model and 1.25 of parent for the other. All of the models were towed in waves 5 feet long at seven different wave steepnesses between 0.0146 and 0.0684. The resistance of the models in still water was measured in separate experiments and the added resistance due to the oncoming waves computed.
(g) The results indicate that the added resistance coefficient depends upon the beam of the ship, the Froude number, and the steepness of the waves. On the average, the added resistance seems to increase as the 1.2 power of the wave height for the narrow model; as approximately the 1.75 power of wave height for the intermediate model; and as the 1.80 power of wave height for the wide model.
(h) "Ship Resistance in Uniform Waves as a Function of Wave Steepness and Beam of the Ship," O. J. Sibul, Univ. of Calif., IER Series 61, Issue 18, September 1959.

(3024) STABILITY OF VESSELS IN SEAWAY.

(b) Society of Naval Architects and Marine Engineers.
(c) Prof. John R. Paulling, Jr., Room 224, Bldg. T-3, Univ. of Calif., Berkeley, Calif.
(d) Experimental and theoretical; applied research.
(e) A study of the effect of the seaway on the transverse stability and capsizing of ships.
(f) Completed.
(h) "On Unstable Ship Motions Resulting from Nonlinear Coupling," J. R. Paulling and R. M. Rosenberg, Journal of Ship Research, Vol. 3, No. 1, June 1959.

(3025) STABILITY OF TUNA CLIPPERS.

(b) University of California.
(c) Prof. J. R. Paulling, Jr., Room 224, Bldg. T-3, Univ. of Calif. Berkeley, Calif.
(d) Theoretical and experimental; applied research.
(e) A study of the transverse stability of a class of fishing vessels while operating in a seaway.
(f) Completed.
(g) The transverse stability of tuna clippers while operating in a seaway may be appreciably less than that computed by the designer using conventional methods.
(h) "Certain Factors Influencing the Transverse Stability of Tuna Clippers," J.R. Paulling,

presented at the second World Fishing Boat Congress sponsored by FAO of UN, Rome, Italy, in April 1959. Transactions of this Congress in preparation.

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

(b) National Science Foundation, and Univ. of Calif. research funds.
(c) Mr. O. J. Sibul, Room 224, Bldg. T-3, Univ. of Calif., Berkeley, Calif.
(d) Basic research; applied research; design.
(e) The work undertaken under this program was the design and construction of a power and control system for the existing wave generator, such that a recorded ocean wave in a desired scale could be reproduced in the towing tank. The system utilizes a magnetic tape input to servo-mechanism which makes the wave-generator follow a prescribed time-distance curve.
(h) "Generation of Irregular Waves in the Univ. of Calif. Towing Tank," Jerry W. Cuthbert. Paper presented to the Northern California Section of SNAME, April 9, 1959.

(3387) PRESSURE DISTRIBUTION ABOUT OSCILLATING BODIES.

(b) Office of Naval Research, Dept. of the Navy.
(c) Mr. W. R. Porter, Dept. of Naval Architecture, Room 224, Bldg. T-3, Univ. of Calif., Berkeley, Calif.
(d) Experimental and theoretical, basic research, doctoral thesis.
(e) Measurement by means of flush-mounted pressure gages of the transient pressure distribution about a body undergoing forced oscillation near a free surface. The first measurements will be made on a circular cylinder and a sphere. Theoretical computations of the pressure distribution will also be made.

(3388) SHIPS OF MINIMUM WAVE RESISTANCE.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. J.V. Wehausen, Dept. of Naval Architecture, Room 224, T-3, Univ. of California, Berkeley, California.
(d) Theoretical.
(e) The usual minimization procedure as carried out by Weinblum and others leads to a form symmetric fore and aft which would, in fact, be unsuitable for the afterbody because of likelihood of separation. In the present investigation the afterbody is fixed and only the forward half of the hull is varied. The minimizing forebody is further limited for the present to certain special polynomials.
(g) Programming for a computer is finished and results will be available shortly.

(3389) MONOGRAPH ON THE THEORY OF WATER WAVES.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. J.V. Wehausen, Dept. of Naval Architecture, Room 224, T-3, Univ. of California, Berkeley, Calif.
(d) Theoretical.
(e) Exposition of the theory of gravity waves for the Encyclopedia of Physics (Springer).
(f) Completed.
(h) "Water Waves," I, II, III, V, VI, by J. V. Wehausen; "Water Waves" IV by E. V. Laitone, IER, Series 82, Issues 6, 7, 8, 9, 10, 11, 1958 and 1959.

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

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

(49) RESEARCH FOUNDATION FOR CROSS-CONNECTION CONTROL.

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

(2270) BACKFLOW PREVENTION.

(b) Dept. of Water and Power, City of Los Angeles, Calif.
(d) The Department had a contract with the University which included, among other objectives, the preparation of specifications for backflow prevention devices.
(f) Contract completed.
(h) "Definitions and Specifications of Double Check Valve Assemblies and Reduced Pressure Principle Backflow Prevention Devices," USCEC Report 48-101, Jan. 30, 1959.

UNIVERSITY OF SOUTHERN CALIFORNIA, School of Engineering.

Inquiries concerning Project No. 2758 should be addressed to Dr. K.C. Reynolds, School of Engineering, Univ. of Southern Calif., Los Angeles 7, Calif.

(2758) FLOW IN AN OPEN CHANNEL SUBJECTED TO TIDES.

(b) Southern California Edison Co., 601 West 5th Street, Los Angeles, Calif.
(d) A model study of flow in a proposed canal to carry cooling water to a steam station generating electricity. The initial capacity of the station will be 400,000 KW.
(f) Completed.
(h) "Model Study of Mandalay Steam Station Cooling Water Intake Canal."

CARNEGIE INSTITUTE OF TECHNOLOGY, Department of Civil Engineering.

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

(1834) AIR-WATER FLOW.

(b) Laboratory project.
(d) Analytical and experimental.
(e) Study of air-binding in pipelines. Particular attention is given to the mechanism and relationships causing separation of air into pockets, re-entrainment of air at a turbulent interface and energy losses associated with the phenomenon.
(g) Experimental studies of 2- and 6-inch diameter pipes have been completed for a variety of flow conditions.

(2064) VIRTUAL MASS.

(b) Laboratory project.
(d) Analytical and experimental.
(e) Determination of the inertia drag on bodies moving in fluids in rotational motion and under varying conditions of translational motion.

(2275) FLOW OF LIQUID-SOLID MIXTURES.

(b) Laboratory project.
(d) Analytical and experimental.
(e) Study of the movement of granular material carried in a fluid through closed conduits. Measurements of velocities, energy losses, concentrations and segregated conditions are made.

(2759) FLOW INTO VERTICAL SHAFTS.

(b) Laboratory project.
(d) Experimental and analytical.
(e) Evaluation of flow into vertical shafts for different conditions of geometry, gradeline, head and surface condition.
(f) Inactive.

(3203) PRESSURE SURGES IN CLOSED CONDUITS.

(b) Laboratory project - National Science Foundation Fellowship.
(d) Analytical and experimental.
(e) Determination of pipe geometry on the reflection and transmission of pressure surges in closed conduits.

(3205) FLOW OF LIQUID-SOLID MIXTURES IN INCLINED PIPES.

(b) Laboratory project.
(d) Analytical and experimental.
(e) Study of the special problems that develop when liquid-solid mixtures are carried in inclined pipes.

(3390) MECHANICS OF NON-NEWTONIAN FLOWS.

(b) Laboratory project.
(c) Dr. G. Bugliarello.
(d) Analytical and experimental.
(e) Study of energy relationships, velocities and flow structure in non-newtonian flows.
(f) Active.

(3391) VORTEX FORMATION.

(b) Laboratory project.
(d) Analytical and experimental.
(e) Study of onset, development, stability and decay of vortex motion in free surface flows.

(3392) SEDIMENT TRANSPORT IN NATURAL STREAMS.

(b) Laboratory project.
(c) Dr. G. Bugliarello.
(d) Experimental and analytical.
(e) Studies of stream geometry, sediment load characteristics and velocities for typical natural stream conditions.

(3393) EVAPORATION FROM MOVING SURFACES.

(b) Laboratory project.
(c) Dr. G. Bugliarello.
(d) Analytical.
(e) Study of the influence of kinematic conditions at the liquid-solid interface on the evaporation process.

COLORADO STATE UNIVERSITY, Department of Civil Engineering.

(55) SNOW COURSE MEASUREMENTS AND FORECAST ANALYSIS.

(b) Soil Conservation Service, Colorado Agricultural Experiment Station.
(c) Mr. Jack N. Washichek, Snow Survey Supervisor, Colo State Univ., Civil Engineering Section, Fort Collins, Colo.
(d) Field investigations; applied research.
(e) Systematic measurements of depth and water content of snow at high elevations in Colo. mountain areas for the purpose of forecasting the runoff of the principal rivers of the state in the interest of irrigation, power, domestic supplies, and other uses. The use of electrical resistance soil moisture units is being tested to determine a factor of soil moisture deficiency for water supply forecast purposes. Most of the major basins now have 2 or more soil moisture stations installed. A period of record must follow before any degree of correlation can be accomplished.
(g) Snow measurement data are correlated with runoff. Once the relationship is established, the snow measurement data are used to predict the runoff for the coming season.
(h) Colorado Agricultural Experiment Station General Series Papers - Monthly Snow Survey Reports for the Rio Grande, Colorado and Platte-Arkansas Drainage Basin.

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

(b) Colorado Agricultural Experiment Station.

(c) Mr. M. M. Skinner, Assistant Civil Engineer, Engineering Research, Colorado State Univ., Fort Collins, Colo.
(d) Field investigation.
(e) The work consists of semiannual measurements of the depth to the water table in about 300 observation wells in the Arkansas and South Platte Valleys in Colorado. Seven continuous recorders are also now in operation. Observation wells are strategically located in pumping areas. Data on power consumption are also gathered for comparison with water-table elevations. The work is coordinated with the Ground Water Branch, U.S.G.S.
(g) Water tables in nearly all areas under canals have recovered to normal levels because of favorable surface water supplies during the last few years following the years of short supply in the early 50's. However, water tables have declined in many areas which depend entirely upon ground water for irrigation and have a small natural recharge in comparison to withdrawals.

(1074) HYDRAULICS OF STILLING BASINS.

(b) U. S. Bureau of Public Roads.
(c) Mr. G L. Smith, Assistant Civil Engineer, Civil Engrg. Section, Colo. State Univ., Fort Collins, Colo.
(d) Experimental; applied and fundamental.
(e) This study consists of several phases. The first phase, which has been completed, was development of generalized design criteria for stilling basins for cantilevered pipe flow. The stilling basin is a pre-shaped scour hole in an alluvial bed armorplated with well graded riprap. The second phase of the study, which is in progress, is to investigate the efficiency of the armorplated, pre-shaped stilling basin in scour control for different boundary geometry.
(f) A project report covering work to date is being written.
(g) Scour in alluvial beds increases with an increase in channel width. The contributing factor to the increased rate of scour is growth and vortex action of secondary currents transverse to the direction of jet flow. Armorplating of channel banks is essential to stability of alluvial channels. Decreasing the slope of the channel banks increases the effectiveness in scour control of the armorplated, pre-shaped stilling basin and banks.
(h) "Analytical Study of the Mechanics of Scour for Three-Dimensional Jet," Y. Iwagaki, G.L. Smith and M.L. Albertson, Colo. State Univ., Civil Engrg. Dept., Report in preparation.
"The Manifold Stilling Basin," G.R. Fiala and M.L. Albertson, Colo. State Univ., Civil Engrg. Dept., Report No. CER58MLA35.

(1837) SEALING OF IRRIGATION CANALS BY BENTONITE SEDIMENTING.

(b) Colo. State Univ. Exp. Sta., USDA - Agr. Research Service and Irrigation Districts and Companies.
(c) Mr. R.D. Dirmeyer, Jr., Proj. Leader, Engrg. Research, Colo. State Univ., Fort Collins, Colorado.
(d) Applied research and development at field sites, supported by laboratory research where needed.
(e) A pilot model approach is being used which utilizes a procedure development and evaluation trial in a representative canal site for each major irrigated area. Development work with Wyoming high-swell bentonite as a sedimenting agent in sealing irrigation canals is essentially complete. The research and development work is now being concentrated on the use of the low-swell varieties of bentonite as a sedimenting agent for sealing irrigation canals and reservoirs.
(g) The main advantages of the low-swell bentonite over the high-swell varieties are listed as follows: (1) The low-swell varieties are relatively common in many parts of the Western United States and in other areas of the world, whereas the high-swell bentonites are mainly found in Wyoming, and (2) the chemical character of the low-swell bentonites make them compatible with salty soils and hard waters whereas the high-swell bentonites can undergo objectional physical changes when subjected to such conditions.
(h) "Evaluation Report on Recent Bentonite Sealing Work in Wyoming Canals," by R. D. Dirmeyer, Jr., Colo. State Univ., Civil Engineering Section, March 1959.
"Testing Bentonite for Sealing Purposes," R.T. Shen, Colo. State Univ., Civil Engrg. Section, (Colo. Ext. Serv. Cir. No. 205 A - Wyo. Ext. Serv. Cir. No. 161).
"Sealing Sandy Ditches with the Bentonite Dispersion Method," R. T. Shen, Colo. State Univ., Civil Engrg. Section, (Colo. Ext. Serv. Cir. No. 202 A - Wyo. Ext. Serv. Cir. No. 158).
"Sealing Rocky Ditches with the Bentonite Multiple-Dam Method," R. T. Shen, Colorado State Univ., Civil Engrg. Section, (Colo. Ext. Serv. Cir. No. 203 A - Wyo. Ext. Serv. Cir. 159).
"Mixing Bentonite for Sealing Purposes," R. T. Shen, Colorado State Univ., Civil Engrg. Sec., (Colo. Ext. Serv. Cir. No. 204 A - Wyo. Ext. Serv. Circular No. 160).
"Sealing Farm Ponds and Reservoirs with Bentonite," R. T. Shen, Colo. State Univ., Civil Engrg. Sec., (Colo. Ext. Serv. Cir. No. 206 A - Wyo. Ext. Serv. Cir. No. 162).

(2066) STUDY OF OPEN CHANNEL CONSTRICTIONS IN A SLOPING FLUME.

(b) U. S. Bureau of Public Roads.
(c) Dr. H.K. Liu, Assoc. Civil Engr., Civil Engrg. Section, Colo. State Univ., Fort Collins, Colorado.
(d) Experimental; applied.
(e) Scour at bridge abutments of various shapes and dimensions have been investigated in the laboratory. Natural sediment having mean sizes of approximately 0.45 mm were used in the tests. Sediment supply of mainly bed load varied from zero to less

than 1000 ppm.

(f) Laboratory tests have been completed. Data are being analyzed and compiled. A report is currently being written.

(g) Criteria for estimating the maximum depth of scour at abutments have been established. The maximum depth of scour, for given sediment size, is found to depend upon the flow depth, velocity, and abutment length and geometry.

(h) "Backwater Effects of Bridge Piers and Abutments," by H.K. Liu, J.N. Bradley, and E.J. Plate, Colo. State Univ., Civil Engrg. Sec., Fort Collins, Colorado.
"Laboratory Observations of Scour at Bridge Abutments," by H.K. Liu, and M.M. Skinner, Colo. State Univ., Fort Collins, Colorado, Bulletin No. 242 Highway Research Board.

(2277) STUDY OF EVAPORATION FROM SOIL SURFACES IN TERMS OF SOIL AND MICROMETEOROLOGICAL FACTORS.

(b) Contributing project to Western Regional Research Proj. W-32, "Basic Hydrological Factors Relating to Water Conservation."

(c) Dr. R.A. Schleusener, Asst. Research Engr., Engineering Research, Colorado State Univ., Fort Collins, Colorado.

(d) Experimental and theoretical; basic research, part of which has been used for master's and doctoral theses.

(e) The project is a comprehensive study of moisture transfer from soil by evaporation from the soil surface. The immediate objectives of this investigation are to evaluate the variables known to affect evaporation from soil in order to determine those that are most important in the field, and secondly to search for relationships among the pertinent variables which will permit quantitative estimates of evaporation from a given soil under prevailing ambient conditions.

(g) Evaporation from soil surfaces has been studied for steady and cyclic ambient atmospheric conditions, using a controlled-environment chamber. Results indicate that under some conditions an inverse relation can exist between the rate of evaporation from a soil in contact with a water table and that from a free-water surface. A theory was developed to explain this phenomenon in terms of a hysteresis property of the soil. This is not in agreement with prior theory which indicates that a limitation from soils should be reached as the evaporation rate increases from a free-water surface. The hystereses hypothesis suggests that evaporation could be reduced by application of a surface treatment which would promote rapid initial desaturation of the soil surface. Measurements of evaporation from soils subjected to various surface treatments indicate a significant reduction of evaporation can be accomplished by treatment with a gravel mulch.

(h) "A Switching Arrangement for Automatic, Remote Temperature Reading," Richard A. Schleusener, Colorado State Univ., Agricultural Engrg. 40(1):32-33, January 1959.
"The Role of Hysteresis in Reducing Evaporation From Soils in Contact With a Water Table," Richard A. Schleusener and A.T. Corey. Jour. of Geophysical Research 64(4):469-75, April 1959.
"Relations Between Evaporativity and Evaporation From Soils in Contact With a Water Table," Richard A. Schleusener. A paper presented to the American Meteorological Society Conference on Practical Problems of Modern Meteorology, Denver, Sept. 24, 1958.

(2278) METHODS OF GENERATING A COMPLEX SEA.

(b) David Taylor Model Basin, Dept. of the Navy.

(c) Robert E. Glover, Engrg. Research, Colo. State Univ., Fort Collins, Colorado.

(d) Theoretical; applied research.

(e) The research is directed toward the development of ways and means to produce in a wave basin seas which will permit the testing of model ships under conditions representing those encountered by ships on the ocean under storm conditions.

(f) Completed.

(g) A new type of wave generator was developed which promises to have the ability to produce a replica of an actual storm sea in a circular or rectangular wave basin. The replica sea would cover essentially the entire area of the wave basin.

(h) "Methods of Creating a Complex Seaway in a Model Basin," R. E. Glover, prepared for the David Taylor Model Basin under Contract Nonr. 1610(02). Colo. State Univ., Civil Engrg. Dept., Report CER58REG43, Sept. 1958.
"Estimates of Bending Moments and Pressures Due to Slamming," R.E. Glover, prepared for the David Taylor Model Basin under Contract Nonr 1610(02). Tech. Report No. 5, Colo. State Univ., Civil Engrg. Dept., Aug. 1957.

(2279) LABORATORY AND FIELD STUDY OF THE VORTEX TUBE SAND TRAP.

Cooperative project: Colorado Agricultural Experiment Station and Agricultural Research Service. See U. S. Department of Agriculture, Agricultural Research Service, page 98.

(2510) RESEARCH DIRECTED TOWARD THE STUDY OF LOW LEVEL TURBULENCE.

(b) Air Force Cambridge Research Center.

(c) Dr. J. E. Cermak, Prof. Mechanics and Civil Engineering, Colorado State Univ., Fort Collins, Colorado.

(d) Experimental; basic research to be used towards a doctoral thesis.

(e) Measurements of mean velocity, mean temperatures, turbulence intensities and turbulent shear stress profiles were made for turbulent air flow over a plane, rough boundary which was heated. A new wind tunnel with low ambient turbulence level and a test section 6 x 6 x 72 feet was designed and partially completed.

(f) Completed.

(g) For the rough, heated surface the velocity defect law for the outer regime of the boundary layer follows the same law for a smooth boundary provided the displacement

thickness includes the variation of density with temperature. The temperature distribution can be expressed by a wall law and a temperature-defect law analogous to the velocity-distribution laws.

(2513) WATER AND SEDIMENT MEASURING EQUIPMENT FOR EPHEMERAL STREAMS.

(b) Rocky Mountain Forest and Range Experiment Station, Agricultural Research Service and Colorado Agricultural Experiment Station.
(c) Mr. A.R. Robinson and Dr. A.R. Chamberlain, Colo. State Univ., Fort Collins, Colorado.
(d) Experimental; applied research.
(e) The present phases of the project are to further develop measureing flumes of trapezoidal shapes for measurement of flows with steep gradients and for a large range of flows.
(g) Model results have been compared with prototype measurements with good agreement. A large 1:2 model has been constructed and is presently being tested to better determine the operating characteristics of the prototype structures.

(2514) STUDY OF RESISTANCE TO FLOW AND SEDIMENT TRANSPORT IN ALLUVIAL CHANNELS.

(b) U. S. Geological Survey.
(c) Mr. D. B. Simons, U.S. Geological Survey, Colo. State Univ., Fort Collins, Colorado.
(d) A study of mechanics of flow in alluvial channels using a large recirculating laboratory flume. Experimental, theoretical and field investigation; basic and applied research. Some phases of the study are being used to develop masters and doctoral theses; however, the investigation is basically a U.S.G.S. research project.
(e) This investigation consists of a laboratory study which will be followed by a field study of (a) resistance to flow in alluvial channels, (b) sediment transport theory, including the effect of very fine sediment on resistance to flow and sediment transport, and (c) the theory of rapid flow phenomenon in alluvial channels.
(f) Active.
(g) Results: Regimes of flow, forms of bed roughness, resistance to flow relations, and sediment transport relations have been developed for the three sizes of sand investigated.
(h) Publications: U.S.G.S., Water Supply Paper 1498-A, and two (2) A.S.C.E. papers have been submitted for publication.

(2649) DEVELOPMENT OF DRAINAGE DESIGN CRITERIA FOR IRRIGATED LANDS.

Cooperative project; Colo. Agr. Exp. Sta. and Agr. Research Service. See U.S. Dept. of Agr., Agricultural Research Service, page 98.

(2760) METEOROLOGICAL OBSERVATIONS.

(b) Colo. Agricultural Experiment Station and U. S. Weather Bureau.
(c) Mr. Maxwell Parshall, Assistant Professor, Civil Engrg. Sec., Colo. State Univ., Fort Collins, Colorado.
(d) Field investigation.
(e) The work is being done to obtain a precise long time record of climatological elements. The elements observed are: maximum, minimum and current air temperature, wet and dry bulb temperatures for dew point temperature and relative humidity, soil temperatures at 3, 6, 12, 24, 36 and 72 inches, wind direction and velocity at 65 feet and 15 inches above surface, barometric pressure, evaporation from a free water surface, water temperature at surface (maximum, minimum and current), precipitation, cloud cover, dew and frost.
(g) New extreme values of temperature have been recorded recently. The long time mean temperature is increasing. Precipitation varies widely with no long time trend apparent.
(h) Summary of 70 years' record of Meteorological data in process of publication.

(2761) A STUDY OF THE ECONOMIC EFFECT OF CONTROLLING WATER USE IN AN AREA WHERE SURFACE AND GROUND WATER RIGHTS APPLY TO A SINGLE SUPPLY.

(b) Colo. Agri. Expt. Sta. and U.S.D.A. Regional Project W-42. (Revised)
(c) Mr. M. W. Bittinger, Asst. Civil Engineer, Civil Engrg. Sec., Colo. State University, Fort Collins, Colorado.
(d) Field investigation; applied research.
(e) The engineering phase of this study has as its purpose the determination of the interrelationships of ground water and surface water in an area where both are used for irrigation. An area in the South Platte Valley has been chosen for this study. The economic phase will be concerned with the implications of various types of legislative controls which may be applied in the situation.
(g) Most of the field data have been obtained for this study. Estimates of the amount of pumping over the past thirty years, the amount of water delivered by canals to the study area during the past thirty years and computations of the gain or loss in the river through the years has been made. Various approaches of analyses have been tried to attempt to correlate various hydrological factors to the flow in the river and to the fluctuations of the water table. Various unknowns such as inflow from unmeasured tributaries, excess irrigation water finding its way directly to the river, and temporary bank storage have masked the relationships between hydrologic factors. A theoretical analysis is now underway and will be correlated with field observations. A basic conclusion that has been drawn so far is that pumping of ground water in this particular area of the South Platte Valley has had no major detrimental effect upon surface water rights.
(h) "Colorado's Ground Water Problems - Ground Water in Colorado," Colo. Agri. Expt. Station Bulletin 504-S, August 1959.

(2767) EDUCATIONAL FILMS ON OPEN CHANNEL FLOW.

(b) U. S. Bureau of Public Roads.
(c) Mr. J.R. Barton, Assoc. Prof., Civil Engrg. Sec., Colo. State Univ., Fort Collins, Colo.
(d) Laboratory and field.
(e) Project involves the making of a color film on open channel flow in connection with highway drainage problems for educational purposes.
(f) In final editing stage.

(2769) EVALUATION OF FLOWMETERS FOR THE MARTIN COMPANY, DENVER DIVISION.

(b) The Martin Company, Denver, Colorado.
(c) Mr. Susumu S. Karaki, Asst. Civil Engineer, Civil Engrg. Sec., Colo. State Univ., Fort Collins, Colorado.
(d) Experimental; applied.
(e) The purpose of the project is to carry out tests on the dynamic, kinematic and general performance characteristics of various types of flow meters to be inserted in pipelines. The flowmeters to be considered are the Gulton, Gentile Tube, and Maxson Ultrasonic, impact strain gauge, turbine and rotameters. The fluids under consideration are water, liquid oxygen, liquid nitrogen, JP-4 fuel, RP-1 fuel and MIL-O-5606 hydraulic fluid.
(h) "Evaluation of the Performance of the Gulton Ultrasonic Gentile Tube and Potter Meter 6-424 Flowmeters," by Fred Videon and G. L. Smith, CSURF, June 1958 CER59FV11. "Evaluation of the Performance of the Floating Rotor Design Flowmeter," S.S. Karaki and Fred Videon. CSURF, September 1959, CER59SSK45.

(2770) A STUDY OF SHEAR STRESS FLUCTUATIONS AT A LIQUID-SOLID INTERFACE BY MEASUREMENT OF THE ELECTROKINETIC POTENTIAL FLUCTUATIONS.

(b) National Science Foundation.
(c) Dr. J.E. Cermak, Prof. Mechanics and Civil Engineering, Colo. State Univ., Fort Collins, Colorado.
(d) Experimental and theoretical.
(e) Electrokinetic-potential-fluctuation spectra are being measured for a range of electrode spacings and the regimes in a glass pipe. These data together with auto-correlation data for the electrokinetic potentials will be used to determine the character of shear stress fluctuations at the pipe wall.
(g) Preliminary electrokinetic-potential-fluctuation spectra show similar energy-frequency distributions as do turbulent velocity fluctuations measured in a turbulent flow near a solid wall.
(h) Ph. D. Dissertation in preparation.

(2771) DISTRIBUTION OF A WETTING AND NON-WETTING FLUID PHASE IN A POROUS SOLID.

(b) National Science Foundation.
(c) Dr. A.T. Corey, presently on temporary assignment as Assoc. Prof. of Civil Engrg., SEATO Graduate School of Engrg., Bangkok, Thailand.
(d) Experimental and theoretical; basic research.
(e) The primary objective of this project is to determine the effect of rate of displacement on the distribution of wetting and non-wetting fluid phases in porous solids. Particular emphasis is placed on the situation occurring when a non-wetting phase displaces a wetting phase at various rates. The ultimate aim is to obtain basic information which will enable better techniques to be devised whereby field situations involving flow in porous media can be studied by laboratory models.
(f) The project is temporarily suspended in the absence of the principal investigator.

(2901) LABORATORY STUDY OF GRAVEL FILTER DESIGN FOR IRRIGATION WELLS.

Cooperative project; Colorado Agricultural Experiment Station and Agricultural Research Service. See U.S. Department of Agriculture, Agricultural Research Service, p.

(2902) DEVELOPMENT IMPROVEMENT OF WATER MEASURING DEVICES.

Cooperative project: Colo. Agri. Expt. Sta. and Agri. Research Serv. See U.S. Dept. of Agri., Agricultural Research Serv. page 100.

(3033) DETERMINATION OF PROPER IRRIGATION WELL CONSTRUCTION MATERIALS AND MAINTENANCE PRACTICES FOR OBTAINING MAXIMUM ECONOMICAL LIFE AND PERFORMANCE.

(b) Colorado Agricultural Experiment Station.
(c) Mr. M.M. Skinner, Asst. Research Engineer, Colo. State Univ., Fort Collins, Colorado.
(d) Experimental and field investigations; applied.
(e) The study is to determine the extent and causes of partial and complete failures of irrigation wells in Colorado and to develop recommendations for construction methods, materials, maintenance and repairs of irrigation wells.
(g) Review of literature available indicates a wide variance in recommendations for materials in irrigation-well construction, and in maintenance methods.

(3034) DISTRIBUTION AND CONCENTRATION OF RADIOACTIVE WASTES IN STREAMS BY FLUVIAL SEDIMENTS.

(b) U. S. Geological Survey.
(c) Dr. A.R. Chamberlain, Chief, Engineering Research, and Acting Dean, College of Engineering, Colo. State Univ., Fort Collins, Colorado.
(d) Experimental; applied research.
(e) This study has thus far been divided into two phases. The first phase has been concerned with reviewing the literature and evaluating the status of research on the disposal of radioactive wastes in natural streams. Particular emphasis is placed on problems arising from sediments which are contaminated by sorption of radioactive nuclides. The second phase is concerned

with determining dispersion and transport rates of contaminated bed sediments in the field. This is to be accomplished through the usage of sediment particles tagged by radionuclides as tracers.

(g) In the first phase, the factors involved and the present status of research concerning disposal of radioactive wastes in streams are reviewed with respect to: (1) Waste characteristics; (2) dispersion theory; (3) sorption by sediments; and (4) sediment transport. Sorption of radiocontaminants by sediments is the rule rather than the exception. Sorption, transport, and distribution of radiocontaminants by sediments depend on a multiplicity of factors, many of which are very complex and only partially understood. The second phase is in its initial phase, and no results as yet have been achieved.

(h) "Progress Report: Dispersion and Concentration of Radioactive Wastes by Stream Sediments," W. W. Sayre, H.P. Guy and A. R. Chamberlain, Report No. CER59ARC26.

(3035) CONSEQUENCES OF RESTRAINT ON MOTIONS OF A MODEL SHIP.

(b) David Taylor Model Basin, Department of the Navy.

(c) Mr. E. F. Schulz, Associate Civil Engineer, Colorado State University, Fort Collins, Colorado.

(d) Experimental; applied research.

(e) The purpose of this project is to obtain experimental data on the influence of restraint on the model motions resulting from wave trains acting on a model ship. Initially the model motions will be restrained and the forces and moments on the model caused by the waves will be measured. A new type wave probe will be used to measure the wave field in the vicinity of the model.

(g) Activity to date has been confined to development of instrumentation. These include the improvement of a capacitance probe which does not touch or disturb the water surface. Six transistorized probe units will be used to measure the waves in the vicinity of the model. Comparison of the records with a record of the undisturbed wave will yield information on the influence of the ship on the waves. A six component balance has been constructed to measure the forces and moments on the restrained model.

(3036) THE LONGITUDINAL DISTRIBUTION OF FORCES AND MOMENTS ON A RESTRAINED MODEL IN WAVES.

(b) S-3 Panel of Hull Structure Committee, Society of Naval Architects and Marine Engineers.

(c) Mr. E. F. Schulz, Associate Civil Engineer, Colorado State University, Fort Collins, Colorado.

(d) Experimental; applied research.

(e) The primary objective of this project is to impose pitching and heaving displacements (separately) varying sinusoidally in time upon a model ship and to measure the forces and moments as a function of time. The models are segmented and attached to an oscillating strongback by means of a stiff spring. The force on each end of the segment is sensed by means of an SR-4 strain gage. The simultaneous records of the forces on the seven segments may be used to construct a longitudinal shear curve. The longitudinal bending moment is found by graphical integration.

(g) The pitching and heaving experiments on a five foot model of a T2-SE-A1 tanker have been completed. The model was oscillated at seven frequencies at rest and at three speeds of advance. The results are being analyzed and will be compared with the analytical findings of Hasking, Havelock and Grimm.

(3037) STUDY OF ATMOSPHERIC SURFACE LAYER PHENOMENA IN A WIND TUNNEL.

(b) National Science Foundation.

(c) Dr. J.E. Cermak, Colorado State University, Fort Collins, Colorado.

(d) Experimental and theoretical; basic research.

(e) Measurements of mean velocities and mean temperatures together with turbulence intensities and correlations have been made over a smooth, plane, heated or unheated surface. The objective of the program is to relate the turbulent boundary layer structure to the thermal stratification obtained by heating.

(g) Heating of the turbulent boundary layer at low Reynolds number has been found to produce the following effects: (1) Increase the coefficient of drag; (2) increase the eddy viscosity; and (3) increase the correlation between vertical and horizontal velocity fluctuations.

(h) "Turbulent Boundary Layer at Low Reynolds Number with Unstable Density Stratification Produced by Heating," J. E. Cermak, Ph. D. Dissertation, Cornell University.

(3038) SCOUR BELOW CULVERT OUTLETS.

(b) Association of American Railroads.

(c) Mr. G. L. Smith, Asst. Civil Engr., Colo. State Univ., Fort Collins, Colorado.

(d) Experimental and theoretical; fundamental.

(e) Systematic measurements were made of the velocity profile of a submerged jet impinging upon a normal boundary to determine its influence on jet diffusion. The velocity profile was measured for the various zones of diffusion and along the boundary. The pressure profile was measured radially along the boundary from the point of stagnation to a point where the mean radial velocity is approximately zero.

(f) First phase completed.

(g) The behavior of the water jet was the same as that found by others for an air jet impinging upon a normal boundary. The error curve serves as a satisfactory representation of diffusion profiles for water jets.

(h) "Flow Characteristics of a Circular Submerged Jet Impinging Normally on a Smooth Boundary," by Michael Poreh, M. S. Thesis, Colorado State Univ., February 1959.

(3040) STUDY OF SPUR DIKES FOR HIGHWAY BRIDGE OPENINGS.

(b) State Highway Departments of Mississippi and Alabama and U.S. Bureau of Public Roads.
(c) Mr. S. Karaki, Asst. Civil Engr., Colo. State Univ., Fort Collins, Colorado.
(d) Experimental; applied research.
(e) Spur dikes at bridge abutments are used to prevent scour at the abutments and adjacent piers. The spur dikes principal functions are to distribute the flow more uniformly through the bridge opening and to streamline the flow. This experimental study is to determine the relationships between the length and shape of the spur dike with the length of roadway embankment and discharge.
(f) Completed.
(g) The results of the study are presented in a form of a tentative design chart. For normal crossings, it was found that the length of spur dike was a direct function of the length of roadway embankment and discharge. Skewed roadways were also studied and found that spur dike length increased if the roadway skewed upstream and decreased if skewed downstream. Spur dikes for small bridges would require longer spur dikes than that presented by the design chart if the concentration of flow through the bridge was great.
(h) "Progress Report on Hydraulic Model Study for Spur Dikes," S.Karaki, CSURF, Jan. 1959. "Hydraulic Model Study of Spur Dikes for Highway Bridge Openings," Susuma S. Karaki, CSU, Civil Engineering Section, Fort Collins, September 1959, CER59SSK36.

(3041) MAGNITUDE AND FREQUENCY OF FLOODS FROM SMALL WATERSHEDS IN ARID AND SEMI-ARID AREAS.

(b) U.S. Bureau of Public Roads.
(c) Dr. Richard A. Schleusener, Civil Engrg. Section, Colo. State Univ., Fort Collins, Colorado.
(d) Applied research.
(e) The purpose of the study is to develop procedures for predicting the magnitude and frequency of runoff from small watersheds in arid and semi-arid areas.
(g) Procedures have been developed for prediction of peak rates of runoff from ungaged watersheds for 10- and 40- year recurrence intervals for a region in eastern Colorado and adjoining areas.
(h) "Preliminary Report on Magnitude and Frequency of Runoff from Small Watersheds in Arid and Semi-Arid Areas," by Richard A. Schleusener, G.L. Smith, and N.Yotsukura, Civil Engineering Section, Colorado State University, CER59RAS39.
"Estimates of Runoff from Small Watersheds in Eastern Colorado, Western Kansas and Nebraska, and Southeastern Wyoming," by Richard A. Schleusener, and G.L. Smith, Civil Engrg. Sec., Colo State Univ., Fort Collins, Colorado. CER59RAS41.

(3394) RESEARCH ON ARTIFICIAL AND NATURAL RECHARGE OF GROUND WATER IN COLORADO.

(b) Colorado Agricultural Experiment Station.
(c) Mr. M.W. Bittinger, Asst. Civil Engr., Colo. State Univ., Fort Collins, Colorado.
(d) Experimental and applied research.
(e) The research under this project is being carried out in three major parts. Part I consists of an overall analysis of the artificial recharge needs and possibilities in seven major ground water basins in Colo. This analysis will be based principally upon available information of water supply, water quality, geology, water use and other physical factors. Part II consists of the selection and establishment of field experiments on representative areas within the various ground water basins. Part III consists of theoretical and laboratory studies to extend the information obtained under Part II.

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

(b) National Science Foundation.
(c) Mr. George L. Smith, Civil Engineering Dept., Colo. State Univ., and Dr. J. E. Cermak, Prof. Mech. and Civil Engineering, Colo. State Univ., Fort Collins, Colorado.
(d) Analytical and experimental; basic research and graduate thesis.
(e) An experimental study of the axi-symmetrical flow resulting from a jet impinging on a solid boundary. Detailed measurements will be made of the turbulent structure within the boundary layer as well as direct measurements of the boundary shear stress. The data will be used to determine the nature of the boundary layer development and to check the determination of the boundary shear stress by means of the momentum integral equation.
(h) "Flow characteristics of a Circular Submerged Jet Impinging Normally on a Smooth Boundary," Michael Poreh and J. E. Cermak, Colo. State Univ., Fort Collins, Colo., American Assoc. of Railroads publication. Proceedings - Midwestern Conf. on Fluid and Solid Mechanics, The Univ. of Texas, Sept. 9, 1959.

(3396) DILLON DAM SPILLWAY.

(b) Tipton and Kalmbach, Inc., Denver, Colorado.
(c) Mr. S.S. Karaki, Asst., Civil Engr., Colo. State Univ., Fort Collins, Colorado.
(d) Experimental; applied research.
(e) The purpose of the study is to hydraulically test the preliminary design of a morning glory spillway for the Dillon Reservoir and to suggest modifications where necessary consistent with adequate hydraulic performance.
(f) Completed.
(g) Excessive negative pressures were measured in the throat and vertical shaft of the spillway and were corrected by installing a deflector above the vertical bend in the tunnel. This served also to streamline the flow through the bend and in the horizontal tunnel. Non-uniform distribution of flow

on the crest was solved by installing piers on the crest. The final model design utilized a hydraulic jump stilling basin and deflector designed so that discharges less than 3000 cfs were contained as a hydraulic jump, while large discharges formed a jet off the end of the basin.

(h) "Hydraulics Model Study of the Morning Glory Spillway, for Dillon Dam," Susumu S. Karaki, Colorado State Univ., Research Foundation, June 1959, CER59SSK21.

(3397) BHUMIPHOL DAM TUNNEL JUNCTION.

(b) Engineering Consultants Inc., Denver, Colo.
(c) Mr. Susumu S. Karaki, Asst. Civil Engr., Colo. State Univ., Fort Collins, Colorado.
(d) Experimental; applied research.
(e) The purpose of this model study is to devise a protective structure within an unlined outlet works tunnel to protect the walls from erosion due to large velocities. Because of the large diameter of the tunnel, and because its use will be limited to two years, a lining for the tunnel is not considered economically justifiable.
(g) Preliminary results show that a hydraulic structure can be constructed within the dam, but it must be accompanied by a partial lining to be suitable. Other structures are being tested to determine an economical solution.

(3398) WIND TUNNEL MODELING OF ATMOSPHERIC DIFFUSION.

(b) National Institutes of Health.
(c) Dr. J.E. Cermak, Prof. Mech. and Civil Engrg., Colo. State Univ., Fort Collins, Colo.
(d) Experimental and theoretical.
(e) A point source of gas (monomethylamine) located within a turbulent boundary layer formed by the flow of air over a flat plate is used to create a concentration field downstream of the source. Provisions are also made to heat the boundary from below to produce a boundary layer with unstable density stratification. Sampling of the concentration field is accomplished by drawing measured volumes of gas through water. The solution is then analyzed colorimetrically to determine the methylamine concentration. The concentration fields are being studied in an attempt to determine the effects of non-isotropic boundary layer turbulence on diffusion. An attempt will be made to correlate wind-tunnel-diffusion phenomena to diffusion phenomena in the atmospheric surface layer.

(3399) CLIMATOLOGY OF THE UPPER COLORADO RIVER BASIN.

(b) State of Colorado - Colorado Water Conservation Board.
(c) Dr. Richard A. Schleusener, Civil Engineering Sec., Colo State Univ., Fort Collins, Colo.
(d) Applied research.
(e) The phase of research conducted at Colo. State Univ., involves a study of the variability of certain meteorological parameters in the Upper Colorado River Basin, and their relation to stream flow.
The study at Colorado State University is in cooperation with two other phases being conducted by the University of Colorado, Bureau of Economic Research and High Altitude Observatory, respectively. In the phase conducted by the Bureau of Economic Research a study is being made of the variability of stream flow of the Colorado River. In the phase being conducted by the High Altitude Observatory, the effect of solar variability on the general circulation of the atmosphere and on observed weather is being studied.

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

(b) Colorado Agricultural Experiment Station; U.S.D.A. Agricultural Research Service.
(c) Mr. Norman A. Evans, Head, Dept. of Agri. Engrg., Colo. State Univ., Fort Collins, Colo.
(d) Experimental and field investigation; basic and applied research, portions will be used for master's and doctoral theses.
(e) The goal of this project is to develop design equations for furrow irrigation systems. The equations should relate furrow shape, slope, infiltration capacity and boundary roughness to non-erosive rates of flow. The first objective is to correlate random types of roughness with flow resistance in rigid, impermeable boundaries. The effect of infiltration through channel boundaries will then be considered. Natural soil will be used in the laboratory to determine the sediment regimes which occur and to develop flow equations for these regimes. As a final phase, field experiments will be conducted to determine the validity of the laboratory results.

(3401) DRAINAGE DESIGN CRITERIA FOR IRRIGATED LANDS.

(b) Colorado Agricultural Experiment Station.
(c) Mr. Norman A. Evans, Head, Agricultural Engineering Dept., State Univ. of Colo., Fort Collins, Colorado.
(d) Applied research.
(e) Data on yields of tile drain systems in northern Colorado were collected, together with physical features and soil characteristics, from which a correlation analysis is made. The prediction equation so obtained is limited in application to the area under study.
(f) An extension of the project will be initiated in the future to study the hydraulics of the region near a tile drain, including the gravel filter.
(g) A prediction equation based on degree of stratification has been found to be very reliable.

(3402) DEVELOPMENT OF AN ULTRASONIC STREAM BED ANALYZER.

(b) Agricultural Research Service.

(c) Mr. S.S. Karaki, Asst. Civil Engr., and Earl Gray, Instructor, Electrical Engrg., Colo State Univ., Fort Collins, Colorado.
(d) Applied research.
(e) The purpose of this research is to develop an electronic instrument to simultaneously measure the profile of the water surface and stream bed configuration under flow conditions in alluvial streams for both laboratory and field. Preliminary investigations indicate that sonic methods may be used to determine both air-water and water-solid interfaces, which enables measurement of water surface and stream bed profiles simultaneously. The instrument is expected to be fully transistorized and packaged for rugged use. The instrument will consist of a micro-second pulse, a broad-band receiver, a time measuring computer, a piezzo-electric transducer, and a two-channel time-marked recorder. A cathode-ray oscilloscope will be optional.
(g) The instrument is being designed for the proper transistor circuits. No tests have been undertaken.

(3403) A STUDY OF TWO-PHASE, SINGLE COMPONENT FLOW IN A VENTURI.

(b) NBS Cryogenic Engineering Lab (equipment) NSF Undergraduate Research Program.
(c) Mr. R.V. Smith, Assoc. Prof. of Mechanical Engineering, Colo. State Univ., Fort Collins, Colorado.
(d) Experimental; both basic and applied.
(e) To analyze the flow process of steam and liquid H_2O from pressure and temperature surveys in the venturi. Vapor to liquid mass ratios, total mass flow and venturi geometry will be varied. Comparative runs for liquid H_2O -air systems will also be made (where no phase change is possible). Most of the work is carried out in the summer months.

(3404) PRESSURE DISTRIBUTION FOR TWO-PHASE FLOW IN A TWO-DIMENSIONAL POROUS MEDIA MODEL.

(b) Laboratory Project (ARS).
(c) Mr. R.H. Brooks, Agricultural Engr., Colo. State Univ., Fort Collins, Colorado.
(d) Experimental verification of the theoretical line where capillary pressure is equal to zero, i.e., $P_c=0$.
(e) A two dimensional porous media model 24 feet long, 4 feet in depth and 1 5/8 inches thick was set at an angle of 30° with the horizontal. The sand in the model consisted of three sands each increasing in permeability downstream. Water was caused to flow downslope under saturated condition through the less permeable sand. The purpose of the project is to determine the pressure distribution in the sands and the position of the line where the capillary pressure is equal to zero.

UNIVERSITY OF COLORADO, Department of Civil Engineering, Hydraulic Laboratory.

(3405) AN EXPERIMENTAL INVESTIGATION OF THE MECHANICS OF AIR ENTRAINMENT.

(b) National Science Foundation.
(c) Prof. J. Ernest Flack, Dept. of Civil Engrg., Univ. of Colorado.
(d) Basic research, master's thesis.
(e) Experimental investigation of air entrainment in a liquid by agitation of the liquid in a cylindrical container. A study of the effects of varying amplitude, frequency and magnitude of agitation along with variation of certain fluid properties on the concentration and distribution of air in a liquid will be made.
(h) Discussion on Air Entrainment by J.E. Flack and W.W. DeLapp presented at 8th Congress, International Association for Hydraulic Research, Montreal, August 27, 1959, mimeograph.

UNIVERSITY OF CONNECTICUT, Hydraulic Research Lab., Civil Engineering Department.

(1078) HYDROLOGIC FACTORS INFLUENCING RAINFALL-RUNOFF RELATIONSHIPS ON SMALL WATERSHEDS IN EASTERN CONNECTICUT.

(b) Laboratory project, State Highway Dept.
(c) Prof. K. C. Tippy, Box U-37, University of Connecticut, Storrs, Conn.
(d) Field investigation; applied research.
(e) Rainfall and runoff measurements are being taken on small watersheds varying in size from 4 to 400 acres.

(2073) A STUDY OF SIDE FLOW INTO GUTTERS AND CHANNELS.

(b) Laboratory project.
(c) Prof. V. Scottron, Box U-37, University of Connecticut, Storrs, Conn.
(d) Experimental and analytical.
(e) Studies are being conducted on the influence of friction on the hydraulics of rectangular channels with sloping bottoms and uniformly entering side flow.

CORNELL UNIVERSITY, School of Civil Engineering.

(2285) QUADRANT EDGE ORIFICE STUDIES.

(b) ASME Research Committee on Fluid Mechanics; laboratory project.
(c) Prof. Marvin Bogema, Applied Hydraulic Laboratory, Cornell Univ., Ithaca, N. Y.
(d) Experimental.
(e) Study of the quadrant edge orifice for discharge measurements at low Reynolds numbers, reproducibility, effect of size and diameter ratio, influence of pipe roughness, tap location and velocity profile. Both oil and water used.
(h) "Progress Report" to Subcommittee No. 2. ASME Research Committee on Fluid Mechanics, November 1958.
"The Quadrant Edge Orifice - A Fluid Meter

for Low Reynolds Numbers," M. Bogema and P. L. Monkmeyer, ASME Paper No. 59-A-140, November 1959.

(2773) ROLL WAVES AND SLUG FLOW.

(b) Basic Research.
(c) Prof. Marvin Bogema, Applied Hydraulics Laboratory, Cornell University, Ithaca, New York.
(d) Theoretical and experimental.
(e) The cause and subsequent development of intermittent flows in open channels has been studied and analyzed. Work is continuing to determine effect of boundary roughness.
(h) "Roll Waves and Slug Flows in Inclined Open Channels," P. G. Mayer, Journal of the Hydraulics Division, Vol. 85, No. HY7, July 1959, pp. 99.

(3406) CALIBRATION OF LARGE METERS.

(c) Prof. Marvin Bogema, Applied Hydraulics Laboratory, Cornell University, Ithaca, New York.
(d) Experimental.
(e) Facilities are available in the Cornell Applied Hydraulic Laboratory for calibration of large primary flow elements using water as the calibrating medium. Calibrations made during the past year include a 20- x 16.4 inch Venturi; an 18 inch O. D. x 13.25 inch I.D. pipe assembly with flow nozzle; a 42 inch magnetic flow meter; and several 12-inch turbine type flow meters.
(g) Calibration reports have been submitted to sponsors.

(3407) OPEN CHANNEL FLOW IN RIGHT ANGLE BEND.

(b) Laboratory.
(c) Prof. S. Davis, School of Civil Engineering, Cornell University, Ithaca, New York.
(d) Experimental; M. S. Thesis.
(e) Study of flow conditions in right angle bends in open channels.

(3408) VENTURI FLUME CHARACTERISTICS.

(b) Laboratory.
(c) Prof. S. Davis, School of Civil Engineering, Cornell University, Ithaca, New York.
(d) Experimental.
(e) Study of submergence characteristics of venturi flume.

(3409) EROSION ABOUT PILES DUE TO WAVE ACTION.

(b) Laboratory.
(c) Prof. Marvin Bogema, Applied Hydraulics Laboratory, Cornell University, Ithaca, New York.
(d) Experimental.
(e) Study of erosion of sand about piles in deep water due to wave action.

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

Inquiries concerning projects Nos. 2298, 3051, 3412 and 3413 should be addressed to Dr. Per Bruun, Head, Coastal Engineering Laboratory, University of Florida, Gainesville, Florida.

(2298) MODEL STUDY OF DESTRUCTION OF WAVE ENERGY BY VERTICAL WALLS.

(b) National Science Foundation.
(d) Experimental and theoretical; basic research.
(e) Destruction of wave energy by vertical walls studied in Laboratory's wave tank.
(f) Active.

(3046) COASTAL ENGINEERING STUDY AT CASEY KEY.

(b) Board of County Commissioners, Sarasota County, Florida.
(c) Board of County Commissioners, Sarasota County, Florida.
(d) Field investigation; applied research.
(e) The purpose of the investigations is to secure information about the actual situation of the erosion of Casey Key and to secure some technical data based upon which recommendations can be made for immediate relief of the acute erosion problem. The plan of research involved investigations of changes in the shore line and beach profiles.
(f) Completed.

(3047) COASTAL ENGINEERING STUDY AT LIDO KEY.

(b) City of Sarasota.
(c) City Manager, City of Sarasota, Florida.
(d) Field investigation; applied research.
(e) The purpose of the investigations is to secure information about the actual situation of the erosion of Lido Key and to secure some technical data based upon which recommendations can be made for immediate relief of the acute erosion problem. The plan of research involved investigations of changes in the shore line and beach profiles.
(f) Completed.

(3048) COASTAL ENGINEERING STUDY AT RAGGED KEYS.

(b) J. W. Moore, Attorney-at-Law.
(c) J. W. Moore, Attorney-at-Law, Miami, Fla.
(d) Field investigation; applied research.
(e) To secure information as basis for recommendations on establishment of fills at Ragged Keys and to furnish information on the influence of channels in the development.
(f) Completed.

(3049) MODEL STUDY OF THE APPLICABILITY OF FIBERGLASS MATERIAL IN COASTAL STRUCTURES.

(b) Owens-Corning Fiberglas Corporation, Newark, Ohio.
(c) Owens-Corning Fiberglas Corp., Newark, O.
(d) Experimental basic research.
(e) Study of applicability of Fiberglass material in coastal structures.
(f) Completed.

(3050) COASTAL ENGINEERING STUDY OF BAKERS HAULOVER INLET.

(b) Dade County Florida.
(c) County Engineer, Dade County Florida.
(d) Field investigation and model research; applied research.
(e) Investigate possibilities of improving navigation conditions at Baker's Haulover Inlet caused by high current velocities and to evaluate the situation in regard to the inlet's contribution to the erosion of the sea shore on both sides of the inlet.
(f) Completed.

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

(b) National Science Foundation.
(d) Field and laboratory study; basic research.
(e) A combined field and laboratory research program analyzing the transfer of energy from wind to water and the effect of sloping offshore profiles as compared with bodies of water with constant depth; study of the combined set-up by waves and wind for different standard profiles. Observations will be made on two platforms in the Gulf of Mexico and laboratory experiments will be carried out in the wave tank of the Coastal Engineering Laboratory.
(f) Preparations for field and laboratory tests have been completed.

(3410) COASTAL ENGINEERING STUDY OF BOCA RATON INLET.

(b) City of Boca Raton, Florida.
(c) City of Boca Raton, Florida.
(d) Field investigation and hydraulic-model study.
(e) Investigation of the possibilities of improving navigation conditions at Boca Raton Inlet which because of high current velocities, are dangerous to navigation; and evaluation of the situation in regard to the inlet's condition to the erosion of the seashore on both sides of the inlet.
(f) Field investigations completed; Model being constructed.

(3411) PRELIMINARY REPORT ON PROPOSED DEVELOPMENT OF CALADESI AND HONEYMOON ISLAND.

(b) Gee and Jenson, Consulting Engineers, West Palm Beach, Florida.
(c) Gee and Jenson, Consulting Engineers, Inc., West Palm Beach, Florida.
(d) Field Investigation; applied research.
(e) To determine consequences of subject development study includes a check depth survey in the sea territories of Big Pass and Hurricane Pass (Florida West Coast) and collection of data on tides and currents.
(f) Completed.

(3412) FLOOD TIDE STUDIES.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) Research into methods of preventing damage to life and property during heavy storm and hurricane tides along Florida shores.
(f) Active.

(3413) INLET STUDIES.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) Study of navigation and erosion problems at various Florida inlets.

GEORGIA INSTITUTE OF TECHNOLOGY, Hydraulics Lab.

(291) FLOW OF WATER OVER HIGHWAY IMBANKMENTS.

(b) Laboratory project.
(d) Experimental; partly sponsored by U. S. Geological Survey.
(e) Experimental data are being obtained on the discharge characteristics of an embankment-shaped weir. Emphasis has been placed on free discharge over smooth-surfaced embankments. Data have been obtained on the influence of embankment height and tail-water submergence. Detailed velocity surveys have been made to define the boundary layer between the upstream edge of the upstream shoulder and the crown. Tests were made on a 1:9-scale model in a 3-foot wide flume.
(f) Completed.
(g) It has been established that the discharge characteristics of an embankment can be related to the theoretical equation of discharge for a broad-crested weir by means of the discharge-displacement boundary-layer thickness. Data and procedures for computing the thickness of the boundary-layer at the control section have been determined as a means of generalizing the discharge equation for various shapes, sizes and roughness of embankments.

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

(b) Laboratory project; sponsored by the National Science Foundation.
(c) Dr. M.R. Carstens, School of Civil Engrg., Georgia Institute of Technology, Atlanta, Georgia.
(d) Experimental; basic research for doctoral dissertation.
(e) The diffusion of macroscopic foreign particles is being studied in a diffusion column in order to determine the difference in diffusion of the foreign particles and the fluid. The diffusion mechanism is created by a pattern of pulsing jets. The amplitude and frequency of the pulse of the jets is controlled. The foreign parcles are ion-exchange resin beads to which are attached radioactive cesium molecules. Particle concentration within the column is determined by gamma-ray radiation count.
(g) The diffusion measurements with the foreign particles is complete.
(h) Dissertation in preparation.

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(1584) FLOW OF WATER OVER WEIRS AND SPILLWAYS.

(b) Water Resources Division, Surface Water Branch, U. S. Geological Survey.
(d) Library search, re-analysis and correlation of published data, plus original research as required.
(e) A comprehensive study of the discharge characteristics of practical forms of weirs and spillways, including the preparation of bibliography and the collection and analysis of experimental data from all known sources. Objectives include the publication, in generalized form, of available experimental data.
(f) Continuing.

(1852) DISCHARGE CHARACTERISTICS OF RECTANGULAR PLATE WEIRS IN RECTANGULAR CHANNELS.

(b) Laboratory project; partly sponsored by the U. S. Geological Survey.
(d) Experimental and analytical; research for three Master's theses and one graduate research problem.
(e) An investigation of the comprehensive discharge characteristics of the basic sharp-edged, rectangular-notch weir. An attempt to evaluate by experimental means the influence of the several variables excluded by restrictions on the standard weir formulas. Tests cover a full range of notch widths, weir heights, and heads. Investigation limited to free flows of water at normal temperatures. Current studies concerned with influence of crest thickness.
(h) Experiments summarized in two Master's theses (James R. Wells, 1954; R.W. Carter, 1956). Third thesis in preparation.

(1855) TRANQUIL FLOW THROUGH SEVERAL OPENINGS IN AN OPEN-CHANNEL WIDTH CONSTRICTION.

(b) Water Resources Division, Surface Water Branch, U. S. Geological Survey.
(d) Experimental; basic research.
(e) Objective is to establish principles of flow division at a multi-opening width constriction. A 14-foot wide by 80-foot long flume is being used in the experimental investigation. Channel shape, degree and pattern of boundary roughness and constriction geometries will be varied. Boundary conditions considered will be governed by highway bridge practice.

(2529) UNIFORM FLOW IN OPEN CHANNELS.

(b) Water resources Division, Surface Water Branch, U. S. Geological Survey.
(d) Re-analysis and correlation of existing data; original experimental research and analysis; theoretical study of turbulence energy transfer and diffusion mechanisms.
(e) A fundamental investigation of the mechanics of uniform flow in open channels, with particular emphasis on the influence of channel shape on velocity distributions and wall shear-stress distributions. Experimental work is being conducted on simple and compound cross sections in a variable-slope 90-ft long flume.
(h) Progress report in preparation.

(3052) DEZ RIVER DAM SPILLWAYS.

(b) Resources and Development Corporation, 50 Broadway, New York City.
(c) Dr. M. R. Carstens, School of Civil Engrg., Georgia Inst. of Tech., Atlanta 13, Georgia.
(d) Experimental; design.
(e) An arch dam, 600 feet high, is being built in a narrow gorge of the Dez River in Iran. Two circular conduit spillways are placed on one side of the canyon. The horizontal portions of the two spillways are placed one above the other and discharge a free jet from the canyon wall. The inlet is a typical ogee section with Tainter gates followed by a horizontal passage which discharges into a vertical shaft. All hydraulic features of the spillways were investigated with the model.
(f) Completed.

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

(b) Laboratory project.
(c) Dr. Paul G. Mayer, School of Civil Engrg., Georgia Inst. of Tech., Atlanta Georgia.
(d) Experimental and theoretical; research for Master's thesis.
(e) Observations on laboratory flume (see Project 2529) revealed a discrepancy between depth measurements and piezometric-head measurements for flow conditions involving disturbed free surface. The phenomenon appears to be analogous to pressure or density variations in unsteady, compressible-fluid flows.
(g) Experimental equipment is being built.

HARVARD UNIVERSITY.

(3053) MODEL STUDIES OF HYDRODYNAMIC SMALL SCALE DELTAS.

(b) Laboratory project, cooperative with U. S. Geological Survey.
(c) Prof. H. A. Thomas, Jr., Civil and Sanitary Engineering Dept., Harvard University, Cambridge, Mass.
(d) Experimental, supplemented by field studies; for a doctor's thesis.
(e) The salient objective of the investigation is to elucidate the hydrodynamic environment controlling the formation of inclined bedding in sedimentary strata. Studies are being made to determine the interrelationship between current velocity, depth of water, thickness of cross-stratified units, particle texture, and the mechanism of turbulence at the site of deposition. Information is also being sought on the mechanics of the formation of "scour and fill" structures in sedimentary rocks.

(3054) HYDROLOGIC ASPECTS OF OVERALL DESIGN OF MULTI-PURPOSE, MULTI-UNIT, WATER RESOURCE SYSTEMS.

(b) Research project in Graduate School of Public Administration, Harvard University.
(c) Prof. Harold A. Thomas, Jr., Div. of Engineering and Applied Physics, Room 223 Pierce Hall, Harvard Univ., Cambridge, Mass.
(d) Experimental and theoretical; applied research.
(e) Examination of various approaches to analysis of physical input-output relationships in complex multi-unit, multi-purpose river basin systems. Includes feasibility of determining optimum system design through use, singly or in combination, of (1) simple mathematical models applied to the deterministic case, (2) queuing theory for the stochastic aspects, and (3) simulation of computers. Also includes analysis of use of synthetic hydology in simulation operation in obtaining meaningful data on systems yields and shortages for a combination of different outputs. The role of operating policy on system design, including the effect of forecasting, is also being studied.
(g) Only preliminary results obtained thus far on simulation procedures and simple mathematical model for deterministic case.

(3415) IRROTATIONAL PLANE FLOWS.

(b) Laboratory project.
(c) Prof. Garrett Birkhoff, Dept. of Mathematics, Harvard University, Cambridge 38, Mass.
(d) Theoretical research.
(e) Irrotational plane flows with free surface of an incompressible fluid, acted on by gravity, are being computed by the nonlinear integral equation method described in Chapter VIII of "Jets, Wakes and Cavities," by G. Birkhoff and E.H. Zarantonello.

UNIV --------

UNIVERSITY OF IDAHO, Engineering Experiment Station.

Inquiries concerning Projects Nos. 1859, 2080, 3056, 3057, and 3416, should be addressed to Associate Director, Prof. C. C. Warnick, College of Engineering, and Projects Nos. 1861, 1862, 2786, 3417, and 3418, should be addressed to Prof. G. L. Corey, Dept. of Agricultural Engineering, Univ. of Idaho, Moscow, Idaho.

(1859) A STUDY OF EFFECTIVENESS OF CANAL LININGS AND SOIL SEDIMENTS IN CONTROLLING SEEPAGE LOSSES.

(b) Laboratory project; cooperative with U. S. Bureau of Reclamation.
(d) Field investigation; basic and operational.
(e) Different types of canal linings are being studied and various ways of evaluating performance are being considered especially ideas for measuring canal seepage from both lined and unlined canals.
(g) New techniques for plastic film linings have been tried as well as natural silting effects. Also several new techniques are being developed for measuring seepage.
(h) Annual progress report is available for limited distribution.

(1861) THE IMPROVEMENT AND DEVELOPMENT OF STREAM-FLOW MEASURING DEVICES.

(b) Laboratory project being carried on under the Agricultural Experiment Station.
(d) Experimental; applied research for master's thesis.
(e) A gage to measure flow over a weir which has approach velocity has been studied.
(f) Completed.
(g) Several gages were developed and tabular relations developed for obtaining discharge direct from these special gage height readings.
(h) "Flow Measurement with Weirs Having an Appreciable Velocity of Approach," Robert L. McFall, M.S. Thesis, University of Idaho, June 1959.
A bulletin is also being prepared.

(1862) DETERMINATION OF ANNUAL RUNOFF FROM WATERSHED CHARACTERISTICS.

(b) Laboratory project, being carried on under Agricultural Experiment Station.
(d) Experimental; applied research.
(e) A study of the hydrological factors affecting the Moscow Mountain Watershed as it applies to the total water use in the area.
(g) Measurement data on a small water shed is continuing to be collected.

(2080) A STUDY OF RIME ICE AND SNOW CAPPING ON HIGH ALTITUDE PRECIPITATION GAGES.

(b) Laboratory project in cooperation with U. S. Weather Bureau, Bureau of Reclamation, Corps of Engineers, Soil Conservation Service and City of Moscow.
(d) Field investigation; basic and applied operational research.
(e) Several experimental gages have been installed to obtain basic data on snow capping. An electrical means of heating the orifice of the gage is being studied.
(f) Completed.
(g) Field gages were operated in winter, 1959, performance checked, and minor changes made in design. Gages will be used in subsequent work on other projects.
(h) Report to be prepared later in connection with other projects.

(2786) FARM IRRIGATION EFFICIENCIES.

(b) Laboratory project cooperative with Bureau of Reclamation under the Agricultural Experiment Station.
(d) Field investigation; basic and applied research.
(e) To evaluate irrigation efficiencies on actual farms to aid in planning of a water use on irrigation projects. To consider efficiency from aspect of farm operations and not just consumptive use of crops.
(g) Project is in second year of a 3-year program of collecting basic field data. Preliminary efficiencies are available on a few groups of farms.
(h) Annual report available on loacn.

(3056) TELEMETERING HYDROLOGIC DATA FROM MOUNTAIN LOCATIONS.

(b) Laboratory project in cooperation with federal agencies and power companies.
(d) Laboratory and field investigation; basic and applied operational research.
(e) A complete system for reporting six or more hydrologic data is being studied and basic parameters of snow are being considered for conversion into time delay circuits for transmission by radio.
(g) Circuit designs have been completed. Prototype of three measuring units is nearing completion.

(3057) CONSERVATION OF WATER FOR RANGE STOCK.

(b) Laboratory project; cooperative with Bureau of Land Management and ranchers.
(d) Field investigation; applied operational research.
(e) Experimental stock watering ponds in desert areas will be lined and evaporation control measures applied to see if extension of water supplies can be developed economically.
(g) Two installations have been completed and instrumentation is being installed. Soils and sites studies are in progress for additional sites.

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

(b) Agricultural Research Service, U. S. Dept. of Agriculture.
(d) Field investigation; applied research.
(e) A study is being made of basic methods of measuring snow water content for use in telemetering data from remote mountain locations.
(g) Project is being activated in November, initial survey of techniques is in progress.
(h) "Research Needs and Progress in Push-Button Snow Surveying," by C. C. Warnick. Paper presented at Annual Meeting of Soil Conservation Society of America, Rapid City, S. D. August 27, 1959.

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

(b) Laboratory project; under investigation in Agricultural Experiment Station.
(d) Theoretical; basic research.
(e) To determine the effect of various furrow geometric parameters and soil conditions on infiltration patterns by analogy methods.
(g) Electrical and model analogs are being constructed.

(3418) AUTOMATIC CONTROL OF SURFACE IRRIGATION WATER.

(b) Laboratory project; under investigation in Agricultural Experiment Station.
(d) Experimental field investigation; applied research.
(e) To develop devices which will automatically control surface irrigation water and to field test these devices to determine their limitations.
(g) Laboratory prototypes of gates that will operate automatically are being constructed. Sensing elements which will activate gates are being tested.

ILLINOIS STATE WATER SURVEY DIVISION.

Inquiries concerning Projects Nos. 559, 560, 2315, 2535, 3059 should be addressed to Mr. R. H. Harmeson, Peoria Lab., Box 717, Peoria, Illinois.

(552) SEDIMENTATION OF ILLINOIS RESERVOIRS.

(b) Laboratory project; cooperative with Agricultural Research Service, Soil Conservation Service, and University of Illinois Agricultural Experiment Station.
(c) Mr. R. L. Corinth, Ill. State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research.
(e) For design of water-supply reservoirs, measurements of sediment accumulation in lakes in Illinois. Sediment samples are analyzed and complete surveys of watershed soil type, slopes, land use, and conservation practices are made.
(g) Results show correlation between rate of sedimentation and land use on watershed; results show six factors in explaining sediment deposition: age of lake, capacity-inflow ratio, watershed gross erosion, a watershed shape factor, the density of non-incised channels, and a watershed slope factor.
(h) State Water Survey publications; Reports of Investigation Nos. 4, 7, 8, 9, 10, 12, 15, 16, and 18; sedimentation surveys of Spring Lake, Ridge Lake, Lake Chautauqua, Carbondale Reservoir, Lake Bracken, West Frankfort Reservoir, Lake Calhoun, Lake Springfield, and Lake Carthage, respectively.
"Water and Land Resources of Crab Orchard Lake Basin," Bulletin 42.
"Correlation of Reservoir Sedimentation and Watershed Factors, Springfield Plain, Ill." Report of Investigation 37.

(555) EVAPORATION IN ILLINOIS.

(b) Laboratory project.
(c) Mr. W. J. Roberts, Illinois State Water Survey, Box 232, Urbana, Ill.
(d) Field investigation; applied research.
(e) Measurements are made of evaporation at four stations in northern, central, and southern Illinois. Vapor pressure gradients are obtained at Urbana. Evaporimeters constructed and installed adjacent to pans for year-round records.
(h) Measurements published in Climatological Data, Illinois Section.

(559) ARTIFICIAL RECHARGE OF GROUND WATER.

(b) Laboratory project.
(d) Experimental, laboratory, and field investigation; basic research.
(e) Experimental pilot plant consists of river intake, control tower with chlorination

equipment, flow-measuring devices, and pumping equipment; two pits. One pit is gravity fed, has 40 by 62.5 feet bottom area, 1:2 side slopes, surface at bottom is 8 ft below river pool stage. Second pit is fed by 3 mgd pump, has 20 by 75 feet bottom area, 1:3 side slopes, bottom surface is 5 feet below river pool stage. A model of 1/8 pit (centerline to diagonal) is being used to study different types of pits and variations in ground-water gradients.

(g) Operation of pits for 8 consecutive winter seasons and one summer season completed by State Water Survey in May 1959. Subsequent operation to be responsibility of city of Peoria.

(h) Completion report of 8 years' operating methods and experience is in preparation.

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

(b) Laboratory project.

(d) Field investigation; basic research.

(e) To determine the ground water resources of the district; inventory of wells made, including construction and logs of wells. Ground water levels are measured continuously, pumpage data collected, river stages and rainfall recorded, physical and chemical analyses for changes in composition of ground water are made, areas of infiltration are determined, and all data are correlated with consideration of local ground conditions.

(g) To date conservation measures have shown more effect than artificial recharge.

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

(b) Laboratory project.

(c) Mr. H. F. Smith, Illinois State Water Survey, Box 232, Urbana, Illinois.

(d) Field investigation; applied research.

(e) To evaluate the potential yield of the sand and gravel deposits beneath the American Bottoms (East St. Louis area). Ground water levels are measured in 111 observation wells, 9 of which are equipped with recording gages. Ground water pumpage, Mississippi River stages, rainfall, and quality of ground water data are continuously collected. Maps are being prepared showing the distribution and areal extent of the hydraulic properties, the thickness of the aquifer, and water-table contours. Computations are being made to determine the amount of recharge from precipitation and from induced infiltration of river water, and the amount of subsurface flow from valley walls into the American Bottoms. A geohydrologic model will be devised to simulate the complex aquifer system.

(1092) HYDROLOGIC CYCLE EVALUATION.

(b) Laboratory project; cooperative with U. S. Geological Survey.

(c) Mr. H. F. Smith, Illinois State Water Survey, Box 232, Urbana, Illinois.

(d) Field investigation; applied research.

(e) Data from rain gage networks (gathered under Project 553) together with information from 3 stream gaging stations and 5 ground water level recorders were collected for use in analyzing storm rainfall-runoff relationships on small watersheds and effect of runoff on water table.

(f) Completed.

(h) Publication is being prepared.

(1335) GROUND WATER INVESTIGATION IN THE CHICAGO AREA.

(b) Laboratory project.

(c) Mr. H. F. Smith, Illinois State Water Survey, Box 232, Urbana, Illinois.

(d) Field investigation; applied research.

(e) Study of variations of natural resources. Investigation of artesian well field with wells 1200 to 2200 feet deep, locally heavily pumped. Study of ground water level recession, interferences, transmissibilities, effect of additional demands.

(g) Results show the ground water resources in Chicago region are developed from four water-yielding units: glacial drift aquifers, shallow dolomite aquifers, Cambrian-Ordovician Aquifer, and Mt. Simon Aquifer. The Cambrian-Ordovician has been the most highly developed source of large ground-water supplies. The glacial drift and shallow dolomite aquifers yielded more than half of the 127.9 mgd of ground water pumped in the region in 1957. Future ground-water supplies should be taken from the shallow aquifers wherever possible.

(h) "Preliminary Report on Ground-Water Resources of the Chicago Region, Illinois," Cooperative Ground-Water Report 1, State Water Survey and State Geological Survey, 1959.

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

(b) Laboratory project, in cooperation with Agricultural Research Service, Soil Conservation Service, and Illinois Agricultural Experiment Station.

(c) Mr. H. W. Humphreys, Illinois State Water Survey, Box 232, Urbana, Illinois.

(d) Experimental; generalized applied research for development and design.

(e) To determine the most desirable proportions and shapes of drop-inlet spillway structures that have unique flow characteristics and to develop anti-vortex devices. To provide the necessary information on flow relations and discharge coefficients so that these structures may be economically designed. Initial phases of study concerned with hydraulics of square risers with free discharge. Effect of lip or crest shape and anti-vortex devices being studied. Second phase to include the complete spillway. Experimental apparatus constructed and tests are being conducted on the complete spillway. Information is being obtained on discharges, vortex effect on discharge, pressures, a flat plate anti-vortex device, and flow conditions.

(g) Hydraulics of various types of flow

possible in square risers are well defined as well as some of the effects of non-square crest shape. Model tests were performed on a drop-inlet spillway to determine whether or not a metal grating deck placed above the inlet can control vortices. The results of the tests show that gratings do not prevent or control strong vortices.

(h) "Some Experiments with Emergency Siphon Spillways," Warren B. McBirney, a discussion by Fred W. Blaisdell and Harold W. Humphreys, Proceedings, ASCE, Paper No. 1807 Vol. 84, No. Hy5, Part 1, October 1958.
"Effect of Metal Grating Deck on Drop-Inlet Spillway Performance," State Water Survey Circular 75.

(2315) INTERFERENCE BETWEEN RECHARGE PITS.

(b) Laboratory project.
(d) Field investigation; basic research.
(e) Two pits were operated simultaneously for three consecutive years.
(g) Analysis of collected data in progress.
(h) Results to be reported with material of project 559.

(2532) EVAPORATION RETARDATION.

(b) Laboratory project.
(c) Mr. W.J. Roberts, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research, design.
(e) Monomolecular chemical films to retard evaporation from water supply lakes and ponds in Illinois. Laboratory studies continuing on smaller containers.
(g) Analysis in progress.
(h) "Reducing Lake Evaporation in the Midwest," W.J. Roberts, Jour, Geophys. res., Vol. 64, No. 10, p. 1605-10.
"State Water Survey Technical Letter No.2," 1959.
"Evaporation Suppression from Water Surfaces," W.J. Roberts, Trans. AGU, 38(5): 740-44, 1957.

(2533) MOISTURE INFLOW STUDY.

(b) Laboratory project.
(c) Mr. R.G. Semonin, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Applied research.
(e) Computation of atmospheric moisture inflow of Illinois and subsequent correlation with precipitation. Moisture and wind data obtained from RAOB data.
(g) Analysis completed.
(h) Report in preparation.

(2534) DENSE RAIN GAGE NETWORK PROJECTS.

(b) Laboratory project.
(c) Mr. G.E. Stout, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research.
(e) Data from four rain gage networks, consisting of 50 gages in 400 square miles, 10 gages in 100 square miles, 51 gages in 550 square miles, and 11 gages in 10 square miles. Studies include: (1) Rainfall variability; (2) frequency of point and areal mean rainfall; (3) area-depth relations; (4) variation of point rainfall with distance; (5) areal representativeness of point rainfall; and (6) reliability of areal mean rainfall estimates.
(h) "Rainfall Relations on Small Areas in Illinois," State Water Survey Bulletin 44.

(2535) FILTERING THROUGH COARSE MATERIALS.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) Various sizes of rounded gravel and of broken limestone were studied in tile rings in the bottom of both recharge pits under field conditions, to determine limit of coarseness of filter material. Further work is planned in the laboratory with control of the variables involved.
(f) Suspended.
(g) Field studies indicate filtering occurs through materials up to 3/4-inch size.

(3058) HYDROMETEOROLOGICAL ANALYSIS OF SEVERE RAINSTORMS.

(b) Laboratory project.
(c) Mr. S.A. Changnon, Jr., Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; applied research.
(e) Field surveys and detailed analyses of severe rainstorms in Illinois. Analyses based upon radar, synoptic weather, and field survey data and include area-depth-duration relations, antecedent rainfall evaluation, isohyetal maps for peak periods of storm.
(g) Analyses completed on 11 storms since 1951.
(h) Reports of Investigation Nos. 14, 24, 27, and 35 of State Water Survey.

(3059) THERMAL LOADINGS AND CHARACTERISTICS OF SURFACE WATERS.

(b) Laboratory project.
(d) Experimental, laboratory, and field investigations; applied research.
(e) To determine the relationships between temperature, water usage, stream assets, and stream recovery capabilities.

(3419) PRECIPITATION DROUGHT CHARACTERISTICS.

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

(3420) FREQUENCY AND DURATION OF LOW FLOWS.

(b) Laboratory project.
(c) Mr. John B. Stall, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Theoretical; applied research.
(e) Analysis of the severity, frequency, and duration of low flows in Illinois streams. Study of the suitability of various theoretical distributions in explaining the occurrence of these low flow events. The synthesis of low flow information at a short-record stream gage from a suitable long stream-gaging record.
(g) Gumbel's Extreme Value Law found satisfactory for explaining the occurrence of independent low-flow periods from 6 months' to 36 months' duration for recurrence intervals from 2 years to 40 years at five stream gaging stations in Illinois, varying in drainage area from 550 square miles to 1310 square miles.
(h) "1952-55 Illinois Drought with Special Reference to Impounding Reservoir Design," H.E. Hudson and W.J. Roberts, State Water Survey Bulletin 43, 1955 (out of print).

(3421) PILOT DRAINAGE BASIN STUDIES IN NAPERVILLE AREA.

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

(3422) STUDY OF FLOW IN SMALL WATER DISTRIBUTION SYSTEMS.

(c) Dr. T.E. Larson, Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Theoretical calculations and field investigation.
(e) To determine the rate of induced movement necessary to provide protection against corrosion of pipe in water distribution systems by forced movement of inhibited waters.

(3423) QUANTITATIVE PRECIPITATION DIFFERENCES BETWEEN EXTREME SOUTHWESTERN LAKE MICHIGAN AND NEARBY LAND AREAS.

(b) Laboratory project.
(c) Mr. S.A. Changnon, Jr., Illinois State Water Survey, Box 232, Urbana, Illinois.
(d) Field investigation; basic research.
(e) Monthly, seasonal, and annual average precipitation data, based on 10 years of records obtained at water intake station located on Lake Michigan four miles east of the Chicago shore line, were compared with precipitation data from nearby land stations to get an estimate of how lake precipitation varied in relation to nearby land precipitation. Secondly, physical factors that appeared to cause differences were studied.
(g) On the average, annual precipitation at the lake-located station was 21% less than land amounts, and the greatest seasonal difference occurred in the spring and fall. Effect of lake appeared to decrease precipitation over the lake especially in summer, while lake and urban effects tend to increase precipitation over Chicago especially in winter.
(h) "Precipitation Contrasts Between Chicago Urban Area and Offshore Station in Southern Lake Michigan," (prepared for publication).

ILLINOIS STATE WATERWAYS DIVISION, Springfield.

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

(b) State of Illinois.
(c) Mr. Thomas B. Casey, Chief Waterway Engineer, Div. of Waterways, Department of Public Works and Buildings, 201 West Monroe Street, Springfield, Illinois.
(d) Field investigation; applied research.
(e) To obtain and correlate basic data on the several forces and factors involved in erosion processes along the Ill. Shore of Lake Michigan to the end that future efforts toward the prevention of erosion might be founded upon a more definite and factual basis with a consequent greater degree of assurance that the works will serve the intended purposes.
(h) "Interim Report for Erosion Control Ill. Shore of Lake Michigan," Thomas B. Casey, 1958.

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

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

(2316) RUNOFF FROM SMALL AGRICULTURAL AREAS IN ILLINOIS.

(b) Laboratory project cooperative with ARS, U. S. Department of Agriculture.
(d) Experimental and field investigation; basic research.
(e) To determine frequencies of peak rates and total amounts of runoff from agricultural watersheds of 25 to 1,500 acres; to determine maximum rates of runoff from agricultural watersheds in different soil association areas in Illinois; to compare runoff from agricultural watersheds under accepted soil conservation practices with watersheds cultivated without soil

conservation practices. Watersheds of 45.5, 63, 82, and 390 acres near Monticello, Illinois are covered with a rain gage network, and runoff is measured at weirs and spillway structures by water level recorders. Maximum stage recorders are installed at field structures on 8 watersheds in Champaign, Piatt, Vermilion, and Ford Counties on watersheds ranging in size from 45 to 1,400 acres. Model studies and field calibrations are made on the field structures.

(h) "Peak Runoff and Rainfall Analyses for Two Agricultural Watersheds," by D.L. Pigg, M.S. Thesis, University of Illinois, Oct. 1959 (available on loan).

(2317) A STUDY OF DRAINAGE OF SOME ILLINOIS SOILS.

(b) Laboratory project cooperative with ARS, U. S. Department of Agriculture.
(d) Field investigation; applied research.
(e) To determine on different soil types the effect of tile spacing and depth on (1) water table as measured by drawdown wells, (2) on crop yields; to verify present tile depth and spacing formulas for soil types investigated; and to compare physical laboratory measurements with field measurements.
The rate of water table drawdown is measured in wells perpendicular to tile lines. Field permeability and laboratory permeability measurements are made as well as physical analysis of the soil type. Crop yields are determined laterally from the tile lines.

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

(b) Laboratory project.
(d) Experimental investigation in the laboratory; applied and basic research.
(e) To investigate the performance of soil and water conservation structures by means of hydraulic model studies, to study water flow patterns into surface drains and to determine the cause of failures and remedial measures of certain conservation structures under flood conditions.
(h) "Critical Flow Criterion for Open Channel Computations," J.A. Replogle, Paper 59-710 presented at the winter meeting of the American Society of Agricultural Engineers, December 1959.

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

(b) Laboratory project cooperative with ARS, U. S. Dept. of Agriculture.
(d) Experimental; basic research.
(e) Natural rainstorms are photographed with a raindrop camera so that the number of raindrops, their size and size distribution, and the kinetic energy of a rainstorm may be calculated. Physical measurements will be made of the soil to determine the effect of the kinetic energy of the rainstorm on soil loss. The nature and properties of rainstorms that occur in this area of Ill. will also be studied.

UNIVERSITY OF ILLINOIS, Civil Engineering Dept.

Inquiries concerning Projects Nos. 564, 1591, 2319, 3063 to 3066, incl., and 3426 should be addressed to Dr. V.T. Chow, Prof. of Hydraulic Engineering; or for Projects Nos. 1589, 2085, 2087, 2088, 2318, 2790, 3060, 3061, 3062, and 3425 should be addressed to Prof. J.C. Guillou, Dept. of Civil Engineering, University of Illinois, Urbana, Illinois.

(564) HYDROLOGY OF URBAN AREAS.

(b) Laboratory project, cooperative with Ill. State Water Survey.
(d) Experimental, theoretical, and field investigation; applied research and design.
(e) Rainfall-runoff study of an urban watershed, having an effective drainage area of 4.45 square miles and a population density of 14 persons per acre. Runoff is measured by a U.S.G.S. stream gage and precipitation by a network of fourteen rain gages strategically located in and out of the watershed. New types of evaporimeter are being developed and check results are being made.

(1589) OPEN CHANNEL METER.

(b) Laboratory project in cooperation with Theoretical and Applied Mechanics Dept.
(d) Experimental and analytical.
(e) This study is concerned with a critical depth meter which may be economically built in a sewer after the sewer has been placed in service. Tests using a 16 inch diameter pipe, with adjustable slope, has been tested using several types of obstructions.

(1591) DETERMINATION OF WATERWAY AREAS.

(b) Laboratory project, cooperative with Ill. Div. of Highways and Bureau of Public Roads.
(d) Analytical and field investigation; applied research and design.
(e) To determine the discharge of water which will reach openings of highway drainage structures, such as bridges and culverts and to provide a simple but scientific procedure for use of engineers in establishing the economical and adequate size of opening.
(g) Six preliminary reports and two field reports have been prepared.
(h) Publications not yet available to the public.

(2085) CALIBRATION AND USE OF CERTAIN INLET GRATES.

(b) Illinois Division of Highways.
(d) Laboratory investigation; applied research.
(e) Full scale model tests of four standard Division of Highways inlets. Original and revised inlet grate designs have been tested.
(f) Completed.
(h) "The Use and Efficiency of Some Gutter Inlet Grates," John C. Guillou, is available from the Engineering Experiment Station as

Bulletin 450.

(2087) EFFECTIVENESS OF SUBWAY GRATINGS FOR HIGHWAY DRAINAGE.

(b) Departmental special study.
(d) Laboratory investigation; applied research.
(e) Full scale model tests of two subway grating designs are being tested in standard Illinois Division of Highways, Type II inlet frame.
(f) Suspended temporarily.

(2088) DISCHARGE CHARACTERISTICS OF RECTANGULAR TYPE INLET BOXES.

(b) Departmental study.
(d) Laboratory investigation; basic research.
(e) Scale model investigation of rectangular inlet box with long Lucite discharge pipe to verify or disprove the weir-orifice discharge theory.
(f) Suspended temporarily.

(2318) FAUBER BRIDGE MODEL STUDY.

(b) Departmental graduate study.
(d) Laboratory investigation; applied research.
(e) A design has been developed whereby a three tube culvert and an energy dissipator may replace an inadequate highway bridge. Model studies have been conducted to verify the proposed design.
(h) Final report in preparation.

(2319) FREQUENCY STUDY OF HYDROLOGIC DATA.

(b) Departmental study.
(d) Basic and applied research.
(e) A survey of existing literature and applications of the probability law to the distribution of hydrologic data. The method of analysis thus developed is being applied to small watersheds in the State of Ill. in order to expose the runoff characteristics of the watersheds.
(g) Results include development of theoretical procedure of analysis, derivation of characteristic values of the probability law, plotting of actual data, and derivation of characteristic indexes of the runoff data.
(h) "Determination of Hydrologic Frequency Factor," Ven Te Chow, Journal of the Hydraulics Division, Proceedings, American Society of Civil Engineers, Paper 2084, Vol. 85, No. HY7, July 1959, pp. 93-98.

(2790) SIDE CHANNEL SPILLWAY STUDY.

(b) Departmental graduate study.
(d) Laboratory investigation, applied research.
(e) Model investigation of flow conditions on the apron below the spillway crest and above the spillway channel. The purpose of the investigation is to determine the geometrics of the apron and the necessity of a critical depth control at the entrance to the spillway channel.

(3060) OPERATIONAL CHARACTERISTICS OF FILTER DRAINS.

(b) Association of American Railroads.
(d) Experimental; applied research.
(e) Literature study and experimental investigation of characteristics of flow through granular filters and perforated drain pipe. Laboratory calibration of coated and uncoated drain pipes has been completed. Three tests have been completed to investigate concrete sand as filter material.
(g) Preliminary tests indicate that arching of filter material is much more important than bridging when stability of the filter material is considered.

(3061) FLOW CHARACTERISTICS OF REND LAKE SPILLWAY.

(b) Laboratory project and class problems.
(d) Model investigation of uncontrolled apron type spillway.
(e) A 1:50 scale model of approach section, spillway and energy dissipator. Tests of the original design have been completed. The spillway walls have been redesigned for more uniform distribution of flow at the hydraulic jump. The redesign has been tested and verified.

(3062) INVESTIGATION OF INFILTRATION THROUGH GRANULAR MEDIA.

(b) Post doctoral research by Dr. Shigeru Tanaka.
(d) Theoretical and experimental.
(e) Investigation of advance of wetted front and attendant pressure temperature and moisture conditions. The test apparatus consists of an instrumental vertical cylinder filled with Ottawa Sand and subject to rates of infiltration.
(f) Laboratory investigation has been completed.

(3063) THEORETICAL STUDY OF PROFILES OF GRADUALLY VARIED FLOW.

(b) Departmental study.
(d) Theoretical; basic and applied research.
(e) Mathematical analysis of the profiles of gradually varied flow in artificial open channels.
(f) Completed.
(g) A mathematical method of integration was developed. Bakhmeteff's varied-flow function table was extended to cover the range of application required by the new method.
(h) "Discussion of a Note on the Differential Equation of Steady, Gradually Non-uniform Flow in Open-Channels, Ven Te Chow, Journal of Geophysical Research, Vol. 64, No. 4, pp. 487-488, April 1959.
"Open-Channel Hydraulics," Ven Te Chow, McGraw-Hill Book Company, New York, 1959.

(3064) FLOW PATTERNS NEAR THE CRACK IN TILE DRAINS.

(b) Graduate project, doctoral thesis for Prof. E. J. Monke.
(d) Theoretical and experimental; basic research for doctoral thesis.
(e) A study of the flow patterns around a circular drain. In the study use was made of

an electrical analog model, a physical hydraulic model for one half the tile in a sand bed, and a mathematical analysis with numerical approximations.

(f) Completed.

(g) The results indicate: Darcy's law is applicable to the surface of seepage existing along the peripheral opening of a nearly empty five-inch circular drain; the effective gain in head in the empty drain was slightly greater than the diameter of the drain which was located in a saturated, homogenous medium 4 feet deep, 100 feet apart, and 8 feet above an impervious layer; when the outer boundary was circular, the effective potential gain was less than the diameter of the drain and varied with the nearness of that boundary; the efflux from the medium of a three-dimensional model varied, not only with drain-opening width, but also with the hydraulic conductivity of the flow medium; and the unsymmetrical drain opening effected by sealing part of the circumferential drain opening gave higher discharges near the drain than in the cases where the openings were symmetrical.

(h) "A Study of Water Flow Patterns Near Subsurface Drains," by E.J. Monke, Doctoral Thesis, Graduate College, University of Illinois, 1959.

(3065) STUDY OF A TORNADO MODEL FOR DESIGN PURPOSES.

(b) Graduate project, doctoral thesis for Mr. G. E. Martin.

(d) Analytical and field investigations; basic research for doctoral thesis.

(e) An attempt is being made to correlate the laws of thermodynamics, atmospheric physics, dynamic meteorology, and fluid mechanics with the available data from actual tornadoes and to construct a model tornado from these data for design purposes that is compatible with the theory. The facilities of both the Civil Engineering Department and the Illinois State Water Survey, including a weather radar, are available for use in this study.

(3066) THE MECHANICS OF SQUARE ELBOW LOSSES.

(b) Graduate project, doctoral thesis for Mr. R. D. Black.

(d) Experimental; basic research for doctoral thesis.

(e) This is a study of the factors that contribute to the loss in energy experienced by the flow of water as it passes through an abrupt angle and size reduction such as that of a plugged "tee." The study will be conducted by means of hydraulic models.

(3425) LOCKPORT SLUICEGATE STUDY.

(b) Metropolitan Sanitary District of Greater Chicago.

(d) Experimental, applied research.

(e) A 1:20 scale model has been constructed and is being tested. The subject sluice gates will be used for supplemental control of storm water releases from the Chicago Drainage Canal. Three turbine pits in the existing powerhouse at Lockport have been modified to receive triple sluice gate. The model results will be used for calibration of the prototype structure.

(3426) TIME FACTORS IN SURFACE RUNOFF.

(b) Departmental graduate study by Ina M. Carpenter.

(d) Experimental and analytical; basic research.

(e) From observed hydrographs, factors may be derived that will describe the retardation of runoff for each area. It is expected that these factors may be used to adjust the observed peak discharges to a common standard of physiographic effects, and thereby facilitate the development of the magnitude-frequency relations. The purpose of this study is to derive, and to test the applicability of the factors that describe the retardation of runoff for small areas on which the annual flood peaks are being observed. One of the areas under present consideration is the watershed of Madden Creek near West Salem, Illinois.

UNIVERSITY OF ILLINOIS, Fluid Mechanics and Hydraulics Laboratory.

Inquiries concerning projects No. 1343 and 2083 should be addressed to W.M. Lansford, 219 Talbot Laboratory, University of Illinois, Urbana, Ill., and projects Nos. 2320, 2536, 2537 and 3427 should be addressed to Professor J. M. Robertson, 125 Talbot Laboratory, University of Ill., Urbana, Ill.

(1343) VELOCITY DISTRIBUTION STUDY IN A FLOOD-PLAIN CHANNEL.

(b) Research.

(d) Basic research.

(f) Inactive - suspended.

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

(b) Research.

(d) Basic research.

(e) Data were obtained from a channel artificially roughened.

(f) Investigation reactivated, additional data being taken.

(2320) TURBULENT BOUNDARY LAYER IN A DIFFUSER.

(b) Laboratory project.

(d) Experimental and analytical; basic research.

(e) Effect of adverse pressure gradient on the development of a turbulent boundary layer is being studied in a 10-degree conical diffuser. Air is the fluid medium being used.

(f) Inactive.

(h) "Separation Prediction in Conical Diffusers," J.M. Robertson and H.R. Fraser, ASME Paper 59-Hyd-14, to be published in ASME Journal of Basic Engineering.
"The Turbulent Boundary Layer in a Conical

Diffuser," H.R. Fraser, ASCE J. Hydr. Div., June 1958, Paper 1684.

(2536) STUDY OF HOMOLOGOUS TURBULENCE.

(b) Laboratory project, formerly National Science Foundation.
(d) Basic research.
(e) The nature of turbulence, its production and dissipation, are to be studied in the simplest possible shear flow. This is to be produced in plane Couette flow in which the shear is constant and the turbulence homogeneous but not isotropic. Mean flow studies essentially complete.
(f) Tests and analysis continue.
(h) "On Turbulent Plane-Couette Flow," by J. M. Robertson, Proc. 6th Midwest Conf. on Fluid Mechanics, Univ. Texas, 1959, pp. 169-182.

(2537) WATER EXIT HYDROBALLISTICS.

(b) Office of Naval Research, Dept. of the Navy.
(d) Basic research; experimental.
(e) Information on water exit behavior of ellipsoidal bodies of fineness ratios 4 and 8 is being obtained photographically. Water is principal test liquid but glycerine and 100 percent brine solutions have also been used.
(f) Tests essentially completed, data being reduced.
(g) Effects are found to be small, velocity first increases and then decreases as body exists. Significant amounts of water are carried out with the body.
(h) "A Study of the Kinematics of Buoyant-Body Water Exit," M. E. Clark and J.M. Robertson, TAM Dept. Report 145, April 1959.
"Transition Stimulation for Terminal Velocity Reduction in Water-Exit Studies," J.M. Robertson, J.C.F. Chow, and M.E. Clark, TAM Dept. Report 152, November 1959.
"Hydroballistic Calculations of the Rise and Water Exit of Buoyant Bodies," J. M. Robertson, TAM Dept. Report 153, Nov. 1959.

(3427) STRUCTURE OF TURBULENCE NEAR ROUGH SURFACES.

(b) Bureau of Ships Fundamental Hydromechanics Research Program.
(d) Basic research; experimental.
(e) Information on mean-flow and turbulence structure (including pressure fluctuations) near a natural roughness to be studied in 8-inch steel pipe line. Basic question is how roughness produces turbulence.
(f) Investigation to start 1 January 1960.

IOWA INSTITUTE OF HYDRAULIC RESEARCH, State University of Iowa.

(66) HYDROLOGIC STUDIES, RALSTON CREEK WATERSHED.

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

(67) COOPERATIVE SURFACE-WATER INVESTIGATIONS IN IOWA.

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

(68) HYDROLOGIC STUDIES, RAPID CREEK WATERSHED.

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

(73) MEASUREMENT OF TURBULENCE IN FLOWING WATER.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical.
(e) Instruments, primarily electrical in operation, are being developed to measure the characteristics of turbulent flow under a wide range of laboratory and field conditions. Both sensing and computing elements are involved.
(g) A combination probe which senses both pressure and velocity simultaneously has been developed and used to measure conditions

in the initial zone of a large air jet, as a preliminary to measurements in water.

(79) CAVITATION.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical; basic research and graduate theses.
(e) Basic information is sought on cavitation for systematically varied boundary conditions. Studies of high-velocity submerged jets are being continued, with supplementary measurements of pressure fluctuations in air; instrumentation has been developed for measurement of the correlation between the velocity and pressure fluctuations to make possible prediction of the incipient cavitation index for given mean-flow conditions. Previous measurements of the pressure distribution on a number of head forms at zero angle have been extended to various angles of yaw. Cavitating flow about a rotating cylinder in a normal stream has been investigated.

(81) MATHEMATICAL ANALYSIS OF PRESSURE DISTRIBUTION.

(b) Cooperative with Office of Naval Research and David Taylor Model Basin, Department of the Navy.
(c) Dr. Louis Landweber, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Theoretical; basic research.
(e) A method for the determination of velocity and pressure distribution about bodies of revolution and symmetrical two-dimensional forms in arbitrary states of motion, based on solutions of integral equations of the first kind, has been programmed for the IBM 650 computer.
(h) "Potential Flow about Bodies of Revolution and Symmetric Two-Dimensional Forms," L. Landweber. Final Report on Contract Nonr-2451(00) to the David Taylor Model Basin, Dec. 1959.

(854) BOUNDARY-LAYER DEVELOPMENT ON SMOOTH AND ROUGH SURFACES.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Louis Landweber, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical; basic research.
(e) Purpose of work is to determine the relations between boundary-layer characteristics for smooth and rough boundaries of arbitrary shape. The three-dimensional boundary layer on an ellipsoid with three unequal axes is being measured.

(1875) CHARACTERISTICS OF STABLE EDDIES.

(b) Laboratory project, partially supported by Office of Naval Research, Department of the Navy.
(c) Dr. Hunter Rouse, Iowa Inst. of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and analytical.
(e) Distributions of velocity, pressure, and turbulence are being investigated throughout the vicinity of separation zones produced by abrupt changes in flow section to the end of establishing the primary eddy characteristics as functions of the boundary geometry.
(g) The study of axisymmetric flow at two comparable boundary configurations - an abrupt pipe inlet and a blunt-nosed shaft - just completed.
(h) "Distribution of Energy in Regions of Separation," Hunter Rouse, La Houille Blanche, in press.

(2091) RESEARCH ON SHIP THEORY.

(b) Cooperative with Office of Naval Research, Dept. of the Navy and Society of Naval Architects and Marine Engineers.
(c) Dr. Louis Landweber, Iowa Inst. of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical; basic research.
(e) To determine the laws governing the forces, moments, and motions of ships in smooth and disturbed seas, in order to furnish design data to the naval architect. Work is under way on the following problems: (1) Wave damping of a series of rolling (Ursell) cylinders. (2) Drag of oscillating plates of various aspect ratios. (3) Effect of turbulence stimulation on roll-damping of ships. (4) Resolution of viscous and wave drag by means of measurements in the wake of a ship. (5) Effect of a free surface and boundary-layer characteristics on separation. (6) Development of an effective turbulence stimulator. (7) Added mass of a prolate spheroid vibrating horizontally in various modes in a free surface. (8) Treatment of vibration of spheroids and shiplike forms on the basis of a unified theory of hydroelasticity. (9) Translation of Ship Motions (Kachka Korablia) by Blagoveschensky.
(h) "Experimental Investigation of the Added Mass of Cylinders Oscillating Horizontally in a Free Surface," C.C. Wu, M.S. Thesis, State University of Iowa, Aug. 1959, (available on loan).
"Roll Damping Due to Bilge Keels," M. Martin, IIHR Research Report, Nov. 1958.
"Experimental Investigation of Ursell's Theory of Wave Making by a Rolling Ship," W.C. McLeod, M.S. Thesis, State University of Iowa, June 1959 (available on loan).
"Added Mass of a Rigid Prolate Spheroid Oscillating Transversely in a Free Surface," L. Landweber and M. Macagno, submitted to Journal of Ship Research.

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

(b) Laboratory project, partially supported by National Science Foundation.
(c) Dr. Hunter Rouse, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Analytical; basic research for doctor's degree.

(e) Determination of streamline configuration through use of digital computer for various relative heights of weir.
(f) Programing for computer essentially completed.

(2328) INVESTIGATION OF SURFACE ROUGHNESS.

(b) Cooperative with U. S. Geological Survey, Department of the Interior.
(c) Dr. Herman J. Koloseus, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental research.
(e) Initial purpose is to determine effect of areal distribution of roughness elements on resistance in both subcritical and supercritical flow. Tests are being conducted on cubical elements cemented to floor of 30-foot tilting flume in varying concentration. An 85-foot tilting flume with an exceptionally plane bottom has just been completed.
(f) Measurements have been carried out with three different roughness concentrations: 1/32, 1/128, and 1/512.

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

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental; applied research.
(e) The purpose is to improve the analysis of turbulent velocity and pressure fluctuations.
(g) An electronic integrating circuit designed for use with a magnetic tape recorder has been built for use in any type of flow.
(h) "Application of a Magnetic Tape Recorder to the Analysis of Continuous Random Signals," J.L. Mortley, M.S. Thesis, State University of Iowa, Aug. 1959 (available on loan).
"Use of a Magnetic Tape Recorder in Measurements of Turbulence," H. W. Ho, IIHR Research Report, 1959.
"Pressure and Velocity Fluctuations in a Submerged Jet," K.C. Peng, IIHR Research Report, 1959.

(2791) MIXING IN STRATIFIED FLOW.

(b) Cooperative with the Office of Ordnance Research, Department of the Army.
(c) Dr. Enzo Oscar Macagno, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical; basic research.
(e) Determination of the characteristics of mixing, due to inherent instability, at the interface of stratified flow. Analysis of the stability of the interface.
(g) Thickness of mixing layer and transfer of mass show a correlation with Froude and Reynolds numbers of a layer comprising the interface. Two regimes are apparent.

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

(b) Cooperative with the Office of Naval Research, Department of the Navy.
(c) Dr. Philip G. Hubbard, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Primarily experimental.
(e) Powered models of a strut-mounted propeller and a merchant vessel are driven in a towing basin, and the wake is investigated with a pitot rake and a hot-wire anemometer.
(g) Measurements of both mean and turbulent quantities in the initial zone of a six-inch propeller have been completed. Mean-velocity data have been obtained in the zone near a ten-foot ship model.
(h) "Decay of Turbulent Wakes Behind a Propeller," G. Aron, M.S. Thesis, State Univ. of Iowa, February 1960 (available on loan).

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

(b) Laboratory project.
(c) Prof. J. W. Howe, Dept. of Mechanics and Hydraulics, State Univ. of Iowa, Iowa City, Iowa.
(d) Statistical.
(e) Exploration of possibility of estimating frequencies of rare floods based on combination of observed frequencies of precipitation and infiltration.
(f) First phase complete. Continuing.
(g) Good correlation for a small, a medium, and a large watershed found.

(2797) OPTIMUM SHAPE OF 90° BEND IN RECTANGULAR CHANNEL.

(b) Laboratory project.
(c) Prof. J.W. Howe, Dept. of Mechanics and Hydraulics, State Univ. of Iowa, Iowa City, Iowa.
(d) Experimental; for master's thesis.
(e) Bend width varied through 50-percent increase to determine optimum proportions.
(f) Completed.
(g) An equal-radius geometry (41-percent increase in width) is the most efficient.
(h) "The Optimum Shape of a 90° Bend in a Rectangular Channel," Carl E. Denzler, M.S. Thesis, State Univ. of Iowa, Feb. 1960 (available on loan).

(3068) DETERMINATION OF DYNAMIC FORCES ON FLASHBOARDS.

(b) Laboratory project.
(c) Prof. J.W. Howe, Dept. of Mechanics and Hydraulics, State Univ. of Iowa, Iowa City, Iowa.
(d) Experimental, for master's thesis.
(e) Measurement by dynamometer of moment exerted by water flowing over flashboard.
(f) Completed.
(g) A parameter involving turning moment on flashboard related to head-and tail-water levels and to slope of downstream apron.
(h) "Moments on a Flashboard," Alan H. Schultz, M.S. Thesis, State Univ. of Iowa, Aug. 1959 (available on loan).

(3069) INSTALLATION OF GRADED RIP-RAP FOR PROTECTION OF PIERS AND ABUTMENTS AGAINST SCOUR.

(b) Graduate project.
(c) Prof. C.J. Posey, Engineering Building,

Iowa City, Iowa.
(d) Experimental; applied, for master's thesis.
(e) Methods of placement and areal extent necessary for effective protection will be studied.
(g) A relationship has been developed between the riprap placement necessary and the size of the scour hole that would form if there were no riprap. This relationship has been tested for the case of single circular piers.
(h) "Riprap Protection Against Scour Around Bridge Piers," Nelson L. de Sousa Pinto, M.S. Thesis, State University of Iowa, Aug. 1959 (available on loan).

(3070) ASPIRATIVE EFFICIENCY OF VARIOUS CHIMNEY SHAPES.

(b) Graduate project.
(c) Prof. C.J. Posey, Engrg., Bldg., Iowa City.
(d) Experimental; applied, for master's thesis.
(e) Investigation of possibility of using winds to move air through pipe systems for evaporative stabilization of pavement subsoils makes it necessary to test efficiency of "chimney" shapes.

(3071) MEASURING EQUIPMENT FOR SURFACE ROUGHNESS.

(b) Graduate project.
(c) Prof. C.J. Posey, Engineering Building, Iowa City, Iowa.
(d) Developmental; applied.
(e) Design and construction of equipment to evaluate roughness parameters for range of surface roughness of interest to hydraulic engineers.
(f) Temporarily suspended.

(3072) SCOUR AT RELIEF BRIDGES.

(b) Laboratory project.
(c) Dr. Lucien M. Brush, Jr., Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental; master's thesis.
(e) To determine the amount and rate of scour at relief bridges.
(f) Completed.
(g) In a model study of relief-bridge abutments, rates of change of scour were measured for runs with bed-load transport. Qualitative estimates of scour without bed-load movement into the scour hole were made from the observed data and indicate a slight increase in scour should occur.
(h) "Scour at Relief Bridges," Robert C. Stiefel, M.S. Thesis, State Univ. of Iowa, Aug. 1959 (available on loan).

(3073) SEDIMENT TRANSPORT IN MEANDERING CHANNELS.

(b) Laboratory project.
(c) Dr. Lucien M. Brush, Jr., Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental; basic research and graduate thesis.
(e) To determine the amount of transport occurring in meandering channels of different curvature.
(f) Completed.
(g) Transport of bed-load in a two-foot-wide, meandering channel was reduced by a factor of 10 over a straight channel for the same mean boundary shear. Two sands, 0.58 and 1.6 mm in diameter, were tested in a fixed-wall, meandering channel with a centerline radius of curvature of 4 ft and a wave length of 16 ft.
(h) "Exploratory Study of Bed-Load Transportation in a Meandering Channel," Lucien M. Brush, Jr., International Assoc. for Hydraulic Research, 8th Congress, Seminar II, Transport of Materials in Water, 1959, Montreal, Canada.

(3074) WAKE OF ZERO MOMENTUM FLUX.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Mr. Arthur Toch, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental.
(e) Distribution of velocity, mean and turbulent, and of pressure is being measured in the field of flow past a bluff, axisymmetric body with a centrally located jet for the particular condition of zero momentum flux.

(3075) ANNULAR JETS IN GROUND PROXIMITY.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Lawrence R. Mack, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical; basic research and graduate theses.
(e) The distributions of mean velocity and mean pressure in the flow and on the boundaries near an annular jet are being studied for four cases: (1) A stationary annular jet impinging against a rigid ground plate; (2) an annular jet impinging against a rigid ground plate in the presence of an ambient transverse flow (wind-tunnel study); (3) a stationary annular jet directed against a nearby water surface; and (4) an annular jet traveling over water. The relative altitude, angle of discharge, and thickness of the jet are being varied. The configuration of the water surface is being measured in the over-water cases.
(h) "Theoretical and Experimental Research on Annular Jets over Land and Water," Lawrence R. Mack and Ben-Chie Yen, paper presented at Symposium on Ground Effect Phenomena, Princeton, N. J., October 1959.
"An Annular Jet Directed against a Nearby Water Surface," Ben-Chie Yen, M.S. Thesis, State University of Iowa, Aug. 1959 (available on loan).
"Studies of an Annular Jet in Proximity to the Ground with Ambient Velocity," Satya P. Garg, M.S. Thesis, State University of Iowa, August 1959 (available on loan).

(3076) EFFECT OF EAVES ON PRESSURE DISTRIBUTION AROUND RECTANGULAR BUILDING MODELS.

(b) Laboratory project.
(c) Prof. J.W. Howe, Dept. of Mechanics and Hydraulics, State Univ. of Iowa, Iowa City.
(d) Experimental; basic research.

(e) Varying widths of eaves on roofs having several different pitches tested in wind tunnel.
(f) Completed for square building.
(g) Eaves effect a reduction in negative pressures on side and back walls of flat-roofed buildings but an increase in the negative pressure over the roof. Gabled roofs showed similar results.
(h) "Effects of Eaves on Pressure Distribution Around Model Buildings," J. V. Nagaraja, M.S. Thesis, State University of Iowa, June 1959 (available on loan).

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

(b) Laboratory project.
(c) Prof. J. W. Howe, Dept. of Mechanics and Hydraulics, State Univ. of Iowa, Iowa City.
(d) Field investigation, basic research for doctor's thesis.
(e) Observations taken on transverse profile of ground-water levels during rise and recession of hydrographs. Sections on Missouri, Des Moines, Boone, Iowa, and English Rivers, Clear Creek, and Rapid Creek.

(3429) JET WITH TRANSVERSE PRESSURE GRADIENT.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Lawrence R. Mack, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and theoretical; basic research.
(e) In order to better understand the effect of jet mixing on an annular jet, the diffusion of a two-dimensional jet directed against a flat plate in the presence of a transverse pressure gradient is being studied.

(3430) AXISYMMETRIC GRAVITY WAVES.

(b) Cooperative with Office of Naval Research, Department of the Navy.
(c) Dr. Lawrence R. Mack, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Theoretical; basic research.
(e) The difference between the mean potential and mean kinetic energies for periodic, finite-amplitude, axisymmetric gravity waves is being computed as a function of relative depth over the entire depth range. This difference, which is zero for infinitesimal waves, has been found to be positive for deep water but, rather surprisingly, negative for shallow water. The kinetic and potential energies are also being computed as functions of time throughout a half-period for both large and small relative depths.

(3431) SEDIMENT SORTING.

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

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

(b) Laboratory project.
(c) Dr. Lucien M. Brush, Jr., Iowa Institute of Hydraulic Research, Iowa City, Iowa.
(d) Experimental and analytical; basic research and Ph. D. thesis.
(e) To determine the effect of fluid oscillation (simple harmonic and random motion) on the fall velocity of a sphere.

(3433) VELOCITY DISTRIBUTION IN OPEN-CHANNEL FLOW.

(b) Graduate project.
(c) Prof. C.J. Posey, Engineering Building, Iowa City, Iowa.
(d) Theoretical; basic, for master's thesis.
(e) Analysis of velocity distribution for turbulent flow in open channels, mainly based on new data from the variable-slope flume at Allenspark, Colorado.

(3434) VORTEX OVER HORIZONTAL ORIFICE.

(b) Graduate project.
(c) Prof. C. J. Posey, Engineering Building, Iowa City, Iowa.
(d) Experimental; basic, for master's thesis.
(e) New tests to include variable head, control of angular momentum of inflow, and measurement of angular momentum of outflow.

IOWA STATE COLLEGE, Department of Agricultural Engineering.

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

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

(b) Laboratory project.
(d) Theoretical and field investigation; basic and applied research; master's and doctor's thesis.
(e) Analytical and physical approach is being studied to determine depth and spacing of tile drains by analyzing soil characteristics and geometry of systems. Work is cooperative with Dr. Kirkham, Soil Physics Department of Agronomy. Studies of the hydraulics of field tile lines are being made.
(g) Model and field studies indicate that actual capacity of tile lines varies from 80 to 100% of present design capacity. Studies also indicate an advantage to longer tile units. Field studies indicated that only slight vacuums develop in easily drained soil because of the ease of air movement into tile lines.

(h) "Hydraulic Characteristics of Single Tile Lines," H.P. Johnson, Ph.D. thesis, Iowa State University, November 1958.

(2331) SURFACE RUNOFF FROM AGRICULTURAL WATERSHEDS.

(b) Laboratory project.
(d) Theoretical; applied research; doctoral thesis.
(e) Surface runoff volumes for individual storms is being estimated by superimposing infiltration curves on the rainfall histogram. Data from point rainfall records are being analyzed. Procedures for developing synthetic hydrographs for watersheds up to 25 square miles in area are being studied.
(g) Study not completed.

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

(b) Laboratory project.
(d) Field investigation; design.
(e) Field study is being continued to determine the effect of different tile backfill materials on the flow of water into the tile drains.
(f) Active.
(g) No new results.

(2334) RUNOFF FROM SMALL WATERSHEDS.

(b) Laboratory project, cooperative with ARS, USDA.
(d) Field investigations; applied research, design.
(e) Measurements are being made of watershed rainfall and surface runoff on ten agricultural watersheds. Sediment measurements are being made in six small reservoirs in the gaged watersheds.
(g) Results of ten years of study are being summarized.
(h) "Selected Intense Storms in the Little Sioux River Watersheds," H. P. Johnson and R.K. Frevert, Journal American Society of Agricultural Engineers, Vol. 40, page 26-29, January 1959.

(3077) INFILTRATION CAPACITIES OF FAYETTE SILT LOAM FROM HYDROLOGIC DATA.

(b) Laboratory study.
(d) Analytical statistical study, master's thesis.
(e) Correlation of antecedent moisture and cover with infiltration rates based on data taken from La Crosse, Wisconsin, runoff plots.
(f) Completed.
(g) Thesis presents infiltration curves for various covers and antecedent moisture conditions.
(h) "Infiltration Capacities of Fayette Silt Loam From Hydrologic Data," J. Ligon, M.S. thesis, Iowa State University, March 1959.

(3078) LOW FLOW CHARACTERISTICS OF STREAMS IN NORTH CENTRAL AND WESTERN IOWA.

(b) Laboratory project.
(d) Analytical study, master's thesis.
(e) An analysis of the frequencies of given discharges from selected streams in the above areas. Theoretical functions being suited to frequency and depletion curves.
(g) Not completed.

THE JOHNS HOPKINS UNIVERSITY, Applied Physics Laboratory.

Inquiries concerning the following projects should be addressed to the Director, Applied Physics Lab., The Johns Hopkins University, 8621 Georgia Avenue, Silver Spring, Maryland.

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

(b) Bureau of Weapons, Department of the Navy.
(d) Theoretical and experimental; applied development and design.
(e) Study the dynamic qualities of an acceleration switching hydraulic servomechanism while operating in a closed loop under the presence of various loads and environmental conditions on the transfer valve, actuator and feedback transducer.
(g) The operation of a broad bandpass servomechanism driving a low resonant frequency linkage has resulted in radial design compromises to prevent instability. Extension of acceleration switching techniques without any mechanical modifications has permitted closed loop operation with bandpasses equal to or exceeding the linkage characteristic.
(h) "A Study of the Load-Flow Characteristics of an Acceleration Switching Valve Driving a Resonant Linkage," APL/JHU CF-2812 by William H. Wright.
"A Design Technique for Improving Servo Bandpass Characteristics when Driving a Resonant Mechanical Linkage," APL/JHU CF-2828 W. Seamone.

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

(b) Bureau of Weapons, Department of the Navy.
(d) Experimental, applied development and design.
(e) Extend to regions of extreme high temperature a servomechanism capable of high performance and horsepower (up to 10 H.P.). The servo valve, actuator and feedback transducer must operate under environmental extremes while the electronic circuitry is maintained in a protected area.
(g) Numerous tests were conducted with oil at 500° F and ambient air temperatures to 750° F at rented facilities. Completion of a high temperature laboratory will permit operation with fluid temperatures to 600° F and ambient air temperatures to 1200°F. Oil temperatures can be programmed to simulate high heating rates due to pump and system inefficiencies coupled

with low oil capacity hydraulic systems.

(h) "Hydraulic (Acceleration Switching) Servo Dynamic Performance under Extreme High Temperature Environment," APL/JHU CF-2737, W. Seamone and K. Duning.
"APL/JHU High Temperature Test Laboratory," APL/JHU CF-2837, M. Shandor.

(3435) HYDRAULIC SUPPLY LINE CHARACTERISTICS.

(b) Bureau of Weapons, Department of the Navy.
(d) Theoretical, experimental.
(e) High performance hydraulic servomechanisms can excite the pressure and return lines into pressure oscillation. Establishment of the physical relationship which could cause pressure oscillation as well as performance deterioration in the servo valve performance is being investigated.
(f) Continuing low priority research study.
(g) The switching activity of an acceleration switching hydraulic servomechanism was noted to create pressure oscillation under specified conditions in length of supply lines. Analysis and experiments have shown that pressure oscillations occur when the acoustic frequency of the hydraulic fluid column is in specific relationship to that of the switching frequency. Where line length changes cannot be used, methods of detuning the supply lines by volume chamber or acoustic filter is developed.
(h) "A Study of the Influence of the Dynamic Properties of the Inlet Fluid on the Stability Characteristics of an Acceleration Switching Hydraulic Servo," APL/JHU CF-2818 by W.D. Mark, G.A. Levine, and W. Seamone.
"Application of Acoustical Filter Theory to Hydraulic Supply Lines," APL/JHU CF-2831 by Sheldon B. Cousin.

(3436) ADAPTIVE ELECTRO HYDRAULIC SERVOMECHANISMS.

(b) Bureau of Weapons, Department of the Navy.
(d) Theoretical and experimental.
(e) Techniques have been developed for designing linear servomechanisms with a limit cycle instability about a relay type nonlinearity. The closed loop characteristics of this servomechanism becomes invariant to any pure gain changes occurring in the linear elements. This servomechanism, categorized as a self-oscillating control servomechanism, appeared to be an evolutionary improvement over the acceleration switching hydraulic servomechanism.
(g) A self-oscillating rate servomechanism has been operated with the loop closed around the valve spool position. Predictable self-oscillation frequency was achieved and dynamic performance bandpass was independent of hydraulic supply pressure between 500 and 2000 psi. A self-oscillating positional servomechanism operating with feedback from the actuator position only, achieved similar results with pressure variation between 500 and 3000 psi. The bandpass of both servomechanisms exceeded 60 cycles per second with the latter operating a complex mechanical load system.
(h) "Investigation of a Non-Linear Electro Hydraulic Power Servomechanism Operating in the Self-Oscillating Control Mode," APL/JHU BBC-5-799 or Univ. of Maryland, Dept. of Mechanical Engineering Thesis, M. S., G. A. Levine.
"Preliminary Examination of an Adaptive Hydraulic Switching Servo," APL/JHU BBC-5-800, by C. H. Sprague.

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

(3437) RESIDENTIAL WATER USE RESEARCH PROJECT.

(b) AWWA, Baltimore County, Baltimore City, Maryland State Dept. of Health, and Federal Housing Administration.
(c) Mr. Jerome B. Wolff, Research Associate, Dept. of Sanitary Engineering and Water Resources, The Johns Hopkins University, Baltimore 18, Maryland.
(d) Experimental and field investigation; applied research and design.
(e) This project is directed toward obtaining data on maximum hourly demands of residential areas having varying populations. It also is directed toward obtaining information on the effect of lawn sprinkling and other high rate-of-use water consuming devices on maximum demands in residential communities. The purpose of the project is to obtain a rational design criteria for water distribution systems.
(g) Stratification of residential areas in terms of age, ground area and social status appears to have an important effect on residential water use. Preliminary data indicates correlation between per capita demands and size of residential lots.
(h) None to date. One progress report has been made dated October 26, 1959 which has been submitted to the contributing sponsors of the project.

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

(b) Baltimore City, Baltimore County, and the U. S. Bureau of Public Roads.
(c) Dr. John C. Geyer, Chairman, Dept. of Sanitary Engineering and Water Resources, The Johns Hopkins Univ., Baltimore, Md.
(d) Field investigation, basic research, and design.
(e) Study of rainfall and runoff relationships as affected by various drainage area parameters. At present, runoff from 9 urban areas ranging in size from 10 to 400 acres are gaged 7 by stage measurements and 2 by Parshall Flumes. Three recording systems which simultaneously record rainfall and runoff from 10 inlet areas provide good opportunity for detailed study. About 9 years of rainfall records now exist for a network of 12 recording gages covering an area of about 50 square miles.
(g) A study of the Baltimore rainfall data for the period 1894-1955 shows: (1) The critical storm in the Baltimore area is the summer type cloud burst. About two-thirds of the storms - greater than 2 year

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frequency occur in the months of July and August. Winter storms are not important for design purposes. (2) The maximum average rainfall rate (for durations up to 60 minutes) generally occurs at the beginning of the storm. (3) Rainfall intensities (during 15, 30, and 60 minute durations) for frequencies greater than 2 yrs. are not uniform. Difference between maximum intensity and average intensity over the duration range from 30% (for the 15 minute duration) to 75% (for the 60 minute duration). Intensities greater than those indicated by rainfall frequency curves occur during more than half the period of the 15, 30 and 60 minute durations studied. Consequently the design storm assumed in the Rational Method is unrealistic. (4) Gagings made by this project and by the Corps of Engineers indicate that where a check on the Rational Method is possible, the Rational Method produces inconsistent results. Further analyses are continuing.

(h) "Progress Report on the Storm Drainage Research Project, June 1959," Warren Viessman, Dept. of Sanitary Engineering and Water Resources, The Johns Hopkins University, Baltimore 18, Md. A limited number of copies are available on request.

(3438) RESIDENTIAL SEWERAGE RESEARCH PROJECT.

(b) Federal Housing Administration.
(c) Dr. John C. Geyer, Chairman, Dept. of Sanitary Engrg. and Water Resources, The Johns Hopkins Univ., Baltimore 18, Md.
(d) Field investigation; operation and design.
(e) Examination of adequacy and utility of residential sewerage system design criteria. Determination of the effects of parameters of design, construction, loading, and natural phenomena on operation of sewerage systems. Research includes analysis and study of representative sewerage systems throughout the country.
(f) Planning stage.
(g) Collection of data not yet begun.

UNIVERSITY OF KANSAS, Department of Engineering Mechanics.

Inquiries concerning projects Nos. 3080 to 3082 incl., should be addressed to Dr. David W. Appel, Dept. of Engineering Mechanics, University of Kansas, Lawrence, Kansas.

(3080) TRANSMISSION AND DISSIPATION OF SURGES IN ELASTIC TUBES.

(b) Sohio Pipe Line Company and Department of Engineering Mechanics.
(d) Basic research; theoretical and experimental investigation. Also M.S. Thesis.
(e) This is a basic study of the speed of propagation and rate of dissipation of surges in liquid-filled elastic tubes. Comparisons are being made between theoretical evaluations of these characteristics and observed values on long oil pipe lines. Additional data are to be obtained from laboratory experiments on tubes having very elastic walls. Application to leak detection is being explored.
(g) Agreement was obtained between an improved theoretical prediction and observed dissipation of surges in oil pipe lines. The limitation on detection of small leaks was found to be extraneous reflections caused by small variations in pipe size and wall thickness within manufacturing tolerances.

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

(b) Kimberly-Clark Corporation, Neenah, Wis.
(d) Experimental; basic research.
(e) The characteristics of mean velocity, mean pressure, and the fluctuations in pressure are to be determined for different expansion ratios using a small re-circulating water tunnel.
(g) The mean velocity distributions for expansion ratios of 2, 4, and 6 have been determined. Observations of the intensity of pressure fluctuations are in progress.

(3082) MEASUREMENT OF LOW VELOCITIES IN WATER.

(b) Laboratory project.
(d) Development.
(e) An instrument is being developed for measuring low velocities in small hydraulic models which will utilize the known relationship between frequency of shedding of vortices in the wake of a circular cylinder and the velocity of flow.
(g) Attempts to use a heated platinum film on a cylindrical probe to detect the frequency of shedding vortices in the wake proved impractical. A heated wire or thermister will be tried.

(3439) SECONDARY MOTIONS IN THE FLOW BETWEEN CONCENTRIC ROTATING CYLINDERS.

(b) Kimberly-Clark Corp. and the Department of Engineering Mechanics.
(d) Experimental; basic research.
(e) To determine the characteristics of secondary motions occurring between concentric rotating cylinders, and the effect of superimposing an axial discharge.
(f) Completed.
(g) Observations of flow in the annulus between a rotating inner cylinder and a stationary outer cylinder were made with and without a superimposed axial flow. The onset of secondary motions called Taylor vortices was found to agree with a theoretical prediction by G. I. Taylor. The point of transition to turbulent Taylor Vortex flow was observed and measurements were also made of the strength of the vortex motion.
(h) "Secondary Motions in the Flow Between Concentric Rotating Cylinders," Dr. D. W. Appel, Journ. of Tech. Assoc. Pulp and Paper Ind. Vol. 42, pps. 767-773, Sept. 1959. Reprints available.

(3440) DRAG IN UNSTEADY FLOW PAST BLUFF BODIES.

(b) The Sandia Corporation.

(c) Dr. John S. McNown, Dean, School of Engineering and Architecture, The University of Kansas, Lawrence, Kansas.
(d) Experimental and theoretical.
(e) The vorticity in the boundary layer upstream from the point of separation is to be related to the strength of the vortex. The force on a flat plate or a cylinder is then related to the growth and motion of the vortex.
(g) Several links in the chain leading to the prediction of drag have been completed.
(h) "Vortex Formation and Resistance in Periodic Motion," by J. S. McNown and G. H. Keulegan, Journal, Engineering Mechanics Division, Proc. ASCE, Vol. 85, No. EM 1, pp. 1-6, January 1959.

LEHIGH UNIVERSITY, Department of Civil Engineering.

Inquiries concerning the following projects should be addressed to Prof. W.J. Eney, Head, Department of Civil Engineering, Director, Fritz Engineering Laboratory, or Prof. J. B. Herbich, Chairman, Hydraulics Division, Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pennsylvania.

(1602) PRESSURE DISTRIBUTION IN CONDUIT BENDS.

(b) Laboratory project.
(d) Experimental; undergraduate special problem.
(e) Study of a rectangular bend with a central dividing wall, by means of electrical analogy has been completed.
(f) Inactive.
(h) "Investigation by Electrical Analogy of Potential Flow in a 90° Elbow with a Dividing Vane," by J. W. Glomb, undergraduate problem, Lehigh University Library, May 1957.

(1603) BUTTERFLY VALVE STUDY.

(b) CDC Controls Services, Inc., Hatboro, Pa.
(d) Experimental; applied research.
(f) Completed.
(h) "Butterfly Valve Flow Characteristics," by M. B. McPherson, H. S. Strausser and J. C. Williams; ASCE Proceedings, Sep. No. 1167, February 1957.

(2339) BUCKET-TYPE ENERGY DISSIPATOR CHARACTERISTICS.

(b) Gannett, Fleming, Corddry and Carpenter, Inc., 600 North Second Street, Harrisburg, Penn.
(d) Experimental; for general design.
(f) Suspended.
(h) "A Study of Bucket-type Energy Dissipator Characteristics," M. B. McPherson and M.H. Karr, ASCE Proc., Sep. no. 1266, June 1957.

(2543) STUDY OF CONDUIT EXIT PORTALS.

(b) Laboratory project.
(d) Experimental; M. S. thesis.
(f) General pressure-distribution study completed.
(g) Tests of square and circular conduit with free-jet, horizontal apron, and three different wall flares, have been completed.
(h) "Exit Portal Pressure Study," by A.R.R. Morel, M.S. thesis, Lehigh University Library, June 1957.
"Outlet Portal Pressure Distribution," by M.B. McPherson and Alain R.R. Morel, paper presented at ASCE Meeting in Chicago, Feb. 1958.

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

(b) District Engineer, U. S. Army Engineer District, Philadelphia, Corps of Engineers.
(d) Applied research.
(e) The main purpose of the study is to improve design of a hopper dredge centrifugal pump for pumping silt-clay-water mixtures. The project has been divided into four phases: (A) Model tests of the existing dredge pump; (B) recommendation for design changes of the dredge pump; (C) model investigation of the modified design of the dredge pump; and (D) analysis of the investigation and final recommendations. Phase A involved installation in the hydraulic laboratory of a 1:8 scale model of the dredge pump now used on the U.S. Corps of Engineers dredge ESSAYONS. Water as well as silt-clay-water mixtures were pumped and complete characteristics of the pump obtained for capacity of 0 to 1200 gallons per minute, speed of 1150 to 1900 revolutions per minute, and liquid concentrations of 1000 to 1320 grams per liter.
(f) (A) Completed; (B) and (C) active.
(h) "Characteristics of a Model Dredge Pump," John B. Herbich, Project Report No. 31, Fritz Engineering Laboratory, Lehigh Univ., September 1959.

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

(b) Laboratory project.
(d) Graduate students project.
(e) 1:100 scale two-dimensional model built of Chief Joseph Dam. Prototype crest pressures compared with the data obtained on the model.
(f) Completed.
(g) Very good correlation obtained between the model and prototype.
(h) "Hydraulic Model Investigation on Chief Joseph Dam Spillway," by P. Brach, V. A. Castro and J. C. Kable, Graduate Students Report, Department of Civil Engineering, January 1959, 41 pages.

(3086) INVESTIGATION OF DESIGN CRITERIA OF SPUR DIKES.

(b) Modjeski and Masters, Consulting Engineers, Lehigh University Institute of Research.
(d) Analytical and experimental.
(e) The project has been divided into three phases: (A) Literature survey; (B) analytical study; (C) experimental study to determine the proper proportions and alignment of spur dikes. A spur dike has been defined as a projection extending upstream

from the bridge abutment. It serves to channel the flow of flood water smoothly through the opening between abutments.

(f) (A) Completed; (B) and (C) active.

(g) Preliminary investigation indicates that a properly designed spur dike can materially reduce the scour at bridge abutments.

(h) "The Effect of Spur Dikes on Flood Flows through Highway Bridge Abutments," by R. J. Carle and J.C. Kable, Graduate Students Report, Department of Civil Engineering, June 1959, 135 pages.
"The Determination of the Length of Spur Dikes for Flood Flows Through Highway Bridge Abutments," J.C. Kable, Graduate Student Report, Dept. of Civil Engineering, July 1959, 61 pages.

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

(b) Laboratory project.

(d) M. S. thesis.

(e) Four-, six-, and eight-inch diameter 90° elbows assembled to form 270° bends. Head loss measurement is obtained for all elbows for various concentration of silt-clay-water mixtures. Prediction equations will be investigated.

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

(b) Research report requirement for master's degree.

(d) Theoretical and experimental.

(e) Design changes in centrifugal pump impeller for handling mud are suggested on basis of past research and theoretical considerations.

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

Inquiries concerning projects Nos. 2546, 2547, 2548, 2801, 3089, 3443, 3444, and 3446, and requests for reprints and Technical Reports should be addressed to Dr. Arthur T. Ippen, Prof. of Hydraulics, Hydrodynamics Laboratory, Massachusetts Institute of Technology, Cambridge 39, Mass.

(307) CONTROL OF FLOW STRATIFIED DUE TO DENSITY DIFFERENCES.

(b) Laboratory project.

(c) Prof. D.R.F. Harleman, Mass. Inst. of Tech., Cambridge 39, Mass.

(d) Theoretical and experimental; graduate research.

(e) A general study of the characteristics of flows in which vertical density gradients are present. Density differences may be due to temperature, chemical composition or solids in suspension. The problem of selective withdrawal of liquids of different density is currently under investigation.

(g) Analytical and experimental results are given for a vertical axis, circular intake located near the bottom of the lower layer of a two-layered fluid system. Fluid is drawn into the intake from the lower layer until a critical discharge is reached at which the upper layer is in a state of incipient drawdown. Rates of flow greater than the critical discharge cause increasing amounts of the upper liquid to be drawn into the intake. The predicted functional relationship between the geometric and flow parameters is verified by the experimental data.

(h) "Characteristics of Intakes in a Vertically Stratified Fluid," S.M. thesis, R.L. Morgan and R. A. Purple, June 1959.
"Selective Withdrawal from a Vertically Stratified Fluid," D.R.F. Harleman, R. L. Morgan and R. Purple, Proceedings 8th Congress of the International Association. for Hydraulic Research, Aug. 1959 (Montreal, Canada).

(1355) CAVITATION INCEPTION FOR STEADY MOTION.

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

(c) Prof. J.W. Daily, Mass. Inst. of Tech., Cambridge 39, Mass.

(d) Experimental; basic research.

(e) Study of cavitation inception for steady motion for systematic variation in boundary layer development and in the turbulence level in the zone of minimum pressure.

(f) Completed.

(g) The working section of a closed jet water tunnel is arranged so that the boundary layer growth is controlled by a systematic change of its shape. Provision is also made for control of turbulence level, pressure intensity and air content. Experiments involving the effect of velocity variation on incipient cavitation and on the influence of dissolved air content have been completed. Information on the turbulence of the flow in the cavitation region has been obtained by high-speed photographs of the cavitation bubbles. Explorations in the boundary layer were made to determine the local mean pressure intensities and their relation to the local velocity and turbulence. This investigation included one case of uniform roughness.

(h) "The Distribution of Mean Pressure in Turbulent Boundary Layers in Relation to Inception of Cavitation," J.W. Daily, L. D. Lin and R.S. Broughton, M.I.T. Hydrodynamics Laboratory Tech. Report No. 34, June 1959.

(1609) EXPERIMENTAL STUDY OF THE SORTING OF BEACH SEDIMENTS BY WAVE ACTION.

(b) Beach Erosion Board, U.S. Army Corps of Engineers.

(c) Prof. P.S. Eagleson, Mass. Inst. of Tech., Cambridge 39, Mass.

(d) Experimental; basic research.

(e) Quantitative study of the mechanics of beach sediment movement by shallow water waves.

(g) An equation of motion yielding net bottom sediment velocities in the offshore region

has been written and verified in the laboratory for single spherical sediments moving on a plane, impermeable beach. Current experiments are testing the applicability of the derived relations for predicting equilibrium characteristics of sand beaches.
An experimental and theoretical investigation has been made of smooth bottom shearing stresses in laminar boundary layers under oscillatory waves.

(h) "The Damping of Oscillatory Waves by Laminar Boundary Layers," P.S. Eagleson, Hydrodynamics Laboratory Technical Report No.32.
"Offshore Profiles of Equilibrium Reaches by Theory and Experiment," by B. Glenne, S.M. thesis, Course I, M.I.T., 1959.
"Wave-Induced Motion of Bottom Sediment Particles," P.S. Eagleson and R.G. Dean, Paper 2202, Proc. A.S.C.E., Jour. of Hydraulics Division, Vol. 85, No. HY 10, October 1959.

(2546) CHARACTERISTICS OF FLOW WITH DILUTE FIBER SUSPENSIONS.

(b) Technical Assoc. of Pulp and Paper Industries.
(d) Experimental and analytical; basic research.
(e) Basic investigation of the hydrodynamic features of paper fiber suspensions.
(g) Following a survey of existing knowledge of the fluid mechanics of the flow of fiber suspensions as related to the flow in paper making machines, an experimental program was initiated for investigating the hydrodynamic characteristics of fiber suspensions in fully developed shear flows and in non-shear fields for both the laminar and turbulent ranges. Measurements of energy loss were made for wood pulp fibers and synthetic fibers flowing through circular tubes of different diameters. This data was correlated with velocity distributions and turbulence records obtained with wood pulp fibers. The results have been reported with reference to the mechanisms of turbulence and momentum transfer in such suspensions.
(h) "The Effects of Fibers on Velocity Distribution, Turbulence and Flow Resistance of Dilute Suspensions," J. W. Daily and G. Bugliarello, M.I.T. Hydrodynamics Laboratory Tech. Report No. 30, October 1958.
"Flow of Nylon Fiber Suspensions - A Progress Report of work under TAPPI Project 147," J.W. Daily and A. Tsuchiya, M.I.T. Hydrodynamics Laboratory Technical Note No. 4, February 1959.
"Measurement and Analysis of Turbulent Flow of Wood Pulp Fiber Suspensions," by J. W. Daily, G. Bugliarello, and W.W. Troutman, M.I.T. Hydrodynamics Laboratory Technical Report No. 35, September 1959.
"A Particular Non-Newtonian Flow: Dilute Fiber Suspensions," J.W. Daily and G. Bugliarello, Industrial and Engineering Chemistry, Vol. 51, page 887, July 1959.

(2547) CHARACTERISTICS OF THE CIRCULAR HYDRAULIC JUMP.

(b) Laboratory project.
(d) Theoretical and experimental; graduate theses.
(e) A study of the characteristics of the circular hydraulic jump which is formed by axially symmetrical supercritical flow from a source or to a sink.
(g) A lucite water table has been constructed to obtain supercritical flows issuing radially outward from a source or directed inward toward a sink. By proper control of tailwater hydraulic jumps circular in plan view are created. Measurements of depths and velocities are being made for comparison with the momentum equations for the two types of jumps described above and with analytical expressions for water surface profiles in the supercritical radial flow regime.
(h) "The Hydraulic Jump in Radial Flow," A. R. Gagnon, S.M. thesis, June 1959.
"Determination of Critical Depth in Radial Free Surface Flow," G.L. Bracken, S.B. thesis, June 1959.

(2548) TURBULENT DIFFUSION IN STRATIFIED FLUIDS.

(b) U. S. Public Health Service.
(d) Theoretical and experimental; basic research.
(e) An investigation of various turbulent diffusion processes for application to salinity intrusion and waste disposal in tidal estuaries.
(g) Experimental facilities have been constructed to study diffusion in a one-dimensional field of uniform turbulence. Turbulence is created mechanically in a body of water contained in a 32 foot long channel by means of a stack of expanded aluminum sheets oscillating vertically with amplitudes up to one-half inch and frequencies up to four cycles per second. Concentrations are measured and recorded electrically at various stations by means of probes sensitive to the changes in resistivity of saline solutions. The turbulence level is specified in terms of the measured rate of energy dissipation within the liquid. The effects of gravity convection due to density differences between the diffusant and receiving fluids are separated from turbulent diffusion effects by a series of control tests with zero density difference.
Experiments are being made to determine the longitudinal distribution of salinity in a uniform basin with fresh water inflow at one end and a constant ocean salinity maintained at the other end. Salinity distributions are determined for various fresh water inflow rates and turbulence levels in the flume and compared with solutions of the diffusion equation.
(h) Diffusion of Two Fluids of Different Density in a Homogeneous Turbulent Field," by D.R.F. Harleman, J.M. Jordaan, and J.D. Lin, M.I.T. Hydrodynamics Laboratory Technical Report No. 31, February 1959.
"Steady State Salinity Distribution in an Idealized Estuary," C.T. Luke, S.M. thesis, August 1959.

(2801) INTERACTION OF WAVES WITH FLOATING BODIES.

(b) Office of Naval Research, Dept. of the Navy.
(d) Theoretical and experimental; basic research for doctoral theses.
(e) Analytical and experimental investigation of interaction of surface waves with basic shapes. Purpose of the study is to develop a feasible prototype floating or moored breakwater structure.
(g) Two problems have been completed. The theoretical portion of each of these problems is based on small-amplitude classical wave mechanics. The numerical solutions were obtained on an IBM 704 digital computer. (1) Theoretical and experimental investigation of the interaction of a fixed, semi-immersed circular cylinder with a train of surface waves. The theory was developed for the case of deep-water; however, the experiments covered both deep and shallow-water waves. The theory predicts reflection and transmission coefficients and force components on the cylinder which are in good agreement, except that an energy loss of approximately 10% occurred in the reflection-transmission process. (2) Theoretical and experimental investigation of a semi-immersed circular cylinder which is oscillating vertically about the mean water surface. The theory was developed for a fluid of arbitrary depth and predicts the amplitude of the generated waves and also the force on the cylinder. The theory shows that if the ratio of water depth to cylinder radius is greater than 10 there is no effect of water depth. The experimental results agree well with the theory; however, in general, the experimental wave heights are a few percent less than predicted.
(h) "Interaction of a Fixed, Semi-Immersed Circular Cylinder with a Train of Surface Waves," Robert G. Dean, Doctor of Science Thesis, August 1959.

(2802) EXPERIMENTAL STUDY OF WAKE MECHANICS.

(b) Office of Naval Research and David Taylor Model Basin, Dept. of the Navy.
(c) Prof. J.W. Daily and Prof. P.S. Eagleson, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental; basic research (doctoral theses).
(e) A study of the effect of trailing edge geometry on the characteristics of the wake of a thin flat plate with particular emphasis on transverse plate vibrations. Tests are carried out in a 7 1/2 x 9 inch water tunnel test section capable of speeds to 40 ft/sec.
(g) The effects of trailing edge geometry, elastic restraint, free stream velocity and ambient pressure level on the dynamic response of thin flat plates to vortex-induced motion has been studied. A total head tube for measurement of high-frequency pressure fluctuations in water has been developed, calibrated and tested.
(h) "The Development of a Total Head Tube for High Frequency Pressure Fluctuations in Water," F.E. Perkins, S.M. thesis, 1959.
"The Development of a Total Head Tube for High Frequency Pressure Fluctuations in Water," F.E. Perkins and P.S. Eagleson, M.I.T. Hydrodynamics Laboratory Technical Note No. 5, July 1959.
"The Hydroelastic Behavior of Flat Plates Related to Trailing Edge Geometry," G. H. Toebes, Ph. D. thesis, 1959.

(2803) PROXIMITY EFFECTS ON DRAG COEFFICIENTS.

(b) Laboratory project.
(c) Prof. P.S. Eagleson, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental; undergraduate theses.
(e) Study of resistance of submerged objects due to boundary layer velocity distributions.
(g) The presence of a velocity gradient and a solid boundary increases the drag coefficient of a sphere over that found at the same Reynolds number in an infinite fluid.
(h) "Resistance Coefficients of Spheres in a Shear Flow," by S. Vladimirschi, B. S. thesis, June 1959.

(3089) EXPERIMENTAL STUDY OF EROSION IN CURVED CHANNELS.

(b) Agricultural Research Service, U.S. Dept. of Agriculture.
(d) Experimental; basic research (doctoral thesis).
(e) Investigation of boundary shear stress distribution and magnitude in curved, open channels to determine location and extent of protection required in natural streams. Of interest is the variation of boundary shear with selected conditions of flow and channel geometry.
(g) The magnitude and distribution of boundary shear stress have been studied in a 60° curve for three conditions of flow. The test channel is trapezoidal with an hydraulically smooth surface, and sides sloping 2 horizontal to 1 vertical. The width: depth ratios have been varied from 8 to 12, with a variation in outer radius; width ratio of 1.75 to 2.17. For the conditions tested, the Froude numbers are in the range 0.38 to 0.55. The boundary shear stress is determined by means of a round surface pitot tube, originally developed for the measurement of local skin friction on smooth surfaces in air. The stresses encountered in the present study are of the order of 0.01 psf.
(h) "Measurement of Boundary Shear Stress in an Open Channel Curve with a Surface Pitot Tube," R.E. Nece, C.A. Givler, and P. A. Drinker, Hydrodynamics Laboratory Technical Note No. 6, August 1959.

(3090) MODEL OF PUMPING PLANT FOR CHARLES RIVER BASIN (BOSTON) DRAINAGE CONTROL.

(b) Commonwealth of Mass., Metropolitan District Commission.
(c) Prof. D.R.F. Harleman, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental.
(e) Model studies to determine forebay and pump suction intake geometry for high

capacity, low head axial flow pumps.

(g) First model reproduces portion of Charles River Dam and ship lock through which flow is admitted asymmetrically to pumping station forebay. Methods of uniformly distributing flow to six pump units were investigated. Second model is for a location one-half mile downstream of first site. Study is concerned with elimination of rotational flow induced by a large bridge pier upstream of the intakes.

(h) "Model Study of a Flood Control Pumping Station at the Charles River Dam," D.R.F. Harleman, R.S. Broughton, C.J. Huval, and H.W. Partenscky, Hydrodynamics Laboratory Technical Report No. 33, June 1959.

(3443) COMPUTER STUDY OF POWER PLANT TRANSIENTS.

(b) Missouri River Division, Corps of Engineers.

(d) Theoretical, field measurements; applied research.

(e) Development of a comprehensive digital computer program for the solution and investigation of the complete transient problem in hydropower installations.

(g) The problem of load rejection has been formulated and is being programmed for a digital computer. A proposal for field measurement of the hydraulic and mechanical variables has been prepared.

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

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

(d) Theoretical and experimental; basic research (doctoral theses).

(e) Investigation of the response of a harbor to waves incident on the harbor opening. A study of the dissipation of energy at the harbor boundary and of the mechanism of energy transfer through the narrow opening.

(g) A small (8' x 8') wave basin has been constructed in which harbors of various geometric shapes may be placed. A circular harbor is under investigation and instrumentation is being developed.

(3445) CHARACTERISTICS OF CROSS WAVES.

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

(c) Prof. D.R.F. Harleman and Prof. L. Howard, Mass. Inst. of Technology, Cambridge 39, Massachusetts.

(d) Theoretical and experimental; doctoral theses.

(e) An investigation of the stability of two-dimensional standing waves which lead to the development of three-dimensional cross (or edge) waves.

(g) Experimental equipment is under construction.

(3446) EFFECT OF PARTICLES ON TURBULENCE AND RESISTANCE IN FREE SURFACE FLOW.

(b) Laboratory project.

(d) Theoretical and experimental; doctoral thesis.

(e) Investigation of the effect of solid particle suspensions on the velocity and turbulence distribution in an open channel.

(g) A 30-foot recirculating sediment flume has been constructed. Control tests for the measurement of turbulence with an impact tube in sediment-free flow are underway.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Department of Mechanical Engineering.

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

(b) Office of Naval Research, U.S. Naval Underwater Ordnance Station.

(c) Prof. Robert W. Mann, Room 3-459A, Mass. Institute of Technology, Cambridge 39, Mass.

(d) Theoretical and experimental; applied research for masters and doctoral theses.

(e) In a partial admission turbine the nozzle flow through the rotor blading constitutes an unsteady flow field. The purpose of this investigation is to study this flow with the ultimate goal of recommending design improvements. The flow field is varying both in time and in space and is therefore very complex. In order to explore theoretical approaches to the flow field the feasibility of experimental models based on interferometry and the hydraulic analogy to compressible fluid flow is here explored. The hydraulic analogy proved a superior approach and an unsteady flow water table simulating the turbine flow has been constructed and successfully tested. The water flow experimental data has been very successfully correlated with the theoretical analysis of shock and rarefraction wave propagation in the rotor channels. The theoretical study of the complex two-dimensional field at the nozzle exit has been limited but has shown good qualitative correlation with experimental data. In order to explore wide ranges of design point, blading geometry, nozzle design and shroud configuration the use of photo-stereo techniques with machine reduction of water height data is being experimentally explored.

(g) The water table has been shown to be an accurate reproduction of the compressible flow gas case. The photo-stereo technique has been developed to the point where excellent data from the water table is obtainable. Data has been reduced for a single turbine geometry over a range of operating points and for different admission arrangements. The flow is very complex and present efforts are directed toward strong shocks in the nozzle flow.

(h) "The Use of Stereophotography and the Hydraulic Analogy to Study Compressible Gas Flow in a Partial-Admission Turbine," Alan H. MacPherson, S.M. thesis, Department of Mechanical Engineering, M.I.T., Cambridge 39, Massachusetts, January 1959.

(3092) PNEUMATIC JET-PIPE VALVE.

(b) Wright Air Development Center.

(c) Prof. S.Y. Lee, Mass. Institute of Tech., Cambridge 39, Mass.

(d) Mostly experimental; applied research.
(e) Study the optimum configuration of a pneumatic jet-pipe valve.
(g) Useful design information obtained in regard to dimensions of a pneumatic jet-pipe valve for optimum performance.
(h) "Optimum Design Parameters of a Pneumatic Jet-Pipe Valve," Karl N. Reid, Jr., submitted for presentation at The First International Congress of The International Federation of Automatic Control, Moscow, Russia, June 1960.

(3093) FLOW BEHAVIOR IN AN ANNULUS FORMED BY TWO CONCENTRIC CYLINDERS WITH THE INNER CYLINDER IN ROTATION.

(b) Lincoln Laboratory, M.I.T.
(c) Prof. Joseph Kaye, Mechanical Engineering Dept., M.I.T., Cambridge 39, Mass.
(d) Experimental and theoretical basic research for M.S. and Sc.D. degrees.
(e) The objective of this research study is to determine the type of flow behavior which exists in an annulus between two concentric cylinders when the outer cylinder is stationary and the inner cylinder is set in rotation. Both adiabatic and diabatic flow in the axial direction will be superimposed on the rotation. The entrance region of such differential flow will also be examined experimentally and theoretically.
(g) Adiabatic and diabatic flow measurements have been made for the fully-developed flow region.
(h) "The Influence of a Radial Temperature Gradient on the Stability of Fluid Motion in an Annulus with an Inner Cylinder Rotating," K.M. Becker and J. Kaye, (in press).

(3094) CYCLONE SEPARATOR RESEARCH.

(b) Laboratory project.
(c) Mr. Joseph L. Smith, Jr., Room 3-266, Mass. Inst. of Tech., Cambridge, Mass.
(d) Experimental and theoretical applied research for M.S. and Ph.D. theses.
(e) The research is directed toward an understanding of the vortex flow in cyclone separators and of the relations between the flow and the overall pressure and separation parameters of the cyclone.
(g) Understanding has been gained from experimental observations and particularly from an application of the previously developed theory of rotating flows.

(3095) WINDAGE AND PUMPING LOSSES IN GAS PARTIAL-ADMISSION TURBINES.

(b) Office of Scientific Research, U. S. Air Force.
(c) Prof. Robert W. Mann, Room 3-495A, Mass. Inst. of Technology, Cambridge 39, Mass.
(d) Experimental; applied research for master's thesis.
(e) Experimental evaluation of windage losses in a partial-admission turbine. The windage losses in a partial-admission turbine can be a controlling factor in their design, especially since shroud and blading geometry most suitable for increasing the efficiency of active flow from one or several nozzles is such as to cause high windage losses in those portions of the rotor not in the active flow. In this investigation, experimental torque measurements will be made over a wide range of Reynolds numbers for progressive variations in blading aspect ratio and solidity and shroud axial and radial clearance. Analytic models which conform to the experimental results will be generated in order to generalize the experimental data.
(f) Completed.
(g) Extra losses from partial admission operation of a gas turbine occur both in the nozzle flow arc and away from it. The latter have been related to the theory of fluid flow over a rotating disc expressing a dimensionless moment coefficient as a function of Reynolds number.
By direct measurements of drag torque, the moment coefficient has been determined over a range of Reynolds number from 2.5×10^4 to 2.5×10^6 for several aspect ratios and axial and radial clearances. Losses increase with increasing aspect ratio. Small increases from minimum practical clearance have little effect, but blade pumping losses become severe at radial and axial clearances of the order of half the disc radius.
(h) "Fuels and Prime Movers for Rotating Auxiliary Power Units," Robert W. Mann, Dynamic Analysis and Control Laboratory, Report No. 121, Mass. Inst. of Technology, Cambridge, Mass.
"Windage and Pumping Losses in Small Partial Admission Gas Turbines," Charles H. Marston, Masters Thesis, Dept. of Mech. Engineering, M.I.T. Cambridge 39, Mass., June 1959.

(3096) REFLECTION OF A MAGNETOHYDRODYNAMIC SHOCK BY A MAGNETIC "WALL".

(b) Cambridge Air Force Research Center.
(c) Prof. Osman K. Mawardi, Dept. of Mech. Engineering, M.I.T., Cambridge 39, Mass.
(d) Thesis work.
(e) This is an experimental investigation of the behavior of a strong shock wave as it penetrates a region within which an intense magnetic field has been established. It is proposed to study the interactions processes (reflection and transmission of the wave) at the boundary. The apparatus is in use.
(h) Mass. Inst. of Tech., Sc.D. Thesis by Z.J.J. Stekly.

(3097) STUDIES OF MAGNETOHYDRODYNAMIC SHOCKS.

(b) Cambridge Air Force Research Center.
(c) Prof. Osman K. Mawardi, Dept. of Mech. Engineering, M.I.T., Cambridge 39, Mass.
(d) Thesis work.
(e) A preliminary theoretical study, on the basis of continuum theory, has been completed in order to establish the dynamics and structure of a hydromagnetic shock wave. The analysis indicates the dependence of the state of the gas upstream and downstream of the shock as a function of

the magnetic field, the pressure and temperature of the ionized gas. A prediction has also been made for the expected behavior of the electric and magnetic fields in the vicinity of the shock. The apparatus required for the experimental verification of this analysis is now being constructed.

(3447) REACTION JET SERVOMOTOR.

(b) Project conducted for: Wright Air Development Center.
(c) Prof. S.Y. Lee, M.I.T., Cambridge 39, Mass.
(d) Theoretical and experimental; applied research.
(e) Study steady-state speed torque performance of a pneumatic reaction jet motor.
(g) Steady-state speed torque curve obtained. Comparison was made with the theoretical solution.
(h) "Development of a Gas Operated Reaction-Jet Servomotor," Robert Scher, to be presented at the Symposium on Recent Mechanical Engineering Developments in Automatic Control, The Institution of Mechanical Engineers in London, England, Jan. 5-7,1960.

(3448) FLOW THROUGH CONTROL VALVE ORIFICES.

(b) Various sponsors including U.S. Chandler-Evans Corp., Moog Servocontrols, Inc.
(c) Prof. J.L. Shearer, M.I.T., Cambridge, Mass.
(d) Applied research.
(e) Experimental investigation of the characteristics of flow through fixed area and variable area orifices with emphasis on resistance to fluid flow and the factors that lead to being able to predict the resistance characteristics over a wide range of Reynolds Numbers.
(g) Actual size and large scale models have been studied for hydraulic and pneumatic flows with special emphasis on low Reynolds Number flows. Small amounts of rounding of the entrance corners have a very great effect on discharge coefficients at low and intermediate Reynolds Numbers with hydraulic flow. Pneumatic flows have demonstrated bi-stable flow conditions accompanied by hysteresis.
(h) "An Experimental Study of Two Dimensional Gas Flow Through Valve-Type Orifices," A.H. Stenning, ASME paper No. 54 - A-45; copies can be obtained by special request from the Author or from the Dynamic Analysis and Control Laboratory, M.I.T., Cambridge 39, Mass.
"Discharge Coefficients for Flow Through Round-Edged Orifices," R.H. Tuffias, S.M. thesis, Dept. of Mechanical Engineering, M.I.T., Cambridge, Mass., August 1957.
"Effects of Nozzle Geometry on Flapper Valve Characteristics," R.F. Mennel, S.B. thesis, Dept. of Mechanical Engineering, M.I.T., Cambridge 39, Mass., January 1956.
"Discharge Coefficients and Steady-State Flow Forces for Hydraulic Poppet Valves," J.A. Stone, ASME paper No. 59-HYD-18, available from American Society of Mech. Engineers, 29 West 39th St., New York 18, New York.
"A Flapper Valve Study," R.E. Norwood, S.M. thesis, Dept. of Mechanical Engineering, M.I.T., Cambridge 39, Mass., June 1959.

(3449) THE HYDROMAGNETIC GUIDE (I).

(b) Air Force Cambridge Research Center.
(c) Prof. Osman K. Mawardi, Dept. of Mechanical Engineering, M.I.T., Cambridge 39, Mass.
(d) Thesis work.
(e) A theoretical study of the propagation of hydromagnetic (Alfven's) waves in a guide has been completed. The guide consists of an electrically conducting conduit inserted in the field of a steady magnetic field. The guide is assumed to be filled with plasma. The character of the waves have been studied for two conditions. In the first case the applied magnetic field is directed along the axis of the guide, while in the second case the field is normal to the axis.

(3450) THE HYDROMAGNETIC GUIDE (II).

(b) Cambridge Air Force Research Center.
(c) Prof. Osman K. Mawardi, Dept. of Mechanical Engineering, M.I.T., Cambridge 39, Mass.
(d) Thesis work.
(e) An experimental verification of the theory developed in (I) is now under way. An alloy of NaK which is liquid at room temperature and which possesses good electrical conductivity has been chosen as a model for a dense plasma. The guide filled with NaK is planned to be inserted in an intense magnetic field (about 40,000 gauss). The Alfven's waves will be excited by an electroacoustic transducer set at right angle to the field. The traveling waves will be detected by measuring the associated electric field.
(f) Completed.
(h) Publication in preparation.

(3451) HYDROMAGNETIC INSTABILITIES.

(b) Cambridge Air Force Research Center.
(c) Prof. Osman K. Mawardi, Department of Mech. Engineering, M.I.T., Cambridge 39, Mass.
(d) Thesis work.
(e) The onset and the growth of the instability in a cylinder of plasma will be studied under various conditions. The preliminary experimental phase of the work will be performed on liquid metals. The situation presently investigated is concerned with an instability similar to that of the pinch effect. Here, however, the electromagnetic forces are caused by the interaction of an applied steady magnetic field parallel to and external to a column of fluid with azimuthal currents induced in the column. The column with free surfaces is simulated by allowing liquid metal to fall unimpeded from a reservoir. The theoretical prediction for the dynamical behavior of the column of fluid is now being studied by means of a normal mode technique.

(3452) INTERACTIONS AMONG BURNING FUEL DROPLETS AND THEIR EFFECTS ON COMBUSTION STABILITY AND ROUGHNESS.

(b) Office of Scientific Research, U.S. Air Force.
(c) Prof. T.Y. Toong, Mass. Inst. of Tech., Cambridge 39, Massachusetts.
(d) Theoretical and experimental; basic research for master's and doctoral theses.
(e) Theoretical and experimental investigations of interactions among burning fuel droplets in a flow field. The main objective is to further a basic understanding of the general problem of combustion instability through a study of these interactions.
(g) Theoretical and experimental investigations of the interactions between two burning fuel cylinders were carried out.

(3453) THE EFFECTS OF A DIFFUSING GAS ON AERODYNAMIC HEATING AT SUPERSONIC SPEEDS.

(b) Air Research and Development Center, Washington, D. C.
(c) Prof. Joseph Kaye, Mechanical Engineering Department, Room 1-210, Massachusetts Institute of Technology, Cambridge 39, Mass.
(d) Experimental and theoretical; basic research for M.S. and Sc.D. degrees.
(e) The objective of this project is to measure and predict analytically the effects of a diffusing gas, such as helium, on the aerodynamic heating process in a boundary layer of a supersonic stream of air. It is expected that results from this project may be of considerable help in the thermal barrier problem.
(g) Some preliminary results are published. See publications below.
(h) "Preliminary Results of Measurement of Effects of Diffusion of Helium Into the Laminar Boundary Layer of a Supersonic Flow of Air in a Tube at Mach 5," S. William Gouse, Jr., George A. Brown, and Joseph Kaye, Aero/Space Sciences, Sept. 1959, Vol. 26, Nos. 8, 9.
"Analysis of Effects of Diffusion of a Foreign Gas Into the Laminar Boundary Layer of a Supersonic Flow of Air in a Tube," John R. Radbill and Joseph Kaye, Aero/Space Sciences, Vol. 26, No. 8, pp. 533-535, August 1959.

(3454) SKEWED TURBULENT BOUNDARY LAYER AND SEPARATION.

(b) Office of Naval Research, Dept. of the Navy.
(c) Prof. E. S. Taylor, Mr. R. Schwind, M.I.T., Room 31-265, Cambridge 39, Massachusetts.
(d) Theoretical and experimental; applied research for doctor's thesis.
(e) Skewed boundary layer often behaves differently from two-dimensional boundary layer. Particularly, three-dimensional separation is sometimes moderate and does not deteriorate the flow so badly as two-dimensional separation does.
(g) A computation scheme for skewed turbulent boundary layer is devised which makes use of the two momentum integral relations and an auxiliary equation which is based on empiricism. Also, a theoretical means of describing velocity distributions if formulated.
(h) "Skewed Turbulent Boundary Layers," by W.A. Nelson, Massachusetts Institute of Technology, Gas Turbine Lab., Report No. 55, August 1959.

(3455) TURBULENT BOUNDARY LAYERS IN RECTANGULAR DUCTS.

(b) Office of Ordnance Research, Dept. of the Army.
(c) Prof. A.H. Shapiro, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Experimental and theoretical.
(e) The character of the turbulent boundary layer, including secondary flow, is being investigated - in the region of interference of two perpendicular walls.

(3456) FLAME STABILIZATION IN A BOUNDARY LAYER.

(b) National Science Foundation.
(c) Prof. T.Y. Toong, Massachusetts Institute of Technology, Cambridge 39, Mass.
(d) Theoretical and experimental; basic research for master's and doctoral theses.
(e) Basic study of mechanism of flame stabilization in a boundary layer over a flat plate.
(g) Theoretical and experimental investigations of the structure and propagation of laminar flames near a heat sink were carried out. Characteristics of flames stabilized in a boundary layer over a hot surface were studied experimentally in a two-dimensional combustion tunnel.
(h) "Flame Stabilization in Boundary Layers," T.Y. Toong, Combustion and Propulsion, Third AGARD Colloquium, Pergamon Press, New York, 1958, pp 581-597.
"Flame Stabilization and Propagation in Boundary Layers," by W.S.Wu, Sc. D. Thesis, M.E. Dept., Mass. Inst. of Tech., June 1959.

(3457) JET MIXING WITH CHEMICAL REACTION.

(b) Shell Oil Company.
(c) Prof. T. Y. Toong, Mass. Inst. of Tech., Cambridge 39, Mass.
(d) Theoretical and experimental; basic research for master's and doctoral theses.
(e) Theoretical and experimental investigations of the effects of chemical reaction on transfers of mass, momentum and heat.
(g) An apparatus has been constructed to study the mixing of two concentric gas streams. Experimental results are to be compared with theoretical predictions.
(h) "An Apparatus for Studying Combustion in a Laminar Mixing Zone," D.F. Merrion, S.M. Thesis, M.E. Dept., M.I.T., August 1959.

(3458) CASCADE PERFORMANCE WITH ACCELERATED OR DECELERATED AXIAL VELOCITY.

(b) Allison, General Electric and Westinghouse.
(c) Prof. Y. Senoo, Mass. Inst. of Technology, Room 31-266, Cambridge 39, Massachusetts.
(d) Theoretical; applied research.
(e) A theoretical method to estimate the effect or axial velocity change through a cascade was investigated. The change of axial velocity was reproduced by distributing sinks and sources within the blade passages.

(f) Completed.
(g) The influence of axial velocity change on the cascade performance is set forth in simple formulae. Several examples were compared with experimental data with good agreement.
(h) "Cascade Performance with Accelerated or Decelerated Axial Velocity," by S. Kubota, M.I.T. Gas Turbine Laboratory, Report No. 56, Sept. 1959.

(3459) ASYMMETRIC INLET FLOW IN AXIAL TURBO MACHINES.

(b) Allison, General Electric and Westinghouse.
(c) Prof. Y. Senoo, Mass. Inst. of Technology, Room 31-266, Cambridge 39, Massachusetts.
(d) Theoretical and experimental; applied research, doctor's thesis.
(e) A modified actuator disk analysis is made, utilizing theoretical unsteady blade forces, for distorted inlet flow through an isolated blade row. A series of experiments were made for comparison.
(f) Completed.
(g) According to experiments conducted on an isolated compressor rotor, the present theory offers an improvement, compared to previous theory, in the prediction of distortion attenuation, effects of flow rates, and effects of varying chord-spacing ratio.
(h) "Asymmetric Inlet Flow in Axial Turbo-Machine," by B.S. Seidel, M.I.T., Gas Turbine Lab., Report No. 51, May 1959.

(3460) FLOW IN A RADIAL VANELESS DIFFUSER.

(b) Allison, General Electic and Westinghouse.
(c) Prof. Y. Senoo, and Mr. W. Jansen, Mass. Inst. of Tech., Room 31-266, Cambridge 39, Massachusetts.
(d) Experimental and theoretical; applied, master's thesis.
(e) Boundary layer in a vaneless diffuser is a simple three-dimensional boundary layer. This project was attempted for better understanding of the three-dimensional boundary layer as well as of direct performance of a vaneless diffuser.
(f) Completed.
(g) Theoretical prediction agrees very well with experimental data.
(h) "Incompressible Fluid Flow in a Radial Vaneless Diffuser," W. Jansen, M.I.T., Gas Turbine Laboratory, Report No. 52, May 1959.

(3461) ROCKET PUMP INDUCER.

(b) Allison, General Electric, Westinghouse.
(c) Prof. Y. Senoo, Mass. Inst. of Technology, Room 31-266, Cambridge 39, Massachusetts.
(d) Experimental; applied research, master's thesis.
(e) A pump inducer was designed using a theory to achieve a good performance at a high suction head. The performance was compared with that of conventional pump inducer.
(f) Suspended.
(g) Performance characteristics of the pump at cavitation and at normal condition were measured. Also high speed movie shows development of cavitation in the pump inducer.
(h) "Rocket Pump Inducer," P. Muller, M.I.T., Gas Turbine Laboratory, Rept. No. 53, May 1959.

(3462) ROTATING WAKE IN A VANELESS DIFFUSER.

(b) Allison, General Electric and Westinghouse.
(c) Prof. Y. Senoo, and Mr. W. Jansen, Mass. Inst. of Technology, Room 31-266, Cambridge 39, Massachusetts.
(d) Theoretical and experimental; applied research.
(e) The flow from a centrifugal impeller is not always axi-symmetric. Consequently the flow in a vaneless diffuser is quite different from what is expected for an axi-symmetric case. A theory predicts a large static pressure rise and a large stagnation pressure drop near the entrance to the vaneless diffuser.
(g) The theory is qualitatively conformed by a preliminary experiment.
(h) "Rotating Wake in a Vaneless Diffuser," by R. C. Dean, Jr., and Y. Senoo, ASME Paper, 1959 A-104.

(3463) THE BEHAVIOR OF WAKE IN ADVERSE PRESSURE GRADIENT.

(b) Allison, General Electric and Westinghouse.
(c) Prof. Y. Senoo, and Mr. U.W. Shaub, M.I.T., Room 31-266, Cambridge 39, Massachusetts.
(d) Theoretical and experimental, applied research.
(e) The mechanism of turbulence in a wake is simpler than that in a boundary layer but they are closely related. The relationship between pressure gradient and the time mean flow and turbulence will be studied.

(3464) INFLUENCE OF TIP CLEARANCE ON STALL LIMITS OF A COMPRESSOR CASCADE.

(b) Allison, General Electric and Westinghouse.
(c) Prof. E.S. Taylor, Mass. Inst. of Technology, Room 31-265, Cambridge 39, Massachusetts.
(d) Experimental; applied research for master's thesis.
(e) Flow at the end of compressor blades is complicated, combination of boundary layer and clearance. Influence of boundary layer has been studied and reasonably understood. Influence of clearance is the present problem to be understood.
(f) Completed.
(g) Using the mirror image technique the end wall boundary layer in the tip clearance was dispensed with. The clearance was found to relieve the pressure gradient and to retard stalling.
(h) "The Influence of Tip Clearance on Stall Limits of a Rectilinear Cascade of Compressor Blades," by G. R. Khabbaz, M.I.T. Gas Turbine Lab., Report No. 54, August 1959.

(3465) UNSTEADY LAMINAR BOUNDARY LAYERS.

(b) General Electric, Allison, and Westinghouse.
(c) Prof. Philip G. Hill, Mass. Inst. of Tech., Room 31-266, Cambridge 39, Massachusetts.
(d) Investigation of a laminar boundary layer

subject to harmonic oscillation of its free stream velocity, basic research for doctor's thesis.

(e) Experimental measurement and analytical calculation of phase and amplitude of velocity oscillations having a wide range of frequency in boundary layers of zero pressure gradient and uniform adverse pressure gradient.

(f) Completed.

(g) Experimental confirmation of existing theoretical developments by Lighthill and Lin for very low and very high frequency oscillations. Development of a method of calculation at intermediate frequency behavior which was experimentally confirmed.

(h) "Laminar Boundary Layers in Oscillatory Flow," P.H. Hill and A.H. Stenning presented at ASME annual meeting, Dec. 1959.

(3466) TWO-DIMENSIONAL SEPARATION.

(b) General Electric, Allison, and Westinghouse.

(c) Mr. Carl R. Peterson, Mass. Inst. of Tech., Room 31-267, Cambridge 39, Massachusetts.

(d) Experimental and theoretical study of a separating laminar boundary layer; basic research for doctor's thesis.

(e) The separated laminar boundary is being studied to determine the controlling factors in its behavior. Experimental measurements are to form the initial stage of the investigation.

UNIVERSITY OF MASSACHUSETTS, School of Engineering.

(2561) HYDROLOGY STUDIES IN WESTERN MASSACHUSETTS.

(b) Cooperative with the U.S. Soil Conservation Service, U.S. Weather Bureau, and U.S. Geological Survey. Student assistance financed by a Faculty Research Grant.

(c) Prof. George R. Higgins, Engineering Research Institute, University of Mass., Amherst, Massachusetts.

(d) Experimental; field and laboratory; for design of watershed yield, flood peak reduction, and general information.

(e) Mass curve studies for reservoir and watershed yield have been done for selected reservoirs and drainage areas in Western Massachusetts. An extension of these data combined with studies of reservoir effect on flood flow, water losses, and other hydrologic factors are planned for the current extension of the project.

(3467) THE EFFECT OF HEADER GEOMETRY UPON FLUID FLOW CHARACTERISTICS IN NUCLEAR REACTORS AND HEAT EXCHANGERS.

(b) Laboratory project; student assistance financed by a Teacher's Research Grant.

(c) Prof. Joseph M. O'Byrne, Engineering Research Institute, University of Mass., Amherst, Massachusetts.

(d) Experimental; applied research; MS thesis.

(e) To determine the relationships between such variables as core and tube diameter, tube lattice and spacing, header height, etc., upon the individual flow per tube for a pressure vessel in which fluid is introduced through a single radial line placed at the base of the header.

MICHIGAN STATE UNIVERSITY, Department of Civil Engineering.

(2125) SEDIMENT TRANSPORT IN RUNOFF WATER FROM SMALL AGRICULTURAL WATERSHEDS.

(b) Michigan Agricultural Experiment Station.

(c) Prof. R.Z. Wheaton, Agricultural Engineering Dept., Michigan State University, East Lansing, Michigan.

(d) Field investigation; for design.

(e) Samples of runoff water are collected at periodic intervals and more frequent intervals during flood flow to determine the concentration of sediment being transported. Runoff gaging stations serviced by USGS. Dense network of 22 recording raingages for 25 square mile area in two watersheds.

(g) Sediment content of runoff is low.

(h) "Variation in Summertime Rainfall in South-Central Michigan," A.H. Eichmeier, R. Z. Wheaton, and E.H. Kidder, Quarterly Bulletin of the Michigan Agricultural Experiment Station, Michigan State Univ., East Lansing, Michigan, Vol. 41, No. 4, pp. 886-888, May 1959.
"Preliminary Report of Excessive Precipitation over Sloan Creek Basin, a Small Watershed," A.H. Eichmeier, R.Z. Wheaton, and E.H. Kidder, Quarterly Bulletin of the Michigan Agricultural Experiment Station, Vol. 41, No. 4, pp. 889-893, May 1959.

(2126) SURFACE AND SUBSURFACE DRAINAGE.

(b) Michigan Agricultural Experiment Station.

(c) Prof. E.H. Kidder, Agricultural Engineering Dept., Michigan State University, East Lansing, Michigan.

(d) Experimental; field investigation, applied research.

(e) To study the effect of bedding, bedding and moling, bedding and tile, and tile drainage on crop yields in a submarginal farming area. Crop yields in a grain-grain hay-hay rotation are measured in increments away from the drainage feature.

(g) Two rod tile lateral spacing has given the highest crop yields. A 60-foot tile spacing ranks second.

(h) "Methods of Draining Pickford Clay and the Effect of Crop Production," S.M. King, E.H. Kidder, and W.A.Cutler, Quarterly Bulletin of the Michigan Agricultural Experiment Station, Vol. 42, No. 1, pp. 52-64, August 1959.

(2127) AN INVESTIGATION OF THE STABILITY AND DURABILITY OF SUBSURFACE DRAINS PLACED IN MUCK.

(b) Michigan Agricultural Experiment Station.

(c) Prof. E.H. Kidder, Agricultural Engineering Dept., Michigan State University, East

Lansing, Michigan.
(d) Experimental; field investigation; applied research.
(e) Four lateral underdrains were placed in muck (ph6.5). Concrete and clay tile in one- and two-foot lengths, perforated steel pipe in eight-foot lengths and perforated fiber pipe in six-foot lengths were installed in 1952. Elevations of the ground surface and the underdrains are taken annually. Quality of the material is checked at four-year intervals.
(g) The soil surface subsided 0.8 to 0.9 feet the first year, with little subsidence since. The underdrains settled 0.3 feet the first year, negligible since. Concrete drain tile from three manufacturers deteriorated by acid action. Considerable rusting was noted on galvanized steel. Hay blinding material was in excellent condition.

(3102) WATER REQUIREMENTS OF PLANTS.

(b) Michigan Agricultural Experiment Station.
(c) Prof. R.Z. Wheaton, Agricultural Engineering Dept., Michigan State University, East Lansing, Michigan.
(d) Experimental, field investigation; applied research.
(e) Four areas are protected against natural rainfall during the cropping season. Precision irrigation is practiced to maintain four levels of avilable water in the soil. Meteorological, evapotranspiration and evaporation data are also collected.
(g) The highest level of available water (range between 70 and 100% in the surface foot) gives the highest yield of potatoes. Consumptive use peak rate of 0.18 inches per day.

(3103) A STUDY OF SECONDARY FLOW IN THE BEND OF A CLOSED CONDUIT.

(b) Michigan Agricultural Experiment Station.
(c) Prof. E.H. Kidder, Agricultural Engineering Dept., Michigan State University, East Lansing, Michigan.
(d) Theoretical; basic research for Ph.D. thesis.
(e) Mathematical analysis of laminar flow following a bend in a closed conduit.
(f) Completed.
(g) For the case of laminar flow an approximate solution was found for the flow in a straight circular pipe following a coiled pipe. The initial conditions at the beginning of the straight pipe was assumed to be given by Dean's solution for the coiled pipe; other simplifying assumptions were also necessary for the solution. The resulting assymptotic solution describing the decay of the secondary flow was used to give an indication of the effect of the Reynolds number and pipe roughness in turbulent flow by substituting a constant turbulent eddy diffusion coefficient for the coefficient of viscosity in the laminar solution.
(h) "A Theoretical Analysis of the Decay of Secondary Flow Following a Pipe Bend," Cornelius Chung-Sheng Shih, Ph.D. thesis, Dept. of Agricultural Engineering, Michigan State Univ., East Lansing, Michigan.

(3104) SPRINKLER IRRIGATION FOR FROST PROTECTION OF PLANTS.

(b) Michigan Agricultural Experiment Station.
(c) Prof. E.H. Kidder, Agricultural Engineering Station, Michigan State Univ., East Lansing, Michigan.
(d) Experimental, laboratory and field investigation; applied research.
(e) To determine the application rates and repeat frequency of water application to give effective protection to plants against frost damage.
(g) Applications rates of 0.1 inch per hour, repeat frequency of 12 to 20 seconds has protected truck crops against minimum temperature of 19°F.

(3105) SHEAR AND PRESSURE DISTRIBUTION ON DUNE-SHAPED BOUNDARIES.

(b) National Science Foundation.
(c) Dr. E.M. Laursen, Dept. of Civil Engineering, Michigan State University, East Lansing, Michigan.
(d) Experimental; basic research.
(e) Since the bed of an alluvial stream commonly consists of dunes and ripples, the distribution of shear and pressure over these roughness elements is of interest in regard to both sediment transportation and resistance to flow. A 44-foot Lucite conduit with schematic triangular dunes and air as the fluid is being used in the experimental investigation.

(3468) FLOW STABILITY.

(b) Laboratory project.
(c) Dr. Karl Brenkert, Jr., Dept. of Applied Mechanics, Michigan State University, East Lansing, Michigan.
(d) Theoretical and experimental; basic research for master's thesis.
(e) Theoretical and experimental study of the stability of the laminar boundary layer in the entrance of a pipe.

UNIVERSITY OF MICHIGAN, Department of Civil Engineering.

(3469) SMALL BOAT HARBOR STUDY.

(b) Dept. of Port Control, Cleveland, Ohio.
(c) Prof. E.F. Brater, 320 West Engineering Bldg., Ann Arbor, Michigan.
(d) Experimental; applied research.
(e) Determination of a procedure for reducing wave action in the mooring area.
(g) The model is in the design stage.

UNIVERSITY OF MINNESOTA, Agricultural Experiment Station.

(1929) DRAIN TILE JUNCTION LOSSES.

Cooperative with St. Anthony Falls Hydraulic Laboratory. See page 65.

(2350) DRAINAGE OF AGRICULTURAL LAND BY PUMPING.

(b) Laboratory project.
(c) Prof. Curtis L. Larson, Dept. of Agricultural Engineering, Univ. of Minnesota, St. Paul 1, Minnesota.
(d) Theoretical and field investigations; applied research.
(e) The project has three phases: (1) The development of basic relations for planning pump drainage systems, (2) the study of rates of drainage, and (3) the study of factors affecting the efficiency.
(g) Expressions for the amount of storage required by automatic and non-automatic pumping plants have been developed. A new device for measuring effluent from partially filled pipes was developed in laboratory tests.

(2576) CONSTRUCTION, DEVELOPMENT, AND PUMPING OF SHALLOW WELLS FOR IRRIGATION.

(b) Field project.
(c) Prof. Evan R. Allred, Dept. of Agricultural Engineering, Univ. of Minn., St. Paul 1, Minnesota.
(d) Field investigation; applied research and development
(e) The objectives of the project are: (1) To study and develop inexpensive methods for construction of shallow irrigation wells, (2) determine hydraulic permeability and characteristics of various aquifers, and (3) to survey and determine extent and availability of shallow ground water sources for irrigation in Minnesota.

(3470) HYDRAULIC PERFORMANCE OF IRRIGATION BOOM-SPRINKLERS.

(b) Field and laboratory project.
(c) Prof. Evan R. Allred, Dept. of Agricultural Engrg., Univ. of Minn., St. Paul 1, Minn.
(d) Primarily field investigation; applied research.
(e) The objective of the project is to determine the effect of wind velocity, nozzle arrangement, rotation speed and operating pressure on the distribution from irrigation boom-sprinklers.

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

(319) WEIR STUDIES.

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

(2578) CORRELATION OF WEIR CREST DEPTH AND WEIR FLOW CHARACTERISTICS.

(b) Laboratory project.
(c) Prof. Clifford D. Muir, Civil Engineering Department, Missouri School of Mines and Metallurgy.
(d) Experimental.
(e) Tests on several cipoletti weirs were made in order to determine the effect of weir thickness, H/P ratio, and Froude's Number on the ratio of crest depths to the critical depth of an imaginary open channel having the same dimensions as the weir flow section.
(g) This study indicated a definite relationship between the crest depth to critical depth ratio and the Froude Number of the imaginary channel. However, the ratio tended to become constant at either high or low Froude Numbers. The H/P ratio had no noticeable affect on this relationship. A continuation of this study indicates probable superiority of crest depth flow relationships, when weirs having a narrow width with respect to head are being used.

(3471) REGULATION OF RIVER BANK DEVELOPMENT THROUGH FLOOD PLAIN ZONING.

(b) Laboratory project.
(c) Prof. E.W. Carlton, Civil Engineering Dept., Missouri School of Mines and Metallurgy.
(d) Field investigation; applied research.
(e) The basic concepts for establishing an effective flood plain zoning program were investigated from three aspects: (1) Establishment of frequency and magnitude of design flood; (2) translation of design flood to zoning limits on the ground through hydraulic computations; and (3) establishment of a sensible adjustment of land use to flood hazard.
(g) In addition a recommended zoning program has been established for a flood plain in Missouri with applications for the entire state and for most regions of the United States. A complete summary of the status of flood plain zoning in the United States has been tabulated.
(h) "Regulation of River Bank Development Through Flood Plain Zoning," William J. O'Neill, master's thesis, Missouri School of Mines 1959 (available on loan).

MONTANA STATE COLLEGE, Agricultural Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. O.W. Monson, Head, Agricultural Engineering Department, Montana State College, Bozeman, Montana.

(3108) FORECASTING OF WATER SUPPLY BASED ON WATER EQUIVALENT OF SNOW AND OTHER HYDROLOGIC FACTORS.

(b) Conducted for Montana Agricultural Experiment Station in cooperation with Soil Conservation Service, USDA.
(d) Experimental; applied research.
(e) The present objective is to (1) forecast maximum or peak discharge for flood control and (2) to forecast recession from peak to base, or mean, flow as an aid to water commissioners and water users whose water rights are based on priorities.
(g) Progress up to present time indicates that maximum or peak discharge can be forecast approximately. Forecasting of recession has not yet proved reliable.
(h) Annual reports to Western Regional Research Conference and to Federal Examiner, O.E.S.

(3109) IRRIGATION EFFICIENCY STUDIES.

(b) Montana Agricultural Experiment Station in cooperation with U.S. Bureau of Reclamation.
(d) Experimental; applied research.
(e) Development of a formula to guide irrigator in the application of the amount of water which can be stored within root zone for use by crop. Intended for irrigation by surface flooding methods of irrigation.
(g) Formula gives size of stream Q (cfs) in terms of length and width of strip, rate of water intake, slope or gradient of field, and a roughness factor depending on density of vegetation.
Formula:

$$Q = \left[\frac{LI}{3600KD}\right]^{-5/2} \left\{\frac{n}{1.486}\right\}^{3/2} \frac{w}{S^{3/4}}$$

(h) Annual reports to Western Regional Research Service and to Federal Examiner, O.E.S.

(3110) REDUCTION OF SEEPAGE IN CANALS BY APPLICATION OF BENTONITE.

(b) Laboratory project in cooperation with Cameron Ditch Co.
(d) Experimental; applied research.
(e) Bentonite applied in a slurry by sedimentation method proved inefficient when canal was constructed through coarse gravel with insufficient fine material to trap the bentonite.
(g) Four miles of ditch in coarse gravel was treated with 12 inch compacted earth lining reduced seepage by about 75%. Bentonite treatment may be necessary.

(3472) INTERCEPTION AND ITS EFFECT ON PRECIPITATION DISPOSAL.

(b) Laboratory project and Western Regional Research.
(d) Experimental and field investigation; basic research.
(e) Measurement of interception of precipitation by various types and densities of canopy cover.

NEWPORT NEWS SHIPBUILDING AND DRY DOCK COMPANY.

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

(123) HYDRAULIC TURBINE TESTS.

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

(124) METER CALIBRATION TESTS.

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

(896) VANE MOMENT TESTS ON ADJUSTABLE BLADE RUNNERS.

(b) Laboratory project.
(d) Experimental; for design data.
(e) Tests are to determine vane moments at various gate openings, blade positions and speeds. The turbine load is applied by an electric dynamometer and speed is measured with a Berkeley "EPUT" meter. The blades are held in position by an amplidyne control system on a spider rod through the shaft. The blade moments are obtained from a proving ring by means of electric strain gages.

(901) SHIP MODEL RESISTANCE TESTS.

(b) Laboratory project.
(d) Experimental; for design data.
(e) Scale ship models are towed to determine the effective horsepower, bare hull, required by the ship. Because of their small size, several models may be towed in a short period of time thus allowing much preliminary work to be done on the choice of lines. The final lines are checked by the David Taylor Model Basin. To eliminate a large portion of this preliminary testing, a schedule of systematic models are arranged in which the beam-draft ratio, the displacement-length ratio, and the prismatic coefficient are varied over a wide range. Towing this set of models is continuing and when completed will provide design data for a standard offset series covering a wide range.

(1132) HYDRAULIC PUMP TESTS.

(b) Laboratory project.
(d) Experimental; for design data.
(e) Scale model pumps, centrifugal and propeller types, are tested at constant speeds for head developed, power consumption, and efficiency at various rates of discharge. Cavitation tests are sometimes conducted by lowering the suction head to a point where the developed head and efficiency break down.

(1133) CAVITATION TESTS OF HYDRAULIC TURBINE MODELS.

(b) Laboratory project.
(d) Experimental; for design data.
(e) Scale model turbines are tested on cavitation stand to determine sigma at which cavitation starts. By the use of a plexiglas throat ring and Strobolux light synchronized with the shaft rotation, visual observations are made to determine the location on the blade where cavitation starts. Tests also run to determine runaway speeds at low sigma values.

(2582) AIR TESTS ON HYDRAULIC TURBINE MODEL.

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

(3111) PUMP-TURBINE TESTS.

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

NEW YORK UNIVERSITY, Department of Chemical Engineering.

Inquiries concerning Projects Nos. 2583, 3113, 3472 and 3473 should be addressed to Prof. J. Happel, Dept. of Chemical Engineering, New York University, University Heights, New York 53, New York.

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

(b) Grants from Texas Company and American Chemical Society; laboratory project.
(d) Theoretical; basic research for doctoral thesis.
(e) The slow translational motion of dilute beds of particles settling through a viscous fluid subjected to the influence of cylindrical boundaries is being studied. This will ultimately enable a theoretical prediction of the effect of particle concentration on pressure drop and sedimentation velocity in beds of particles.
(g) The fluid velocity for a large number of field points within a cylindrical container has been computed for a spherical particle settling at six evenly spaced locations along the cylinder radius. The velocity field for all locations has also been obtained from the computed points by interpolation.

(3113) THE INTERACTION OF TWO SPHERES FALLING SLOWLY IN A VISCOUS FLUID.

(b) Laboratory project.
(d) Experimental; basic research for the master's degree.
(e) Determination of the terminal settling velocity of two equal size spheres moving one above the other and side by side as a function of the ratio of sphere diameter to center-to-center distance at very low Reynolds numbers (Creeping Motion Range). The distance between spheres was varied from one to 50 sphere diameters.

(3115) SOLUTION OF OSEEN'S EQUATIONS FOR FLOW PAST AN OFF-CENTERED SPHERE IN A CYLINDER.

(b) Laboratory project.
(c) Prof. Howard Brenner, Dept. of Chemical Engineering, New York University, New York 53, N. Y.
(d) Theoretical; basic research for doctoral degree.
(e) It is the purpose of this project to determine the sidewise force exerted on an off-centered sphere in a cylinder. This will be obtained by satisfying the boundary conditions in the solution to Oseen's equations for fluid flow.
(f) Completed.
(g) Experiments were conducted in a five foot tall, sixteen inch diameter glass column so that errors due to wall and end effects were minimized. The results were correlated against the theoretical equations of Stimson and Jeffrey, Wakiya, Famularo and others including corrections for wall effect. Close agreement was achieved in almost all cases.
(h) "The Interaction of Two Spheres Falling Slowly in a Viscous Fluid," Ernest Bart, Master's Thesis, 1959 (available on loan).

(3116) LAMINAR FLOW FROM A POINT SOURCE INTO A PIPE.

(b) Laboratory project.
(c) Prof. Howard Brenner, Dept. of Chemical Engineering, New York University, New York 53, N. Y.
(d) Theoretical; basic research for the master's degree.
(e) The development of laminar flow in a pipe

from a symmetrically placed point source at low Reynolds numbers. The problem investigated here was how many pipe diameters one had to be from the source before the velocity distribution in the pipe became Poiseuillian.

(f) Completed.

(g) An exact solution has been derived by the method of reflection resulting in an infinite series expressing Stokes stream function as a function of position. A plot of constant stream lines versus position along the cylinder was obtained.

(h) "Laminar Flow from a Point Source into a Pipe," Richard Pintz, Master's Thesis, 1959 (available on loan).

(3117) NON-NEWTONIAN FLUIDS THROUGH A FLUIDIZED BED.

(b) Laboratory project.

(c) Prof. Howard Brenner, Dept. of Chemical Engineering, New York Univ., New York 53, N. Y.

(d) Experimental; basic research for master's thesis.

(e) To determine the pressure drop due to the flow of a Non-Newtonian fluid through a packed bed. Suspensions of calcium carbonate in water are being employed.

(g) At high velocities the pressure drop relation is the same as for the flow of a Newtonian fluid having the same viscosity as that of the suspension at infinite shear rate.

(3473) VISCOUS FLOW RELATIVE TO ARRAYS OF CYLINDERS.

(b) Laboratory project.

(d) Theoretical; basic research.

(e) A mathematical treatment is developed on the basis that two concentric cylinders can serve as the model for viscous flow both perpendicular and parallel to random assemblages of cylinders. By using appropriate boundary conditions which apply to the model, closed solutions of the Stokes-Navier equations of motion were obtained.

(f) Completed.

(g) The analytical solutions are shown to be in good agreement with existing data on beds of fibers of various types and flow through bundles of heat exchanger tubes for cases where they can reasonably be expected to apply. Close agreement in the dilute range with the only theoretical treatment for flow parallel to a square array of cylinders provides an interesting validation of the model.

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

(b) Laboratory project.

(d) Theoretical; basic research for doctoral thesis.

(e) An analytical solution is developed by assuming a model where fluid is flowing between two concentric spheres which are maintained at different temperatures. The partial differential equations applicable are solved by assuming solutions in the form of a power series in temperature. The results of the analytic solutions will be compared to existing data on heat and mass transfer in packed and fluidized beds.

NEW YORK UNIVERSITY, Fluid Mechanics Laboratory.

(1912) DISCHARGE CHARACTERISTICS OF A SIDE WEIR.

(b) Laboratory project.

(c) Prof. A.H. Griswold, New York University, New York 53, N. Y.

(f) Currently inactive.

NEW YORK UNIVERSITY, Department of Meteorology and Oceanography.

(2356) SHIP MOTIONS PROJECT.

(b) David Taylor Model Basin, Department of the Navy.

(c) Prof. Willard J. Pierson, Jr., Associate Professor of Meteorology, New York Univ., University Heights, New York 53, N. Y.

(d) Theoretical and experimental; basic and applied research.

(e) Studies of the theory of a stationary Gaussian process as applied to the motions of ships in waves; experimental and theoretical determination of co-spectra and quadrature spectra.

(g) Theoretical studies of cross spectra, and theoretical papers on wave theory and ship motion theory.

(h) "Differential Equations with Frequency Dependent Coefficients," Leo J. Tick, Jour. of Ship Research, Vol. 3, No. 3, pp. 45-46, 1959.

(2357) WAVE PROJECT.

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

(c) Prof. Willard J. Pierson, Jr., Associate Prof. of Meteorology, New York University, University Heights, New York 53, N. Y.

(d) Theoretical and experimental; and basic and applied research.

(e) Attempts to solve various probabilistic problems in connection with stationary Gaussian noise.

(g) Work is continuing on the joint density of amplitude and half period and on improved zero and ordinate crossing techniques.

(h) "Operating Procedures for Computing Zero and Ordinate Crossings of Stationary Gaussian Noise Using an IBM 650 Calculator," R.G. Stevens, Technical Report, College of Engineering, New York University, 1959.

(3120) OFFICE OF NAVAL RESEARCH OCEAN ATMOSPHERE INTERACTION AND WAVE PROJECT.

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

(c) Prof. Gerhard Neumann, Prof. of Oceanography, and Prof. Willard J. Pierson, Jr., Assoc. Professor of Meteorology.

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(d) Experimental and theoretical; basic and applied research.
(e) Study of wave generation and propagation in deep water; non-linear properties of capillary and gravity waves. Observations of temperature humidity and wind over the sea surface Albedo measurements. Wind stress on water surfaces and the oceanic circulation.
(g) It has been shown that wave spectra cannot form a nested family of waves for fully developed seas. Non-linear effects were not too pronounced in project SWOP and a revised version of the report is in preparation. A model of the Gulf Stream that shows both cyclonic and anticyclonic shear regions has been obtained.
(h) "On the Mass Transport of Wind-Driven Currents in a Baroclinic Ocean with Application to the North Atlantic," G. Neumann, Zeitschr. für Meteorologie, Vol. 12, No. 4-6, pp. 138-147, April-June 1958.
"Notes on the Stress of Light Winds on the Sea," G. Neumann, Bull. American Met. Soc., Vol. 40, No. 3, pp. 146-148, Mar. 1959.
"A Non-Linear Random Model of Gravity Waves," L.J. Tick, Jour. of Math. and Mech., Vol. 8, No. 5, Sept. 1959, pp. 643-653.
"A Note on the Growth of the Spectrum of Wind Generated Gravity Waves as Determined by Non-Linear Considerations," W.J. Pierson, J. Geophys. Res., Vol. 64, No. 8, pp. 1007-1011, 1959.
"A Study of Wave Forecasting Methods and of the Height of a Fully Developed Sea on the Basis of Some Wave Records Obtained by the OWS Weather Explorer During a Storm at Sea," W.J. Pierson. (To appear in Deutsche Hydrogr. Zeitschr., 1960.)

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

(1636) RAINFALL, INTENSITY, DURATION, FREQUENCY, CURVES FOR NORTH CAROLINA.

(b) Laboratory project.
(c) Prof. Chas. Smallwood, Dept. of Engineering Research, North Carolina State College, Raleigh, North Carolina.
(d) Experimental work consists of collecting information on rainfall.
(e) The collection and analysis of the data pertaining to intensity, duration and frequency of rainfall in North Carolina.
(h) Information will be published later.

NORTH DAKOTA AGRICULTURAL COLLEGE, Agricultural Engineering Department.

(3121) PREFABRICATED DITCH LININGS.

(b) Laboratory project.
(c) Mr. Harold Holmen, Assst. Agricultural Engineer, Agricultural Engineering Dept., North Dakota Agricultural College, Fargo, North Dakota.
(d) Experimental; applied research.
(e) Four, six and eight mil polyethyline linings were installed in irrigation ditches and seepage tests were conducted to determine its effectiveness in preventing seepage.

(3475) SURFACE DRAINAGE.

(b) Laboratory project.
(c) Mr. E. W. French, Asst. Agricultural Engr., Agricultural Engineering Dept., North Dak. Agricultural College, Fargo, North Dakota.
(d) Field investigation; applied research.
(e) To study the effect of parallel ditch spacing, land forming and smoothing on crop yields in the Red River Valley. To determine the feasibility and practicability of using farm sized equipment to perform the work.

NORTHWESTERN UNIVERSITY, The Technological Institute.

(2361) FATE OF FISSION PRODUCTS IN SURFACE WATERS.

(b) U. S. Atomic Energy Commission.
(c) Prof. W.S. Hamilton, Dept. of Civil Engrg., Northwestern Univ., Evanston, Ill.
(d) Theoretical and experimental; doctoral research of Mr. Ivor Thomas.
(e) Study of the fate of fission products when injected into the Chicago Sanitary Ship Canal near Lemont, Ill. Two injections have been made and the data have been analyzed to obtain longitudinal dispersion coefficients.
(f) Completed.
(g) Average dispersion coefficient was determined to be 38 ft^2/sec. Reduction in radioactivity is due to decay and dispersion; removal by settling of organic material is likely to be temporary with subsequent reentry during flood stages.
(h) "An Investigation of the Fate of Fission Products in the Illinois Waterway System," I.E. Thomas, W.S. Hamilton and C.G. Bell, Report to the Atomic Energy Commission, January 1959.
"Dispersion in Open Channel Flow," I.E. Thomas, Doctoral Dissertation, Northwestern University, August 1958.

(2586) DISPERSION OF FLUID IN POROUS MEDIA.

(b) Laboratory project.
(c) Prof. Robert B. Banks, Dept. of Civil Engineering, Northwestern Univ., Evanston, Illinois.
(d) Theoretical, experimental,
(e) Packed column apparatus permits sampling of fluid flow to determine effects of dispersion, diffusion and convection on the change in solute concentration. One-dimensional studies have been completed; experiments in progress on radial flow apparatus.
(f) Continuing.
(g) A theoretical analysis of the problem indicates that the phenomena is described by an equation similar to the heat

conduction equation. It has been found that the longitudinal dispersion coefficient is proportional to the product of the fluid velocity and the grain diameter.

(h) "Dispersion of Fluid Flow in Porous Media," Akio Ogata and Robert B. Banks, Report to the Atomic Energy Commission, Jan. 1959.

(2818) DIFFUSION IN TIDAL ESTUARIES.

(b) Laboratory project.
(c) Prof. Robert B. Banks, Dept. of Civil Engrg., Northwestern Univ., Evanston, Illinois.
(d) Theoretical and experimental; doctoral thesis.
(e) Experimental work is being conducted in long, variable slope channel, modified to simulate a tidal estuary. Test results will be interpreted in the light of turbulent diffusion coefficients obtained by measurement of the longitudinal distribution of fluid tracers.
(f) Completed.
(g) A method of estimating the pollution distribution in a simplified estuary was derived for the instantaneous injection case. Test data for dispersion in a rectangular channel and the Savannah Estuary model were tabulated.
(h) "Dispersion in Tidal Estuaries," Paul J. Huiswaard, Robert B. Banks and C.G. Bell, Jr., Report to Atomic Energy Commission, January 1959.

(3122) MASS, HEAT AND MOMENTUM TRANSFER IN THE FLOW OF GASES PAST SINGLE SPHERES.

(b) Laboratory project.
(c) Prof. George Thodos, Dept. of Chemical Engrg., Northwestern Univ., Evanston, Ill.
(d) Experimental.
(e) Analogies of mass, heat and momentum are being tested.
(f) Nearly completed.
(g) Analogies involving j-factors point to equivalence of mass, heat and momentum as long as the skin friction alone is accounted for in this study.

(3476) FLOOD WAVE ROUTING IN PRISMATIC CHANNELS.

(b) Laboratory project.
(c) Prof. W.S. Hamilton, Dept. of Civil Engrg., Northwestern University, Evanston, Illinois.
(d) Doctoral thesis.
(e) The purpose is to set up a workable method of calculating the movement of flood waves in non-rectangular channels. Solution using finite differences along characteristic curves is to be tried first.

(3477) THE EFFECT OF JET MIXING AND DENSITY GRADIENTS ON SEDIMENTATION EFFICIENCY.

(b) Laboratory project.
(c) Prof. R.B. Banks, Dept. of Civil Engineering, Northwestern Univ., Evanston, Ill.
(d) Theoretical and experimental; doctoral thesis.
(e) Two somewhat related studies involving sedimentation are being initiated. The first is concerned with the effect of mixing, caused by a two-dimensional jet, on the percentage of particles removed in a rectangular sedimentation basin. The second involves the effect of changes of influent density on removal efficiencies.

(3478) EFFECTS OF TEMPERATURE DISTRIBUTION WITHIN OILFILMS OF BEARINGS.

(c) Prof. O.C.Zienkiewicz, Dept. of Civil Engineering, Northwestern Univ., Evanston, Illinois.
(d) Theoretical.
(e) Numerical solution of energy and heat dissipation equations and a study of the effects of viscosity variation across and along the oilfilms on the build up at lifting pressures.
(f) First stage concluded.
(h) "Temperature Distribution Within Lubricating Films Between Parallel Bearing Surfaces and its Effect as Pressures Developed," O.C. Zienkiewicz, Conference on Lubrication and Wear, London, I.M.E., Oct. 1957. "Effects of Temperature Distribution in a Simple Wedge Bearing," submitted to the Inst. of Mech. Eng., London, August 1959.

(3479) MASS TRANSFER STUDIES IN FLUIDIZED BEDS.

(b) Laboratory project.
(c) Prof. George Thodos, Dept. of Chemical Engineering, Northwestern Univ., Evanston, Illinois.
(d) Experimental.
(e) Mass transfer studies from surface of fluidized particles of p-dichlorobenzene are being conducted in order to investigate their relationships to mass transfer studies in fixed beds.
(h) M.S. thesis, Richard Riccetti, 1959.

(3480) THE FLOW OF NEWTONIAN AND OF NON-NEWTONIAN FLUIDS IN THE ENTRANCE OF A TUBE.

(b) Laboratory project.
(c) Prof. John C. Slattery, Dept. of Chemical Engrg., Technological Inst., Northwestern University, Evanston, Illinois.
(d) Theoretical; basic research for thesis.
(e) Boundary layer analysis is being applied to calculate pressure and velocity distributions.

(3481) BOUNDARY-LAYER FLOW PAST SUBMERGED BODIES.

(b) Laboratory project.
(c) Prof. John C. Slattery, Dept. of Chemical Engineering, Technological Institute, Northwestern University, Evanston, Ill.
(d) Theoretical; basic research for thesis.
(e) Boundary layer analysis is being applied to flow past a circular cylinder, flow past a sphere, through a tube bank, and through a bed of spheres. The object of these calculations will be to estimate the pressure distribution, form drag, and total drag in each of these cases. Both Newtonian and non-Newtonian fluids are being considered.

(3482) NON-NEWTONIAN FLOW THROUGH AN ANNULUS.

(b) Laboratory project.
(c) Prof. John C. Slattery, Dept. of Chemical Engrg., Northwestern Univ., Evanston, Ill.
(d) Theoretical; basic research for thesis.
(e) The flow of non-Newtonian fluids through a thin annulus (the ratio of the inner diameter to the outer diameter greater than 0.6) is being studied; the results will be extended to annuli with rotating cores.

(3483) GROUND EFFECT PHENOMENA.

(b) Laboratory project.
(c) Prof. A. A. Kovitz, Dept. of Mech. Engrg., Northwestern University, Evanston, Ill.
(d) Theoretical, basic research.
(e) To study the thrust augmentation capabilities of jet devices near surfaces, including both rigid and deformable surfaces.

(3484) MIXING AND REACTION KINETICS IN FLOWS.

(b) Arnold Engrg. Development Center, ARDC, USAF.
(c) Prof. A.A. Kovitz, Dept. of Mech. Engrg., Northwestern University, Evanston, Ill.
(d) Theoretical; basic research.
(e) To study the flow of real gases in high speed, high temperature phenomena including non-equilibrium effects.
(g) Study completed of mixing of dissociated with undissociated gas using simplified rate law. Obtained closed form solution describing approach to equilibrium in boundary layer type mixing.
(h) "Memorandum on Flow with Recombination Behind an Oblique Shock Wave," Memo No. III-1 Contract AF 40(600)-748.
"Non-Equilibrium Effects in Parallel Stream Mixing," Memo No. III-2, Contract AF 40 (600)-748.
"A Solution for Laminar, Parallel Stream Mixing with Dissociation and Recombination," with R.F. Hoglund. Submitted to Physics of Fluids.

UNIVERSITY OF NOTRE DAME, Dept. of Civil Engineering.

(1643) BIBLIOGRAPHY OF HYDROMETRY.

(b) Research project with a grant from the National Science Foundation.
(c) Dr. S. Kolupaila, Dept. of Civil Engineering, University of Notre Dame, Notre Dame, Indiana.
(d) Bibliographical research.
(e) Literature on water measurements for hydrology, water supply, irrigation, hydraulic structures, hydraulic machinery, hydraulic laboratories, in more than 30 languages, with English transliteration, translation and annotations.
(g) To be completed to September 1, 1960.
(h) Bibliography is being published by the University of Notre Dame.

(3124) HISTORY OF HYDROMETRY IN THE UNITED STATES.

(c) Dr. S. Kolupaila, Dept. of Civil Engrg., University of Notre Dame, Notre Dame, Ind.
(h) "Early History of Hydrometry in the United States," Part I is being published in the Journal of the Hydraulics Division, American Society of Civil Engineers.

OKLAHOMA STATE UNIVERSITY, Agricultural Engineering Department.

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

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

(2828) THE EFFECTIVENESS OF MONOMOLECULAR FILMS FOR REDUCING EVAPORATION FROM RESERVOIRS.

(b) Oklahoma Agricultural Experiment Station.
(c) Prof. F.R. Crow, Oklahoma State Univ., Dept. of Agricultural Engineering, Stillwater, Oklahoma.
(d) Experimental; applied research.
(e) Studies are being made on plastic lined experimental evaporation reservoirs to develop methods of application and determination of effectiveness of hexadecanol and octadecanol films for reducing evaporation. Effect of wind on stability of monolayers is being studied in low-speed laboratory wind tunnel.
(g) Evaporation reductions of 25 to 40% have been obtained using a slurry method of applying film to experimental pond. Curves have been developed relating wind speed and required film application rate.

THE PENNSYLVANIA STATE UNIVERSITY, Ordnance Research Laboratory, College of Engineering and Architecture.

(2832) MEASUREMENT OF FORCES ON A MODEL IN A WATER TUNNEL.

(b) Laboratory project.
(c) Messrs. G. B. Gurney and T. E. Peirce, Ord. Research Lab., Univ. Park, Pennsylvania.
(d) Experimental; developmental.
(e) The problem concerns the measurement of

forces on models in a water tunnel over a velocity range up to 80 fps, pressure ranges of 3 to 60 psia.

(g) Two four-component (lift, drag, pitching moment, and rolling moment) balances for use in water tunnels have been developed and have been in successful operation for approximately one year. The balances utilize strain-gaged pre-tensioned flexure beams as the force and moment sensing devices. One balance is strut-mounted for use with models up to about 15 inches in diameter and 115 inches long. The other balance is for sting mounting of smaller 3 to 5-inch diameter models.

(h) Summary report available.

(2833) EXCITATION OF CAVITY RESONANCE BY WATER FLOW.

(b) Laboratory project sponsored by the Bureau of Ships.

(c) Mr. R.E. Bland, Dr. E.J. Skudrzyk, Ordnance Research Laboratory, University Park, Penna.

(d) Primarily experimental, some theoretical; basic research.

(e) Experiments involving the excitation of cavity resonance by water flow past an opening or cavity, i.e., trapped water on one side of the opening and flowing water on the other side.

(3143) REDUCTION OF SKIN FRICTION DRAG.

(b) Joint program of investigation with the General Electric Company sponsored by the Bureau of Ordnance.

(c) Mr. A.F. Lehman, Ordnance Research Lab., University Park, Pennsylvania.

(d) Experimental; applied research.

(e) Investigations into the application of boundary layer control through suction on underwater bodies.

(3485) DEVELOPMENT OF TURBULENCE-MEASURING EQUIPMENT FOR USE IN WATER.

(b) Laboratory project sponsored by the Bureau of Ordnance.

(c) Dr. John Lumley, Ordnance Research Laboratory, University Park, Pennsylvania.

(d) Experimental; developmental.

(e) Probes and associated (constant temperature) electronic gear are being developed to investigate the suitability of thermistors as turbulence-sensing devices for use in water.

(3486) TURBULENCE MEASUREMENTS IN WATER.

(b) Laboratory project sponsored by the Bureau of Ordnance.

(c) Dr. John Lumley, Ordnance Research Laboratory, University Park, Penn.

(d) Experimental.

(e) Using a constant temperature probe, some turbulent flows at high Reynolds numbers will be investigated with particular attention to homogeneous grid-produced turbulence and turbulent dispersion in a shear flow.

(3487) FLOW DISTORTION FEEDING INTO A PROPELLER.

(b) Laboratory project sponsored by the Bureau of Ordnance.

(c) Mr. J.J. Eisenhuth, Ordnance Research Lab., University Park, Penn.

(d) Theoretical and experimental.

(e) This is a study of the interaction effects between control surfaces and a propeller when the surfaces are located in front of the propeller and feed a distorted flow into it. The primary goal is to determine how effectively the propeller cancels the forces produced by the control surfaces.

(3488) FLOW OVER A BODY OF REVOLUTION WITH STABILIZING SURFACES.

(b) Laboratory project sponsored by the Bureau of Ordnance.

(c) Mr. E.J. Rodgers, Ordnance Research Lab., University Park, Penn.

(d) Theoretical and experimental.

(e) This study is directed toward the understanding of the flow conditions around a body of revolution with stabilizing fins under conditions of pitch or yaw. The eventual goal is to be able to predict more precisely the hydrodynamic coefficients of such a body by virtue of a better understanding of the flow conditions.

(3489) INVESTIGATION OF THE EFFECT OF MINOR CHANGES IN THE FORM SHAPE OF THE LEADING EDGES OF PROPELLERS ON INCIPIENT CAVITATION.

(b) Laboratory project.

(c) Mr. G.B. Gurney, Ord. Research Laboratory, University Park, Penn.

(d) Theoretical; experimental for master's thesis.

(e) Experimental evidence has suggested very minor departures from the idealized airfoil shape at the leading edge of propellers may have major effects on cavitation performance. A theoretical investigation involving conformal mapping will be followed by experimental tests to validate the theoretical predictions.

PURDUE UNIVERSITY, Agricultural Experiment Station.

(2596) THE USE OF A RAINFALL SIMULATOR FOR SOIL AND WATER MANAGEMENT STUDIES.

(b) Agricultural Research Service, SWC, ESW, USDA and Purdue University.

(c) Mr. L. Donald Meyer, ARS, Agr. Engr. Bldg., Purdue University, Lafayette, Indiana.

(d) Field investigation; applied research.

(e) The rainfall simulator is used on runoff plots for comparison of treatments which affect erosion and infiltration. Research includes studies of tillage methods, crop residue management, slope, soil type, crop rotations, and intensity histograms.

(2597) THE EFFECTS OF TILLAGE ON RUNOFF AND EROSION.

(b) Laboratory project.

(c) Mr. W. D. Lembke, Agricultural Engineering

Department, Purdue University, Lafayette, Indiana.
(d) Field investigation; applied research.
(e) Runoff is measured from 15 watersheds in five different tillage systems. These systems involve two surface soil treatments and three subsoil treatments, including subsoil fertilization and vertical mulching. A hydrologic analyses of these small watersheds are used to evaluate the effects of tillage on soil moisture, crop growth and yield, and runoff.

(2835) PRELIMINARY INVESTIGATION OF WATER TABLE CONTROL IN SANDY SOIL.

(b) Laboratory project.
(c) Mr. W. D. Lembke, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
(d) Field investigation; applied research.
(e) The water table in an adjacent sandy field is controlled from a supply ditch in which the water level is kept high. The depths to the water table are continuously measured during the growing seasons at various distances from the ditch. Crop yield data are collected and compared with regard to the depths to the controlled water table.

(2837) TREATMENT OF SURFACE WATERS FOR DOMESTIC USE ON THE FARM.

(b) Laboratory project.
(c) Prof. A. C. Dale, Agricultural Engineering Department, Purdue University, Lafayette, Indiana.
(d) Field investigation; applied research.
(e) The effectiveness of treating pond water through slow sand and diatomaceous earth filters is being determined.

(3490) INVESTIGATION OF FLOW CHARACTERISTICS IN DRAIN TILE AND THE RELATIONSHIP OF THESE FLOW CHARACTERISTICS TO SEDIMENTATION.

(b) Laboratory project.
(c) Professor E. J. Monke, Agricultural Engineering Department, Purdue University, Lafayette,Indiana.
(d) Laboratory investigation; basic and applied research.
(e) Flow of water through a transparent drain will be observed to note the effects of flow velocity on sediment deposition and sediment movement into the drain. The change in the velocity of flow and the corresponding surface curve near an outlet with high roughness is being studied at the present time.

PURDUE UNIVERSITY, School of Civil Engineering, Hydraulic Laboratory.

(2839) HYDRAULICS OF RIVER FLOW UNDER ARCH BRIDGES.

(b) State Highway Department of Indiana and Bureau of Public Roads.
(c) Dr. J. W. Delleur, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., lafayette, Indiana.
(d) Experimental; for design, for master's theses.
(e) The purpose of the research is to study systematically the hydraulic efficiency of waterways under arch bridges, to provide a criterion for determining the proper clear span of arch bridges so as to compensate for the loss of efficiency at high flows, and to provide a method for computing the backwater upstream of arch bridges.
(g) Preliminary testing of small scale models in a 6 inch wide 12 feet long tilting flume included semi-circular sharp edged constrictions and semi-circular arch bridge models with three different contraction ratios in smooth and rough channels. The backwater ratio and the discharge coefficient were plotted in terms of the Froude Number and the contraction ratio. Larger scale testing is in progress in a tilting flume 5 feet wide and 64 feet long. Tests of the semi-circular sharp edged constriction in a smooth channel have been completed in the large flume.
(h) "Hydraulics of River Flow Under Arch Bridges, A Progress Report," H. J. Owen, A. Sooky, S. T. Husain and J. W. Delleur. Proceedings of the 45th Annual Road School, Engineering Extension Department, - Extension Series No. 100, Purdue University, p. 100-112, March 30 - April 12, 1959.

(2840) MECHANISM OF TURBULENCE IN FREE SURFACE FLOW.

(b) Purdue Research Foundation and National Science Foundation.
(c) Dr. J. W. Delleur, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
(d) Theoretical and experimental; for Ph. D. theses.
(e) Analytical and experimental investigation of the mechanism of turbulence in free surface flow. The analytical part of the project will investigate important flow characteristics such as the spectrum of turbulence, correlation of velocities in the turbulent field, degree of isotropy, and the various velocity functions. The experimental portion of the program will make tests coincident with theoretical studies.
(g) Precision test flume designed. The flume has variable longitudinal slope and changeable cross section. The cross section may be triangular, rectangular or trapezoidal with different widths and side slopes. A hot wire anemometer is being designed.
(h) "Secondary Flow in Straight Open Channels," by J. W. Delleur and D. S. McManus, Proceedings, Sixth Midwestern Conference on Fluid Mechanics, The University of Texas, P. 81-97, September 9-11, 1959.

(2841) STUDY OF RUNOFF FROM SMALL WATERSHEDS FOR HIGHWAY DRAINAGE DESIGN IN INDIANA.

(b) State Highway Department of Indiana.
(c) Dr. J. W. Delleur, Hydraulic Laboratory, School of Civil Engineering, Purdue Univ., Lafayette, Indiana.
(d) Analysis and field investigations, for Ph. D. thesis.
(e) The purpose of the research is to study the hydrology of watersheds less than one hundred square miles throughout the State of Indiana to improve the existing methods for estimating the runoff from small watersheds, and to improve the present methods of design of highway drainage structures servicing small watersheds.
(g) Runoff and rainfall data have been collected, and analyzed.

(3146) HYDROMECHANICS OF FLUID COLLECTOR SYSTEM IN POROUS MEDIA.

(b) Purdue Research Foundation.
(c) Dr. J. W. Delleur, Hydraulic Laboratory, School of Civil Engineering, Purdue University, Lafayette, Indiana.
(d) Theoretical, and experimental, for Ph. D. thesis.
(e) Analytical and experimental investigation of the hydrodynamics of flow patterns around horizontal fluid collector systems in porous media. Theoretical investigation will include two- and three-dimensional analyses. Theoretical considerations will be based on existing data and concepts drawn from investigation with electrical analog. The analog instrument is designed to indicate equipotential curves for various water table and permeability conditions.
(f) Active.
(g) Extensive European literature is being compiled. A hydraulic model has been built to measure the discharge distribution along the collector pipe. Measurements are made at different initial water depths, drawdowns and number of collectors. A direct current analog indicates the flow patterns with various boundary conditions for the two-dimensional counterpart of the problem.
(h) "Ground Water Seminar," by J.W. Delleur, Hydromechanic Report No. 10, Hydraulic Laboratory, School of Civil Engineering, Purdue University, 160 pages, Spring 1959. "Model Study of Horizontal Collector Wells," J. W. Delleur and A. L. Simon, Hydromechanic Report No. 11, Hydraulic Laboratory, School of Civil Engineering, Purdue University, 12 pages, August 1959.

(3147) GEOHYDRAULICS.

(b) Laboratory project.
(c) Messrs. J. W. Delleur and A. L. Simon, Hydraulic Laboratory, School of Civil Engineering, Purdue University, Lafayette, Indiana.
(d) Theoretical; basic research.
(e) Geohydraulic theory is being developed as a science based on Fluid Mechanics and Hydrogeology. Quantitative analyses are developed. A bibliography includes principal works of European scientists and others.
(h) "An Investigation of Seepage," J. Juhasz, translated from Hungarian by A. L. Simon, Hydromechanic Report No. 4, Hydraulic Laboratory, School of Civil Engineering, Purdue University, Spring 1959.

(3491) NUMERICAL METHODS IN ANALYSIS OF HYDROMECHANICS PROBLEM.

(b) Engineering Experiment Station, Purdue University.
(c) Dr. G. H. Toebes, Hydraulic Laboratory, School of Civil Engineering, Purdue University, Lafayette, Indiana.
(d) Analytical and applied research for Ph.D. thesis.
(e) The purpose of the research is to make available to the hydraulic engineers the mathematical tools which are normally beyond his competence. The techniques of solving numerically a wide variety of hydromechanics and hydraulic engineering problems will be explored. The emphasis will be on methods making use of electric desk calculators, digital and analog computers.

(3492) TRANSIENT FLOW OF GROUND WATER WITH FREE SURFACE THROUGH INCLINED LAYERED SYSTEM.

(c) Dr. M. E. Harr, School of Civil Engineering, Department of Soil Mechanics, Purdue University, Lafayette, Indiana.
(d) Theoretical for Ph. D. thesis.
(e) The study is aimed at the development of a rational treatment of the "rapid drawdown" condition for the analysis of sloping core type earth and rockfill dams.
(f) Preliminary stage.

(3493) SEEPAGE INTO SHEETED EXCAVATION.

(c) Dr. M. E. Harr, School of Civil Engineering, Department of Soil Mechanics, Purdue University, Lafayette, Indiana.
(d) Theoretical.
(e) The closed form solution of the problem for the factor of safety with respect to heaving of the base of sheeted excavation and the quantity of seepage. A nomographic chart for solution of the equations reduces the results into a form directly applicable for design.
(h) Report to be submitted for publication.

PURDUE UNIVERSITY, School of Electrical Engineering.

(3494) AN INVESTIGATION OF THE FEASIBILITY OF A MAGNETICALLY CONTROLLED POPPET VALVE HYDRAULIC SERVOMECHANISM.

(b) Laboratory project.
(c) Dr. J. E. Gibson, School of Electrical Engineering, Purdue University, Lafayette, Indiana.
(d) Experimental and theoretical research for master's thesis.
(e) This project includes the design, analysis,

and experimental testing of a method of controlling a hydraulic-mechanical energy converter by means of a time-varying oil pressure source and two electro-magnetically controlled poppet valves.

PURDUE UNIVERSITY, Jet Propulsion Center.

(2374) THE MECHANISM OF TWO PHASE FLOW OF ANNULAR LIQUID FILMS IN A VERTICAL TUBE.

(b) Office of Naval Research, Dept of the Navy.
(c) Dr. M. J. Zucrow, Jet Propulsion Center, Purdue Univ., West Lafayette, Indiana.
(d) Experimental and theoretical; basic research for doctoral theses.
(e) This problem is concerned with the analytical and experimental study of the mechanism of the downward flow of a liquid film on the inside wall of a vertical circular tube with co-current gas flow in the core of the tube. Systematic experiments were conducted for determining the effect of the rates of air and water upon the mean thickness of the liquid film and the pressure gradient in the gas stream.
(g) A detailed statistical investigation of the relationship between the amplitude of the interfacial waves and their respective frequencies as a function of the rates of flow of the two fluid media was conducted. The amplitudes and frequencies of the interfacial waves were related by definite spectra and those spectra characterized the structure of the interfacial surface. The interfacial structure was found to influence the flow of the gas in a manner similar to that of the roughness of the wall of a pipe.
(h) "A Review of the Published Literature Pertaining to the Annular, Two-Phase Flow of a Liquid and a Gaseous Medium in a Pipe," D.A. Charvonia, Jet Propulsion Center, Purdue Univ., Nov. 1958, Report No. TM-58-1. "A Study of the Mean Thickness of the Liquid Film and the Characteristics of the Interfacial Surface in Annular, Two-Phase Flow in a Vertical Pipe," D. A. Charvonia, Jet Propulsion Center, Purdue Univ., May 1959, Report I-59-1.

PURDUE UNIVERSITY, School of Mechanical Engineering.

(3495) CONTROL OF TURBULENCE BY MEANS OF SCREENS.

(b) Laboratory project.
(c) Dr. J.B. Jones, Prof. of Mechanical Engrg., Purdue University, Lafayette, Indiana.
(d) Experimental basic research for master's thesis.
(e) The purpose of this investigation is to gain knowledge on the effect of screens on turbulence intensity in incompressible flow with various levels of turbulence intensity at the screen inlets. This study is preliminary to a broader investigation which will require means of controlling turbulence intensity in a flow channel.

ROCKY MOUNTAIN HYDRAULIC LABORATORY.

(2140) EVALUATION OF OPEN-CHANNEL FRICTION LOSSES.

(b) National Science Foundation, Water Resources Division of the U.S. Geological Survey, and the State University of Iowa cooperating.
(c) Prof. C.J. Posey, Allenspark, Colorado (summer), State Univ. of Iowa, Engineering Building, Iowa City, Iowa (winter).
(d) Experimental; basic.
(e) Variable-slope flume long enough to permit accurate evaluation of open-channel friction losses is being tested at slopes into the steep range, determining normal depth and velocity distribution for batten and rolled natural-type roughnesses in triangular and trapezoidal cross-sections.
(f) Active experimentation during summers.
(h) "Resistance Experiments in a Triangular Channel," Ralph W. Powell and Chesley J. Posey, Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, Paper 2018, May 1959.

(3496) TESTS OF RIPRAP SCOUR PROTECTION.

(b) Standard Oil Company of Texas.
(c) Prof. C.J. Posey, Allenspark, Colorado (summer), State Univ. of Iowa, Engineering Building, Iowa City, Iowa (winter).
(d) Experimental; design development.
(e) To find economical design of riprap to protect off-shore drilling structure from underscour.
(f) Completed.
(h) "Model Tests of Riprap Scour Protection," Nelson L. de Sousa Pinto, Jack H. Sybert, and Chesley J. Posey, Rocky Mountain Hydraulic Laboratory, 1959.

ST. ANTHONY FALLS HYDRAULIC LABORATORY, UNIVERSITY OF MINNESOTA.

Inquiries concerning Projects Nos. 2143, 2144, 2603, 2604, 2606, 2610, 3152, 3153, 3155, 3156, 3158, 3159, 3160, 3161, 3164, 3165, and 3497 to 3504, incl., should be addressed to Dr. Lorenz G. Straub, Director, St. Anthony Falls Hydraulic Laboratory, Mississippi River at Third Avenue, S.E., Minneapolis 14, Minnesota.

Inquiries concerning Projects Nos. 111, 1168, 1929, 2386, and 2860, which are conducted in cooperation with the Agricultural Research Service, should be addressed to Mr. Fred W. Blaisdell, Project Supervisor, Watershed Technology Research Branch, Soil and Water Conservation Research Division, Agricultural Research Service, St. Anthony Falls Hydraulic Laboratory, Minneapolis 14, Minnesota.

Inquiries concerning Project No. 194, which is conducted in cooperation with the Corps of Engineers and the U.S. Geological Survey, should be addressed to Engineer in Charge, Byrnon Colby, Federal Inter-Agency Sedimentation Project, St. Anthony Falls Hydraulic Laboratory, Mississippi River at Third Avenue, Minneapolis 14, Minnesota.

(111) CLOSED CONDUIT SPILLWAY.

(b) Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Minnesota Agricultural Experiment Station and the St. Anthony Falls Hydraulic Lab.
(d) Experimental; generalized applied research for development and design.
(e) Tests have been made on three different sizes of Lucite pipe set on slopes ranging from 2.5% to 30% to verify the similarity relationships. Information on discharges, pressures, and flow conditions has been obtained. The study of the characteristics, performance, losses and pressures in the hood drop inlet has been temporarily suspended. Current work is on a two-sided drop inlet of variable length having a flat plate anti-vortex device. The characteristics, performance, losses and pressures in the drop inlet and on the anti-vortex plate are determined for various heights and overhangs of the anti-vortex plates. Water is used to determine the performance and characteristics during flows of water-air mixtures. Air is to be used to determine the loss and pressure coefficients for full flow.
(g) Theory has been developed, verified, and published. Generalized methods for analysis and reporting results have been developed. Pipe culverts laid on steep slopes will flow completely full even though the outlet discharges freely. A conduit on either steep or flat slopes will flow full if the hood inlet is used, the hood being formed by cutting the pipe so that the crown projects beyond the invert by 3/4 of a pipe diameter. Minimum circular and square drop inlet sizes and heights have been determined for a conduit slope of 20%. Entrance loss coefficients vary with drop inlet size and height. Hood drop inlets with the conduit on a 20% slope perform satisfactorily for any height of drop inlet if the circular or square drop inlet is sufficiently large.

(1168) A STUDY OF CANTILEVERED OUTLETS.

(b) Agricultural Research Service, U.S. Dept. of Agriculture, in cooperation with the Minnesota Agricultural Experiment Station and the St. Anthony Falls Hydraulic Lab.
(d) Experimental; generalized applied research for design.
(e) Pipe outlet conduits for small spillways are frequently cantilevered beyond the toe of the earth dam. Attempts will be made to determine quantitatively the size of the scour hole to be expected under various field conditions.
(f) Suspended.

(1929) DRAIN TILE JUNCTION LOSSES.

(b) Minnesota Agricultural Experiment Station in cooperation with the Agricultural Research Service, U.S. Dept. of Agriculture and the St. Anthony Falls Hydraulic Lab.
(c) Prof. Philip W. Manson, Univ. of Minn., St. Paul Campus, St. Paul, Minn.
(d) Experimental; generalized applied research for design.
(e) The junction losses in drain tile flowing full are determined for laterals of different sizes entering mains of different sizes at various angles. The laterals enter the main at the center line. Additional tests have been made with the crowns (or inverts) of both main and lateral in the same plane.
(g) Tests have been completed on sharp edge junctions entering the main at angles varying in 15 degree increments from 15 degrees to 165 degrees. Both the lateral and the main are completely full. The tests cover all possible combinations of discharge in the lateral and the main. Laterals having areas 1/1, 1/2, 1/4, 1/7 and 1/16 that of the main have been tested. The data are being analyzed and a comprehensive report is in preparation. A sound color motion picture film entitled "Energy Losses at Converging Pipe Junctions," has been completed and is available. The 16 mm film is 800 feet long.

(2143) EXPERIMENTAL STUDIES OF SURFACE WAVE ABSORPTION.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental; basic research.
(e) Procurement of experimental data on performance and power requirements of pneumatic and hydraulic breakwaters.
(f) Completed.
(g) A comparison of data obtained for the two systems indicates that attenuations approaching 100 percent can be obtained with the hydraulic breakwater as compared to maximums of 60 to 80 percent for the pneumatic breakwater. For attenuations on the order of 60 percent and waves with length-to-depth ratios less than 2 the pneumatic system requires less power than the hydraulic. Both systems require considerable power which may make them uneconomical except for some military or other temporary installations.
(h) "Experimental Studies of Pneumatic and Hydraulic Breakwaters," by Lorenz G. Straub, C.E. Bowers, and Zal S. Tarapore, St. Anthony Falls Hydraulic Laboratory Technical Paper No. 25, Series B, Aug. 1959.

(2144) EXPERIMENTAL AND ANALYTICAL STUDIES OF HYDROFOILS.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental and analytical; basic research.
(e) Investigation of the quantity of air required to create and sustain an inflated cavity on a submerged hydrofoil of finite span.
(g) Experimental investigations utilizing Tulin-Burkart supercavitating sections submerged below a horizontal free-surface have indicated that by introducing air to the foil a small cavitation number can be obtained at relatively low velocities. For small air flows supplied to the cavity, the resulting cavitation number is roughly proportional to the air flow. A reentrant jet was observed for these conditions. As the air flow was increased, the reentrant jet disappeared and the cavity appeared to

vibrate. From this point, an increase in air flow resulted in very little reduction of the cavitation number. The actual mechanism by which air leaves the cavity is being investigated. Lift force measurements made for these sections extrapolated to zero cavitation number agree satisfactorily with theory.

(2386) GENERALIZED DESIGN OF TRANSITIONS FOR SUPERCRITICAL VELOCITIES.

(b) Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Minn. Agricultural Experiment Station and the St. Anthony Falls Hydraulic Laboratory.
(d) Experimental; generalized applied research for development and design.
(e) Studies will be made to develop a transition and to determine the rules for its design. The transition will be used to change the flow cross section from circular to rectangular when the velocities are supercritical.
(f) Suspended.

(2603) WATER TUNNEL AIR CONTENT STUDIES.

(b) David Taylor Model Basin, Dept. of the Navy.
(d) Experimental and analytical.
(e) Development and evaluation of methods and measures for controlled maintenance of small air bubbles (cavitation nuclei) in tunnel water. Influence of air content control on cavitation inception and acoustic noise was sought.
(f) Completed.
(g) Program developed instrumentation for measuring volume and size and number of free gas nuclei in the tunnel water. The influence of these nuclei on cavitation inception and acoustic noise was evaluated.
(h) "A Study of the Influence of Gas Nuclei on Scale Effects and Acoustic Noise for Incipient Cavitation in a Water Tunnel," John F. Ripken and John M. Killen, St. Anthony Falls Hydraulic Laboratory Technical Paper No. 27, Series B, September 1959.

(2604) FULL-SCALE TEST OF CONCRETE PIPE.

(b) State Road Department of Florida and Bureau of Public Roads.
(d) Experimental; applied.
(e) Procure experimental data on friction coefficient for 24-inch and 36-inch concrete pipe with (1) joints similar to field conditions and (2) smooth joints. Tests were performed on both machine tamped and cast and vibrated pipe.
(f) Completed.
(g) Results indicate that 36-inch tamped pipe with joints similar to field installations had Darcy f value of about 0.0157 (n = 0.011); with smooth joints f was about 0.0152 (n = 0.0108). In tests of 36-inch pipe f varied as a function of Reynolds number for both "field" and smooth joints; resulting curves were approximately parallel to smooth-pipe curve. Field joints produced f value about 3 percent higher than smooth joints.
(h) "Hydraulic Tests of Large Concrete Pipe," Lorenz G. Straub, C.E. Bowers, and Meir Pilch, St. Anthony Falls Hydraulic Laboratory Technical Paper No. 22, Series B, 1959

(2606) PRIEST RAPIDS MODEL STUDIES.

(b) Public Utility District of Grant County, Ephrata, Washington.
(d) Experimental; design and operation.
(e) A 1:120 scale model of the Priest Rapids Development Project on the Columbia River is reproduced to a study the hydraulic design of the spillway, powerhouse and fish facilities.
(f) Completed.
(g) Report in progress.

(2610) LABORATORY WAVE PROFILE RECORDER.

(b) David Taylor Model Basin, Department of the Navy.
(d) Experimental; applied.
(e) Study of sonic-ranging type profile recorder for specialized laboratory use.
(f) Completed.
(g) An instrument was developed which will measure the height of water surface waves in terms of a changing electrical voltage. This voltage output may be readily applied to many commercially available recorders to give a written record of wave height. Measurement is based on the sonic ranging principle in air. Range of application is arbitrarily limited to wave heights of 2 inch to 24 inch and wave steepness of 1:15. This gives a maximum error of approximately $\pm$ 3 percent at the midpoint of the wave for the lowest wave height. Error at the crest and trough are under 1 percent for all conditions. The equipment was tested at velocities up to 20 ft per second with no loss of accuracy. A small phase shift occurs due to the filtering of the measuring samples and the relative motion of the carriage. All errors can be reduced to a small value by a simple geometric correction if conditions warrant greater accuracy.
(h) "The Sonic Surface-Wave Transducer," by John M. Killen, St. Anthony Falls Hydraulic Laboratory Technical Paper No. 23, Series B, July 1959.

(2860) CALIBRATION OF MEASURING WEIRS.

(b) Agricultural Research Service, U. S. Dept. of Agriculture, in cooperation with the Minnesota Agricultural Experiment Station and the St. Anthony Falls Hydraulic Lab.
(d) Experimental; determination of rating curves.
(e) A portion of the stream and the weir used to measure the flow in certain steep streams of Northern Vermont were modeled to experimentally design and calibrate the installations.
(f) Suspended.
(g) Discharge rating curves were measured for various degrees of channel roughness to assist in the development of a prototype rating curve defined by a limited number of current meter measurements. Model

studies led to the abandonment of one site due to the physical characteristics of the river channel.

(3152) KARADJ REREGULATING SPILLWAY MODEL STUDIES.

(b) Harza Engineering Company, Chicago; Government of Iran.
(d) Experimental; design and operation.
(e) A 1:60 scale model of Karadj Reregulating Dam and Spillway to study the operation of the spillway. A 1:180 pilot model and a 1:78 scale section model were also used.
(f) Tests completed.
(g) Recommendation of a deeply submerged flip bucket to replace ski jump design proposed.

(3153) FLOW ABOUT BODIES AT SMALL CAVITATION NUMBERS.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental and analytical; basic research.
(e) Current interest is in ventilated cavities. Using the two-dimensional, free-jet water tunnel, air is supplied to the wakes of two-dimensional and half-span, lifting and non-lifting bodies. The relation between rate of air supply, cavitation number, and other cavity properties is under study.
(g) Numerical results for the rate of air supply to obtain a given cavitation number have been determined. An instability has been found to occur in ventilated cavities when the cavitation number is reduced too far by adding air.
(h) "Experimental Studies of Supercavitating Flow About Simple Two-Dimensional Bodies in a Jet," Edward Silberman, St. Anthony Falls Hydraulic Laboratory Technical Paper 19, Series A, 1959. (Reprint of article in Journal of Fluid Mechanics, Volume 5, Part 3, pp. 337-354, 1959).
"The St. Anthony Falls Hydraulic Laboratory Gravity-Flow Free-Jet Water Tunnel," by Edward Silberman and John F. Ripken, St. Anthony Falls Hydraulic Laboratory Tech. Paper No. 24, Series B, August 1959.
"Instability of Ventilated Cavities," by Edward Silberman and C.S. Song, St. Anthony Falls Hydraulic Laboratory Technical Paper No. 29, Series B, Nov. 1959. (Will be published in a technical periodical.)

(3155) FLUID JETS.

(b) David Taylor Model Basin, Dept. of the Navy.
(d) Experimental and analytical; basic research.
(e) This project involves study of the dispersion of a jet discharged into a stream of moving fluid, the angle between the jet and the fluid being a right angle or other angle and the jet and stream being of the same or different fluids. The associated loss of energy and diffusion of momentum are also of interest.
(f) Completed.
(g) Results of previous experimental and theoretical studies pertinent to air jets in air were found to be valid for water jets into water. Air-water mixture jets discharged into water were also similar to the others if the velocity of the jet through the orifice was taken as the water velocity through the orifice obtained by subtracting the area occupied by air from the orifice area. The project was terminated without investigating jets of immiscible fluids.
(h) "Studies on Fluid Jets Discharging Normally Into Moving Liquid," by Robert L. Gordier, St. Anthony Falls Hydraulic Laboratory Technical Paper No. 28, Series B, August 1959.

(3156) WANAPUM SPILLWAY STUDIES.

(b) Harza Engineering Company, Chicago; Public Utility District of Grant County, Ephrata, Washington.
(d) Experimental; design and operation.
(e) A 1:144 scale partial comprehensive model for Wanapum Power Project on Columbia River to arrive at optimum alinement of the earth fill dam and optimum exterior geometry for the fish passing facilities.

(3158) FLOATING BREAKWATERS.

(b) U. S. Naval Civil Engineering, Dept. of the Navy, Eleventh Naval District.
(d) Experimental and analytical.
(e) Primarily a study whose objective is to develop new ideas for floating type devices intended to attenuate ocean type incident waves.
(g) Preliminary tests indicate that immersed bags of suitable form and position can effectively attenuate waves. The character of the fluid filling the bag has a significant effect on the attenuation.
(h) "An Exploratory Investigation of Mobile Breakwaters," H.D. Frederiksen and J. M. Wetzel, St. Anthony Falls Hydraulic Lab. Project Report No. 60, September 1959.

(3159) HYDRAULIC STUDIES OF BAIE COMEAU PAPER MACHINE.

(b) The Ontario Paper Company, Ltd., Thorold, Ontario, Canada.
(d) Experimental; for design.
(e) To study flow patterns resulting from combination cascaded miter bends and vaned dividers.
(f) Suspended.
(g) Measurements indicate that the quality of flow at the system outlet was very similar for both the vaned miter bends and for the long radius elbows originally installed. Just downstream of the turns, however, the flow patterns were characteristic of the turning devices.

(3160) MISSION DAM SPILLWAY MODEL STUDIES.

(b) British Columbia Engineering Company, Vancouver, B.C., Canada.
(d) Experimental; design and operation.
(e) A 1:80 scale comprehensive model of the flip bucket spillway for the Mission Dam on the Bridge River in British Columbia to study the operation of the spillway.
(f) Tests completed.
(g) Recommendation of a non-symmetrical flip

bucket deflector giving a high degree of dispersion.

(3161) HYDRAULICS OF SEWER DROPSHAFTS.

(b) City of St. Paul, Minnesota.
(d) Experimental; applied.
(e) Investigate relative merits of sewer drop structures for discharges up to 1000 cfs and drops up to about 100 feet.
(f) Test work completed.
(g) Impact type energy dissipator developed to stabilize flow and eliminate air from lower interceptor line. Report in progress.

(3164) SCOUR AROUND BRIDGE PIERS.

(b) Laboratory project.
(d) Experimental and analytical; Ph. D. thesis.
(e) Prediction and measurement of ultimate depths of scour around known shape and size of pier.

(3165) CHARACTERISTICS OF TURBULENT FLOW THROUGH A RECTANGULAR-BAR BAFFLE.

(b) Laboratory project.
(d) Experimental and analytical; master's thesis.
(e) To determine the relationships between the headloss caused by a bar-baffle and the Reynold's number, solidarity and the bar depth.
(f) Completed.
(h) "Characteristics of Turbulent Flow Through a Rectangular-Bar-Baffle," by John F. Orsborn, master's thesis, 1959, on file at the University of Minnesota Library.

(3497) WANAPUM FISH FACILITIES STUDIES.

(b) Harza Engineering Company, Chicago; Public Utility District of Grant County, Ephrata, Washington.
(d) Experimental; design and operation.
(e) Two 1:36 scale models of right bank attraction water flow system and orifice and weir fish entrances for design verification and comparison of effectiveness of orifice versus weir entrances.

(3498) EXPERIMENTAL STUDY OF DECAY OF DISCHARGE VORTICES.

(b) Laboratory project.
(d) Experimental; master's thesis.
(e) To study the effect of initial circulation on the formation of a vortex over the vertical discharge outlet in the bottom of a circular tank. The outlet valve was opened after various decay times and the head at which a vortex formed was measured. Various outlet sizes were investigated.
(f) Completed.
(g) The results showed that the head at which a vortex formed depended upon the strength of the circulation. Given a sufficiently long decay time no vortex would form. The results agree with Lamb's analysis of the decay of a vortex.
(h) "Experimental Study of Decay of Discharge Vortices," by Bangalore M. Rajasekhara, master's thesis, 1959, on file at the Univ. of Minnesota Library.

(3499) STUDIES OF HYDROFOIL CONFIGURATIONS IN REGULAR WAVES.

(b) David Taylor Model Basin, Dept. of the Navy.
(d) Experimental.
(e) Experimental investigation of the longitudinal stability (heave and pitch) of a tandem "V" foil hydrofoil configuration for regular head and following seas to verify existing non-linear theory.
(g) Satisfactory agreement has been obtained between experimental heave and pitch responses of a tandem "V" foil configuration and solutions of non-linear differential equations developed by Ogilvie for head and following seas and craft velocities of 5 and 10 fps. For small wave amplitudes, the linearized equations adequately describe the heave and pitch responses. The solutions to the non-linear equations indicate a steady-downward heave component that tends to cause the craft to crash, particularly in following seas. This component has been observed experimentally, although the actual magnitude has not been satisfactorily determined.

(3500) LITTLE NERANG DRUM GATE MODEL STUDIES.

(b) Harza Engineering Company, Chicago; Tulloch, Ltd., Rhodes, New South Wales, Australia; Town of South Coast, Queensland, Australia.
(d) Experimental; design and operation.
(e) A 1:25 scale section model to obtain the hydraulic characteristics of the drum type gates.
(f) Completed.
(g) Discharge coefficients, nappe profiles and piezometric pressures were recorded for a wide range of flow conditions. A ten minute sound movie on the study was made.

(3501) PEARL RIVER RESERVOIR SPILLWAY STUDIES.

(b) Harza Engineering Company, Chicago; Horace B. Lester, Engineer, Jackson, Mississippi; Pearl River Valley Water Supply District.
(d) Experimental; design and operation.
(e) A 1:60 spillway section model to arrive at optimum design of the 10 gate low head spillway. A 1:72 comprehensive model to study the overall hydraulics of the spillway.

(3502) MANGLA SPILLWAY STUDIES.

(b) Harza Engineering Company, Chicago; Binnie, Deacon, and Gourley, London; Government of Pakistan.
(d) Experimental; design and operation.
(e) Two 1:300 scale models of Mangla spillway for comparison between a ski jump and stilling basin energy dissipator. A comprehensive study of all important hydraulic features. Typical dimensions of earth fill dam spillway include a drop in water level of 330 feet and a design of flow of 1,126,000 cfs.
(f) Active.

(3503) ARKANSAS RIVER DEVELOPMENT SEDIMENT STUDIES.

(b) U.S. Army Engineering District, Little Rock.
(d) Experimental; design.
(e) To investigate the feasibility of constructing an armor layer on the bed of a stream to stabilize the bed and prevent degradation.
(g) Preliminary results suggest that the armor material will stabilize the bed under certain conditions.

(3504) EXPERIMENTAL DETERMINATION OF UNSTEADY LIFT AND DRAG FORCES ON DIHEDRAL HYDROFOILS IN WAVES.

(b) David Taylor Model Basin, Dept. of the Navy.
(d) Experimental, basic research.
(e) General investigation of the forces on dihedral, surface-piercing hydrofoils in regular waves. This includes a study of the forces on a hydrofoil placed in the wake of another, as would be the case in a tandem configuration.

INTER-AGENCY SEDIMENTATION PROJECT IN COOPERATION WITH ST. ANTHONY FALLS HYDRAULIC LABORATORY.

(194) A STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS.

(b) Subcommittee on Sedimentation, Inter-Agency Committee on Water Resources. Personnel of the U.S. Army Corps of Engineers and U.S. Geological Survey are actively engaged on the project.
(c) Engineer in Charge, Byrnon C. Colby, Federal Inter-Agency Sedimentation Project, St. Anthony Falls Hydraulic Laboratory, Mississippi River at Third Avenue S.E., Minneapolis 14, Minnesota.
(d) Experimental; applied research and development.
(e) Plans and specifications to facilitate the manufacture of suspended-sediment and bed-material samplers, particle-size analyzers and associated laboratory apparatus have been prepared. Approved designs of suspended-sediment samplers include a 4-pound hand sampler, a single-stage sampler, a hand line and a medium weight sampler weighing 22 and 62 pounds, respectively, and heavy samplers weighing 100 and 300 pounds. Bed-material samplers include a hand-operated sampler, 25- and 50-pound hand line samplers, and a 100-pound sampler for cable suspension. Other available instruments include a sediment sample splitter, a bottom withdrawal tube, and a particle-size analyzing apparatus using visual-accumulation tubes for sand samples. The primary objective of the current program is the development of an automatic recording instrument for suspended sediment concentrations in flowing streams.
(g) Tests on the single-stage suspended-sediment sampler developed for flashy and intermittent streams have been completed and a report is being prepared. Prototype tests on the intermittent pumping and settling type sampler at a field station were continued. Tests on experimental apparatus for sensing suspended sediment concentrations by means of differential pressures within the suspension medium have been temporarily halted and a report is being written. Preliminary tests are in progress on a commercial turbidimeter having a continuous recording unit. Periodic field tests were conducted on a nuclear sediment density probe and scaler unit.
(h) "Preliminary Report on Recommended Types of Automatic Single-Stage Samplers," 7 pages, October 1958.
"Operation and Maintenance of US P-46 Suspended-Sediment Sampler," Report I, a revision, 68 pages, 1958.
"Operating Instructions for US DH-48 Suspended-Sediment Hand Sampler," Report J, 5 pages, November 1958.
"Operator's Manual on the Visual-Accumulation Tube Method for Sedimentation Analysis of Sands," Report K, a revision, 29 pages, October 1958.
"Operation and Maintenance of US BM-54 Bed-Material Sampler," Report M, 17 pages, November 1958.
"Federal Inter-Agency Sedimentation Instruments and Reports," Report AA, 38 pages, May 1959.

SCRIPPS INSTITUTION OF OCEANOGRAPHY, University of California.

(3505) DIRECTIONAL SPECTRUM OF OCEAN WAVES.

(b) Office of Naval Research, Dept. of the Navy.
(c) Dr. Walter H. Munk, Prof. of Geophysics, Univ. of California, La Jolla, California.
(d) Theoretical and field investigation; basic research.
(e) A tri-partite directional array of bottom-mounted (300 ft) absolute pressure recorders has been installed off the west coast of San Clemente Island. The frequency-modulated signals from these recorders are telemetered to La Jolla, and the data are analyzed by digital methods. The analysis is aimed at determining the directional energy distribution per unit frequency band in the frequency spectrum from 0.1 - 0.02 cycles per second.
(g) Data accumulated over past six months now nearing completion of analysis. Preliminary results indicate that remote individual storms can be tracked for several days. The incoming energy is confined within a fairly narrow beam and shifts in frequency from day to day.

(3506) IMPULSIVELY GENERATED WAVES.

(b) Office of Naval Research, Department of the Navy.
(c) Dr. Wm. G. Van Dorn, Senior Engineer, the Scripps Institution of Oceanography, La Jolla, California.
(d) Theoretical and field investigations; basic research.
(e) This project is a four-year continuing study of the mechanisms of generation, propagation, and coastal effects of

long-period water surface waves generated by impulsive disturbances; such as, earthquakes on the sea floor and large nuclear explosions. Observations of long-period waves were conducted more or less continuously with special recording equipment from small Pacific Islands.

(f) Completed.

(g) The nature of such waves and their subsequent behavior was found to be quite different than that predicted by classical theory. An empirical model was derived which predicts the local effects from long waves on an arbitrary coastline, given the intensity and location of the source disturbance.

(h) "The Local Effects from Impulsively Generated Waves," Wm. G. Van Dorn, Interim Report under contract Nonr 233(35), 80 pp., August 1959, obtainable from the Office of Naval Research, Code 418.

UNIVERSITY OF SOUTH CAROLINA, Civil Engineering Department.

Inquiries concerning the following projects should be addressed to Dr. Harold Flinsch, Head, Civil Engineering Department, University of South Carolina, Columbia, South Carolina.

(4) THE DEVELOPMENT OF SURFACE WAVES BY WIND.

(b) Laboratory project.

(d) General theoretical and experimental research.

(e) Research on the theories of surface wave origin and growth, on measurements in the laboratory and in nature, and on the comparative results of theory and measurement.

(g) Experimental equipment has been developed for the recording of wave height, wave period, and wave direction, and telemetering equipment has been tested for the transmission of measurements from open water to a shore recording station.

(1631) THE EFFECT OF WAVES ON BEACHES.

(b) Laboratory project.

(d) General theoretical and experimental research.

(e) Research on beach slopes and contours, in the laboratory and in nature.

(g) General formulas have been developed, which are now being applied to the Carolina capes and shores.

(1907) SHIP STABILITY AND ROLLING PERIOD.

(b) Laboratory project.

(d) General theoretical and experimental research.

(e) Rolling period and metacentric height relationships are studied, in the laboratory and in nature, for stationary and moving ships, in still water and under wave action.

(g) Model experiments have been assembled in a brief report. Additional data under wave action are being assembled.

STANFORD UNIVERSITY, Department of Civil Engineering.

(1944) STUDY OF METHODS OF ESTIMATING RESERVOIR EVAPORATION.

(b) U.S. Weather Bureau.

(c) Prof. Joseph B. Franzini, Dept. of Civil Engineering, Stanford University, Stanford, California.

(d) Field investigation; applied research.

(e) An attempt is being made to develop a simple, rugged radiation integrator for use in estimating reservoir evaporation.

(f) Three small-scale radiation integrators patterned after Cumming's model have been tested and the data are being analyzed.

(1945) ESTIMATING RAINFALL INTENSITY FROM TOPOGRAPHIC PARAMETERS.

(b) U. S. Bureau of Public Roads.

(c) Prof. Ray K. Linsley, Dept. of Civil Engineering, Stanford Univ., Stanford, Calif.

(d) Statistical analysis; applied research.

(e) Hourly rainfall intensities in Northern California for a two-year period are correlated with various topographic and climatological parameters.

(f) Completed.

(g) A relation having a correlation coefficient of 0.88 and standard error of 0.77 inch per hour was derived. A rainfall intensity map for Northern California was completed.

(h) "Correlation of Rainfall Intensity and Topography in Northern California," by Ray K. Linsley, Trans. Am. Geophysical Union, Vol. 39, No. 1, pp. 15-18, 1958.

(1946) SYNTHESIS OF HYDROGRAPHS FOR SMALL AREAS.

(b) National Science Foundation.

(c) Prof. Ray K. Linsley, Dept. of Civil Engrg., Stanford University, Stanford, California.

(d) Theoretical and field investigation; basic and applied research; Ph. D. thesis.

(e) An attempt to develop a universal method for estimating the runoff hydrographs from small areas.

(f) A simplified theory for non-equilibrium conditions has been compared with experimental results taken under controlled laboratory conditions. A statistical analysis of data from several typical basins has been started. A mathematical analysis of the non-equilibrium flow in a simple channel with lateral inflow has been completed. The later work is being extended to more complex conditions via digital computing methods.

(g) "Unsteady Open Channel Flow with Lateral Inflow," James A. Liggett, Tech. Report No. 2, Dept. of Civil Engineering, Stanford University, July 1959.

(2150) STUDY OF FLOW FROM A SLOTTED PIPE.

(b) Laboratory project.

(c) Prof. John K. Vennard, Dept. of Civil Engineering, Stanford University.

(d) Experimental; engineer thesis.

(e) Extension of manifold port problem to

continuous slot.
(f) Experimental work completed; thesis being written.

(2151) MODEL STUDY OF PETERS DAM CHUTE SPILLWAY.

(b) Laboratory project.
(c) Prof. John K. Vennard, Dept. of Civil Engineering, Stanford University.
(d) Experimental; engineer thesis.
(e) Comparison of spillway performance and design predictions.
(f) Experimental work completed; thesis being written.

(2614) PIPE FRICTION IN UNSTEADY FLOW.

(b) Laboratory project.
(c) Prof. John K. Vennard, Dept. of Civil Engineering, Stanford University.
(d) Experimental and analytical; Ph.D. thesis.
(e) Comparison of friction processes for steady and unsteady states.
(f) Experimental work completed and analyzed; thesis being written.

(2863) FLOW THROUGH POROUS MEDIA.

(b) National Science Foundation.
(c) Prof. Byrne Perry, Dept. of Civil Engineering, Stanford University, Stanford, Calif.
(d) Theoretical and experimental; basic research.
(e) New analytical methods are being developed for unsteady seepage flow with a free surface, e.g., the seepage through an earth dam. The effect of non-rectilinear boundaries is also being considered.
(g) Theoretical work in progress.
(h) "Unsteady-State Phenomena in Flow Through Porous Media," Roger J.M. DeWiest, Tech. Report No. 3, Dept. of Civil Engineering, Stanford Univ., July 1959. (A condensed version will appear in the Journ. of Fluid Mechanics).

(3166) HYDRODYNAMICS OF FLOW INTO CURB INLETS.

(b) U. S. Bureau of Public Roads.
(c) Prof. John K. Vennard and Prof. Byrne Perry, Dept. of Civil Engineering, Stanford University, Stanford, California.
(d) Experimental and analytical; Ph. D. thesis.
(e) Attempt to develop analytical methods for predicting phenomena observed.
(f) Experimental apparatus constructed; measurements and analytical work in progress.

(3507) STUDY OF INFILTRATION.

(b) Graduate research; doctoral thesis.
(c) Prof. Joseph B. Franzini, Dept. of Civil Engineering, Stanford Univ., Stanford, California.
(d) Theoretical investigation; laboratory and field studies.
(e) An attempt will be made to develop analytically relations between soil parameters, precipitation rates and duration, and infiltration capacities. The analytical work will be supplemented by laboratory and field studies.
(f) Project is underway.

(3508) EVAPORATION SUPPRESSION.

(b) U. S. Public Health Service.
(c) Prof. Joseph B. Franzini, Dept. of Civil Engineering, Stanford Univ., Stanford, Calif.
(d) Laboratory and field investigations; engineer thesis.
(e) Project currently consists of: (1) Laboratory studies using Langmuir tray to find the monomolecular film with optimum healing properties. (2) Field studies using Class A evaporation pans and smaller containers to evaluate the evaporation reduction capabilities and biological attrition resistances of the various monomolecular films tested in (1). (3) Development of a practical method for the application of a monomolecular film to the surface of a reservoir. In later stages of the project the effect of a monomolecular film on the biota in a 45 acre lake will be evaluated.
(g) Analysis of preliminary data is complete.

STEVENS INSTITUTE OF TECHNOLOGY, Davidson Laboratory.

(340) HYDROFOILS AND HYDROSKIS.

(b) Office of Naval Research, Department of the Navy.
(c) Mr. Daniel Savitsky, Davidson Laboratory, Stevens Institute of Tech., 711 Hudson Street, Hoboken, New Jersey.
(d) Theoretical and experimental; basic research.
(e) A continuous series of theoretical and experimental studies of the basic hydrodynamic process involved in the operation of surface piercing hydrofoil elements and system primarily as applied to high speed craft such as water based aircraft. In particular force characteristics both steady and impact and dynamic stability are being studied.
(g) Basic studies have been completed on the steady state force and impact characteristics of dihedral surface piercing, supercavitating hydrofoil elements. An analytical parametric study has also been completed of the effect of various geometric and hydrodynamic variables on the longitudinal dynamic stability of tandem surface piercing hydrofoil systems. Similar studies are currently underway on vertical and swift surface piercing hydrofoils.
(h) "A Generalized Theory of the Impact Characteristics of Surface Piercing, Fully Ventilated Dihedral Hydrofoils," Peter Ward Brown, Davidson Laboratory, Report No. 731, July 1959.
"Longitudinal Stability of Surface Piercing Hydrofoil Systems for Water Based Aircraft," Gerard Fridsma, Davidson Lab., Report 732, October 1959.

(2153) EVALUATION BY COMPUTATIONAL METHOD OF THE THRUST DEDUCTION AND WAKE FRACTION OF A

SHIP PROPELLER.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Dr. Stavros Tsakonas, Staff Scientist, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Theoretical; applied research.
(e) The purpose of this investigation is to develop a working computational method on a sound physical basis for the evaluation of the wake fraction and thrust deduction of a ship propeller and to test the validity of the method by carrying out numerical work on a Victory ship. The following two mathematical models have been used: (a) The hull is represented by a discrete sink-source distribution and the propeller action by a cylindrical vortex sheet originating at the propeller disc and extending to infinity aft. (b) The hull form is subdivided by transverse plane into various compartments which are represented by a source or sink, placed at the centroids, of strength proportional to the difference between the cross-sectional areas of the ends of the sections. The propeller action is simulated by a sink disc of strength determined from the momentum theory.
(f) The project is completed and a preliminary report will shortly be submitted to DTMB for approval.
(g) General expressions are developed for the evaluation of the strength of the singularity system representing the hull in the first mathematical model. Expressions for the wake and thrust deduction fraction are also evolved in closed form in terms of complete elliptic integrals. Results of the numerical work applied to a Victory ship are shown to be unrealistic (of very low magnitude). This indicates that the method of representing the hull form by discrete singularities is impractical and inconclusive. Expressions have been developed for the strength of the discrete sink a source and its axial and vertical location for the second mathematical model. The numerical results using this model are physically compatible.

(2154) INVESTIGATION OF SHIP MOTIONS.

(b) Office of Naval Research, Department of the Navy.
(c) Prof. Edward V. Lewis, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Theoretical and experimental; basic research.
(e) The development of a method of calculation for predicting ship motions caused by head or following seas. Towing tank tests of ship forms differing widely from the forms currently used in practice, in search of considerable improvement in seakeeping qualities of ships.
(g) The linearized theory of ship motions in head or following seas was completed and computations were made for eight ship models for comparison with experimental data, with good results. The possibility of a semi-submerged vessel for high-speed operation in waves has been explored, and other unusual hull types are now being studied.
(h) "Possibilities for Reducing Ship Motions at Sea," E. V. Lewis, published in the Journal of the American Society of Naval Engineers, November 1958.
"Preliminary Evaluation of a Semi-Submerged Ship for High-Speed Operation in Rough Seas," E. V. Lewis and C. Odenbrett, Davidson Laboratory Report 736, March 1959.

(2155) SEAKEEPING QUALITIES OF SHIPS AT ALL HEADINGS TO WAVES.

(b) Bureau of Ships, Dept. of the Navy (DTMB Technical Supervision).
(c) Prof. Edward V. Lewis, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Theoretical and experimental; basic research.
(e) To investigate the coupled responses of ship models at all headings to waves in order to assist in the prediction of seakeeping qualities and to evaluate means of reducing or controlling ship motions so as to increase sea speeds. A self-propelled and rudder-controlled ship model is being tested at various headings to both regular and irregular long-crested waves. Coupled motion responses are being measured and parallel analytic studies are being made of equations of motion for ships with six degrees of freedom.
(g) Basic test program has been completed, showing small effects of roll or yaw on pitch and heave. At oblique headings a large leeway angle is sometimes necessary to maintain a desired course.
(h) Report on test results is in progress.

(2156) MOTION AND STABILITY OF HYDROFOIL SYSTEMS.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Dr. M. Martin, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
(d) Theoretical; basic research.
(e) To determine the longitudinal stability characteristics of tandem hydrofoil configurations in waves, including the effects of unsteady forces and moments. The resulting motions of the system and the loadings on the foils can then be determined.
(g) A theoretical analysis of motion in smooth water has been completed. An analysis of the forces and moments in waves has been completed and tests have been made, the results of which compare well with the theory. The results have been incorporated into a study of motions in waves, which has been completed. A study has also been made of the drag of hydrofoils in unsteady motion, together with a study of the surface waves created by oscillating and translating surface pressure distributions. Further studies of motion in waves using unsteady flow theory have been carried out.
(h) "Longitudinal Stability and Motions of a

Tandem Hydrofoil System in a Regular Seaway," Paul Kaplan, Davidson Laboratory Report No. 517, October 1959.
"Theoretical Analysis of Hydrofoil Motion in Waves Using Unsteady Flow Theory," Paul Kaplan, to be submitted to the Journal of Ship Research.

(2387) BENDING MOMENTS OF SHIPS IN WAVES.

(b) Society of Naval Architects and Marine Engineers.
(c) Prof. Edward V. Lewis, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Experimental and analytical; applied research.
(e) Calculation of bending moments in waves, taking into account dynamic effects of ships motions and forward speed, for comparison with experimentally determined bending moments. Prediction of bending moments in irregular waves and comparison with irregular tank wave results. Extension to measurements of model bending moments at a range of headings to long crested regular waves.
(g) Fairly good agreement has been obtained between calculated and observed bending moments in head seas, giving theoretical confirmation of reduction of moments under dynamic conditions of forward speed and pitching and heaving motions. Tests at oblique headings to waves have shown that horizontal bending moment can become large in relation to vertical bending moment while torsional moments are relatively small.
(h) A report on bending moment tests at oblique headings to waves is near completion.

(2390) CONTROLLED FINS FOR REDUCING SHIP PITCHING.

(b) Bureau of Ships, Department of the Navy (DTMB Technical Supervision).
(c) Prof. Edward V. Lewis, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Experimental and analytical; applied research.
(e) To determine the most desirable action of controllable fins at the bow or stern of a ship to reduce pitching in regular and irregular head seas.
(g) Analytical studies indicate that a combination of fixed fins at the bow and oscillating fins at the stern seems most promising in reducing ship pitching motions; model experiments have verified these findings.
(h) A final report is in preparation.

(2391) DETERMINATION OF THE VIBRATORY FORCE GENERATED ON A LARGE FLAT PLATE PARALLEL TO A SHIP PROPELLER.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Dr. J. P. Breslin, Director, Davidson Laboratory , Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
(d) Theoretical; applied research.
(e) The force and moment on a flat plate due to the pulsating field of a nearby propeller are found by a momentum analysis.
(f) Project completed.
(g) Calculations of the vibratory forces and moments on a doubly infinite flat-plate parallel to the axis of a propeller. These show that for a propeller having three blades or more, the force and moment on the plate are zero. A thin elastic plate will, nevertheless, vibrate and a formula to calculate the amplitudes is given.
(h) "A Theory for the Vibratory Effects Produced by a Propeller on a Large Plate," by J. P. Breslin will appear in the January 1960 issue of the Journal of Ship Research.

(2393) MOTIONS AND BENDING MOMENTS OF SHIPS IN WAVES.

(b) Bureau of Ships, Department of the Navy (DTMB Technical Supervision).
(c) Prof. Edward V. Lewis, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Experimental and analytical; applied research.
(e) Measurements of motions and external bending moments and shear of a jointed model of a high-speed naval vessel underway in irregular head waves in a towing tank. Results will be analyzed by cross-spectral techniques to determine frequency response functions.
(g) Pilot studies indicate that when cross-spectral techniques are applied to the analysis of moderate irregular wave data, the resulting frequency response functions show good agreement with response functions obtained from regular wave tests.

(2615) FORCES AND MOMENTS ON SUBMERGED BODIES BELOW WAVES.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Dr. M. Martin, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Experimental and theoretical; basic and applied research.
(e) To measure the forces and moments acting on submerged bodies moving obliquely to the crests of regular waves, and to compare the results with available theory.
(g) Slender-body theory has been applied to determine the forces and moments due to the waves acting on a submerged body while moving under regular waves at various headings relative to the wave crests. The forces have also been found on body-appendage combinations by the same theory. Experiments have been carried out using a long slender, axially-symmetric model with and without a conning tower. The wave length-body length ratio was varied from 0.5 to 2.5. Tests were made at headings of 0° (head seas), 30°, 60°, and 90° (beam seas), speeds of 0, 2, 4, and 6 feet per second. A comparison of theoretical and experimental results is in progress. The data so far analyzed show reasonably good agreement with theory.

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(h) "Virtual Mass and Slender-Body Theory for Bodies in Waves," Paul Kaplan and Pung Hu, published in proceedings of the Midwestern Conference on Fluid and Solid Mechanics, University of Texas, 1959.

(2616) THE BLADE-FREQUENCY FORCE GENERATED ON A BODY OF REVOLUTION BY AN OFFSET PROPELLER.

(b) David Taylor Model Basin, Bureau of Ships, Department of the Navy.
(c) Dr. J. P. Breslin, Director and Dr. A. Winzer, Senior Research Engineer, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
(d) Theoretical, applied research.
(e) Purpose is to evaluate the importance of the pulsating near field of the propeller in generating vibratory forces on ships and to determine the attenuation of this force with tip clearance and number of blades.
(g) Results obtained using approximate cross flow corrections to the body to account for presence of propeller give reasonable values for the vibratory force. Present study seeks to improve the accuracy by using a distribution of time-dependent sources over the surface of the body.

(2617) STUDY OF THE VIBRATORY THRUST PRODUCED BY A SHIP PROPELLER OPERATING IN THE WAKE OF A HULL.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Dr. J. P. Breslin, Director, Davidson Lab., Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
(d) Theoretical; applied research.
(e) Comparison of results of calculations by method given in Experimental Towing Tank Report No. 686 is currently being made with measurements of vibratory thrust taken at DTMB and on a ship at sea (AE21).

(2865) EFFECT OF SPEED AND FULLNESS ON HULL BENDING MOMENTS IN WAVES.

(b) American Bureau of Shipping.
(c) Prof. Edward V. Lewis, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
(d) Experimental; applied research.
(e) To determine to what extent, if any, different longitudinal strength standards should be adopted for ships of different fullness and service speeds. The hull midship bending moments of three models with block coefficients ranging from 0.68 and 0.80 were measured in regular and irregular head and following seas. Work is continuing in oblique waves.
(g) Experimental results show that dynamic midship hull bending moments in regular model length waves vary with fullness at low speeds according to the trend predicted by standard static calculations.
(h) "Effect of Speed and Fullness on Hull Bending Moments in Waves," John F. Dalzell, Davidson Laboratory Report No. 707.

(2866) AN ANALYTIC STUDY OF THE PRESSURE FIELD NEAR COUNTER-ROTATING PROPELLERS.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Dr. J. P. Breslin, Director and Dr. S. Tsakonas, Staff Scientist, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson Street, Hoboken, N. J.
(d) Theoretical; applied research.
(e) In tackling the problem of mitigating the vibratory hydrodynamic forces applied by a marine propeller, the free-space field of a counter-rotating propeller has been studied. The study is divided into two parts. In the first, the effects on both propellers are treated as though they were independent; in the second an approximate treatment of the effect of blade interaction is underway.
(g) Preliminary report in preparation.

(3167) POTENTIAL AND VISCOUS PARTS OF THE THRUST DEDUCTION AND WAKE FRACTION FOR AN ELLIPSOID OF REVOLUTION.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Dr. S. Tsakonas, Staff Scientist and Miss Winnifred R. Jacobs, Senior Research Engineer, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson Street, Hoboken, N.J.
(d) Theoretical, applied research.
(e) The purpose is: (1) Develop a method for the evaluation of the potential and viscous part of wake fraction and thrust deduction for a body of revolution. (2) Exhibit their functional dependence on axial propeller clearance, body slenderness, afterbody geometry and Reynolds number. The potential contribution is obtained by representing the hull by a line source sink distribution and the propeller by a sink disc. The viscous effect is determined by Lighthill's method of equivalent sources distributed on the surface having strength proportional to the displacement thickness and its derivative.
(f) Completed; preliminary report will be submitted shortly to DTMB for approval.
(g) The potential and viscous components of drag augmentation and wake fraction are equally vital contributions. The sensitivity of the viscous thrust deduction and wake fraction to the method of boundary layer evaluation is hardly noticeable. The axial clearance effect is very pronounced in the potential flow case in contrast to the frictional case, which is almost independent on the clearance in the range of practical clearances. The potential next depends very strongly on the slenderness of the body and to the first order upon the slope of the cross-sectional area of the afterbody.

(3168) STUDY OF THREE-DIMENSIONAL SHIP DAMPING.

(b) Society of Naval Architects and Marine Engineers.
(c) Dr. M. Martin, Davidson Laboratory, Stevens

Institute of Technology, 711 Hudson Street, Hoboken, N. J.

(d) Theoretical; basic research.

(e) To evaluate the damping force acting on a local strip of an oscillating ship, including all the three-dimensional flow contributions. The effect of forward speed on the total damping will also be determined.

(g) Study has shown that local force and moment on a submerged oscillating spheroid and a Michell (thin) ship at zero forward speed differ appreciably from that found using two-dimensional flow values, depending upon frequency and location of local observation point. Calculations are continuing for the case of the Michell ship.

(h) "Three-Dimensional Stripwise Damping Coefficients for Heave and Pitch of a Submerged Spheroid," Paul Kaplan and Pung Nien Hu, Experimental Towing Tank Note No. 555, August 1959.

(3169) WAKE FORMS BEHIND HIGH SPEED PLANING SURFACES.

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

(c) Mr. Robert L. Van Dyck, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.

(d) Experimental; basic research.

(e) An experimental study is being conducted in order to determine the surface contours of the wake shapes developed by planing forms associated with high-speed water-based aircraft. This work was undertaken because of the lack of accurate information concerning the wakes of planing forms operated at high speeds, high angles of attack, and heavy loadings. The effects of vee-bottom angle, chine flare, and step shape will be evaluated in addition to the above-mentioned parameters.

(g) Testing was accomplished using small longitudinally-curved models of two-inch beam towed at a thirty-foot radius on a large rotating-arm apparatus. Measurements of the wake cross-sections were made with vertical probes manually adjusted by an observer riding with the model.
Close observation of the flows involved indicates that an analytical extrapolation of the data might be made assuming a simple two-dimensional expansion and filling in of the trough at any cross section relative to reference axes fixed in the undisturbed water. Thus, for a given geometry and initial draft at the step, only the initial vertical velocities must be reproduced in order to obtain the wake shape independent of the particular angle of attack or speed coefficient used. Since the initial vertical velocities are primarily a function of angle of attack, τ, and speed coefficient, C_V, -- namely, $C_V \sin\tau$ any combination of C_V and τ that produces the same $C_V \sin\tau$ at the same draft will produce a similar wake, but with the longitudinal dimension aft of the planing surface stretched according to time relative to the step passing.

(3171) THEORETICAL STUDIES OF THRUST DEDUCTION OF A PROPELLER WORKING BEHIND A THIN SHIP.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.

(c) Dr. S. Tsakonas, Staff Scientist, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.

(d) Theoretical, applied research.

(e) It is intended to study analytically the importance of the parameters involved in the thrust deduction problem. Functional relationships of thrust deduction with the axial clearances and vertical position of the propeller will be developed for various thin ship configurations and compared to each other.

(f) Project is in the process of development.

(g) Mathematical procedures have been developed for the thrust deduction force in the case of a thin ship having a longitudinal wedge shape with a flat plate bottom, as well as with a wedge cross section, when the propeller is situated at the maximum submergence of the stern.

(3172) LIFT ON SLENDER BODY OF REVOLUTION.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.

(c) Dr. M. Martin, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.

(d) Theoretical; basic research.

(e) Analytical study of the lift force acting on a slender body of revolution at an angle of attack, assuming the flow about any cross-section on the after portion of the body contains a vortex separation region. Method of wake displacement thickness and integral equations used to determine the force and the variations of the force with the body form parameters.

(3173) HYDROELASTIC INSTABILITIES OF SUPERCAVITATING HYDROFOILS.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.

(c) Mr. Charles J. Henry, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.

(d) Theoretical; basic research.

(e) Theoretical analysis of the conditions for the occurrence of hydroelastic instabilities (i.e. divergence and flutter) of supercavitating hydrofoils in two dimensions as functions of cavitation number, point of separation, elastic axis location, center of gravity location and elastic spring constant.

(f) Completed.

(g) A two-dimensional analysis of the static and dynamic stability of rigid supercavitating hydrofoil sections supported elastically showed that the instabilities commonly called divergence and flutter in aeroelastic literature are quite likely to occur in typical supercavitating hydrofoil installations. The analysis indicated that the speed at which divergence will

occur is increased by increasing the radius of gyration, moving the elastic axis forward, decreasing the cavitation number or moving the point of separation forward. It is found that the region of dynamic stability will increase when the radius of gyration is increased, the elastic axis is moved forward, the center of gravity is moved forward and/or the ratio of the stiffness in translation to the stiffness in rotation is increased.

(h) To be published as a Davidson Laboratory Technical Note.

(3174) SUPERCAVITATING HYDROFOILS WITH GENERALIZED OSCILLATORY MOTIONS.

(b) Office of Naval Research, Dept. of the Navy.
(c) Dr. M. Martin, Davidson Laboratory, Stevens Institute of Tech., 711 Hudson Street, Hoboken, N. J.
(d) Theoretical; basic research.
(e) Analytical studies of the forces acting on supercavitating hydrofoils with any type of oscillatory motion. Techniques of mapping are to be used, in the two-dimensional case, and consideration will be given to the infinite cavity case and also to the finite cavity case, taking account of cavity volume changes.
(g) An alternative method, involving the use of an integral equation, has been developed for obtaining the complex acceleration potential of a supercavitating hydrofoil in oscillatory motion which appears promising as a general means of determining the forces for any type of harmonic oscillation.

(3176) THEORY OF LATERAL MOTIONS OF SHIPS IN WAVES.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Dr. M. Martin, Davidson Laboratory, Stevens Inst. of Tech., 711 Hudson St., Hoboken, New Jersey.
(d) Theoretical; basic research.
(e) Analytical study of the lateral motions of surface ships with three degrees of freedom in oblique waves. The virtual mass, damping and dynamic coupling of a surface ship in oscillatory motion, as well as the hydrodynamic excitation forces and moments due to oblique waves have been evaluated. The free surface influence on the hydrodynamic forces have been included in the above. Further work on determining lateral ship motions is continuing.
(h) A Davidson Laboratory report on the completed portion of the work described in (e) is in preparation.

(3177) STUDY OF THE HYDRODYNAMIC STATIC AND DYNAMIC FORCE AND MOMENT RATE COEFFICIENTS FOR SURFACE SHIPS.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Dr. S. Tsakonas, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.
(d) Experimental, basic research.
(e) The problem of determining the hydrodynamic characteristics which are essential for turning and course keeping stability of surface ships, has led: (a) To an investigation of whether or not the rotating arm facility are reliable means of evaluating the static as well as the dynamic characteristics; (b) a study of the hydrodynamic behavior of a flat plate with profile areas and geometry like that of the surface ship and to a comparison of the results with those for the corresponding configurations of the surface vessels; and (c) to a correlation of the experimental results with the existing theories of low aspect ratio thin airfoils.
(f) Completed, final report has been issued.
(g) Entirely reliable static force and moment coefficients for straight, course motion can be obtained from rotating arm data. The similarity of results obtained for the hull skeg configuration and corresponding flat plates of the same profile area strengthens the prevailing belief in the analogy of surface ships to low aspect ratio wings, but no immediate practical use can be made as long as no correction for the magnitude of the lateral force on the plate is provided. The aspect ratio variation fails to account for the discrepancy between the low aspect ratio wing theories and the experimental results. The discrepancy may be attributed to the fullness of the ship form.
(h) "Effect of Appendage and Hull Form on Hydrodynamic Coefficients of Surface Ships," by Stavros Tsakonas, Davidson Laboratory, Report No. 740, July 1959.

(3509) THEORETICAL CALCULATIONS OF THE VIBRATORY THRUST PRODUCED BY A SHIP PROPELLER OPERATING IN THE WAKE OF A HULL.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.
(c) Dr. S. Tsakonas, Staff Scientist, and Winnifred R. Jacobs, Senior Research Engineer, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
(d) Theoretical; applied research.
(e) Computational work is carried out to test the validity of the theory developed by Ritger and Breslin, "On the Quasi-steady and Unsteady Thrust and Torque of a Propeller in a Ship Wake." Comparison is made with the experimental results.
(g) A comparison of the theoretical computations with the results obtained during ship trials and 1/25 scale model tests of the single screw ship AE 21, here shown: (a) the unsteady theoretical thrust is on the average 90% of the model test data, while the quasi-steady values are about 87% of the experimental. (b) The deviation of the unsteady theoretical thrust are 9% of the mean thrust which is about the average of the ship trial results over the range of RPM from 68 to 92. On the other hand the quasi-steady computation at 29% of the mean appears to be the upper limit of the

model test results.

(h) A detailed description of the computational procedure and also certain improvements of the basic theory have been written up in preliminary form. The final report has been delayed in expectation of information from DTMB about another set of experiments.

(3510) THE BLADE FREQUENCY VELOCITY FIELD NEAR AN OPERATING MARINE PROPELLER DUE TO LOADING AND THICKNESS EFFECTS.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.

(c) Dr. J. P. Breslin, Director and Dr. S. Tsakonas, Staff Scientist Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.

(d) Theoretical; applied research.

(e) A study is undertaken of the velocity fluctuating due to loading and blade thickness effects at any point in the vicinity of a propeller operating in open water conditions in an incompressible ideal fluid. The velocity and the pressure field together constitute the essential requirements for studying the vibratory effects of marine propellers on nearby bodies. The propeller is represented by a line-vortex array (bound vortex, helical vortex and hub vortex) of constant strength density and the blade sections by a source-sink distribution of density proportional to its slope of the section.

(f) Project completed.

(g) The blade frequency velocity components of a three bladed propeller are given generally in closed form expressions in terms of elliptic integrals. Broad conclusions are drawn as to the relative magnitudes of the contributions of each of the elements to the various velocity components, so that ommission of effects from the helical vortices can be justified for practical application. The inclusion of blade thickness effects in the calculation of the velocity field near an operating marine propeller is shown to be of primary importance.

(h) "The Blade Frequency Velocity Field Near an Operating Marine Propeller Due to Loading and Thickness Effects," John Breslin and Stavros Tsakonas, Davidson Laboratory Note No. 540, June 1959, presented at the 6th Midwestern Conference on Fluid and Solid Mechanics, September 1959.

(3511) RESEARCH STUDIES OF THE SOUND PRESSURE GENERATED BY A MARINE PROPELLER OPERATING IN A WAKE.

(b) United Aircraft Corporation, Research Dept.

(c) Dr. S. Tsakonas, Staff Scientist, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.

(d) Theoretical; applied research.

(e) In this study of the blade-frequency sound pressure of a propeller operating in a wake of known characteristics it is intended to derive general expressions for the blade frequency pressure due to loading effects (thrust and torque) under variable inflow conditions and then to simplify them on physically sound basis. A comparison of all results will be made and conclusions will be drawn as to the effectiveness of the various assumptions made.

(f) This project is in the formative stage.

(g) The sound pressure field of a rotating propeller in rectilinear motion is obtained by replacing the normal pressure distribution over the propeller by a distribution of acoustic pressure doublets acting at the propeller disc. The strength of this acoustic doublet distribution is obtained from the non-stationary airfoil theory in conjunction with the Kutta Joukowski formula.

(3512) BLADE FREQUENCY PRESSURE NEAR AN OPERATING MARINE PROPELLER IN A WAKE.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.

(c) Dr. J. P. Breslin, Director and Dr. S. Tsakonas, Staff Scientist, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.

(d) Theoretical; applied research.

(e) The purpose is to provide more realistic information than is at present available on the exciting forces generated by the transient flow produced by a marine propeller operating in the vicinity of a hull and its appendages. This information is essential for a study of the vibration of the hull as a whole as well as the hydroelastic behavior of plating and control surfaces.

(g) The linearized pressure change can be determined by means of the velocity potential of a doublet distribution of variable density normal to the helocoidal surface bounded by the line-vortex array, representing propeller action, provided that the spanwise strength density is obtained from the non-stationary airfoil theory. Thus the characteristics of the wake will enter through the cross-flow velocity which is a linear combination of the tangential and axial constituents of the wake.

(3513) THEORETICAL STUDY OF THE VIBRATORY PRESSURE FIELD NEAR A MARINE PROPELLER DUE TO LOADING AND THICKNESS EFFECTS.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.

(c) Dr. John Breslin, Director and Dr. Stavros Tsakonas, Staff Scientist, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.

(d) Theoretical; applied research.

(e) Theoretical studies of the vibratory pressure field around a marine propeller have been undertaken as being essential to the study of propeller excited ship vibrations. The thrust and torque loading effects are evaluated by representing the propeller by a line-vortex array (hub, bound, helical) of constant strength density. The effect of the blade thickness by replacing the blade sections at 7/10 of the radius by a source-sink distribution of

density proportional to the slope of the section.

(f) Completed.

(g) General expressions for the blade-frequency pressure field about a three bladed marine propeller due to loading and thickness effects have been developed in closed forms in terms of elliptic integrals. Asymptotic formulas of extreme simplicity are presented to reveal the dependence of the pressure on the major parameters such as tip clearance, axial clearance and number of blades. Comparison with experimental results for one model of a ship propeller shows that this complete theory now explains the observed axial-pressure signature and gives very satisfactory agreement with the data obtained over a range of tip clearances.

(h) "Marine Propeller Pressure Field Due to Loading and Thickness Effects," John P. Breslin and Stavros Tsakonas, Davidson Laboratory Note No. 518, Jan. 1959. Presented at the annual meeting of the SNAME, November 12, 1959.

(3514) THEORETICAL AND EXPERIMENTAL INVESTIGATION OF FLUTTER OF FULLY-WETTED HYDROFOILS.

(b) David Taylor Model Basin, Office of Naval Research, Navy Department.

(c) Mr. Charles J. Henry, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.

(d) Theoretical and experimental; basic research.

(e) Previous flutter investigations have shown disagreement between experimental results and theoretical predictions of the critical flutter speed of hydrofoils (see Henry, Dugundji, Ashley, "Aeroelastic Instabilities of Lifting Surfaces in High Density Media," Journal of Ship Research, Vol. 2, No. 4, March 1959). Experiments will be carried out at several combinations of the parameters involved and the results will be compared with theoretical predictions. Several modifications of the present theory will be investigated in order to achieve good agreement between theory and experiment.

(3515) HYDRODYNAMICS OF HIGH SPEED SHIPS.

(b) U. S. Maritime Administration.

(c) Prof. Edward V. Lewis, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.

(d) Experimental, developmental research.

(e) Model tests on a series of models of varying proportions suitable for very high speeds. Tests cover resistance in calm water and motions in waves.

(3516) INVESTIGATION OF HULL BENDING MOMENTS IN WAVES OF EXTREME STEEPNESS.

(b) Ship Structure Committee.

(c) Prof. Edward V. Lewis, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, New Jersey.

(d) Experimental; applied research.

(e) Model tests are to be carried out on a jointed model of a typical merchant ship to determine midship bending moments in very steep waves. Objective is to determine upper physical limit of wave bending moments.

(h) Exploratory tests are reported in "A Long-Range Research Program in Ship Structural Design," Report SSC-124, published by the Ship Structure Committee and available from the National Academy of Science-National Research Council, 2101 Constitution Ave., Washington 25, D. C.

(3517) SHIPS OF MINIMUM WAVE RESISTANCE.

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

(c) Dr. Milton Martin, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.

(d) Theoretical and experimental; basic research.

(e) An investigation is underway to evaluate the agreement between computed and measured wave resistance of ship models of minimum wave resistance at high Froude numbers as determined from Weinblum's tables, in which the lines are modified to compensate for the boundary layer displacement thickness. Comparison will be made with the thin ship theory calculations and calculations satisfying the boundary conditions on the wetted hull surface to be made on the NORC.

(g) Computations based on Weinblum's Tables have been made of minimum wave resistance forms for a large Froude number range, of ships of length-draft ratio 33.3 and prismatics between 0.56 and 0.74. A model of minimum wave resistance at a Froude number of 0.5, whose principal proportions are those of a destroyer, has been constructed and is at present being tested at several drafts. Estimates of the boundary layer displacement thickness have been made and these will be used to modify the lines of the model for the second series of tests.

(3518) THE EFFECT OF HIGH SPEED ON LATERAL SHIP STABILITY.

(b) David Taylor Model Basin, Bureau of Ships, Navy Department.

(c) Dr. Milton Martin, Davidson Laboratory, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.

(d) Theoretical; basic research.

(e) Conduct theoretical study of the effect of high speed on surface ship stability and maneuverability, including determination of lateral stability derivatives, stability indices and variations, and steady-state turning diameters.

UNIVERSITY OF TENNESSEE, Hydraulic Laboratory, Department of Civil Engineering.

Inquiries concerning the following projects should be addressed to Dr. Harry H. Ambrose, Dept. of Civil Engineering, University of Tennessee, Knoxville 16, Tennessee.

(2159) DISCHARGE COEFFICIENTS FOR TAINTOR GATES

ON SPILLWAYS.

(b) Cooperative with the Tennessee Valley Authority.
(d) Experimental, basic research, for master's thesis.
(e) A generalized model of a taintor gate on a spillway was investigated for the head-discharge relationship. The effect of the trunnion location as well as that of relative head and of relative gate opening was evaluated.
(g) Experimental work completed, reanalysis of results and publication will be activated in 1960.

(2619) BOUNDARY ROUGHNESS EFFECTS UPON TURBULENT FLOW.

(b) Cooperative with the National Science Foundation.
(d) Experimental; basic research.
(e) Measurements of velocity distributions and piezometric gradients for turbulent flow in a pipe with uniform, artificial boundary roughness are being made to assess the specific effects of certain characteristics of the roughness-element geometry (relative spacing, relative height, whether discrete or continuous). It is anticipated that comparative tests for the same roughness patterns will be made in an open flume.
(f) In the overall project tests have been completed on 17 patterns of discrete depressions of four sizes, 13 patterns of discrete projections of two sizes, and 5 patterns of continuous strip-roughness (ring-and-groove) of a single size.
(g) Results show the effects of roughness-element geometry to be in the following order of descending importance: whether depression or projection, whether discrete or continuous, relative spacing, relative height. The relative height is an adequate criterion only for roughness patterns that are geometrically similar. A definite critical spacing of discrete projections or of strip roughness yields the maximum roughness effect.
(h) A complete project report is in preparation.

TEXAS A AND M COLLEGE, Department of Oceanography and Meteorology.

(2868) INVESTIGATION OF STORM SURGES ALONG THE SOUTH SHORE OF NEW ENGLAND.

(b) Beach Erosion Board, Corps of Engineers, U.S. Army, Contract DA-49-055-civ-eng-56-4.
(c) Prof. Robert O. Reid, Project Supervisor, Texas A. and M. College, College Station, Texas.
(d) Numerical analysis; applied research.
(e) Numerical and graphical procedures are utilized in the evaluation of storm surge behavior in schematic (mathematical) models of Narragansett Bay, Long Island Sound, and Buzzards Bay, particular attention being devoted to Narragansett Bay. The numerical work is being carried out using an IBM 650 computer. Numerical studies of astronomical tides in Narragansett Bay are also being carried out.
(g) A numerical procedure for computation of water level changes in coastal bays and estuaries has been utilized for estimating the potential storm surges in Narragansett Bay, Long Island Sound, and Buzzards Bay for a selected design hurricane. The numerical calculations are based upon the quasi-linear, one-dimensional equations of motion and continuity. In the numerical evaluation of storm surge generation over the continental shelf, the equations are modified so as to allow for long shore dispersion of energy in an approximate manner. The calculations for the modification of the surge as it enters the bay include the provision for energy loss by bottom friction and energy gain by wind stress over the bay. In the calculations for Narragansett Bay, the latter is regarded as a network of interconnecting channels, each of which is considered to be of uniform width and depth. The method of calculation has been "calibrated" by using the known data for the September 21, 1938 hurricane as a control. The calibration involves the selection of appropriate friction, reflection, and refraction conditions for the system, which will allow the best fit of the numerical results with the control data. Further tests of the method to be carried out using data from other hurricanes. The method of computation is also being tested by attempting to predict the regime of periodic tide under normal conditions.

(2869) INVESTIGATION OF PROBLEMS ASSOCIATED WITH PREDICTION OF STORM-INDUCED WATER LEVELS.

(b) U.S. Weather Bureau, Dept. of Commerce, Contract CWB-9559.
(c) Prof. R. O. Reid, Project Supervisor, Texas A.and M. College, College Station, Texas.
(d) Theoretical with verification from existing data; applied and basic research.
(e) This project is concerned with the development of criteria for the prediction of storm surges based upon deductions from hydrodynamic theory.
(f) Completed.
(g) Free and forced surges of one- and two-dimensional character have been investigated analytically for cases of regular bottom topography with simple boundary conditions. The one-dimensional stress-induced surge for variable depth has been investigated numerically. In the two-dimensional studies the influence of the rotation of the earth and the development of quasi-geotrophic type surges have been investigated. The results of the various analytical models lead to certain criteria which are tested in terms of the observations of storm surges along the east coast of the United States.
(h) "A Theoretical and Empirical Study of Storm Induced Water Level Anomalies," by K. Kajiura, Final Report Project 202 (Ref. 59-23F), Texas A. and M. Res. Fdn., Dec.

1959.

(2870) MODEL STUDY OF SURGE ACTION IN A PORT.

(b) Office of Naval Research, U.S. Navy Project NR 083-036, Contract N7 ONR 487 02.
(c) Dr. B. W. Wilson, Principal Investigator, Texas A. and M. College, College Sta., Texas.
(d) Experimental; basic and applied research.
(e) To collate results and conclusions from a model study of long period wave action in Table Bay Harbor, Cape Town, South Africa.
(f) Initiated 1958; completed 1958.
(g) The nature of the surge phenomenon has been uncovered. Its reproduction in an engineering model and experiments to control it are described. It is shown that effects on shipping can be brought under control by suitably containing the existing harbor within an outer basin of tight mole construction.
(h) "Research and Model Studies on Range Action in Table Bay Harbour, Cape Town," B. W. Wilson, S.A. Inst. C.E. (Johannesburg, S.A.), v. 1, June/July 1959, pp. 131-148 and 153-177.

(2871) DIFFRACTION OF PLANE GRAVITY WATER WAVES IN THE PRESENCE OF A HORIZONTALLY SUBMERGED CIRCULAR CYLINDER.

(b) Department project.
(c) Prof. R. O. Reid, Chairman (Faculty Comm.), Texas A and M College, College Sta., Texas.
(d) Experimental; basic research; Ph. D. dissertation (Robert Ellis).
(e) To determine the nature of the pressure changes brought about at the bed boundary by the presence of a horizontally submerged circular cylinder, fixed transversely in the path of a uniform train of waves in water of uniform depth.
(f) Completed.
(g) Experiments have been conducted in a wave tank for generating water waves in which wave pressures have been measured at a number of locations at the bottom of the tank relative to a horizontally submerged circular cylinder, fixed transversely at different elevations in water of various depths. The ratio of the root-mean-square pressure in the presence of the cylinder to that in the absence of the cylinder is found to vacillate with distance symmetrically on either side of the cylinder. An empirical formula which satisfactorily predicts the pressure change has been derived but the theoretical solution of the problem has not yet been attained.
(h) "A Study of Gravity Wave Induced Pressure Variations in the Presence of a Submerged Cylinder," R. Ellis, Ph.D. Dissertation, A. and M. College of Texas, May 1959, 65 pp.

(2873) COMPUTATION OF DESIGN STORM-TIDE FOR THE NEW YORK BAY AREA.

(b) Beach Erosion Board, Corps of Engineers, U. S. Army and New York District, Corps of Engineers, Contract DA-49-055-civ-eng-58-9.
(c) Dr. B.W. Wilson, Project Supervisor, Texas A. and M. College, College Station, Texas.
(d) Numerical analysis; applied research.
(e) This project concerns the correlation of observed effects in New York Bay with the characteristics of known storms and its application to the prediction of storm-tides for a design hurricane.
(f) Completed.
(g) Least squares multiple regression correlation of known storm-tide elevation at the mouth of New York Bay with antecedent storm characteristics (wind stress and pressure gradient) at a number of offshore stations has been undertaken with data for four storms, tabulated at 20 min. intervals. The derived coefficients of correlation have been used in the prediction formula to predict the time-sequences of water level change at the bay-mouth for each of the four storms as a check on the validity of the formula. The formula has then been applied to the case of a design hurricane travelling on a given path at six possible speeds. High speed digital computer techniques have been used for this study. In an extension of this work predictions have been made for a more severe design-hurricane in three combinations of size and speed and finally for a Probable Maximum Hurricane.
(h) "The Prediction of Hurricane Storm-Tides in New York Bay," B.W. Wilson, Preliminary Report No. 165-1, Texas A. and M. Res. Fdn., Jan. 1959.
"The Prediction of Hurricane Storm-Tides in New York Bay," B.W. Wilson, Tech. Report. No. 165-2, Texas A. and M. Res. Fdn., Feb. 1959, 119 pp.
"The Prediction of Hurricane Storm-Tides in New York Bay," B.W. Wilson, Tech. Report No. 165-3, Texas A and M Res. Fdn., Oct. 1959, 120 pp.

(3179) MOORING OF SHIPS EXPOSED TO WAVES.

(b) Office of Naval Research, U.S. Navy, Project NR 083-036, Contract N 7 ONR 487-02.
(c) Dr. B.W. Wilson, Principal Investigator, Texas A and M College, College Sta., Texas.
(d) Theoretical; basic and applied research.
(e) To investigate the motion of a drifting ship under the influence of waves in head and beam seas in water of various depths; hence to determine the kinetic energy that must be absorbed through the tendency of a ship to drift in contact with offshore structures in exposed locations. Finally, to consider the nature of ship motion in waves when restrained by mooring ropes.
(f) Completed.
(g) Problem has been investigated on the basis that a ship can be simulated by a rectangular block of equivalent displacement. Treatment determines ship surge, heave and pitch in a head sea of uniform long-crested waves and sway, heave and roll in a beam sea. Most critical conditions of approach of a ship to a berth in an exposed location apply in broadside on-movement in a beam sea. The kinetic energy to be absorbed depends on whether structure is permeable to the waves or reflects them. The non-linear problem of the surging of a

moored ship under mooring restraints is analyzed.

(h) "The Energy Problem in the Mooring of Ships Exposed to Waves," by B. W. Wilson, Bulln. Perm. Internatl. Assoc. Navig. Congr., 1960 (publication pending).

(3181) GRAVITY-CAPILLARY WAVES IN WATER AT A VIBRATING BOUNDARY.

(b) United Gas Pipeline Co. Fellowship.
(c) Prof. R. O. Reid, Chairman (Faculty Committee), Texas A and M College, College Station, Texas.
(d) Experimental; basic and applied research; M.S. thesis (C. S. Wells).
(e) To examine the nature of gravity-capillary waves in water developing transversely to a vibrating boundary.
(f) Completed.
(g) The oscillation of cone and wedge-shaped cylindrical plungers in water at high frequency was found to induce standing edge waves transverse to the water-plunger boundary. It was found that this phenomenon had been discovered by Faraday and interpreted by Rayleigh as a non-linear mechanism capable of existence in several distinct modes. It was found that the resulting standing water-wave system was unstable and capable of developing sub-harmonic as well as super-harmonic modes of oscillation in relation to the forcing frequency. The wave length-frequency relationship of the waves in the fundamental mode was found to agree satisfactorily with Kelvin's analysis for gravity-capillary waves of small amplitude.
(h) "Transverse Gravity-Capillary Waves near a Vibrating Boundary" by C. S. Wells, M. S. Thesis, A. and M. College of Texas, January 1959.

(3519) DEEP SEA MOORING OF SHIPS IN WAVES AND CURRENTS.

(b) David Taylor Model Basin, U. S. Dept. of the Navy, Contract No. Nonr-2119(02).
(c) Dr. B. W. Wilson, Project Supervisor, Texas A and M College, College Station, Texas.
(d) Theoretical; basic research.
(e) To determine the mooring line tensions arising from hydro-dynamic forces of waves and currents acting on a ship and mooring cable(s) in deep water.
(g) Following a literature survey of work previously done on this and allied studies, the first problem posed for solution has been concerned with the configuration of a negatively buoyant mooring cable used to anchor a ship in a uniform horizontal current prevailing over full water depth in the absence of waves. The steady state configuration of a deep-sea cable is then being integrated from the solution of the above case applied to variable vertical distributions of horizontal steady current, conforming to realistic ocean patterns. Facilities of a high speed digital computer are being used for evaluating sets of cable parameters applicable to a wide variety of possible mooring line situations. Further research will be involved with the transient effects of waves and fluctuating wind.
(h) "A Case of Critical Surging of a Moored Ship" by B. W. Wilson, Proc. ASCE, Vol. 85(WW 4), Part I, Dec. 1959, pp. 157-176.
"A Study of the Movement of Moored Ships Subjected to Wave Action" (Discussion), Proc. Inst. C. E. (London). Publication pending.

(3520) FORECASTING OF OCEAN WAVES GENERATED BY MOVABLE VARIABLE WIND SYSTEMS IN DEEP AND SHALLOW WATER.

(b) Engineering Foundation, New York; Magnolia Petroleum Co., Dallas; Humble Oil and Refining Co., Houston; Office of Naval Research, U. S. Navy, Contract N7 onr 48702(Project No. NR 083-036).
(c) Dr. B. W. Wilson, Texas A and M College, College Station, Texas.
(d) Theoretical and empirical; basic and applied research.
(e) To verify a moving fetch variable-wind graphical forecasting procedure by direct comparison of results with wave observations at one or more offshore stations. Thence to investigate the possibility of extending the method to rapid forecasting of wave conditions in near-shore environments where water depth, friction and refraction are complicating factors in wave generation.
(g) Analysis is being made of the sea conditions induced by hurricane Audrey of June 1957. Complete synoptic maps for the Gulf of Mexico area are being prepared for the period of activity of Audrey with a view to securing accurate space-time wind fields for several different lines of approach of waves to the Bay Marchand area off the coast of Louisiana. Wave data for this area are available for comparison with predictions. The graphical wave forecast method has now been substantiated theoretically and adapted to high speed digital processing on an IBM No. 650 computer for the deep water situation. Application to shallow water is proceeding.

(3521) TIDAL RESPONSE OF A BAY WITH A CONSTRICTED OPENING TO THE SEA.

(b) Department project.
(c) Prof. R. O. Reid, Chairman (Faculty Committee), Texas A and M College, College Station, Texas.
(d) Theoretical; basic and applied research; M.S. thesis (R. W. Love).
(e) (1) Determination of the variation of amplitude and phase angle of the fundamental tidal co-oscillation induced in a simple rectangular basin with a constricted opening to the sea; also of the second and third harmonic co-oscillations; (2) determination of the tidal current distribution; and, (3) comparison of theoretical results with measurements from a model.
(f) Completed.
(g) Linearized equation of motion and equation of continuity and non-linear boundary conditions are used in theoretical treatment of this problem, taking into account the flow through the constricted entrance to

the basin. A method of successive approximation is applied to determine amplitudes and phases of tidal harmonics. Data from the Corps of Engineers (U.S. Army) model of Narragansett Bay is used as a check on theoretical derivations.

(h) "Tidal Response of a Bay with a Constricted Opening to the Sea," R. W. Love, M.S. Thesis, A and M College of Texas, Aug. 1959, 66 pp.

UNIVERSITY OF TEXAS, Department of Civil Engineering.

Inquiries concerning Projects Nos. 948, 2162, 2396, 2397, 2629, 2874, 3523, and 3524 should be addressed to Dr. Walter L. Moore, Dept. of Civil Engineering, University of Texas, Austin 12, Texas.

(948) DIFFUSION OF A TWO-DIMENSIONAL SUBMERGED JET.

(b) Laboratory project.
(d) Basic experimental.
(e) An investigation was made of the diffusion of momentum in a two-dimensional jet as influenced by the proximity to a plane boundary. Apparatus was constructed for measuring the velocity field in the diffusion region of an air jet 0.05 ft thick and 3.0 ft wide with a plane parallel boundary at various distances from the axis of the jet. Measurements have been made covering a range of the variables.
(f) Inactive.

(2161) CHARACTERISTICS OF A HYDRAULIC JUMP AT AN ABRUPT CHANGE IN BOTTOM ELEVATION.

(b) University of Texas Research Institute and Bureau of Engineering Research.
(c) Prof. Carl W. Morgan, Assoc. Prof. of Civil Engineering, Univ. of Texas, Austin 12, Tex.
(d) Experimental.
(e) Experimental determinations are made of the flow characteristics at two-dimensional channel drops and rises. The velocity distribution and surface profile will be determined throughout the length of the jump for various relative changes in bottom elevation. The longitudinal location of the jump in relation to the change in bottom elevation will be varied over a broad range in distinction to previous related investigations in which relative location of the jump was held constant.
(g) Results for the abrupt drop are complete and have been published. For a given entering Froude number lying between 2 and 8 three types of jump may form, the type and its longitudinal location depending only on the relative downstream depth. The velocities near the bottom below the drop are always less than the mean velocity in the downstream channel for the jump type of maximum height. Experimental measurements have been made on the related investigation for an abrupt rise and report is being prepared.

(2162) HYDROLOGIC STUDIES, WALLER CREEK WATERSHED.

(b) Cooperative with U.S. Geological Survey.
(d) Field investigation; applied research.
(e) Measurements of rainfall and runoff for a 4 sq. mile and a 2 sq. mile portion of the Waller Creek watershed are being made to provide basic information for estimating runoff from small urban watersheds in the Southwest area. Two streamflow stations and a rain gage net are in operation. Studies of the correlation between runoff, rainfall, and the characteristics of the drainage basin are being made by various proposed methods to serve as a base for comparison with the data as it is collected from the stream.
(g) Careful estimates of the peak discharges at the gaging station were made by various proposed methods based on measurable characteristics of the basin. These results will be of interest to compare with observed peak discharges in later years when the record is long enough to be significant.

(2396) RESISTANCE OF PIERS IN FREE SURFACE FLOW.

(b) Laboratory project.
(d) Theoretical and experimental (thesis).
(e) An investigation is being made of the drag resistance of piers as a function of shape, relative submergence, spacing, and Froude numbers. The pier resistance is being correlated with the head loss for flow in a channel.
(g) A phase of the investigation has been completed for Froude numbers less than 0.5 with cylindrical piers at various submergence and spacing. An investigation of the resistance of H section piers at various orientations and longitudinal spacings has been completed. Another phase has been completed which demonstrates that the velocity gradient along a cylindrical pier affects the drag coefficient. The local drag coefficient decreases along the pier in the direction toward the end of the pier where the velocity is high. The reduction in drag coefficient is related to a dimensionless measure of the velocity gradient along the cylinder.

(2397) EFFECT OF UPSTREAM DEVELOPMENT ON THE RUNOFF FROM SMALL WATERSHEDS IN THE SOUTHWEST.

(b) Laboratory project.
(d) Field investigation (thesis).
(e) For a selected watershed rainfall and runoff relations before the period of upstream development are being analyzed. The relations obtained for this period will be applied to the rainfall records after the upstream development and the predicted runoff compared with the actual runoff.
(g) Sources of data have been located, the available information tabulated, and a method of evaluating the runoff devised that appears to be reasonable. Multiple correlation diagrams have been developed which may be used with storm rainfall records to predict the annual runoff of the

selected watershed for the period before upstream development.

(h) "Multiple Correlation of Rainfall and Other Factors to Runoff," Manton A. Nations, M.S. thesis, June 1959.

(2629) A MECHANICAL TURBULENCE INDICATOR FOR LIQUIDS.

(b) Bureau of Engineering Research, University of Texas.

(d) Experimental instrument development.

(e) There is need for a relatively simple device to give a quantitative measure of the degree of turbulence in a flowing fluid. Electrical instruments commonly measure the root mean square of the turbulent fluctuations as an indication of the intensity. The instrument being developed measures the maximum turbulent fluctuation as an indication of the intensity. The instrument is similar to a 1/2-inch diameter Prandtl velocity tube except that it has two stagnation openings; the conventional one which gives the mean stagnation head and an additional one which leads through a sensitive check valve and accumulator to a manometer tube. The check valve and accumulator elements are located in the tube less than 3/8 of an inch from the stagnation opening to minimize inertia effects.

(g) The instrument has been built and calibrated. Measurements have been made to evaluate the operation of the instrument in the turbulent field of a hydraulic jump. A report is being prepared describing the instrument, the calibration technique and the results in the hydraulic jump.

(2874) AN INVESTIGATION OF THE SCOUR RESISTANCE OF COHESIVE SEDIMENTS.

(b) Bureau of Engineering Research, University of Texas.

(d) Analytical and experimental (laboratory).

(e) Exploratory tests have been made with two different schemes, one with radially outward flow between a circular disc and the soil sample, and one with a submerged vertical circular jet impinging on a horizontal soil surface. With the first scheme it was not possible to obtain the necessary precision of measurement at low scour rates, but with the second scheme satisfactory measurements were obtained. A correlation based on dimensional analysis gave consistent results in evaluating the relative scour resistance of several materials. Apparatus is being fabricated for a new test which is expected to permit direct evaluation of the shear stress at the soil surface. In this test a cylindrical soil sample is submerged in a transparent concentric cylinder which can be rotated at a controlled speed to generate a shear stress on the soil surface. An attempt will be made to relate the scour resistance to other measurable soil properties, and finally to interpret the results in relation to field observations.

(3522) LONG TIME FLUCTUATIONS IN STREAM RUNOFF.

(b) Laboratory project.

(c) Dr. Carl W. Morgan, Dept of Civil Engineering, Univ. of Texas, Austin 12, Texas.

(d) Analytical and field study.

(e) Values of runoff from selected drainage areas in the lower Mississippi River basin and in basins of the rivers emptying directly into the Gulf of Mexico were studied. Variations in the runoff values for each stream were considered and these trends compared with solar variations. The relative sunspot numbers were used as the measure of solar variations and were correlated with the mean annual runoff. Further correlations are being made with different "lag" periods between solar activity and surface runoff.

(g) The gradual shifting of the centers of runoff excess and deficiency is consistent rather than random and appears to represent a gradual cyclic change in the runoff pattern. It appears that the locations of the centers of runoff deficiency is following roughly the same path that it did some 22 to 24 years previously. Correlation coefficients of +0.2 to +0.5 are obtained for selected rivers in Mississippi, Alabama, Georgia, and Arkansas when sunspot numbers in the 11-year sunspot cycle are correlated with runoff. Texas streams do not give significant correlation with the 11-year sunspot cycle but give better correlation if runoff is compared with the double sunspot cycle in which sunspot numbers are assumed as negative in alternate cycles.

(h) "Surface Runoff in the Gulf Coast Area in Relation to Solar Activity," by Carl W. Morgan, Ph. D. Dissertation, June 1958.

(3523) EQUIVALENT PIPE CONCEPT IN RELATION TO THE GENERAL RESISTANCE DIAGRAM.

(b) Laboratory project.

(d) Theoretical and experimental, basic research.

(e) The investigation was conducted to clarify the relationship between modern concepts of pipe resistance and the older empirical formulas.

(f) Completed.

(g) A simple procedure is developed to derive an expotential formula applicable to a known range of flow conditions. The analysis makes apparent the range of flow conditions for which any particular expotential formula is applicable. Limitations of the equivalent pipe concept are discussed. Data on resistance measurements in water mains in service indicate that the head loss varies with the discharge to a power nearly equal to 2.0 rather than 1.85 as commonly assumed.

(h) "Relationships Between Pipe Resistance Formulas," Walter L. Moore, Proceedings, ASCE, Vol. 85, No. HY3, pp. 25-41, March 1959.

(3524) GROUND WATER FLOW AND SEEPAGE IN NON-HOMOGENEOUS, NON-ISOTROPIC SEDIMENTS.

(b) Laboratory project.
(d) Theoretical, basic research.
(e) A relaxation solution for the Laplace equation has been developed which is applicable across a boundary between two regions of different permeabilities. It is believed that the method can be expanded to apply to any specified non-homogeneous and non-isotropic condition. It is intended that the solution be set up for computation on an electronic computer and that selected numerical solutions be checked against those from an electrolytic tank.

UTAH STATE UNIVERSITY, Engineering Experiment Station.

(3183) DYNAMICS OF FLOW IN STEEP, ROUGH, OPEN CHANNELS.

(b) Laboratory project.
(c) Dr. Dean F. Peterson, Dean of Engineering, Utah State University, Logan, Utah.
(d) Experimental theoretical field investigation; basic research for doctoral thesis.
(e) A basic study of parameters involved in flow in steep, rough channels where the roughness is relatively an appreciative part of the depth, and where channels are sufficiently steep that super critical flow can occur in connection with contractions caused by the roughnesses. The work is basic, however, it could have application to steep mountain streams and to hydraulic structures. Basic over-all parameters have been investigated for simple cases. The continuing project will study the effect of a single roughness inducing super critical flow and acting as a control. The interaction of roughnesses and the effect of roughnesses of distributed sizes will be studied in a sloping flume during this year.
(g) Flow regimes have been classified into three major regimes and seven sub-regimes. Parameters delineating the regimes for very simple roughness cases have been suggested. In the tumbling regime the rough channel acts as a continuing critical depth control, thus a reach of tumbling flow channel may be considered as a "virtual" weir.
(h) "Turbulent Flow in Steep, Rough, Open Channels," P.K. Mohanty, Ph.D. thesis.
"Flume Studies of Flow in Steep, Rough, Open Channels," P.K. Mohanty and Dean F. Peterson presented at meeting of Hydraulics Division, American Society of Civil Engineers, Fort Collins, Colorado, July 1, 1959.

(3184) FLOW TO PARTIALLY PENETRATING WELL IN AN UNCONFINED AQUIFER.

(b) Laboratory project.
(c) Dr. Dean F. Peterson, Dean of Engineering, Utah State University, Logan, Utah.
(d) Experimental basic research for doctoral thesis.
(e) The effect of drawdown relative to depth of penetration, well diameter, and relative thickness of aquifer on flow into an ideal partially-penetrating, unconfined well system was studied using a combination electrical and membrane analogue, and an electrical resistance analogue computer. Functional relationships between the geometrical and the flow parameters are proposed based on dimensional considerations and experimental results.
(g) The effect of partial penetration for a well of the unconfined type is thoroughly treated.
(h) "Discharge to Partially-Penetrating Wells in Unconfined Aquifers," by Mostafa M. Soliman, Ph.D. thesis.
"Discharge to Partially-Penetrating Wells in Unconfined Aquifers," by Mostafa M. Soliman and Dean F. Peterson. Manuscript prepared and submitted to Hydraulics Division, Am. Society of Civil Engineers.

(3185) HYDRAULICS OF SURFACE IRRIGATION.

(b) Laboratory research.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State University, Logan, Utah.
(d) Experimental, theoretical; basic research.
(e) Hydrodynamic study for movement of water over a porous surface when intake varies with time. Free surface and the rate of advance are defined.
(g) A paper has been completed for publication. It contains the results of basic mathematical developments defining the free surface and the rate of advance. A resulting differential equation must be solved by approximation. Solutions of this equation have been obtained to compare with field measurements of the rate of advance. The results are within ten percent of field observations. Additional studies are now being planned to utilize high speed computers to obtain sufficient typical solutions to permit the development of characteristic of parametric curves so that solutions can be obtained more readily from the complex differential equations.
(h) "Hydraulics of Irrigation Water Application is Effected by Soils and Other Factors," Vaughn E. Hansen, paper 1788, Journal of the Irrigation and Drainage Division, Proceedings, American Society of Civil Engineers, September 1958.
"Hydraulics of Unsteady Open Channel Flow over a Porous Bed," Harry Haun-yen Loo and Vaughn E. Hansen, prepared for publication, October 1959.

(3186) EVALUATION OF GROUND WATER IN A NON-HOMOGENEOUS, ANISOTROPIC MEDIA.

(b) Laboratory project.
(c) Dr. Vaughn E. Hansen, Director Engineering Experiment Station, Utah State University, Logan, Utah.
(d) Experimental, theoretical; basic research. Two masters theses have been completed.
(e) A variable resistance network has been developed wherein problems of non-homogenous anisotropic flow can be evaluated. This network has been used to establish the

procedure, validity, and accuracy of solutions which can be expected from this approach. Boundary conditions necessary for unique solutions and the method of application of boundary conditions have been studied.

(h) "Evaluation of Ground Water Problem in a Non-homogeneous, Anisotropic Media Using a Variable Resistance," David W. Hendricks, master thesis being written.

(3187) INVESTIGATION OF THE HYDRAULIC AND MECHANICAL CHARACTERISTICS OF SPRINKLERS.

(b) Laboratory project.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State Univ., Logan, Utah.
(d) Experimental; field investigation.
(e) The basic criterion in the study was to reduce the turbulence in mechanical sprinklers in order to improve the range.
(f) Completed.
(g) Several rather simple modifications in the commericial product could be modified to materially increase the range.

(3188) STEADY FLOW TOWARD AN UNCONFINED WELL.

(b) Laboratory project.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State Univ., Logan, Utah.
(d) Theoretical; doctoral thesis.
(e) Unconfined flow toward a well is extremely complex because of the existence of a free surface. The object of this project is to arrive at a more sound mathematical evaluation of the flow by using better boundary conditions when solving the equations. The unsteady flow case is also analyzed. New boundary conditions are evaluated.
(g) Boundary conditions have been clarified and equations have developed utilizing the improved boundary conditions. The results have been compared with other methods of computing the free surface shape for flow toward a well. An equation for unsteady flow has also been developed.
(h) "Analysis of Steady and Non-Steady Flow toward an Unconfined Well," Harry Haunyen Loo, doctoral dissertation, Civil and Irrigation Engineering Department, Utah State University, Logan, Utah, June 1959.

(3525) MEASUREMENT OF FLOW FROM HORIZONTAL PIPE BY THE COORDINATE METHOD.

(b) Laboratory project.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State Univ., Logan, Utah.
(d) Experimental, theoretical; applied research.
(g) The error involved in the conventional method of measurement is shown to be large. The coefficient has been defined and parameters developed so that more accurate measurements can be obtained in a quick, easy method of water measurement.
(h) "Discharge Coefficient in the Coordinate Method of Measuring Pipe Flow," D. L. Bassett, Master's Thesis, Civil Engineering Department, Utah State Univ., 1952 - A bulletin outlining field procedure to be followed with the methods is now being prepared.

(3526) QUICK COUPLING FOR FLEXIBLE PIPE.

(b) Laboratory project.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Sta., Utah State University, Logan, Utah.
(d) Experimental; design and development.
(e) A coupling which can be light and flexible and also permit ease of coupling and disconnecting flexible pipe in the field is being developed.
(g) A coupler has been developed which does permit ready use in the field.

(3527) DEVELOPMENT OF LOW COST WATER LEVEL RECORDER.

(b) Laboratory project.
(c) Dr. Vaughn E. Hansen, Director, Engineering Experiment Station, Utah State University, Logan, Utah.
(d) Experimental, development.
(e) In general, the available instrumentation for measuring fluctuation in water level is costly. Most equipment is designed for a wide range of application. However, many areas require only a limited fluctuation in water level. This is particularly true in irrigation practice. Objective of the project is to develop a low-cost recorder which will fit these needs and thereby permit a more extensive use.
(g) A water level recorder has been developed which does meet the requirements and is now being modified and adapted for commercial production.

(3528) THE EFFECT OF SEDIMENT PROPERTIES ON THE ATTENUATION OF AN ULTRASONIC PLANE WAVE.

(b) Laboratory project.
(c) Dr. Gordon H. Flammer, Assoc. Prof., Dept. of Civil and Irrigation Engineering, Utah State University, Logan, Utah.
(d) Theoretical and experimental; basic research.
(e) The attenuation of an ultrasonic plane wave passing through a homogenous suspension has been the subject of several theoretical and experimental investigations from which theoretical relations have been obtained. Experimental results cover only part of the range of ratios of sound wave length to particle circumference. Theoretical relations for the range not covered by experimental results ignore sediment properties other than sphericity. Recent experimental work indicates that other sediment properties need to be considered as well. These results were incidental to the study of a measurement technique and hence, were of a preliminary nature. There remains considerable basic research on the effect on the attenuation relation of various sediment properties such as density, elasticity, sphericity, sonic refractive index, absorption, and transparency.
(g) A paper has been written on the "Use of Ultrasonics in the Measurement of Suspended Sediment Size Distribution and Concentration,"

this paper touches only lightly on the subject of interest here.

(h) "The Use of Ultrasonics in the Measurement of Suspended Sediment Size Distribution and Concentration," Gordon H. Flammer, Ph. D. Thesis, Univ. of Minn., Minneapolis, Minn., 1958.

(3529) DEVELOPMENT OF LOW COST IRRIGATION WATER METER.

(b) Cooperative with Irrigation Dept., Univ. of California, Davis, California.
(c) Dr. J. E. Christiansen, Prof. of Civil and Irrigation Engineering, Utah State University, Logan, Utah.
(d) Experimental; applied research-development.
(e) Tests on the use of a domestic type water meter as a by-pass meter for irrigation service were conducted on three types of primary head producing divisions for use with water meter.
(f) Experimental work completed. Manuscript in preparation.
(g) Results indicates that a small domestic type of water meter can be employed as a by-pass meter for measuring large flows in pipe lines with a fair degree of accuracy.

(3530) WATER REQUIREMENTS OF WILDLIFE AREAS.

(b) Utah State Fish and Game Department, Salt Lake City, Utah.
(c) Dr. J. E. Christiansen, Prof. of Civil and Irrigation Engineering, Utah State Univ., Logan, Utah.
(d) Field Investigation - applied research.
(e) Large area of marshy lands adjacent to the Great Salt Lake have been developed and improved by the State Fish and Game Dept., and the Federal Wildlife Service, as Migratory Bird Refuges. Available stream flow from several of the major streams flowing into the Salt Lake, flow into these areas where the water is impounded behind dikes to create habitat suitable for nesting, feeding and resting of water fowl. Millions of ducks and geese utilize this area each year during their migratory flights.
The basic purpose of the study is to determine the quantities of water necessary for this area in order to maintain them in a productive state.

WASHINGTON STATE UNIVERSITY, The R. L. Albrook Hydraulic Laboratory.

Inquiries concerning the following projects should be addressed to Dr. E. Roy Tinney, Head, The R. L. Albrook Hydraulic Laboratory, Division of Industrial Research, Washington State University, Pullman, Washington.

(1689) STUDY OF FLUID FLOW IN PIPE NETWORKS.

(b) Personnel responsible for the design and/or operation of water and gas distribution systems.
(d) Analyses by analogue and digital computers.
(e) Flow distributions have been made with the McIlroy Analyzer for over forty cities, several gas systems, an air system, a generator cooling system, and several other unique systems. Losses throughout the system are obtained. Engineers use the analogue to design system pumps, tanks, and piping additions or revisions. A program has been prepared whereby some of the problems not readily solvable by the McIlroy Analyzer can be analyzed on an IBM digital computer.
(h) "Network Flow Distribution Using the McIlroy Analyzer or IBM 650 Digital Computer," by C.C. Lomax, Bulletin 247 is available upon request.

(2165) THE INFLUENCE OF LOGGING OPERATIONS ON RUN-OFF FROM PRECIPITATION.

(b) Laboratory project.
(d) Analytical with field investigation.
(e) Analysis of the run-off from watersheds on which extensive logging has been made is being conducted to determine the correlation between run-off and logging in regions where the rainfall is heavy and regrowth rapid.
(h) Paper submitted for publication.

(2631) ROCKY REACH HYDROELECTRIC DEVELOPMENT.

(b) Chelan County Public Utility District No. 1.
(d) Experimental; design.
(e) A 1:75 model 109 ft by 40 ft has been constructed of 7500 ft of the Columbia River to study construction phases and the operation of the complete development of the Rocky Reach site. Studies have been completed on the cofferdam layouts and tests are now underway on the operation of the spillway and fishway entrances. In addition, a 1:44.9 scale model of two bays of the spillway has been constructed in a large glass-sided flume to determine specifically the design of baffles on the apron and skip buckets on the ogee.
(h) Status reports to the client. Final reports in preparation.

(2632) PRIEST RAPIDS PENSTOCK GATE STUDIES.

(b) Pacific Coast Engineering Company.
(d) Experimental; design.
(e) A 1:18 model of fixed wheel intake gates for the Priest Rapids Hydroelectric Project has been constructed to determine the hydraulic downpull for several lip designs. A generalized study has also been made to investigate various designs of intake gates with a view toward a more economical design of gates and gantry cranes.
(h) Final report to client.

(2633) WATER WALL FOR ATOMIC REACTORS.

(d) Experimental; design.
(e) A 1:3 model of a large manifold has been constructed to determine the hydraulic stability, flow patterns, and pressure losses.
(f) Completed.
(h) Final report to client.

(2876) BROWNLEE FISH BARRIER.

(b) Idaho Power Company.
(e) An analytical development was pursued to determine the forces and three-dimensional shape of a 2800 feet long and 120 feet deep fish barrier that was built in the Brownlee hydroelectric development reservoir. The solution of the differential equations developed was carried out on an IBM 650 digital computer. In order to check the theory, a 1:150 scale model of the fish barrier was built. The model was also used to design the anchorage system.
(f) Completed.
(h) Final report published by the Idaho Power Company.

(2877) FISHWAY MODELS.

(b) Chelan County PUD No. 1.
(d) Experimental; design.
(e) Two 1:12 scale models have been built of the fish transportation facilities for the Rocky Reach Hydroelectric Development. One model is of the upper end of the ladder and orifice section of the facility and the second model is of the trifurcation at the junction of the powerhourse and spillway.
(f) Completed.
(h) Washington State Institute of Technology Technical Report No. 9, Part II, being printed.

(2878) HYDRODYNAMICAL STUDIES.

(b) Laboratory project.
(d) Theoretical.
(e) A mathematical analysis of segmental flip buckets has been developed using free streamline theory. Analysis gives the relation between the dimensions of the bucket, the thickness of the nappe, the face angle of the dam, and the exit angle of the jet. Evaluation of the integrals arising from the conformal transformation has been made using an IBM 650 digital computer. Experimental tests are being conducted as part of a Master's Program.

(2879) HYDRAULICS OF LEVEL IRRIGATION.

(b) Laboratory project cooperative with the Department of Agricultural Engineering.
(d) Theoretical and experimental.
(e) Analysis is being developed to define rate of advance and recession of the water front on a level irrigation border taking into account the infiltration. A tilting flume 75 feet long, 3 feet wide and 2 feet deep has been erected. A mechanical apparatus to simulate infiltration is being installed.

(3192) ADVANCE OF A SHALLOW LIQUID FRONT DOWN A DRY CHANNEL.

(b) National Science Foundation Grant.
(d) Theoretical and experimental; basic research.
(e) Mathematical analysis of equations is being conducted. Experiments will be conducted in a tilting flume to supplement and verify the theoretical approach. A glass lined tilting flume is under construction.

(3531) WANAPUM MODEL.

(b) Harza Engineering Company.
(d) Experimental; design.
(e) A 1:120 scale comprehensive model has been constructed of the Wanapum Project on the Columbia river. Cofferdam studies have been completed. Further tests will be concerned with velocity patterns and magnitudes in the vicinities of the fish ladders and spillway apron.
(h) Status reports to the client.

(3532) DIAMOND GARDNER MODEL.

(b) Diamond Gardner Company.
(d) Experimental; design.
(e) A distorted model, 1:150 horizontal scale 1:60 vertical scale, has been built of the Pend Oreille river downstream of Albeni Falls Dam. This model is being used to study the formation and growth of a sediment bar in the log booming area. Further studies will be concerned with corrective and preventive measures to insure adequate depth for booming operation in slack water.

(3533) NOXON MODEL.

(b) Ebasco Services.
(d) Experimental; design.
(e) A flume model to a scale of 1:50 has been constructed and tested to determine methods of preventing excessive erosion of the baffle teeth.
(g) Reshaping of the baffle teeth and "skip buckets" on the spillway indicate good energy dissipation without serious erosion of the structure or river bed and without low pressures.
(h) Report to client.

(3534) WELLS MODEL.

(b) Bechtel Corporation.
(d) Experimental; design.
(e) A 1:45 flume model of the spillway for the proposed Wells Dam was built and tested. These tests of the preliminary design were made to insure that the design was satisfactory from the standpoints of bed erosion, spillway and pier pressures, and discharge rating of the spillway.
(h) Report to client.

UNIVERSITY OF WASHINGTON, Fisheries Research Inst.

(3535) EFFECTS OF LOGGING ON THE PRODUCTIVITY OF PINK SALMON STREAMS IN ALASKA.

(b) Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service.
(c) Dr. William F. Royce, Director, Fisheries Research Institute, University of Washington, Seattle 5, Washington.

(d) Field investigation; applied research and development; some phases master's and doctoral theses.

(e) The objectives of this program are: (1) To define patterns of physical and biological conditions in the streams before and after logging so that changes may be measured as logging progresses; (2) to compare patterns of physical and biological changes between streams being logged and unlogged control streams; (3) to determine immediate causes of mortality of salmon eggs and larvae and when these causes are most operative; and, (4) to show whether a change in environment produced by logging will or will not alter an immediate mortality factor during periods when it is operative. The main work location is in the Hollis area of Southeast Alaska where four streams are being investigated, two to be logged, two to be left unlogged as controls. Included in the extensive overall program are studies of: (1) Composition of streambed materials; (2) nature, extent and effect of gravel movement; and, (3) permeability of streambed gravels.

(g) Results of preliminary studies indicate that salmon survival depends on the extent of gravel movement and degree of permeability which in turn both depend in part on streambed composition and flow. High mortalities of salmon eggs in two of the study streams have been attributed to extensive gravel movement caused by severe floods. On the other hand this type of mortality has not occurred in one of the control streams having a more stable streambed. Extensive mortalities of salmon eggs in the gravel have also been associated with periods of low stream flows, when interchange of water between stream and streambed is reduced and dissolved oxygen levels in the streambed are low.

(h) Progress report on file with Bureau of Commercial Fisheries, Juneau, Alaska. Several manuscripts of publications in preparation.

UNIVERSITY OF WASHINGTON, Charles W. Harris Hydraulics Laboratory.

(2884) A MODEL STUDY OF THE SPILLWAY SYSTEM FOR THE SOUTH FORK TOLT RIVER DAM.

(b) Department of Engineering, City of Seattle.

(c) Prof. E. P. Richey, 201 More Hall, Univ. of Washington, Seattle 5, Washington.

(d) Experimental investigation; design verification.

(e) Morning glory shaft spillway with conduit flowing as open channel. Horizontal and vertical bend in same. Ending in chute spillway standard stilling basins at end. Entire structure tested for hydraulic performance and proven satisfactory.

(f) Completed.

(g) Investigation indicated consultant's design to be satisfactory for the most part; some minor alterations made in the interests of economy.

(h) Report to Department of Engineering, Board of Public Works, City of Seattle. Contact this agency for copy of report.

(3536) A MODEL STUDY OF DOWNSTREAM MIGRANT COLLECTION FACILITIES ON MAYFIELD DAM, COWLITZ RIVER.

(b) City Light Company, Tacoma, Washington.

(c) Prof. E. P. Richey, 201 More Hall, Univ. of Washington, Seattle 5, Washington.

(d) Experimental investigation; design verification and/or correction.

(e) Primary separation by Louvre screens in power channel; fish bypassed through cascade of vanes in pier and conducted to secondary separator of as yet undetermined type.

(g) No significant results as yet.

(3537) FLOW VISUALIZATION ABOUT A SALMON.

(b) Salmon Fatigue Laboratory, University of Washington, Seattle 5, Washington in cooperation with U. S. Department of the Navy, Naval Ordnance Test Station, China Lake, California.

(c) Dr. Joseph C. Kent, University of Washington Seattle 5, Washington and Mr. Wallace Allen, NOTS, China Lake, Calif.

(d) Basic research.

(e) To photograph the pattern of turbulence created by a fish swimming in still or moving water with use of plastic beads and dye. To determine magnitude of drag of flexible fish to solid bodies.

UNIVERSITY OF WISCONSIN, Hydraulics Laboratory.

(149) THE EFFECT OF SUBMERGENCE ON FLOW CHARACTERISTICS OF HYDRAULIC STRUCTURES.

(b) Laboratory project.

(c) Prof. J. R. Villemonte, Hydraulics Lab., Univ. of Wisconsin, Madison 6, Wisconsin.

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

(e) The effects of submergence on discharge of large circular thin-plate weirs and orifices and broad-crested weirs are being studied.

(g) General correlation equations have been developed for all thin-plate weirs Parshall Flumes, and one type of Ogee spillway.

(h) "Effect of Submergence on Petenwell Spillway Model," by M. Desmukh, M.S. Thesis, University of Wisconsin, 1956.
"Submerged Flow in Circular Weirs and Orifices," A. Achyuthan, M.S. Thesis, Univ. of Wisconsin, 1959.

(368) DEVELOPMENT OF A FLOOD FORECASTING PROCEDURE FOR THE WISCONSIN RIVER.

(b) Laboratory project.

(c) Dr. A. T. Lenz, Chairman of Dept. of Civil Engineering, University of Wisconsin.

(d) Experimental; M.S. thesis.

(e) Fundamental studies of rainfall-runoff relations were made to estimate runoff values to be used in flood forecasting by the unit hydrograph method.

(f) Suspended.
(g) Six M.S. and two Ph.D. theses have been completed and are available on loan.
(h) "Snow Melt Runoff," H. Zoller and A.T. Lenz, ASCE Hydro. Div. Paper 1834, November 1958.

(956) ENERGY LOSS IN LIQUID FLOW IN PIPES AND FITTINGS UNDER HIGH PRESSURE.

(b) Laboratory project in cooperation with the Ladish Company, Cudahy, Wisconsin, and the Wisconsin Alumni Research Foundation.
(c) Prof. J. R. Villemonte, Hydraulics Laboratory, Univ. of Wisconsin, Madison 6, Wis.
(d) Theoretical and experimental; applied research and design for B.S., M.S. and Ph.D. theses.
(e) Energy loss measurements in straight pipes and fittings have been completed on sizes 1/4 inch to 2 inches. Pressure range 0-2500 psi, temperature range 60 to 120°F. Reynolds number range 50 to 150,000.
(f) Suspended.
(g) If viscosity, density, and temperature relations are known, the standard pipe friction theory applies at high pressures. The fitting loss constants for laminar flow are about 3 times those for turbulent flow when N_R=2000. The loss gradually reduces to zero at N_R=150.
(h) "Pipe Friction Loss at High Pressures," J.G. Slater, J.R. Villemonte, H.J. Day, ASCE Hydro Div. Proceedings Paper 1163, February 1957.
"Energy Losses in Bends of Large Curvature Ratios," A. El Kough, Ph.D. Thesis, Univ. of Wisconsin, 1957.
Several B.S. and M.S. Theses.

(957) THE THERMODYNAMICS OF LIQUIDS.

(b) Laboratory project cooperative with the Dynex Corporation, Milwaukee, Wisconsin.
(c) Prof. J.R. Villemonte, Hydraulics Laboratory, Univ. of Wisconsin, Madison 6, Wis.
(d) Theoretical and experimental; basic and applied research for Ph.D. thesis.
(e) New equipment has been assembled to increase the pressure range to 10,000 psi. The viscosity-pressure-temperature relationships for several petroleum oils will be studied using the Gunaji high-pressure falling sphere viscometer.
(f) Suspended.
(g) A general correlation has been developed for the viscosity-pressure-temperature relationships for five industrial petroleum oils. Pressure range 0-2000 psi, temperature range 60-120°F.

(959) HYDROLOGIC INVESTIGATION OF LAKE MENDOTA DRAINAGE BASIN.

(b) Part of a larger project entitled "Origin and Quantities of Algal Fertilizers Tributary to Lake Mendota." Cooperative study sponsored by University of Wisconsin.
(c) Dr. A. T. Lenz, Chairman of Department of Civil Engineering, University of Wisconsin, Madison 6, Wisconsin.
(d) Field investigation; applied research for Ph.D., M.S. theses.
(e) Five stream gaging stations have been installed to measure tributary inflow to Lake Mendota and Yahara River outflow. Precipitation records are being obtained from fourteen recording rain gages. Current efforts are concentrating on publication of summary of results to date.
(f) Suspended.
(g) Three M.S. and six B.S. and two Ph.D. theses completed, (available on loan).

(1181) VORTEX FLOW FROM HORIZONTAL THIN-PLATE ORIFICES.

(b) Wisconsin Alumni Res. Foundation and J. C. Stevens, Consulting Engr., Portland, Oregon.
(c) Prof. J.R. Villemonte, Hydraulics Laboratory, University of Wisconsin, Madison 6, Wis.
(d) Theoretical and experimental; basic research for M.S. and Ph.D. theses.
(e) The effects of vorticity on orifice discharge were studied over a wide range of vorticity, head, and orifice size.
(g) A new parameter, the vortex number, was developed as the ratio of inertial and centrifugal forces. A general correlation procedure was also developed for estimating discharge rates through orifices with varying degrees of vorticity.
(h) "Vortex Flow Through Horizontal Orifices," J.C. Stevens, R.C. Kolf, ASCE Sanitary Div. Proceedings Paper 1461, December 1957.

(1707) PROBLEMS OF SCOUR AT BRIDGE AND CULVERT OPENINGS.

(b) Consolidated's Civic Foundation, Inc.
(c) Dr. A.T. Lenz, Chairman, Dept. of Civil Engineering, Univ. of Wis., Madison 6, Wis.
(d) Experimental; for M.S. and B.S. theses.
(e) Hydraulic model studies were made to determine methods of estimating probable scour pattern for a proposed structure having certain physical site characteristics and conditions of flow. Remedial methods were studied at existing structures so scour will be reduced or eliminated.
(f) Completed.
(g) Causes of scour at one location were correlated with topography and water levels. Study of the design of training walls to get better flow under the bridge structures was completed.
(h) Three M.S. theses are available on loan.

(1709) CALIBRATION OF V-NOTCH WEIRS AT ENDS OF CULVERTS.

(b) Wisconsin Culvert Co.
(c) Dr. A.T. Lenz, Chairman, Dept. of Civil Engineering, Univ. of Wis., Madison 6, Wis.
(d) Experimental; for M.S. and B.S. theses.
(e) A 90° V-notch was installed in a rectangular flume and was used as a control for flows up to and above the top of the weir plate.
(f) Completed.
(g) Mathematical interpretation of the flows as the summation of V-notch and rectangular weir flows was made and coefficients determined to express the total flow as a function of the head above the bottom of the V-notch.

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(h) One B.S. thesis available on loan.

(3538) ANALOG MODELS OF GROUNDWATER FLOW.

(b) Marathon Paper Co., Wausau, Wisconsin.
(c) Dr. A.T. Lenz, Chairman of Dept. of Civil Engineering, Univ. of Wis., Madison 6, Wis.
(d) Experimental; M.S. thesis.
(e) This problem deals with the movement of two miscible fluids of different densities in an aquifer - one is water and the other is a waste product from the manufacture of paper.
The problem is analyzed by utilizing an electric analog plotter and by a two-dimensional hydraulic model.
(g) One M.S. thesis is available on loan.

(3539) THE EFFECT OF BOUNDARY ROUGHNESS AND CONFIGURATION ON TURBULENCE LEVEL AND VELOCITY DISTRIBUTION.

(b) Wisconsin Alumni Research Foundation.
(c) Prof. J.R. Villemonte, Hydraulics Lab., Univ. of Wisconsin, Madison 6, Wis.
(d) Theoretical and experimental; basic research for M.S. and Ph.D. theses.
(e) New instrumentation has been developed to measure turbulence levels in pipes and ducts. The effects of boundary roughnesses on the decay of extra turbulence caused by a variety of boundary configurations is being studied.

(3540) MODEL STUDIES OF PUMP INLET STRUCTURES.

(b) Wisconsin Alumni Res. Foundation in cooperation with the Government of West Bengal, India.
(c) Prof. J.R. Villemonte, Hydraulic Laboratory, University of Wisconsin, Madison 6, Wis.
(d) Experimental; design for M.S. thesis.
(e) A 1/16-scale model of the inlet structure for one of four axial flow pumps at the Uttarbhag Pumping Station (Sonarpur, India) has been made. Studies of inlet flow patterns and pressure coefficients for a wide variety of flow situations are being made for the purpose of reducing the cavitation threshold.

(3541) HYDRAULIC CHARACTERISTICS OF CIRCULAR SEDIMENTATION BASINS.

(b) National Institute of Health, Washington, D. C.
(c) Prof. G. A. Rohlich and Prof. J. R. Villemonte, Hydraulics Laboratory, Univ. of Wisconsin, Madison 6, Wisconsin.
(d) Experimental; basic research and design for M.S. and Ph.D. theses.
(e) A versatile, transparent, 6-ft dia. cylindrical basin has been constructed which will permit model studies at depth to diameter ratios of 0.67 to 0.083. Flow patterns and dispersion characteristics will be observed over a wide range of overflow rates. New instrumentation for measuring small velocities and dispersion functions are being developed.

(3542) RESEARCH ON FLOW IN CULVERTS.

(b) Laboratory project.
(c) Dr. J.G. Woodburn, Prof. of Civil Engineering, Univ. of Wisconsin, Madison 6, Wis.
(d) Theoretical and experimental; design; M. S. and Ph.D. theses.
(e) Hydraulic characteristics of a variety of culvert models will be studied, with particular attention to the location of critical depth under various conditions of inlet and discharge control.

WORCESTER POLYTECHNIC INSTITUTE, Alden Hydraulic Laboratory.

Inquiries concerning the following projects should be addressed to Prof. L.J. Hooper, Director, Alden Hydraulic Laboratory, Worcester Polytechnic Inst., Worcester 9, Mass.

(1963) METER CALIBRATION.

(b) Foxboro Company.
(d) Experimental; for design.
(e) Laboratory calibration of various sizes from 1" to 36" diameter magnetic flow meters.

(2411) METER CALIBRATION.

(b) Foster Engineering Company.
(d) Experimental; for design.
(e) Laboratory calibration of various sizes from 2" to 24" diameter.

(2638) METER CALIBRATION.

(b) Penn Instrument Div. -Burgess-Manning Co.
(d) Experimental; for design.
(e) Calibration of both open flow nozzles and venturi meters from 6" to 30" diameter pipe.

(2897) ELRAMA POWER PLANT.

(b) Stone and Webster Engineering Corp.
(d) Experimental; for design.
(e) A distorted model with vertical scale of 1/90 and horizontal scale of 1/30 was constructed of a section of the Monongahela River upstream and downstream of the power plant. Velocity distribution in the area of the intake and outlet as well as heat transfer characteristics of the river were determined.
(f) Completed.

(2890) NEW JERSEY ZINC COMPANY.

(b) Albright and Friel, Inc.
(d) Experimental; for design.
(e) A 1/250 horizontal scale and 1/80 vertical scale model of a section of the Delaware River was constructed to study the flow pattern in the area of the New Jersey Zinc plant.
(f) Completed.

(2891) PENNSYLVANIA RAILROAD.

(b) Pennsylvania Railroad.
(d) Experimental; for design.

(e) A 1/200 horizontal scale and a 1/60 vertical scale model of a section of the Delaware River was constructed. The flow pattern in the river near the Pennsylvania Railroad pier was studied.
(f) Completed.

(3202) NIAGARA POWER PROJECT (PASSNY).

(b) Uhl, Hall and Rich.
(d) Experimental; for design.
(e) A 1/50 scale model of a section of the Niagara River has been reproduced including the area for the water intakes for the development. The model intakes were duplicated along with gate structures and the two underground conduits leading to the outlet structure at the power canal. The power canal along with the Tuscarora pump-generating station and the Lewiston power station were represented. Studies of water level in canal and conduit for various operating conditions were made.
(f) Completed.

(3543) NIAGARA POWER PROJECT (PASSNY).

(b) Uhl, Hall and Rich.
(d) Experimental; for design.
(c) Prof. L. J. Hooper.
(e) A 1/25 scale model of a section of one power conduit plus the gate structure has been installed in the 3 ft glass sided flume. A model gate and model stop logs have been fabricated. Tests will be conducted of the planned conduit filling operation during which the dynamic forces on the stop logs will be measured.
(g) Test in progress.

(3544) SWING CHECK VALVES.

(b) Atwood and Morrill Company.
(d) Experimental; for design.
(e) Tests including determination of pressure drop, leakage, disc orientation were conducted on a variety of valves varying in nominal size from 2 inch to 16 inch.
(g) Tests in progress.

(3545) HYDRAULIC CYCLONE.

(b) Bird Machine Company.
(d) Experimental; for design.
(e) Evaluation of the percentage break up of the flow between accepts and rejects in a cyclone type separator were determined. The character of the flow in the three different flow sections was also analyzed.
(g) Tests in Progress.

(3546) SUN OIL COMPANY - SINCLAIR REFINING COMPANY.

(b) Bird Machine Company.
(d) Experimental; for design.
(e) A 1/100 horizontal scale and 1/50 vertical scale model of a section of the Delaware River was constructed to study the flow pattern in the river area adjacent to structures owned and operated by Sun Oil Company and Sinclair Refining Company.

(3547) TRONERAS PROJECT.

(b) Gannett, Fleming, Corddry and Carpenter, Incorporated.
(d) Experimental; for design.
(e) A 1/43 scale model of a diversion tunnel intake has been constructed along with a section of the Guadalupe River upstream of the intake. The flow pattern for a range of expected flows will be studied. In addition flow studies and pressure measurements in the intake structure are to be made.
(g) Model under construction.

(3548) OTISCO DAM.

(b) O'Brien and Gere.
(d) Experimental; for design.
(e) A 1/20 scale model of a section of the river bed including the old, new and rebuilt spillways have been constructed. It is proposed to study the flow pattern over the new spillway plus emergency channels with a view to locating guide walls, gate structures, spilling pool boundaries and a section of highway.
(g) Test in progress.

(3549) PEIXOTO H.E.D.

(b) Ebasco International.
(d) Experimental; for design.
(e) A 1/70 scale model of a section of the Rio Grande River in Brazil was duplicated. In addition three structures comprising the powerhouse, arch dam and spillway for the development were installed. The purpose of the test program was to study the flow pattern from the spillway and powerhouse in order to determine adequate protection for the upstream river banks.
(f) Tests completed.

U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, Soil and Water Conservation Research Division.

EASTERN SOIL AND WATER MANAGEMENT RESEARCH BRANCH.

Runoff and Erosion Control Section.

(1966) IMPROVED SYSTEMS FOR CONTROL OF RUNOFF AND EROSION.

(b) Cooperative with the following state Agricultural Experiment Stations and other agencies for use throughout the 31 Eastern States: Georgia, Illinois, Indiana, Iowa, Maine, Minnesota, Mississippi, Missouri, New Hampshire, New York, Wisconsin. Some studies under this project are reported in more detail as cooperative research under the respective states.

(c) Dr. L. B. Nelson, Eastern Soil and Water Management Research Branch, Plant Industry Station, Beltsville, Maryland.

(d) Experimental and field investigation, both basic and applied for development and design.

(e) The purpose of these studies is to obtain fundamental information on the mechanics of rainfall runoff and erosion, to determine the effects of the basic factors -- climatic, topographic, soil and cover on runoff and soil loss, and to evaluate various soil and water management practices from the standpoint of runoff and erosion control in the humid region. Erosion control practices including terracing and strip cropping are developed and improved to function effectively in the present day multiple-row-power system of farming. The relationships and evaluations secured from the studies are combined into equations or graphs for estimating runoff and individual field soil loss for use in the design of conservation farm plans and in determining probable sediment production for use in watershed protection programs. The work is carried on in laboratory and fractional acre plot studies and on primary unit watersheds. Both meteorological and hydrological measurements are made. The basic data are assembled in a central statistical laboratory for placement on punch cards for machine and graphical correlation analysis.

(g) Work continued on evaluation of factors in a universal soil loss prediction equation. Rainfall erosion indices and their monthly distribution curves have been computed for 150 locations in the U.S. where rainfall erosion is serious. Crop-management factors for use in the equation have been evaluated from existing data for 108 crop cover-management combinations. Additional runoff and soil loss data were secured from fractional acre plots under both natural and simulated rainfall.

(h) "How Intense Rainfall Affects Runoff and Soil Erosion," A.P. Barnett, Agr. Engin., Vol. 39, No. 11, pp. 703-707 711, Nov.1958.
"Influence of the Coarse Fraction in Two Maine Potato Soils on Infiltration, Runoff and Erosion," W.J. Grant and R. A. Struchtemeyer, SSSA Proceedings 23, No. 5, pp. 391-394, September-October 1959.
"The Effect of Farming Across Terraces with Straight Row Field Operations," B.A. Jones, R.E. Burwell, H.B. Atkinson, R.C. Hay, and C.A. Van Doren, Transactions ASAE 2, No. 1, pp. 115-117, 119, 1959.
"Agricultural Drought in New England," R.S. Palmer, New Hampshire Agr. Expt. Sta. Tech. Bul. 97, December 1958.
"Highway Erosion Control in N.W. Georgia," E.C. Richardson, E.G. Diseker, and B. H. Hendrickson, Soil Conservation, USDA, Vol. 24, pp. 244-245, October 1958.
"A Rainfall Erosion Index for a Universal Soil-Loss Equation," W.H. Wischmeier, Soil Sci. Soc. Amer. Proc. 23, pp. 249-250, May-June 1959.

U. S. SALINITY LABORATORY.

(26) DRAINAGE INVESTIGATIONS IN COACHELLA VALLEY, CALIFORNIA.

See University of California, College of Agriculture, Division of Irrigation and Soils, page 6.

(2172) MOVEMENT AND DISTRIBUTION OF WATER AND SALTS IN UNSATURATED SOIL.

(b) Laboratory project.

(c) Dr. L.A. Richards, Post Office Box 672, Riverside, California.

(d) Field investigations; basic research.

(f) Suspended, discontinued.

(h) "Solutions of the Flow Equation for the Drying of Soils and Other Porous Media," W.R. Gardner, Soil Sci. Soc. Amer. Proc. 23: 183-187, 1959.
"Transpiration of Alfalfa Determined from Soil Water Content Changes," Gen Ogata, L.A. Richards and W.R. Gardner, Soil Science, 1959.

(2173) EVAPORATION FROM FIELD SOILS IN THE PRESENCE OF A WATER TABLE.

(b) Laboratory project.

(c) Mr. Ronald C. Reeve, P.O. Box 672, Riverside, California.

(d) Experimental; applied research.

(e) A study that is being conducted at selected field sites to develop a reliable method for measuring evaporation from soils in the field and to determine the applicability of the theory for evaporation from soils in the presence of a water table to the solution of field problems.

(2648) EVALUATION OF THE LEACHING REQUIREMENT THEORY FOR CONTROLLING SOIL SALINITY.

(b) Laboratory project.

(c) Mr. R.C. Reeve, U.S. Salinity Laboratory, P. O. Box 672, Riverside, California.

(d) Experimental; basic research.

(e) Involves the measurement of both inflow and outflow of both water and salt from soil columns in lysimeters in which crops are grown under varying water table depths and irrigation regimes. To test the validity

of the leaching requirement theory for controlling soil salinity and to determine the effects of soil salinity and water table conditions on the growth of crops.

(g) Experimental results add support to the leaching requirement theory.

(2900) ENTRY OF WATER INTO SOILS.

(b) Laboratory project.

(c) Dr. W.R. Gardner, P. O. Box 672, Riverside, California.

(d) Theoretical and experimental; basic research.

(e) The diffusion equation is applied to the movement of water into soil. The effect of water content and soil properties on intake rates is determined. The influence of exchangeable sodium and salinity of irrigation water is also included.

(h) "The Effect of Electrolyte Concentration and Exchangeable Sodium Percentage on the Diffusivity of Water in Soil," W.R. Gardner, M.S. Mayhugh, J.O. Goertzen, and C.A. Bower, (submitted for publication).

WATERSHED TECHNOLOGY RESEARCH BRANCH.

(150) EXPERIMENTAL WATERSHEDS STUDIES.

(b) Cooperative with State Agricultural Experiment Stations, Soil Conservation Service, U.S. Bureau of Reclamation, Univ. of Iowa, St. Anthony Falls Hydraulic Laboratory, University of Idaho, Central and Southern Florida Flood Control District, and the Wisconsin Valley Improvement Company.

(c) Mr. Louis M. Glymph, Jr., Watershed Tech. Research Branch, Plant Industry Station, Beltsville, Maryland.

(d) Experimental; field and laboratory; for design and planning of watershed protection and flood prevention projects, upstream structures, and farm water disposal systems.

(e) The purpose of the studies is to develop procedures for predicting flood runoff and water yield from ungaged upstream watersheds. Studies are carried out on watersheds ranging in size from 1 to 75,000 acres. In addition to rainfall and runoff measurements, studies are made of evapotranspiration, moisture storage and transmission through the soil, accretion and movement of groundwater, hydrologic effect of physiography, and ground surface conditions, vegetal covers and soils and geology, and the effect of conservation farming on runoff, erosion and the hydrologic performance of underlying aquifers. Hydrologic records are being obtained on some 153 watersheds at: Safford and Tombstone, Arizona; Ft. Lauderdale and Vero Beach, Florida; Watkinsville, Georgia; Monticello, Illinois; Iowa City, Iowa; College Park and Hagerstown, Maryland; East Lansing, Michigan; Oxford, Mississippi; McCredie, Missouri; Hastings, Nebraska; High Point, North Carolina; Newell, South Dakota; Albuquerque and Santa Rosa, New Mexico; Cohocton and Dutchess County, New York; Coshocton, Ohio; Stillwater, Oklahoma; Riesel (Waco), Texas; Blacksburg, Virginia; Moorefield, West Virginia; Colby, Fennimore and La Crosse, Wisconsin; Montpelier, Vermont. Other studies include analysis and interpretation of accumulated records and the Cooperative Water Yield Procedures Study at Lincoln, Nebraska by Soil Conservation Service, Bureau of Reclamation and Agricultural Research Service to develop methods for estimating the effect of watershed treatment upon yields of stream flow.

(g) Summarization for a document, "Selected Runoff Events," for approximately 60 watersheds is in process. It will give precipitation and runoff detail for selected storm runoff events on each of the watersheds. The detailed data for substantially all other watersheds is available to all users at the offices of the various project locations. A major experimental watershed is being established in the Pacific Northwest with headquarters at Boise, Idaho. The selection of an experimental watershed of about 50 sq. mi. in area is under way. At Riesel, Texas, for the Blackland's soils and land use, antecedent soil moisture has been shown to be of major importance in defining the precipitation-runoff relationship. The functional relationships developed are being tested for estimating volumes of storm runoff from large, mixed cover watersheds.

Procedures have been developed for synthesizing storm hydrographs for the Claypan Prairies from the data for Edwardsville, Illinois watersheds. Computed hydrographs have been found to agree well with observed hydrographs. Claypan Prairie data from small watersheds in Ohio and Missouri have been found to follow the same principles developed in Illinois. Analyses of flow recession curves for runoff data at Ft. Lauderdale, Florida indicate three distinct types of flow: surface flow, inter-litter flow, and subsurface flow. Analytical procedures are being developed for separating the three components of flow from observed storm hydrographs. Studies at Coshocton, Ohio have also indicated several components of storm flow. Lysimeters data at Ft. Lauderdale, Florida have indicated that depth to the free water surface is an important factor influencing watershed retention and riparian uses of stream flow. Lysimeter and groundwater well elevations at Coshocton, Ohio indicate that depth of plant rooting affects watershed retention. Lysimeter studies also indicated that evaporation from the soil is almost equal in magnitude to transpiration by a crop. Studies of streamflow data from four small upland agricultural watersheds at Coshocton, Ohio showed that annual streamflow from a 44-acre watershed converted from cultivation to farm woods has decreased by over five inches annually after 20 years while annual streamflow from cultivated watersheds on which conservation practices were installed was reduced by a little more than one inch. Also at Coshocton, Ohio, data from small single cover watersheds were analyzed for effects of land use and treatment on surface runoff amount. From a watershed of

abandoned and eroded cropland which has been converted to woodland in 1939, the amount of surface runoff has been greatly reduced. For crop-rotation land, over a complete 4-year rotation of corn-wheat-meadow-meadow on well drained soil, the total surface flow was reduced by four inches by a treatment of contour tillage, improved fertility, and deep-rooted legume. When compared to prevailing practices of straight-row farming, fairly low fertility, and shallow-rooted meadow crop this was a 46 percent reduction. The greatest part of this reduction was in the corn season. On slowly permeable soils there was no overall runoff reduction for the crop rotation cycle, although there was a reduction in the corn season. Analysis of lysimeter percolation data at Coshocton, Ohio indicates how several levels of crop management affect contributions to groundwater. After 19 years the lysimeters managed for high crop yields are percolating about two inches less than the lysimeters managed for average crop yields. From another set of lysimeters, annual percolation was on the average five inches less from a deep-rooted alfalfa-brome cover than from a shallow-rooted blue grass cover. A study of ground water depletion curves at Coshocton, Ohio showed that ground water flow past the stream gage before improved agricultural practices or tree planting was more sustained than it was in the period after establishment of a complete cover. Ground water well records in the wooded watershed showed a general decline of about one inch per year, coincident with the conversion from shallow-rooted grass to deep-rooted trees. A study of average annual amounts of streamflow versus size of drainage area for the Coshocton area indicated that much of the infiltration on small upland watersheds recurred as streamflow at downstream points. Average annual yield tended to become a constant for larger drainage areas regardless of size. The Cooperative Water Yield Procedures Study was continued. The objective of the study is to devise methods for estimating the effects of land use and treatment on stream flow of both small watersheds and major basins. A vast amount of literature has been reviewed and data analyzed, but the work is not yet completed. Plans are underway to obtain geologic information pertinent to the accretion and movement of groundwater on selected watersheds over the nation where hydrologic records are currently maintained. This geologic information is needed on a range of watershed sizes and geologic formations to determine the conformation and lateral extent of underlying aquifers and to determine the cross section of water bearing alluvial deposits for use in the design and interrelation of groundwater observations toward a more complete determination of total water yield as related to watershed treatment.

(h) "Evaluation of Agricultural Hydrology by Monolith Lysimeters," L.L. Harrold and F.R. Dreibelbis, USDA Tech. Bul. No. 1179, 1958.
"Effects of Vegetation on Soil Moisture," L.L. Harrold, Trans. Amer. Soc. Agr. Engr., Vol. 1, No. 1, 1958.
"Determination of Peak Discharge-Frequency Relationships for Streams Within a Selected Area in California," E.L. Neff and P.C. Sheffer, Watershed Technology Research Branch, ARS-41-32, September 1959.
"Discussion of 'Factors Affecting Evaporation from Plants and Soils'", C.B. Tanner, Jour. of Soil and Water Conserv., Sept. 1957. A.L. Sharp, Jour. of Soil and Water Conserv., Vol. 14, No. 2, pp. 78-79, March 1959.
"Prediction of Soil Moisture from Rainfall and Pan Evaporation Records," M.A. Hartman, R.W. Baird, J.B. Pope and W.G. Knisel. Presented to Assoc. Southern Agr. Workers, Memphis, Tenn., Feb. 1959.
"Problems Involved in Determining the Effects of Land Use and Treatment on Water Yields," A.L. Sharp, A.E. Gibbs, and W. J. Owen. Paper presented at Amer. Geophy. Union, Washington, D.C., May 1959.
"Runoff - How Fast and How Much," J. B. Burford and J.H. Lillard, Soil Conservation, Vol. 24, pp. 81-83, November 1958.
"Transpiration Evaluation on Plastic-covered Lysimeters in Corn," L.L. Harrold, D.B. Peters, F.R. Dreibelbis, and J.L. McGuinnes, Soil Sci. Soc. Amer. Proceedings, Vol. 23, No. 2, pp. 174-178, March-April, 1959.
"Effects of Land Use on Seasonal Streamflow Amounts," D.L. Brakensiek and C.R. Amerman, pending publication transactions, Amer. Soc. of Ag. Eng.
"Selecting the Water Year for Small Agricultural Watersheds," D.L. Brakensiek, Trans. Am. Soc. of Agr. Engr., Vol. 2, No. 1, pp. 5-8, 1959.

(1723) THE HYDRAULICS OF CONSERVATION STRUCTURES.

See St. Anthony Falls Hydraulic Laboratory Projects Nos. 111, 1168, 1929, 2386 and 2860.

(b) Cooperative with the Oklahoma and Minnesota Agricultural Experiment Stations, with St. Anthony Falls Hydraulic Laboratory, and Illinois State Water Survey, Urbana, Ill.

(c) Mr. Louis M. Glymph, Jr., Watershed Technology Research Branch, Plant Industry Station, Beltsville, Maryland.

(d) Experimental; applied research for development and design.

(e) Research dealing with the design, construction, and testing of structures for controlling and conserving soil and water are carried out under this project. Field studies are made to determine the causes of deterioration of drainage ditches, terrace outlets, and hydraulic structures that have failed in service. Laboratory experiments in methods of preventing such deterioration are supplemented by field tests of those measures of devices that appear promising. At the Stillwater, Oklahoma Outdoor Hydraulic Laboratory tests are being made to establish friction coefficients of various vegetative linings for use in the Manning

channel flow formula, the hydraulics of trash racks on drop spillways are under study, and studies are being continued on the use of highway culverts for measuring flow rates. At the St. Anthony Falls Hydraulic Laboratory studies were continued on the capacity and performance of the hood inlet to the closed conduit spillway and studies were initiated on the hydraulic design characteristics of anti-vortex devices for drop spillways. Cooperative studies on drop inlets were continued with the Illinois State Water Survey at Urbana, Illinois.

(g) At the St. Anthony Falls Laboratory at Minneapolis, Minn. an electronic computer program was developed to facilitate the analysis of the voluminous data that has been collected from tests of the hood inlet to permit the ready determination of optimum dimensions for desired hydraulic performance. General regression equations for performance of tile junctions were developed and these equations, together with theoretical equations, have been applied in the analyses. Indications are that the junction energy loss for many agricultural drainage systems will be so small that it can be neglected. Results indicate that the junction between a main and a lateral can be made in the simplest manner and at the most convenient angle without introducing significant losses. At Stillwater, Oklahoma, full scale tests were made of the hydraulic characteristics of deck grating as an anti-vortex platform for a closed conduit spillway. Both clear water and trash-laden flows were used. Debris accumulation on the grating during pipe flow reduced the discharge capacity by 50 percent. Model studies are underway to develop improved design for a debris guard to be used with a solid table top anti-vortex device. Investigations of the magnitude of retardance coefficients for row crops in diversion terraces were made for a variety of row crops. Data processing is underway.
At the St. Anthony Falls Laboratory, model studies were made to assist in the design and flow rating of flumes for construction in the relatively steep channel system of the Sleepers River Watershed in Vermont. Both the capacity and performance of these weirs were found to be affected considerably by the roughness of the approach channel. The general form of the rating curve was determined using various model roughness. The applicable rating of the weir will be determined by field measurements. A flow measuring flume was designed and tested at Stillwater, Oklahoma for use in Walnut Gulch near Tombstone, Arizona. Model studies showed that the flume controlled the flow, that hydraulic heads could be measured in the throat of the flume, and that a satisfactory rating would be developed. A V-notch weir was designed for installation at the upstream end of highway culverts for Virginia hydrologic studies. The combined weir and culvert constitute a flow measuring device of satisfactory accuracy. The structure was calibrated by model studies for both clean entrance conditions and for sand deposit conditions. The hydraulics of the table top anti-vortex baffle when used with a two-way entry to the drop inlet type spillway will be studied in models at the St. Anthony Falls Laboratory. Air flow will be used instead of water on some phases of the study to speed up the investigations. Various designs for debris guards on spillways will be developed, tested, and rated and studies of the hydraulic performance of vegetated spillways and waterways will be continued at the Stillwater, Oklahoma Outdoor Hydraulics Laboratory.

(h) "Discussion of 'Flow Through Circular Weirs'," J.C. Stevens, Proceedings American Society of Civil Engineers, Paper 1455, Vol. 83, No. HY 6, December 1957, F.W. Blaisdell, Proc. of Hydr. Div. ASCE, Vol. 84, June 1958.
"Retardance Coefficients for Row Crops in Diversion Terraces," W.O. Ree, Transactions of American Society of Agricultural Engineers, Vol. 1, No. 1, 1958.
"Tests of a Closed Conduit Spillway Debris Guard and Anti-Vortex Baffle," W. O. Ree and W. R. Gwinn, WTRB, SWCRD, Research Report No.313, Oct. 1958.
"Discussion of 'Some Experiments with Emergency Siphon Spillways', Warren McBirney, Proceedings of Hydraulics Division, American Society of Civil Engineers, Paper No. 1807, October 1958," by F. W. Blaisdell and H. W. Humphreys, Proceedings of Hydr. Div. ASCE, Vol. 85, pp. 103, April 1959.

(2175) SEDIMENTATION IN RESERVOIRS, STREAMS AND VALLEYS.

See also Colorado State University Project No. 3402, page 22, California Institute of Technology Project No. 2748, page 4, and Massachusetts Institute of Technology Project No. 3089 page 46.

(b) Cooperative with State Agricultural Experiment Stations in Mississippi, Nebraska and New York, with the University of Mississippi and with Massachusetts Institute of Tech. at Boston, Mass.

(c) Mr. Louis M. Glymph, Jr., Watershed Tech. Research Branch, Plant Industry Station, Beltsville, Maryland.

(d) Experimental; field and laboratory.

(e) Field and laboratory studies are made to determine sediment sources in watersheds, the character and amount of sediment carried out of watersheds, the nature and rate of movement in channels, the nature and rate of streambank erosion, and the nature and rate of deposition of sediment in channels, on flood plains and in reservoirs and harbors. Field studies generally are confined to watersheds of less than 100 square miles in area. Evaluation studies are made of various types of control measures to determine their effectiveness in reducing sedimentation damages. The work is oriented to supply information for planning and design of watershed treatment programs in connection with soil conservation

and flood prevention work. Studies are being carried on from field headquarters at Oxford, Miss.; Lincoln and Hastings, Nebr.; and East Aurora, New York.

(g) At Riesel, Texas, analysis of data collected in the 1938 to 1943 period indicate an annual gross erosion rate ranging from 7.3 to 9.4 tons per acre on areas of 5900 to 21 acres respectively at the Blacklands Experimental Watershed. The measured sediment from the same areas varied from 1.3 to 6.4 tons per acre with an average sediment deliver ratio of about 0.35. A decrease in sediment delivery ratio with increasing drainage area size was indicated. An analysis of soil loss records for 3 acre plots in the Riesel watershed study area indicates that the sediment production is 3 times larger from cotton cropped areas than from oat cropped areas.

Sediment investigations of stock water ponds in the Walnut Gulch watershed of Arizona have indicated annual sediment yields varying from 0.55 to 1.55 tons per acre with variations depending upon soil types, drainage slopes, and rainfall and runoff. The drainage areas involved range from 18 to 376 acres.

In the Republican River drainage basin near Hastings, Nebr., two watersheds in the 400-acre size class have been studied. One area was farmed using conventional straight row methods and the other using recommended conservation practices on a portion of the watershed. In calendar year 1958 sediment yield for the conventional watershed was 3.0 tons per acre and 2.6 tons per acre from the area using recommended conservation practices. Reduction in yield decreases with increasing storm activity.

In the Pigeon Roost Creek watershed, near Oxford, Miss., two years of detailed data collection indicate gross erosion rates varying from 6.5 to 20.3 tons per acre (of which about 20 percent is from gully erosion) from drainage areas ranging from 114 to 17,980 acres. Cultivation within the areas varies from 3 to 29 percent. Available data indicates that unmeasured sediment load in Pigeon Roost Creek varies from 8 percent to 34 percent of the total transport, depending upon station location, and averages about 20 percent. A study of data for the Medicine Creek watershed of Nebraska, between 1951 and 1958, is being made to develop methods of predicting long-time sediment yields. Preliminary results indicate that the flow-duration, sediment-rating curve approach is a promising one although continuing study by regression analysis may indicate other more applicable procedures.

At Coshocton, Ohio, 3 years of observation of the effects of the plow-plant system on soil loss in lieu of conventional plowing and tillage operations indicate that the peak rates of runoff and the amount of soil loss per acre is much less from the flow-plant watershed.

A study of deposition in flood retarding reservoirs in the loessial hills area of Nebraska, Iowa, and Kansas, has led to the development of a method for predicting sediment distribution and relation between sediment depth and outlet sill elevation. It is planned to expand this study to other areas utilizing resurvey data supplied by the Soil Conservation Service.

Studies in Miss. have established the existence of a discontinuity in stage-discharge relationships on some sand bed channels which is related to bed configuration. The flow at a given stage may be double at one time what it is at another depending upon the flow resistance which is in turn related to the stream bed configuration (dune, antidune, plane). Analysis of the average bed elevations, as obtained by cross-section measurements during the past two years, do not indicate any significant change with time.

On Buffalo Creek near East Aurora, New York an effort to qualitatively delineate the intensity of the attack or shear stress placed on the bank by water movement around the outside of a stream bend is continuing. An interpretation of aerial photographs and stream cross sections of Buffalo Creek has led to the development of some generalized concepts of bend erosion in relation to the area of maximum anticipated scour. Studies at Stillwater, Okla., on greased waterways are indicating incompatibility between the velocity and tractive force stability parameters. Extension of the studies are also being made to evaluate the applicability of previously established permissible velocity criteria for vegetated waterways when applied to grassed spillway design. Preliminary results involving the study of vegetative planting row direction indicate that no difference in rilling action occurred in the lengthwise and crosswise rows. It was further observed that cover density had the greatest effect on rilling.

At Oxford, Miss. a resurvey of a channel reach below Powerline Dam on East Goose Creek has shown that in a 6500 foot channel length scour in the amount of 21,300 cu. yds. has occurred between 1951 and 1958 with a channel slope reduction from 0.0056 to 0.0044 and no noticeable change in the mean size of bed material. The new Sedimentation Laboratory at Oxford, Miss. includes two sediment transport flumes for studying the mechanics of sediment movement and deposition. Close coordination between laboratory and field findings will be maintained.

(h) "Sedimentation Research in the Loess Hills and Terraces of the Lower Mississippi Basin," Russell Woodburn, Soil Conservation, Vol. 24, pp. 174-178, March 1959.

"Discontinuous Rating Curves for Pigeon Roost and Cuffawa Creeks in Northern Mississippi," Bruce R. Colby, WTRB, SWCRD, in cooperation with University of Mississippi and Mississippi State University, ARS-41-36.

"Measurement of Boundary Shear Stress in an Open Channel Curve with a Surface Pitot Tube," R. H. Nece, C. A. Givler, and P. A. Drinker, Technical Note No. 6, Hydrodynamics Laboratory, Mass. Institute of Tech., August 1959. (Prepared under Contract No. 12-14-100-2590 (41).

"Observations of Flood Flow Effects on Channel Boundaries," D.A. Parsons, paper presented at Meeting of ASCE, Cleveland, Ohio, May 4-8, 1959.

WESTERN SOIL AND WATER MANAGEMENT RESEARCH BRANCH.

(151) LINING OF IRRIGATION CANALS AND RESERVOIRS.

(b) Laboratory project, Agricultural Research Service, Utah State University, and Bureau of Reclamation cooperating.
(c) Dr. C.W. Lauritzen, Soil Scientist, Agricultural Research Service, Utah State Univ., 101 Engineering Building, Logan, Utah.
(d) Experimental; basic and applied research.
(e) Linings for irrigation canals and reservoirs are being tested to develop more effective and lower cost methods of reducing seepage losses in irrigation systems. The investigation includes: (1) Evaluation of physical properties of lining materials; (2) model testing of linings in an outdoor laboratory; and (3) field testing at selected sites to determine relative durability under varying subgrade and climatic conditions.
(g) A prefabricated asphalt-burlap lining has been developed which appears to be superior to in-place built-up lining of the same materials. Installation techniques are being devised and a "heat sealed" joint which is very satisfactory has been developed. Surface coatings to protect the asphalt and various mildew proofing treatments for the burlap are being investigated. Test installations have been made in three different climatic regions.
(h) "Asphalt-burlap Linings for Canals and Reservoirs," C.W. Lauritzen and F.W. Haws, Amer. Soc. Agric. Eng. Jour., 40:6, 340-344, June 1959.
"Plastic Film Linings," C.W. Lauritzen, Crops and Soils (in press).
"Types and Characteristics of Linings used in Irrigation Canals," C.W.Lauritzen, Irrigation Engineering and Maintenance (in press).

(2177) WATER REQUIREMENTS IN THE IRRIGATED AREAS OF THE WEST.

(b) Field project of the Western Soil and Water Management Research Branch, ARS-SWC, U.S. Department of Agriculture in cooperation with Western State Agricultural Colleges, State Engineers, and Soil Conservation Service.
(c) Dr. Howard R. Haise, Soil Scientist, Agricultural Research Service, P.O. Box 758, Fort Collins, Colorado, or Harry F. Blaney, Irrigation Engineer, Agricultural Research Service, 1131 Bartlett Building, 215 West Seventh Street, Los Angeles, California.
(d) Field experiments and office analysis.
(e) (1) To determine the consumptive use of water by agricultural crops and native vegetation and water requirements for irrigated crops. (2) To compile and prepare for publication available data relating to irrigation requirements and consumptive use as determined by field experiments. (3) To estimate water requirements from climatological and other data.
(f) Investigation has been underway for several years and has not been completed.
(g) Monthly rates of consumptive use and water requirements have been estimated and provisional reports are prepared for western states. These values have been computed by the Blaney-Criddle formula, $u = kf$, where (u) is the monthly consumptive use in inches, (k) is a monthly empirical coefficient based on experimental measurements and (f) is a monthly factor determined from the product of monthly mean temperatures by percent of daytime hours.
(h) "Monthly Consumptive Use of Water by Irrigated Crops and Natural Vegetation," Harry F. Blaney, Extraits - Assemblee Generale de Toronto, 1957 (Gentbrugge, Belgium 1958) pp. 431-439 illus., Intern. Union Geodesy Geophys., Vol. II, pp. 412-422, 1958.
"Monthly Consumptive Use Requirements for Irrigated Crops," Harry F. Blaney. Paper No. 1963, Journ. Irrig. and Drainage Div., Amer. Soc. Civil Eng. Proc., Vol. 85:IR, 1-12, March 1959.
"Determining Irrigation Requirements from Consumptive Use Water Rates," Harry F. Blaney. Proc., V Intern. Contress of Agric. Eng., Brussels, Belgium, 1958.

(2179) EVAPORATION AND CONSUMPTIVE USE OF WATER INVESTIGATIONS IN THE SAN FRANCISCO BAY AND ADJACENT AREA.

(b) Laboratory project, cooperative with Div. of Water Resources, State of California; and the Corps of Engineers, San Francisco Bay District, U.S. Army.
(c) Mr. Dean C. Muckel, Irrigation Engineer, P. O. Box 180, Berkeley, California.
(d) Field investigation.
(e) To determine rates of evaporation from fresh water surfaces, the consumptive use of fresh water by marshland vegetation (tules and cattails), and the consumptive use of water by salt grass at varying depths to water table in the San Francisco Bay and adjacent areas.
(f) Field work terminated.
(h) Final report to Corps of Engineers (in press).

(2180) EVAPORATION LOSSES FROM RESERVOIRS AND LAKES.

(b) Field project of Western Soil and Water Management Research Branch, ARS-SWC, U. S. Department of Agriculture, in cooperation with State of California County Flood Control Districts and cities.
(c) Mr. Harry F. Blaney, Irrigation Engineer, Agricultural Research Service, 1131 Bartlett Building, 215 West Seventh Street, Los Angeles, California.
(d) Experimental; measurements and compilation and analysis of data.
(e) To determine evaporation losses from reservoirs and lakes in California and compile and prepare for publication reliable evaporation and related data measured since 1945 in cooperation with the State of California, Department of Water Resources. Field measurements are being made in cooperation with

the State and local agencies on 20 stations, ranging from 100 feet above sea level in coastal areas in Southern California to 9,200 feet in the Sierra-Nevada Mountains in Central California.

(g) Monthly evaporation from pans, temperature, humidity, wind movement, and precipitation are being compiled and analyzed for the various stations.
Evaporation from Lakes' surface is being computed by reduction factors. In the mountain areas records are being kept at Shaver Lake (elevation 5,376 feet); Huntington Lake (elevation 6,954 feet); Vermillion Lake (elevation 7,300 feet); Florence Lake (elevation 7,345 feet); Kaiser Pass (elevation 9,194 feet). California State Bulletin 54-B, "Evaporation from Water Surfaces in California (A Summary of Pan Records and Coefficients 1881-1954)," is being revised as California State Bulletin No. 73 by Harry F. Blaney and Dean C. Muckel.

(h) "Evaporation from Free Water Surfaces at High Altitudes," Harry F. Blaney, Paper No. 2925, Amer. Soc. Civil Engr., Trans., Vol. 123, p. 385, 1958.

(2181) STORAGE OF WATER UNDERGROUND FOR IRRIGATION IN CALIFORNIA.

(b) Laboratory and field project.

(c) Mr. Leonard Schiff, Hydraulic Engineer, Agricultural Research Service, 4816 East Shields Avenue, Fresno 3, California.

(d) Experimental; laboratory and field investigations, applied research.

(e) To efficiently store and use underground water in quantity and of a quality needed in various locations. The objectives are: (1) To determine the physical and chemical characteristics of surface soil and substrata on selected sites and to relate these characteristics to infiltration and percolation rates and to lateral flow; (2) to determine the feasibility of recharge irrigation (deep percolaltion by sufficient irrigation of crops) as a means of storing water underground; (3) to determine the effect of recharge on the quality of water reaching the groundwater table under selected site conditions and on the quality of the ground water; and (4) to prepare a recharge guide which permits the evaluation of a site for recharge, suggests methods and systems of recharge to be used and indicates the quality of ground water that may be expected as a result of recharge.

(f) On July 1, 1959 this recharge project moved from Bakersfield to Fresno, Calif., and is active in an expanded and reoriented program.

(g) Prior to the recent reorientation of objectives the project had published results on soil and/or water treatments and operational procedures that increase the hydraulic conductivity of soils and increase the hydraulic gradient. Hydraulic conductivity has been increased by the use of chemicals, organic residues and grasses, and the removal of soil layers of low conductivity. Hydraulic gradients have been increased by using greater depths of water on soil surfaces and in pits, shafts and trenches. Clogging of soils and model wells has been alleviated or reduced by scraping and by the use of filters, respectively. Infiltration rates into aquifer material has been increased by placing various filter materials over such material. Systems including strip water spreading to take advantage of lateral flow and rotational water spreading have been suggested.

(h) "Utilizing the Decomposition of Organic Residues to Increase Infiltration Rates in Water Spreading," C.E. Johnson, Amer. Geophys. Union Trans., 38: 326-332, 1957.
"Water Spreading for Ground-water Recharge," Edited by Leonard Schiff, Conference on Water Spreading for Ground-water Recharge Proc., March 1957.
"The Use of Filters to Maintain High Infiltration Rates in Aquifers for Ground Water Recharge," Leonard Schiff, Extrait des Comptes Rendus et Rapports - Assemblee Générale de Toronto, Tome II, p. 207 a 211, Gentbrugge, 1958.
"Effect of Chlorination on Some Physical and Biological Properties of a Submerged Soil," C.E. Johnson, Soil Sci. Soc. Amer. Proc., 22: pp 244-246, 1958.
"Chlorine Increases Water Intake for Underground Storage," C.E. Johnson, Crops and Soils, 11:4, 24, January 1959.

(2185) SPRINKLING AS A METHOD OF APPLYING WATER TO IRRIGATED FARM LANDS ITS PROBLEMS AND LIMITATIONS.

(f) Suspended.

(2279) LABORATORY AND FIELD STUDY OF THE VORTEX TUBE SAND TRAP.

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

(c) Mr. A.R. Robinson, Agricultural Engineer, Hydraulics Laboratory, Colorado State Univ., Fort Collins, Colorado.

(d) Experimental; applied research.

(e) The study is being made to develop generalized criteria for the design of the vortex tube sand trap. The sand trap will be used in irrigation and power canals for removal of bed load material.

(g) Tests indicate that with the proper design, the vortex tube sand trap is very effective in the removal of bed load material for sizes greater than 0.3 mm. The efficiency of trapping varies with the velocity of flow across the tube and the size of material. High efficiencies can be maintained even though the amount of flow removed by the tube is reduced from 15 to 5 percent. Tubes of different shapes seem to operate equally well. However, the cross-sectional area and length of tube seem to be critical points of design.

(2649) DEVELOPMENT OF DRAINAGE DESIGN CRITERIA FOR IRRIGATED LANDS.

(f) Suspended.

(2650) EFFECT OF WATER TABLE DEPTH ON IRRIGATION REQUIREMENTS AND YIELD OF LAHONTAN ALFALFA.

(b) U.S. Dept. of Agriculture, Agricultural Research Service, Soil and Water Conservation Research Division.
(c) Mr. Rhys Tovey, Agricultural Engineer, Agricultural Research Service, Box 9186 University Station, Reno, Nevada.
(d) Experimental; applied research.
(e) To determine surface-irrigation requirements of Lahontan alfalfa grown on three soil textures with constant water tables at various depths, and on well-drained soil in the absence of a water table; to determine the effect of plant growth stage on the rate of water use by Lahontan alfalfa; to determine the relation between the use of water by alfalfa under various water table conditions, evaporation from porous atmometer bulbs, and evaporation from a Weather Bureau evaporation pan; and to evaluate the effects of a fluctuating water table on the yield and growth rate of alfalfa. Sixty-three lysimeter tanks, 3 feet in diameter and varying in depth from 3 to 9 feet, have been installed on the Univ. of Nevada Main Agricultural Experiment Station Farm at Reno. The variables, which are replicated, include the following: (1) Three soil textures (sandy loam, loam, clay loam); (2) three water-table depths (2, 4, and 8 feet); (3) irrigated and nonirrigated conditions; and (4) well-drained soil conditions. Alfalfa stands have been established in the tanks and in the surrounding areas. Tensiometers are being installed in some of the tanks to study the movement of water in the capillary fringe of the nonirrigated tanks. A weather station is being established at the site to measure net radiation, temperature, humidity, precipitation, evaporation from U.S. Weather Bureau pan, evaporation from atmometer bulbs, and wind velocity.
(g) Results to date indicate that alfalfa grown under constant high water-table conditions has a considerably higher consumptive use rate than alfalfa grown under well-drained field conditions.

(2651) DRAINAGE INVESTIGATIONS IN THE NORTH SHORE AREA OF CARSON LAKE, NEVADA.

(f) Suspended.

(2652) UTILIZATION OF AVAILABLE WATER SUPPLIES IN THE COLORADO RIVER BASIN OF NEVADA.

(b) Laboratory project, cooperative with Nevada Agricultural Experiment Station and the Soil Conservation Service.
(c) Mr. Victor I. Myers, Agricultural Engineer, Agricultural Research Service, Box 9186, Univ. Station, Univ. of Nevada, Reno, Nev.
(e) A study to determine the present disposition of water in the Colorado River Basin within Nevada and to evaluate the potential water supply available for beneficial use in this basin.

(2653) CONSUMPTIVE USE, WATER SUPPLY AND IRRIGATION STUDIES IN SANTA BARBARA COUNTY, CALIFORNIA.

(b) Laboratory project in cooperation with Santa Barbara County Water Agency, U.S. Geological Survey, California State Department of Water Resources, and U.S. Bureau of Reclamation.
(c) Mr. Paul R. Nixon, Agricultural Engineer, Agricultural Research Service, P.O. Box 1176, Lompoc, California.
(d) Field investigation; applied research.
(e) Objectives are: (1) To obtain basic data on consumptive use of water by irrigated crops and native vegetation; (2) to determine the contribution of rainfall and return waters from irrigation to the ground water supply; (3) to make irrigation efficiency studies to improve irrigation practices.
(g) Downward translocation of moisture has been observed to continue for a number of months during the dry season following above normal winter precipitation. This migration of moisture in unsaturated soil was observed in all soils studied but was most pronounced in sandy soil. Rather marked increase in evapotranspiration rates have been observed as distances increase from 4 to 28 miles from the ocean.
(h) "Translocation of Moisture with Time in Unsaturated Soil Profiles," G. Paul Lawless and Paul R. Nixon, Jour. of Geophys. Res. (in press).

(2901) LABORATORY STUDY OF GRAVEL FILTER DESIGN FOR IRRIGATION WELLS.

(b) Laboratory project.
(c) E. Gordon Kruse, Agricultural Engineer, Agricultural Research Service, Hydraulics Laboratory, Colorado State University, Fort Collins, Colorado.
(d) Experimental; applied.
(e) Laboratory studies were conducted to: (1) Determine the relationship of pack-aquifer ratios and gradations to the amount of aquifer movement when wells are pumped; and (2) develop generalized criteria for the selection and placement of gravel pack materials.
(f) Completed.
(g) The criteria for stability of uniform and nonuniform aquifers and gravel packs were determined by a series of tests in a radial flow model simulating a section of an irrigation well. The test results indicated: (1) Less aquifer movement occurs with nonuniform gravel packs than with uniform gravel packs at the same pack-aquifer ratio. (2) At low pack-aquifer ratios, increasing aquifer uniformity decreases initial sand movement. (3) At high pack-aquifer ratios, increasing aquifer uniformity increases sand movement. (4) Reversing flow through the model to produce a surging effect reduced head loss at the pack-aquifer interface considerably.
Quantitative values of stable pack-aquifer ratios for uniform and nonuniform materials were determined.
(h) "Selection of Gravel Packs for Wells in Unconsolidated Aquifers," E. Gordon Kruse, Colo. State Univ. Expt. Sta. Tech. Bul. (in

press).

(2902) DEVELOPMENT AND IMPROVEMENT OF WATER MEASURING DEVICES.

(b) Agricultural Research Service, U.S. Dept. of Agriculture and the Colorado Agricultural Experiment Station.
(c) Mr. A.R. Robinson, Agricultural Engineer, Agricultural Research Service, Hydraulics Laboratory, Colorado State University, Fort Collins, Colorado.
(d) Experimental; applied research.
(e) The purpose of this project is to develop new water measuring devices and to improve existing ones for the measurement of irrigation water. Present phases are concerned with the devlopment of trapezoidal measuring flumes and the calibration of orifice plates for furrow flow measurements.
(g) Preliminary tests on the trapezoidal flumes were previously reported. Much larger sizes have now been studied and have been found generally superior in operation to those with rectangular sections. The general shape of the trapezoidal flume is more easily adapted to the problem of open channel flow measurement.
Furrow orifices have been calibrated for a wide range of operating conditions. The sizes range from 3/4 to 4 inches in diameter.
(h) "Trapezoidal Flumes for Open Channel Flow Measurement," A.R. Robinson and A.R. Chamberlain. (Approved for publication in Amer. Soc. Agric. Engr. Trans., 1960).

(3209) CONSUMPTIVE USE OF WATER BY CROPS IN ARIZONA.

(b) Cooperative with the Arizona Agricultural Experiment Station.
(c) Mr. Leonard J. Erie, Irrigation Engineer, Southwest Water Conservation Laboratory, Box 816-A, Rt. No. 2, Tempe, Arizona, and Mr. Karl Harris, Civil Engineer, Agricultural Research Service, Arizona Savings Building (Room 420), Phoenix, Arizona.
(d) Experimental; field research.
(e) The objectives of this project are to: (1) To determine consumptive use of new crops; (2) keep consumptive use measurements up to date as varieties and production changes take place and; (3) develop better information on peak period uses and to obtain soil moisture tensions at certain stages of plant development.
(h) "Cotton Irrigation in the Southwest," Karl Harris, Leonard J. Erie and Burke Peterson. ARS 41-26, May 1959.

(3210) RECHARGE OF UNDERGROUND AQUIFERS USING GRAVEL FILLED SHAFTS.

(f) Suspended.

(3211) THE RATE OF ADVANCE OF IRRIGATION WATER IN FURROWS AS A FUNCTION OF MEASURABLE PHYSICAL FACTORS.

(b) Laboratory project.
(c) Mr. Hollis Shull, Agricultural Engineer, Agricultural Research Service, Southwestern Irrigation Field Station, P.O. Box 1339, Brawley, California.
(d) Experimental; applied research.
(e) The objectives of this project are: (1) To develop a mathematical expression, either numerical or graphical, from which the rate of advance of irrigation water down furrows may be accurately predicted; (2) to outline a procedure by which the expression developed may be utilized in the design of furrow irrigation systems.
(h) "A By-pass Furrow Infiltrometer," Hollis Shull, Amer. Soc. Agric. Eng. Trans. (in press).

(3212) THE HYDRAULICS OF CYLINDER INFILTROMETERS.

(b) Laboratory project.
(c) Mr. Charles T. Bourns, Agricultural Engineer, Agricultural Research Service, Irrigation Building (Room 215), University of California, Davis, California.
(d) Experimental; basic research and developmental.
(e) This is a three-dimension model study of the hydraulics of cylinder type infiltrometers to determine the flow regime of this device, the necessity for buffer cylinders, the effect of diameter on its function, the effect of methods and depths of placement on results, the effect of location of less permeable soil strata in relation to depth of placement of infiltrometer, and the effect of various operational techniques on reliability of results.

(3213) DEVELOPMENT OF A DEVICE FOR FIELD MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SOIL STRATA.

(b) Laboratory project.
(c) Mr. William W. Donnan, Drainage Engineer, Agricultural Research Service, P. O. Box 629, Pomona, California.
(d) The objectives of this project are to develop a relatively simple field device for measuring hydraulic conductivity rates of sand strata and to set forth a methodology which can be used by field technicians in getting data for design of drainage systems.
(e) Experimental laboratory and applied field research.
(g) A simple brass screen well point has been developed in the laboratory and has been given extensive tests. The well point is now being tested in the field under actual field conditions.

(3214) BASIN IRRIGATION SYSTEMS FOR EROSION CONTROL AND WATER CONSERVATION ON THE IRRIGATED LANDS OF WESTERN NEBRASKA.

(f) Suspended.

(3215) DETERMINATION OF THE QUANTITY AND EFFECTS OF PLAYA LAKE SEDIMENTS RETAINED IN MULTIPLE PURPOSE WELLS USED FOR GROUND WATER RECHARGE AND IRRIGATION IN THE HIGH PLAINS OF TEXAS.

(b) Laboratory project; cooperating with the

High Plains Underground Water Conservation District No. 1, the Texas Agricultural Experiment Station, and the Soil Conservation Service.

(c) Mr. Wayne Clyma, Agricultural Engineer, Agricultural Research Service, Southwestern Great Plains Field Station, Bushland, Texas.

(d) Field investigation; applied research.

(e) The primary objectives of the study are: (1) To determine the quantity of sand, silt and clay entering recharge wells during the recharge operation from Playa lakes; (2) to determine the quantity of sand, silt and clay pumped from multiple-purpose wells during the pumping cycle of a recharge operation and; (3) to determine the changes in specific yield of study wells resulting from retained sediments.

(g) Eighty-nine to 93 percent of the clay (less 0.005 mm.) entering the well during recharge is retained in the water-bearing sands after a 1-hour pumping cycle. The retention of sand and silt does not appear to be appreciable.

(h) "What Happens to Sediments in Playa Lake Water When Used for Underground Recharge in Wells," M.E. Jensen and W. Clyma, The Cross Section, 5:8, 2-3, January 1959.

(3216) PERFORMANCE OF SUBSURFACE DRAINAGE INSTALLATIONS IN THE LOWER RIO GRANDE VALLEY OF TEXAS.

(b) Cooperative with the Texas Agricultural Experiment Station, Soil Conservation Service and the Lower Rio Grande Valley Soil Conservation Districts.

(c) Mr. L.R. Ussery, Agricultural Engineer, Agricultural Research Service, P.O. Box 157, Weslaco, Texas.

(d) Experimental; field research.

(e) The purpose of the study is to measure the influence of drains on depths to and fluctuation of ground water tables. Actual field data will be related to present design criteria and empirical drain spacing formulas.

(3217) HYDROLOGIC STUDIES OF GROUND WATER IN RED RIVER VALLEY OF NORTH DAKOTA.

(b) Project cooperative with the North Dakota Agricultural Experiment Station.

(c) Mr. Rome Mickelson, Agricultural Engineer, Agricultural Research Service, P. O. Box 806, Grand Forks, North Dakota.

(d) Field research.

(e) The objectives of the study are: (1) To determine the water table levels in a segment of the problem area; (2) to evaluate artesian and downward flow condition in the area; (3) to determine the direction of ground water flow and extent and benefits of natural and artificial drains existing in the area; (4) to study ground water quality in observation wells in the area and; (5) to study and analyze the physical and chemical properties of soils in the area as related to the water transmissibilities of the soil substrata.

(3218) SOIL EROSION AND ROUGHNESS CHARACTERISTICS UNDER FURROW IRRIGATION.

(b) Project cooperative with the Washington Agricultural Experiment Station.

(c) Mr. S. J. Mech, Agricultural Engineer, Agricultural Research Service, Irrigation Experiment Station, Prosser, Washington.

(d) Field research.

(e) The influence of soil management and water intake on erosion under furrow irrigation is being studied. Some of the variables being considered are cropping practices, moisture levels and slope. The variation of the roughness coefficient (Manning n) is being studied.

(f) Field work terminated.

(h) "Soil Erosion and its Control Under Furrow Irrigation in the Arid West," Stephen J. Mech, USDA Agric. Information Bul. No. 184, pp. 1-6, August 1959.

(3550) THE EFFECT OF SPRINKLER PATTERN VARIATION ON IRRIGATION EFFICIENCY.

(b) Laboratory project.

(c) Mr. Claude H. Pair, Irrigation Engineer, Agricultural Research Service, P. O. Box 835, Boise, Idaho.

(d) Experimental; applied research and design.

(e) To determine the effect of sprinkler pattern on field irrigation efficiency and to develop a method for calculation of field irrigation efficiency for a sprinkler system from sprinkler pattern, wind velocity, humidity, temperature, irrigation period, and related factors. Work is continuing to: (1) Obtain more precise information for the design, layout, installation, and operation of sprinkler irrigation systems on various soil types, slopes, and crops under various weather conditions, and (2) determine the effect of sprinkling upon various soils and crops.

(h) "Automation Possibilities in Irrigation," Claude H. Pair, (approved for publication in Agric. Eng. or Amer. Soc. Agric. Eng. Trans.).
"Sprinkler Irrigation," Claude H. Pair, USDA Leaflet (in press).

(3551) CONSUMPTIVE USE OF WATER BY PHREATOPHYTES IN THE PACIFIC SOUTHWEST.

(b) Field project of Western Soil and Water Management Research Branch, ARS-SWC, U. S. Department of Agriculture.

(c) Mr. Harry F. Blaney, Irrigation Engineer, Agricultural Research Service, 1131 Bartlett Building, 215 West Seventh St., Los Angeles, California.

(d) Field experiments and office analysis.

(e) (1) To determine the consumptive use (evapotranspiration) by phreatophytes (ground-water loving natural vegetation) such as salt cedar, cottonwoods, willows, saltgrass, etc., (2) to compile and prepare for publication available data, and (3) to develop empirical formula for estimating water use from climatological data.

(f) Study has been underway for several years and has not been completed.

(g) Consumptive use has been measured in some sites and estimated for other areas by

empirical formula; U = KF, where U = consumptive use in inches (for growing period), K = empirical coefficient based on research studies, and F = factor determined from mean monthly temperatures and percent of daytime hours. Information may be used to estimate amount of water that can be salvaged and conserved for irrigated crops by controlling phreatophytes in river channels and areas of high water table.

(h) "Relationship of Pan Evaporation to Evapotranspiration by Phreatophytes and Hydrophytes," Harry F. Blaney, Phreatophyte Symposium, Amer. Geophys. Union Trans., pp. 1-7, 1957.
"Consumptive Use of Ground Water by Phreatophytes and Hydrophytes," Harry F. Blaney, Third Annual New Mexico Water Conference Proc., New Mexico State College, 1958.

(3552) HYDRAULICS OF SURFACE IRRIGATION.

(b) Laboratory project.
(c) Mr. James A. Bondurant, Agricultural Engineer, Agricultural Research Service, P. O. Box 835, Boise, Idaho.
(d) Experimental; field investigation, basic research.
(e) To investigate the factors that influence the advance and recession of water in an irrigation border strip.

(3553) MECHANIZATION OF SURFACE IRRIGATION.

(b) Laboratory project.
(c) Mr. James A. Bondurant, Agricultural Engineer, Agricultural Research Service, P. O. Box 835, Boise, Idaho.
(d) Experimental; design and development.
(e) To develop completely mechanized control systems for surface irrigation.

(3554) DEVELOPMENT OF AN ECONOMICAL FILTER SYSTEM FOR FILTERING THE SEDIMENTS FROM PLAYA LAKE WATER DURING RECHARGE OPERATIONS WITH MULTIPLE PURPOSE WELLS.

(b) Laboratory project; cooperating with the High Plains Underground Water Conservation District No. 1, Texas Agricultural Experiment Station, and the Soil Conservation Service.
(c) Mr. Wayne Clyma, Agricultural Engineer, Agricultural Research Service, Southwestern Great Plains Field Station, Bushland, Tex.
(d) Experimental; applied research.
(e) Development of an economical method of removing sediments from playa lake water, used for ground water recharge, by the use of flocculating agents along or flocculating agents in conjunction with a sand filter.
(g) Tests conducted to present indicate that from 50 to 93 percent of the silt and clay sediments in playa lake water may be removed with the use of a flocculent alone.

(3555) FEASIBILITY OF LOW-COST SUBSURFACE PLASTIC DRAINS FOR IRRIGATED AREAS.

(b) Laboratory project.
(c) Mr. William W. Donnan, Drainage Engineer, Agricultural Research Service, P.O. Box 629, Pomona, California.
(d) Applied field research.
(e) The objectives of this project are to determine the applicability of shallow depth drainage to specific drainage problems in the arid Western United States and to test the adaptability of plastic mole drains to western conditions.
(g) To date eight field research test plots and four other supplemental test plots of plastic-lined mole drains have been installed in California, Nevada, Utah and Colorado. These installations have been in operation about 5 months. Physical measurements were made of the sites prior to installation and observations of the plastic drains and the performance of these drains is now in progress.

(3556) FARM CONVEYANCE AND WATER APPLICATIONS.

(b) Laboratory project, Agricultural Research Service and Utah State Univ. cooperating.
(c) Dr. C.W. Lauritzen, Agricultural Research Service, Utah State Univ., 101 Engineering Building, Logan, Utah.
(d) Experimental; basic and applied research.
(e) New methods and equipment for conveying and applying irrigation water are being developed. The hydraulic properties of lay-flat tubing are being studied and new materials are being evaluated to determine their use in conveyance structures.
(g) The coefficient of friction of lay-flat tubing in the range from nearly flat to full round has been determined experimentally The strength requirements and dimensional changes which accompany the stressing of reinforced plastic tubing have also been investigated.
In addition, tubings constructed of several materials have been field tested on a limited scale.

(3557) THE DEVELOPMENT OF TECHNIQUES AND PROCEDURES FOR INVESTIGATING THE DRAINAGE PROBLEMS ON AN ALLUVIAL FLOOD PLAIN.

(b) Laboratory project.
(c) Mr. Victor I. Myers, Agricultural Engineer, Agricultural Research Service, Box 9186 University Station, Reno, Nevada.
(d) Applied research.
(e) Techniques, procedures, and equipment are being developed to aid in the investigation of drainage problems on an alluvial flood plain. Soil conservation surveys are utilized as a basis for the studies. In addition, deep stratum surveys are being made, hydraulic conductivity measurements taken, canal seepage measured, farm irrigation efficiencies measured, plastic tile evaluated, and other data collected.
(g) A drainage classification system has been established to relate soil conservation surveys to drainage problems and problem areas. The system is designed for use in most areas of the United States. A map of the Newlands Reclamation Project of Nevada has been constructed showing locations of canals and drains in relation to drainage

categories. An improved seepage meter has been fabricated and tested.

(h) "The Physical and Economic Considerations for Drainage Project Feasibility," Victor I. Myers, (submitted for publication in Amer. Soc. Agric. Eng. Trans.).

(3558) A STUDY OF THE PHYSICAL AND CHEMICAL PROPERTIES OF BENTONITES THAT MAY BE INVOLVED IN THE BENTONITE DISPERSION METHOD OF SEALING IRRIGATION CANALS.

(b) Laboratory project.
(c) Mr. Myron B. Rollins, Soil Scientist, Agricultural Research Service, Box 9186 Univ. Station, Reno, Nevada.
(d) Experimental; applied research, and Master's thesis.
(e) The physical properties of bentonites will be studied to determine their effects upon the actual sealing process involved in the bentonite dispersion method of sealing irrigation canals. Such properties will be: swelling behavior, colloidal yield, grit content, dispersion characteristics, viscosity and gelling qualities. The chemical and mineralogical properties of the bentonites will in turn be studied to determine their effects upon the above physical properties.
(g) It has been found that most dispersed bentonites continue to expand for various lengths of time after dispersion. This will have a very definite effect upon the sealing process.

(3559) HYDRAULIC CHARACTERISTICS OF SURFACE RUNOFF FLOWS FROM SIMULATED RAINFALL ON LEVEL AND GRADED FURROW AND BORDER STRIP IRRIGATION SYSTEMS.

(b) Nebraska Agricultural Experiment Station and Agricultural Research Service.
(c) Mr. Norris P. Swanson, Agricultural Engineer, Agricultural Research Service, Agricultural Engineering Building (Room 20.), University of Nebraska, Lincoln 3, Nebr.
(d) Field investigation; findings will be used for design purposes.
(e) Simulated rainfall is applied to plots several hundred feet long on selected sites with growing crops. In the case of row crops, the application of the simulated rainfall is such that each furrow becomes an individual watershed subject to a different rainfall intensity. Timed initial and antecedent moisture condition storms are applied. Instrumentation provides for measurement of furrow runoff flows and depth of flow by stations. Furrow stream velocities are measured by salt injection. Cross sections of representative furrows are recorded by stations prior to each storm and after the last. Erosion measurements are obtained and soil particle size distributions obtained.
(g) Furrow cross-sections have been found to enlarge at downstream stations.

(3560) EVAPOTRANSPIRATION BY MEADOW VEGETATION IN THE HUMBOLDT RIVER BASIN.

(b) U. S. Department of Agriculture, Agricultural Research Service, Soil and Water Conservation Research Division.
(c) Mr. Rhys Tovey, Agricultural Engineer, Agricultural Research Service, Box 9186 Univ. Station, Reno, Nevada.
(d) Experimental; applied research.
(e) Nine plastic lysimeters have been installed on an experimental plot adjacent to the Humboldt River near Winnemucca, Nevada to study the consumptive use of water by meadow vegetation grown under present high water table conditions and related weather factors.
(f) Three types of meadow grasses will be established in the lysimeters and the water supply systems installed during the 1960 growing season. The measurement of consumptive use and weather data will begin in the spring of 1961.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Alaska Forest Research Center.

(2654) EFFECT OF LOGGING ON PHYSICAL CHARACTERISTICS OF SALMON STREAMS IN SOUTHEAST ALASKA.

(b) Laboratory project.
(c) Mr. Austin E. Helmers, Acting Forester in Charge, Alaska Forest Research Center, Box 740, Juneau, Alaska.
(d) Field investigation; applied research.
(e) In developing the timber resources of the region, it is essential that adequate steps be taken to safeguard the important fisheries resource. The objective is to determine whether logging, carried out in accordance with provisions required by the Forest Service to protect salmon spawning streams, causes physical changes to the watershed and stream regimen which might be harmful to the stream for salmon protection. The following factors are being investigated: (1) Changes in the stream regimen; (2) erosion and sedimentation; (3) stream channel change; (4) accumulation of debris in streams; (5) change in stream bottom material; and (6) water temperature and pH.
(g) The first, or calibration phase of this study has resulted in information on the hydrological characteristics of undisturbed streams in a glaciated region with heavy precipitation.
(h) "Watershed Management and Research on Salmon Streams of Southeast Alaska," H. E. Anderson and G. A. James, Jour. Forestry, Vol. 55, No. 1, pp. 14-17, Jan. 1957. "The Effect of Logging on Discharge, Temperature, and Sedimentation of a Salmon Stream," G.A. James, Alaska Forest Research Center Tech. Paper No. 39, 2 pp., 1957.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE Central States Forest Experiment Station.

Inquiries concerning the following projects should be addressed to Dr. W.G. McGinnies, 111 Old Federal Building, Columbus 15, Ohio.

(3561) WATERSHED PREDICTION METHODS.

(b) Laboratory project.
(d) Experimental and field investigation; basic and applied research.
(e) An analysis of records to determine the relation of precipitation to runoff in hardwood forest types in the 30-45 inch rainfall belt of the Central United States.
(f) Completed.
(g) Precipitation and runoff records for three small watersheds near Rolla, Missouri were analyzed. The three watersheds differ in size, shape, land use, and cover type. The smallest covers 0.6 square mile and is open land. The middle one had approximately 2.1 square miles of oak forest and 4.3 square miles of grain crops and pasture. The largest contains approximately 9.3 square miles of oak forest and 4.7 square miles of grain crops and pasture. In the seven year period 1948 to 1955 the annual precipitation varied widely - from 18 to 65 inches - and averaged 38 inches.
In these Ozark watersheds effective ground water storage areas occurred in the lower reaches - the branch bottoms - where soils were deeper and hydraulic gradients were rather low. The smaller watersheds had smaller water yields, probably because more water seeped to lower ground levels. For predicting annual water yields from annual precipitation a water year commencing June 1 and ending May 31 gave the best correlation. Since ample soil moisture was not always available, total amount of evapotranspiration increased as growing season precipitation increased.
Further analyses of the hydrographs showed that only 22 storms were recorded in an average year. This contrasts sharply with 68 at Coshocton, Ohio and 128 at Coweeta, near Franklin, North Carolina. The period May-July had the largest number of storms and highest storm flows and the period September-December the lowest number of storms and smallest storm peak discharges. Generally, storm peaks were higher and more numerous on small watersheds than on larger watersheds because the frequency and magnitude of storm peaks usually vary inversely with watershed size. In the 7-year period studied here the smallest watershed had 96 peak flows exceeding 40 c.s.m. (cubic feet per second per square mile) while the middle sized had 65 such peaks and the largest only 44. The smaller watershed had more storms in the higher peak classes with one maximum of 2800 c.s.m. The majority of peaks occurred during the growing season.
(h) "Some Basic Hydrologic Relationships for Three Small Watersheds in the Missouri Ozarks," Ronald Z. Whipkey, Master of Science in Forestry Thesis, on file at Univ. of Missouri Library, pp. 129, 1958.
"Precipitation and Runoff Relationships for Three Small Watersheds in the Missouri Ozarks," Ronald Z. Whipkey and P.W. Fletcher, Missouri Agric. Expt. Sta Research Bulletin 692, pp. 28, 1959.
"Water Yields from Small Ozark Watersheds," Ronald Z. Whipkey, (in preparation).

(3562) RESTORING DEPLETED SLOPES, COSHOCTON HYDROLOGIC LABORATORY, OHIO.

(b) Laboratory project.
(d) Field investigation; basic and applied research.
(e) An evaluation of hydrologic changes that occur in a broomsedge, poverty-grass covered watershed after it is rehabilitated by planting tree seedlings.
(f) Completed.
(g) Prior to the installation of a gaging station in 1938, two-thirds of a 43.6 acre watershed had a stand of grass and brush and the other one-third had a stand of uneven-aged hardwoods. In 1938 and 1939 three small parts of the non-forested area were planted with black locust and the balance was planted with white, red, pitch, Scotch and Virginia pine. In late 1958 the residual hardwood stand had a total of 126 square feet of basal area per acre, the pine plantations had 78, and the locust plantations had 143.
Hydrograph analyses showed: (1) In the average year streamflow equalled or exceeded 0.18 cubic feet per second per square mile for 182.5 days and was zero for 84 days. When precipitation was low the stream was dry as many as 225 days a year and exceeded flows of 0.5 c.s.m. as little as 10 percent of the time. Streamflow was continuous in 1950 when precipitation totaled 43.6 inches. (2) Conversion of the watershed to complete forest cover decreased the ground water depletion time by 7 days, from 30 days in 1939-1945 to 23 days in 1952-1957. (3) Average annual base flow for the 11-year period 1939-45 and 1952-57 was 8.88 inches (4/5 of the total annual flow). It was greatest 5.5 inches during the ground water recharge period and least, 0.89 inches, during the soil moisture recharge period. (4) The 11-year average annual stormflow yield was 2.2 inches (1/5 of total annual flow). It was greatest, 1.16 inches, during the ground water recharge period and least, 0.15 inches, during the soil moisture recharge period. (5) Converting the watershed to complete forest cover did not change the proportion of baseflow and storm water yield, but did decrease the quantity of each. Baseflow was decreased by 4.4 inches and stormflow by 1.4 inches. The greatest changes in each occurred during the period of ground water recharge and the least during the period of maximum evapo-transpiration. (6) A 53 percent reduction in the occurrence of stormflows equal to or greater than 20 c.s.m. was discovered in a comparison of stormflows at plantation ages of 1-6 with those of 13-17 years. A reduction of 80 percent was found in the occurrence of flows with a peak equal to or greater than 60 c.s.m.
(h) "Influence of The Establishment and Development of a Plantation Upon Some Precipitation and Runoff Relationships on a Small Watershed in Southeastern Ohio," Lawrence W. Hill; Master of Forestry Thesis, on file at University of Michigan library, 145 pp., 1959.

(3563) SUBSOIL WATER MANAGEMENT ON NORTHERN HARDWOOD FOREST AREAS.

(b) Laboratory project.
(d) Experimental and field investigations; basic and applied research.
(e) Movement of subsoil water will be studied in various geologic and soil types to: (1) Develop techniques for quantitatively measuring subsurface water movement from small plots; (2) to learn the effect of artificial rainfall on quantity and timing of subsurface water movement; and (3) to develop a flow equation, including coefficients for the significant variables affecting that flow. This information will aid watershed technicians in making land management decisions on areas that have lots of subsurface stormflow.
(g) A water applicator consisting of a high pressure fire pump, a pressure distribution manifold assembled from standard pieces of pipe, and six "swirling", lawn sprinkler heads, performed satisfactorily. An average intensity of 5 inches per hour, applied for one-half hour, gave subsurface stormflow from a 10 foot by 20 foot soil block for approximately two hours.

(3564) SOIL MOISTURE STORAGE.

(b) Laboratory project.
(d) Study designed to determine the soil moisture regime for grass, shrub, pine and hardwood cover types in the 30-45 inch rainfall belt of the Central United States.
(f) Completed.
(g) Soil moisture was studied for 22 months in southeastern Ohio to a depth of 36 inches on oak, pine, grass, brush, and clearcut plots. The average of gravimetric samples, taken from the 0-36 inch profile on several dates near the end of the dormant season, used as a measure of field capacity, varied from 11.49 inches of water under pine to 13.12 inches under grass. Generally, soil moisture declined throughout the summer and was recharged during the winter, but occasionally summer rainstorms were large enough to cause recharge to field capacity. Late summer soil moisture deficits were greater under oak than under pine, those under pine were greater than under brush, those under brush greater than under grass, and those under grass greater than under clearcut, whether calculated on the basis of measured field depths or on the basis of equal volumes of soil. Total water used in a 6-month growing season ranged from 21 inches under clearcut to 25 inches under pine. Additional water was used by pine during the dormant season and the two-year average amount of precipitation required to recharge the soil was 6-1/2 inches greater under pine than under grass - grass being the minimum cover condition practical here. Little or no concrete frost occurred in the soil under the forest cover.
(h) A manuscript "Influence of Five Forest Land Cover Conditions on Soil Moisture" is being preapred by Richard B. Marston.

(3565) EFFECT OF LAND MANAGEMENT ON STREAMFLOW, LEESVILLE RESERVOIR, OHIO.

(b) Laboratory project.
(d) Field investigation; basic and applied research.
(e) An examination of streamflow and precipitation records at Leesville Dam for the period 1938 to 1958 to ascertain the effect of improvement in the management of the watershed's farms and woodlands upon stormflow volumes. Using only those rainfalls of 1 inch or more in 24 hours, rainfall depth was related to the resulting stream rise to get the average stormflow for a given amount of rainfall.
(f) Completed.
(g) Improvement in the management of the watershed lands reduced stormflow volumes especially near the end of the 20-year period. Over the period, winter flows declined most, fall and summer flows decreased lesser amounts, average annual flows trended slightly downward, but spring flows increased. Flows were reduced most for rainfalls of 1 to 2 inches and less for storms of 2 to 3 inches. No meaningful change was found in any season for storms above 3 inches. The upward trend for the April through June season may have been due to the extremely heavy rains in June 1947 and April 1958 and an unusual ice storm in April 1957. Large flows from these storms could have been largely responsible for the upward slope of the trend line for the entire spring season. Rainfall in these spring months is erratic, ranging from winter type frontal-storms of long duration and low intensities to summer type thunderstorms of short duration but high intensity. Usually soil moisture remains high in this period even though some water may be lost through evapo-transpiration. This means the soil moisture storage opportunity is so low that most of the precipitation runs off, either over or through the soil. Summer rainfall comes as high intensity, short-duration storms, but soil moisture is usually much less than in the spring. More of the rain can be stored in the soil so less goes to streamflow. Fall and winter precipitation is usually of low intensity, but flood flows may occur in winter even from well-managed areas, if large quantities of rain fall on open, solidly-frozen ground.
Soil type, geology, climate, topography, land use, and vegetative cover control the streamflow from a watershed. Through the 20 year period the last two of these have changed steadily on the Leesville watershed. Although half the watershed is still being farmed and logged as it was 20 years ago, the general trend on the watershed is toward better land use. It is reasonable to assume that this trend will continue until most of the watershed is under a soil conserving program. From the results of this analysis it is also reasonable to assume that as improved land management continues stormflows will decrease, at least for the smaller storms.

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(h) "Twenty Years of Streamflow Records at Leesville Reservoir Show Benefit of Land Management in Ohio's Muskingum Watershed Conservancy District," Ronald Z. Whipkey, in preparation.

(3566) HYDROLOGY OF STRIP MINED AREAS, SOUTHEASTERN OHIO.

(b) Laboratory project.
(d) Field investigations; basic and applied research.
(e) A study of overland flow, soil erosion, water quality, and biological phases of the water resource as influenced by strip mining on forested lands in the United States.
(f) Suspended.
(g) Most of the forested lands now being strip-mined in the Central States are rehabilitated by regrading and planting the spoil banks. One reclamation practice recently tried in southeastern Ohio was the formation of small ponds among the spoil banks. On one such area (a 3-year old, strip-mined, bare-slope, 16-acre watershed containing a 5-acre pond) precipitation and water level records, though of a preliminary nature, showed that approximately one-half the rainfall ran off the surface of bare spoil banks. Correlating calculated runoff with rainfall depth from six summer thunderstorms that ranged from 0.24 to 2.00 inches gave a linear regression equation of $RO = 0.603\ P - 0.1$ where RO = runoff depth and P = precipitation depth. Ponds in reclaimed, stripped areas can trap overland flow from bare spoil banks and delay or prevent it from becoming streamflow. Most of the deleterious sediment contained in such overland flow can also be trapped in the ponds.
(h) A manuscript "How Precipitation Affects Water Levels in Strip-Mine Ponds in Southeast Ohio," by Lawrence W. Hill, is in preparation.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Intermountain Forest and Range Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. Reed W. Bailey, Dir. Intermountain Forest and Range Expt. Sta., Ogden, Utah.

(2903) STUDIES OF HYDROLOGIC PROCESSES ON FOREST, BRUSH, AND RELATED RANGELANDS IN CENTRAL AND NORTHERN UTAH AND SOUTHWESTERN IDAHO.

(b) Laboratory project.
(d) Experimental and field investigations; basic and applied research.
(e) Studies include the determination of variability and probability of amount, rate, duration, time of occurrence, and depth-area and depth-area-intensity relations of gross rainfall and snowfall; determination of forces and factors affecting water content, accumulation, movement, and melting of snow; determination of forces, factors, and soil profile characteristics affecting the capacity of soil and rock mantles to absorb and store soil water and the extent to which storage functions can be altered by modifying the soil, vegetation, and associated soil organisms and animals; and determination of forces and factors involved in water loss by evaporation and evapotranspiration processes and the effects of altering vegetation and site conditionson these processes.
(g) Maintained seasonal records at 18 rainfall recording stations and on three snow courses and yearlong precipitation records at seven stations in northern Utah. Operated 10 precipitation storage gages, 10 seasonal and one yearlong recording rain gage, and conducted snow surveys at five locations in central Utah. Initiated this past year two seasonal rainfall recording stations in southern Montana, and two yearlong precipitation recording stations and 5 yearlong precipitation storage gages in eastern California. Significant relationships between maximum snow water equivalent and elevation, aspect, and forest canopy density reported last year for northern Idaho have been further refined by a power series analysis involving nine variables: three of elevation, four of aspect, and two of canopy density. The analysis showed that all variables except the 4th power functions of aspect have a highly significant influence on the maximum snow water equivalent. The index of multiple correlation was 0.980.
(h) "Use of Nuclear Soil Moisture Meter in Studies of Evapotranspiration on Mountain Soils," Richard B. Marston, Proc. Soc. Amer. Foresters, 1958, pp. 39-41.

(2904) STUDIES OF EROSIONAL PROCESSES ON FOREST, BRUSH AND RELATED RANGELANDS.

(b) Laboratory project.
(d) Experimental and field investigations; basic and applied research.
(e) Study includes the evaluation of the effects of aspen, brush and herbaceous vegetation on surface runoff and soil erosion caused by high-intensity summer storms on runoff plots in northern Utah.
(g) Analysis of summer storm rainfall depth, intensity, and duration of 52 storms of the past 12 years, indicate that storm intensity is the dominant factor affecting overland flow, soil detachment, and sediment transport. Amount of sediment eroded per cubic foot of overland flow increases with storm intensity. Increases in both storm depth and duration caused similar increases in the sediment: overland flow ratio up to 1.50 inches per hour.

(2905) IMPROVED WATERSHED MEASUREMENTS AND EVALUATION TECHNIQUES FOR FOREST, BRUSH, AND RELATED RANGELANDS.

(b) Laboratory project.
(d) Experimental and field investigations; basic and applied research.
(e) Studies to develop methods and procedures for predicting various characteristics of water yields such as amount, rate, timeliness, sediment load and other aspects of

water quality from ungaged drainage basins in forest, brush and related range areas; and to develop and test an instrument to detect and record the occurrence of free-water in snow and its ponding on the soil surface during the snowmelt period.

(g) Weir sites were selected on two pilot watersheds which sample old-growth, cutover, and burned pine-fir areas of the Truckee basin in eastern California. Calibration of new 120° V-notch weirs at two gaging stations on high-elevation rangelands in central Utah was completed. Current meter measurements at heads ranging up to 1.30 feet gave higher discharge rates at heads above 0.5 foot than those calculated from the equation derived from the rating weir data. Probable reason for this discrepancy is an excessive approach velocity. New discharge equation, based on both current meter and rating weir data, is:

$$Q = 5.08H^{2.49}.$$

An instrument to detect free-water in snow will be tested another winter season. Last winter shallow snowpacks, coupled with gradual melting, prevented detection of free-water in snow.

(2907) METHODS OF PREVENTING WATERSHED DETERIORATION ON OPERATED FOREST, BRUSH, AND RELATED RANGELANDS IN IDAHO AND MONTANA.

(b) Laboratory project.

(d) Experimental and field investigation; basic and applied research.

(e) Studies to develop, apply, and evaluate the hydrologic and soil stabilizing effects of modified logging practices and improved post-logging measures on sediment production from operated ponderosa pine forests on granitic soils in southwestern Idaho and on peak flow discharges and sediment production in dense snow pack forests in northern Idaho and Montana; and to evaluate the hydrologic effects of modified grazing practices on high mountain ranges of central Utah.

(g) Developed method for locating and treating new logging roads to prevent serious erosion and damaging runoff. Method consists of two parts: (1) Provides a quick and accurate check against positioning too much of any proposed logging road too near a stream channel and (2) describes a way of intensifying the treatment as slope distance between a new road and stream channel decreases. Purpose of intensive treatment is to prevent sediment originating on roads from traversing even narrow protective strips below roads. Treatments of five intensities depend upon the width of protective strips: (a) Greater than 200 feet; (b) 120 to 200 feet; (c) 60 to 120 feet; (d) less than 60 feet; and (e) approaching zero width. An infiltrometer study was made on a cattle allotment to show effects of grazing on plots established on areas supporting native vegetation and on areas that had been seeded to grass seven years ago. Half of the plots on each area were grazed the past four years; the other half were covered by wire cages and had not been grazed since 1952. Results show infiltration to be higher and soil erodibility lower on protected plots. There were no significant differences in infiltration or erodibility between seeded or native plots which had been grazed.

(h) "Road and Slope Characteristics Affecting Sediment Movement from Logging Roads," Harold F. Haupt, Jour. Forestry, 57:329-332, 1959.
"A Method for Controlling Sediment from Logging Roads," Harold F. Haupt, Intermountain Forest and Range Exp. Sta., Misc. Pub. No. 22, pp 22, illus., 1959.

(2908) METHODS OF REHABILITATING FLOOD AND SEDIMENT SOURCE AREAS ON DAMAGED FOREST, BRUSH, AND RELATED RANGELANDS.

(b) Laboratory project.

(d) Experimental and field investigations; basic and applied research.

(e) Studies to develop and evaluate methods and techniques of controlling excessive surface runoff and sheet and rill erosion from seriously depleted or inadequately protected sloping forest, brush, and related rangelands; to develop and evaluate methods of stabilizing eroding cut and fill slopes bared by construction or other disturbances to lessen sediment production; and to evaluate the hydrologic effects of rehabilitation treatment on pilot watersheds in northern Utah range areas.

(g) On newly constructed contour trenches, fertilizing and reseeding markedly improved plant cover density in southern Idaho. Fertilizers containing nitrogen alone or in combination with phosphorous produced significantly more plant cover of greater height than did applications of phosphorous alone. Infiltrometer studies on high subalpine range in central Utah show that artificial restoration has increased initial infiltration but decreased final infiltration. Reduced final infiltration is attributed to pore sealing brought about by partial breakdown of soil structure due to disking. However, studies of high-intensity summer storm patterns reveal that the highest intensities of such storms usually occur in the first few minutes. In this case, higher initial infiltration is of prime importance and lower final infiltration is expected to be of less consequence, especially if overland flow is kept in check by contour trenches. Final infiltration capacity is expected to increase as soil structure improves. Soil movemement and ground cover (litter plus plant basal area) measurements from game-proof enclosures on depleted and eroding range in Montana reveal that on winter game range sites which have little or no snow cover during periods of alternate freezing and thawing in spring, mere protection from grazing without ground cover improvement may produce increased soil movement due simply to loosening of the surface soil. From two pilot watersheds in northern Utah, time trend analysis of

stream flow by various periods show that the restoration of plant cover on denuded headwater areas after a period of 22 years has caused a statistically significant reduction in water yield. However, the actual difference is so small (0.015 inches per year) that it is of little practical significance.

(2909) METHODS OF IMPROVING WATER YIELDS FROM FOREST, BRUSH, ALPINE, AND RELATED RANGELANDS.

(b) Laboratory project.
(d) Experimental and field investigations; basic and applied research.
(e) Studies to develop and evaluate methods of converting vegetation types on well-drained slopes to increase amount or improve timeliness of water yields, without accelerating erosion, increasing flood and sediment discharges or impairing water quality; and to develop and evaluate methods for artificially controlling snow accumulation and melt to improve timeliness of water yields from subalpine range areas.
(g) Continued calibration of paired watersheds for the vegetation conversion study. Over the past 6 years their total annual discharges in area inches are highly correlated ($r = 0.996$). The induced snow drifting study will be extended to two other locations using different sizes of fences.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Northeastern Forest Experiment Station.

Inquiries concerning the following projects should be addressed to Dr. Ralph W. Marquis, Director, Northeastern Forest Experiment Station, 102 Motors Avenue, Upper Darby, Pennsylvania.

(656) WATERSHED MANAGEMENT RESEARCH, DELAWARE-LEHIGH-EXPERIMENTAL FOREST, PENNSYLVANIA.

(b) Laboratory project; in cooperation with the Pennsylvania Department of Forests and Waters and U. S. Geological Survey.
(d) Field investigation; basic and applied research.
(e) A study was started in 1948 on the Delaware-Lehigh Experimental Forest, Monroe County, Pa., to determine the water economy for a 1,530-acre watershed covered with scrub oak. The cover is now being converted by planting and fire protection to conifers and the effect on water relations will be measured.
(f) Suspended.
(g) The watershed was calibrated on the basis of the first six year's daily climatic and streamflow record by relating monthly, seasonal, and annual discharge to rainfall and air temperature. About 300 acres have been planted; further planting depends on results of seed-spot tests. Stream gaging and climatic research were discontinued December 31, 1958 until such time vegetation has changed sufficiently to warrant further gaging to determine the effect of che change on streamflow.

(966) WATERSHED MANAGEMENT RESEARCH, POCONO EXPERIMENTAL FOREST, PENNSYLVANIA.

(b) Laboratory project.
(d) Field investigation; basic and applied research.
(e) Studies have been started on the Pocono Experimental Forest, Wayne County, Pa., to determine effects of forest management practices and logging operations upon the quantity and quality of water yielded by a small watershed. Installations have been established to measure precipitation, streamflow and rainfall interception.
(f) Suspended.
(g) Stream-gaging was stopped December 31, 1958, after 6 years of record, and will be started when the watershed is subjected to a forest treatment.

(1188) WATERSHED MANAGEMENT RESEARCH, FERNOW EXPERIMENTAL FOREST, WEST VIRGINIA.

(b) Laboratory project.
(d) Field investigation; basic and applied research.
(e) Studies were started in 1951 on the Fernow Experimental Forest, Tucker County, W. Va., to determine the effect of different levels of cutting practices, different logging methods, and different forest uses upon water quantity and quality. Nine watersheds have been equipped with streamgaging stations and rain-gages.
(g) Following six years of record taking, and analysis for calibration, treatment of one group of five watersheds was started in May 1957 and completed in 1958. Records are being continued to determine treatment effects on streamflow.
(h) "Poor Logging Makes Muddy Streams," K. G. Reinhart and John J. Phillips. West Va. Conserv. 22: 20-23, 1959.
"Logging Roads in Northeastern Municipal Watersheds," George R. Trimble, Jr., Jour. Amer. Water Works Assoc. 51: 407-410, 1959.

(2419) WATERSHED MANAGEMENT RESEARCH, HUBBARD BROOK EXPERIMENTAL FOREST, NEW HAMPSHIRE.

(b) Laboratory project.
(d) Field investigation; basic and applied research.
(e) The objective is to determine the effect of forest type, condition, and treatment on quantity and quality of streamflow. Studies are conducted in plots and experimental watersheds on the 7500-acre experimental forest in the White Mountains at West Thornton, New Hampshire.
(g) Four weirs have been built and climatic stations established.
(h) "Sow Seed on Logging Roads to Control Erosion," John C. Bjorkbom, and George R. Trimble, Jr., Northeastern Logger 7: 18-19, 36-37, 46, 1958.
"A Problem Analysis and Program for Watershed Management Research in the White Mountains of New Hampshire," George R. Trimble, Jr. Northeastern Forest Expt. Sta.

Paper 116, 46 pp., illus., 1959.
"A Soil Survey of Forest Land," Lloyd E. Garland, Robert S. Pierce, and George R. Trimble, Jr. Jour. Soil and Water Conserv. 14: 199-204, 1959.

(2910) WATERSHED MANAGEMENT RESEARCH, LEADING RIDGE WATERSHED, PENNSYLVANIA.

(b) Laboratory project, in cooperation with the School of Forestry, Pennsylvania State University and the Pennsylvania Department of Forests and Waters.
(d) Field investigation; basic and applied research.
(e) A cooperative study was started in 1957 to determine the effect of forest cover and treatment on quantity and quality of streamflow in the oak-hickory type in Penn., and to study associated and basic soil-water relationships.
(g) Three experimental watersheds have been selected, weirs have been constructed, and a climatic station established.

(3567) WATERSHED MANAGEMENT RESEARCH, BALTIMORE WATERSHEDS, BALTIMORE, MARYLAND.

(b) Laboratory project in cooperation with the Baltimore Bureau of Water Supply.
(d) Field investigation; basic and applied research.
(e) A cooperative study started in 1958 to determine effect of growth of loblolly and white pine in plantations on streamflow, and to compare streamflow from watersheds in conifer plantations with streamflow from a hardwood-forest watershed.
(g) Streamflow of three experimental watersheds is being measured and a climatic station has been established.

(3568) WATERSHED MANAGEMENT RESEARCH, NEWARK WATERSHEDS, NEWFOUNDLAND, N. J.

(b) Laboratory project in cooperation with the Division of Water Supply of the City of Newark, N.J., Newfoundland, N. J.
(d) Field investigation; basic and applied research.
(e) A cooperative study to determine the influence of selected treatments of forested municipal watersheds on water supply.
(g) Weirs on 3 experimental watersheds were built in the fall of 1958 and stream gaging and climatic measurements were started in the spring of 1959.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Pacific Northwest Forest and Range Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. R.W. Cowlin, Director, Pacific Northwest Forest and Range Experiment Station, P. O. Box 4059, Portland 8, Oregon.

(969) EFFECT OF LOGGING, CLEARCUTTING AND OTHER FOREST OPERATIONS ON STREAMFLOW.

(b) Laboratory project.
(d) Field investigation, applied research.
(e) H.J. Andrews Experimental Forest, McKenzie River drainage, west central Oregon. Streamflow from three small experimental watersheds in virgin Douglas-fir has been measured for six years by means of trapezoidal flume stream gages. These observations provide a pretreatment calibration which will be carried on for three years or more. Planned treatments will test effect of two systems of timber cutting on water yield and erosion. In 1959 logging roads were constructed in one of the three watersheds to supply information on sediment yields.
Bull Run watershed in cooperation with City of Portland Water Bureau. Pretreatment calibration measurements now being taken on three small watersheds within the Bull Run watershed, source of Portland's water supply. Cover is virgin Douglas-fir. Streamflow is being measured by trapezoidal flumes. Results of this study will help determine the future management policy on the watershed.
Burns Creek, Entiat River drainage. This is the first of several watershed studies in the grano-diorite area of north-central Washington. Streamflow is measured through a 120-degree V-notch weir.
(h) "How Much Debris Down the Drainage?", Jack Rothacher. The Timberman, May 29, 1959.

(2187) EFFECT OF CATTLE GRAZING ON EROSION.

(b) Laboratory project.
(d) Field investigation, applied research.
(e) Starkey Experimental Forest and Range, northeast Oregon. Study to determine the effect of heavy, moderate and light grazing on erosion, sediment production and runoff. Sediment catchment basins have been constructed in small drainages, one in each of six pastures in which are tested three rates of grazing and two systems of management: deferred-rotation and season-long use. Major effect on erosion will be determined by volume of sediment accumulated in the basins. Study now in its fifth year.

(2911) INFLUENCE OF FOREST COVER ON INTERCEPTION OF PRECIPITATION.

(b) Laboratory project.
(d) Field investigation, applied research.
(e) H.J. Andrews Experimental Forest. A study of interception in old-growth Douglas-fir was begun in the summer of 1957. Net precipitation is measured by moving rain gages located at six representative sites; measurements of gross precipitation are being made in adjoining cutover areas.

(2912) EFFECT OF LOGGING ON EROSION.

(b) Laboratory project.
(d) Field investigation, basic and applied research.
(e) Wenatchee River drainage, central Washington. Soils derived from three major parent materials were sampled and are being analyzed to determine their basic physical and

chemical characteristics. Parent materials are Swauk sandstone, basalt and granite.

(3219) INFLUENCE OF OPENINGS IN CONIFEROUS FOREST ON SNOWMELT.

(b) Laboratory project.
(d) Field investigation, applied research.
(e) Northeastern Oregon. A study to relate maximum snow accumulation and rate of snow melt to several physiographic and vegetative factors. Fifty plots in each of two elevational ranges (4000-5000 ft. and 5000-6000 ft.) studied in the winter of 1957-58.
(f) Suspended.
(g) Contradictory results were obtained for accumulation and melt in the two areas.

(3221) EROSION FROM TRACTOR SKID ROADS.

(b) Laboratory project.
(d) Field investigation, applied research.
(e) A study in southwest Oregon to relate erosion and runoff from tractor skid roads in logged forests to several soil, physiographic and climatic variables. The essential purpose of the study is to determine under what conditions tractor logging results in excessive erosion.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Pacific Southwest Forest and Range Experiment Station.

(261) WATERSHED MANAGEMENT RESEARCH, SOUTHERN CALIFORNIA.

(b) Laboratory project.
(c) Dr. R. Keith Arnold, Director, Pacific Southwest Forest and Range Experiment Sta., P.O. Box 245, Berkeley 1, California.
(d) Experimental; field investigations; basic and applied research.
(e) Purposes are (1) to determine how watersheds function: what happens to the precipitation, and how water and soil movement are influenced by conditions of vegetation, soil, geology, and topography; and (2) to develop methods of watershed management, including treatment of areas denuded by fire, to insure maximum yield of usable water and satisfactory flood runoff and soil erosion control.
Major work center is the San Dimas Experimental Forest situated in the San Gabriel Mountains of southern California. Here rainfall and runoff are measured on two major drainage areas, on 10 large and 7 small watersheds within these areas, and on 24 experimental plots. Sedimentation is measured from the major drainages, small watersheds, and plots. Vegetation cover on the watersheds is mostly mature brush or chaparral, unburned for 40 years or more. Fifteen of the plots are equipped to obtain detailed information on the disposition of rainfall from annual grass, native scrub oak-chaparral, and a 30-year-old Coulter pine plantation. Twenty-six large lysimeters furnish comparisons of water use and surface runoff control by five species of native shrubs, one species of pine, and a bunch-grass association. Climatic data are obtained from several meteorological stations. Rainfall interception by grass is determined on small sample sites in the field and with artificial rain on grass samples grown in a greenhouse.
Measurements to determine kinds, rates, and volume of soil movement (soil, rock, and organic debris) are made at nine study sites on brush covered slopes in the Los Angeles River watershed. Vegetation on seven of the sites in Arroyo Seco Canyon was burned by wild fire in October 1959.
(g) Tests of applied watershed management to increase water yield were continued on the San Dimas Experimental Forest. Vegetation is being changed on selected portions of two calibrated watersheds. Two adjacent watersheds are being maintained as untreated controls. Clearing woodland-riparian vegetation from 38 acres along the main channel in Monroe Canyon was completed in April 1959. First year results indicate that removal of vegetation in Monroe Canyon has increased streamflow. The effects of the clearing were computed by comparing the flow from Monroe Canyon (875 acres) with that of adjacent untreated Volfe Canyon (740 acres), for years of similar rainfall before and after treatment.
Streamflow yields from Monroe and Volfe are usually about the same, but Monroe's flow for the first test year after treatment was about twice that of Volfe. From June 1, 1958 through May 31, 1959 the measured flow from Monroe was 70 acre-feet. This flow was approximately 30 feet more than predicted if the canyon bottom trees and brush had not been removed - an increase of 0.8 acre-foot per acre cleared. Sixteen acre-feet of the increase occurred during the first dry period starting in June 1958, 11 feet during the 1958-59 rainy period, and 3 feet through May of the current dry period.
During two periods in June and July 1959, water temperatures were recorded in Monroe and Volfe Canyons at points upstream where water first surfaced in quantity and at the mouth of each canyon, about 6,000 feet downstream. Ground water emerged in each canyon at nearly identical temperatures. However, water temperatures at the mouth of cleared Monroe Canyon were at least 20°F. above the maximum at the point of surfacing. In untreated Volfe Canyon the difference was 3° to 4°F. Daily fluctuations in water temperatures also were much greater in the cleared canyon, ranging from 15° to 19°F., compared to 4° and 5°F. in the untreated canyon.
The brush on 40 acres of side slopes with deep soil in 100-acre Bell Watershed No. 2 sprayed with silvicides in the spring of 1958 received a second treatment in May 1959. In each instance a misture of 2,4-D-2,4,5-T was applied by helicopter. A good leaf kill resulted from each spraying, but much of the brush is still alive. Streamflow from Bell No. 2 has been continuous since the first spraying, but intermittent

in the control watershed, Bell No. 3. Based upon rainfall and streamflow records, the flow from the treated watershed would have ceased about September 15, 1958 and about July 1, 1959 had the vegetation been undisturbed. Treatment effects have not been evaluated quantitatively.
Annual evaporative losses from a 30-year old Coulter pine plantation on the San Dimas Experimental Forest for the period 1952-53 through 1955-56 ranged from 17.9 to 24 inches depth compared to losses from a nearby dense brush cover during the same period of 17.9 to 23.6 inches. Rainfall during these years was below the 28-inch average for the site. Runoff from the pine and brush was no more than a trace any year. In none of the years did moisture penetrate through the 9 feet of soil under the pine or the 12 feet under the brush. During 1952-53 evapotranspiration (17.9 inches for pine and 19.0 for brush) exceeded the rainfall (15.5 inches) due to a carryover of soil moisture from the preceeding year's 41 inches of rain. The greater use by the brush resulted from this carryover in the 9- to 12-foot soil depth. While total annual evaporative losses were similar, Coulter pine used more water during winter and early spring than the brush (12.9 inches compared to 9.4 inches during each of two similar periods).
Preliminary measurements of rainfall interception by grass mulch during a five-month period in which 10.6 inches of rain fell, showed interception losses varying from 2.5 percent in very light mulch to 8.4 percent of the rain in heavy mulch.

(h) "Simplified Methods of Sampling Rainfall on the San Dimas Experimental Forest," by E.L. Hamilton and L.F. Reimann, California Forest and Range Experiment Station. Tech. Paper 26, 8 pp., October 1958.
"Nuclear Probe Compared with Other Soil Moisture Measurement Methods," R.A. Merriam, California Forest and Range Experiment Station Res. Note 146, 5 pp., January 1959.
"Flowering and Growth Responses to Photoperiod and Temperature for Six Southern California Grasses," W.C. Ashby and H. Hellmers, The Botanical Gazette, Vol. 120, No. 3, March 1959, pp. 151-157, illus.
"Increasing Water Yield in Southern Calif. Mountains," J.H. Patric, Jour. of Amer. Water Works Assn., Vol. 51, No. 4, April 1959, pp. 474-480, illus.
"Sulfur Dioxide as a Defoliant of Chaparral Plants," J.H. Patric, Jour. of Forestry, Vol. 57, No. 6, June 1959, pp. 437-438, illus.
"The San Dimas Disturbed Soil Lysimeters," J.D. Sinclair and J.H. Patric, Proc. Symposium on Forest and Water, Hannover-Munden, Germany, Vol. II, September 1959.
"Ceanothus Leucodermis and Soil Nitrogen in Southern California Mountains," H. Hellmers and J.M. Kelleher, Forest Science, Vol. 5, No. 3, pp., 275-278, September 1959.
"Summer Slides and Winter Scour - Dry-Wet Erosion in Southern California Mountains," H.W. Anderson, G.B. Coleman, and P.J. Zinke, Pacific Southwest Forest and Range Expt. Station, Tech. Paper No. 36, 12 pp., illus., July 1959.
"Mountain Evaporation - Data From the San Dimas Experimental Forest at Elevations of 1,500 to 5,100 feet," by L.F. Reimann, Pacific Southwest Forest and Range Experiment Station, Misc. Paper No. 35, 14 pp., illus., July 1959.
"Mountain Temperatures - Twenty-Five Years of Data from the San Dimas Experimental Forest," L.F. Reimann, Pacific Southwest Forest and Range Experiment Station, Misc. Paper No. 36, 32 pp., illus., July 1959.
"Four Hundred Sixty Storms - Twenty Five Years of Rainfall Data from the San Dimas Experimental Forest," L.F. Reimann and E.L. Hamilton, Pacific Southwest Forest and Range Experiment Station, Misc. Paper No. 37, 95 pp., illus., July 1959.
"More Water From the Uplands," Walt Hopkins, Minutes Biennial Convention Irrig. Dists. Assn. of Calif., pp. 2-5, March 1959.

(2415) WATERSHED MANAGEMENT RESEARCH, NORTHERN CALIFORNIA.

(b) Laboratory project.
(d) Experimental; field investigations; basic and applied research.
(e) The aim is to develop a hydrologic base for land management decisions. The hydrologic effects of wildfires, of attempts at conversion of brushlands to grass, and of logging and other land uses are to be evaluated. Present studies emphasize development of methods of management of high elevation snowpacks for maximum control and yield of water.
Major work center is in Berkeley with 18 studies being conducted throughout northern California in the headwaters of the Kings, American, Yuba, Truckee, and Feather Rivers. At the Teakettle watersheds in the headwaters of the Kings River Basin, five small watersheds are under calibration for evaluation of streamflow and sedimentation.
In the Onion Creek watersheds in the headwaters of the American River Basin, five streams are being gaged and sediment measured. Snow accumulation and soil moisture are being measured in logged and unlogged forest and in brush areas, at both Onion Creek and Castle Creek. Castle Creek in the Yuba River Basin is being gaged, suspended sediment measured, and basic snow physics studies are under way. Daily meteorological measurements are being taken at three stations, and radiation and snow physics at the headquarters station.
At Sagehen Creek in the Truckee River Basin, sediment and streamflow and their effects on fishlife are being studied in cooperation with the Department of Zoology, Univ. of California. Also the effects of conversion of brushfields to forest are being studied.
At Swain Mountain Experimental Forest in the Feather River Basin, snow and soil moisture are being measured where forests were cut in strips and blocks and where logging slash was treated and untreated. In all, snow accumulation is being measured at

70 special snow courses, soil moisture at 60 plots.

(g) At the Central Sierra Snow Laboratory the snow water (in inches) in various forest conditions (average for all slopes) at the time of maximum snow accumulation, about April 22, 1958 and again after about one-half to two-thirds of the snow had melted June 1, 1958, was: in forest openings 63.2 and 26.8, in forest adjacent to openings 56.0 and 25.1, in dense forest (80-100%) 48.1 and 19.0, in moderate forests (50-80%) 50.3 and 25.0, and in open forests (20-50%) 57.7 and 25.0. The maximum snow on April 22 and still on June 1, 1958 was in forest openings; maximum melt occurred there, too. Minimum melt was found in forests, the least being in the moderately dense forests.
Evaporation from the snow was measured daily in a small forest opening and in an 80 percent dense forest at an elevation of 6,700 feet. Evaporation from January through June 1959 totalled 1.7 in the forest openings and 0.9 inches in the forest itself. In a short term study, the snow evaporation in a meadow was one and a half times that of the small openings, and snow evaporation on exposed ridge tops was as much as three times that of the openings. In mid-June of 1958 a snow patch was gaining nearly 3/100 of an inch of water per day due to condensation.
Summer soil moisture losses and losses of summer precipitation were measured at 45 sites in the Castle Creek Basin. The first analysis indicates that for a 75-day period - July 1 to October 15, 1958 - losses from a soil 4-foot deep were as follows: In old-growth red fir forests 5.1, in young red fir forests 4.8, in Wyethia (Wild Sunflower) 3.5, and in bare ground 1.3. In each type an additional loss of 2.6 inches of summer precipitation occurred in the period.
Summer water losses in 1958 in a high elevation brushfield cleared by bulldozing was 2.7 inches less (for a 4-foot soil) than in the untreated brush. Loss in the untreated brush was 4.8 inches, including 1.4 inches of summer precipitation.
Annual water losses for three types of logging were compared. Differences in water losses in cut strips, two times the height of the trees, was 9 inches less than in adjacent uncut forest, loss in a 17-acre block-cut forest was 6 inches less than uncut forest, and loss in a forest cut by commercial selection was 3 inches less than in uncut forest.

(h) "Water Yield Control Through Management in Snowpack Watersheds," H.W. Anderson, Proc. First Intersociety Conf. on Irrig. and Drainage, pp. 13-18, March 1959.
"Snow Management Research in High Sierra Range," R.M. Rice, Jour. of Range Management 12:13-16, 1959.
"Summer Evapotranspiration Measurements Using a Radio-Active Soil Moisture Probe," by K.R. Knoerr, (Abstract) Jour. Geophys. Res. 64 (6): 691, 1959.
"Winter and Summer Water Losses in the High Sierra," A.J. West and K.R. Knoerr, Jour. American Water Works Assoc. 51(4): 481-88, 1959.
"Snow in Forest Openings and Forest Stands," H.W. Anderson, R.M. Rice and A.J. West, Proc. Soc. Amer. Foresters, pp. 46-50, 1958.
"Snow Evaporation and Condensation," A.J. West, 27th Ann. Western Snow Conf. Proc., 1959.
"Logging Effects on Snow, Soil Moisture and Water Losses," H.W. Anderson and C. H. Gleason, 27th Ann. Western Snow Conf. Proc., 1959.
"Snow Management Research in the Sierra Nevada - a Review and a Look Ahead," by Walt Hopkins, 27th Ann. Western Snow Conf. Proc., 1959.
"Forest Effects on Floods in Northwestern United States," H.W. Anderson and R.L. Hobba, Proc. Symposium on Forests and Water, Hannover-Munden, Germany, pp. 110-119, Sept. 1959.
"Progress Report, 1958-59, Cooperative Snow Management Research," H.W. Anderson and Lucille G. Richards, Pacific Southwest Forest and Range Experiment Station, pp. 57-94, June 1959.
"Forest Density, Openings, Ground Cover and Slopes in the Snowzone of the Sierra West Side," Lucille G. Richards, Pacific Southwest Forest and Range Experiment Station, Tech. Paper No. 40, 16 pp., October 1959.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Rocky Mountain Forest and Range Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. Raymond Price, Director, Rocky Mountain Forest and Range Experiment Station, Room 221 Forestry Building, Fort Collins, Colorado.

(376) WATERSHED MANAGEMENT RESEARCH, MANITOU EXPERIMENTAL FOREST.

(b) Laboratory project.
(d) Field investigations; applied research.
(e) Studies of the influence of grazing, timber cutting, and revegetation of depleted watershed lands upon water supplies, erosion and sedimentation, to solve problems in management of watershed lands of the Rocky Mountain Front Range such as: (1) Runoff and erosion from natural storms on bunchgrass plots; (2) runoff and erosion from natural storms on young pine plots; (3) effect of type conversion on runoff and erosion from small watersheds; (4) effect of logging intensities on snow accumulation in ponderosa pine-Douglas fir type; and (5) characteristics of runoff from cloudburst storms on a large watershed.
(f) Discontinued.
(h) Annual report, 1958, Rocky Mountain Forest and Range Experiment Sta., Fort Collins, Colo.
"Rangeland Watershed Management," L.D. Love, Proceedings Soc. of American Foresters, Salt Lake City, Utah, 1958. Pages 198-200.

(377) WATERSHED MANAGEMENT RESEARCH, FRASER HYDROLOGIC LABORATORY.

(b) Laboratory project.

(d) Field investigations; applied research.
(e) (1) To determine influence of lodgepole pine and spruce-fir forests and of the management of these forests on the yield of water. (2) To evaluate the alpine snowfields of the Colorado Rockies with respect to their contribution to summer streamflow. (3) To measure the rate of snow accumulation in natural catchment basins under alpine conditions. This is the pretreatment calibration of a series of drift sites, part of which will be supplemented by drift fences at a later date to test the effectiveness of such structures in enlarging and deepening such alpine snow drifts.
(g) The cutting and removal of half of the timber from one 714-acre watershed was completed in 1956. For the years 1956 to 1958 the increase in water yield attributable to the timber harvest was 24 percent or 200 acre-feet. Periodic records at the Fraser Experimental Forest reveal that the mean monthly air temperature is 32°F. February has provided the coldest monthly mean of 10°F. The highest recorded temperature for the period is 83°F; the coldest is 42.5°F. below zero. For 88 percent of the year, the temperature drops below 32°F. during each day. Soil temperatures have been taken at a depth of 3.5 feet. The lowest recorded winter temperature was 31°F. and the highest summer reading was 52°F. For four consecutive years, the average yearly precipitation was 23.5 inches. It is interesting to note that there was an annual average of 1.61 inches more precipitation at the Fraser Experimental Forest headquarters than in the town of Fraser located 5 miles away and 440 feet lower in elevation. During the winter 1958-59 snow depth was read at 98 stakes located in six small natural catchment basins in the alpine portion of the Colorado Rocky Mountains. Snow accumulation for this period varied from 19 feet in the deep parts of two of the catchments to less than 1 foot on the wind exposed edges of the catchments. It averaged 8.4 feet per stake for the group of 98 stakes. The five largest storms accounted for 62 percent of the total snow accumulation; the two largest storms contributed 33 percent with 20 percent coming during the largest storm of the year. Standard snow fencing appears to increase the amount of snow trapped in such natural catchments but data are not conclusive.
(h) Annual report, 1958, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
"Watershed Studies at Fraser, Colorado," Bertram C. Goodell, Proc. Soc. of American Foresters, Salt Lake City, Utah, 1958, pp. 42-45.
"A Preliminary Report on the First Year's Effects of Timber Harvesting on Water Yield From a Colorado Watershed," Bertram C. Goodell, Station Paper No. 33, 12 pp., Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
"Some Hydrologic Aspects of Alpine Snowfields Under Summer Conditions," by M. Martinelli, Jour. of Geophysical Research, Vol. 4, No. 4, April 1959, pp. 451-455.
"Alpine Snowfields - Their Characteristics and Management Possibilities," M. Martinelli, Symposium of Hannoversch-Münden, Vol. 1, pp. 120-127, Publication No. 48 de L'Association Internationale d'Hydrologie Scientifique, Sept. 1959.

(657) WATERSHED MANAGEMENT RESEARCH, TEMPE, ARIZONA.

(b) Laboratory project.
(d) Experimental; basic and applied research.
(e) The purpose is: (1) To study the disposition of rainfall as influenced by watershed vegetation; (2) to determine the influence of various types of forest and grassland vegetation as well as vegetation modified by cultural treatment such as grazing and timber harvest, on streamflow, water use, water loss, and erosion and sediment yield; (3) to determine for phraetophytic vegetation (water-loving plants) the amount of water used, methods for reducing water use by phraetophytes or for replacing them with more useful plants; and (4) for mixed conifer and chaparral types of vegetation to determine the hydrologic characteristics of natural watersheds and the effect of cover modification upon water yields, soil stability and other resource values.
At Sierra Ancha Experimental Watersheds in central Arizona, rainfall, runoff, and erosion are measured on three watersheds in the pine-fir vegetation type at high elevation, on two watersheds in the ponderosa-chaparral type, and from four watersheds in the grassland-chaparral type at intermediate elevation, and on nine small watersheds in the semidesert-chaparral type at low elevations. Water use by different types of plants in various soils is studied on eleven large lysimeters. Three watersheds have also been established in the pure ponderosa pine type and two in the mixed conifer type to test the effects of logging practices upon water yield and soil stability. Gaging stations for four watersheds in the pure chaparral type are also available to evaluate watershed-game interrelations. One cluster of two watersheds and another cluster of three watersheds are available for testing the effect of manipulating chaparral cover. Supplemental studies are determining the proper use of chemicals, fire and mechanical treatment for manipulating shrub in the type. Ecology of Tamarix pentandra is under investigation. Germination, seedling survival, and rate of spread studies were continued. A field apparatus employing the infrared analyzer for detecting moisture has been used for detailed measurements of evapo-transpiration of phraetophyte types.
(g) In the Pine-fir forests comparative moisture samples among grassland, aspen, and coniferous sub-types showed that from October to April there was some gain in soil moisture under grassland and aspen, and some loss under conifers. From April to May soil moisture recharge compensated for and exceeded moisture use by any of the three

kinds of vegetation. Snow measurements during the winter of 1958 indicated that snowmelt from the cooler aspects contribute mostly to peak discharge of streamflow. Within the Chaparral type measured water yields have varied from 0 to 2.35 inches depending upon amount, distribution and intensity of precipitation, depth and character of the soil mantle, and kind and abundance of plant cover.
Continued work on the Phreatophyte, 5-stamen tamarisk, showed that evapo-transpiration was greater from mixtures of tamarisk and bermuda grass sod than from the bermuda grass alone. On the plots sampled, evapotranspiration rate seemed to increase about linerally with the amount of tamarisk. Tamarisk was found to develop a taproot extending down to a deep water table and to spread laterally from a main taproot where there is a shallow water table. Two other phreatophytes, seepwillow and arrowweed seem to be shallow rooted, maintaining most of their roots in the upper foot of the soil profile.

(h) "Estimating Surface Area of Ponderosa Pine Foliage in Central Arizona," Dwight R. Cable. Forest Sci. 4(1):45-49, 1958.
"The Problem of Phreatophytes," Jerome S. Horton, Symposium of Hannoversch-Münden, Vol. 1, pp. 76-83. Publication No. 48 de L'Association Internationale d'Hydrologie Scientifique, Sept. 1959.
"Current Watershed Management Research by the U. S. Forest Service in Arizona," H.G. Reynolds. Third Annual Watershed Symposium, Arizona Water Resources Committee, State Land Dept., Phoenix, Arizona, 1959.
"Research in Management on Chaparral Lands in Arizona," H. G. Reynolds and G. E. Glendening. Arizona Cattlelog 14(12): 13-16, 1959.
"Hydrologic Research Using Lysimeter of Undisturbed Soil Blocks," Lowell R. Rich. Symposium of Hannoversch-Münden, Vol. II, pp. 139-145. Publication No. 49 L'Association Internationale d'Hydrologie Scientifique, Sept. 1959.

(1969) WATERSHED MANAGEMENT RESEARCH, ALBUQUERQUE, NEW MEXICO.

(b) Cooperative study with Bureau of Land Management and Geological Survey.
(d) Applied research.
(e) Evaluation of range-watershed conditions on small watersheds in the San Luis drainage of the Rio Puerco. Three contiguous watersheds, ranging from 338 to 555 acres located about 8 miles north of the San Luis community and west of the Rio Puerco main channel provide the study area. Water and sediment inflow are measured in small reservoirs formed by earthen dams. Precipitation amounts and vegetation changes are periodically measured over the watersheds. The preliminary survey and investigation phase is completed; and watershed boundary fences installed and four years of data have been collected under cattle grazing during the six month overwinter period (November 1 to May 1). Soil elevation measurements have been obtained on the three watersheds for purposes of determining soil losses from the alluvial soils. Rising stage sediment samplers have been installed on the three watersheds.
(h) Annual report, 1958, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

(1971) WATERSHED MANAGEMENT RESEARCH, GRAND JUNCTION, COLORADO.

(b) Laboratory project, in cooperation with Bureau of Land Management, Bureau of Reclamation, Geological Survey, and Fish and Wildlife Service.
(d) Experimental; applied research.
(e) To determine the effect of exclusion of livestock grazing on erosion and runoff from semidesert lands in western Colorado.
(g) Pretreatment measurements were made in 1953-1954 of infiltration and erosion, using the Rocky Mountain infiltrometer. Measurements during the period of treatment started in 1958 and will be continued at 5-year intervals. Data from plots located on the mixed soil type (comprising 67% of all plots) have been analyzed statistically. The analysis showed that infiltration rates (f_c) on the mixed soil have increased significantly since 1953. However, this increase was approximately the same for both the grazed and protected watersheds. Average infiltration rates were as follows:

Treatment	Infiltration rate (f_c)	
	1953,54	1958
	- - - - - inches/hr.	- - - -
Grazed	.79	.95
Protected	.60	.78

(2188) WATERSHED MANAGEMENT RESEARCH, ALBUQUERQUE, NEW MEXICO.

(b) Laboratory project.
(d) Applied research.
(e) Soil moisture studies. Coleman soil electrical units were installed at 3-inch depth intervals from the 1-1½ inch soil depth to bedrock or to a depth beyond any anticipated moisture penetration. Recording and standard gages were used to measure precipitation. Moist pinyon-juniper zone (17-inch annual precipitation). A record of precipitation and soil moisture was maintained under three ground-cover conditions; under pinyon trees and in a woodland opening; in grassland; and in a bared area kept free of vegetation by chemical spraying. Dry pinyon-juniper-sagebrush zone (13-inch annual precipitation). A record of precipitation and soil moisture was maintained under four conditions: native sagebrush under protection from livestock grazing; and in crested wheatgrass under 25 percent utilization, under 75 percent utilization and under full protection from cattle grazing.
(f) Field study terminated at Pine Flat (moist pinyon-juniper zone) and at Cebolla Mesa

(dry pinyon-juniper sagebrush zone).

(h) Annual report, 1958, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. Other publication planned.

(2420) WATERSHED MANAGEMENT RESEARCH, GRAND JUNCTION, COLORADO.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) To compare the amount of soil moisture withdrawal under aspen, spruce and mixed grass-weed type. Measurements were taken in 1955, 1957 and 1958. Three sites were sampled in each type. Seven gravimetric samples were taken at random on a 30-foot grid superimposed on each site. Samples were taken approximately July 1 and Nov. 1, the difference in water content representing gross use by vegetation. Water use values will be adjusted for current precipitation. Samples were taken in 1-foot increments to a depth of 8 feet.
(f) Completed.
(g) The final analysis included only those sites where soil moisture was at or above wilting point both spring and fall. The analysis showed that the amount of water used by the three vegetation types was significantly different. Aspen used an average of 20.0" during the growing season, spruce used 14.0" and grassland only 8.3".
(h) Annual reports of the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

(2657) WATERSHED MANAGEMENT RESEARCH, GRAND JUNCTION, COLORADO.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) To determine the effect of range conditions and related factors on sediment production and runoff on three mountain grassland watersheds in western Colorado. Range condition is being measured by means of 20 or more 3-step transects on each watershed. Ninety degree V-notch weirs are used to gage the watersheds which vary in size from 86 to 272 acres. Water samples are taken several times daily during snowmelt and periods of storm runoff for determination of suspended sediment; bed load is measured in the weir ponds.
(h) Annual reports of the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

(2658) WATERSHED MANAGEMENT RESEARCH, RAPID CITY, SOUTH DAKOTA.

(b) Laboratory project.
(d) Experimental; basic and applied research.
(e) (1) To determine how heavy grazing of bluegrass range in the Black Hills has influenced soil structure. Involves measurement of bulk density and pore space of soil inside and outside livestock exclosures. (2) Study of basic soil-water relationships under dense ponderosa pine in the Black Hills to determine how thinning influences amount of water available for streamflow. Involves measurement of precipitation under thinned and unthinned pine, stemflow, and soil moisture. (3) To establish Black Hills precipitation and streamflow characteristics from existing records.
(f) Items 1 and 2 active. Item 1 submitted for publication. Item 2 continuing. Item 3 completed.
(g) (1) Soil was more compact to about 2 or 4 inches depth on grazed range than inside livestock exclosures. Most compaction and greatest depth of compaction associated with highest silt plus clay content of the soil. (2) Precipitation in the open was 22.77 and 17.71 in the first and second years of study. Thinned stand with a basal area of 80 square feet per acre intercepted 13 and 14 percent of precipitation. The unthinned stand with basal area of 171 square feet per acre intercepted 25 and 29 percent of precipitation. (3) Water yield was 3.06 inches from a watershed receiving 21.46 inches precipitation per year, more than half of which falls in the growing season. Indication of trend was toward less water yield per unit of precipitation, possibly as result of development of dense second growth ponderosa pine.
(h) "Precipitation and Streamflow in the Black Hills," Howard K. Orr. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo. Station Paper 44, 25 pp. illus. Annual Report, 1958, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

(2913) BEAVER CREEK WATERSHED PROJECT.

(b) Laboratory project, cooperative with Coconino National Forest, Flagstaff, Ariz.
(d) Field investigation; basic research.
(e) Calibration of 12 small watersheds, 6 in ponderosa pine type, 3 in alligator juniper type, and 3 in Utah juniper type. A newly designed modified trapezoidal Venturi flume is being used to measure discharge from these steep ephemeral streams. Precipitation measurements are being taken.
(g) Preliminary runoff figures for 24-month period on Beaver Creek (Fall 1957, 1958, and Spring 1959)

Types	Precipitation inches	Runoff inches	
Ponderosa pine	51.4	10.6	Average of 2 watersheds
Alligator juniper	48.5	3.6	One watershed only
Utah juniper	42.1	2.0	Average of 2 watersheds

(h) "National Forest Watershed Projects in Arizona," Fred H. Kennedy. U.S. Forest Service, Southwestern Region, Albuquerque, New Mexico, Sept. 1959, pp. 7-9.

(3222) BEAVER CREEK WATERSHED PROJECT.

(b) Laboratory project, cooperative with Coconino National Forest, Flagstaff, Ariz.
(d) Field investigation; basic research.

(e) Study of the disposition of precipitation in the Utah juniper type, including measurements of precipitation, interception, surface runoff, and soil moisture budget by stand density class.
(g) One year's measurements showed that of 15 inches precipitation, interception accounted for 5 to 20% and surface runoff 0.5 to 2.5%, depending on stand density. Soil moisture loss, drawing on overwinter storage, exceeded precipitation by 0.7 to 4.6 inches, depending on soil depth.

(3223) WATERSHED MANAGEMENT RESEARCH, FORT COLLINS, COLORADO.

(b) Laboratory project.
(d) Field investigations; applied research.
(e) A physical evaluation of mechanical erosion control practices established on the Trout Creek Watershed, Salida District, San Isabel National Forest, Colorado. Evaluation of mechanical erosion control practices on depleted lands in the Colorado Front Range. The following soil associations are represented: Edloe-Stecum association derived from granite, Chubba-Laporte (limestone), Trout Creek-gano-Heath (shale and sandstone), Buena Vista-Rods-Outcrop (Trachyte).
(g) Appraisal of erosion control structures built 20-25 years ago shows that their effectiveness in stabilizing gully channels is related to channel gradient, construction materials, capacity of structures to pass expected storm flows, and changes in land use.
(h) Annual Report 1958, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

(3224) BEAVER CREEK WATERSHED PROJECT.

(b) Laboratory project, cooperative with Coconino National Forest, Flagstaff, Ariz.
(d) Field investigation; basic research.
(e) Rainfall interception by nine densities of pole-size ponderosa pine.
(f) Completed except for reporting.
(h) Report in preparation.

(3569) WATERSHED MANAGEMENT RESEARCH, LARAMIE, WYOMING.

(b) Laboratory project.
(d) Field investigations; applied research.
(e) Watershed and range management investigations are combined in this study. The objectives of the watershed management investigations are to determine the effects of (1) complete chemical control of sagebrush and (2) chemical control of sagebrush in alternate 100-foot strips on snow storage, runoff, sediment movement, soil moisture withdrawal and ground cover. Three contiguous high-elevation sagebrush watersheds, ranging from 60 to 106 acres, in western Wyoming provide the study area. V-notch weirs gage the runoff, and water samples are taken periodically during snowmelt and storm runoff to determine suspended sediment loads. Peak snowpack is sampled on permanent transects and at random points. Soil moisture is sampled gravimetrically after snow disappearance in the spring and before snow accumulation begins in the fall. Summer precipitation is sampled by a network of recording and nonrecording rain gages. Winter precipitation is sampled by a standpipe snow accumulation gage. Ground cover will be determined before and after treatments by the square-foot-density method.

(3570) WATERSHED MANAGEMENT RESEARCH, ALBUQUERQUE, NEW MEXICO.

(b) Laboratory project.
(d) Field investigation - exploratory.
(e) Appraise snowpack conditions, including accumulation and melt at several locations in the Sangre de Cristo Range as a basis for conducting future basic research in snowpack management.

(3571) WATERSHED MANAGEMENT RESEARCH, ALBUQUERQUE, NEW MEXICO.

(b) Laboratory project.
(d) Field investigation - exploratory.
(e) Determine for Engelmann spruce, Douglas-fir, ponderosa pine, and aspen on north and south aspects: (1) Periods of soil moisture deficit and surplus, (2) relative soil moisture and temperature variations during growth and dormant season, (3) occurrence and depth of soil freezing. Basis for fundamental research.

(3572) WATERSHED-RANGE MANAGEMENT RESEARCH, ALBUQUERQUE, NEW MEXICO.

(b) Bureau of Land Management.
(d) Applied research.
(e) Evaluation of soil pitting (Calkins pitter) on surface runoff, erosion and vegetation. Surface runoff plots (24), 10 feet by 30 feet, are installed on 3 slope aspects, representing different soil conditions, in the Rio Jemez drainage. Precipitation, runoff, sediment and changes in vegetation are measured.

(3573) WATERSHED-RANGE MANAGEMENT RESEARCH, ALBUQUERQUE, NEW MEXICO.

(b) Bureau of Land Management.
(d) Applied research.
(e) Evaluation of soil ripping (Jayhawker) on surface runoff, erosion and vegetation. Surface runoff plots (72), 10 feet by 30 feet, are installed on a north and south aspect and upper and lower slopes representing different soil conditions in the Rio Jemez drainage. Seeding grass (alkali sacaton) and browse (chamiza) and protection from livestock and rabbits is also evaluated. Precipitation, runoff, sediment, and changes in vegetation are measured.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Southeastern Forest Experiment Station.

(380) WATER RESOURCE AND WATERSHED MANAGEMENT RESEARCH.

(b) Laboratory project. For general public use and information.

(c) Mr. J.F. Pechanec, Director, Southeastern Forest Experiment Station, U.S. Forest Service, P.O. Box 2570, Asheville, N. C.

(d) General investigations of forest influences in the southeastern United States, with primary emphasis on fundamental hydrologic research on watershed processes and related applications in watershed management.

(e) Basic research into forest hydrologic processes from the precipitation of water over an area until it leaves the watershed as streamflow or evapo-transpiration. Demonstrations of several cover types and land management practices and their effect upon water yield, quality and flow characteristics. Development of watershed management methods pertinent to the region and cooperative trials and demonstrations of these methods. Most of the experimentation and hydrologic data collection is on the 5600-acre Coweeta Hydrologic Laboratory located in the zone of maximum precipitation for the eastern United States (Nantahala Range of the Southern Appalachians). Seventeen individual and two multiple watersheds are currently active and along with an additional nineteen standby watersheds whose streamflow has been gaged for over 24 years provide the locale for the experimental program. Over 570 cumulative years of streamflow records are available for drainages ranging from 4 acres to 8 square miles. The Laboratory has 10 recording and 57 non-recording (standard) rain gages, 1 recording ground water well, 4 recording hydro-thermographs, 2 recording soil thermographs, 2 recording water thermographs, 1 metering anemometer, 1 evaporation pan and 2 recording pyrheliometers. Water samples are collected from selected watersheds for quality analysis on a storm period basis. Soil moisture is measured in the field with a portable neutron scattering device.
Basic research in plant-soil-moisture relations is emphasized at the Union Research Center. Current or planned soil moisture studies include development of field measurement techniques for moisture investigations by the neutron method, comparative water use requirements of cover types, moisture recharge and depletion investigations, soil storage characteristics, and depth of moisture withdrawal by representative cover types. Secondary studies include index measures of runoff and erosion from several small Piedmont watersheds, effect of watershed reclamation on stormflow and sediment production, and hydrologic properties of forest soils. The center has laboratory facilities for analysis of foliage and physical and chemical properties of soils, a portable neutron scattering device for measuring soil moisture, 4 gaged watersheds, three recording and 7 standard raingages, one recording ground water well, and a standard Weather Bureau weather station.
All projects are to be carried to completion through analysis of data, preparation of reports, and publication of technical articles. Research studies include: (1) Evapotranspiration from forest land, hydrologic effects of reducing basal area 50 percent. (2) Rehabilitation treatment of experimental watersheds formerly used in studies of mountain farming, woodland grazing, and exploitive mountain logging. (3) Type conversion on drained slopes. (4) Soil moisture regime in relation to evapo-transpiration. (5) Operating forest pilot watersheds to demonstrate proper location and layout of logging roads.
A study of soil moisture regime under typical Piedmont cover types (Union Center) has been terminated and results published (h).

(g) Removal of vegetation from selected watersheds by several different cutting patterns produced increased annual water yields without detecting changes in stormflow or soils. Currently established type-conversions from existing hardwood cover to white pine and to grass are to demonstrate differential water use, if any, by varying cover types. Several studies of soil moisture storage and movement are in progress. The annual range of storage flux is rather narrow, 24 to 29 inches in a 7 foot grass-covered mountain profile. Preliminary tests show that under a forest cover this annual range will be greater. Soil moisture accretion and loss is being followed but its value as an indicator of evapo-transpiration may be limited in the mountains to June through December when profile drainage assumes a low, constant value. Field and model studies designed to determine the physics of soil moisture movement and the dynamics of its storage on steep slopes suggest that a possible source of appreciable quantities of base flow in the mountains may be soil moisture in the so-called field capacity range, rather than saturated aquifers. The effect of slope and aspect upon solar energy avilability and its possible part in evapo-transpiration from mountain watersheds has been studied on a theoretical basis and instruments are being tested which would permit accompanying field measurements. Studies of hydrologic constants for small mountain watersheds, including some cooperative work with SCS, indicate that conventional flood estimation methods are not adaptable to these small watersheds. Early demonstrations of good and poor watershed management practices and necessary rehabilitation methods have been of great educational value to the public and have helped document recommendations for proper land practices on public and private lands. Moisture depletion rates and recharge were found to vary by cover types and soil depth over a 7-year period. No noticeable difference in depletion between pine and pine-hardwood cover types was observed although forest and grass cover differed in their water use particularly below 30-inch depths. Rehabilitation of a small eroded watershed greatly reduced peak discharge and erosion from the watershed.

(h) "A Method for Calculating Error of Soil Moisture Volumes in Gravimetric Sampling," J.D. Hewlett and J.E. Douglass. Submitted to Forest Science.
"Increasing Water Yields by Cutting Forest Vegetation," H.G. Meginnis. Water and Woodlands, Vol. 1, Transactions of Meeting of the International Association of Scientific Hydrology in Germany, 1959, (in press).
"The Effect of Mountain Topography on Solar Energy Theoretically Available for Evapotranspiration," L. W. Swift, Jr. Manuscript in preparation.
"Soil Moisture Depletion Under Several Piedmont Cover Types," Louis J. Metz and James E. Douglass. USDA Tech. Bul. No. 1207. Forest Service, September 1959.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Southern Forest Experiment Station.

Inquiries concerning the following projects should be addressed to Mr. Philip A. Briegleb, Director, Southern Forest Experiment Station, 2026 St. Charles Avenue, New Orleans 13, Louisiana.

(2914) WATERSHED MANAGEMENT RESEARCH, OXFORD RESEARCH CENTER, OXFORD, MISSISSIPPI.

(b) Laboratory project, in cooperation with Soil Conservation Service, Agricultural Research Service, and University of Miss.
(d) Field investigation of runoff and erosion from small experimental watersheds on forest and potential forest lands; basic and applied research.
(e) Twelve small natural headwater catchments, two to four acres in size, have been installed in batteries of three to determine runoff and erosion from old fields, depleted upland hardwoods, mature upland hardwood-pine, and loblolly pine plantations. The watersheds will be calibrated some years before treatments are applied. Related studies include soil moisture-tree growth relationships.
(g) Watershed studies - system developed for estimating soil moisture over large areas from single installation. Annual surface runoff on small watersheds during 1958 was 2.4 percent of precipitation for pine plantations, 9.9 percent for depleted upland hardwoods, and 14.5 percent from old-field units.
(h) Annual Report, Southern Forest Experiment Station.

(3225) WATERSHED MANAGEMENT RESEARCH, HARRISON RESEARCH CENTER, HARRISON, ARKANSAS.

(b) Laboratory project, in cooperation with Soil Conservation Service and University of Arkansas.
(d) Field investigations of hydrologic effects of land conversion from hardwood forest to native range, applied research.
(e) Duplicate runoff plots 12 x 100 feet were installed on woodland not grazed, woodland grazed, and woodland converted to range by aerial spraying and grazed. The study will measure effects of conversion and grazing on runoff and erosion, changes in litter-humus character, soil moisture, and surface soil physical properties.
(g) Litter and humus decreased almost half on treated areas one year after trees were sprayed.
(h) Annual Report, Southern Forest Expt. Station.

(3226) SOIL MOISTURE RESEARCH, VICKSBURG RESEARCH CENTER, VICKSBURG, MISSISSIPPI.

(b) Waterways Experiment Station, Corps of Engineers, U. S. Army.
(d) Field and laboratory investigations, basic and applied research on factors affecting soil moisture.
(e) Project is aimed at development of a soil-moisture prediction method based on field studies throughout the United States and possessions. Present studies include refinement of prediction methods, environmental factors, problem soils, and methods and techniques.
(g) A workable soil-moisture prediction method has been developed for use in vehicle trafficability ratings without previous contact with the soil.
(h) Annual Report, Southern Forest Expt. Sta.
"Soil Moisture Constants and their Variation," W.M. Broadfoot and H.D. Burke, Southern Forest Expt. Sta. Occasional Paper 166, 1958.

U. S. DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS, Beach Erosion Board.

Inquiries concerning the following projects should be addressed to the President, Beach Erosion Board, 5201 Little Falls Road, Washington 16, D. C.

(181) EQUILIBRIUM PROFILE OF BEACHES AND STUDY OF MODEL SCALE EFFECTS.

(b) Laboratory project.
(d) Experimental.
(e) Equilibrium beach profiles will be determined experimentally for waves up to 6 feet in height in a prototype tank; the waves will will be modeled at a 1 to 10 scale in small laboratory tanks for various median diameter and specific gravity sediments to determine scale effect.
(g) A single test was made using crushed coal of specific gravity 1.5 (modeled by the settling velocity relationship to give corresponding characteristics of material tested in the large tank). Observed material movement and profile changes corresponded much more nearly to the large scale results in the prototype tank, although the coal slope deteriorated somewhat faster. A very few additional small scale tests utilizing the same sands as in the large tank have also been completed. Testing is now being resumed with the coal.

(660) OBSERVED WAVE CHARACTERISTICS.

(b) Laboratory and field project.

(d) Field investigation; basic research.
(e) To secure a more thorough knowledge of the characteristics of ocean waves. A number of electrical recording wave gages have been installed in coastal waters and these records are analyzed for significant height and period.
(g) The new type plastic wave gage sections have proven superior to the neoprene coated aluminum channel type and have been installed at all Beach Erosion Board wave gage installations. Anti-fouling paint has been applied to several of the gages and has proved very effective in reducing the marine growth on the gages, depending upon location. The wave spectrum analyzer utilizing a revolving tape head is now in the testing stage. Experimental records obtained with a tape recorder at Atlantic City, N.J., are being analysed for comparison with analysis by hand and by other automatic analyses. An improved staff type wave gage is being fabricated for the New Orleans district for use in Lake Pontchartrain, La. This gage is unique in that it is designed to operate in water with salinity changes ranging from fresh water to sea water.

(975) METHODS OF BY-PASSING SAND PAST INLETS.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) To study methods and requirements for pumping sand past inlets and to determine the applicability of the methods in stabilization of beaches adjacent to inlets. A study is being made of the sand by-passing operations carried out at Port Hueneme, California and Lake Worth, Florida. Data are being obtained on the operation of the stationary sand transfer plant located on the north jetty of Lake Worth Inlet, Florida. These data include periodic hydrographic surveys south and north of the inlet, wave data, sand samples, detailed records of pumping operations, and detailed records of entrance channel maintenance. Additional survey data taken at Port Hueneme are being analysed and a report prepared. Study is being made of the possibility of adapting commercial instruments utilizing a radioactive source to measure density of material pumped in by-passing.

(976) ESTABLISHMENT OF CRITERIA FOR CONSTRUCTION OF ARTIFICIAL BEACHES.

(b) Laboratory
(d) Theoretical; applied research.
(e) To develop criteria for construction of beaches by artificial means. The present phase of this general study involves the measurement of a natural beach slope and attempts to determine its response to the forces normally incident upon the shore such as wave height and period, angle of wave approach, tide, and direction and magnitude of littoral current. By statistical methods the relative importance of the forces or combinations of forces may be evaluated. A complementary study relating grain size distribution parameters to the direction of littoral drift and wave height and period has been initiated. Trend surface techniques are being applied to such size distribution parameters as the mean, standard deviation, skewness and kurtosis.
(g) Computing machine techniques are being applied to the statistical evaluation of the importance of the forces and of the parameters. Preliminary results indicate that wave height and wave period are more important in the general study and that the mean and the standard deviation are important in the trend surfaces.

(977) DEVELOPMENT OF WAVE HEIGHT AND WAVE DIRECTION GAGES.

(b) Laboratory project.
(d) Experimental; development.
(e) To develop wave height and wave direction gages for use in securing accurate records of wave characteristics. (See also Project 660).
(g) Parts for a new type wave direction gage have been placed under procurement. Laboratory tests of this gage are expected in the next six months.

(2190) STUDY OF EFFECT OF A GROIN SYSTEM ON THE RATE OF LITTORAL MOVEMENT.

(b) Laboratory project.
(d) Experimental; basic research.
(e) To study the effect of groins on the rate of littoral drift passing a groin system. Initial tests consist of waves generated at a 30-degree angle to the sand beach. Measurement of material movement is being made at the down beach end. The tests planned for the immediate future, as have the current season tests, will continue to emphasize the task of establishing sound calibration data relative to littoral transport and wave characteristics. This is now considered a prerequisite to attempting more detailed study and testing on the effects of groins on the rate of littoral drift.
(g) The new series of tests started last year on a 1 on 10 slope and a 90-foot length of beach have been further modified to include tests on a 30-foot length of beach. Preliminary analysis of these tests shows that this length of beach (30 feet) may be adequate for many model tests of littoral drift. Sand drift rates were essentially idential (within 5% during each of two 50-hour tests;) the first utilizing a 90-foot length of beach while the second used only a 30-foot length of beach. Further littoral drift tests are currently underway. Waves in the present tests are at a higher steepness value (shorter wave period and higher wave height). One effect of the higher steepness is that essentially the same level of wave energy is applied to the beach but at a faster rate. One such test has been completed in the current season from which a sand (littoral) drift of 2200 lbs. per hour (dry weight) has been measured.
In the 1 on 20 slope section, a series of

four tests have been completed during 1959. Beach length for these tests is approximately 100 feet. The first of these tests was run for 75 hours using a variable wave period consisting of three values: a median (3.00 sec.), high (3.75 sec.) and a low (2.50 sec.). The wave period was cycled in 15 minute intervals. Three follow-up tests were planned for a duration of 50 hours, to test in turn at a constant wave period the median 3.00 sec., the high 3.75 sec., and the low 2.50 sec. wave period respectively. Preliminary analysis of the variable-wave period test, (75 hours) shows an approximate average sand drift rate of 1400 lbs. per hour (dry weight of sand). The two constant-wave-period tests which have been completed show comparable sand drifts rates of 1150 lbs. per hour for the 3.00 sec. wave period, and 690 lbs. per hour for the 3.75 sec. wave period. Only 20 hours of the 2.50 sec. constant-wave-period have been completed for which a sand drift rate of 890 lbs. per hour is estimated.

(h) "Laboratory Study of the Effect of Groins on the Rate of Littoral Transport." Equipment Development and Initial Tests by R. P. Savage, June 1959, Beach Erosion Board Technical Memorandum No. 114.

(2192) REGIONAL STUDIES OF THE SOUTH SHORE OF LONG ISLAND, NEW YORK; ATLANTIC COAST OF NEW JERSEY, AND THE DELAWARE-MARYLAND-VIRGINIA SHORE LINE FROM CAPE HENLOPEN TO CAPE CHARLES.

(b) Laboratory project.
(d) Field investigations; basic research.
(e) To compile all existing factual data pertinent to shore processes on a regional scale. Report to consist of four chapters; geomorphology and shore line histories, littoral forces, littoral materials and summary and conclusions. Subject matter to include physiography, geological development of the shore region, sources of littoral material, waves, tides or water level fluctuations, current physical characteristics of the littoral materials, interrelation of sedimentary properties, relation to properties of littoral materials to position in the littoral zone, and changes in shore line configuration.
(g) All chapters for New Jersey completed except for editing. Geomorphology, shore line history and littoral forces, of south shore of Long Island essentially completed.

(2193) SHORE PROTECTION PLANNING AND DESIGN.

(b) Laboratory project.
(d) Design.
(e) The purpose of this project is to supplement and revise the Beach Erosion Board's Technical Report No. 4, "Shore Protection Planning and Design" as new data and techniques are developed for use in the solution of coastal engineering problems.
(g) Second addenda sheets to this report are being prepared for publication early in 1960. A second edition of the entire report, which will include the two addenda to the first edition, is also being prepared. It will include recent data on forces on piles, rubble breakwater design, sand by-passing plants, beach fill design and dune stabilization.

(2195) RE-EXAMINATION OF ARTIFICIALLY NOURISHED AND CONSTRUCTED BEACHES.

(b) Laboratory project.
(d) Field investigation; applied research.
(e) To study the behavior of beach fills placed to nourish and protect adjacent shores. A selected number of beach fills are being re-examined.
(g) Comparative survey and sand sample data taken at Virginia Beach, Virginia were analyzed to determine the behavior of beach fill placed to restore and nourish the beach at this resort location. Initial restoration was accomplished in 1952-53 and sand nourishment added periodically thereafter. Conclusions are drawn that the restored beach has been virtually stabilized by annual nourishment at the rate of about 2.5 cubic yards per lineal foot of shore. Periodic nourishment at this rate is concluded to be the most economical method of maintaining required beach dimensions.
(h) "Behavior of Beach Fill at Virginia Beach, Virginia," George M. Watts, June 1959, Beach Erosion Board, Technical Memorandum No. 113.

(2659) LARGE SCALE TESTS OF WAVE FORCES ON PILING.

(b) Laboratory project.
(d) Experimental; applied research, design.
(e) To determine the nature and magnitude of forces on piles caused by breaking and non-breaking waves.
(g) The maximum forces on a 12-inch pipe pile are given in the report below for waves 2 to 7 feet high with periods from 3.75 to 16 seconds with water depths from 5 to 16 feet. The data cover both breaking and non-breaking waves and the effect at adjacent piles. A study of the variation of the wave force through complete wave cycles is in progress.
(h) "Large-Scale Tests of Wave Forces on Piling, (Preliminary Report)," Beach Erosion Board, Technical Memorandum No. 111 by Culbertson Ross.

(2660) WAVE TANK STUDY OF QUANTITY OF SAND IN SUSPENSION IN THE SURF ZONE (INCLUDING TEMPERATURE EFFECTS).

(b) Laboratory project.
(d) Experimental; basic research.
(e) A vacuum pump type suspended sediment sampler has been used to collect suspended sand samples under various laboratory conditions of waves, water temperature and sand. A large field sampler has been used to obtain suspended samples in the prototype wave tank. The purpose of the study is to determine the relationship between wave, water, and sand characteristics and the amount of material maintained in suspension and hence available for longshore

transport by currents.

(g) Data and some analysis on the quantity of sediment placed in suspension by wave action are presented in the report named below. The data was obtained in laboratory wave tanks and concerns the collection and analysis of wave-induced suspended sediment using waves of both small scale (2 to 6-inch heights) and relatively large scale (2 to 6-foot heights). Quantitative analysis relates principally to the effect of water temperature on concentration and size characteristics of suspended material. However, considerable discussion is devoted to procedures and techniques for sampling suspended material and the physical procedures governing its behavior.

(h) "Suspended Sediment Sampling in Laboratory Wave Action," John C. Fairchild, June 1959, Beach Erosion Board Technical Memo. No.115.

(2661) WAVE RUN-UP ON SHORE STRUCTURES.

(b) Laboratory project.
(d) Experimental; design.
(e) Wave run-up is determined experimentally by various waves for different types of shore structures. Effect of both structure roughness and permeability is being investigated.
(g) Relatively large scale data have been taken on a 1 on 1-1/2 slope structure having a single layer of riprap, 3 layers of riprap, and a permeable rubble mound structure. These results indicate the probable existence of a scale effect for rubble structures (as has been previously indicated for smooth slopes).

(2916) WAVE AND SURGE FORECASTING RELATIONSHIPS AND TECHNIQUES.

(b) Laboratory project.
(d) Theoretical, basic research.
(e) To determine methods of predicting wave and storm surge characteristics.
(g) Methods of developing surge predictions for hurricanes have been reviewed, extended, and summarized. Revision to previously adopted wave forecasting relationships have been determined to better account for additional wave data. Wave records from a wide variety of locations have been utilized in a statistical analysis of the probability distribution of wave heights and wave periods; and a family of wave spectra which allows for arbitrary linear correlation between wave height and wave period squared is suggested. Additional wave records are being analyzed by the wave spectrum analyzer, in order to correlate the wave statistical distribution with the wave spectra obtained by electronic means. Theoretical investigations are being made for waves of finite height, with particular emphasis on the design wave.
(h) "Wave Spectra and Wave Variability for Wind Generated Gravity Waves," Charles L. Bretschneider, Beach Erosion Board Tech. Memo. No. 118.
"Hurricane Surge Prediction for Chesapeake Bay," Charles L. Bretschneider, Beach Erosion Board, Misc. Paper No. 3-59.

(3227) DEVELOPMENT OF INPLACE SEDIMENT DENSITY GAGE.

(b) Laboratory project.
(d) Field, development.
(e) To develop an inplace gage to determine density of material under water in shoal areas (navigation channels, reservoirs, etc.).
(g) The probe has been field-tested. These tests indicated that the enlargement of the probe casing at the top made it unduly difficult to push the probe into the shoal materials. The probe has been recased to a uniform diameter of 1-1/2 inches to overcome this fault. The draft of the final report on the development of the probe is 95% complete.

(3228) MODEL TESTS OF WAVE SET-UP ON BEACHES.

(b) Laboratory project.
(d) Experimental.
(e) To relate increase in water level at the shore due to wave action alone to the incident wave characteristics and shore hydrography.
(g) Additional tests on a 1 on 30 slope show a wave set-up as great as 3 feet for a 30-foot wave height. Small scale laboratory data indicate addition of a submerged offshore barrier may radically increase the wave set-up at the shore. This finding has been confirmed for short period waves of 2 to 3-foot height in the prototype wave tank.

(3574) PNEUMATIC BREAKWATER.

(b) Laboratory project.
(d) Experimental, basic research.
(e) Air compressors were used to force air through small holes in a pipe placed along the bottom of the large wave tank and thence into the flowing wave stream. The purpose of the project was to investigate the effectiveness of this method or mechanism in reducing the height of a wave of given wave height and wave period; also, to determine any possible scale effect between these tests and those performed elsewhere on a smaller scale.
(f) Discontinued due to lack of funds.
(g) Tests were completed for wave of 3 to 5-feet with period of 2.6 to 5.3 seconds.

U. S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS, Portland, Bonneville Hydraulic Laboratory.

Inquiries concerning Projects Nos. 405, 406, 407, 2662, 2665, 2666, 2919, 2921, 3229, and 3575 to 3578, inclusive, should be addressed to the District Engineer, U. S. Army Engineer, District, Walla Walla, Bldg. 602, City-County Airport, Walla Walla, Washington, and Projects Nos. 1462, 1466, 3230, and 3231 should be addressed to the District Engineer, U.S. Army Engineer, District, Portland, 628 Pittock Block, Portland 5, Oregon.

(405) GENERAL MODEL STUDY OF ICE HARBOR DAM, SNAKE RIVER, WASHINGTON.

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(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
(d) Experimental; for design.
(e) A 1:100-scale, undistorted, fixed-bed model reproduced 2.7 miles of the Snake River at the dam site. The adopted structures include a 6-unit powerhouse (3-unit initial construction), 10-bay (tainter-gate controlled) spillway, 86- by 675-ft navigation lock, and facilities for migrant fish. The latter include two fish ladders, 16 ft wide on north bank and 24 ft wide on south bank, and a powerhouse collection system. Auxiliary flow for both ladders and collection system will be provided by low-head pumps. Studies were made to determine flow conditions during various construction stages and after structures have been installed.
(f) Tests completed.
(g) Tests of first-step cofferdam indicated that realignment of the steel-pile cells would reduce backwater effect and lower water-surface elevations along the cofferdam face. Movable bed studies were made to assist in estimating amount and location of prototype channel erosion. Effect of rock groins along river bank opposite cofferdam was investigated as an aid to fish migration during first-stage construction. Second-stage cofferdam tests showed that realignment of downstream leg of cofferdam improved conditions for fish passage and reduced velocities along toe of downstream fill. Conditions for fish passage at low flows were further improved by additional forebay excavation and use of powerhouse skeleton units to pass a portion of river flow. General flow conditions were observed with the proposed structures installed. Three tailrace alignments were investigated, and tests were made to determine a better layout for the north fish ladder. Two-foot sills installed in end bays of spillway provided downstream flow at spillway entrances to fishways. Tests of final design structures were made to provide project operating data. Uniform spillway operation produced the best overall conditions. Tests of several alternative designs of a river outlet for the navigation lock were made to determine probable wave heights and tailwater variations during a typical lock emptying cycle.
(h) The final report is in preparation.

(406) MODEL STUDY OF ICE HARBOR SPILLWAY, SNAKE RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.
(d) Experimental; for design.
(e) A 1:40-scale model included a 3-bay section of the 10-bay spillway. Tests were made to determine hydraulic performance of the proposed spillway and stilling basin and to develop revisions in design that would improve performance or reduce construction and maintenance costs.
(f) Tests completed.
(g) Satisfactory design of spillway and stilling basin and determination of crest rating, pressure data, and method of gate operation were accomplished.
(h) Final report is in preparation.

(407) MODEL STUDY OF ICE HARBOR NAVIGATION LOCK, SNAKE RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.
(d) Experimental; for design.
(e) Two models were used to test performance of proposed designs for the hydraulic system and to develop modifications for necessary improvement. A 1:25-scale model reproduced the 86- by 675-ft lock chamber, culvert systems, and portions of the upstream and downstream approach channels. A 1:16-scale model of a single lateral culvert of the lock filling system was used to determine designs that would produce uniform flow distribution from the culvert ports.
(f) Tests completed.
(g) Offsets in lateral culvert walls were revised to improve flow distribution. Final design tests were completed. At maximum initial head, 103 ft, the lock chamber fills in approximately 11 min and empties in 13 min with a 4.0-min filling valve schedule and a 2.2-min emptying valve schedule. Maximum hawser forces of 4 to 6 tons, depending upon resonance, have been observed with an 11,040-ton barge tow at maximum initial head. Positive pressures exist downstream from the filling valves.
(h) Final report is in preparation.

(1462) GENERAL MODEL STUDY OF THE DALLES DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) U. S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.
(d) Experimental; for design.
(e) A 1:80-scale, undistorted, fixed-bed model reproduced 2.7 miles of the Columbia River at the dam site. The original layout consisted of a circular-arc, 30-bay spillway, a 22-unit powerhouse, and 86- x 675-ft navigation lock, a rock-fill nonoverflow section, and facilities for passing fish over the dam. A straight 23-bay spillway is included in the final design. Purposes were to study the structures alinement and flow conditions affecting navigation, power generation, cofferdam placement, rock-fill dam construction, and fish passage.
(f) Tests completed.
(g) Four major layout plans were tested and the most economical plan that effected satisfactory hydraulic conditions was selected. The tests indicated that the number of spillway bays could be reduced and forebay excavation raised 30 ft in elevation. Data relative to water-surface elevations and velocities in the tailrace and the effects of excess fill placed in the forebay were obtained. Flow conditions during various stages of construction and with the project completed were observed; special attention was given to fish and navigation problems. Tests were conducted to compare flow conditions in model and prototype when the 1957 peak discharge of 643,500 cfs was passed through the spillway. The test was

repeated with five powerhouse units operating - the expected installation at time of 1958 high water. Additional studies of flow conditions in downstream approach to navigation lock were made with extensions to contract plan guard wall of 200, 400, and 600 ft.

(h) Final report is in preparation.

(1466) MODEL STUDY OF THE DALLES DAM NAVIGATION LOCK, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) U. S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.
(d) Experimental; for design.
(e) A 1:25-scale model reproduced the 86- by 675-ft lock chamber, its culvert systems, and portions of the upstream and downstream approach channels. Studies were made of various types of filling and emptying systems to determine the most advantageous design from the standpoints of rate of operations during a maximum lift of 90 ft, degree of turbulence, and economy. The proposed plans included lateral culverts within the lock chamber combined with several locations of intake ports, longitudinal culverts, and outlet ports.
(f) Tests completed.
(g) Designs were selected for all features of the lock. A valve-opening schedule of 4 min resulted in a filling time of 12.5 min and a maximum hawser force of 8 tons, without supplemental use of the upstream lock tainter gate. The lock emptied in 16 min. Studies have shown that staggered valve operation will reduce maximum hawser forces. Operational tests of the final design were made with several heads and barge positions using a 4-min valve-opening schedule. One combination of head and barge position corresponded to conditions existing during prototype tests performed in December 1957.
(h) Final report is in preparation.

(2662) GENERAL MODEL STUDY OF JOHN DAY LOCK AND DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.
(d) Experimental; for design.
(e) A fixed-bed model constructed to an undistorted scale of 1:80 reproduces the Columbia River bed from Mile 213.7 to 216.8. The dam axis is at Mile 215.6. The original structures layout consists of a straight, 20-bay, gravity-type spillway controlled by 50- by 58.5-ft tainter gates, a powerhouse for 20 Kaplan turbines (initial installation 10 units), an 86- by 675-ft navigation lock having a maximum lift of 113 ft, a concrete nonover-flow section, rock-fill abutments, and facilities for passing anadromous fish over the dam. Cofferdams having steel cells in the river legs and earth-and-rock shore connections are designed to withstand river flows to 700,000 cfs during first- and second-stage construction periods and 300,000 cfs during third-stage diversion. Purposes of the model study are to check the structures alinement and flow conditions affecting power generation, cofferdam placement, and fish passage.
(g) After model construction and verification were completed in 1958, various phases of cofferdam construction were investigated, several schemes for minimizing interference with river navigation during the construction period were studied, and base tests of proposed elements for the project were made. Results of the tests indicated that the first-step cofferdam was satisfactory after minor revisions, whereas numerous changes in the alinement and height of cells for the second-step cofferdam were necessary. Flow conditions adjacent to the proposed structures were fairly satisfactory. Plans to improve flow conditions in the downstream lock approach and at the fishway entrances are being investigated.

(2665) MODEL STUDY OF ICE HARBOR POWERHOUSE INTAKE GATES, SNAKE RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.
(d) Experimental; for design.
(e) The 1:25-scale model contained a test unit that consisted of an intake, with emergency closure gates and gate slots, and a scroll case. The middle closure gate was reproduced in plastic with a synchronous-motor-operated lifting mechanism to simulate prototype operating speed. Provision was made to measure pressures on the gate lip with several lip designs. Tests were made to determine the gate design that produced the least downpull force during emergency closure.
(f) Tests completed.
(g) Tests have been made of one unit of Chief Joseph powerhouse to correlate model downpull forces on an intake gage with tests made at Chief Joseph Dam during 1955. Correlation was made to obtain a basis for evaluating tests of Ice Harbor powerhouse intake gates. The powerhouse intake gate for Ice Harbor Dam has been tested with 12-, 15-, 18-, and 20-inch lip extensions and with 30-, 35-, 40-, and 45-degree tapered lips. Stationary gate openings and zero seal clearances were used during studies with an initial discharge of 24,500 cfs (intermediate between a maximum operating discharge of approximately 16,000 cfs and an estimated runaway speed discharge of 30,600 cfs). Maximum hydraulic downpull on the entire gate varied from 328 kips (12-in. extended lip) to 188 kips (45-degree tapered lip). Downpull on the bottom beam and lip of each shape tested was approximately 94 percent of the total downpull on the gate. All maximum downpulls occurred at gate openings of 4.1 to4.2 ft.
(h) Final report is in preparation.

(2666) MODEL STUDY OF ICE HARBOR DAM FISH LADDERS, SNAKE RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
(d) Experimental; for design.
(d) A 1:10-scale model reproduced a 41-pool

tangent of the 1-on-16 slope, 24-ft-wide south fish ladder and a 6-foot orifice-control section of the south fish ladder. Investigations were concerned with the causes and remedies for self-induced surge within the fish ladder and the location of orifices in nonoverflow weirs in the control section to function with a 5-ft change in pool elevation without creating undesirable flow conditions. Later the model was modified to include the orifice-control section for the 1-on-10-slope, 16-ft-wide north fish ladder at Ice Harbor Dam.

(f) Tests completed.

(g) Test results indicated that surge would occur within operating range of both fish ladders unless a weir crest approximating a sharp edge was used. Surge was reduced with a contracted weir. Uniformity of heads in control sections was obtained by varying the spacing of orifices in alternate baffles (24-ft ladder), or by varying the spacing of the two orifices in each baffle (16-ft ladder). A 16-ft-wide, 1-on-10 slope fish ladder design was developed in which flow conditions were comparable to the 16-ft-wide, 1-on-16 slope fish ladder. This was accomplished by placing a 6-ft-long barrier in the center of the weir to reduce the overflow and fins extending 1.5 ft upstream from each end of the barrier to control the jet issuing from the submerged orifices. Through use of the fins an orifice-control section was developed with constant size and spacing of orifices. The tests led to adoption of structurally simple yet effective designs for the project.

(h) Final report is in preparation.

(2919) MODEL STUDY OF CHANNEL IMPROVEMENT PLANS, PALOUSE RIVER, COLFAX, WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.

(d) Experimental; for design.

(e) A 1:40-scale flume model is being used to determine the extent of channel enlargement and modification, levees, flood walls, and revetments necessary to protect the town of Colfax, Washington, from higher-than-record discharges: 14,500 cfs in the South Fork, 16,800 cfs in the Palouse River above the mouth of the South Fork, and 28,000 cfs in Palouse River below the mouth of the South Fork. Space limitations require sharply curved channels of varying cross section which are further restricted by existing bridge piers at several locations. Owing to the scale ratio used, the model surfaces (enameled plywood) were too rough to reproduce the prototype concrete surfaces, "n" = 0.014. Similitude was obtained through use of a slope correction factor in determining model gradients.

(g) Design and construction of the original improvement plan were completed. Salient test results to date show the need for revision of several transitions and addition of streamlined pier nose extensions to railroad and highway bridges on both North and South Forks. Studies are being made to determine channel invert slopes and wall alinements that will create and maintain a hydraulic jump at desired locations in each channel.

(2920) MODEL TESTS OF SERVICE GATE SEALS, EAGLE GORGE DAM, GREEN RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Seattle, Corps of Engineers, Seattle, Washington.

(c) District Engineer, U.S. Army Engineer Dist., Seattle, 1519 South Alaskan Way, Seattle 4, Washington.

(d) Experimental; for design.

(e) A square-bulb, "J" rubber seal, with and without a brass chafing strip cast into the bulb, was tested to determine: (1) Maximum satisfactory clearance between retainer bar and sealing plate; (2) maximum seal and support plate clearance that will be closed by force of the top seal; and (3) friction factors. Heads of 100, 150, and 200 ft were tested.

(f) Tests completed.

(g) It was found that 1/2-in. clearance could be used between the retainer bar and seal plate. To prevent leakage around the side seal at its point of intersection with the top seal, it was necessary to eliminate clearance between the side seal and support plate. Friction tests performed by the Los Angeles District Laboratory indicated that friction factors for an unclad rectangular seal were lower than for a seal having a brass chafing strip. A music note seal had the least surface bearing against the seal plate and showed the least frictional drag on stainless and chrome-plated steel plates.

(h) Final report is in preparation.

(2921) MODEL STUDY OF ICE HARBOR SPILLWAY STOP LOG, SNAKE RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.

(d) Experimental; for design.

(e) A 1:20-scale model of a single bay of Ice Harbor spillway dam will be installed in an existing Laboratory flume. Structural features of stop log will be reproduced and facilities will be provided for direct measurement of hydraulic load on a stop log as it is lowered into place in high-velocity flow.

(f) Inactive.

(g) Design is complete.

(3229) MODEL STUDY OF SPILLWAY FOR JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.

(d) Experimental; for design.

(e) A 1:41.14-scale model of three bays of the spillway dam was used to determine the hydraulic characteristics of the proposed spillway and stilling basin and to develop revisions in design that would improve performance or reduce construction costs.

(f) Tests completed.

(g) Satisfactory design of spillway and stilling basin, and determination of pressure data and discharge rating curves for free

and gated flows were accomplished. The tests led to selection of revised designs for the crest pier noses, stop-log slots, stilling basin, and end sill. Additional tests were made to determine the best height and location for: (1) a sill that will be placed on the basin floor in Bay 1 in order to maintain downstream flow at adjacent fishway entrances; and (2) baffles adjacent to Pier 1 and the wall between the spillway and powerhouse to prevent entry of fish into operating section of spillway.

(3230) MODEL STUDY OF NAVIGATION CHANNEL IMPROVEMENT AT BONNEVILLE DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) U. S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.
(d) Experimental; for design.
(e) A 1:130-scale, undistorted, fixed-bed model reproduces 5.6 miles of the Columbia River adjacent to the dam site. The original layout includes existing structures and river bed (survey made in summer and fall of 1958). The purpose of the model is to study methods for improving navigation conditions in the approaches to Bonneville lock for seagoing vessels. A remotely-controlled model of a C-2 freighter is used to assist evaluation of flow conditions in the navigation channel.
(g) Model design and construction were completed. After verification for existing conditions (1958), tests were made to determine effects of 1959 dredge cuts in the lock approach, together with alternative improvement plans (rock-fill or concrete groins, permeable guard walls or dykes, and partial revision of the lock approach). None of the preliminary plans was satisfactory, and approximately 15 major channel revisions were tested singly or in combinations in efforts to provide the most practical and economical solution to the problems involved. The most desirable plan will include approximately 900,000 cu yd of excavation along the Washington shore, 86,000 cu yd of excavation at the downstream end of Bradford Island, 180,000 cu yd along the Oregon shore, and 100,000 cu yd of excavation at the north side of the lock approach.

(3231) MODEL STUDY OF COUGAR DAM OUTLET STILLING BASIN, SOUTH FORK, McKENZIE RIVER, OREGON.

(b) U. S. Army Engineer District, Portland, Corps of Engineers, Portland, Oregon.
(d) Experimental; for design.
(e) A 1:25-scale model included 1045 ft of 13.5-ft-dia regulating tunnel, portal and transition to 20-ft-wide open concrete chute, transition from chute to stilling basin through a 150-ft-radius bucket, and 1500 ft of downstream channel and overbank topography. Tests were made to check the adequacy of the original design and to develop modifications if required.
(f) Tests completed.
(g) Flow conditions in tunnel and transition to 20-ft-wide chute were satisfactory for the design flow of 6000 cfs. Although various baffle sizes, arrangements, and positions and designs of end sill were investigated, the 30-ft-wide stilling basin was too small to prevent high velocities and excessive wave action on riprapped walls of the downstream channel. Acceptable conditions were obtained with a longer transition into a 50-ft-wide basin that contained five baffles each 4 ft high and 5 ft wide and ended at a stepped end sill 8 ft high. Although the design flow of 6000 cfs can be expected to occur frequently, pressures on the baffles will remain above the range of cavitation.
(h) Final report is in preparation.

(3575) MODEL STUDY OF JOHN DAY NAVIGATION LOCK, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.
(d) Experimental; for design.
(e) A 1:25-scale model reproduces the 86- by 675-ft lock chamber, culvert systems, and portions of the upstream and downstream approach channels. Filling and emptying systems will be studied to determine the most advantageous design from the standpoints of rate of operation, degree of turbulence, and economy. The lock will have a maximum lift of 113 ft.
(g) Design and construction of the model were completed.

(3576) MODEL STUDY OF NORTH FISH LADDER DIFFUSERS, JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.
(d) Experimental; for design.
(e) A 1:8-scale model will reproduce diffusers 3 through 6, ladder weirs 155 through 161, and a section of the auxiliary water-supply conduit. Water supply to the 24-ft-wide, 1-on-10 sloped north fish ladder will be a constant 100 cfs, but flow in the water-supply conduit will vary from 600 cfs to 1300 cfs. Provision will be made in the model for measurement of outflows from the ladder, the water-supply conduit, and individual diffusers. The model will be constructed so that dimensions or other details of the weirs, orifices, and diffuser wells can be altered to improve their hydraulic characteristics if necessary.
(g) Model design and construction were begun.

(3577) GENERAL MODEL STUDY OF LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.
(d) Experimental; for design.
(e) A 1:100-scale, undistorted, fixed-bed model reproduces approximately 2.4 miles of Snake River bed and overbank topography at the dam site. The dam axis is at River Mile

41.5, about 60 miles from the city of Pasco, Washington. Studies will be made to determine flow conditions during various construction stages and after proposed structures have been installed.

(g) Design and construction of the model were completed and verification tests begun.

(3578) MODEL STUDY OF FISH LADDERS FOR JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON.

(b) U. S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Wash.

(d) Experimental; for design.

(e) An existing 1:10-scale fish ladder model was revised to reproduce 23 pools of the fixed weir section of a 1-on-10 slope, 24-ft-wide fish ladder. Tests will be made to develop a design which will provide flow conditions comparable to a 1-on-16 slope, 24-ft-wide ladder.

(g) Construction was completed and tests begun.

U. S. ARMY ENGINEER DISTRICT, CORPS OF ENGINEERS, St. Paul.

(194) A STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS.

U. S. Army Engineer District, St. Paul and U. S. Geological Survey, in cooperation with St. Anthony Falls Hydraulic Laboratory. See St. Anthony Falls Hydraulic Laboratory, page 69.

U. S. DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS, Waterways Experiment Station.

Inquiries concerning the following projects should be addressed to The Director, Waterways Experiment Station, Corps of Engineers, P. O. Box 631, Vicksburg, Mississippi.

(218) CONDUIT INTAKE MODEL TESTS.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.

(d) Experimental; applied research.

(e) Scale models are being used for a general study of the hydraulic characteristics of entrance curves. Tests of (1) a gated tunnel having a rectangular entrance with floor at same elevation as approach channel (entrance flared in three directions), and (2) a rectangular conduit in which parallel side walls are extended upstream from the entrance and only the roof is flared (entrance floor at same elevation as approach channel) were conducted to develop entrance shapes that would not be damaged by cavitation and yet would be as small as possible in cross section. Pressure measurements were made on a transparent conduit, 0.283 foot wide by 0.500 foot high by 8.64 feet long, connected to a steel pressure headbay tank.

(g) Test results indicate that pressure conditions probably acceptable for most installations can be obtained by the use of elliptical entrance curves with the minor axis equal to one-third the major axis. For entrances flared in three directions, the major axes for the entrance curves should be equal to the dimensions of the conduit proper in the directions concerned. For an entrance in which only the top is flared, the major axis of the entrance curve should be equal to at least 1.5 times the depth of the conduit proper. At installations where high heads and little back pressure result in hydraulic conditions highly susceptible to cavitation, an entrance formed by a compound elliptical curve is desirable.

(h) "Entrances to Conduits of Rectangular Cross Section; Investigation of Entrances Flared in Three Directions and in One Direction," Waterways Experiment Station Technical Memorandum No. 2-428, Report 2, June 1959. (Available on loan.)

(236) MISSISSIPPI BASIN MODEL.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.

(d) Experimental; for design.

(e) The project provides for construction and operation of a model of the Mississippi River Basin including the Mississippi, Ohio, Missouri, White, Arkansas, and Red Rivers, and their principal tributaries. All existing and proposed flood-control reservoirs, dikes, floodwalls, and other pertinent works will be reproduced. The model area comprises 200 acres, and measures 4,500 feet east and west, and 3,900 feet north and south. Completed construction consists of the Upper Mississippi River from Hannibal, Missouri, to Helena, Arkansas; the Missouri River from Sioux City, Iowa, to the mouth; the Arkansas River from Blackburn Dam Site, Oklahoma, to Pine Bluff, Arkansas; the Ohio River from Louisville, Kentucky, to the mouth; the Cumberland River from Old Hickory Dam, Tennessee, to the mouth; and the Tennessee River from Pickwick Dam to the mouth. The topography of the streams and flood plains are being reproduced to a horizontal scale of 1:2,000 and vertical scale of 1:100. Water-surface elevations are measured by electrically operated stage devices with the recorders located in central control buildings. Stream flow is introduced and controlled by automatic instruments called inflow controllers. The model was designed to aid in the development of coordinated basin-wide plans for flood control and operation of flood-control structures.

(g) The extent of model operation each year is determined by the testing programs requested by Districts and Divisions that have operable sections on the model. Tests were conducted during the current year for the U. S. Army Engineer Divisions, Missouri River, Ohio River, and Lower Mississippi Valley. Verification tests of the Missouri, Ohio, and Mississippi Rivers were conducted, and special tests were made to determine:

the effects of installing a low head dam in Chain of Rocks reach of the Mississippi River near St. Louis, the effects of installing a levee in Columbia Bottoms area in the vicinity of St. Louis, stage-discharge relations in the Kentucky Reservoir on the Tennessee River for various flows with various pool elevations, and the closeness with which the model could reproduce the 1945 and 1950 floods when using the entire model for basin-wide studies.

(h) "Effects of Proposed Highway Fill Across Chouteau Island" and "Effects of Proposed Chain of Rocks Dam, Mississippi River, Mile 190.1," U. S. Army Engineer Waterways Experiment Station Mississippi Basin Model Reports 81-1 and 81-2, issued in January and September 1959, respectively. "Distribution of Ungaged Flows for 1949, 1950, and 1951 Floods, Van Buren-to-Little Rock Reach, Arkansas River and Tributaries," U. S. Army Engineer Waterways Experiment Station Miscellaneous Paper No. 2-331, March 1959. (Available on loan.)

(425) COMPREHENSIVE MODEL STUDY, DELAWARE RIVER, PENNSYLVANIA.

(b) District Engineer, U. S. Army Engineer District, Philadelphia, Corps of Engineers, Philadelphia, Pennsylvania.

(d) Experimental; for design.

(e) To develop and test plans for reduction of shoaling in several ranges of the navigation channel, the entire Delaware River estuary from the Atlantic Ocean to Trenton is reproduced in the model which is of the fixed-bed, silt-injection type, with scale ratios of 1:1,000 horizontally and 1:100 vertically. Tides and tidal currents are reproduced by automatic tide generators. Observed prototype salinities are reproduced in the Delaware Bay portion of the model, and provisions made for the injection of silt, and for measuring silt deposits. Studies are also made of salinity intrusion and the dispersion and dilution of wastes discharged into the estuary.

(g) Proposed barriers across the Delaware in the vicinity of New Castle, Delaware, were tested to determine the general type of structure required to effectively halt salt-water intrusion and create a source of fresh water. It was concluded that a barrier having an ungated navigation opening would have no beneficial effects on salinities upstream from the barrier. Substitution of navigation locks for the ungated opening would cause more extensive salinity intrusion than now exists; however, the addition of an appropriate scavenger system to the navigation-lock-type barrier would probably provide effective control over the intrusion of sea water into the upper pool. The effects of the barrier types tested on tides and currents were also determined.

(h) "Effects of Salt-Water Barriers Across the Delaware River; Preliminary Hydraulic Model Investigation." U. S. Army Engineer Waterways Experiment Station Miscellaneous Paper No. 2-358, September 1959. (Available on loan.)

(993) CAVITATION RESEARCH.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.

(d) Experimental; applied research.

(e) The cavitation characteristics of such elements as baffle piers, steps in stilling basins, spillway and conduit gate slots, and offset joints are studied in either a vacuum tank or a variable-pressure, closed-jet water tunnel. The investigation includes a review of literature to evaluate the many variables that affect cavitation results.

(994) EFFECTS OF MODEL DISTORTION.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.

(d) Experimental; applied research.

(e) This is a general study to determine the hydraulic effects of various types and degrees of model scale distortion on velocity distribution and other hydraulic conditions, with the ultimate aim of establishing limits of permissible distortion for the various types of models. Tests are in progress of a rectangular flume having a 90-degree bend with provisions for changing the vertical scale to provide a distortion of 0 to 10.

(g) Results indicate that the effects of distortion are due principally to the change in the width-depth ratio of the channel caused by the distortion of the linear scales.

(998) STUDY OF WAVE FORCE ON BREAKWATERS.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.

(d) Experimental; applied research.

(e) A general investigation is planned of wave phenomena and resulting forces, to be conducted in a wave tank, to develop formulas, supported by experimental data, from which wave pressures on impervious surfaces, vertical and inclined, can be determined.

(f) Suspended.

(999) STABILITY OF RUBBLE-MOUND BREAKWATERS.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.

(d) Experimental; applied research.

(e) Rubble-mound structures are studied in a 5- by 4- by 119-foot wave tank to develop formulas, supported by experimental data, from which the design of safe and economical breakwaters can be determined. In addition to quarrystone, tetrapods, tetrahedrons, tribars, and other specially molded armor units are being studied.

(g) The results of stability tests in pell-mell-placed protective cover layers of quarrystone, tetrapods, tribars, and tetrahedrons are represented with very good accuracy by the formula

$$W_r = \frac{\gamma_r H^3}{K_\Delta (S_r - 1)^3 \cot \alpha}$$

where W_r is weight of individual armor units, γ_r is the specific weight of the armor units, H is height of selected design wave, S_r is the specific gravity of armor units relative to the fluid in which the structure is located (γ_r/γ_w), α is the angle of the breakwater face, measured from the horizontal, and K_Δ is a dimensionless coefficient.

(h) "Design of Tribar and Tetrapod Cover Layers for Rubble-Mound Breakwaters," U. S. Army Engineer Waterways Experiment Station Miscellaneous Paper No. 2-296, January 1959. (Available on loan.)

(1002) EFFECTS OF SCALE AND OPERATING TECHNIQUES ON HARBOR WAVE ACTION MODELS.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.
(d) Experimental; applied research.
(e) Tests are conducted in flumes and harbor model basins to obtain information that will allow more accurate determination of optimum scales for wave models, and the effects of different scale and operating techniques on the accuracy of model results. The efficiency of flexible-element wave filters is being investigated to facilitate continuous operation of wave flumes. Resonant chambers for harbor entrances and attenuation of waves in a three-dimensional model are being studied.

(1004) INSTRUMENTATION.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.
(d) Experimental; development.
(e) Various types of measurement and control equipment for use in hydraulic studies are being developed. These include equipment for measuring subsurface currents and for operation of a model boat by remote control. The development of miscellaneous model and field measuring instruments was continued as the need arose.

(1207) INTAKE EMERGENCY GATES (MODEL STUDY OF PENSTOCK INTAKE AND SLUICE COASTER GATES).

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.
(d) Experimental; applied research.
(e) This is a general study of relative merits of various penstock intake and sluice coaster gate lip shapes, seals, and recesses, and includes determination of downpull effects of changes in gate lip shape, length and shape of seals, size and shape of the recess in the face of the dam, and need for an air vent in the entrance. A 1:20 model of a sluice coaster gate was tested in combination with a typical sluice which included a slide gate, standard entrance curves conforming to the elliptical equation

$$(x^2/D^2) + (y^2/(D/3)^2) = 1.$$

(f) Inactive.

(1211) MODEL STUDY OF HOOSIC RIVER, NORTH ADAMS, MASSACHUSETTS.

(b) District Engineer, U. S. Army Engineer District, New York, Corps of Engineers, New York, New York.
(d) Experimental; for design.
(e) A 1:30 model was used to verify the hydraulic design for improvement of certain sections of the North and South Branches of Hoosic River in North Adams, Mass., and to determine whether changes should be made for safety, increased efficiency, or economy. The flow in the major portion of these channels will be below critical depth. The model was used to check such design features as channel alignment, transitions, superelevation in bends, characteristics of weirs, stilling basins, drop structures, the treatment of intakes and outlets, wall heights, and elevations of bridges.
(f) Final report in preparation.

(1212) MODEL STUDIES OF OUTLET WORKS, OAHE DAM, MISSOURI RIVER, SOUTH DAKOTA.

(b) District Engineer, U. S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Nebraska.
(d) Experimental; for design.
(e) Hydraulic performance of the outlet works for Oahe Dam was studied on three models: a 1:60 model reproducing the downstream ends of the six 18.25-foot-diameter outlet tunnels, the stilling basin, and portions of the discharge and pilot channels; a 1:25 model of the portion of one tunnel upstream of the central control shaft, including the intake; and a 1:25 model of one of the control shafts, containing tandem vertical-lift gates, and the tunnel downstream therefrom.
(f) Final report in preparation.

(1467) ANALYSIS OF HYDRAULIC EXPERIMENTAL DATA (MODEL AND PROTOTYPE) AND DEVELOPMENT OF DESIGN CRITERIA.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.
(d) Analytical (model and prototype) and field investigations; for design.
(e) A general study to develop, analyze, and disseminate to Corps of Engineers establishments, hydraulic design criteria to insure adequate capacity, economy of construction, and safe and satisfactory operation. Criteria are developed from model and prototype tests relating to the design of spillways, outlet works, gates and valves, channels, and navigation structures. Program also includes prototype tests in cooperation with other Corps of Engineers establishments.
(g) "Hydraulic Design Criteria" charts have been prepared on the effects of latitude and altitude on the acceleration of gravity, bridge pier losses in open channel flow,

trash rack losses, spillway bucket-type energy dissipators, loss coefficients for reverse tainter valves, and pressures in culvert bends. Prototype measurements were made of hoist loads for an emergency bulkhead at the entrance to a sluice at Hulah Dam. Hydraulic measurements of velocities and pressures were made in a 22-foot-diameter tunnel at Fort Randall Dam at discharges giving average velocities between about 5 and 50 feet per sec.

(h) "Considerations of Various Factors Entering Into the Evaluation of Intake Losses From Experimental Measurements," "Prototype Hydraulic Tests of Flood-Control Conduit, Enid Dam, Yocona River, Mississippi," and "Prototype Tests of Spillway Crest and Flip Bucket, Pine Flat Dam, Kings River, Calif.," U. S. Army Engineer Waterways Experiment Station Miscellaneous Paper No. 2-320 and Tech. Reports Nos. 2-510 and 2-511, issued in Feb., June, and June 1959, respectively. (Available on loan.) "Hydraulic Design Criteria" Issue No. 9. (Available for purchase in limited quantities.)

(1474) OPERATING FORCES OF MITER-TYPE LOCK GATES.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.

(d) Experimental; applied research.

(e) A general study to collect basic data on operating forces of miter-type lock gates and to determine the effect of various elements upon these forces was conducted in a 1:20 model. A lock chamber 110 feet wide was reproduced with provisions for varying the length up to 600 feet on each side of the gate. Forces required for operation of miter gates were measured for variations of the following elements: gate leaves, speeds and accelerations of operation, submerged depths, recess shapes, bottom clearances, chamber lengths, and nonsynchronous operation of gate leaves. Variations in the type linkage driving the gate were also investigated.

(f) Tests completed; final report in preparation.

(1475) SIPHON ACTION AT PUMPING PLANTS.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.

(d) Experimental; applied research.

(e) This study was conducted to aid in developing design criteria for pumping plants that depend on development of siphonic action in the discharge side of the pumps in order to yield the required discharge. Full-size models of a 6-inch and 12-inch plastic discharge line were tested. Variables investigated during the tests were: rates of flow, water levels in the discharge side of the pumps, slope and length of the riverward leg, and venting conditions at the crown.

(g) The minimum initial priming velocity and length of time required to prime the siphons were determined for the following variables: Rates of flow, water levels on the discharge side of the pumps, slope and length of the riverward leg, and venting conditions at the crown. The equation developed from model data to determine the minimum initial velocity required to achieve a full prime is:

$$V_{min} = 0.362\sqrt{gD}\left(\frac{L/D}{\sin\theta}\right)^{0.161}$$

where V_{min} = minimum initial priming velocity, feet per second, g = acceleration of gravity, feet per second squared, D = diameter of siphon, feet, L = length of sloping portion of riverward leg, feet, and θ = angle of riverward leg with the horizontal.

(h) Final report in preparation.

(1738) MODEL STUDY OF GATES AND STILLING BASIN, GREENUP LOCKS AND DAM, OHIO RIVER.

(b) District Engineer, U. S. Army Engineer District, Huntington, Corps of Engineers, Huntington, West Virginia.

(d) Experimental; for design.

(e) A 1:25 section model reproducing 400 feet of the approach area, a portion of the spillway crest and stilling basins, and 800 feet of the exit area was used to examine the hydraulic performance of the spillway weir and stilling basin. Additional phases of the study involved measurements of hydraulic forces acting on a submergible-type spillway tainter gate and a girder-type emergency gate in the lock, both constructed to a scale of 1:25. The emergency gate for the lock consists of two, vertical, upstream and downstream leaves.

(f) Final report in preparation.

(g) In the study of the emergency lock gate, particular emphasis was placed on determining the vertical forces acting on the downstream leaf of the gate and selecting a crest shape for this leaf that would minimize downpull without causing uncontrollable uplift of the gate. The gate as originally designed was found to bounce (vertical displacement) violently under certain tailwater conditions. This was attributed primarily to negative pressures on the curved gate crest and to the back roller from the outflow nappe which tended to force the gate upward. Venting of the gate crest eliminated bouncing at low tailwater but not at high tailwater. No curved-surface gate crest would ideally fit all flow conditions, so tests were made of a plane-surface crest. After tests of eight gate designs, a triangular-crest gate with girder flanges turned down was found stable for all conditions investigated and required no aeration of the crest. Tests to determine pressures on the upstream gate leaf indicated satisfactory performance for all conditions investigated.

(h) "Emergency Gate, Greenup Locks, Ohio River, Kentucky; Hydraulic Model Investigation." U. S. Army Engineer Waterways Experiment Station Technical Report No. 2-527, Oct. 1959.
Available on loan.

(1739) MODEL STUDY OF GATE AND STILLING BASIN, MARKLAND LOCKS AND DAM, OHIO RIVER.

(b) District Engineer, U.S. Army Engineer District, Louisville, Corps of Engineers, Louisville, Kentucky.
(d) Experimental; for design.
(e) A 1:25 section model reproducing 400 feet of the approach area, a portion of the spillway crest and stilling basin, and 800 feet of the exit area was used to examine the hydraulic performance of the spillway weir and stilling basin. A second phase of the study involved measurements of hydraulic forces acting on a submergible-type spillway tainter gate.
(f) Final report in preparation.

(1982) MODEL STUDY OF OLD RIVER LOW-SILL CONTROL STRUCTURE, OLD RIVER, LOUISIANA.

(b) President, Mississippi River Commission, Corps of Engineers, Vicksburg, Mississippi.
(d) Experimental; for design.
(e) The Old River low-sill control structure will control flow into Old River, which links the Mississippi and Atchafalaya Rivers, so that Mississippi River flows will be divided between the lower reaches of the Mississippi and Atchafalaya. Flow through the structure will be regulated by eleven, multiple-leaf, vertical-lift gages discharging into a horizontal apron with baffle piers and end sill. Upstream and downstream training walls will guide flow through the structure and protect adjacent levees from high-velocity currents. Tests on two 1:36 section models and a 1:36 comprehensive model were concerned with overall capacity of the structure, flow conditions at the abutments, and effectiveness of the stilling basin for a wide range of hydraulic conditions.
(f) Completed.
(g) Tests showed no reduction in capacity of the structure as a result of unsymmetrical flow distribution in the approach channel caused by flow from the Mississippi River. Unusual care was used in developing satisfactory designs for the training walls upstream and downstream of the abutments. The stilling basin appeared to perform adequately under all flow conditions. Economies in apron construction (increase in elevation and reduction in length) were found possible. A baffle pier arrangement was evolved that provided adequate energy dissipation of both high and low tailwaters.
(h) "Old River Low-Sill Control Structure; Report 3, Study of Over-all Performance; Hydraulic Model Investigation." U. S. Army Engineer Waterways Expt. Sta. Tech. Report No. 2-447, June 1959. (Available on loan.)

(1986) SALT WATER INTRUSION AND RELATED PHENOMENA.

(b) Committee on Tidal Hydraulics, Corps of Engineers (correspondence should be addressed to Mr. C.F. Wicker, Chairman, Committee on Tidal Hydraulics, U. S. Army Engineer District, Philadelphia, Corps of Engineers, Philadelphia, Pennsylvania.
(d) Experimental; applied research.
(e) To determine the effects of salinity and related phenomena on the vertical distribution of currents and shoaling characteristics in estuaries, tests are being made in a lucite flume 327 feet long, 1.5 feet deep, and 0.75 foot wide. One end of the flume is connected to a 25-foot-square tidal basin in which any desired tide may be produced and in which the salinity may be controlled. The opposite end is connected to a fresh-water source. Combinations of tidal range, tidal period, source salinity, mean depth, and fresh-water inflow are studied. A total of nine tests were made during the year. The results are being analyzed; however no conclusions have been reached at this time.

(1987) MODEL REPRODUCTION OF PROTOTYPE EROSION BELOW STILLING BASINS.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.
(d) Experimental; applied research.
(e) Study will be made of erosion characteristics of various sizes of riprap and gravel material with a view to securing adequate protection at minimum cost. Measurements of velocity and turbulence at which movement of material begins will be made.
(f) Inactive during 1959 but will be resumed under title "Riprap Protection at Hydraulic Structures."

(1988) WATER TEMPERATURE EFFECTS ON BED FORMS AND ROUGHNESS.

(b) Office of the Chief of Engineers, Dept. of the Army, Washington, D. C.
(d) Experimental; applied research.
(e) A laboratory flume, in which water temperatures can be varied to simulate normally experienced summer and winter temperatures, is being used to investigate the effects of water temperature on stream-bed forms and roughness of various types of bed materials.

(2427) MODEL STUDY OF OUTLET WORKS, ABIQUIU DAM, RIO CHAMA, NEW MEXICO.

(b) District Engineer, U. S. Army Engineer District, Albuquerque, Corps of Engineers, Albuquerque, New Mexico.
(d) Experimental; for design.
(e) A 1:20 model was used to study flow conditions in the control section of a 12-foot-diameter flood-control tunnel, at the junction of this tunnel and an uncontrolled, 10-foot-diameter outlet, and in the energy dissipator for the tunnels. Of particular interest were the transitions between the rectangular gate passages and the circular tunnel and the junction of the two tunnels.
(f) Completed.
(g) From a hydraulic standpoint, completely satisfactory designs were not developed for the transition from the rectangular gate passages to the 12-foot-diameter tunnel and for the junction of the two tunnels. The design accepted for the transition included a steel lining throughout

the gate passages, transition, and into the 12-foot-diameter tunnel. It is planned that this lining will retard likely cavitation damage to an acceptable degree. A top-entry junction that will not interfere with normal releases was adopted. Should the uncontrolled outlet go into operation, damage at the junction is likely but, because of the short duration of flows, should not be critical. The flip bucket energy dissipator was considered an inexpensive means of obtaining desired dispersion of flow.

(h) "Outlet Works for Abiquiu Dam, Rio Chama, New Mexico; Hydraulic Model Investigation." U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-513, June 1959. (Available on loan.)

(2428) MODEL STUDY OF SAVANNAH HARBOR, GEORGIA.

(b) District Engineer, U.S. Army Engineer District, Savannah, Corps of Engineers, Savannah, Georgia.

(d) Experimental; for design.

(e) The investigation is being conducted in a model which reproduces the following: (1) That portion of the Atlantic Ocean, adjacent to the harbor entrance, from Calibogue Sound on the north to Wassaw Sound on the south; (2) the Savannah River and its flood plain to the head of tide at Ebenezer Landing; and (3) that portion of the Intracoastal Waterway which crosses the area included in the model. The model is of fixed-bed construction with scale ratios, model to prototype, of 1:800 horizontally and 1:80 vertically. Automatic tide generators are used to reproduce tides and tidal currents throughout the harbor, and salt water is used in the model ocean to reproduce the effects of density difference on current velocities and distributions. Shoaling studies are made by injecting finely ground gilsonite into the model to reproduce the patterns of shoaling as observed in the prototype, following which the effects of proposed improvement plans on shoaling patterns may be observed and evaluated. Studies are also made of the effects of proposed improvement plans on dispersion and dilution of contaminants discharged into the harbor. Refinements of plans for reducing and localizing shoaling are being tested.

(2429) MODEL STUDIES OF THE CORNWALL ISLAND AND BARNHART ISLAND-LAKE ST. FRANCIS REACHES, ST. LAWRENCE RIVER.

(b) District Engineer, U.S. Army Engineer Dist., Buffalo, Corps of Engineers, Buffalo, New York.

(d) Experimental; for design.

(e) Two fixed-bed models were used to study plans for navigation improvement in the lower portion of the International Rapids section of the St. Lawrence River. A 1:100 model of the Cornwall Island Reach reproduced all features of the river from just below the tailrace of the proposed Barnhart Island powerhouse to about the mid-point of Cornwall Island, and included portions of both the north and south Cornwall Island channels, Polly's Gut, and the entrance to Grass River locks. A model of the Barnhart Island-Lake St. Francis Reach, built to scales of 1:300 horizontally and 1:100 vertically, reproduced a greater area upstream and downstream of Cornwall Island. Both models were used to study navigation conditions in the approach to the Grass River locks, proposed plans for excavations in both Cornwall Island channels to effect navigation improvement in South Channel, and to determine conditions that will be encountered by navigation during the construction of the project features in the Cornwall Island Reach.

(h) Preparation of final report in progress.

(2673) MODEL STUDIES OF BARKLEY LOCK AND DAM, CUMBERLAND RIVER, TENNESSEE.

(b) District Engineer, U.S. Army Engineer Dist., Nashville, Corps of Engineers, Nashville, Tennessee.

(d) Experimental; for design.

(e) A 1:120 model, reproducing the Cumberland River from mile 29.4 to 32.2, the lock, dam, and powerhouse, is being used to investigate flow characteristics in the approaches to the lock. A 1:36 model, reproducing the riverward downstream lock wall including the culvert manifold which discharges into the spillway stilling basin, a discharge manifold discharging through the stilling basin, five spillway bays, 324 feet of approach channel, and 596 feet of exit channel, was used to investigate flow characteristics in the stilling basin and exit channel. The proposed design for the lock filling and emptying system was tested in a 1:33 model simulating the upper approach channel, intake manifolds in both walls serving culverts 16 feet square, lateral culvert diffusers in the lock chamber floor, and port manifolds in the spillway stilling basin for discharging flow from both culverts. The emergency lock gate is being studied in a 1:25 model which reproduces the gate, gate sill, and portions of the upstream lock approach and the lock chamber downstream from the gate. This model will be used to determine: (1) hydraulic forces on and stability of the gate under various flows including free flow over the lock miter sill; (2) hydrostatic forces on the gate in various positions; (3) gate wheel reactions and sill roller reactions at given positions; and (4) head loss through the bridge decking.

(g) Tests of the 1:25 emergency lock gate revealed that with the original design gate uplift forces on the gate were greater than the dry weight of the gate (360 kips). This was corrected by the use of a 45-degree lip on the apex of the gate. For this design the gate was stable throughout its range of operation, and hydraulic forces were in the range of 107 kips downpull and 207 kips uplift. Reaction data revealed that the centroid of the gate was never above the upper support of the gate,

which eliminated any tendency for this gate to be rotated in a downstream direction. In the 1:120 general model, a satisfactory alinement of the right bank downstream from the powerhouse was developed.

(2675) MODEL STUDIES OF DARDANELLE LOCK AND DAM, ARKANSAS RIVER, ARKANSAS.

(b) District Engineer, U.S. Army Engineer Dist., Little Rock, Corps of Engineers, Little Rock, Arkansas.
(d) Experimental; for design.
(e) Three models were used for the investigation. A 1:120 model reproduced the structures and 4,000 feet of approach channel and 8,000 feet of exit channel. The approach channel was molded in concrete to overburden contours while the exit channel was molded in concrete to bedrock contours with the overburden topography molded in pea gravel to facilitate revision of the channel configuration. Currents were measured around the lock approaches for all arrangements of structures. A 1:50 section model reproducing one full and two adjacent half bays of the spillway and stilling basin was utilized for studies of the adequacy of the weir and stilling basin design. This model had a glass side so that flow patterns could be observed directly. This section model was also used to test a revised crest pier design with wider gate bays which will be incorporated. A 1:25 model reproducing 700 feet of upstream lock approach channel, the guide wall, the lock culvert intakes, the lock culverts through the filling valves, and three adjacent spillways bays (the downstream portions of the lock culvert and lock chamber are reproduced schematically) was used to develop a satisfactory lock intake system and approach channel. Provisions were made for mechanical operation of the culvert valves and automatic recording of pertinent data.
(f) Tests completed.
(h) Preparation of final reports in progress.

(2678) MODEL STUDY OF LOCKS AND DAM NO. 41, LOUISVILLE, KENTUCKY.

(b) District Engineer, U.S. Army Engineer Dist., Louisville, Corps of Engineers, Louisville, Kentucky.
(d) Experimental; for design.
(e) A fixed-bed, 1:120 model reproduces a six-mile reach of the Ohio River including adjacent overbank areas, the locks and dam structures and all bridges and other structures that might affect flow conditions. Purposes of the model study are to: determine the effects of location, size, and alinement of the dam on stages and currents in the upper pool; determine the effects of location, size, and alinement of a new approach channel on navigation and surge conditions; determine the best location for a new navigable span on the Pennsylvania Railroad bridge; determine a method of operating the dam for optimum navigation conditions; study navigation conditions in the lower approach as affected by flow through dam, powerhouse, and lock-emptying system; and provide a means for navigation interests to satisfy themselves as to the acceptability of the proposed plan by observing the model in operation.
(g) Preliminary tests are in progress.

(2680) MODEL STUDY OF HURRICANE TIDES IN NARRAGANSETT BAY, RHODE ISLAND.

(b) Division Engineer, U.S. Army Engineer Div., New England, Corps of Engineers, Boston, Massachusetts.
(d) Experimental; for design.
(e) A fixed-bed model, 1:1,000 horizontally and 1:100 vertically, reproduces all of Narragansett Bay and an adjacent portion of the Atlantic Ocean. An automatic tide generator reproduces normal tides throughout the model, and a separate, manually operated generator reproduces hurricane tides of the desired characteristics at the bay entrance. Numerous barrier plans for prevention of hurricane-tide damage have been proposed. The relative and absolute effectiveness of these plans in reducing hurricane-tide elevations throughout the bay system were determined and the effects of the best plan on such important factors as tidal circulation, pollution, salinity, and shoaling for normal conditions were investigated. Additional hydraulic, salinity, shoaling, and pollution studies of a lower bay barrier plan recommended by the Navy were made; however, analysis of the tests results is not complete. Fresh water only was used in the model during tests of the proposed barrier plans, but both salt and fresh water are being used in the tests to determine the effects of the best barrier plan on all significant factors for normal conditions. Model appurtenances consist of automatic tide gages to record both hurricane-tide and normal-tide elevations at critical points, recording salinity meters, recording dye meters for observing pollution and/or flushing characteristics, current velocity meters, and equipment for simulating shoaling of the channels and other navigation facilities.
(g) Results of tests to determine the effects of the authorized Fox Point barrier on water temperatures in the upper Providence River, and on the temperature of cooling water for two generating stations in particular, indicated that the Fox Point barrier would cause a significant increase in average river water temperatures upstream from the barrier, while temperatures downstream from the barrier would be reduced slightly. Further tests indicated that the detrimental effects of the Fox Point barrier on cooling-water temperature could be eliminated by construction of a cooling-water intake channel along the west side of the Providence River to supply cooling water from the downstream side of the barrier.
(h) Interim Report 2, "Effects of Lower Bay Barriers on Salinities, Shoaling and Pollution in Narragansett Bay," Interim Report 3, "Effects of Fox Point Barrier on Water

Temperatures," and Interim Report 4, "Effects of Cooling-Water Channel on Temperatures of Cooling Water for Power Stations," were published in January, September, and September 1959, respectively.

(2681) SCALE-EFFECT TESTS OF RUBBLE-MOUND BREAKWATERS.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
(d) Experimental; applied research.
(e) Tests are being conducted by the Beach Erosion Board, under the supervision of the Waterways Experiment Station, to investigate the effects of model scale on the results of experimentally determined criteria for the design of rubble-mound breakwaters. Stability tests are being made of a breakwater slope of 1 on 1-1/2 using wave periods of 2.61, 3.75, 7.87, and 11.33 seconds. Tests in the Beach Erosion Board wave flume (15 feet by 20 feet by 635 feet) are being conducted using a linear scale of 7.5 to 1 based on the tests conducted in the Waterways Experiment Station 5- by 4- by 119-foot wave flume. Stability tests have also been conducted in the Waterways Experiment Station small wave flume (1 foot by 1.5 feet by 94 feet) using a scale of 0.5 to 1 based on tests conducted in the 5- by 4- by 119-foot wave flume. Therefore, data on the stability of rubble-mound breakwaters will be available for three different linear scales, 0.5 to 1, 1 to 1, and 7.5 to 1. Test data from the Beach Erosion Board wave flume will be correlated with data from the Waterways Experiment Station flumes as soon as calibration of the flume is completed.

(2682) SACRAMENTO BARGE CANAL LOCK MODEL STUDIES, SACRAMENTO RIVER, CALIFORNIA.

(b) District Engineer, U.S. Army Engineer District, Sacramento, Corps of Engineers, Sacramento, California.
(d) Experimental; for design.
(e) The Sacramento Barge Canal Lock is part of the proposed improvement for the Sacramento River Deep Water Ship Canal. The project plan consists of (1) a deep water channel from Suisan Bay to Washington Lake, 30 feet deep at mean low water, 200 feet wide in tangents, and 300 feet wide in curves and through existing channels, (2) a 70-acre, 30-foot-deep harbor at Lake Washington, (3) a connecting barge canal from Washington Lake to Sacramento River, 13 feet deep and 120 feet wide with a navigation lock 86 by 600 feet, and a combination highway and railroad bascule bridge. The maximum anticipated lock lift is 21.1 feet. A minimum depth of 13 feet is provided over the upper and lower gate sills. Because of the possibility of a reversal of head, sector gates were selected for the lock and also are to be used as the means of filling and emptying the lock. Flow will pass directly into or from the lock between the gate leaves as they are opened. In addition the gate leaves and recesses have been designed so that flow will pass between the faces of the leaves and the walls of the recesses, thereby providing three flow passages at each end of the lock. The immediate approaches and entire lock were reproduced in a 1:20 model. Provisions were made for mechanical operation of the sector gates and automatic recording of pertinent data.
(h) Final report in preparation.

(2685) MODEL STUDY OF WAVE ACTION, SUPERIOR ENTRY, DULUTH-SUPERIOR HARBOR, LAKE SUPERIOR.

(b) District Engineer, U.S. Army Engineer Dist., St. Paul, Corps of Engineers, St. Paul, Minnesota.
(d) Experimental; for design.
(e) A 1:150 fixed-bed model reproduces all the navigation approach channel and harbor breakwater structures as well as the inner harbor dock area serving Superior, Wis., and includes adjacent lake and shore-line areas to permit reproduction of storm waves from all critical directions. Investigations are being made: to determine the reasons for the wind-wave problems that exist and cause ship damage in the vicinity of the Superior Entry; and to develop the most effective remedy possible so that navigation and docking hazards now prevailing will be adequately remedied.
(g) The optimum lengths of detached breakwaters located in four positions have been determined based on a wave-action-in-docks criterion of 3-foot-high waves occurring no more frequently than once in five years. The choice of plan will depend upon minimum channel widths acceptable to ship captains.

(2925) ULTRASONIC FLOW MEASUREMENT.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
(d) Experimental; development.
(e) Various types of ultrasonic equipment will be investigated in a 24-inch by 14-inch conduit, with full and partial flow, to determine the relative accuracy of each type. Tests to date have been concerned with the adjustment and modification of test equipment.

(2927) MODEL STUDY OF NAVIGATION CONDITIONS, TROY LOCK AND DAM, HUDSON RIVER, NEW YORK.

(b) District Engineer, U.S. Army Engineer Dist., New York, Corps of Engineers, New York, New York.
(d) Experimental; for design.
(e) Navigation conditions at Troy Lock are adversely affected by the facts that the lock and dam are the upper limit of tidewater in Hudson River, and a branch of the Mohawk River enters the Hudson in an upstream direction just above the lock. Tests to determine the most effective and economical plan for eliminating the hazardous navigation conditions at the upper entrance to the lock were conducted in a 1:100 model of the pertinent reach of the Hudson and the lower 1,800 feet of the Mohawk branch. The model included the lock and dam, all bridge

piers within the model limits, and sufficient overbank area to reproduce flood flows. A remote-controlled towboat with tow was used to determine the effect of currents on tows entering and leaving the locks.

(f) Completed.

(g) Tests indicated that navigation difficulties are due principally to (1) position of lock and guard wall which are not alined with the project channel and the main currents within the lock approach, and (2) limited maneuver area available for tows attempting to overcome effects of the adverse currents in the approach. Conditions are also somewhat affected by flow from the Mohawk River branch, the bend in the Hudson upstream of the lock, the elevation of the tops of the ports in the guard wall, and the relatively large flow over the low section of the dam near the lock. The most satisfactory improvement plan appeared to be: (1) replacement of the existing guide wall with a short wing wall angled toward the near bank, (2) extension of the guard wall, and (3) lowering of the elevation of the guard wall ports.

(h) "Navigation Conditions at Troy Lock and Dam, Hudson River, New York; Hydraulic Model Investigation." U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-517, July 1959. (Available on loan)

(2929) MODEL STUDY OF NEW RICHMOND LOCKS AND DAM, OHIO RIVER.

(b) District Engineer, U.S. Army Engineer Dist., Huntington, Corps of Engineers, Huntington, West Virginia.

(d) Experimental; for design.

(e) A 1:120 model reproducing three miles of the Ohio River and the main and auxiliary locks together with the dam structures was used to: determine the best arrangement of the locks and appurtenant walls; study approach conditions under various river flows and methods of operation of dam control gates; develop modifications required to overcome any undesirable conditions; and demonstrate to navigation interests the acceptability of the proposed design from a navigation standpoint.

(f) Completed.

(g) The study revealed that no hazardous navigation conditions would exist in the upper and lower lock approaches for any of the flows and conditions investigated. With the original design structures, tows might experience some difficulty in approaching the auxiliary lock and in pulling away from the guard wall. Lowering the tops of the ports in the upper guard wall 3 feet would reduce appreciably the force required to pull a tow away from the guard wall and would also tend to reduce velocities in the upper approach. Placing dredged spoil along the right bank upstream of the locks would decrease the overbank flow bypassing the locks and increase the crosscurrents at the upper end of the guard wall. Shifting the locks 50 feet landward would have no appreciable effect on navigation conditions in the lock approaches. Emergency navigation over the fixed-crest weir should be feasible during flood stages if the weir is at least 250 feet long.

(h) "Navigation Conditions at New Richmond Locks and Dam, Ohio River; Hydraulic Model Investigation," U. S. Army Engineer Waterways Experiment Station Technical Report is in publication. (Will be available on loan.)

(2930) MODEL STUDIES OF SPILLWAY AND STILLING BASIN, LOCK, AND NAVIGATION CONDITIONS, JACKSON LOCK AND DAM, TOMBIGBEE RIVER, ALA.

(b) District Engineer, U.S. Army Engineer Dist., Mobile, Corps of Engineers, Mobile, Alabama.

(d) Experimental; for design.

(e) Four models were used to develop profiles and capacities of a fixed-crest and a gated spillway, dimensions of the stilling basins below each, to study currents and velocities in the lock approaches, and to investigate the lock filling and emptying system and effect of lock operation on conditions in the approaches. A 1:36 model of a section of the approach area, fixed-crest spillway, stilling basin, and exit area, and a 1:50 model of a like section of the gated spillway were tested. Navigation conditons at the locks were investigated in a 1:120 model of a 2.3-mile reach of the river including the lock and dam and approach channels. Navigation conditions in the upper and lower lock approaches and over the fixed-crest spillway were observed, and modifications in lock or channel configurations were tested to modify any undesirable conditions noted. A 1:25 model of the complete filling and emptying system with an outlet system discharging riverward of the lock was used to study various locations, designs, and numbers of lock chamber wall ports. Filling and emptying times were determined, and culvert pressures, surging, hawser stresses, and vibration of the valves were measured.

(f) Tests completed.

(g) Tests on the 1:120 navigation model indicated that no serious difficulties should be encountered by navigation in the lock approaches and that tows with sufficient power to navigate the reach during flood stages should be capable of navigating over the fixed-crest spillway. Dredging to realign the riverbanks adjacent to the upstream and downstream lock approach channels was found to appreciably improve navigation conditions for both upbound and downbound tows. Tests on the 1:36 and 1:50 spillway models revealed that the original designs of the gated and fixed-crest spillways were satisfactory. A horizontal stilling basin with sloped end sill was selected for the gated spillway. The basin below the fixed-crest spillway will consist of a small roller bucket.

(h) "Navigation Conditions at Jackson Lock and Dam, Tombigbee River; Hydraulic Model Investigation," and "Spillways and Stilling Basins, Jackson Dam, Tombigbee River, Ala.; Hydraulic Model Investigation," Waterways Experiment Station Technical Reports are in

publication. (Will be available on loan.)

(2931) MODEL STUDY OF SOUTHWEST PASS, MISSISSIPPI RIVER.

(b) District Engineer, U.S. Army Engineer Dist., New Orleans, Corps of Engineers, New Orleans, Louisiana.
(d) Experimental; for design.
(e) To determine the effectiveness of proposed improvement works (jetty extensions, channel realignments, and contraction works) in eliminating or reducing the periodic maintenance now required in order for deep-draft vessels to navigate the jetty and bar channels of Southwest Pass, the lower 12 miles of the Pass and the adjacent area of the Gulf of Mexico were reproduced in a fixed-bed model to scale ratios of 1:500 horizontally and 1:100 vertically. Tides, tidal currents, littoral currents, and wave action in the Gulf of Mexico, and salt- and fresh-water flows in Southwest Pass and the bar channel were reproduced in the model. Shoaling studies were made by introducing various mixtures of plastic materials into the model to simulate prototype shoaling materials and thus reproduced in the model the patterns and distribution of shoaling that occur in the prototype.
(f) Tests completed.
(g) Tests of proposed plans for reducing shoaling in the jetty and bar channels indicated that plans involving a curved realinement to the jetty channel, and plans involving relocating the bar upstream from ends of the jetties would greatly reduce shoaling for the authorized project depth of -40 feet, as compared to a 40-foot-deep channel on the alinement of the existing channel. The tests indicated that reducing the jetty channel width from 800 to 600 feet would also be beneficial in reducing shoaling.
(h) "Summary of Best Plans for Reducing Shoaling, Southwest Pass, Mississippi River; Hydraulic Model Investigation." U.S. Army Engineer Waterways Experiment Station Miscellaneous Paper No. 2-349, July 1959. (Available on loan.)

(2932) MODEL STUDY OF HUDSON RIVER, NEW YORK.

(b) District Engineer, U.S. Army Engineer Dist., New York, Corps of Engineers, New York, New York.
(d) Experimental; for design.
(e) A fixed-bed model constructed to linear scales of 1:100 vertically and 1:1,000 horizontally, is being used to determine the source of material shoaling the Hudson River in the vicinity of Edgewater and Weehawken piers and the most effective means of reducing or eliminating this shoaling. The model reproduces Upper and Lower New York Bays, Raritan Bay, Hudson River to Hyde Park, East River to Throgs Neck, and tributaries flowing into the modeled bodies of water. Provisions are made to reproduce tides, fresh-water discharge, salinity intrusion, and shoaling.
(g) The results of model tests indicate that shoaling of the Hudson River navigation channels between the Battery and the George Washington Bridge can be reduced appreciably by (1) the provision of sediment traps in critical locations, (2) enlargement of the constricted cross-sectional area at the George Washington Bridge, or (3) a combination of these two schemes.

(2933) STUDY OF HARBOR DESIGN.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
(d) Experimental; applied research.
(e) A testing program is planned to determine general criteria for designing harbors and harbor works to obtain optimum protection from wave action. Program will include both wind waves and seiches, and wave refraction and diffraction as applied to harbor and break-water planning will be investigated.
(f) Suspended.

(2934) DESIGN OF RUBBLE WAVE ABSORBERS.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
(d) Experimental; applied research.
(e) Rubble wave absorbers are to be studied in a wave flume to determine criteria for the design and construction of such structures. The study will include investigation of the effects of slope and shape of face of the structure, and size, shape, volume, and porosity of materials on the wave-absorbing characteristics of the structure.
(f) Suspended.

(2935) MODEL STUDY OF BUFFALO HARBOR, LAKE ERIE.

(b) District Engineer, U.S. Army Engineer Dist., Buffalo, Corps of Engineers, Buffalo, N. Y.
(d) Experimental; for design.
(e) A 1:125 model was used to determine the effects on wave action in the harbor of relocating the navigation approach channel to the harbor, and since the new channel would necessitate removal of a section of the existing breakwater, to determine whether a new detached breakwater is necessary to reduce storm-wave action at the proposed new entrance. The fixed-bed model reproduced about 13.2 square miles, including nearly all of the harbor and sufficient adjacent lake area to permit reproduction of storm waves from all critical directions. Currents caused by discharge from Lake Erie into Niagara River were simulated.
(f) Completed.
(g) Tests indicated that a detached breakwater about 1,800 feet long located on the north side of the proposed navigation approach channel and about 2,500 feet lakeward of the old breakwater, will provide adequate protection to the harbor from storm-wave action.
(h) "Effects on Wave Action of Proposed Relocation of North Entrance Channel, Buffalo Harbor, New York; Hydraulic Model Investigation," U. S. Army Engineer Waterways

Experiment Station Technical Report is in publication. (Will be available on loan.)

(2936) MODEL STUDY OF BARCELONA HARBOR, LAKE ERIE.

(b) District Engineer, U.S. Army Engineer Dist., Buffalo, Corps of Engineers, Buffalo, N. Y.
(d) Experimental; for design.
(e) The site of the proposed harbor, located on the south shore of Lake Erie, is exposed to waves from west-southwest clockwise to north-northeast. A fixed-bed, 1:68 scale model was used to develop a system of breakwaters to protect pleasure and fishing craft from these wind-generated waves. The model reproduced a sufficient area in the harbor vicinity, upshore and downshore and lakeward, to permit generation of waves. Various breakwater schemes were installed in the model and wave heights measured.
(f) Completed.
(g) Tests showed that a simple arrowhead-type breakwater system, consisting of two legs, would protect the enclosed mooring basin from storm waves, but would reduce wave heights only moderately in the entrance channel. Tests also indicated the desirability of narrowing the navigation opening width from 200 feet to 150 feet and straightening one breakwater leg, as well as the feasibility of reducing the length of the other leg by 200 feet.
(h) "Wave Action and Breakwater Location, Harbor of Refuge for Light-Draft Vessels, Barcelona, New York; Hydraulic Model Investigation." U.S. Army Engineer Waterways Experiment Station Technical Report No. 2-523, September 1959. (Available on loan.)

(2937) MODEL TESTS OF CULVERT TAINTER VALVES FOR NEW LOCK NO. 19, MISSISSIPPI RIVER, KEOKUK, IOWA.

(b) District Engineer, U.S. Army Engineer Dist., Rock Island, Corps of Engineers, Rock Island, Illinois.
(d) Experimental; for design.
(e) Flow through the 14.5- by 14.5-foot longitudinal culverts in each lock wall is regulated by reverse tainter valves. Trial operation in the prototype disclosed that when the valves were operated at greater than two-thirds angular opening, severe load pulsations occurred which resulted in intermittent reversals in loading on the valve hoist and a consequent clattering in the operating machinery, which made operation of the valves at large openings risky. A 1:12 model of one valve was used to study causes of load reversals on the hoist and to develop valve modifications that would eliminate clattering and permit normal valve operation.
(f) Completed.
(g) A major cause of load reversals was found to be hydraulic forces tending to raise the valve, combined with fluctuating pressure differentials across the web of the lower horizontal girder. Valve modifications which materially improved loadings included removal of knee braces between the lower girder and trunnion arms and installation of a cover plate from the upstream flange of the lower girder to the bottom of the skin plate. Also, installation of a diaphragm in the bulkhead well downstream from the valve reduced load pulsations at a particular valve opening. On the basis of these findings, one prototype valve was modified and observations of its operation revealed that load reversals on the hoist were eliminated.
(h) "Culvert Tainter Valves, New Lock No. 19, Mississippi River; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Tech. Report is in publication. (Will be available on loan.)

(2941) MODEL STUDIES OF KEYSTONE DAM, ARKANSAS RIVER, OKLAHOMA.

(b) District Engineer, U.S. Army Engineer Dist., Tulsa, Corps of Engineers, Tulsa, Oklahoma.
(d) Experimental; for design.
(e) Several models were used to determine: the adequacy of design of the stilling basin, weir, and training walls; the best spacing for the nine flood-control sluices; and the alinement and outlet design of the sluices. A 1:100 general model was used to study flow patterns in the approach and exit channels, develop a satisfactory alinement of the right training walls, and determine the required spacing of the flood-control sluices. A 1:36 spillway section model was used for the stilling basin and sluice alinement tests. Final refinements in the sluice outlet design were tested in a conduit model at a scale of 1:20.
(f) Tests completed. Preparation of final report in progress.
(g) The conduit model provided more detailed data which established the desirability of an alternate sluice design.

(2942) OLD RIVER ROCK-FILL CLOSURE DAM MODEL STUDIES.

(b) District Engineer, U.S. Army Engineer Dist., New Orleans, Corps of Engineers, New Orleans, Louisiana.
(d) Experimental; for design.
(e) Initial closure of the present Old River channel will be accomplished by dumping rock, weighing more than two tons, into low velocity water. A 1:10 section model reproducing 100 feet of the length of the fill was used to test the stability of the downstream slope under critical flow conditions and to determine the maximum amount of seepage that will occur. Carefully graded limestone rock with a specific weight of about 168 pounds per cubic foot was used in the tests.
(f) Completed.
(g) Stability of the downstream slope of the hand-placed and dumped fills was found to be adequate under overflow discharges for all possible river stages. Seepage rates through the embankment were high but were reduced to tolerable levels by placing a well-graded seal blanket on the upstream slope. It was found that steeper slopes could be used for both upstream and

downstream faces of the dam, thereby reducing the volume of the fill by about 40 percent.

(h) "Old River Project, Rock-Fill Initial Closure Dam; Hydraulic Model Investigation." U.S. Army Engineer Waterways Experiment Station Tech. Report No. 2-496, March 1959. (Available on loan.)

(3232) MODEL STUDY OF FILLING AND EMPTYING SYSTEM, OLD RIVER LOCK, LOUISIANA.

(b) President, Mississippi River Commission, Corps of Engineers, Vicksburg, Mississippi.
(d) Experimental; for design.
(e) Old River lock will be 1,250 by 75 feet with a minimum depth of 13 feet over the sills. Under normal operating conditions, lifts are not expected to exceed 15 feet but provisions were made for a lift of 32 feet which could occur with the low-sill control structure inoperative. Manifold intakes in the approach walls lead to longitudinal wall culverts which discharge into the lock chamber through side ports at the bottom of the chamber. The discharge manifold consists of two floor laterals with side ports from each of the two longitudinal wall culverts. Reverse tainter valves are used for flow regulation. A 1:25 model was used to study the hydraulic characteristics of the filling and emptying system.
(h) Final report in preparation.

(3233) MODEL STUDY OF SPILLWAY BULKHEADS, GREENUP DAM, OHIO RIVER.

(b) District Engineers, U.S. Army Engineer Districts, Huntington and Louisville, Corps of Engineers, Huntington, West Virginia, and Louisville, Kentucky.
(d) Experimental; for design.
(e) A 1:25 model of a solid, girder-type bulkhead with upstream and downstream skin plate and lifting beam was used to determine the vertical forces acting on the bulkhead and lifting beam as they are lowered in flowing water.
(h) Final report in preparation.

(3234) MODEL STUDY OF PASNY INTAKE, NIAGARA RIVER.

(b) District Engineer, U.S. Army Engineer Dist., Buffalo, Corps of Engineers, Buffalo, N. Y.
(d) Experimental; for design.
(e) The hydraulic investigation of the PASNY intake structure was conducted on an existing model used previously to study the development of power and the preservation and enhancement of the scenic spectacle at Niagara Falls. The model was constructed to linear scale ratios, model to prototype, of 1:360 horizontally and 1:60 vertically and reproduced that portion of the Niagara River from the Falls upstream to and including part of Lake Erie. Tests were conducted to determine the effect of the intake structure on flow conditions and distribution, water-surface elevations, and velocities to insure that the flows diverted to the structure would have no detrimental effects from scenic and navigation standpoints.
(f) Completed.
(g) Tests showed that installation of the intake structure caused: (1) no significant effects on flow distribution; (2) lower water-surface elevations in the American channel upstream; and (3) slightly higher velocities in the river flow in the American channel. However, its over-all effect on hydraulic conditions appeared to be satisfactory.
(h) "Effect of PASNY Intake Structure, Niagara River; Hydraulic Model Investigation." U.S. Army Engineer Waterways Experiment Station Miscellaneous Paper No. 2-337, April 1959. (Available on loan.)

(3235) MODEL STUDY OF PIKE ISLAND LOCKS AND DAM, OHIO RIVER.

(b) District Engineer, U.S. Army Engineer Dist., Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
(d) Experimental; for design.
(e) A 1:120, fixed-bed type, comprehensive model, reproducing about 4 miles of the Ohio River and the locks and dam structures, is being used to select the most favorable site location by studying approach conditions under various river flows, and to develop modifications required to overcome any undesirable conditions at selected site.
(g) Ports in the lower guard wall would be ineffective in improving conditions in the lower approach without some means of diverting flow through the ports. The effect of filling along the left bank on the size of the eddy in the lower approach would be small.

(3236) MODEL STUDY OF MAXWELL LOCKS AND DAM, MONONGAHELA RIVER, PENNSYLVANIA.

(b) District Engineer, U.S. Army Engineer Dist., Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
(d) Experimental; for design.
(e) A 1:120 fixed-bed type, comprehensive model, reproducing about 2.5 miles of the Monongahela River and the locks and dam structures, is being used to study approach conditions under various river flows and methods of operation of control gates; to determine effects of design modifications; to develop modifications required to overcome any undesirable conditions; and to demonstrate to navigation interests the acceptability of the proposed design from a navigation standpoint.
(g) Tests indicated that the size of the eddy in the lower approach could be reduced by an arrangement of ports in the lower guard wall and concrete cells extending at an angle of about 25 degrees from the wall.

(3237) MODEL STUDY OF OUTLET WORKS, BLACK BUTTE DAM, STONY CREEK, CALIFORNIA.

(b) District Engineer, U.S. Army Engineer Dist., Sacramento, Corps of Engineers, Sacramento, California.
(d) Experimental; for design.
(e) A 1:16 model, which reproduced 160 feet of

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the tunnel, the energy dissipator, irrigation diversion outlets, and 560 feet of the exit channel, was used to determine: (1) The most economical dimensions for the combination energy dissipator and irrigation diversion structures; (2) the extent of armor plating required at the south side canal intake slot for protection against cavitation forces; (3) the inside dimensions and lip elevation of a flip bucket that will give a satisfactory flow and erosion pattern in the downstream exit channel; (4) pressures on the irrigation outlet gates; and (5) the effect of irrigation diversion schemes on flow conditions with and without diversion.

(f) Tests completed.

(g) The original design was improved by reducing the flare of the vertical side walls from 1 on 6 to 1 on 8, lengthening the basin from 110 to 155 feet, removing the flip bucket with crest at elevation 387.5 and replacing it with an end sill with crest at elevation 385.0 with a sloping upstream face. The irrigation slots were placed in the right wall 9 feet upstream of the toe of the sill.

(h) Final report in preparation.

(3238) MODEL STUDY OF EUFAULA DAM, CANADIAN RIVER, OKLAHOMA.

(b) District Engineer, U.S. Army Engineer Dist., Tulsa, Corps of Engineers, Tulsa, Oklahoma.

(d) Experimental; for design.

(e) A 1:36 section model, reproducing one full bay and two flanking half bays of the 520-foot-long, gated spillway, the horizontal stilling basin, and approach and exit channels, was used to determine the adequacy of design of the stilling basin elements, and to investigate pressure conditions on the spillway crest.

(f) Tests completed.

(g) Model tests proved the feasibility of shortening the stilling basin and raising the apron elevation. In addition, proper location of the baffle piers was established and their height increased; a recommended end-sill height was also determined.

(h) Preparation of final report in progress.

(3239) MODEL STUDY OF SPILLWAY CREST GATE, STILLING BASIN, AND BULKHEAD, NEW CUMBERLAND LOCKS AND DAM, OHIO RIVER, PENNSYLVANIA.

(b) District Engineer, U.S. Army Engineer Dist., Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.

(d) Experimental; for design.

(e) A 1:25 section model reproducing 400 feet of the approach area, a portion of the gated spillway crest and stilling basin, and 800 feet of the exit area was used to examine the hydraulic performance of the spillway weir and stilling basin. A second phase of this study involved measurements of hydraulic forces acting on a submergible-type spillway tainter gate. A 1:25 model of a truss-type bulkhead with an upstream skin plate and lifting beam was used to determine the vertical forces acting on the bulkhead and lifting beam as they are lowered in flowing water. A 1:25 section model reproducing a 25-foot-wide section of the spillway and stilling basin was installed in a glass-sided flume which permitted observation of subsurface basin action.

(f) Tests completed.

(g) Supplementary stilling basin tests indicated that the unsatisfactory basin action previously observed in the model could be eliminated if the ratio of head on the spillway to drop from crest to stilling basin was 3.0 or greater. Tests also indicated that the location of basin elements had no effect on basin action if the ratio of height of baffle to its distance downstream from the spillway toe was 0.15 or less.

(h) Final report in preparation.

(3240) MODEL STUDY OF CANACADEA CREEK, HORNELL, NEW YORK.

(b) Department of Public Works, State of New York.

(d) Experimental; for design.

(e) A highway bridge is proposed for construction across Canacadea Creek just upstream from the existing Seneca Street Bridge. In order to pass flood flows under the new bridge, the existing Seneca Street weir, located just upstream from the existing bridge, should be removed and a similar structure constructed just upstream from the proposed bridge. Principal problems to be resolved by the model study are determination of the optimum crest elevation for the replacement weir and the need for superelevation of the channel bottom in a bend downstream of the bridge.

(g) Tests conducted to date indicate a weir at the proposed site with a laterally sloping crest rather than a horizontal crest produced a smoother water surface downstream of the weir. A crest sloping from elevation 1159 at the side walls to a 20-foot-wide low-flow notch at elevation 1156.3 at the center of the channel produced freeboards in the reach upstream of the weir about one foot lower than obtained with the existing weir. At the Seneca Street bridge, the average water surface was 0.6 foot higher than obtained with the existing weir, but standing waves were not as pronounced.

(3241) MODEL STUDY OF SEICHE ACTION, DULUTH-SUPERIOR HARBOR, LAKE SUPERIOR.

(b) District Engineer, U.S. Army Engineer Dist., St. Paul, Corps of Engineers, St. Paul, Minnesota.

(d) Experimental; for design.

(e) To determine whether a practical plan can be developed for reducing the resonant response to lake seiches that occurs in Duluth-Superior Harbor and entrance channels, tests will be made on a fixed-bed model constructed to scales of 1:1,000 horizontally and 1:100 vertically. Waves and currents will be simulated.

(g) Analysis of prototype stage records has shown that troublesome current conditions at harbor are due to Lake Superior seiches,

not Duluth-Superior Harbor seiches.

(3242) MODEL STUDY OF CONNEAUT HARBOR, OHIO, ON LAKE ERIE.

(b) District Engineer, U.S. Army Engineer Dist., Buffalo, Corps of Engineers, Buffalo, N. Y.
(d) Experimental; for design.
(e) A 1:125 fixed-bed model is being used to determine the influence of seiche currents and short-period wind-wave action in causing damage to ships navigating or berthed in Conneaut Harbor (located on the south shore of Lake Erie about 30 miles southwest of Erie, Pa.). The model reproduces about 7.3 square miles including all the area within the harbor and sufficient adjacent lake area to permit reproduction of storm waves from all critical directions. A circulating system installed in the model permits simulation of currents through and past the harbor which result during periods of seiche on the lake.
(g) Both wind waves and seiches cause currents dangerous to navigation. The currents can be minimized by extending East Breakwater to shore, and maintaining existing breakwaters at design elevations. Entrance to inner harbor can be widened, by shortening and realigning East Pier and making 350-foot-wide entrance instead of one 200 feet wide, without increasing wave action inside harbor.

(3243) MODEL STUDY OF LOCKS AND DAM NO. 4, MONONGAHELA RIVER.

(b) District Engineer, U.S. Army Engineer Dist., Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
(d) Experimental; for design.
(e) A 1:120 fixed-bed, comprehensive model, reproducing about 2.5 miles of the Monongahela River and the locks and dam structures is being used to determine the effects of modifications to the existing locks and dam on navigation conditions, and to develop modifications required to overcome any undesirable conditions.
(g) Tests indicate that with the modified locks and dam, velocities in the upper approach would tend to be high. These velocities could be reduced by dredging along the left bank and filling within the approach channel to the right of the dredge cut.

(3244) MODEL STUDY OF COLUMBIA LOCK AND DAM, CHATTAHOOCHEE RIVER.

(b) District Engineer, U.S. Army Engineer Dist., Mobile, Corps of Engineers, Mobile, Alabama.
(d) Experimental; for design.
(e) A 1:100 fixed-bed type, comprehensive model, reproducing about 1.5 miles of the Chattahoochee River and the lock and dam structures was used to study navigation conditions within the lock approaches and the head on lower lock gate during lock-emptying operations, and to develop modifications required to overcome any undesirable conditions found. Two section models were also used in the investigation to develop final spillway profiles and stilling basin dimensions: a 1:36 model of the fixed-crest spillway reproducing 250 feet of the approach area, a 36-foot-wide portion of the spillway and stilling basin, and 300 feet of the exit area; and a 1:27.2 model of the gated spillway, 400 feet of the approach area, a portion of the spillway crest and stilling basin (one full gate bay and two half piers), and 400 feet of the exit area.
(f) Tests completed.
(g) Tests of the spillway section models indicated that while the spillways performed satisfactorily, the stilling basins provided little or no energy dissipation. In the case of the gated spillway, flow passed over the spillway along the surface of the tailwater or dived over the stilling basin into the exit channel. With the fixed-crest spillway, flow normally does not begin until the tailwater over the basin is fairly deep. In such cases there was no measurable velocity at the spillway toe. Based on these observations, both basins were eliminated from prototype construction. Pressures on the gated spillway were positive for all conditions and instantaneous pressure fluctuations were negligible.
(h) Final report in preparation.

(3579) MODEL STUDY OF PIER SLIP SHOALING, NEW YORK HARBOR.

(b) District Engineer, U.S. Army Engineer Dist., New York, Corps of Engineers, New York, New York.
(d) Experimental; for design.
(e) The study will be conducted in a section model reproducing that portion of the Hudson River between the George Washington Bridge and the Battery, constructed to scales of 1:100 vertically and 1:200 or 1:300 horizontally, in which the tides, tidal currents, and shoaling of navigation slips will be reproduced. The purpose of the studies is to determine the causes of shoaling in the pier slips in New York Harbor and to develop plans for reduction of such shoaling.

(3580) MODEL STUDY OF NIAGARA REMEDIAL WORKS.

(b) District Engineer, U.S. Army Engineer Dist., Buffalo, Corps of Engineers, Buffalo, N. Y.
(d) Experimental; for design.
(e) The hydraulic investigation of the Niagara Remedial Works was conducted on an existing model, scales of 1:360 horizontally and 1:60 vertically, used previously to study the preservation and enhancement of the scenic spectacle of Niagara Falls. The purpose of the study was to determine the adequacy of the control dam as built to maintain desired water-surface elevations in Chippawa-Grass Island pool under various conditions of diversions for power.
(f) Tests completed.
(g) An additional length of control dam will be required to satisfy all anticipated conditions.
(h) Preparation of report in progress.

(3581) MODEL STUDY OF LAKE PONTCHARTRAIN, LA.

(b) District Engineer, U.S. Army Engineer Dist., New Orleans, Corps of Engineers, New Orleans, Louisiana.
(d) Experimental; for design.
(e) The investigation will be conducted in a fixed-bed model that will reproduce to scales of 1:2,000 horizontally and 1:100 vertically, Mississippi Sound west of Grand Island, and Lakes Borgne, Pontchartrain, and Maurepas, together with significant tributaries. The model will reproduce the tides, tidal currents, salinities, and fresh-water discharges of the prototype. The purpose of the study is to determine the effect of proposed hurricane structures across the connections between Lake Borgne and Lake Pontchartrain upon the hydraulic and salinity regimens of the area landward from the structures.

(3582) ARKANSAS RIVER CHANNEL MODEL.

(b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.
(d) Experimental; for design.
(e) The Arkansas River project has as one of its major aims the development of river navigation from the Mississippi River to the general area of Tulsa, Oklahoma. The Arkansas River channel model is of the movable-bed type with a horizontal scale of 1:150 and a vertical scale of 1:36 and reproduces the Arkansas River between miles 140.0 and 151.2. The model study constitutes an idealized experimental approach to the solution of sedimentation problems involved in the canalization of the Arkansas River and is designed to investigate problems typical of and to provide results generally applicable to the various reaches of the over-all length of the river to be developed for navigation.

(3583) MODEL STUDIES OF CARLYLE DAM, KASKASKIA RIVER, ILLINOIS.

(b) District Engineer, U.S. Army Engineer District, St. Louis, Corps of Engineers, St. Louis, Missouri.
(d) Experimental; for design.
(e) A 1:36 comprehensive model is being used to verify the spillway and stilling basin performance; to determine the best alignment for the approach channel and training walls, the best schedule of gate operation, optimum stilling basin design, and an acceptable downstream training wall design; and to furnish pressure profiles for stability analysis. The model reproduces the structure (less sluices), approximately 1,650 feet of approach channel, and 950 feet of exit channel.
(g) Several designs have been tested in an effort to obtain the optimum approach conditions. The ogee spillway crest design has been established, and a recommended gate operating schedule has been submitted which includes a means of passing drift accumulations. The stilling basin is currently under study to determine apron elevation and baffle pier height. A revised design for the stilling basin training walls has been established through the model tests.

(3584) MODEL STUDY OF RED ROCK DAM, DES MOINES RIVER, IOWA.

(b) District Engineer, U.S. Army Engineer District, Rock Island, Corps of Engineers, Rock Island, Illinois.
(d) Experimental; for design.
(e) A 1:50 model, reproducing 900 feet of the approach channel above the spillway, an 825-foot-wide section along the dam, the spillway, conduits, stilling basin, and 575 feet of the outlet channel is being used to verify stilling basin and training wall design. The model reproduces the entire spillway and stilling basin, sufficient approach area to assure natural flow conditions over the spillway and at the abutments, and sufficient exit area to permit formation of the natural flow pattern in the exit channel.
(g) The spillway design discharge was passed at a head of 57 feet with square abutments. Rounding the abutments (radius 7.8 feet) lowered the head to 55 feet at the spillway design discharge, 331,500 cubic feet per second. Bottom-velocity measurements in the upper approach indicated that the embankment near the abutments will be exposed to bottom velocities of about 9 feet per second, thus indicating the need for riprap protection.

(3585) MODEL STUDY OF NEW POE LOCK, ST. MARYS RIVER.

(b) District Engineer, U.S. Army Engineer District, Buffalo, Corps of Engineers, Buffalo, New York.
(d) Experimental; for design.
(e) A 1:25 preliminary culvert and single lateral model was used to test flow distribution within the lateral under various operating conditions. The major investigations are being conducted in a 1:25 comprehensive model reproducing 600 feet of upstream approach, intake manifolds, 1,000 feet of lock chamber, culverts, bottom lateral outlet manifolds, and 300 feet of downstream approach. This model includes provision for changing the arrangement of bottom laterals, lock length, culvert height, and culvert valve operating schedules, and is being used to confirm the suitability of the initial design hydraulic filling and emptying system or to develop, if possible, improvements in the system. A 1:12 culvert valve model is being used to study proposed valve design.
(g) Tests in the preliminary model established the best lateral design. Tests in the general model have established the best lateral arrangement and valve schedules for filling and emptying the lock. Satisfactory flow distribution through the intakes has been obtained in the general model, but vortex conditions in the approach channel have not been completely eliminated. A

revised intake manifold with two additional ports (total of eight ports in each wall) is being investigated in an attempt to reduce or eliminate vortex tendencies. A satisfactory vertically framed culvert tainter valve design was developed in the valve model studies.

(3586) MODEL STUDY OF HOPPER DRAGHEAD.

(b) District Engineer, U.S. Army Engineer District, Philadelphia, Corps of Engineers, Philadelphia, Pennsylvania.
(d) Experimental; for design.
(e) To develop improved dragheads designed to attain a greater rate of intake of solids when dredging mud and silt mixtures (soft materials) and dredging densely packed, fine sand (hard material), and investigation is being conducted in an 80- by 10-foot flume containing various types of bed material. The draghead and suction line, constructed to a scale of 1:6, are connected to a suction pump mounted on a double carriage that provides travel, both longitudinally and transversely, along the top of the flume.

(3587) MODEL STUDIES OF JOHN REDMOND DAM, GRAND RIVER, KANSAS.

(b) District Engineer, U.S. Army Engineer District, Tulsa, Corps of Engineers, Tulsa, Oklahoma.
(d) Experimental; for design.
(e) A 1:100 model, reproducing 2,900 feet of the approach channel above the spillway, stilling basin, and 2,450 feet of the outlet channel, and a 1:36 model, reproducing one full bay and two half bays of the spillway and the stilling basin, are being used to study flow conditions in the shallow, curved spillway approach channel; to verify capacity of the structure and adequacy of the stilling basin and exit channel; and to determine minimum requirements for training walls.
(g) The spillway design discharge, 577,000 cubic feet per second, was passed at a head of 44 feet, 2.5 feet higher than the computed value. The upper pool elevation was lowered 0.5 foot at the design discharge by rounding the abutments. A rock dike in the right embankment reduced the upper port another 0.5 foot by reducing the lateral flow at the right abutment.

(3588) MODEL STUDY OF SPILLWAY, BIG BEND RESERVOIR, MISSOURI RIVER, SOUTH DAKOTA.

(b) District Engineer, U.S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Nebraska.
(d) Experimental; for design.
(e) A 1:60 model, reproducing 2,400 feet of the approach channel, the spillway and stilling basin, and 1,000 feet of the exit channel will be used to determine: (1) velocity and flow characteristics in the approach channel; (2) spillway discharge rating data with emphasis on the effects of weir submergence; and (3) stilling basin behavior and exit channel velocity and scour data.

(3589) MODEL STUDY OF SPILLWAY, PIKE ISLAND DAM, OHIO RIVER, WEST VIRGINIA, OHIO.

(b) District Engineer, U.S. Army Engineer District, Omaha, Corps of Engineers, Omaha, Nebraska.
(d) Experimental; for design.
(e) A 1:25 section model reproducing 300 feet of the approach area, a portion of the spillway crest and stilling basin, and 600 feet of the exit area is being used to examine the hydraulic performance of the spillway and stilling basin.
(g) Stilling basin tests revealed unsatisfactory basin action for certain baffle pier locations. For satisfactory basin action with 6-foot baffles, the baffles had to be a minimum of 42 feet from the spillway toe. The use of 4-foot baffles required a distance of 37 feet from the spillway toe. Bottom velocities in the exit area below the stilling basin did not exceed 7 feet per second for normal tailwater conditions.

(3590) MODEL STUDY OF WAVE ACTION, EAST PASSAGE, NARRAGANSETT BAY, RHODE ISLAND.

(b) Division Engineer, U.S. Army Engineer Div., New England, Corps of Engineers, Waltham, Massachusetts.
(d) Experimental; for design.
(e) A 1:150 model will be used to determine the effects of hurricane surge currents, waves, and winds on the operation of an aircraft carrier in East Passage. A barrier across East Passage has been proposed to limit quantity of water entering Narragansett Bay from hurricane surge, and model study will examine ship navigation conditions with respect to barrier location and its navigation opening.

(3591) MODEL STUDY OF EVERETT DAM, PISCATAQUA RIVER, NEW HAMPSHIRE.

(b) Division Engineer, U.S. Army Engineer Div., New England, Corps of Engineers, Waltham, Massachusetts.
(d) Experimental; for design.
(e) The investigation is being conducted in a 1:36 model that reproduces 350 feet of the approach channel above the spillway, entire spillway width plus 125 feet of the dam on each side, and 700 feet of the discharge channel. The spillway is an uncontrolled ogee weir with a crest length of 180 feet. To eliminate excessive rock excavation the weir bucket inverts have been stepped down, varying from elevation 412 to elevation 385. The four different toe elevations below the spillway and the various slopes in the upstream portion of the channel make prediction of flow conditions uncertain.
(g) Very close agreement between model and computed rating curves was obtained. Tests at the spillway design discharge indicate the bridge abutment seats and bridge pier on the crest may need raising. No objectionable waves formed in the discharge channel.

(3592) MODEL STUDY OF TYPICAL NAVIGATION DAM, ARKANSAS RIVER.

(b) District Engineer, U.S. Army Engineer District, Little Rock, Corps of Engineers, Little Rock, Arkansas.
(d) Experimental; for design.
(e) The Arkansas River multipurpose project includes the development of river navigation from the Mississippi River to the general area of Tulsa. Present plans for navigation include construction of several navigation locks and dams. The purposes of the model study are to investigate various problems that occur in the vicinity of the structures. The investigation is being conducted initially on a movable-bed model constructed to linear scales of 1:120 horizontally and 1:40 vertically, reproducing a 15-mile reach of a typical stream having characteristics generally similar to reaches of the Arkansas River, including a typical Arkansas River lock and dam structure. Provisions have been made for modifications to reproduce other selected reaches of similar length but different curvatures. The model of each reach studied on the movable-bed model will be converted to a fixed-bed, 1:120 model to study navigation conditions in the approaches to the locks.

(3593) MODEL STUDY OF SPILLWAY, MAXWELL DAM, MONONGAHELA RIVER, PENNSYLVANIA.

(b) District Engineer, U.S. Army Engineer District, Pittsburgh, Corps of Engineers, Pittsburgh, Pennsylvania.
(d) Experimental; for design.
(e) A 1:25 section model reproducing 200 feet of the approach channel, a portion of the spillway crest and stilling basin, and 300 feet of the exit area was used to examine the hydraulic performance of the spillway weir and stilling basin. A second phase of the study consisted of determining the most efficient and economical stilling basin below Opekiska Dam, a structure similar to Maxwell.
(f) Tests completed.
(g) Tests indicated that a stilling basin consisting of a horizontal apron 16.8 feet long with a 4-foot dentated end sill performed the most satisfactorily for both Maxwell and Opekiska structures. Maximum bottom velocities in the exit below basin did not exceed 7 feet per second for normal tailwater conditions with all spillway gates operating.
(h) Final report in preparation.

(3594) MODEL STUDY OF RIPRAP REQUIREMENTS FOR R.R. RELOCATION FILLS, ICE HARBOR DAM AND JOHN DAY DAM PROJECTS, WASHINGTON AND OREGON.

(b) District Engineer, U.S. Army Engineer District, Walla Walla, Corps of Engineers, Walla Walla, Washington.
(d) Experimental; for design.
(e) Tests are being conducted in a 5-foot-wide, 4-foot-deep, and 119-foot-long wave flume, using a linear scale of 1:12, model to prototype, to determine the stability of graded riprap, gravel, and rock fill as cover-layer materials for protection of railroad relocation fills. The stability of the different types of cover-layer materials is being determined as a function of depth below still-water level, slope of fill, depth of water, and wave period.
(g) The results of stability tests on three different gradations of riprap material are represented with very good accuracy by the formula

$$W_{50} = \frac{\gamma_r H^3}{K_\Delta (S_r - 1)^3 \cot \alpha}$$

Where W_{50} is weight of riprap (50 percent finer than), γ_r is the specific weight of riprap material, H is height of selected design wave, S_r is the specific gravity of riprap relative to the fluid in which the structure is located (γ_r/γ_w), α is the angle of the fill slope, and K_Δ is a dimensionless coefficient. The weights of materials underlying the riprap should be at least 1/20 of the weights of the riprap.

(3595) MODEL STUDY OF RUBBLE-MOUND BREAKWATER, NAWILIWILI HARBOR, KAUAI, HAWAII.

(b) District Engineer, U.S. Army Engineer District, Honolulu, Corps of Engineers, Honolulu, Hawaii.
(d) Experimental; for design.
(e) Tests were conducted in a flume 119 feet long, 5 feet wide, and 4 feet deep using a linear scale of 1:55.5 to obtain data from which competitive designs could be prepared for repair of the damaged breakwater. Models of proposed designs were constructed of concrete, sized rock representing quarrystones, and molded tetrapods and tribars. Waves were generated by a plunger-type wave machine and measured and recorded electrically. The stability of the various designs was determined for the no-damage condition with overtopping of the structure, and with waves breaking directly on the breakwater slope and crown.
(f) Completed.
(g) Tests showed that it was not feasible to repair the damaged breakwater with quarrystones available at Nawiliwili; sections constructed of either tribars or tetrapods would provide a stable breakwater. Sections constructed of tribars would be more economical than similar sections of tetrapods. Because the height of the breakwater crown is low compared with the design-wave height, it will be necessary to protect the crown from overtopping waves with a concrete cap. The seaward face of the concrete cap should be vertical to prevent waves from washing armor units over the crest of the breakwater.
(h) "Designs for Rubble-Mound Breakwater Repairs, Nawiliwili Harbor, Nawiliwili, Hawaii; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment

Station Technical Report is in publication. (Will be available on loan.)

(3596) HYDRAULIC STUDIES FOR IMPACT ENERGY DISSIPATOR DESIGN.

(b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
(d) Experimental; applied research.
(e) A general investigation to determine the energy loss coefficient of an impact energy dissipator of variable height and diameter for varying slopes, diameters, and energy of flows of the upstream conduit will be conducted on a 1.0-foot-diameter impact energy dissipator. The energy of the influx will be determined from measurements of the discharge and the hydraulic gradient. Velocity traverses across the exit of the dissipator will be measured to determine the energy content of the efflux. The slope and size of the incoming pipe will be varied to determine the effect of each upon the energy dissipated. For a particular slope and diameter of the incoming pipe and a particular height and depth of the dissipator, the relative energy content of the efflux to the influx will be determined for a range of Reynolds numbers from 1×10^4 to 2×10^6 or greater to determine the effect of Reynolds number upon the energy loss in the dissipator.

(3597) CORRUGATED PIPE ROUGHNESS STUDY.

(b) Office of the Chief of Engineers, Department of the Army, and Bureau of Public Roads, Dept. of Commerce, Washington, D. C.
(d) Experimental; applied research.
(e) This is a general investigation to determine a resistance coefficient and the law of velocity distribution for flow in structural plate corrugated pipe. A fiber-glass test section reproducing standard corrugations at a scale of 1:4 was tested in order to obtain additional data on the resistance coefficient and velocity distribution and to correlate model work with full-scale tests. Fiber-glass test sections reproducing structural plate corrugations at scales of 1:4, 1:8, and 1:16 will be tested to determine the effect of relative roughness upon the resistance coefficient and the velocity distribution. Each of the four test sections will have a diameter between the crests of the corrugations of 15 inches and a length of 125 feet. The hydraulic gradient and the energy loss through a 70-foot length of the test section will be established by piezometers located at 5-foot intervals. These piezometers will be 1/8-inch in diameter, on center of the crests of the corrugations, and four in number around the periphery of the pipe. Vertical velocity traverses will be made by means of calibrated pitot tubes at locations of 50, 75, and 100 feet below the entry to the test section for determination of the velocity distribution.
(g) Tests conducted on the model reproducing standard corrugations at a scale of 1:4 have been completed and the results of tests for a range of Reynolds number from 4×10^4 to 2×10^6 agree favorably with results of full-scale studies made at Bonneville Hydraulic Laboratory.

(3598) MODEL STUDIES OF CONTAMINATION DISPERSION IN ESTUARIES.

(b) Nuclear Projects Office, Maritime Administration, U.S. Department of Commerce.
(d) Experimental; applied research.
(e) The increasing use of nuclear reactors in the production of automotive power, both on land and sea, presents new problems pertaining to the dispersal of radioactive waste released either accidentally or purposely into rivers, estuaries, and harbors. The Maritime Administration is concerned with the probable dispersion patterns of radioactive matter that might be released in accidents involving nuclear-powered ships. A series of tests was undertaken on several existing models of important estuaries, including the Delaware River, Narragansett Bay, New York Harbor, and Savannah Harbor, in order to obtain data from which dispersion effects could be computed. Tides, tidal currents, salinities, and fresh-water flow were reproduced for all tests. Methylene blue chloride dye was used to simulate contamination, and the dye releases were generally made at the most adverse time of tide in relation to the potential upstream spread of the contaminant. Water samples were obtained periodically throughout the contaminated area for spectrophotometer analysis, and in addition, meters which automatically measured and recorded dye concentrations were in continuous operation at strategic locations. Results obtained are expressed as percentages of the initial concentration.
(g) Tests in the Delaware River, Narragansett Bay, and New York Harbor models have been completed, and the results of the Delaware River and Narragansett Bay tests are presented in reports listed below. The reports contain descriptions of test procedures and techniques, and tables and plates presenting the data obtained. Analyses of data will be made and conclusions drawn by Dr. D.W. Pritchard of Johns Hopkins Univ.
(h) "Contamination Dispersion in Estuaries; Report 1, Delaware River; Hydraulic Model Investigation," and "Contamination Dispersion in Estuaries; Report 2, Narragansett Bay; Hydraulic Model Investigation," U.S. Army Engineer Waterways Experiment Station Miscellaneous Paper No. 2-332, April 1959. (Available on loan.)

U.S. DEPARTMENT OF COMMERCE, BUREAU OF PUBLIC ROADS.

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

Cooperative with Johns Hopkins University. See page 41.

(1074) HYDRAULICS OF STILLING BASINS.

Cooperative with Colorado State University. See page 16.

(1591) DETERMINATION OF WATERWAY AREAS.

Cooperative with University of Illinois. See page 32.

(1945) ESTIMATING RAINFALL INTENSITY FROM TOPOGRAPHIC PARAMETERS.

Cooperative with Stanford University. See page 70.

(2066) STUDY OF OPEN CHANNEL CONSTRICTIONS IN A SLOPING FLUME.

Cooperative with Colorado State University. See page 16.

(2435) HYDRAULICS OF PIPE CULVERTS.

Cooperative with National Bureau of Standards. See page 144.

(2604) FULL-SCALE TEST OF CONCRETE PIPE.

Cooperative with St. Anthony Falls Hydraulic Laboratory. See page 66.

(2767) EDUCATIONAL FILMS ON OPEN CHANNEL FLOW.

Cooperative with Colorado State University. See page 19.

(2839) HYDRAULICS OF RIVER FLOW UNDER ARCH BRIDGES.

Cooperative with Purdue Univ. See page 62.

(3040) STUDY OF SPUR DIKES FOR HIGHWAY BRIDGE OPENINGS.

Cooperative with Colorado State University. See page 21.

(3041) MAGNITUDE AND FREQUENCY OF FLOODS FROM SMALL WATERSHEDS IN ARID AND SEMI-ARID AREAS.

Cooperative with Colorado State University. See page 21.

(3166) HYDRODYNAMICS OF FLOW INTO CURB INLETS.

Cooperative with Stanford University. See page 71.

(3597) CORRUGATED PIPE ROUGHNESS STUDY.

Cooperative with the Waterways Experiment Station. See page 143.

U. S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, Fluid Mechanics Section.

Inquiries concerning the following projects should be addressed to the Chief, Fluid Mechanics Section, National Bureau of Standards, Washington 25, D. C.

(159) MODEL LAWS FOR DENSITY CURRENTS.

(b) Waterways Experiment Station, Corps of Engineers, Department of the Army.
(d) Theoretical and experimental; basic and applied research.
(e) To determine model laws for models involving the motion of stratified liquids. The two major problems are (1) the motion of a heavy liquid initially confined in a "lock" when released into a long channel containing a stationary lighter liquid, and (2) the motion of a heavy liquid from a "sea" into a long channel with either still or flowing lighter liquid.
(h) "Mixing Effect of Wind Induced Waves," by Garbis H. Keulegan, NBS Report No. 6638, January 18, 1960.

(1478) WIND WAVES.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental and theoretical; basic research.
(e) Includes mathematical and experimental studies of (1) wind tides (setup), (2) growth of wind waves, and (3) surface traction of wind on wavy surfaces.

(2435) HYDRAULICS OF PIPE CULVERTS.

(b) Bureau of Public Roads.
(d) Experimental; applied research.
(e) To determine hydraulic characteristics of various types of culvert entrances and to develop inlets of improved design.

(2436) FLOW OVER HYDROPHOBIC MATERIALS.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental; applied research.
(e) To determine augmented dissipation of hydrophobic disks and plates oscillated in various fluids.
(h) "Energy Dissipation in Standing Waves in Rectangular Basins," by G. H. Keulegan, Jour. of Fluid Mechanics, Vol. 6, No. 1, July 1959.

(3250) INERTIAL FORCES IN UNSTEADY FLOW.

(b) Office of Naval Research, Dept. of the Navy.
(d) Experimental; basic research.
(e) Determination of inertia and drag coefficients of cylinders and plates when subjected to a varying monotonically varying flow.
(h) "Separation and Scaling of Inertial and Viscous Forces in Periodic Flows," by Gershon Kulin. Paper presented July 1, 1959, Amer. Soc. of Civil Engineers, Colo. State University, Fort Collins, Colorado.

(3599) MOTION OF CYLINDERS IN STRATIFIED LAYERS.

(b) Office of Naval Research, Dept. of the Navy.
(d) Theoretical and experimental; basic and applied research.
(e) A study is made of the internal waves produced by the horizontal motion of a cylinder through the liquid. Experiments are made with two liquid layers of different

densities and with a liquid with linear density gradient. In the latter case the surface disturbance is also examined.

(h) "Disturbances Due to the Motion of a Cylinder in a Two-Layer Liquid System," L. H. Carpenter and G.H. Keulegan, NBS Report 6622, January 4, 1960.

(3600) DAMPING OF PROGRESSIVE OSCILLATORY INTERNAL WAVES.

(b) Office of Naval Research, Dept. of the Navy.
(d) Theoretical and experimental; basic and applied research.
(e) A study is being made of the velocity and damping of internal progressive oscillatory waves of a two-layer system.

DEPARTMENT OF COMMERCE, U. S. WEATHER BUREAU.

Inquiries concerning the following projects, except as indicated, should be addressed to Mr. Willian E. Hiatt, Chief, Hydrologic Services Division, U. S. Weather Bureau, Washington 25, D. C.

(1015) MEASUREMENT OF EVAPORATION.

(b) Laboratory project.
(d) Theoretical and field investigation; applied research.
(e) Studies are directed toward the derivations of reliable procedures for estimating evaporation from reservoirs (existing and proposed) and land surfaces, utilizing readily available meteorological data and pan evaporation observations.
(g) An evaporation atlas for the United States has been published in Weather Bureau Tech. Paper No. 37, "Evaporation Maps for the United States." The following series of maps with brief text are presented: Plate 1 - Average Annual Class A Pan Evaporation; Plate 2 - Average Annual Lake Evaporation; Plate 3 - Average Annual Class A Pan Coefficient; Plate 4 - Average May-October Evaporation in Percent of Annual; Plate 5 - Standard Deviation of Annual Class A Pan Evaporation.
Evaporation studies are being continued at the Silver Hill Observatory, Md. The data are being analyzed for preparation of a report covering studies to date.
An evapo-transpiration study is being conducted to test a basin accounting method for estimating soil-moisture deficiency. The soil-moisture deficiency in the studies to date shows promise as an improved index of antecedent soil condition for use in rainfall-runoff relations.
(h) "Salton Sea Evaporation Study," by W. W. Lamoreux, U. S. Weather Bureau manuscript.

(1744) DEVELOPMENT OF RIVER FORECASTING METHODS.

(b) River Forecast Centers for: Ohio River Basin, Cincinnati, Ohio; Susquehanna and Delaware River Basins, Harrisburg, Pa.; Lower Missouri River Basin, Kansas City, Mo.; Columbia River Basin, Portland, Oregon; Middle and Upper Mississippi River Basin, St. Louis, Mo.; Arkansas and Red River Basins, Tulsa Okla.; New England and Hudson River Basins, Hartford, Conn.; South Atlantic and East Gulf River Basins, Augusta, Ga.; and Middle Atlantic River Basins, Washington, D. C.
(d) Theoretical and field investigation; operation and applied research.
(e) The purpose of these investigations is to develop modern river forecast procedures for all ranges of flow for various streams of each basin. Procedures include: (1) rainfall-runoff relations involving consideration of the physics of soil moisture, vegetative reception, transpiration, evaporation and geological features of the basins; (2) snowmelt forecasting relations involving consideration of the physics of snow and heat transfer; (3) unit hydrographs; and (4) streamflow routing procedures, based upon adaptations of basic hydraulic principles, using electronic or mechanical analogues.
(g) Forecasting procedures have been developed for key points; refinement of these procedures and development for other basins are under way.

(1745) WATER SUPPLY FORECASTS FOR WESTERN UNITED STATES.

(b) Work being conducted in following field offices: River Forecast Center, Portland, Oregon; Water Supply Forecast Unit, Salt Lake City, Utah; River Forecast Center, Kansas City, Mo.; and Weather Bureau Office, Sacramento, California.
(d) Theoretical and field investigation; operation and applied research.
(e) The purpose of these investigations is the development of precipitation-runoff relations for water supply forecasting utilizing statistical methods to correlate precipitation during the winter with runoff during the melting season.
(g) Water Supply Forecasts are prepared for about 350 points in the Western United States. These forecasts of water-year and residual flow are released in Monthly Water Supply Forecast Bulletins, January through May. This research program is of a continuing nature designed to improve and extend the present forecasting service.
(h) "Evaluating the Utility of Water Supply Forecasts," M. A. Kohler, Proceedings of the Western Snow Conference, April 21-23, 1959, Reno, Nevada.

(1751) MAXIMUM STATION PRECIPITATION.

(b) Corps of Engineers, Dept. of the Army.
(d) Analysis of data.
(e) Tabulations of maximum recorded 1-, 2-, 3-, 6-, 12-, and 24-hour precipitation, for automatic recording rain-gage stations, by states.
(h) Twenty-three states completed and published as parts of Weather Bureau Tech. Paper No. 15; Arkansas and Oklahoma in process.

(2437) UNITED STATES STORM CHARACTERISTICS PROJECT.

(b) Soil Conservation Service, Department of Agriculture.
(d) Theoretical and field investigation; applied research and design.
(e) Studies to provide rainfall data for design criteria in estimating required capacities of hydraulic structures. Work includes: (1) development of a generalized relationship between depth, area, duration and frequency for areas up to 400 square miles, durations of 20 minutes to 24 hours, and return periods from 1 to 100 years; (2) development of a generalized portrayal of the probable maximum precipitation for areas up to 400 square miles, and durations up to 24 hours in the United States west of longitude 105; and (3) combination of (1) and (2) for Puerto Rico.
(h) "Generalized Estimates of Probable Maximum Precipitation for the United States West of 105th Meridian for Areas Up to 400 Square Miles and for Durations Up to 24 Hours," U.S. Weather Bureau Tech. Paper No. 38.

(2438) STORM TIDE PREDICTIONS.

(b) Laboratory projects.
(c) Mr. D. Lee Harris, Scientific Services Division, U.S. Weather Bureau, Washington 25, D. C.
(d) Theoretical and field investigation; basic and applied research.
(e) The differences between the observed and predicted tides during storms are being studied with the goal of improving the accuracy of storm tide forecasting.
(g) Empirical methods of forecasting these inundations are being developed and used in the Weather Bureau's hurricane and storm warning service. Continued improvement in these forecasts is expected to result from this research.
(h) "Meteorological Aspects of Storm Surge Generation," by D. Lee Harris, Journal of the Hydraulics Div., Proceedings of the American Society of Civil Engineers, Paper 1859, December 1958.
"An Interim Hurricane Storm Surge Forecasting Guide," by D. Lee Harris, National Hurricane Research Project Report No. 32, USWB, Washington 25, D. C.

(2441) HURRICANE RAINFALL AND ITS QUANTITATIVE FORECASTING.

(b) Corps of Engineers, Department of the Army.
(d) Theoretical and field investigation; applied research and design.
(e) Collection, analysis, and effective presentation of existing data on hurricane rainfall and development of methods of forecasting the intensity and quantity of rainfall from future hurricanes for design of protective works, planning of evacuation procedures, etc.

(2442) HURRICANE WIND ANALYSIS.

(b) Corps of Engineers, Department of the Army.
(d) Theoretical and field investigation; applied research and design.
(e) Development of methods for obtaining detailed wind speeds and directions in hurricanes just above the sea-surface indirectly from available data, which is mostly on land. Also construction by indirect means of detailed analyses of the winds over specific areas of the sea where the energy of the wind develops waves and tides damaging to specific coastal areas.
(h) "Meteorological Considerations Pertinent to Standard Project Hurricane, Atlantic and Gulf Coast of United States," U.S. Weather Bureau - National Hurricane Research Project series No. 33.

(2443) RADAR-RAINFALL PROJECT.

(b) Laboratory project in cooperation with Univ. of Miami, Coral Gables, Florida and Texas A and M College, College Station, Tex.
(d) Experimental operation.
(e) Integration of the instantaneous PPI scope image over time by photographic process to provide a pattern of accumulated rainfall over an area that can be calibrated with key rainfall observations for the period of integration. To be used in flood forecasting with other radar intelligence.
(f) Completed.
(g) Various photographic processes developed currently undergoing operational tests.

(2943) RADAR BEACON FOR REPORTING RAINFALL.

(b) Laboratory project.
(d) Experimental; development.
(e) A compact device capable of being installed in relatively remote areas within line of sight of a radar. Activated by a tipping bucket rain gage and pulse signal from the radar, instrument transmits delayed pulse which appears on radarscope indicating accumulated amounts of precipitation. Additional investigations underway for applying beacon principle to the reporting of river and tide stage, and radioactive snow water equivalent gage.
(g) Initial field installation now operational, additional beacons being built.
(h) "The Use of a Radar Beacon for Telemetering Precipitation Data," by D.R. Soltow and R.D. Tarble, Journal of Geophysical Research, November 1959.

(2944) PROBABLE MAXIMUM PRECIPITATION OVER CALIF. BASINS.

(b) Corps of Engineers, Department of the Army.
(d) Design and applied research.
(e) Estimate of probable maximum precipitation over basins in California based on simple model of wind flow up orographic slopes, checked against December 1955 flood-producing storm, combined with non-orographic storm precipitation.
(g) Estimates furnished sponsor. Methods being refined.

(2945) MECHANICAL FLOOD ROUTING ANALOGUE.

(b) Laboratory project.
(d) Field investigation; operation and applied research.

(e) A mechanical analogue has been developed which will solve flood routing based on a variable lag and variable storage factor (K). The analogue can be operated by one person and the size is such that it can be placed on a desk.
(g) The pilot model has been constructed and will be tested thoroughly in order to determine refinements necessary.

(3251) RAINFALL DISTRIBUTION AS DETERMINED BY RADAR.

(b) U. S. Geological Survey.
(d) Experimental; applied research.
(e) Using time-lapse film of the radar PPI scope, various methods of determining the areal distribution of rainfall intensity are being tested. A 50-square-mile basin, heavily instrumented with recording rain gages, is used as a control basin. To be used for flood forecasting and storm studies.
(f) Inactive, awaiting data from improved weather search radar being installed in test area.

(3601) STUDY OF TECHNIQUES FOR MEASURING RAINFALL BY REFERENCE TO RADAR ATTENUATION.

(b) Laboratory project in cooperation with Stanford Research Institute.
(d) Experimental; development.
(e) By measuring the attenuation of short wave length radar energy over a fixed course and relating it to the measured precipitation along the path of the radar beam, it is hoped that a relationship can be established which will enable a relatively simple instrument to be developed which can monitor areas above damsites and headwaters of streams to alert downstream interests of heavy rainfall.

(3602) EXTENSION OF RATING CURVES.

(b) Laboratory project.
(d) Theoretical and field investigation; operation and applied research.
(e) The flood forecasting procedures used by the Weather Bureau are primarily based on discharge. However, the flood warnings to be of any value must be in terms of stage (or elevation). This is accomplished by use of U.S. Geological Survey rating curves relating discharge to stage. Rating curves are defined only to the maximum observed stage of record. Therefore, it is imperative to devise a reliable method of extending rating curves in order to issue accurate stage predictions for the record breaking flood.
(g) This study has just been started.

U.S. DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY.

(690) DISCHARGE THROUGH MULTIPLE OPENINGS.

(b) Laboratory project.
(c) Mr. H. J. Tracy, U.S. Geological Survey, Atlanta, Georgia.
(d) Experimental; applied research.
(e) Laboratory studies to define the distribution of flow through multiple bridge openings with any given natural distribution and varied number, size, and location of openings.
(g) Laboratory tests and analyses completed; report in preparation.

(1221) STEADY STATE ELECTRIC FLOW NET MODELS.

(b) Laboratory project.
(c) Mr. R.R. Bennett, U.S. Geological Survey, Washington 25, D. C.
(d) Applied research.
(e) Preparation of electric flow net models using graphite paper, conductive paints, etc. Includes design and construction of a variable resistor grid analogous plotter.

(1755) CHARACTERISTICS OF SAND CHANNEL STREAMS.

(b) Laboratory project.
(c) Mr. R.W. Carter, U.S. Geological Survey, Washington 25, D. C.
(d) Field investigation; applied research.
(e) Compilation and analysis of the data collected in a 1,900-foot reach of the Elkhorn River in Nebraska to evaluate bed roughness, extent of scour and fill, and sediment movement.
(h) Report in preparation.

(1764) COMBINED PHYSIOGRAPHIC AND HYDRAULIC STUDIES.

(b) Laboratory project.
(c) Dr. Luna B. Leopold, U.S. Geological Survey, Washington 25, D. C.
(d) Field and office research.
(e) Hydraulic and physiographic factors controlling overbank flow, slope, and pattern of natural river channels and flood plains.

(1995) COMPARATIVE STUDY OF SOIL MOISTURE EQUIPMENT.

(b) Laboratory project.
(c) Mr. Irwin Remson, U.S. Geological Survey, Trenton, N.J.
(d) Field investigation; applied research.
(e) A comparative study of all commercially available instruments for measuring soil moisture, possible design of new instruments.

(2444) REDESIGN OF PRICE CURRENT METER (INSTRUMENT DEVELOPMENT).

(b) Laboratory project.
(c) Mr. E.G. Barron, U.S. Geological Survey, Columbus 12, Ohio.
(d) Development.
(e) To design a vane-type rotor for the Price current meter that can be mass-produced with identical rating calibration and be affected little or not at all by vertical velocity components and proximity to the water surface.
(g) Fifty identical rotors are under test.

(2687) AQUIFER ANALYTICAL METHODS.

(b) Laboratory project.

(c) Mr. R. H. Brown, U. S. Geological Survey, Washington, D. C.
(d) Analytical; applied research.
(e) To develop more versatile and comprehen - sive methods of determining and evaluating aquifer and ground-water reservoir hydrologic characteristics.
(f) Suspended.

(2688) MECHANICS OF AQUIFERS.

(b) Laboratory project.
(c) Mr. J. F. Poland, U.S. Geological Survey, Sacramento, California.
(d) Field investigation; basic and applied research.
(e) To determine the principles and factors involved in the strain, deformation, and compaction of water-bearing rocks resulting chiefly from changes in hydrologic environment.

(2689) DIFFUSIONAL PROCESSES AND HYDRODYNAMICS OF SALT-FRESH WATER INTERFACE IN AQUIFERS.

(b) Laboratory project.
(c) Mr. H. H. Cooper, U.S. Geological Survey, Tallahassee, Florida.
(d) Field and laboratory investigation; basic and applied research.
(e) To determine the factors affecting the distribution of salt water in coastal aquifers subject to salt water encroachment.

(2690) MICROSCOPIC FLOW THROUGH POROUS MEDIA.

(b) Laboratory project.
(c) Mr. E. S. Simpson, U.S. Geological Survey, Mineola, Long Island, New York.
(d) Laboratory investigation; basic research.
(e) To determine the factors affecting the pattern of microscopic flow of water and other liquids through porous media.
(h) Report being reviewed.

(2692) ANALOGUE COMPUTER FOR ANALYSIS OF GROUND-WATER FLOW SYSTEMS.

(b) Laboratory project.
(c) Mr. H.E. Skibitzke, U.S. Geological Survey, Tucson, Arizona.
(d) Theoretical study and instrument development.
(e) Development of the physical and mathematical theory of ground-water flow systems and construction of an analogue computer for analyzing ground-water flow systems under transient conditions.
(g) Function generators being developed.

(2694) FLOW OF WATER OVER WEIRS AND SPILLWAYS.

(b) Laboratory project.
(c) Prof. C. E. Kindsvater, Georgia Institute of Technology, Atlanta, Georgia.
(d) Library search, re-analysis and correlation of published data, plus some original research.
(e) A comprehensive study of the discharge characteristics of practical forms of weirs and spillways. Objectives include the publication, in generalized form, of available experimental data.
(h) Final report in preparation.

(2695) CONTINUOUS DISCHARGE RECORDS IN TIDAL STREAMS.

(b) Laboratory project.
(c) Mr. John Shen, U. S. Geological Survey, Washington 25, D. C.
(d) Theoretical and applied research.
(e) The objective of this study is to develop methods of obtaining continuous discharge records in tidal streams. Equations developed from theoretical considerations will be checked by field observations.
(g) Several sets of field data are now being used to verify the theoretical results.
(h) Report in preparation.

(2698) EVALUATION OF EFFECT OF CHANNEL STORAGE ON PEAK DISCHARGE.

(b) Laboratory project.
(c) Mr. W. D. Mitchell, U.S. Geological Survey, Champaign, Illinois.
(d) Analytical and experimental.
(e) The objective of the project is to develop parameters that describe channel storage effectively in an areal correlation of peak flow.
(h) Report in preparation.

(2699) UNIFORM FLOW IN OPEN CHANNELS.

(b) Laboratory project.
(c) Mr. H. J. Tracy, U.S. Geological Survey, Atlanta, Georgia.
(d) Theoretical and experimental; basic research.
(e) A comprehensive laboratory study of uniform flow in open channels.
(h) Initial report in preparation.

(2700) PARAMETERS CONTROLLING THE SHAPE AND PATTERN OF NATURAL STREAM CHANNELS.

(b) Laboratory project.
(c) Mr. M. G. Wolman, Dr. L.B. Brush, Jr., and Dr. L. B. Leopold, U.S. Geological Survey, Washington 25, D. C.
(d) Basic research.
(e) The effect of discharge, load, grain size, slope, and channel curvature was studied in a small channel free to adjust both bed and side walls.
(h) Reports being reviewed.

(2701) SEDIMENT TRANSPORT INVESTIGATIONS.

(b) Field project (cooperative with Bureau of Reclamation).
(c) Mr. D. M. Culvertson, U.S. Geological Survey, Lincoln, Nebraska.
(d) Field observations and theoretical analysis.
(e) Field and theoretical investigations of the methods, equipment, and computations used for determining sediment movement and the theory of sediment transport. Specifically included are studies on sampling techniques; the effect of water temperature on sediment transport; the relationship of roughness to sediment discharge, slope,

and width-to-depth ratio; the effect of Kolk action on the vertical distribution of velocity and sediment; the revaluation of Von Karman's Universal Constant of momentum exchange for sediment-laden flow; the influence of suspended sediment on vertical distribution of velocity; the influence of ice cover on sediment transport; the influence of cobble-bed streams on total sediment transport; and other related sediment transport problems.

(g) Evaluation of the equal-transit-rate (ETR) method of measuring suspended-sediment discharge indicates the method is satisfactory when properly used. Tests of a new (petrolatum-type) surface bed-material sampler give results that compare favorably with the core-type of sampler. The modified Einstein procedure is adequate for computing total load when water temperature is near freezing. In general low values of roughness are associated with low temperatures and high sediment loads on Middle Loup River at Dunning, Nebraska.

(h) "Investigations of Some Sedimentation Characteristics of a Sand-bed Stream," by D. W. Hubbell and others, open file release. One additional report completed, to be published in the near future, also ultrasonic methods for measuring dune movement and roughness.

(2702) ROUGHNESS AND WATER-SEDIMENT MOVEMENT IN ALLUVIAL CHANNELS.

(b) Laboratory project.
(c) Dr. D. B. Simons, Geological Survey, Colo. State University, Fort Collins, Colorado.
(d) Basic and applied research.
(e) A study of mechanics of flow in alluvial channels using a large recirculating laboratory flume. Based upon a laboratory study and field studies, relationships which describe flow in alluvial channels are being developed. The study has been completed for three (3) bed materials. Three additional sizes of material will be investigated during the 1960 fiscal year. Regimes of flow, forms of bed roughness, resistance to flow relations, and sediment transport relations have been developed for the three sizes of sand investigated.
(h) "A Study of Resistance to Flow in Alluvial Channels - Flume Studies Using 0.45 mm Sand," by D. B. Simons, E. V. Richardson, and M.L.Albertson, U.S. Geological Survey, Water-Supply Paper 1498-A (in process of publication).
"Theory and Design of Stable Channels," by D. B. Simons and M. L. Albertson. Paper presented at ASCE Hydraulics Division Conference, Atlanta, Georgia, August 1958.
"A Study of Resistance to Flow in Alluvial Channels," by D. B. Simons and E. V. Richardson. Paper presented at American Society of Civil Engineers Annual Convention, New York, N. Y., October 1958.
"Sediment Transport in Alluvial Channels," D. B. Simons and E. V. Richardson. Paper presented at ASCE Hydraulics Division Conference, Fort Collins, Colorado, July 1959.

(2703) EVAPORATION SUPPRESSION.

(b) Work coordinated with, and executed in cooperation with the Southwest Research Institute, Texas State Dept. of Agriculture, Texas A and M Research Foundation and U. S. Bureau of Reclamation.
(c) Mr. G. E. Koberg, U.S. Geological Survey, Denver, Colorado.
(d) Basic and applied research.
(e) Evaporation from test reservoirs, both with and without monomolecular surface films, is being measured. Laboratory tests will be made to determine the effects of monomolecular films on emissivity and reflectivity and on the vertical humidity profile.

(2947) STUDY OF AGGRADATION AND DEGRADATION IN ALLUVIAL CHANNELS.

(b) Laboratory project.
(c) Dr. Lucien M. Brush Jr., USGS, Wash. 25,D.C.
(d) Basic research.
(e) A study of channel and hydraulic parameters associated with aggradation and degradation in muddy Creek, near Baggs, Wyoming.

(2948) ANALOGUE MODEL ANALYZER FOR STEADY-STATE GROUND-WATER FLOW PROBLEMS.

(b) Laboratory project.
(c) Mr. R.W. Stallman, USGS, Washington 25, D.C.
(d) Theoretical study and instrument development.
(e) Design and development of a variable resistance grid analyzer for use in analyzing steady-state ground-water flow problems in which the transmissibility varies in space.
(g) Basic unit completed.
(h) Report in preparation.

(2949) ULTRASONIC FLOW METER.

(b) U. S. Geological Survey.
(c) Mr. R.W. Carter, USGS, Washington 25, D. C.
(d) Experimental; equipment development.
(e) The objective is to measure the mean velocity in a natural channel by accoustic means.
(g) Initial instrument is undergoing tests.

(2950) SEDIMENT TRANSPORT AND CHANNEL ROUGHNESS IN NATURAL AND ARTIFICIAL CHANNELS.

(b) Laboratory project.
(c) Mr. Thomas Maddock, Jr., U. S. Geological Survey, Washington 25, D. C.
(d) Basic research.
(e) Field and laboratory studies, original and other investigations will be analyzed in terms of sediment movement, channel roughness, shear distribution in channel prism and other effects on shape of natural channels.
(h) Report in preparation.

(3252) INTERRELATIONS OF LANDFORM MORPHOLOGY, DIRECT STREAM RUNOFF AND GROUND WATER DRAINAGE.

(b) Laboratory project.
(c) Dr. Charles W.D. Carlston, U.S. Geological

Survey, Washington 25, D. C.
(d) Basic research.
(e) Evaluation on the effects of geology on drainage density and groundwater drainage; the effects of relief on runoff characteristics; and the relations of drainage density to direct runoff and ground water drainage.
(h) Report in preparation.

(3253) CHANNEL STABILITY IN AN EPHEMERAL STREAM.

(b) Laboratory project.
(c) Dr. Luna B. Leopold, U.S. Geological Survey, Washington 25, D. C.
(d) Field investigation; basic research.
(e) In an ephemeral stream (arroyo), measurements are being made on the following: stress on rocks during a flow,movement and location of rocks after flow, extent of scour and fill, movement of bars, and changes in cross sections at certain locations.

(3254) DISPERSION IN NATURAL STREAMS.

(b) Atomic Energy Commission.
(c) Mr. R.G. Godfrey, U.S. Geological Survey, Washington 25, D. C.
(d) Field and analytical studies.
(e) To measure and relate dispersal patterns to channel geometry, fluid properties, and flow characteristics.
(g) Initial field tests completed.

(3255) ELECTROMAGNETIC FLOW METER.

(b) U.S. Geological Survey.
(c) Mr. E.G. Barron, U.S. Geological Survey, Columbus 12, Ohio.
(d) Instrumentation.
(e) To redesign, adapt, and repackage the electromagnetic flow meter currently used by the U.S. Navy to measure velocities in an open channel.
(g) First model is under construction.

(3256) EFFECT OF ROUGHNESS CONCENTRATION ON OPEN CHANNEL FLOW.

(b) Laboratory project.
(c) Mr. J.H. Koloseus, U.S. Geological Survey, Iowa City, Iowa.
(d) Analytical and experimental.
(e) To investigate the effect of bed roughness on open channel flow by increasing the concentrations of 3/16-inch cubes cemented on the flume floor.
(g) Laboratory tests in progress.

(3257) MEASUREMENT OF TOTAL SEDIMENT DISCHARGE OF COARSE SEDIMENTS.

(b) Laboratory project.
(c) Mr. D.W. Hubbell, U.S. Geological Survey, Lincoln, Nebraska.
(d) Analytical; applied research.
(e) A review of the types of equipment currently used to measure sediment moving as bed load and the preparation of a report covering criteria for sampler design and use.
(h) Progress report completed.

(3258) TRANSIENT FLOW IN A POROUS MEDIUM.

(b) Laboratory project.
(c) Mr. W.O. Smith, U.S. Geological Survey, Washington 25, D. C.
(d) Theoretical and experimental; basic research.
(e) To determine validity of Darcy's law under non-steady state conditions of flow.
(g) Laboratory apparatus completed. Measurement pbase in progress.

(3260) SOIL-MOISTURE EQUIPMENT.

(b) Laboratory project.
(c) Mr. A.I. Johnson, Chief, Hydrologic Lab., U. S. Geological Survey, Denver, Colorado.
(d) Laboratory and field investigation; applied research.
(e) Laboratory model and field comparative study of techniques and of various commercially available instruments for measuring soil moisture. New equipment may also be designed as result of study.
(g) Field and laboratory calibrations of neutron meter, tensiometers, moisture blocks and sampling equipment. Evaluation of neutron meter. Design of small-diameter fast-response tensiometer. Library research.
(h) The following report is in the process of review: "References on Soil-Moisture Measurement Under Field Conditions," by A. I. Johnson (mimeo.).

(3261) MODEL STUDY FOR SALT WATER DIFFUSION.

(b) Laboratory study.
(c) Mr. A.I. Johnson, Chief, Hydrologic Lab., U. S. Geological Survey, Denver, Colorado, or Mr. H.H. Cooper, Jr., Research Engineer, U.S. Geological Survey, Tallahassee, Florida.
(d) Experimental; applied research.
(e) Model study is being used to study diffusion at the interface between fresh and salt water. Variable movement of interface simulates effects of various amplitudes and periods of tidal action.
(g) Design and construct plastic model and conductivity-recording equipment; one test run with fine-sand size glass beads and one test run on medium-sand size glass beads completed.

(3262) SMALL-DIAMETER OBSERVATION-WELL EQUIPMENT AND TECHNIQUES.

(b) Laboratory project.
(c) Mr. A.I. Johnson, Chief, Hydrologic Lab., U.S. Geological Survey, Denver, Colorado.
(d) Laboratory and field investigation; applied research.
(e) Design and evaluate equipment for recording depth-to-water in small-diameter wells; test in model well in laboratory and on ground-water wells under field conditions.
(g) Design and construct model well; construct small-diameter observation wells in field; design and construct equipment to be adapted to water-stage recorders on small-diameter wells; evaluation on model well in progress.
(h) "Powered Float for Recording Water Levels

in Wells of Small Diameter," by F. C. Koopman and W.N. Palmquist, Water Resources Bulletin (Internal publ.).

(3263) SPECIFIC YIELD AND RELATED PROPERTIES.

(b) Cooperative with the State of California.
(c) Mr. A.I. Johnson, Chief, Hydrologic Lab., USGS, Denver, Colorado.
(d) Laboratory and field investigation; basic and applied research.
(e) Theoretical laboratory and field study of specific yield, and related properties, such as moisture equivalent, field capacity, moisture tension, relative permeability and time-drainage relationships, as related to ground-water storage. Evaluation of existing, and possible development of new, methods for determining these properties.
(g) Library research; laboratory study in progress or completed of factors affecting column drainage, centrifuge moisture equivalent, moisture tension and relative permeability.
(h) The following reports are in process of review:
"Specific Yield and Related Properties - An Annotated Bibliography, Part I," A. I. Johnson, D.A. Morris and R.C. Prill.
"Specific Yield and Related Properties - Research Progress Report, July 1, 1957 - June 30, 1958," A.I. Johnson, R.C. Prill and D.A. Morris.

(3264) SUBSURFACE EXPLORATION EQUIPMENT AND TECHNIQUES.

(b) Laboratory project.
(c) Mr. A.I. Johnson, Chief, Hydrologic Lab., USGS, Denver, Colorado.
(d) Laboratory and field investigation; applied research.
(e) Evaluate and adapt subsurface exploration equipment and techniques, such as gamma ray and electric loggers, fluid velocity and conductivity loggers, temperature loggers, power augers and core samplers, for solving ground-water occurrence problems.
(g) Portable temperature logger nearly completed; core samplers designed and commercial models procured and compared under field conditions; power augering equipment and techniques evaluated; evaluation in progress of gamma-ray, conductivity and temperature logging equipment for salt-water encroachment problems. Library research in progress.
(h) The following report is in process of review:
"References on Laboratory and Field Methods in Ground-Water Hydrology," by A.I. Johnson (mimeo.).

(3265) INVESTIGATION OF VADOSE FLOW THROUGH HOMOGENEOUS ISOTROPIC MEDIA.

(b) Laboratory project.
(c) Mr. A.I. Johnson, Chief, Hydrologic Lab., USGS, Denver, Colorado.
(d) Experimental; basic and applied research.
(e) Laboratory model study of infiltration of fluids from surface pits into a thick unsaturated zone above the water table.
(g) Model tank designed and constructed; several test runs with beads of different particle size completed; library research; test runs photographed by slide and movie.
(h) Progress report in review. Silent lapse-time movie on second and third phase of model study completed.

(3603) SURFACE FOLLOWER.

(b) Laboratory project.
(c) Mr. E.G. Barron, USGS, Columbus 12, Ohio.
(d) Instrumentation.
(e) The surface follower is designed to operate a recorder while following the level of the water in a 2-inch vertical pipe. A switch in a "float" closes either the up or down circuit which rotates a drum raising or lowering the float. A shaft input recorder is coupled to the drum.
(g) Twenty-five units are undergoing field tests.

(3604) TRANSPORT OF RADIONUCLIDES BY FLUVIAL SEDIMENT.

(b) Atomic Energy Commission.
(c) Dr. A.R. Chamberlain, U.S.Geological Survey, Colo. State Univ., Fort Collins, Colorado.
(d) Field investigation; basic research.
(e) Study of dispersion, transportation, and concentration of radionuclides by stream sediments for representative hydrologic and geologic environments.
(h) Report on present status of research in preparation.

(3605) MINERALOGY OF FLUVIAL SEDIMENTS.

(b) Atomic Energy Commission.
(c) Mr. J.D. Hem, USGS, Denver, Colorado.
(d) Laboratory and field investigations.
(e) Study of the mineralogy and cation-exchange capacity of fluvial sediments for typical hydrologic and geologic environments.

(3606) STREAM CHANNEL GEOMETRY AS RELATED TO FLOOD FREQUENCY.

(b) Laboratory project.
(c) Mr. F.A. Kilpatrick, USGS, Atlanta 8, Ga.
(d) Field and analytical studies.
(e) The study is pointed toward finding a relation between channel characteristics (bank-full stage, bed slope, etc.) and flood frequency.
(g) Twenty reaches in the Piedmont have been selected and surveyed. Floods have been observed in several of the reaches.

(3607) BATTERY OPERATED DIGITAL RECORDER.

(b) U. S. Geological Survey.
(c) Mr. E.G. Barron, USGS, Columbus 12, Ohio.
(d) Instrumentation.
(e) The objective is to develop a battery operated digital punch to record streamflow data. The punch accepts a shaft rotation input. The output is in 16 channel parallel code on paper tape.
(g) Two prototype models have been extensively tested in an environmental chamber. Eighty

production units will be field tested this year.

U. S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION.

Inquiries concerning the following projects should be addressed to Mr. Grant Bloodgood, Assistant Commissioner and Chief Engineer, Bureau of Reclamation, Denver Federal Center, Denver, Colorado.

(1502) STABLE CHANNEL STUDIES--TRACTIVE FORCES REQUIRED TO MOVE NONCOHESIVE MATERIALS.

(f) Completed.
(h) Report in preparation.

(1777) SIPHON SPILLWAY STUDIES.

(b) Laboratory project.
(d) Combined field investigation and applied research; for design.
(e) Develop an improved design for lower priming head and short priming time. Attempts will be made to design a partialization device to regulate the discharge of the siphon by means of a self-regulating air intake, thereby enabling the siphon to operate more or less continually at reduced flow rather than intermittently at full capacity.
(g) The priming head for minimum operating discharge has been reduced to 25 percent of the head required for the standard design; minimum discharge is about 20 percent of the minimum discharge for the standard design. Shape and length of a bucket on the downstream end of the barrel have been proportioned for maximum discharge coefficient. Position and angle of a deflector in the barrel has been determined.

(2455) CASA COLORADA CHANNEL ALINEMENT--MIDDLE RIO GRANDE.

(f) Completed.
(h) Report in preparation.

(2457) EROSION AND TRACTIVE FORCE STUDY OF UNLINED AND EARTH-LINED CANALS.

(f) Field data and laboratory testing completed.
(h) Report in preparation.

(2705) TRINITY DAM--MORNING-GLORY SPILLWAY.

(f) Both model studies completed.
(h) Reports in review

(2719) GLEN CANYON DAM SPILLWAY.

(b) Laboratory project.
(d) Experimental; design.
(e) The model, built to a scale of 1:63.5, includes the tunnel spillways on both sides of the river, the curved arch dam, the outlet works, the powerhouse and a section of the Colorado River upstream and downstream from the dam. The tunnel spillways are modeled in transparent plastic so that flow conditions can be thoroughly investigated. Other features being studied are the approach channels to the spillway, the discharge capacity of the spillways, the pressures throughout the spillways, the flip buckets and scour at the downstream portal of the tunnels, and the effect in the river when all structures are discharging.
(g) Alinements for the excavated spillway approach channels, tunnel transitions between the spillway crest and the inclined tunnel, new type flip buckets in new locations, and other recommended features and procedures have resulted from the studies.
(h) Report in preparation.

(2724) FRICTION FACTOR TEST IN LARGE PRESSURE CONDUITS--WEBER-COULEE SIPHON.

(f) Completed.
(h) Report in preparation. (Combined with Project No. 3275.)

(2952) WOODSTON DIVERSION DAM--GENERAL STUDIES OF HEADWORKS AND SLUICEWAY STRUCTURES.

(f) Completed.
(g) A satisfactory arrangement consisting of a combination of curved guide walls and an overhanging sill have been developed to minimize the amount of sediment entering the canal.
(h) Report in review.

(2953) STUDIES OF WIND WAVES ON CANALS.

(b) Laboratory and field project.
(d) Experimental; for design.
(e) Laboratory and field studies are being conducted to develop relationships to predict erosion produced by surface waves on canal banks.
(g) Waves have been measured on field canals, and wave characteristics have been correlated with channel characteristics, and wind velocity and direction. Tests on earth material from one canal have been completed in the laboratory flume, and the data have been analyzed. Plans are being made to install wave and wind recording equipment on a field canal.
(h) Progress report in review.

(2954) GLEN CANYON TUNNEL PLUG OUTLET WORKS.

(b) Laboratory project.
(d) Experimental; for design.
(e) Air and hydraulic model studies are being made to develop the rectangular bellmouth entrance, the alinement of the 3 conduits containing 7- by 10.5-foot regulating slide gates, and the shape of the flip bucket at the end of the 41-foot-diameter tunnel.
(g) The bellmouth entrance shape and the conduit alinement have been established. Performance is good with symmetrical or unsymmetrical gate operation at heads up to the maximum of 410 feet. Tests on the flip-bucket are continuing.
(h) Report in preparation.

(2955) CAVITATION IN SUDDEN ENLARGEMENTS DOWNSTREAM FROM ORIFICES AND GATE VALVES.

(b) Laboratory project.
(d) Experimental; for design.
(e) Tests are being made at heads from 200 to 400 feet to determine the critical cavitation indexes for gate valves operating at partial openings and discharging into pipe sections 1.5, 1.75, and 2.0 times the nominal valve diameter. Cavitation potential and pressure fluctuation in pipelines downstream from orifices of different sizes will be investigated.
(h) Report to be prepared.

(2957) PAONIA DAM SPILLWAY AND OUTLET WORKS.

(f) Completed.
(h) "Hydraulic Model Studies of Paonia Dam Spillway and Outlet Works," Report Hyd-444, G. L. Beichley.

(2958) HOLLOW-JET VALVE STILLING BASINS FOR OUTLET WORKS.

(f) Completed.
(h) Report in preparation.

(2959) STILLING BASINS FOR SLIDE GATE CONTROLLED OUTLET WORKS.

(f) Tests in progress.
(h) Report to be prepared.

(2960) FLAMING GORGE DAM SPILLWAY.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:36 scale model has been constructed to develop a satisfactory spillway and outlet works.
(g) A satisfactory approach channel has been developed, and good flow conditions through the crest section, transition and throughout the spillway tunnel have been obtained by the use of an unusual center pier. A new type of flip bucket has been developed permitting the height of one sidewall to be reduced without causing adverse flow conditions. The extent of riprap protection in the powerplant afterbay necessary during diversion through the outlet works has been determined.
(h) Report in preparation.

(3267) CANAL INLET AND OUTLET TRANSITION STUDIES.

(b) Laboratory project.
(d) Experimental; for design.
(e) Tests are in progress to determine the angle of divergence between the pipe and canal, and the effects of the slope and elevation of the pipe with respect to the canal.
(h) Report to be prepared.

(3268) PRINEVILLE SPILLWAY AND OUTLET WORKS.

(f) Completed.
(h) "Hydraulic Model Studies of the Spillway and Outlet Works for Prineville Dam, Crooked River Project, Oregon," Report Hyd-452 by W. P. Simmons, Jr.

(3269) EFFECT OF SHADE PRODUCED BY SUSPENDED SEDIMENTS ON THE GROWTH OF AQUATIC WEEDS.

(b) Laboratory project.
(d) Experimental; for operation and maintenance.
(e) Three types of aquatic weeds have been grown in eight 55-gallon drums containing varying concentrations of two types of sediment. Weeds were grown in two drums containing clear water for control and comparison purposes.
(f) Tests are completed and results are being analyzed.
(g) Results indicate a dark colored field sediment has an effect on reducing growth of the aquatic weeds tested.
(h) Report in preparation.

(3270) SAN ACACIA DIVERSION--HEADWORKS AND SLUICEWAY.

(b) Laboratory project.
(d) Experimental; for design and rehabilitation.
(e) A 1:20 undistorted scale, movable bed, hydraulic model has been constructed to study the headworks and sluiceway. Tests are being made to determine a modification that will reduce sediment inflow into the canal to a minimum.
(g) Results of completed tests indicate streambed guide vanes are effective in decreasing the amount of coarse bed sediment entering the canal.
(h) A report will be prepared.

(3271) CHANNELIZATION IN ALLUVIAL RIVERS USING STEEL JACKS AND JETTIES.

(f) Completed.
(h) Report in preparation.

(3272) NAVAJO DAM SPILLWAY AND AUXILIARY OUTLET WORKS.

(f) Completed.
(h) Report in preparation.

(3273) NAVAJO DAM DIVERSION AND OUTLET WORKS STILLING BASIN.

(f) Completed.
(h) Report in preparation.

(3274) CONSTANT HEAD ORIFICE TURNOUT.

(b) Laboratory project.
(d) Experimental; applied research for design.
(e) A 24-inch slide gate turnout is being calibrated by means of a 1:2 scale model. Design changes resulting from use of the turnout have necessitated an analysis and calibration of the variables affecting the discharge capacity.
(g) Results show that submergence of the orifice or of the upstream gate of the two-gate turnout has a major effect on the discharge coefficient. A calibration curve for a 9-cfs standard turnout and several comparative calibrations of modified turnouts have been

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obtained
(h) Report in preparation.

(3275) FRICTION FACTOR TESTS IN LARGE PRESSURE CONDUITS---EKLUTNA TUNNEL, ALASKA.

(b) Laboratory project.
(d) Field investigation; design.
(e) Extension of data to provide information on friction factors for smooth interior finishes of concrete that can be consistently produced with present day construction methods. Tests have been completed on a 9-foot-inside-diameter concrete-lined tunnel. Head losses were measured over a length of 2,534 diameters. Average velocities of flow were determined from calibrated pressure taps in two turbine scrollcases.
(f) Tests and data analyses completed.
(g) Data were obtained for seven test discharges over a Reynolds Number range of 7.1 by 10^5 to 4.6 by 10^6. Friction factors computed from the Darcy-Weisbach equation ranged from 0.017 to 0.014, respectively.
(h) Report in preparation. (Combined with Project No. 2724.)

(3276) FOSS DAM OUTLET WORKS.

(f) Completed.
(h) Report in preparation.

(3278) CAVITATION OF CONCRETE SURFACE IRREGULARITIES.

(b) Laboratory project.
(d) Experimental; for research.
(e) The cavitation producing potential of concrete surface irregularities such as abrupt offsets, protruding filler material, bug holes, etc., is being investigated. The test apparatus employs full-scale velocities and pressures.
(h) "Importance of Smooth Surfaces on Flow Boundaries Downstream from Outlet Works Control Gates," Report Hyd-448 by J. W. Ball.

(3280) GLENDO DAM OUTLET WORKS.

(f) Completed.
(h) Report in preparation.

(3281) ISLAND BEND CONTROL GATES.

(f) Completed.
(h) Report in preparation.

(3608) TWIN BUTTES OUTLET WORKS.

(b) Laboratory project.
(d) Experimental; design.
(e) A 1:30 scale model has been constructed to investigate the flow from the three 15-foot, 6-inch-diameter circular conduits. The gatehouse structure contains three 12- by 15-foot top seal radial gates and three 12- by 15-foot fixed-wheel emergency gates. Three 17-foot horseshoe conduits extend from the radial control gates to a common hydraulic stilling basin.
(f) Tests in progress.
(g) Satisfactory flow conditions exist in the circular conduits, the gatehouse and horseshoe conduits. Tests are being continued to develop piers to reduce a large water plume that forms at the contact of adjacent jets issuing from the horseshoe conduits, and to determine the most economical stilling basin arrangement.
(h) Report to be prepared.

(3609) TWIN BUTTES OUTLET WORKS INTAKE STRUCTURE.

(b) Laboratory project.
(d) Experimental; for design.
(e) A 1:23.25 scale model of the intake structure has been installed for air tests. The outlet works consists of three paralled 15-foot, 6-inch conduits at the same elevation and on 20-foot centers. The proper entrance shapes for the three conduits will be designed from this study.
(f) Tests in progress.
(g) For one study, circular bellmouth entrances were installed. Adverse pressure conditions, i.e., cavitation pressures, existed on the walls of the entrances and downstream from the stoplog slots, 8 feet, 6 inches downstream from the entrances. Tests are continuing with rectangular bellmouth entrances and transitions to the 15-foot, 6-inch circular conduits.
(h) Report to be prepared.

(3610) HYDRAULIC DOWNPULL ON HIGH HEAD SLIDE GATES.

(b) Laboratory study.
(d) Compiling laboratory and prototype data for design purposes.
(e) Laboratory studies have been completed using the pressure-area computation method to determine hydraulic downpull on a recently developed slide gate with narrow slots with offset downstream corners. Prototype downpull data have been obtained from two large gates and the results analyzed in terms of forces on the operating hoists. Loads due to friction and the weight of moving parts of the gate have been isolated to determine the true hydraulic downpull. Model-prototype comparisons of downpull will be presented in the report.
(h) Report in preparation.

(3611) ADJUSTABLE WEIR.

(b) Laboratory project.
(d) Combined laboratory and field research.
(e) Weirs having an adjustable crest height are used for checking water surface levels for upstream water delivery and for water measurement beyond the weir. An investigation of the head discharge capacity of a single 2-foot-crest-length weir was recently completed. Extension of the study to include combinations of weirs and those having adjustable crest length is contemplated.
(f) Single weir investigation completed.
(g) Capacity of weir for crest heights greater than 0.1 foot above fixed blade compare very favorably with standard 2-foot Cipolletti weir.
(h) Report in preparation.

(3612) DISCHARGE COEFFICIENTS FOR RADIAL GATES.

(b) Laboratory project.
(d) Combined laboratory and field research.
(e) Radial gates are used extensively in irrigation systems for discharge and water surface level control. Intelligent operation of the systems requires that the rate of flow passing the gated structure be known. Literature research resulted in an analytical approach and adjusted equation for the gate capacity with unsubmerged flow. A model gate was designed and will be installed in the laboratory to obtain data for checking the proposed formula and extending the scope of presently available information.
(f) Model to be constructed.
(h) "Problems Encountered in the Use of Low Head Radial Gates," T. J. Rhone, Journal of Proceedings, Hydraulic Division, ASCE, Vol. 85, HY2, February 1959.

(3613) COMPOUND WEIR STUDIES.

(b) Laboratory project.
(d) Applied research; for design.
(e) Develop relationships for flows through combined V-notch and rectangular contracted weirs, particularly in the transition range of discharges. Several sizes to be tested.
(f) Tests in progress.
(h) Report to be prepared.

(3614) EXPERIMENTAL STUDY OF SUBCRITICAL FLOW IN CURVED CHANNELS.

(b) Laboratory project.
(d) Experimental; for design and maintenance.
(e) A fixed bed, hydraulic model is being built to determine the possibility of reduction in scour and deposition in unlined channels due to secondary currents. Preliminary investigations will be conducted by varying the radius of curvature and the central angle.
(f) Model being constructed.

(3615) TUNNEL SPILLWAY FLIP BUCKETS.

(b) Laboratory study.
(d) Compiling available data; for paper.
(f) Completed.
(g) Several new types of flip buckets developed from hydraulic model studies are described. Using data from these tests, dimensionless charts are presented to aid in determining the jet trajectory length, the spreading of the jet, the tailwater drawn down at the bucket, and the pressures on the floor and sidewalls of the bucket.
(h) "Improved Tunnel Spillway Flip Buckets," by T. J. Rhone and A. J. Peterka. Paper presented at the ASCE Hydraulics Conference, Fort Collins, Colo., July 1959. Reprints are available.

(3616) SLOTTED SPILLWAY BUCKETS.

(b) Laboratory study.
(d) Experimental; for design.
(e) Laboratory tests on 6-, 9-, 12- and 18-inch radius buckets were made to develop dimensionless curves for the design of prototype buckets over large ranges of discharge, height of fall, and bucket radius.
(f) Completed.
(h) "Hydraulic Design of Slotted Spillway Buckets," by G. L. Beichley and A. J. Peterka, Journal of the Hydraulics Division, ASCE, October 1959.

U. S. DEPARTMENT OF THE NAVY, DAVID TAYLOR MODEL BASIN.

Inquiries concerning the following projects should be addressed to the Commanding Officer and Director, David Taylor Model Basin, Washington 7, D. C.

(709) THEORY OF WAVE RESISTANCE.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Hydrodynamic research.
(e) A mathematical study of the theory of wave resistance for the purpose of establishing methods for extending the theory to the analysis of ship resistance. Studies will include the general theory of waves in liquids and will encompass a review of existing theory and comparisons with existing experimental data.
(g) A synopsis has been written on the application of the theory to the calculations of wave resistance.
Calculations were made to obtain general information about wave resistance of submerged bodies of revolution. The forms considered are ellipsoids, Rankine ovoids, and a simple family of streamlined bodies. A report of this work is to be published.
(h) "The Wave Resistance of a Floating Slender Body", by W. E. Cummins, dissertation presented to American University, May 1956.

(710) RESEARCH ON MAIN INJECTION SCOOPS AND OVERBOARD DISCHARGES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical; applied research.
(e) Investigations to determine the characteristics of a broad series of injection scoops and discharges to provide design data for use in design of future high-speed ships.
(g) An improved method for estimating the velocity profile and thickness of a ship's boundary layer is being developed.
(h) "Boundary Layer Investigation on the USS TIMMERMAN EAG152 (ex-DD828)," by C. L. Sayre, Jr. and R. J. Duerr, TMB Report 1170, to be published.
"Estimating the Thickness of the Boundary Layer on the Hull of a Ship," by C. L. Sayre, in preparation.

(711) CAVITATION RESEARCH.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental; applied research.
(e) Research on the mechanism and effects of cavitation phenomena including the physics

and analytical description of steady-state cavities in real and ideal fluids and investigations of the inception of cavitation, and growth and collapse processes of transient cavities, and the effects of cavitation on the forces on underwater bodies. Studies will be made on the application of linearized theory to problems in cavitation. Additional studies will be made on the effects of roughness elements on cavitation inception and of body form on cavitation and degassing. Cavitating vortex cores as produced by shear flows will be investigated. Such cavitating sources have been observed on appendages to ships and may be responsible for flow noise excitation at high speeds.

(g) In one case the excitation of vibration of a ship has been traced to cavitation on rudder. (See DTMB Report 1188).

(h) "Rudder-Excited Hull Vibration on USS FORREST SHERMAN (DD931) - A Problem in Hydroelasticity," by R.T. McGoldrick, presented at the annual meeting of the Society of Naval Architects and Marine Engineers, New York, N.Y., November 12-13, 1959. "Linearized Theory for Flows About Lifting Foils at Zero Cavitation Number," by M. P. Tulin and M. P. Burkart, TMB Report C-638 (Declassified) of February 1955.

(1506) STIMULATION OF TURBULENCE ON SHIP MODELS.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Frictional resistance research.

(e) Development of a turbulence stimulating device which will insure adequate turbulence in the boundary layer over the entire length of any ship model. Empirical and theoretical studies will be conducted to evaluate the relative effectiveness of turbulence rods, trip wires, sand roughness, isolated stubs, noise makers and vibrators. Their relative effectiveness will be calculated by studying the model resistance and the character of the boundary layer flow around ship models as determined by the dye-method, the chemical compound, and the hot-wire survey method.

(f) Suspended.

(g) The work of the previous year was devoted to the study of the stimulating effect of studs and the development of the technique of the chemical compound. The effect of various stimulators on the BSRA model has been established and the evaluations work will compare the results for each stimulator with the results obtained by the English tanks. The evaluation of the stimulators used is still continuing.

(1514) MANEUVERING CHARACTERISTICS OF SINGLE-SCREW VESSELS.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Experimental testing.

(e) Measurements of side forces on propeller, rudder, and hull of a single-screw ship model during successive phases of starting, stopping, and backing maneuvers.

(f) Inactive.

(g) A test program has been formulated. A side-force dynamometer has been designed and completed. Testing is expected to begin when priority considerations permit.

(1521) 36-INCH VARIABLE PRESSURE WATER TUNNEL.

(b) Bureau of Ships; David Taylor Model Basin.

(d) New facility.

(e) Design and construction of a 36-inch variable pressure water tunnel for investigation of propulsion, cavitation, and noise characteristics of propellers as well as tests on sub-surface bodies. Interchangeable test sections of open and closed jet type will be provided. The maximum design speed is 85 f.p.s.

(g) Estimated completion is spring of 1960.

(1778) HYDRODYNAMIC NOISE.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Hydrodynamic research.

(e) Investigations of the characteristics of underwater noise associated with various hydrodynamic phenomena such as cavitation, bubble oscillation, turbulence and splashing.

(g) Experimental and theoretical studies have been made of noise produced by cavitation, splashing, oscillating air bubbles, and turbulence.

(h) "Splashes as Sources of Sound in Liquids," by G.J. Franz, Journal of the Acoustical Society of America, August 1959. "The Near-Sound Field of Turbulence," by G.J. Franz, TMB Report 982, October 1959. "Survey of Thermal, Radiation, and Viscous Damping of Pulsating Air Bubbles in Water," by C. Devin, Jr., Journal of the Acoustical Society of America, December 1959.

(1779) TURBULENT BOUNDARY LAYERS.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Theoretical and experimental; applied research.

(e) A theoretical and experimental investigation of the velocity profile and wall shearing stresses in turbulent boundary layer. In order to provide a simple and accurate determination of shear stress at the wall, the use of surface tube technique for measuring this characteristic has been investigated in both zero and adverse pressure gradients.

(h) "The Determination of the Local Skin Friction and the Thickness of Turbulent Boundary Layers from the Velocity Similarity Laws," P.S. Granville, TMB Report 1340, Oct. 1959.

(1780) BUBBLE FLOW STUDIES.

(b) Bureau of Ships; David Taylor Model Basin.

(d) Experimental and theoretical; applied research.

(e) Theoretical computations of bubble paths for various shapes to determine points of collision and conditions for non-collision will be made. The validity of the theory will be checked experimentally in a few cases.

(h) "Motion of Rigid and Fluid Spheres in

Stationary and Moving Liquids Inside Cylindrical Tubes," by W. L. Haberman and R. M. Sayre, TMB Report 1143, October 1958.

(1781) ROTATING-ARM AND MANEUVERING BASIN.

(b) Bureau of Ships; David Taylor Model Basin.
(d) New facility.
(e) Design and construction of a circular basin of 260-foot diameter with a rotating arm whose radius can be varied from 18 to 120 feet. To be used for towing tests of surface and sub-surface models. Also, design and construction of a maneuvering basin 350 feet long and 230 feet wide, equipped with traveling bridge and towing carriages, and wavemakers for the purpose of making maneuvering tests on ship models.
(g) Construction contract awarded in May 1956 with a completion date in early 1960.

(1783) MATHEMATICAL SHIP LINES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical research.
(e) Development of a suitable method for the mathematical determination of ship lines which can be applied to a wide variety of ship forms especially to those of modern design.
(g) A method has been developed for the mathematical fairing of graphical lines. This is a first step toward the development of a flexible system of mathematical ship lines. Future work is directed toward the development of a system of mathematical lines which will permit the derivation of a hull form for a given set of parameters.
(h) A partial result of this project has been reported in a paper entitled, "The Use of Digital Computers for Ship Design and Data Reduction at David Taylor Model Basin," by P. C. Pien and J. B. Hadler. This paper was presented at the ATTC meeting at Berkeley, Calif., September 1959.

(1786) STUDIES OF THE SLAMMING OF SHIPS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical; basic research.
(e) Computations and measurements of the maximum pressure and impact forces on the bottoms of slamming ships for the purpose of developing design criteria to effect their reduction.
(g) Studies with ship models were made to determine hydrodynamic impact forces on ships. Regular and confused seas were studied to determine conditions favorable for slamming.
(h) "A Theoretical Consideration of Impact Pressure at Ship Slamming," by K. Ochi and M. D. Bledsoe, TMB Report 1321. (To be published.)
"Hydrodynamic Impact Measurements," by V. G. Szebehely and E. E. Zarnick, First Conference on Coastal Engineering Instruments, 1955.

(1788) WAX DEVELOPMENT.

(b) David Taylor Model Basin.
(d) Experimental testing.
(e) Development of a wax composition and manufacturing techniques for the manufacture of ship models up to 30 ft. on water-line length.
(f) Completed.
(g) The blend developed is entirely suited to the climatic conditions existing in Wash., D.C. The strength of this material is such that all types of models, including submarines, may be constructed and handled with no greater care than is given to corresponding wood models. Ninety-one models, varying in length between 19 and 24 ft. and in weight between 1,000 and 4,500 lbs., and four 30 ft. models have been successfully manufactured and tested since the development of this new wax blend. The introduction of wax model construction technique has resulted in a substantial saving in time and cost of ship model manufacturing at TMB.
(h) The following reports are being reviewed prior to publication:
"The Development of a N-Butyl Methacrylate Wax Blend for Manufacturing Wax Models at TMB," by W. Hinterthan.
"Development and Application of a Wax Composition for the Manufacture of Experimental Ship Models," W. Hinterthan.
"Methods to be Followed in the Blending of Wax for TMB Wax Model Production," Memorandum, by W. Hinterthan.
"Wax Model Construction for Shallow Draft and Light Displacement Ships at the David Taylor Model Basin," W.B. Hinterthan, TMB Report 1354.

(2019) SERIES 60 - PROPELLER EXCITED VIBRATION.

(b) David Taylor Model Basin and Society of Naval Architects and Marine Engineers.
(d) Experimental basic research.
(e) Measurement of propeller induced vibratory forces on a series of models with variations in stern shape.
(g) The instrumentation and test techniques for measuring the propeller induced vibratory forces on a single screw ship model has been developed sufficiently to obtain repetitive results. Although there is insufficient information available to permit extrapolation to full scale forces, comparison of test results of models of similar type and dimensions appears valid. During the past year tests were conducted of a series of 3 models, based on the 0.70 C_B Series 60 parent form, with variations in stern section shape from U to V.
Measurement of instantaneous pressure have been made on the hull of the USS TIMMERMAN and on the hull of a 30 foot model of that vessel. Preliminary data indicates that the model measurements when similarly extrapolated also produce higher values than were measured on board ship.
(h) "The Measurement of Propeller Induced Vibratory Forces on Scale Ship Models," P.C. Pien and N.L. Ficken, American Towing Tank Conference Paper, September 1959.

(2229) NEAR SURFACE EFFECTS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Hydrodynamic research.
(e) A mathematical study of the forces and moments acting on bodies due to the proximity of a free surface. The studies will include both the case in which the surface is initially undisturbed and the case in which there are disturbances originating at a distance.
(g) Methods have been developed for computing the forces and moments acting on bodies of revolution, both due to waves generated by the body itself and to regular trains of waves. Experiments have been carried out using a spheroid moving under waves. The experimental results largely confirmed the theory except in following seas.
(h) "The Moment Acting on a Rankine Ovoid Moving Under a Free Surface," H.L. Pond, Jour. of Ship Research, Vol. 2, No. 4, March 1959. "A Comparison of the Experimental and Theoretical Hydrodynamic Forces and Moments Acting on a Spheroid Moving Under a Regular Train of Waves," by S.S. Hagara, TMB Report 1213, Report in review.

(2230) THEORY OF SEAWORTHINESS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Hydrodynamic research.
(e) A theoretical and experimental study of factors affecting the seaworthiness of ships, for the purpose of developing procedures for predicting their motion.
(g) Tests have been completed on two geometrically similar ship models of different lengths. The analysis of these tests will aid in estimating the validity of model tests for predicting full scale behavior. A ship model has been oscillated in heave and pitch to determine the dependency of the damping and added mass forces on speed, frequency and amplitude of oscillation. Comparisons will be made with theoretical methods currently used to compute these forces.
(h) "On Ship Model Testing for the Prediction of Extreme Conditions in Confused Seas," W.E. Cummins, Proceedings of the Symposium on the Behavior of Ships in a Seaway, Sept. 1957.
"On the Prediction of Full Scale Ship Motions from Model Tests," W. Marks, Proceedings of the Symposium on the Behavior of Ships in a Seaway, September 1957.
"On the Reduction of Motion Data from Model Tests in Confused Seas," by M. St. Denis, Proceedings of the Symposium on the Behavior of Ships in a Seaway, September 1957.
"Reduction of Seakeeping Data at the Taylor Model Basin," TMB Report 1363, Sept. 1959.
"A Study of the Transient Pitching Oscillations of a Ship," by P. Golovato, Jour. of Ship Research, March 1959.

(2231) HYDRAULIC ROUGHNESS STUDIES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental; applied research.
(e) Theoretical and experimental research on methods for analyzing and predicting the frictional resistance of arbitrary rough surfaces, especially the painted surfaces of ship hulls. The geometrical characteristics of arbitrary rough surfaces are to be analyzed by amplitude-frequency spectra while the hydrodynamic characteristics are to be analyzed by similarity laws.
(g) The low frequency characteristics of the roughness records necessitate the development of a low frequency spectrum analyzer. The analytical procedures for predicting the frictional resistance of arbitrary rough surfaces from similarity laws have been completed. A method has been derived for predicting full scale resistance of arbitrary rough surfaces from tests of model plates. Relations for the local skin friction and shape parameter have been derived for use in calculating the development of turbulent boundary layers in pressure gradients for rough surfaces. Boundary layer measurements are being made in a wind tunnel on randomly rough surfaces using a floating element dynamometer.
(h) "The Frictional Resistance and Turbulent Boundary of Rough Surfaces," P.S. Granville, Journal of Ship Research, Vol. 2, No. 3, December 1958.

(2232) PRESSURE AND VELOCITY DISTRIBUTIONS ON TWO-DIMENSIONAL AND AXI-SYMMETRIC THREE-DIMENSIONAL FORMS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical; applied research.
(e) Investigate analytic techniques for determining the pressure and velocity distribution on two-dimensional and axi-symmetric three-dimensional forms. The solution is to be amenable to coding for a high speed computor.
(g) An iterative solution was developed and coded for the UNIVAC. The pressure distribution for a number of bodies whose pressure distribution is known were completed and verified. Some difficulty was experienced, however, with convergence in certain portions of the calculations. In the future a superior method developed by Smith at Douglas Aircraft (TMB external research contract) will be employed on the 704 High Speed Computor.
(h) "The Axially Symmetric Potential Flow About Elongated Bodies of Revolution," by L. Landweber, TMB Report 761, August 1951.

(2233) THE STRUCTURE OF TURBULENCE IN BOUNDARY LAYERS AND WAKES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental; applied research.
(e) A study to investigate the behavior of basic turbulence quantities in boundary layer and wake flows. Investigations of the effect of background turbulence level on the turbulence characteristics of the wake behind two-dimensional forms and circular disks will be continued. Systematic measurements of a turbulent boundary layer in adverse pressure gradients will be undertaken.
(g) Experimental results indicate that the intensity decay and width increase of the

turbulent wake in its downstream course behind three-dimensional bluff bodies (discs and plates) are in agreement with those theoretically predicted. Future tests will be extended to include practical configurations which will be investigated in both unpowered and powered conditions. Measurements of a turbulent boundary layer in adverse pressure gradients include precise velocity profiles, local skin-friction measurements with surface tubes, and hot-wire anemometry.

(h) "Measurement of the Fluctuating Pressure and Velocity in the Wake Behind a Cylinder," by M. Strasberg and R. D. Cooper, 9th International Congress of Applied Mechanics, Brussels, pp. 384-393, Vol. II, (1956). "Time Constant and Frequency Response of Coated Hot Wires Used as Turbulence Sensing Elements," by Avis Borden, TMB Report 952, June 1957.

(2235) LIBERTY SHIP SEAWORTHINESS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical.
(e) Thorough seaworthiness investigations of a Liberty Ship and a modified Liberty Ship hull. Full scale trials were conducted during hind crossings of the North Atlantic. Speed reduction, ship motions and slamming pressures were investigated.

(2236) OSCILLATING PRESSURES IN THE VICINITY OF PROPELLERS.

(b) David Taylor Model Basin.
(d) Experimental and theoretical; applied research.
(e) Studies of the oscillating pressures on boundaries and in the free space produced by propeller operation. The purpose of the work is to determine the magnitude of the hydrodynamic propeller excited vibratory forces acting on ship's hulls and the effect of operating parameters.
(f) Completed.
(g) Experimental results have been completed.
(h) "The Measurement of Thrust Fluctuation and Free-Space Oscillating Pressures for a Propeller," by A. J. Tachmindji and M. C. Dickerson, DTMB Report 1107, January 1957. "The Measurement of Oscillating Pressures in the Vicinity of a Propeller," by A. J. Tachmindji and M. C. Dickerson, DTMB Report 1130, April 1957.

(2237) LIFTING SURFACE THEORY OF PROPELLERS.

(b) Cooperative with Bureau of Ships.
(d) Theoretical; applied research.
(e) Studies of the corrections on lifting line theory which arise from the finite extent of the blades.
(f) Application of an approximate lifting surface theory is completed. Development of a rigorous theory currently in progress.
(g) The available results are being applied to propeller design methods.
(h) "Propeller Induction Factors," by W. B. Morgan, TMB Report 1183.

(2462) PITCH REDUCTION STUDIES.

(b) Bureau of Ships.
(d) Experimental and theoretical.
(e) To investigate the effect of horizontal fin appendages on the motion of surface ships in a seaway. A motion prediction theory is being developed and experimental investigations will be conducted.
(h) "Model Experiments with Fixed Bow Anti-Pitching Fins," by G.P. Stefun, TMB Report 1118, submitted to the Journal of Ship Research.
"Hull Vibrations Due to Bow Anti-Pitching Fins," by G.P. Stefun and F.N. Schwartz, TMB Report in preparation.

(2463) STUDIES OF LOW ASPECT-RATIO CONTROL SURFACES.

(b) David Taylor Model Basin; Laboratory project.
(d) Experimental investigation; basic research.
(e) Determine the aerodynamic characteristics of a family of low aspect-ratio control surfaces which can be used by the designer of submarines and surface ships.
Phase I is an investigation of a family of all-movable control surfaces. Phase II is an investigation of the same family with plain flaps of different chord length.
(f) Phase I, completed; Phase II, active.
(g) The results of Phase I indicate that many of the aerodynamic characteristics of low aspect-ratio surfaces can be accurately predicted from lifting surface theory.
(h) The results of Phase I and comparisons with lifting surface theory are presented in DTMB Report No. 933.

(2470) CAVITY RESONANCE.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical investigation of the excitations of cavity resonance by fluid flow.
(e) Studies to determine the mechanism of excitation of the cavity resonance by fluid flow past orifice will be undertaken. The experimental investigation will employ the low turbulence wind tunnel and circulating water channel. The amplitude of pressure fluctuations in the cavity will be investigated as function of the size, shape and number of orifices, as well as the turbulence characteristics in the boundary layer flow.

(2471) THEORY OF CONTRA-ROTATING PROPELLERS.

(b) Cooperative with the Bureau of Ships.
(d) Theoretical; applied research.
(e) Studies of the theory of contra-rotating propellers without assumptions regarding the orientation of the resultant induced velocity.
(g) Application to open water and wake adapted propellers.
(h) "Effect of Propeller Pitch Changes on Torque Unbalance of Contra-Rotating Propellers," W.B. Morgan, DTMB Report 1124,

March 1957.
"The Axial Velocity Field of an Optimum Infinitely Bladed Propeller," by A. J. Tachmindji, TMB Report 1294, January 1959.

(2472) COOPERATIVE TESTS ON A VICTORY SHIP DESIGN.

(b) David Taylor Model Basin: Skin Friction Committee of the International Towing Tank Conference.
(d) Experimental testing; basic research.
(e) The investigation was authorized by the International Committee on "Scale Effect on Propellers," and on "Self-Propulsion Factors," as part of the international cooperative test program in ship basins. The International Committee will compare the results from the various basins and present a report to the coming International Conference. The tests will be carried out with a wax model of scale 1:23 equipped with different kinds of stimulators. The friction corrections will be calculated by the various basins according to their methods.
(g) The specified program of model testing has been completed. The required calculation for the power predictions have to be done before the evaluation work can proceed.
(h) Results have been reported to the International Towing Conference. A TMB Report is being prepared comparing TMB results with those of other basins.

(2727) THE EFFECT OF HUB DIAMETER ON THE OPTIMUM DISTRIBUTION OF CIRCULATION OF PROPELLERS.

(b) David Taylor Model Basin
(d) Theoretical; applied research.
(e) Studies of the effect of hub diameters on the optimum distribution of circulation.
(f) Inactive.
(g) Calculations have been completed.
(h) "The Calculation of the Circulation Distribution for Propellers with Finite Hub Having Three, Four, Five and Six Blades," A. J. Tachmindji and A. B. Milan, DTMB Report 1141, July 1957 and International Shipbuilding Progress, September 1957.
"The Ideal Efficiency of Optimum Propellers Having Finite Hubs and Finite Number of Blades," by J.W. Shultz, Jr., DTMB Report 1148, July 1957.

(2729) HULL FORM RESEARCH WITH A FLEXIBLE MODEL.

(b) David Taylor Model Basin.
(d) Development and experimental work.
(e) A flexible model which can be quickly changed to have any fullness and any shape of section area curve is to be developed first. The effect of section area curve parameters, such as t_F, t_A, C_{PF}, C_{PA}, L_E, L_x, X_F, X_A, etc., upon resistance will be systematically investigated by using this flexible model.
(g) The flexible model has been built and experimental test work begun. Thirty resistance tests have been conducted during the past fiscal year. Preliminary work with this flexible model indicates its adaptability for this work is satisfactory. An analysis of the test results has not been completed.
(h) The results of the first phase of this project has been reported in TMB Report 1344 entitled, "Hull Form Research With a Flexible Model," by P.C. Pien, November 1959.

(2730) MOLECULAR - PHYSICAL SKIN EFFECT.

(b) David Taylor Model Basin.
(d) Experimental applied research.
(e) The frictional resistance of a "new" plate consisting of a special molecular coating will be compared with the frictional resistance of a hydraulically smooth brass plate and of a mirror smooth glass plate. The test equipment will be designed and constructed to study wave and spray formation for the determination of the true wetted surface. The plate will be tested with maximum speed of 15.0 knots and with various stimulation devices.
(g) The Nikuradse coated plates have been tested. Significant resistance differences between coated and non-coated plates have been measured on a coated brass plate and an uncoated aluminum plate. Since the contours of the leading and trailing edges of the two plates vary considerably a doubt is raised at whether the coating or the difference in the contours caused the resistance differences. A stainless steel plate having the same contours as the coated brass plate has been constructed and tested. The resistance of this plate has been obtained and the relation between the coated and uncoated plate will be the subject of an additional report.

(2962) SHIP MOTION.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Field investigation (full scale trials).
(e) An account of seakeeping trials carried out jointly by the Royal Netherlands Navy and the United States Navy with three destroyers.
(g) Measurements were made of motions, slamming pressures and stresses. These were analyzed to determine the effect of the seaway, of speed and of relative course. A data report is currently in preparation.

(2966) STUDY OF BOUNDARY LAYERS OF SUBMERGED BODIES OF REVOLUTION.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental basic research.
(e) Experiments have been carried out on an elongated body of revolution in 8 x 10 ft. subsonic wind tunnel. The model consists of a basic body of revolution with removable model deck, conning tower, and tail control surfaces, to simulate the geometrical form of a submarine. The measurements consisted of boundary layer survey and local skin friction measurements by surface pitot tubes at various angular locations throughout a range of speeds. Comparison is being made with full scale results.
(h) "Measurement of Transition on a Sphere at

High Reynolds Numbers," by M.S. Macovsky and E.Y. Hus, TMB Report 1110, June 1957.

(2967) CONTROL SURFACE FLUTTER.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical basic investigation.
(e) Experiments are being conducted with a flutter apparatus to determine flutter speeds as a function of inertias, spring and damping constants. The results will be compared with a simplified rudder flutter analysis which can then be applied to design procedures.
(g) Control-surface flutter action (sub-critical) has been demonstrated with TMB flutter apparatus, (See TMB Report 1222). The apparatus is being modified so as to extend the range of variation of parameters to include those producing critically unstable flutter action.
(h) "A Control Surface Flutter Study in the Field of Naval Architecture," by R. T. McGoldrick, and D.A. Jewell, DTMB Report 1222, September 1959.

(2969) FLOW STUDIES ON THREE-DIMENSIONAL FORMS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical basic research.
(e) Pressure distributions and flow studies have been made in a wind tunnel on several shapes similar to those of certain sonar domes. Data will be used in predicting those conditions of ship speed, yaw and pitch which are conducive to cavitation on sonar domes.
(h) "Pressure Distribution About Four Sonar Domes," R.D. Cahn (report in preparation).

(2970) STUDIES OF HYDRODYNAMIC LOADING ON BARE AND FAIRED CABLES.

(b) David Taylor Model Basin.
(d) Experimental investigation; basic research.
(e) Measure the tangential and normal hydrodynamic forces acting on a long cylinder towed at various angles to the stream over a range of Reynolds numbers. Tests will be made with various degrees of roughness simulating stranded cable, and various trailing-type fairing designs.

(2971) FULL SCALE TRIAL AND MODEL PREDICTION CORRELATION.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental testing and re-evaluation of existing test data.
(e) The accuracy of full scale power predictions from model test results depends upon the selection of the proper correlation allowance (ΔC_f) to be used in model calculations. Model tests have been conducted and past correlations have been re-analyzed such that a total of 54 correlations have been completed. An analysis of this data has begun.
(g) Analysis of the completed correlations has begun and is scheduled for completion by July 1960. The presentation of a paper to the Society of Naval Architects and Marine Engineers is projected.

(3282) RADIAL DISTRIBUTION OF PROPELLER THRUST FROM MODEL WAKE MEASUREMENTS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental; applied research.
(e) Information concerning the radial distribution of thrust is needed for a propeller operating behind a submerged body of revolution. The results of theory and experiment are compared. The experimental thrust distribution was obtained from the axial momentum equation by applying appropriate corrections for slip stream rotation and contraction. The theoretical thrust distribution was obtained from the circulation distribution of the propeller with a finite hub.
(f) Completed.
(g) The radial distribution of propeller thrust-load coefficient is calculated from experimental wake data obtained from towed and self-propulsion tests on a body of revolution. The experimentally obtained thrust distribution is in excellent agreement with a theoretically calculated distribution. Numerical integration yields a total thrust-load coefficient which is in good agreement with propulsion test results.
(h) "The Radial Distribution of Propeller Thrust from Model Wake Measurements," by John L. Beveridge, DTMB Report No. 1136, Nov. 1958.

(3283) FUNDAMENTAL HYDROMECHANICS RESEARCH.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Applied research.
(e) Survey of work carried out under Bureau of Ships Fundamental Hydromechanics Research Program.
(g) Survey includes results obtained during the period of 1952 to present.
(h) To be published in Journal of Ship Research, SNAME, beginning August 1959.

(3284) HYDROFOIL SUPPORTED CRAFT.

(b) Bureau of Ships, David Taylor Model Basin.
(d) Experimental and theoretical applied research.
(e) Obtain hydrofoil craft design criteria by determining steady and unsteady forces on and motions of single and multiple hydrofoil configurations under the influence of waves, ventilation, cavitation and mutual interference.
(g) Hydrofoil configurations in regular waves have been studied.
(h) "Experimental and Theoretical Studies of Hydrofoil Configurations in Regular Waves," CDR Patrick Leehey, USN and John M. Steele, Jr., TMB Report 1140 of October 1957. "The Theoretical Prediction of the Longitudinal Motions of Hydrofoil Craft," T.F. Ogilvie, TMB Report 1138 of November 1958.

(3285) HYDROELASTIC PROBLEMS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental.
(e) Theoretical and experimental investigations

will be made of the interaction of fluctuating flows and the elastic motion of bodies. Experiments will include; correlation of shedding frequency and geometrical parameters of struts; span-wise correlation of fluctuations in flow as a function of Reynolds number and examination of the parameters affecting the elastic response of rudder-like forms.

(h) "A Control-Surface Flutter Study in the Field of Naval Architecture," by R. T. McGoldrick and D. A. Jewell, TMB Report 1222, September 1959.
"Rudder-Excited Hull Vibration on USS FORREST SHERMAN (DD931), A Problem in Hydroelasticity," by R.T. McGoldrick, presented at the annual meeting of the Society of Naval Architects and Marine Engineers, New York, N.Y., November 12-13, 1959.

(3286) THEORY OF SUPERCAVITATING PROPELLERS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental; applied research.
(e) Studies and design of propellers designed to operate at high speeds.
(g) The prediction and experimental confirmation of the performance of such propellers have been completed.
(h) "The Design and Performance of Supercavitating Propellers," by A.J. Tachmindji et al, TMB Report C-807 (Unclassified).
"Supercavitating Flow Past Bodies with Finite Edge Thickness," by J. N. Newman, TMB Report 1081.
"Centroid and Moments of Inertia of SC Sections," by W.B. Morgan, TMB Report 1193.
"Optimum SC Section," by W.B. Morgan, TMB Report C-856.
"The Design and Estimated Performance of a Series of Supercavitating Propellers," by A.J. Tachmindji and W.B. Morgan, paper to Second Symposium on Naval Hydrodynamics, August 1958.
"TMB 3-Bladed Supercavitating Propeller Series," by E.B.Caster, TMB Report 1245, August 1959.

(3287) EFFECT OF STERN MODIFICATION TO A SERIES 60 VESSEL, RESISTANCE POWERING, WAKE DISTRIBUTION AND PROPELLER INDUCE VIBRATION.

(b) David Taylor Model Basin; Maritime Administration.
(d) Experimental testing and evaluation of data for basic research.
(e) Models representing specific variations in stern shapes and designed for special instrumentation installation will be built. The basic design will be the Series 60, 0.70 Block Coefficient Parent. Six other forms will be derived having systematic changes in section shapes (from extreme V to extreme U) and for variation in waterline endings (from fine to blunt). An attempt will be made to develop formulation to mathematically express the stern variations from the parent.
(g) The basic model has been constructed and powering data has been obtained.
(h) "Effect of Hull Modifications on Resistance and Propulsion Characteristics of a Series 60 Stern C_D = 0.70," by W.B. Hinterthan and E.E. West, TMB Report 1345, being reviewed prior to publication.

(3288) SHIP STABILIZATION.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical; applied research.
(e) The roll response of an AK cargo vessel converted for use as a missile tracking station has been simulated on an analog computer to evaluate the stabilization accomplished by passive anti-rolling tanks. A description of the simulation, the ship responses to regular wave action and some comparison with experimental values will be presented in the report of the study.
(f) Completed.
(h) "Analog Simulation of a Passive Anti-Rolling Tank System for a Missile-Range Ship," by J.W. Church, TMB Report 1322, May 1959.

(3292) EXPLORATORY STUDIES AND PLANS AT DTMB FOR MODEL TESTS IN 3-DIMENSIONS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental; basic research.
(e) A rectangular ship model testing facility is described. Advantages over existing methods are discussed and new problems in analysis of data are revealed.
(g) Segmented wave generators provide the ability to produce oblique waves. Programming to individual wavemakers results in generation of confused seas of almost any nature. The rectangular basin offers opportunity to test in any relative heading to the waves and even in cross seas. Problems in analysis involve determination of the seaway (in the tank) as a function of frequency and direction. Ship motions in confused seas may be random in nature and may be analyzed by spectrum methods.
(h) "On the Status of Complex Wave Generation in Model Tanks," by W. Marks, Trans. of the Eleventh General Meeting of the American Towing Tank Conference, September 1956, also TMB Report 1069.
"Wave Propagation in the Tenth-Scale Model of the Seakeeping Basin, Part II - Generation of Oblique Waves," W. Marks, TMB Report in review.
"The Determination of Directional Wave Spectra in the TMB Maneuvering-Seakeeping Basin," by W.E. Cummins, TMB Report 1362, July 1959.

(3293) INFLUENCE OF HULL FORM ON SEAWORTHINESS.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical; basic research.
(e) Various hull forms will be investigated with respect to their seakeeping characteristics in order to determine the effects of hull variations on pitch and heave amplitudes, speed in waves, wetness, etc. An attempt will be made to correlate sea behavior with basic ship parameters such as beam-draft ratio, block coefficient, waterplane area or displacement-length ratio.

(g) A preliminary study of results obtained from various model tests in waves indicates that variations in pitch and heave amplitudes among the different models can be attributed to variations of the average beam-draft ratios in the case of heave, and to variations of the modified displacement-length ratios in the case of pitch.
(h) "The Influence of Ship Form on Pitch and Heave Amplitudes," by G. P. Stefun, TMB Report 1235, September 1958.

(3294) SEAWORTHINESS OF HYDROFOIL CRAFT.

(b) Bureau of Ships, David Taylor Model Basin.
(d) Theoretical research.
(e) A theoretical study of the vertical plane motions of a hydrofoil craft in sinusoidal waves.
(g) An earlier theoretical development of the equations of motion for hydrofoil craft has been extended to include unsteadiness and non-linearities. Computer solutions have been obtained for the pitching and heaving motions in sinusoidal waves. Good agreement with an available set of experimental results have been obtained.
(h) "The Theoretical Prediction of the Longitudinal Motions of Hydrofoil Craft," by T.F. Ogilvie, TMB Report 1138, Nov. 1958.

(3617) VENTILATED PROPELLER DEVELOPMENT.

(b) David Taylor Model Basin.
(d) Theoretical and experimental; applied research.
(e) Studies and design of ventilated propellers for operation at intermediate speeds.
(g) Experiments have been completed on the first ventilated propeller.
(h) "Performance of a Ventilated Propeller," W.B. Morgan, Paper presented at American Towing Tank Conference, Berkeley, Calif., August 1959.

(3618) PRESSURE DISTRIBUTION ON BLADES OF MARINE PROPELLERS UNDER OPERATING CONDITIONS.

(b) David Taylor Model Basin.
(d) Experimental; applied research.
(e) Experimental determination of the pressure distribution on the blades of marine propellers under operating conditions and comparison with theoretical values obtained from two-dimensional airfoil theory.
(g) Experimentation on one propeller completed.
(h) "Measurement of Pressure Distribution on Blades of Marine Propellers," J. Auslaender. Paper presented at American Towing Tank Conference, Berkeley, California, Aug. 1959.

(3619) VERTICAL AXIS PROPELLER.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Experimental and theoretical; applied research.
(e) Theoretical and experimental studies of performance characteristics of various types of vertical axis propellers.
(g) First phase of experimental work has been completed.

(3620) PROPELLER PERFORMANCE IN UNSTEADY FLOW.

(b) David Taylor Model Basin.
(d) Experimental and theoretical; applied research.
(e) Experimentation to evaluate the effect of various dimensional characteristics on the time dependent propeller forces while operating in waves. Correlation of results with wave theory.
(g) A 16" diameter bronze propeller has been tested in various waves. The thrust and torque coefficients were calculated for the wave crests and wave troughs. The wave velocity from the trochoidal wave theory was applied the advance coefficients.
(h) "Propeller Performance in Unsteady Flow." W. H. Norley, Paper presented at the Am. Towing Tank Conference, Berkeley, Calif., August 1959.

(3621) STUDY OF BENDING MOMENTS OF A SHIP MODEL MOVING IN WAVES.

(b) Bureau of Ships; David Taylor Model Basin.
(d) Theoretical and experimental basic research.
(e) To provide ship designers with more exact information concerning the magnitude of bending moment and shear forces in a ship moving in waves.
(g) Bending moment about the transverse axis and vertical shear forces were measured experimentally in regular head seas and results compared with analytical calculations of motions bending moments and shear forces.

(3622) FLUCTUATING FLOWS.

(b) Bureau of Ships, David Taylor Model Basin.
(d) Experimental and theoretical basic research.
(e) The mechanism of the fluctuations in the flow about a body in a moving stream will be studied. Correlations of varying forces and motions of the body will be sought. In one experiment a cylinder while being towed will be oscillated at frequencies above and below the frequency of vortex shedding with a view toward an explanation of the lack of span-wise correlation of vortex shedding from rigid cylinders.

U. S. DEPARTMENT OF THE NAVY, NAVAL BOILER AND TURBINE LABORATORY.

(2731) EFFECT OF PIPE ROUGHNESS ON ORIFICE METER ACCURACY.

(b) American Gas Association.
(c) American Gas Association, 420 Lexington Avenue, New York 17, New York.
(d) Experimental; applied research.
(e) This project is under the cognizance of the AGA Supervisory Committee to Study Pipe Roughness. Its objective is to determine the effect of meter tube roughness on the discharge coefficient of orifice meters for tube surfaces varying in roughness from that of run-of-the-mill pipe to that of bored and honed tubes. Tests have been

made with two-inch diameter meter runs using water as the media and with four-inch diameter meter runs using natural gas.

(g) Experimental work completed; report being prepared.

(3623) HIGH PRESSURE-TEMPERATURE WATER FLOW METER CALIBRATION.

(b) Bureau of Ships; U. S. Naval Boiler and Turbine Laboratory.
(d) Experimental; applied research.
(e) A facility has been constructed at the U.S. Naval Boiler and Turbine Laboratory for calibrating water flow meters at pressures and temperatures up to 2500 psi and 600 F, respectively. The facility has a capacity of 100 gpm at the maximum temperature and pressure and a greater capacity at lower pressures and temperatures. After flowing through the metering section the water is cooled and can be weighed at rates up to 45,000 pounds per hour. In addition to the calibration function, the facility will be used to investigate and verify orifice meter coefficients at pressures and temperatures above those at which the coefficients in use were established.

(3624) INVESTIGATION OF ELBOW FLOW METERS.

(b) Bureau of Ships; U. S. Naval Boiler and Turbine Laboratory.
(d) Experimental; applied research.
(e) The objective of this test program is the development of a flow meter for shipboard use that can be installed without alteration to existing piping configurations. The elbow meter is attractive because an existing elbow could be used, and no additional pressure drop would be imposed on the system. The relationship between flow and pressure differential, however, has not been established well enough for reliable measurements. Testing will be confined to the long turn 90 degree, type A elbows of specificiation MIL-F-1183 to establish criteria for their installation and use.

U. S. DEPT. OF THE NAVY, OFFICE OF NAVAL RESEARCH.

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TENNESSEE VALLEY AUTHORITY, Hydraulic Data Branch.

Inquiries concerning all TVA projects should be addressed to Mr. Albert S. Fry, Hydraulic Data Branch, Tennessee Valley Authority, Knoxville, Tennessee.

Hydraulic Operations and Tests Section.

(731) SOUTH HOLSTON DAM, SURGE TANK MODEL STUDY.

(d) Experimental; for design.
(e) A 1:50 model of the penstock and surge chamber was used to determine (1) the orifice size and characteristic shape to produce favorable pressure and water surface elevations to be expected in the surge chamber; and (2) the operational

characteristics or the selected design.
(f) Model studies completed.
(g) With the proper orifice between the riser and the surge chamber as satisfactory results can be obtained as with the differential riser type of surge tank.
(h) Report in preparation.

(739) CHEROKEE DAM, SLUICE RATING.

(d) Field investigation; operation.
(e) Measurement of discharges and differential pressures in the sluices have been used to establish the discharge ratings for the eight sluices. Tables of discharge for any headwater elevation within the operating range have been prepared for the wide open gate positions.

(745) FONTANA DAM, SLUICE RATING.

(d) Field investigation; operation.
(e) Model tests, checked by field measurements, are to be used in determining the discharge ratings for all anticipated operating conditions. Discharge tables for the fully opened gate positions have been prepared for operating purposes.
(f) Model studies completed.

(758) CHEROKEE DAM, PROTOTYPE CHECK TESTS.

(d) Field investigation; applied research.
(e) Periodic checks and observations will be made on the various hydraulic appurtenances to determine the operating characteristics of the structures and the effect of operation on the structures.
(g) Measurement of pressures in the sluice barrel have been obtained and will be compared with pressures obtained in model tests. The apron and sluice barrels were inspected in 1953 to determine the effect of intermittent operation during the past eleven years.
(h) Report in preparation.

(759) DOUGLAS DAM, PROTOTYPE CHECK TESTS.

(d) Field investigation; applied research.
(e) Periodic checks and observations will be made on the various hydraulic appurtenances to determine the operating characteristics of the structures and the effect of operation on the structure.
(g) Measurement of pressures in the sluice barrel have been obtained and will be compared with pressures obtained in model tests. The apron and sluice barrels were inspected in 1953 to determine the effect of intermittent operation during the past ten years.
(h) Report in preparation.

(762) SOUTH HOLSTON DAM, SURGE TANK PROTOTYPE CHECK TESTS.

(d) Field investigation; applied research.
(e) The prototype installation was equipped to allow testing in a manner similar to that used in the model studies which established the design. A check on the model accuracy can thus be obtained.
(g) Tests made in February 1951, July and Oct. 1958 at headwater elevations 1630, 1719, and 1690, respectively.

(1038) HALES BAR DAM, SPILLWAY APPROACH STUDIES.

(b) Experimental; for design.
(e) Tests are made on a 1:65 model to determine effect of the remains of cofferdam structures upstream of the spillway on the spillway discharge and to determine amount of the obstructions which should be removed.
(g) Removal of the obstructions upstream from the dam increased the discharge of individual spillway bays from 1 to 7 percent. The total spillway discharge was increased approximately 3.5 percent.
(h) Report completed.

(1534) FORT PATRICK HENRY DAM, SPILLWAY MODEL STUDIES.

(d) Experimental; for design.
(e) Tests were conducted on a 1:50 scale and 1:112.5 scale model to determine the apron design, training wall dimensions, and other related data.
(f) Model studies completed.
(g) An apron using a single row of rectangular baffle blocks was developed on the 1:50 scale model. This apron was then used in the 1:112.5 scale model and the necessary appurtenant structures developed. Of main interest in the developed design was the lack of training walls. Studies to determine the effect of vegetative growth on the island areas below the spillway showed which areas must be kept free of growth and which may be allowed to grow up. Installation completed and instruction manual partially completed and issued.
(h) Report in preparation.

(1794) WATTS BAR LOCK PROTOTYPE TESTS.

(d) Field investigation; applied research.
(e) The prototype installation was equipped with piezometers to allow checking of culvert and port pressures and discharges. The culverts and ports were designed from model studies. Thus, measurement on the prototype would provide model-prototype verification data.
(f) Complete field tests were conducted in 1952.
(h) Reduction of data is being completed.

(2241) KINGSTON STEAM PLANT - CONDENSER COOLING WATER CONDUIT LOSS.

(d) Experimental; for design.
(e) Longitudinal interior support was required for 96-inch concrete pipe conduit. A study was made of the relative loss for a six-inch thick vertical concrete wall, I beams separated by 4-1/2-inch pipe columns and I beams separated by streamlined 4-1/2 inch pipe columns.
(f) Laboratory studies completed; partial field tests performed.

(2479) WILSON LOCK HYDRAULIC MODEL STUDIES.

(d) Experimental; for design.
(e) The new Wilson lock is 110 feet wide, 675 feet center-to-center pintles with a 100-foot maximum lift. A 1:36 scale model of a single transverse lateral with 12 ports was used to determine the proper lateral and port designs. A 1:16 scale model of the lock chamber, intake, culverts, gates and other details was used to determine the overall designs.
(f) Laboratory model studies completed.
(g) The basic design for the filling and emptying systems was determined from the model studies. Filling will be achieved through the use of 6 lateral culverts each containing 12 equally spaced ports 3.5 ft high by 1.5 ft wide. The upper three laterals will be fed from the landward main culvert and the lower three laterals by the riverward culvert. At minimum tailwater elevation only 23 ft of water cushion is available at the bottom of the controlling reverse-flow tainter valves. Dangerously low pressures were eliminated by use of a fast initial opening rate followed by a slow rate for the major portion of the opening and by modifications of the valve shape and of the upper seal nose design. A stepped lateral design was found necessary to produce stable flow conditions.
(h) Report on lock filling and emptying system in preparation.

(2973) REVISION TO PRESENT WILSON NAVIGATION LOCK.

(d) Experimental; for design.
(e) Upon completion of the new Wilson Lock construction, the tailwater in the navigation canal at the dam will be lowered 10 feet. To make the present two-lift lock operable under the new conditions, the lower chamber floor will be lowered 10 feet and a new filling and emptying system provided.
(f) Model studies have been completed to determine the exact hydraulic design to be used in the renovations.
(g) The new filling system consists of a single culvert located on the longitudinal centerline of the lock with ports located near the bottom along both sides. The old valves are much above tailwater elevations; therefore, the culverts above tailwater were reduced in cross-sectional area to minimize the air entrainment problems.
(h) Report in preparation.

(2974) DEVELOPMENT OF IMPACT TUBE-PRESSURE TRANSDUCER TURBULENCE PROBE.

(d) Experimental; applied research in field investigations.
(e) Development of a turbulence probe and auxiliary analog computer for field use.
(f) Development active.
(g) Based on project (578) of Mass. Inst. of Tech., a turbulence probe for use in natural streams is to be developed. An analog computer which will produce autocorrelation factors directly from the pressure cell data is also under development.

(3299) WILSON POWERHOUSE EXTENSION, HYDRAULIC MODEL STUDIES.

(d) Experimental for design.
(e) A 1:28.5 scale model of two turbine intakes and one spillway bay was constructed to determine (1) if there is a possibility of air being drawn into the intakes; (2) if changes will be required in the shape of the intake mouths and trash rack arrangement to improve flow conditions; and (3) if the flow through the adjacent spillway bay will effect the flow into the intake.
(f) Model studies completed.
(g) Design requirements in renovating an existing structure made it necessary to locate the turbine intakes closer to the water surface than is normally desirable. The model tests indicated that vortices would form at the intakes and air might be drawn into the units. The vortex action was essentially eliminated by installing a specially designed vortex eliminating structure above the intakes to the units.
(h) Report to be preapred.

(3300) HIWASSEE, PUMP TURBINE RATING.

(d) Field investigation; operation.
(e) Measurements of the discharge and differential pressures in the pump turbine scroll case have been used to establish the discharge rating for the pump turbine over all operating conditions. The discharge was measured by using Apalachia reservoir as a volumetric tank. Water was both pumped from the reservoir and discharged into the reservoir for a period of 12 hours. The reservoir area was obtained from aerial photographs taken at the beginning and end of each test. Five recording gages were used to measure the reservoir level. From these measurements the volume and corresponding discharge was computed.
(h) Report in preparation.

(3302) WIDOWS CREEK STEAM PLANT, AIR AND GAS DUCT TESTS.

(d) Experimental; for design.
(e) Model studies were conducted to improve flow conditions and reduce pressure losses in the gas duct which will carry gases from the furnace to the smoke stack for a 500-mw unit. Calibration of the air foil metering section in the forced-draft fan inlet ducts was also made by model studies.
(f) Model studies completed.
(g) Flow conditions were improved by use of flow straighteners and vanes.
(h) Report in preparation.

(3303) WIDOWS CREEK STEAM PLANT, CONDENSER WATER PUMP TESTS.

(d) Field investigations; operation.
(e) Condenser water pump acceptance tests on four pumps for a 500-mw steam turbine will be conducted to determine the flow, head, and power requirements in accordance with the latest ASME test codes for centrifugal pump and hydraulic prime movers modified

to use pitometer traverses. Velocity measurements will be made in the 9-foot 6-inch square concrete pump discharge conduit.

(f) Tests to be conducted in 1960.

(3625) 96-INCH HOWELL-BUNGER VALVE RATING.

(d) Field investigation; operation.

(e) Discharge ratings for four 96-inch Howell-Bunger valves installed at the Watauga and South Holston projects were determined by correlating field discharge measurements with differential pressures obtained in the valve. Discharge tables were prepared from this rating.

(3626) WHEELER LOCK, HYDRAULIC MODEL STUDIES.

(d) Experimental, for design.

(e) The proposed lock will be 600 feet long by 110 feet wide with a maximum lift of 52 ft. Initial tests to develop a satisfactory filling system were conducted utilizing a 1:50 scale model which simulated the basic details of one-half of the lock filling system. A 1:16 scale model of the lock chamber, intake, gates, culverts and other details will be used to determine the final design.

(f) 1:50 scale model tests completed. 1:16 scale model under construction.

(g) The filling system developed from the 1:50 scale model tests and which is to be checked in the 1:16 scale model uses approximately 1200 eight-inch pipes for discharge. These pipes feed the water directly from the longitudinal culverts into the lock chamber. 1:2.25 and 1:5.78 scale models of one of the 8-inch discharge pipes indicated that cavitation effects in the pipe can be eliminated by installing a flared entrance constructed from a standard 12 x 8 inch reducer.

(3627) MELTON HILL DAM, HYDRAULIC MODEL STUDIES.

(d) Experimental; for design.

(e) The proposed projects include three spillway bays, a powerhouse with 3 units and a 75 x 400 ft navigation lock with a maximum lift of 60 feet. A 1:75 scale fixed bed model reproducing the general area, spillway, lock, and powerhouse and a 1:31 scale model reproducing two spillway bays and the powerhouse have been constructed to determine the apron design, training wall dimensions, lock wall designs, method of operation necessary to provide satisfactory navigation conditions at the lock approaches, spillway capacity and other related hydraulic data. An additional model will be constructed to develop the lock design.

(f) Model studies started.

(3628) KINGSTON, GAS DUCT MODEL STUDIES.

(d) Experimental; for design.

(e) A comprehensive 1:16 scale model study of the gas duct system which carries gases to the stacks has been conducted to (1) reduce pressure losses in the duct system; (2) determine the effect of the flow distribution within the existing duct on the operation of the mechanical fly ash collector; and (3) determine a means of obtaining a uniform velocity distribution through the proposed electrostatic precipitators.

(f) Model studies completed.

(g) Flow conditions were improved and pressure losses reduced in the ducts by use of flow straighteners and vanes. The mechanical collector was found to be an efficient flow distributor and any non-uniformity in the flow approaching it would be removed. A uniform velocity distribution through the electrostatic precipitator was obtained by the use of perforated plates, suitable vaning and flow straighteners in the approach duct.

(h) Report in preparation.

(3629) LOW POWER VHF RADIO GAGES FOR REPORTING RAINFALL AND STREAM LEVEL DATA.

(d) Development.

(e) Transistorized radio components operating from nickel cadmium batteries charged by solar cells will be used. Data in binary coded decimal form will be transmitted by audio tone pulses. Long-term, unattended operation is a primary consideration in design.

Hydraulic Investigations Section.

(764) DETERMINATION OF SEDIMENT CARRIED IN SUSPENSION BY TENNESSEE RIVER AND TRIBUTARIES.

(d) Field investigation; basic research.

(e) To provide data for estimating effective life of storage reservoirs, and loss of soil from the land. Samples of water were collected periodically at stream gaging stations in the watershed, analyzed to determine the sediment content, and correlated with river discharge to determine the suspended sediment load at each station.

(h) Report in preparation.

(765) EVAPORATION IN THE TENNESSEE BASIN.

(d) Field investigation; applied research.

(e) To provide data for estimating reservoir losses and derive a general rule, applicable to the Basin, permitting computation of evaporation from pans at six locations in Basin, together with standard meteorological readings.

(h) "Precipitation in Tennessee River Basin," published in monthly and annual bulletins.

(768) PRECIPITATION IN TENNESSEE RIVER BASIN.

(d) Field investigation; basic research.

(e) A comprehensive study of rainfall and other weather phenomena for purposes of water dispatching and improvements in water control; storm studies as related to maximum precipitation, rainfall-runoff, spillway design and operation, etc.

(h) Monthly bulletin, "Precipitation in Tenn. River Basin." Also annual summary.

(769) RESERVOIR AND STREAM TEMPERATURES.

(d) Field investigation; basic research.
(e) Study of water utilization and water movement as concerns industrial plant locations and stream pollution. Variations in temperature from surface to bottom in reservoirs throughout the year are determined by soundings, and by continuous recording gages in natural streams.

(771) GALLERY DRAINAGE IN LARGE DAMS.

(d) Field investigations; design.
(e) Weirs are placed in main galleries and drainage measured as check on tightness and stability.

(785) SEDIMENTATION OF EXISTING RESERVOIRS.

(d) Field investigation; basic research.
(e) Selected ranges in reservoirs are probed and sounded, volumetric samples are collected and analyzed, quantity and distribution of sediment are computed to determine deposition by stream, probable life of reservoir, effect of sediment storage on navigation channels and sedimentation of downstream reservoirs, and probable sedimentation in future reservoirs.

(786) WATER TRAVEL IN NATURAL STREAMS.

(d) Field investigations; applied research.
(e) Sanitary and chemical changes in water during passage downstream are determined. A given mass of water is identified by electrical conductivity or chemical titration.
(f) No work done in recent years.

(787) MOVEMENT OF WATER THROUGH LARGE RESERVOIRS.

(d) Field investigation; applied research.
(e) Because of slow water travel, samples are collected by traverse through lake.
(f) No work done in recent years.
(g) Water entering a reservoir does not intermix with the rest of the reservoir, but remains as a density current as a result of the difference in temperature between the inflowing water and that in the reservoir. During certain seasons of the year, in Watts Bar Reservoir the cold water released from Norris Reservoir passes upstream along the bottom of the Emory River arm of the former reservoir.

Hydrology Section.

(779) MAXIMUM POSSIBLE PRECIPITATION IN TENNESSEE VALLEY.

(b) Cooperative with U. S. Weather Bureau.
(d) Theoretical; applied research.
(e) Hydrometeorological analysis of large storms with upward adjustments of controlling factors to maximum limits as applied to the Tennessee Valley and subdivisions.
(g) Results to be published as one of current series of hydrometeorological reports by the U.S.W.B. and cooperating agencies.

(780) PERIODIC EVALUATION OF GROUND-WATER STORAGE.

(d) Theoretical; operation.
(e) By analysis of current records of stream discharge, the volumes of runoff in groundwater and channel storage are determined for use in operation of multi-purpose reservoirs.
(g) Results reported monthly and weekly within the organization.

(2975) SUPPLY AND UTILIZATION OF WATER IN THE TENNESSEE VALLEY.

(c) Mr. Reed A. Elliot, Chief Water Control Planning Engineer, Tennessee Valley Authority, Knoxville, Tennessee.
(d) Assembly and analysis of basic information on water resources and uses, including field investigation of water uses for irrigation, mining operations, industry, and other purposes.
(e) All available data are being analyzed to present a comparison of the water resource of the area with the present and expected 1975 demand upon that resource. Problems of shortage and conflict are being developed and possible solutions suggested.
(g) No widespread shortages exist now or are expected by 1975, although some local shortages on smaller streams are anticipated.
(h) Report in preparation.

(3306) COOPERATIVE RESEARCH PROJECT IN WESTERN NORTH CAROLINA.

(b) Project conducted in cooperation with North Carolina State College of Agriculture and Engineering.
(d) To determine water-land relationships for some of the principal soils used for agricultural purposes in western North Carolina under important vegetative covers. Observations include rainfall, runoff, soil-moisture, potential evapotranspiration, and actual evapotranspiration.
(e) A statistically designed rotation of four covers on four small watersheds and a separate evaluation of deep-rooted crop on a fifth watershed.
(g) Results to date are summarized in annual reports on the project.
(h) "Soil Moisture Relations of Some Cultivated Mountain Soils of North Carolina," by M.J. Gilbert. Master's Thesis, North Carolina State College, Raleigh, 1953.
"A Simple Field Installation for Measuring Maximum Evapotranspiration," by M. J. Gilbert and C.H.M. van Bavel; Trans. AGU, December 1954.

(3307) PARKER BRANCH PILOT WATERSHED RESEARCH PROJECT.

(b) Project conducted in cooperation with North Carolina State College of Agriculture and Engineering.
(d) To determine the effects upon the hydrology of the watershed of an intensive farm development program designed to give the optimum economic well-being of the people using the land. Rainfall, runoff, suspended and deposited sediment are observed,

periodic soils-land-use inventories are made, and records of income summaries and public and private investments are maintained.

(e) Project activities are divided into calibration, action, and evaluation phases.

(g) Results to date are summarized in annual report on the project.

(h) "Economic Use of Agricultural Resources in Relation to Watershed Hydrology," by E. H. Lesesne and A. J. Coutu. Duplimat, TVA, June 1956.
"Economic and Hydrologic Developments in the Parker Branch Pilot Tributary Watershed Research Project," by E. L. Baum. Duplimat, TVA, October 1958.
"The Parker Branch Story." A sound motion picture prepared by North Carolina State College and Tennessee Valley Authority.

(3308) WHITE HOLLOW WATERSHED.

(d) To study the effect of changes in the vegetal cover on a watershed taken out of cultivation on the hydrologic factors of runoff and soil erosion.

(e) Continuous record from 1935 of rainfall, runoff, and suspended sediment, and periodic determination of vegetal cover indexes.

(g) During the 21-year period 1935-1955, the forest cover improvement in the watershed resulted in greater watershed protection with no measurable decrease in water yield, no change in volume of either surface runoff or ground-water runoff, marked reductions in summer peak rates of discharge with lesser reductions in winter rates, a prolongation of the period of draining of surface runoff from the channel system, and a 96 percent reduction in the sediment load.

(h) Report in preparation covering the vegetal cover inprovement influences upon hydrologic characteristics since 1935.

(3309) PINE TREE BRANCH WATERSHED.

(d) To determine the effects upon the hydrology of the watershed by reforestation and erosion control measures.

(e) Continuous record from 1941 of rainfall, runoff, ground water, and sediment loads.

(g) During the 10-year period 1941-1950, the cover improvement and erosion control in the watershed resulted in a decrease in surface runoff volumes and an increase in ground-water discharges, marked reductions in summer and winter peak flood discharges, a reduction in overland surface velocities, a prolongation of the period of draining of surface runoff from the channel system, and a 90 percent reduction in the sediment load.

H. G. ACRES AND COMPANY LIMITED, Hydraulic Laboratory.

Inquiries concerning the following projects should be addressed to Mr. I. W. McCaig, Hydraulic Engineer, H.G. Acres and Company Limited, Consulting Engineers, Niagara Falls, Canada.

(3312) THIRD MODEL OF INTAKE FOR CHUTE-DES-PASSES HYDRO-ELECTRIC DEVELOPMENT.

(b) Aluminum Company of Canada Limited.
(d) Experimental; for design.
(e) Hydraulic model tests on intake to determine size of floating grid required above entrance to intake tunnel to prevent vortex formation and drawdown of ice.
(f) Tests on series of floating grids completed.
(g) Model gave grid arrangements that would prevent vortex formation and drawdown of ice. Area of floating grid actually required will depend on model-prototype correlation.

(3316) TURBULENCE STUDY.

(b) Laboratory project.
(d) Experimental.
(e) Hydraulic model tests on conduit to determine pressure fluctuations at a 45-degree wye with the horizontal section flowing partly full and water entering from an inclined branch.
(f) Tests in progress.

(3630) FRICTION FACTOR TESTS IN LARGE PRESSURE CONDUITS, BERSIMIS NO. 1 DEVELOPMENT, QUEBEC, CANADA.

(b) Quebec Hydro-Electric Commission.
(d) Field investigation; design.
(e) Extension of data on friction factors in large diameter conduits. Tests were completed on a 31'-0" inside diameter concrete-lined supply tunnel. Head losses were measured over a length of 39,205 feet. Average velocities of flow were determined from efficiency tests on the turbines.
(f) Preliminary tests completed.
(g) Data were obtained for seven test discharges over a Reynolds Number range from 1.21×10^7 to 2.76×10^7. Friction factors computed from Darcy-Wiesbach equation ranged from 0.0111 to 0.0108, respectively.
(h) Report submitted to sponsor and paper delivered to the American Society of Civil Engineers.

(3631) BYPASS GATE FOR BERSIMIS NO. 1 DEVELOPMENT.

(b) Canadian Vickers Limited.
(d) Experimental; for design.
(e) Model tests on gate bottom to prevent vibration and cavitation.
(f) Tests completed.
(g) Tested, showed that at part gate openings control shifted from the gate bottom to the upstream face. Vibration associated with these unstable flow conditions could be cured by an inexpensive modification.
(h) Report submitted to sponsor.

(3632) INTAKE FOR CHUTE-DES-PASSES HYDRO-ELECTRIC DEVELOPMENT.

(b) Aluminum Company of Canada Limited.
(d) Experimental; for design.
(e) Prototype observations of vortex formation to determine model prototype correlation.
(f) Tests in progress.

UNIVERSITY OF ALBERTA, Hydraulics Laboratory.

(3633) STATISTICAL INTERPRETATION OF CANADIAN HYDROMETRIC DATA.

(b) Statistical investigation.
(c) Prof. T. Blench, Dept. of Civil Engineering, Univ. of Alberta, Edmonton, Alberta.
(d) Experimental and theoretical; basic research; master's thesis.
(e) Examine the statistical validity of prediction of flood frequencies from field data, with special reference to the logarithmic normal distribution, and prepare routine instructions.
(f) Completed.
(g) Confidence bands show no basic reason for preferring any of several common statistical fitting curves accepted in practice. The log normal has the practical advantages of simplicity in calculation and applicability to gauges referred to a mean bed level as datum.
(h) "Statistical Interpretation of Canadian Hydrometric Data," by R.W. Ansley. Part requirement for degree of M.Sc. from Univ. of Alberta, 1959.

(3634) SMALL RIVER MODELS.

(b) Laboratory project.
(c) Prof. T. Blench, Dept. of Civil Engineering, Univ. of Alberta, Edmonton, Alberta.
(d) Experimental and theoretical; basic research; master's thesis.
(e) Examine possibility of improved quantitative use of small river models; record data and chronology of river phenomena for future analysis; describe development of an assisted cut-off and of certain scour patterns at spurs and attempt to reproduce a bridge scour problem for prediction.
(f) Completed.
(g) Information useful to model makers contemplating quantitative predictions.
(h) "Small River Models," by R. Deeprose. Part requirement for degree of M.Sc. from Univ. of Alberta, 1959.

UNIVERSITY OF BRITISH COLUMBIA, Hydraulics Laboratory.

(1044) FRASER RIVER MODEL.

(b) Hydraulic model studies cooperative with the Department of Public Works of Canada, Vancouver, B.C.
(c) Prof. E.S. Pretious, Dept. of Civil Engineering, University of British Columbia,

Vancouver, Canada.

(d) Experimental project to aid engineering studies of navigation requirements involving river regulation and control.

(e) An outdoor erodible-bed tidal river model to study methods for improving and maintaining the navigation channels of the Fraser River estuary. Horizontal scale 1:600, vertical scale 1:70. The model occupies approximately 4 acres of the campus and represents the tide-water reaches of the lower Fraser River extending from its seaward end at the Strait of Georgia to the head of tide water at Sumas, a distance of approximately 60 miles. Pitt River and Pitt Lake (30 square miles in area) are subject to tidal influence and are included in the model. Natural tides and river discharges can be snychronized and simulated on the model and are controlled automatically by electronic servo-systems. Sand injection can be controlled automatically as a function of river discharge. Instantaneous water surface slopes can be obtained over the whole model by automatic electrically-recording point gauges situated at controlling points. Natural river sand of appropriate grain size is used for the bed material.

(h) Progress and technical reports submitted periodically to the Department of Public Works of Canada.

(2737) CURVED CHANNEL FLOW.

(b) Laboratory project financed by a National Research Council grant.

(c) Dr. A.W. Marris, Dept. of Civil Engineering, Univ. of British Columbia, Canada.

(d) Basic research.

(e) To investigate the effect of thickening and possible separation of the stable convex (inner wall) boundary layer on the radial distributions of temporal-mean peripheral velocity and static pressure for two-dimensional mean turbulent flow in curved channels.

(g) Initial experiments with two channels of widely differing width to mean radius ratios showed the following: (1) For the narrower channel the results approximated closely to the constant angular momentum distribution of potential flow cyclic irrotational motion, except in the immediate vicinity of the channel walls. (2) For the wide channel an anomaly in the velocity profile in the form of a superimposed jet of faster moving water was obtained and a corresponding low pressure trough. The latter phenomenon was ascribed to a convergence of the main stream due to thickening and perhaps separation of the convex (inner wall) boundary layer.
The investigation of the phenomenon was continued with a further series of channels. The boundary layers were studied with dye tracers. It appears that the degree of the anomaly is reduced when the radius of curvature of the channel is decreased owing to the greater stability of the inner wall boundary layer at the sharper curvature.

(h) "Radial Distributions of Temporal Mean Peripheral Velocity and Pressure for Fully Developed Turbulent Flow in Curved Channels," A.W. Marris: American Society of Mechanical Engineers: Paper No. 59 A-51.

(3635) HARBOUR BREAKWATER, WESTVIEW, B.C.

(b) Hydraulic model studies cooperative with the Dept. of Public Works of Canada, Vancouver, B.C.

(c) Prof. E.S. Pretious, Dept. of Civil Engineering, University of British Columbia, Vancouver, Canada.

(d) Experimental project to determine the best breakwater location for a new boat harbour and Government wharf at Westview, B. C.

(e) An undistorted fixed-bed model of the harbour and offshore ocean bed was constructed to a scale of 1:100. The area represented by the model measured 1,000 feet by 2,400 feet in the prototype. The model was installed in an outdoor testing basin 40 feet long and 20 feet wide. The wave generator consisted merely of a wood plank 12 inches wide, 2 inches thick and 15 feet long, hinged and thus free to rotate about its lower edge. The rocking movement producing the waves was facilitated by a long handle attached to the plank. Templates for controlling wave height and length were installed close to the generator and the generator was oriented to conform to the direction of the prevailing storm-wave trains. Prototype data on wave heights and lengths were rather limited and time was not available for a complete prototype investigation. Wave reflections in the model were eliminated by absorbing the wave trains in loose gravel placed strategically along the edges.

(f) Completed.

(g) The study was successful in directing the engineers towards a suitable breakwater alinement.

(h) A report will be prepared by the Department of Public Works, Canada.

(3636) FLOW OF WATER DOWN INCLINED SCREENS.

(b) Laboratory studies cooperative with the Department of Fisheries, Canada.

(c) Prof. E.S. Pretious, Dept. of Civil Engineering, Univ. of British Columbia, Vancouver, Canada.

(d) Experimental project to determine the cut-off point of water flowing down inclined screens for various heads, angles of inclination and screen openings.

(e) Two sizes of screens were tested, designated as 3/16 - 21 and 1/2 - 19 by the manufacturers, (Pedlar People Ltd.). Both of these screens are flattened expanded metal mesh with diamond-shaped openings. These screens are under consideration for use as inclined-plane screens for collecting downstream migrant juvenile fish at the Robertson Creek Test Flume. The tests were made on a full-scale model representing a longitudinal section of the flume and inclined screen.

(f) Completed.

(g) The information obtained from the laboratory tests is to be supplemented with further data from additional field tests to give more conclusive results regarding the cut-off point and also the suitability of the screens from a biological point of view.
(h) A report will be prepared by the Dept. of Fisheries, Canada.

(3637) FISH LADDER MODEL STUDIES.

(b) Laboratory project.
(c) Dr. Eugen Ruus, Asst. Prof. Dept. of Civil Engineering, University of British Columbia, Vancouver, Canada
(d) Experimental; applied research.
(e) To design an obstruction-free fish ladder at a steep slope. In the models tested the primary flow down a sloping plane was retarded by a secondary flow through nozzles directed up the plane.
(f) Completed as preliminary study.
(g) Suitable flow conditions were reached at a certain discharge from the nozzles and at a ladder slope of 1:5.
(h) A report is being prepared for the President's Committee on Research at U. B. C.

(3638) STUDIES OF THE WATER TEMPERATURE AND VELOCITY CHANGES DUE TO PROPOSED LOW HEAD DAMS ACROSS THE FRASER RIVER BETWEEN HOPE AND LYTTON.

(b) General study.
(c) Dr. Eugen Ruus, Dept. of Civil Engineering, University of British Columbia, Vancouver, Canada.
(d) Investigation; applied research.
(e) To find the influence of reservoirs created by these dams on water temperature and velocities during the period of upstream and downstream migration of fish.
(f) Preliminary study completed. (Further studies require extensive field data which is not yet available.)
(g) (a) A small or negligible change in the water temperature will result. (b) Minimum water velocities in the range of 0.5 - 0.7 ft/sec will occur in reservoirs during the upstream migration period. (c) A minimum velocity of 3 ft/sec will occur in reservoirs during the downstream migration period.
(h) A report is being prepared for the President's Committee on Research at U. B. C.

(3639) LARGE WATER LEVEL DISPLACEMENTS IN THE SIMPLE SURGE TANK.

(b) Laboratory project financed by a National Research Council grant.
(c) Dr. A. W. Marris, Asst. Prof., Dept. of Civil Engineering, University of British Columbia, Vancouver, B. C.
(d) Basic research.
(e) To investigate by means of a model the criteria for perpetual oscillations of constant amplitude, and for drainage, for a simple surge tank. The tank operates in conjunction with a turbine accepting constant hydraulic power for the case of sudden acceptance of full load from an initial zero flow condition.
(f) Completed.
(g) The theoretical results obtained from the complete non-linear equation of motion, indicating that the classical Thoma condition gives instability for non-infinitesimal load changes, were experimentally verified. The theoretical predictions of drainage at low conduit friction were also experimentally verified.
(h) "Large Water Level Displacements in the Simple Surge Tank," A. W. Marris, A.S.M.E. paper 58-A-29, to appear shortly in Basic Engineering Journal of the Trans. of the American Society of Mechanical Engineers.

(3640) PASSAGE OF YOUNG FISH THROUGH TURBINES.

(b) Laboratory project.
(c) Prof. J. F. Muir, Head, Dept. of Civil Engineering, Univ. of British Columbia, Vancouver, Canada.
(d) Theoretical and applied research to develop the hypothesis that mortality among young fish passing through turbines is caused mainly by exposure to cavitation.
(e) Cohoe fingerlings were subjected to pressures above and below atmospheric and to cavitation in special apparatus constructed in the laboratory.
(f) Project completed.
(h) "Passage of Young Fish Through Turbines," J. F. Muir, Journal of the Power Division, A.S.C.E. Vol. PO1, pages 23-46, Feb. 1959.

(3641) A HYDRAULIC ANALOGUE FOR PIPE NETWORK FLOW STUDIES.

(b) Laboratory project.
(c) Prof. J. F. Muir, Head, Dept. of Civil Engineering, Univ. of British Columbia, Vancouver, Canada.
(d) Theoretical and applied research.
(e) The apparatus consists of a network of Saran tubes representing the water distribution pipes of the first portion of the townsite developed by the Aluminum Co. of Canada, at Kitimat, B. C. Length and diameter scale ratios are 400:1 and 32:1 respectively.
(f) Project completed.
(g) Theoretical and experimental prototype-model rate of flow and friction loss relationships are discussed in a report being prepared.

(3642) THE EFFECT OF SUSPENDED SEDIMENT IN A STREAM IN THE PERMEABILITY OF THE STREAM BED.

(b) Laboratory flume studies cooperative with the International Pacific Salmon Fisheries Commission.
(c) Prof. E. S. Pretious, Dept. of Civil Engineering, Univ. of British Columbia, Vancouver, Canada.
(d) Experimental project to evaluate the effect of suspended sediments in natural streams on the permeability of the stream bed and

to assess the effect of variable stream velocity, bed roughness and gravel composition. One of the gravels tested was representative of gravels found in salmon-spawning stream beds.

(e) The gravel to be tested was placed in a laboratory flume and sediment laden water was circulated over the gravel for an arbitrary period of time. A fixed concentration of suspended sediment finer than 74 microns was maintained artificially. Five different gravel compositions were tested, each one being tested for three different surface configurations: (1) a relatively smooth flat bed; (2) a rough flat bed; and (3) a simulated salmon-spawning redd. Each surface configuration was tested under four different water velocities varying from 1 to 4 feet per second, representative of field condition. The concentration of suspended sediment was checked by measurements with a photoelectric cell and photolometer, previously calibrated for known concentrations. The permeability of the gravel bed was measured before and after each test by measuring the slope of the hydraulic grade line for the flow through the gravel.

(f) Completed.

(g) Suspended sediments which would not be deposited on the surface of the stream bed, reduce the permeability of the bed as a result of deposition within the gravel pores.

(h) A report will be prepared by the International Pacific Salmon Fisheries Commission.

THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO, Hydraulic Model Laboratory.

Inquiries concerning projects Nos. 3324 to 3326, incl., 3330, 3333, 3335 and 3643 to 3646 inclusive should be addressed to Mr. J.B. Bryce, Hydraulic Engineer, Hydraulic Generation Dept., 620 Univ. Ave., Toronto 2, Ontario, Canada.

(3324) ST. LAWRENCE RIVER MODEL - OGDENSBURG TO LEISHMAN'S POINT.

(b) Ontario Hydro and the Power Authority of the State of New York.

(d) Experimental; for design, development and operation.

(e) A 1:500 x 1:100 scale model of the St. Lawrence River between Ogdensburg and Leishman's Point, a distance of 16.1 miles, was constructed to determine the design of channel enlargements, the location of the Iroquois Control Dam and a plan of river control during construction of the St. Lawrence Power Project.

(f) Work is essentially completed but model is still active.

(g) Channel enlargements were developed which met the criteria stipulated by the International Joint Commission with respect to navigation and ice-forming velocities and the seaway navigation channel was located. The optimum arrangement and location for the Iroquois Control Dam was determined. A plan of river control during construction was developed.

(3325) ST. LAWRENCE RIVER MODEL - OGDEN ISLAND REACH.

(b) Ontario Hydro and Power Authority of the State of New York.

(d) Experimental; for design, development and operation.

(e) A 1:500 x 1:100 scale model of the St. Lawrence River reproducing 7.9 miles of the river between the towns of Iroquois and Morrisburg, was constructed to determine the design of channel enlargements and a plan of river control during construction of the St. Lawrence Power Project.

(f) Work is essentially completed but model is still active.

(g) Channel enlargements were developed which met the ice-forming criteria stipulated by the International Joint Commission and a satisfactory Seaway Navigation channel was located. A plan of river control during construction was developed.

(3326) ST. LAWRENCE RIVER MODEL - DEWATERING AND CLOSURE AREA.

(b) Ontario Hydro and Power Authority of the State of New York.

(d) Experimental; for design, development and operation.

(e) A 1:500 x 1:100 scale model of the St. Lawrence River reproducing 13.8 miles from Cat Island to below the powerhouses was constructed to develop plans for dewatering the Long Sault Dam and the powerhouse and to investigate conditions during the various stages of their construction.

(f) Work is completed but model is still active.

(g) Dewatering diversion channels were designed in detail and a plan of construction developed to preserve the necessary water levels for existing navigation and ensure adequate discharge capacity in the various stages of construction. Velocities in the Seaway Channel were also investigated. The Power Pool filling operation was investigated in detail.

(3330) ST. LAWRENCE POWER PROJECT - COMPREHENSIVE MODEL OF IROQUOIS CONTROL DAM.

(b) Ontario Hydro and the Power Authority of the State of New York.

(d) Experimental; for design, development and operation.

(e) A comprehensive 1:80 scale model, size 130 feet x 54 feet, of the complete Iroquois Control Dam was constructed including 1-1/2 miles of river channel and the downstream approach to the Iroquois lock. Its purpose was to determine a plan of river control during construction, a plan of dewatering, the velocities at the cofferdams during their construction, verification of the performance of energy-dissipating works, and the discharge calibration of the sluiceways.

(g) The dewatering plans were tested in the model, and the velocities and currents that would occur during construction of the

cofferdam were determined. A plan of river control was developed to maintain satisfactory levels and navigation conditions during the construction of the dam. The performance of the energy-dissipating works, which had been developed in a sectional model, was verified. A discharge calibration of the dam was obtained for the construction period and gate opening patterns developed. Performance data for operational use is still being obtained.

(3333) ST. LAWRENCE RIVER MODEL - TAILRACE AREA.

(b) Ontario Hydro and Power Authority of the State of New York.
(d) Experimental; for design.
(e) A 1:160 x 1:80 scale model reproducing 2.5 miles of the St. Lawrence River from above the powerhouses to below Polly's Gut, has been constructed to develop the design of an economic tailrace improvement and a suitable dewatering scheme.
(f) Work essentially completed but model still active.
(g) An economic tailrace enlargement was developed in the model. A cofferdamming plan to dewater much of the enlargement area was devised and the velocities at various stages observed.

(3335) RED ROCK GENERATING STATION MODEL.

(b) Ontario Hydro-Electric Power Commission.
(d) Experimental; for design.
(e) A 1:60 scale comprehensive model of the sluiceways, powerhouse and upstream and downstream river channel has been constructed to determine the dewatering arrangements for construction, velocities along cofferdams, energy-dissipating works at the sluices, the rating of the diversion sluices, ports and sluiceways, the tailrace excavation, and location of log slide.
(f) Work is essentially completed but model is still active.
(g) Hydraulic design is completed but model is active for problems during construction.

(3336) NIAGARA POWER PROJECT - NIAGARA RIVER MODEL.

(b) Power Authority of the State of New York.
(c) Mr. Asa George, Assistant Chief Engineer, Power Authority of the State of New York, The Coliseum Tower, 10 Columbus Circle, New York 19, New York.
(d) Experimental; for design and operation.
(e) An existing 1:250 x 1:50 scale model reproducing five miles of the Niagara River from Buckhorn Island to below the Cataracts is being used to determine the location in detail of the intakes for the Lewiston Generating Station, and to determine the necessary river excavation and improvement. This model was previously used by Ontario Hydro in the investigation of remedial works necessary for the preservation and enhancement of Niagara Falls and for the location of the intake for the Sir Adam Beck Generating Station No. 2 and the necessary river improvement.
(g) Work is largely completed but still in progress.

(3337) NIAGARA POWER PROJECT - MODEL OF INTAKES.

(b) Power Authority of the State of New York.
(c) Mr. Asa George, Assistant Chief Engineer, Power Authority of the State of New York, The Coliseum Tower, 10 Columbus Circle, New York 19, New York.
(d) Experimental; for design, development and operation.
(e) A 1:60 scale model of a portion of the Niagara River and the two large submerged gathering tube intakes for the Niagara Power Project has been constructed to develop the detailed hydraulic design of the intakes and to determine their operating performance.
(f) Work is completed and model removed.
(g) A design has been developed which will provide a minimum economic head loss and a minimum attraction for river ice.

(3643) HEADGATE MODEL.

(b) Ontario Hydro - Electric Power Commission.
(d) Experimental; applied research.
(e) A 1:24 scale model of a St. Lawrence powerhouse headgate and inlet water passage was built to investigate the hydraulic forces on gates with upstream and downstream skin plates under conditions of horizontal and sloping floors and submerged and free discharge conditions.

(3644) OTTER RAPIDS GENERATING STATION MODEL.

(b) Ontario Hydro-Electric Power Commission.
(d) Experimental; for design.
(e) A 1:72 scale comprehensive model of the sluiceways, powerhouse and upstream and downstream river channels has been constructed to determine the dewatering arrangement for construction, velocities at and along cofferdams, height location and slope of high water channel sluiceway training walls, the rating of the diversion ports and the sluiceways and the tailrace channel enlargement.

(3645) DISTORTION MODEL OF NIAGARA CONTROL STRUCTURE.

(b) Ontario Hydro-Electric Power Commission.
(d) Experimental; applied research.
(e) A sectional model of three of the 100-foot sluices in the Niagara River Control Structure were built of plexiglas so that the effects of distortion of a model structure might be investigated at distortion scales of 5:1, 2-1/2:1 and undistorted.

(3646) PENSTOCK WATER PASSAGES MODEL.

(b) Ontario Hydro-Electric Power Commission.
(d) Experimental.
(e) A 1:24 scale model of the water passages from the dam face to the circular penstock of an existing unit was built and variations of inlet width, pier length, roof slope, bed height and transition shape were investigated in order to reduce hydraulic

losses and to improve performance characteristics.

LASALLE HYDRAULIC LABORATORY.

Inquiries concerning the following projects should be addressed to Mr. E. Pariset, LaSalle Hydraulic Laboratory, 0250 St. Patrick Street, LaSalle, P. Q., Canada.

(2989) GENERAL STUDY OF THE LACHINE POWER PROJECT.

(b) Quebec Hydro-Electric Commission.
(d) Model tests to study the general hydraulic problems of the Lachine Power Project.
(e) A 1:125 vertical and 1:200 horizontal scale model is used to study different problems brought up by the construction of the project. Main tests are made to determine the velocities in the upstream part and the dredgings in order to have a good operation of the Power during the winter period.

(3341) FORMATION OF AN ICE-COVER IN FRONT OF A DAM.

(b) Quebec Hydro-Electric Commission.
(d) Basic research both theoretically and experimentally.
(e) Research of the basic laws governing the formation of an ice cover in front of a dam. Systematic tests were made in a flume with blocks of paraffin and polyethylene. Comparison of the results with those of ice covers in rivers in view of introducing the effect of ice cohesion.
(h) Some preliminary reports issued to sponsor. Publications in "Eight Congress 1959, Montreal, International Association for Hydraulic Research."

(3342) STUDY OF ICE SPILLWAYS FOR THE LACHINE POWER PROJECT.

(b) Quebec Hydro-Electric Commission.
(d) Theoretical and experimental; applied research.
(e) A model at a scale of 1:40 was built. Three types of spillways specially designed were tested for the passage of ice, a surface converging sluice, a vortex type spillway and a semi-circular shaft spillway. The vortex spillway was tested in a flume built in nature, at a scale of 1:5, on the St. Lawrence River.
(f) Completed.
(g) The semi-circular shaft spillway has outstanding characteristics.
(h) "Ice Spillways for Run-of-River Power Plants," E. Pariset and B. Michel, International Association for Hydraulic Research, Eight Congress, Montreal 1959. Report submitted to sponsor.

(3346) MODEL STUDY OF THE CARILLON POWER PROJECT.

(b) Quebec Hydro-Electric Commission.
(d) Experimental; applied research.
(e) The model of the Ottawa River at the Carillon Site was built at a scale of 1:110 to study the hydraulic problems pertaining to the construction and operation of the Carillon Project. Studies have been concentrated on: economical study of tailrace excavations, effect of surges caused by sudden load acceptance and rejection on navigation conditions at locks, protection of navigation dyke from waves caused by spillway in operation.

(3347) CARILLON LOCK MODEL STUDY.

(b) Quebec Hydro-Electric Commission.
(d) Experimental; applied research.
(e) A model at a scale of 1:20 has been used to obtain a final hydraulic design of the 200 feet by 45 feet lock operation with a 53 feet lift. A longitudinal culvert feeds a central T-shape culvert at the bottom central part of the lock which is surrounded by rectangular ports. All hydraulic problems pertaining to the operation of this lock were studied on the model.
(f) Completed.
(h) "Hydraulic study of the Carillon Lock," E. Pariset, G. Galiana, International Association for Hydraulic Research, 8th Congress, Montreal 1959. Report submitted to sponsor.

(3348) MODEL OF THE HART-JAUNE DEVELOPMENT INTERMEDIATE SITE.

(b) Montreal Engineering Co. Ltd.
(d) Experimental; applied research.
(e) The model at a scale of 1:25 represents the bottom tunnel through the earth dam that will also be used as temporary diversion for the project. The model was used to determine the capacity of the outlet, to study problems of cavitation, vibration and ventilation at the gate and to design a lip at the end of the tunnel that would give satisfactory jet operation.
(f) Completed.
(h) Report submitted to sponsor.

(3647) MODEL STUDY OF THE 40,000 C.F.S. DIVERSION STRUCTURE.

(b) Quebec Hydro-Electric Commission.
(d) Experimental; applied research.
(e) The hydraulic structure is mainly a spillway that will enable to divert, when required, 40,000 cfs from the St. Lawrence River by the St. Lawrence Seaway, thus bypassing the future Lachine Power Development. Operating curves, energy dissipation, design of downstream channel, passage of ice were studied on the 1:60 model.
(f) Completed.
(h) Report submitted to sponsor.

(3648) WHITEHORSE RAPIDS MODEL STUDIES.

(b) Montreal Engineering Co. Ltd.
(d) Experimental; applied research.
(e) The model was used to study fish facilities at the Power Project. A general model at a scale of 1:36 was used to study mainly the best arrangements of the entrance to

the fish transportation channel and for the fish-ladder. A smaller model at a scale of 1:16 was built in a laboratory flume to obtain the best hydraulic characteristics of rest pools for the fish.
(f) Completed.
(h) Report submitted to sponsor.

(3649) SNARE FALLS DEVELOPMENT MODEL STUDIES.

(b) Montreal Engineering Company, Ltd.
(d) Experimental, applied research.
(e) The model built at a scale of 1:40 represents the Snare Falls Storage Dam and its hydraulic structures. The operation of the upstream and downstream rock excavated canals, diversion tunnel, spillway, and intake structure were studied on the model.
(f) Completed.
(h) Report submitted to sponsor.

(3650) MONT LOUIS BREAKWATER.

(b) National Research Council.
(d) Experimental research.
(e) Study in a wave flume at a scale of 1:30 of the protective facing to be used for the repair of Mt. Louis Breakwater. Two solutions were submitted, one with 14 to 16 tons quarry stones and the other one with 8 tons tetrapods.
(f) Completed.
(h) Report submitted to sponsor.

(3651) THE DECARIE RAIMBAULT SEWAGE COLLECTOR.

(b) City of Montreal.
(d) Experimental research.
(e) Study on a model at a scale of 1:15 of solutions to increase the discharge of domestic water towards the interceptor. Study on the same model of a discharge meter for domestic and flood water.
(f) Completed.
(h) Report submitted to sponsor.

(3652) ROCKFIELD AUTOMATIC SEWAGE REGULATOR.

(b) City of Montreal.
(d) Experimental research.
(e) Study on a 1:24 scale model of the maximum curing discharge to be introduced at all times in this collector that would be compatible with its flow conditions. The solution being studied consists of automatic sewage regulators with downstream control, patented by the Laboratory (publications in IAHR, Eight Congress Montreal 1959).

(3653) WATER INTAKES AT THE MONTREAL FILTRATION PLANT.

(b) City of Montreal.
(d) Experimental research.
(e) Study on a 1:24 scale model of the elimination of vortices at these intakes.

(3654) RATE OF ICE PRODUCTION ON AN OPEN WATER SURFACE.

(b) Quebec Hydro-Electric Commission.
(d) Experimental research.
(e) Studies were made by means of an isothermic container of water whose surface was exposed to atmospheric conditions.
(g) First results are, on the average, in good agreement with the empirical formula of MacLachlan, but they give the effect of the wind, which is not always negligible.
(h) "Rate of ice production on an open water surface," R. Hausser and R. Beauchemin, Eighth Congress, International Association for Hydraulic Research, Montreal 1959. Preliminary report issued to sponsor.

(3655) CARILLON SPILLWAY.

(b) Quebec Hydro-Electric Commission.
(d) Experimental; applied research.
(e) The model built at a scale of 1:48 represents four of the fourteen bays of the Carillon Spillway and part of the Powerhouse. The model is used for spillway calibration and mainly to obtain an economic design of the downstream apron and lip that will prevent scouring at the lip caused by transverse currents produced by the low trajectory jet.

NATIONAL RESEARCH COUNCIL, Division of Mechanical Engineering.

Inquiries concerning projects Nos. 2041, 3352, 3355, 3356, 3361, 3656, 3657 inclusive, should be addressed to Dr. D.C. MacPhail, Director, Division of Mechanical Engineering, National Research Council, Montreal Road, Ottawa, Ontario, Canada.

(2041) ST. LAWRENCE RIVER MODEL - CORNWALL ISLAND REACH.

(b) St. Lawrence Seaway Authority.
(d) Experimental project for design and development.
(e) A 1:480 by 1:96 scale model of five miles of the St. Lawrence River in the vicinity of Cornwall, Ontario, was constructed to study navigation and power developments in the area.
(g) The model was used to study dredging procedures and, in particular, to determine the quantity of dredging required to maintain natureal discharge distribution about Cornwall Island. In addition, the effect of navigation improvements and channel modifications on the level of the tailwater at the powerhouse were studied.
(h) The project is complete and a final report is being prepared.

(3352) SAINT JOHN HARBOUR, NEW BRUNSWICK.

(b) Department of Public Works, Canada.
(d) Experimental; for harbour improvement.
(e) A hydrographic survey of the harbour was undertaken during the summer of 1958 and a partial survey during the spring of 1959 to determine the effect of the high discharge from the Saint John River. Automatic wave recorders were installed at two locations. On the basis of data obtained from these surveys, harbour improvements

will be recommended.
(f) The survey work has been completed and the data partly analyzed and plotted.
(g) The data show that a strong density current due to the river is the principal cause of shoaling in various parts of the harbour. Data are being analyzed in preparation for a final report.

(3355) PORT CARTIER HARBOUR.

(b) C. D. Howe Company, Montreal.
(d) Experimental; for design.
(e) A 1:120 scale model of a proposed harbour, to be constructed on the north shore of the St. Lawrence River, about 15 miles southwest of Seven Islands, was made to study the shape of the entrance and ship basin which would offer the best protection from waves.
(f) Project completed.
(g) An entrance channel and wave absorbing beaches have been designed to provide satisfactory conditions within the harbour.
(h) A report has been issued to the sponsor.

(3356) CHANDLER HARBOUR, QUEBEC.

(b) Department of Public Works, Canada.
(d) Experimental; for harbour improvement.
(e) A 1:100 scale model was constructed to determine the best arrangement of additional breakwaters required for harbour improvements.
(f) Project completed.
(g) Three different breakwaters were designed which would provide adequate protection to the harbour and allow for expansion of the harbour facilities.
(h) A final report has been issued to the sponsor.

(3361) RESEARCH ON THE DESIGN OF FISHING BOATS.

(b) Laboratory project.
(d) Experimental and theoretical to improve design.
(e) This project is being undertaken in cooperation with the Department of Fisheries, Canada, to obtain data for improving the design and operation of fishing boats.
(g) Tests on models and full scale craft indicate that many improvements to both boats and fishing gear are possible. A model incorporating a number of advanced features has shown promising results.
(h) Papers were presented at the Second World Fishing Boat Congress, Rome, 1959, and memoranda have been issued to the Department of Fisheries.

(3656) LOG CHUTE.

(b) Shawinigan Engineering Company, Limited, Montreal.
(d) Experimental; for improvements.
(e) A 1/12 scale model of a log chute having a crest width of 35 ft. and a chute width of 14 ft. was constructed to determine the changes required to the downstream end which has a slope of 1 3/4:1 to prevent damage from logs.
(f) Project completed.
(g) A reduced slope and shorter horizontal floor at the extreme end were sufficient to prevent logs from hitting the floor violently.
(h) A final report has been issued to the sponsor.

(3657) LUNENBURG HARBOUR, NOVA SCOTIA.

(b) Department of Public Works, Canada.
(d) Theoretical; for harbour improvement.
(e) Harbour improvements, consisting of two rubble-mound breakwaters, were suggested on the basis of wave refraction diagrams.
(f) Completed.
(g) A report has been issued to the sponsor.

ONTARIO AGRICULTURAL COLLEGE.

(2492) RUNOFF FROM SMALL WATERSHEDS.

(b) Laboratory project.
(c) Prof. D.F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Experimental; applied research.
(e) Relationship of precipitation and snow melt to runoff characteristics on four watersheds of twenty acres each, under various land use practices is being evaluated.
(g) Winter surface runoff from watersheds with good grass-legume cover is greater than from watersheds plowed during the winter season.

(2498) THE USE OF INFILTRATION DETERMINATIONS FOR RUNOFF ESTIMATES.

(b) Laboratory project.
(c) Prof. H.D. Ayers, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Experimental; basic research, for masters thesis.
(e) The purpose of the project is to evaluate the separate factors affecting infiltration and to develop a technique for runoff estimation on a watershed utilizing infiltration data.
(f) Suspended.
(g) Laboratory studies have indicated that the available storage in the sand media was a highly significant factor in the initial infiltration process. Regression equations have been developed in which mass infiltration is given as a function of time and particle dimension.
(h) "The Relationship of Mass Infiltration to Water Storage Capacity in Sand Media," by S. Redman, Thesis, on file Massey Library, Ontario Agricultural College.

(2739) PERMEABILITY OF THE SOIL IN THE FROZEN STATE.

(b) Laboratory project.
(c) Prof. H.D. Ayers, Ontario Agrigultural College, Guelph, Ontario, Canada.
(d) Experimental; basic research, for masters thesis.
(e) Air permeabilities will be obtained of

soils at various moisture content in the frozen state. The results will be used to determine if there is a correlation of moisture content and permeability of frozen soils on experimental watersheds.

(f) Suspended.

(g) Air permeabilities were determined on prepared samples. Regression equations expressing the permeability in Darcys as a function of the particle size and percent moisture saturation have been derived.

(h) "Relationship of Permeability to Percent Moisture Saturation in Sand Media in Frozen State," by N.G. Vered, Thesis on file Massey Library, Ontario Agricultural College.

(2740) MAIN TILE DRAIN SIZES FOR COMPOSITE DRAINAGE OF BROOKSTON CLAY SOIL.

(b) Laboratory project.

(c) Prof. F.R. Hore, Ontario Agricultural College, Guelph, Ontario, Canada.

(d) Field investigation; applied research.

(e) Discharge measurements from lateral tile drains in Brookston clay soil are being made to determine the proper drainage coefficient to use in the design of main tile drains and to determine the effect of lateral tile drain spacing on the drainage rate.

(g) Observations to date indicate that drainage rates in excess of one-half inch per day are fairly common. This is higher than the present design drainage coefficient. Tile drain outflow has been shown to occur at times when the soil moisture content was below field capacity.

(3363) HYDROLOGIC CHARACTERISTICS OF ORGANIC SOIL.

(b) Laboratory project.

(c) Prof. R.W. Irwin, Ontario Agricultural College, Guelph, Ontario, Canada.

(d) Field investigation; applied research.

(e) The study is being carried out to establish criteria to be used in the development and operation of the water control program for organic soils. In the investigation, an attempt will be made to establish a hydrologic water balance for the field area by measuring, recording and analyzing so far as possible evaporation, seepage, transpiration, precipitation, water table elevation and ground water discharge through tile drains.

(3658) THE RESISTIVITY METHOD FOR GROUND WATER EXPLORATION.

(b) Laboratory project.

(c) Prof. D.F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.

(d) Field investigation; applied research.

(e) Resistivity traverses are to be carried out adjacent to existing wells and borings, for which logs are available. An attempt will be made to evaluate the resolution of changes in subsurface material by resistivity measurements in the glaciated area of the province.

(3659) DROUGHT FREQUENCY ANALYSIS.

(b) Laboratory project.

(c) Prof. H.D. Ayers, Ontario Agricultural College, Guelph, Ontario, Canada.

(d) Experimental; development.

(e) The objective of this analysis is to determine the frequency of droughts in southwestern Ontario. The information is to be used in determining the irrigation requirements for specific crops on various soil types. Water budget techniques are to be used and applied to actual meteorological observations in order to calculate the frequency and magnitude of irrigation requirements. Irrigation needs are to be supplied in the water budget computations at predetermined levels of soil moisture deficiency. Water budgets have been computed by the Thornthwaite method and it is anticipated that computations will also be carried out using the Penman method.

(g) Calculated irrigation needs are in excess of calculated moisture deficits because of the necessity for starting irrigation prior to the occurrence of the moisture deficit of a magnitude creating a drought condition. It is expected that this information will enable a determination of the economic feasibility of irrigation in various regions of Ontario.

(3660) RAINFALL DEPTH-AREA-INTENSITY RELATIONSHIPS IN CENTRAL ONTARIO.

(b) Laboratory project.

(c) Prof. D.F. Witherspoon, Ontario Agricultural College, Guelph, Ontario, Canada.

(d) Field investigation; applied research.

(e) A dense network of standard and recording rain gauges has been established in the Guelph area with the cooperation of the Meteorological Branch, Department of Transport. The network is over an area of approximately 12 square miles with an average gauge density of 1 per square mile. The purpose of this study is to obtain more detailed information on precipitation characteristics from some summer thunder storms for use in the hydrologic design for small drainage basins.

(g) Data have been collected for one summer only. Several thunder storms occurred most of which were highly variable in their areal distribution patterns.

(3661) HYDROLOGIC FACTORS AFFECTING BRIDGE DESIGN.

(b) Laboratory project in cooperation with Ontario Dept. of Highways and University of Toronto.

(c) Prof. F.R. Hore, Ontario Agricultural College, Guelph, Ontario, Canada.

(d) Experimental; masters thesis.

(e) The purpose of this project is to develop satisfactory design criteria for bridges and culverts based on watershed runoff relationships for Ontario. Frequency analyses of existing stream flow data for the province are being carried out. An attempt is being made to correlate watershed

characteristics with peak discharge relationships.

(g) A master's thesis will be completed in 1960 and the report will be published at that time.

(3662) POTENTIAL EVAPOTRANSPIRATION AND CONSUMPTIVE USE OF WATER BY CROPS.

(b) Laboratory project.
(c) Dr. K. M. King, Dept. of Soils, Ontario Agricultural College, Guelph, Ontario, Canada.
(d) Field investigation; basic research.
(e) The purpose of this investigation is to evaluate the factors influencing evapotranspiration by the use of a specially designed floating lysimeter. Temperature and air velocity gradients in addition to radiation measurements are taken over a growing crop where a satisfactory moisture supply is maintained by the use of irrigation.
(g) The correlation coefficient between evapotranspiration calculated by the vertical heat budget and as measured by the floating lysimeter was 0.98. The percentage of net radiation used for evapotranspiration was 80 to 90 percent on a daylight basis and about 100 percent on a 24-hour day basis. These values apply to a corn crop grown during 1958.

QUEEN'S UNIVERSITY, Hydraulic Laboratory.

(2044) ECONOMICAL CONSTRUCTION OF SAFE PULPWOOD HOLDING GROUNDS.

(b) Pulp and Paper Institute of Canada Ltd., 3420 University Street, Montreal, Quebec, Canada.
(c) Prof. R. J. Kennedy, Department of Civil Engineering, Queen's Univ. at Kingston, Ontario, Canada.
(d) Applied research; experimental, field and laboratory investigation.
(e) Field measurements of forces acting on various holding grounds.

(3364) LITTORAL DRIFT AND ITS EFFECT ON THE HARBOURS ON THE NORTH SHORE OF LAKE ONTARIO.

(b) The National Research Council of Canada.
(c) Dr. Arthur Brebner, Department of Civil Engineering, Queen's Univ. at Kingston, Ontario, Canada.
(d) Experimental and field; basic and applied research.
(e) Field and laboratory examination of silting due to littoral drift.
(h) "Littoral Drift in Lake Ontario Harbours," Brebner and Kennedy, Journal of the Engineering Institute of Canada, Vol. 42, No. 9, September 1959.

(3365) THE HYDRAULIC EFFICIENCY OF NEW AND USED ALUMINUM PIPE AND TUBING.

(b) Aluminum Laboratories Limited, P.O. Box 84, Kingston, Ontario, Canada.
(c) Dr. A. Brebner, Department of Civil Engineering, Queen's University at Kingston, Ontario, Canada.
(d) Field investigation of friction factor up to N_R 2×10^6.
(f) Suspended.
(h) "The Prediction of Flow-Rates in Aluminum Pipe," Brebner and Campbell, Transactions of the Engineering Institute of Canada, Vol. 3, No. 1, April 1959 (Reprints available from (b)).

(3663) SECONDARY FLOW IN OPEN CHANNELS.

(c) Prof. R. J. Kennedy, Department of Civil Engineering, Queen's Univ. at Kingston, Ontario, Canada.
(d) Laboratory investigation for doctoral thesis.
(e) An investigation into the mechanism of secondary flow.

(3664) PERIODICAL GRAVITY WAVE MOTION ON DISCONTINUITIES AS APPLIED TO HARBOUR ENGINEERING.

(c) Dr. Bernard LeMéhauté, Department of Civil Engineering, Queen's Univ. at Kingston, Ontario, Canada.
(d) Theoretical analysis of gravity waves on a discontinuity.
(e) Experimental verification of empirical relations.

(3665) THE EFFECT OF AIR-BUBBLING BREAKWATERS ON WAVE MASS TRANSPORT.

(b) The National Research Council of Canada.
(c) Dr. A. Brebner, Dept. of Civil Engineering, Queen's University at Kingston, Ontario, Canada.
(d) Experimental laboratory investigation.
(e) To establish the relation between wave attenuation and mass transport attenuation across an air-bubble curtain.

(3666) CRITICAL MASS-TRANSPORT VELOCITIES FOR PARTICLES OF VARIOUS SIZES.

(b) The National Research Council of Canada.
(c) Dr. A. Brebner, Dept. of Civil Engineering, Queen's Univ. at Kingston, Ontario, Canada.
(d) Experimental laboratory investigation.
(e) To establish the critical velocities of particles found in Lake Ontario harbours.

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