

# Hydraulic Research in the United States

1956



United States Department of Commerce

National Bureau of Standards

Miscellaneous Publication 218

## **NBS PUBLICATIONS . . . . .**

### **Capacities of Plumbing Stacks in Buildings**

A study of the maximum load that can be brought from a horizontal branch into a stack down which water is being discharged from fixtures on higher floors. This phase of a projected complete investigation, intended to make drainage design more economical, is concentrated on the drainage stack and the building drain. The report describes tests to determine terminal velocities and terminal lengths in stacks as well as tests on stacks and drains. It analyzes stack conditions in a multistory building and suggests applications of the study's results.

Order NBS Building Materials and Structures Report 132, Capacities of Plumbing Stacks in Buildings, 28 pages. Price: 25 cents.

### **Self-Siphonage of Fixture Traps**

An explanation of the extent to which trap-seal losses are influenced by such considerations as the diameter of the trap and the depth of trap seal, the diameter and slope of the fixture drain, the type of vent fitting used, and the rate of discharge of the fixture. The report shows the importance of standardizing fixture traps and the hydraulic characteristics of plumbing fixtures, such as lavatories, sinks, and trays; and it makes recommendations for use by code-writing authorities.

Order NBS Building Materials and Structures Report 126, Self-Siphonage of Fixture Traps, 32 pages. Price: 20 cents.

### **Wet Venting of Plumbing Fixtures**

An account of extensive research and laboratory tests to determine the feasibility of using vented one- and two-story plumbing drainage systems. The conclusions reached regarding satisfactory operation limits for wet-vented fixtures are given in a form suitable for inclusion in plumbing codes. The report describes test procedures and explains results. Diagrams, tables, and graphs are included showing the trap-seal losses that occur under various conditions of wet venting and indicating the maximum permissible unvented lengths of fixture drain.

Order NBS Building Materials and Structures Report 119, Wet Venting of Plumbing Fixtures, 27 pages. Price: 25 cents.

### **Stack Venting of Plumbing Fixtures**

A report describing tests involving use of pipes, traps, connections, and vents made of transparent plastics which make all flow phenomena visible. Similar tests were made with regular metal fittings to obtain comparative data and to permit correlation of results. The report discusses and interprets results,

# Hydraulic Research in the United States

1956

(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.

Projects are numbered chronologically, and the number once assigned is repeated for identification purposes until a project is completed. Numbers commencing with 2255 refer to projects which are reported for the first time. All projects are in active state, unless otherwise noted under (f).

It is emphasized that the National Bureau of Standards does not have in its files 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 Prof. J. Th. Thijssse, 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 bulletin entitled "Directory of Hydromechanics Research Projects in the United States Related to Naval Architecture and Marine Engineering" is prepared by the Hydrodynamics Committee of the Society of Naval Architects and Marine Engineers. Copies may be obtained by addressing the Secretary of the Society, Captain W. N. Landers, Society of Naval Architects and Marine Engineers, 74 Trinity Place, New York 6, N. Y.

A. V. Astin, Director

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## Key to Projects

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

# LIST OF CONTRIBUTING LABORATORIES

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ARKANSAS, UNIVERSITY OF	1
College of Agriculture, Fayetteville, Arkansas	
Prof. Kyle Engler, Head, Department of Agricultural Engineering	
ARKANSAS, UNIVERSITY OF	1
College of Engineering, Fayetteville, Arkansas	
Dean George F. Branigan, Head	
BALDWIN-LIMA-HAMILTON CORPORATION, THE	1
Hydraulic Turbine Laboratory, Philadelphia 42, Pa.	
Mr. C. H. Diehl, Supervisor of Hydraulic Turbine Laboratory	
BEACH EROSION BOARD (see U. S. Government)	
BONNEVILLE HYDRAULIC LABORATORY (see U. S. Government)	
CALIFORNIA INSTITUTE OF TECHNOLOGY	2
Civil Engineering Department, Pasadena 4, Calif.	
CALIFORNIA INSTITUTE OF TECHNOLOGY	3
Hydrodynamics Laboratory, Pasadena 4, Calif.	
CALIFORNIA, UNIVERSITY OF	7
College of Agriculture, Davis, Calif.	
Prof. F. J. Veihmeyer, Directing Head, Department of Irrigation	
CALIFORNIA, UNIVERSITY OF	10
College of Agriculture, Los Angeles 24, Calif.	
Prof. M. R. Huberty, Chairman, Dept. of Irrigation and Soils	
CALIFORNIA, UNIVERSITY OF	10
College of Engineering, Berkeley 4, Calif.	
Dr. H. A. Einstein, Professor of Hydraulic Engineering	
CALIFORNIA, UNIVERSITY OF	17
Department of Engineering, Los Angeles 24, Calif.	
Mr. Walter C. Hurty, Vice Chairman, Institute of Industrial Cooperation	
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Research Foundation for Cross-Connection Control, Los Angeles 7, Calif.	
Dr. Robert E. Vivian, Director	
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Department of Civil Engineering, Pittsburgh 13, Pa.	
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Department of Civil Engineering, Fort Collins, Colo.	
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Civil Engineering Department, Golden, Colo.	
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Department of Civil Engineering, Boulder, Colo.	
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Department of Civil Engineering, New York 27, N. Y.	
Dr. Richard Skalak, Fluid Mechanics Laboratory	

CONNECTICUT, UNIVERSITY OF	28
Hydraulic Research Laboratory, Box U-37, Storrs, Conn.	
Prof. Victor Scottron, Associate Professor of Civil Engineering	
CONNECTICUT, UNIVERSITY OF	29
Soils Mechanics Laboratory, Box U-37, Storrs, Conn.	
Prof. Edward V. Gant, Associate Professor of Civil Engineering	
CORNELL UNIVERSITY	30
Department of Agricultural Engineering, Ithaca, N. Y.	
Prof. O. C. French, Head of Department	
CORNELL UNIVERSITY	30
School of Civil Engineering, Ithaca, N. Y.	
Dr. N. A. Christiansen, Director	
Prof. Andre L. Jorissen, Head, Dept. of Hydraulics and Hydraulic Engineering	
DAVID TAYLOR MODEL BASIN (see U. S. Government)	
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Engineering Subdivision, Box 232, Urbana, Ill.	
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Engineering Research Subdivision, Box 117, Peoria, Ill.	
Dr. Max Suter, Head	
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Department of Public Works and Buildings, 201 West Monroe St., Springfield, Ill.	
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Department of Civil Engineering, 320 West Engineering Building, Ann Arbor, Mich.	
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Experimental Naval Tank, 326 West Engineering Building, Ann Arbor, Mich.	
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OKLAHOMA A AND M COLLEGE Department of Agricultural Engineering, Stillwater, Okla. Prof. E. W. Schroeder, Head	80
PELTON WATER WHEEL COMPANY, THE 2929 - 19th Street, San Francisco 10, Calif. Mr. L. M. White, Manager of Engineering Mr. R. M. Bacchi, Development Engineer	80
PENNSYLVANIA STATE UNIVERSITY Hydraulics Laboratory, University Park, Pa. Prof. Sam Shulits, Head	80



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Hydrodynamics Test Facility, 1048 Potomac St., N. W., Wash. 7, D. C.	
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74 Trinity Place, New York 6, N. Y. Capt. W. N. Landers, Secretary	
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Experimental Towing Tank, 711 Hudson St., Hoboken, N. J. Dr. Kenneth S. M. Davidson, Director	
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17 - 19 Union Square West, New York 3, N. Y. Dr. Jack Kotik	
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Department of Civil Engineering, Seattle 5, Wash.	
Prof. R. B. van Horn, Acting Director	
WATERWAYS EXPERIMENT STATION (see U. S. Government)	
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Rear Admiral E. H. Smith, U. S. Coast Guard (ret), Director	
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U. S. GOVERNMENT AGENCIES	
DEPARTMENT OF AGRICULTURE	
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Soil and Water Conservation Research Branch, Beltsville, Md.	
Dr. C. H. Wadleigh, Chief	
DEPARTMENT OF AGRICULTURE	
FOREST SERVICE	
California Forest and Range Experiment Station	119
P. O. Box 245, Berkeley 1, Calif.	
Dr. George M. Jemison, Director	
Central States Forest Experiment Station	121
111 Old Federal Building, Columbus 15, Ohio	
Mr. W. B. McGinnies, Director	
International Forest and Range Experiment Station	122
Ogden, Utah	
Mr. Reed W. Bailey, Director	
Northwestern Forest Experiment Station	123
102 Motors Avenue, Upper Darby, Pa.	
Dr. Ralph W. Marquis, Director	
Pacific Northwest Forest and Range Experiment Station	125
Post Office Box 4039, Portland 8, Ore.	
Mr. R. W. Cowlin, Director	

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221 Forestry Building, Fort Collins, Colo.  
Mr. Raymond Price, Director
- Southeastern Forest Experiment Station 128  
P. O. Box 2570, Asheville, N. C.  
Mr. E. L. Demmon, Director

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- Bonneville Hydraulic Laboratory 132  
628 Pittock Block, Portland 5, Ore.  
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- Jacksonville District 136  
575 Riverside Avenue, Jacksonville 4, Fla.  
The District Engineer
- Los Angeles District 137  
P. O. Box 17277 Foy Station, Los Angeles 17, Calif.  
The District Engineer
- St. Paul District 138  
1217 U. S. Post Office and Custom House, St. Paul 1, Minn.  
The District Engineer
- Waterways Experiment Station 140  
P. O. Box 631, Vicksburg, Miss.  
The Director

## DEPARTMENT OF COMMERCE

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Hydraulics Branch, Wash. 25, D. C.  
Mr. Carl F. Izzard, Chief
- NATIONAL BUREAU OF STANDARDS 156  
National Hydraulic Laboratory  
Wash. 25, D. C.
- WEATHER BUREAU 158  
Hydrologic Services Division, Wash. 25, D. C.  
Mr. William E. Hiatt, Chief

## DEPARTMENT OF THE INTERIOR

- GEOLOGICAL SURVEY 162  
Washington 25, D. C.  
Mr. R. W. Davenport, Acting Chief Hydraulic Engineer

## DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION 168  
Branch of Design and Construction  
Denver Federal Center, Denver, Colo.  
Mr. L. N. McClellan, Chief Engineer

## DEPARTMENT OF THE NAVY

DAVID TAYLOR MODEL BASIN 175  
Washington 7, D. C.  
The Commanding Officer and Director

NAVAL BOILER AND TURBINE LABORATORY 187  
Philadelphia 12, Pa.  
The Commanding Officer and Director

NAVAL ORDNANCE TEST STATION 187  
Pasadena Annex, 3202 E. Foothill Blvd., Pasadena 8, Calif.  
The Commander, Attn. Code P807

OFFICE OF NAVAL RESEARCH 188  
Washington 25, D. C.

## TENNESSEE VALLEY AUTHORITY

HYDRAULIC DATA BRANCH 190  
Knoxville, Tenn.  
Mr. Albert S. Fry, Chief

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## CANADIAN LABORATORIES

ALBERTA, UNIVERSITY OF 198  
Hydraulics Laboratory, Edmonton, Alberta, Canada  
Prof. T. Blench, Head, Department of Civil Engineering

BRITISH COLUMBIA, UNIVERSITY OF 198  
Hydraulics Laboratory, British Columbia, Vancouver, Canada  
Prof. H. C. Gunning, Dean, Faculty of Applied Science

MONTREAL, ECOLE POLYTECHNIQUE DE 199  
Hydraulics Laboratory, 1430 Rue Saint-Denis, Montreal 18, Canada  
Prof. Raymond Boucher, Head, Dept. of Hydraulic Engineering

NATIONAL RESEARCH COUNCIL 200  
Division of Mechanical Engineering, Montreal Road, Ottawa, Canada  
Mr. J. H. Parkin, Director

ONTARIO AGRICULTURAL COLLEGE 202  
Agricultural Engineering Department, Guelph, Canada  
Prof. C. G. E. Downing, Head

QUEEN'S UNIVERSITY 203  
Hydraulics Laboratory, Kingston, Ontario, Canada  
Prof. R. J. Kennedy, Directing Head, Faculty of Applied Science

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UNIVERSITY OF ARKANSAS, Agricultural Engineering Department.

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

- (b) Arkansas Agricultural Experiment Station, University of Arkansas, Fayetteville, Arkansas.
- (c) Prof. Kyle Engler, Head of Agricultural Engineering Department, University of Arkansas, Fayetteville, Arkansas.
- (d) Basic and applied research.
- (e) Observations in test wells are established immediately surrounding a 16-inch vertical recharge well. The test wells will permit sampling for chemical qualities and bacterial contamination, as well as permitting measurements of hydrologic characteristics of the aquifer. Preparations are under way for using treated and filtered surface water as the recharge media. The object of the project is to determine feasibility of storing irrigation water supplies in an aquifer by use of wells.
- (g) The project is not developed to a point for satisfactory reporting of results.
- (h) "Changes in Water Levels in Deposits of Quaternary Age in Eastern Arkansas from 1938 to 1953", H. B. Counts and Kyle Engler, Report Series 42, 11 pp., June 1954.

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UNIVERSITY OF ARKANSAS, College of Engineering.

(2256) STUDY OF EFFECT OF GRAIN SIZE ON QUALITY IN WATER FILTRATION.

- (c) Prof. Loren R. Heiple, Head, Civil Engineering Department, University of Arkansas, Fayetteville, Arkansas.
- (d) Field investigation concerning operation and development.
- (e) Investigation of water filtration in regard to effect of sand and gravel particle size upon turbidity and bacterial removal.
- (g) Stage of investigation is too early for report of results.

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

Inquiries concerning Projects Nos. 271, 1814, 2049, 2050, and 2257, should be addressed to Mr. C. H. Diehl, Hydraulic Turbine Laboratory, Baldwin-Lima-Hamilton Corporation, 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.

(1814) PUMP MODELS.

- (b) Laboratory project.
- (d) Experimental; applied research.
- (e) Model pumps of the centrifugal and axial flow types have been tested to determine characteristics of efficiency, horsepower, discharge, cavitation, thrust, runaway speeds, blade and wicket gate torques.

The Baldwin-Lima-Hamilton Corporation  
California Institute of Technology

(2049) DRAFT TUBE INVESTIGATIONS.

- (b) Laboratory project.
- (d) Experimental; applied research.
- (e) Draft tubes of various lengths, widths, heights, and flares have been tested. The purpose was to determine the effects of dimensional changes on the performance of various propeller type turbines.
- (g) The results will provide information that will extend the application of propeller type turbines.

(2050) PUMP TURBINE LABORATORY.

- (b) Laboratory project.
- (d) Experimental; applied research.
- (e) Various pump turbine designs have been designed and manufactured, and will be installed and tested in our newly completed pump turbine laboratory. The performance characteristics of efficiency, horsepower, cavitation, discharge, runaway speeds, thrust, gate and blade torques will be obtained on models of prototype designs.

(2257) FIXED BLADE PROPELLER FOR BARNHART ISLAND POWER PLANT, ST. LAWRENCE SEAWAY PROJECT.

- (b) Power Authority of the State of New York.
- (d) Experimental; applied research for design.
- (e) A completely homologous model was tested through the entire operating range expected on the prototype installation.
- (f) Completed.
- (g) Results of the model tests indicate that all operating requirements for the prototype were generously exceeded.

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CALIFORNIA INSTITUTE OF TECHNOLOGY, Civil Engineering Department.

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

- (b) The United States Public Health Service.
- (c) Dr. A. C. Ingersoll, Assistant Professor of Civil Engineering, California Institute of Technology, Pasadena, California.
- (d) Experimental, directed from theoretical considerations. Fundamental study on mechanics of flocculent suspensions will be doctoral thesis material for Mr. R. T. McLaughlin.
- (e) The purpose of the work is to investigate the resuspension of flocculent settled material from the sludge bed in settling tanks and to formulate the laws governing equilibrium between sedimentation and resuspension, (b) to minimize this resuspension, to improve the efficiency of settling tanks, (c) to test the methods evolved from theory in laboratory models and in a full-scale settling tank, and (d) to evaluate current parameters of efficiency for settling tanks and to provide laboratory apparatus that will provide better measures of performance. First trial elutriation meter for efficiency measurement and laboratory apparatus for study of flocculent suspensions have been built.

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## CALIFORNIA INSTITUTE OF TECHNOLOGY, Hydrodynamics Laboratory.

Inquiries concerning projects should be addressed to the following, all at Hydrodynamics Laboratory, California Institute of Technology, Pasadena 4, California.

Nos. 6, 805, 2259.....to Prof. Vito A. Vanoni  
Nos. 15, 804, 1815.....to Dr. Robert D. Knapp  
Nos. 16, 1301, 2052, 2053, 2054.....to Mr. Robt. W. Kermeen  
No. 279.....to Prof. A. J. Acosta  
Nos. 803, 1548, 1816, 1817.....to Prof. Milton S. Plessett  
No. 2051.....to Prof. A. Hollander

## (6) MECHANICS OF SEDIMENT TRANSPORTATION.

- (b) Cooperative with the U. S. Army, Corps of Engineers, Missouri River Division.
- (d) Experimental and theoretical; basic research.
- (e) To investigate the mechanics of transportation of sediment by flowing fluids, including studies of the suspended load as well as the bed load phases of the problem.
- (h) "Mechanics of Streams with Movable Beds of Fine Sand", Proceedings Amer. Soc. of Civil Engineers, Vol. 81, Separate No. 668.

## (15) STUDIES OF CAVITATION PHENOMENA.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental; basic research.
- (e) Details of fixed void type cavitation have been studied experimentally in the water tunnel. Special emphasis has been given to characteristics of the interface, dynamics of entrainment at downstream end of cavity, and behavior of entrained voids.
- (g) Further studies of cyclic process in fixed cavitation show that (a) cycle period can be estimated by momentum considerations. Period varies over wide ranges for same guiding surface and same velocity as function of cavitation parameter. (b) At very low flow velocity cycle is poorly defined, probably due to effects of friction of guiding surface on re-entrant flow.
- (h) "Further Studies of the Mechanics and Damage Potential of Fixed Type Cavities". Presented at Symposium on Cavitation in Hydrodynamics, National Physical Laboratory, Teddington, England, September 14-17, 1955.

## (16) HYDRODYNAMIC FORCES ON SUBMERGED BODIES.

- (b) Bureau of Ordnance and Office of Naval Research, Department of the Navy.
- (d) Experimental; basic and applied research.
- (e) Hydrodynamic forces on bodies of different shapes and designs are measured in water tunnels and a vertical drop tank. The important steady state and damping force coefficients are obtained. These data are used to predict full scale behavior.
- (h) "Water Tunnel and Drop Tank Tests of a Streamlined Body of Revolution for the Naval Ordnance Test Station, Pasadena, California", by R. W. Kermeen and R. L. Waid, California Institute of Technology Hydrodynamics Laboratory Report No. E-61, December 1954. "Hydrodynamic Forces on Prolate Ellipsoidal Bodies", by John A. Stallkamp, California Institute of Technology Hydrodynamics Laboratory Report No. E-35.4, September 1955.

## (279) FLOW IN ROTATING CHANNELS.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental and theoretical.
- (e) Studies on the internal and over-all flow behavior and hydrodynamic performance of centrifugal pump impellers, volutes and axial flow pumps.

- (h) "Effect of the Volute on Performance of a Centrifugal Pump Impeller", by R. D. Bowerman, California Institute of Technology, Hydrodynamics Laboratory Report No. E-19.7, March 1955.  
 "An Experimental Study of Centrifugal Pump Impellers", by A. J. Acosta and R. D. Bowerman, California Institute of Technology Hydrodynamics Laboratory Report No. E-19.8, August 1955.  
 "A Note on Partial Cavitation of Flat Plate Hydrofoils", by A. J. Acosta, California Institute of Technology Hydrodynamics Laboratory Report No. E-19.9, October 1955.  
 "The Design of Axial Flow Pumps", by R. D. Bowerman, ASME Paper 55-A-127 presented at the Annual Meeting 1955, Chicago.
- (803) DYNAMICS OF CAVITATION AND CAVITATION DAMAGE.
- (b) Office of Naval Research, Department of the Navy.
  - (d) Theoretical and experimental; basic research.
  - (e) Dynamic behavior of cavitation bubbles; theoretical and experimental studies of cavitation damage.
  - (h) "Techniques for Pressure Pulse Measurements and High-Speed Photography in Ultrasonic Cavitation", A. T. Ellis, California Institute of Technology Hydrodynamics Laboratory Report No. 21-20, June 1955.  
 "The Production of Accelerated Cavitation Damage by an Acoustic Field in a Cylindrical Cavity", A. T. Ellis, California Institute of Technology Hydrodynamics Laboratory Report No. 21-14, September 1954. Reprinted in the Journal of the Acoustical Society, Vol. 27, No. 5, pp. 913-921, September 1955.  
 "A Photoelastic Study of Strain Waves Caused by Cavitation", George W. Sutton, California Institute of Technology Hydrodynamics Laboratory Report No. 21-21, in press.  
 "On the Mechanism of Cavitation Damage", M. S. Plesset and A. T. Ellis, Transactions ASME, Vol. 77, No. 7, pp. 1055-1065, October 1955.
- (804) THE EFFECT OF PHYSICAL CHARACTERISTICS OF LIQUID ON THE INCEPTION OF CAVITATION.
- (b) Office of Naval Research, Department of the Navy.
  - (d) Experimental; basic research.
  - (e) Scope of investigations has been extended to include the dynamic testing of treated samples under normal flow conditions. To date pressurized samples show significant apparent tensile strengths, but of somewhat lower magnitude than those determined by boiling-point measurements. The results of these experiments, like all others in this particular research, appear to have inherent wide scatter. Thus, considerable additional work will be required before generalizations can be made.
- (805) DIFFUSION IN TURBULENT FLOW.
- (b) U. S. Air Force.
  - (d) Experimental.
  - (e) Diffusion and turbulence measurements have been made in a water tunnel with a 12-inch square working section for three similar turbulence-producing grids. Tracers were used to define fluid trajectories.
  - (f) Completed.
  - (g) Turbulence intensities and Lagrangian correlation coefficients were measured. The results and discussion of advantages and limitations of the tracer technique for turbulence studies are given in the final report.
  - (h) "A Study of Turbulence and Diffusion Using Tracers in a Water Tunnel", by Vito A. Vanoni and Norman H. Brooks, California Institute of Technology Hydrodynamics Laboratory Report No. E-46, January 1955.



## (1301) HYDRODYNAMICS OF FREE BOUNDARY AND CAVITY FLOWS.

- (b) Bureau of Ordnance and Office of Naval Research, Department of the Navy.
- (d) Experimental and analytical; basic and applied research.
- (e) Free-surface and closed-jet water tunnels are used in experimental and analytical studies of cavity and jet flows in two and three dimensions.
- (g) Drag and cavity shape measurements on a variety of body shapes including cones, disks and spheres. The results have been compared wherever possible with theoretical results. Scale and tunnel blockage effects have also been studied.
- (h) "Flow Around Bodies with Attached Open Cavities", J. P. O'Neill, California Institute of Technology, Hydrodynamics Laboratory Report No. E-24.7, Dec. 1954.

## (1548) SPECIAL PROBLEMS IN HYDRODYNAMICS.

- (b) Office of Naval Research, Department of the Navy.
- (d) Theoretical and experimental; basic research.
- (e) Studies of cavitating and noncavitating flow.
- (h) "A Free Streamline Theory for Two-Dimensional Fully Cavitated Hydrofoils", by T. Yao-tsu Wu, California Institute of Technology, Hydrodynamics Laboratory Report No. 21-17, July 1955.  
"Hydrofoils in Cavitating and Noncavitating Flow", M. S. Plesset and B. R. Parkin, paper presented to National Physical Laboratory Symposium on Cavitation, Teddington, Middlesex, England, Sept. 1955.

## (1815) THE CORRELATION OF THE MECHANICS OF CAVITATION WITH THAT OF PHYSICAL DAMAGE.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental; basic research.
- (e) Objective is on the basis of the present knowledge of the mechanics of the cavitation process to endeavor to clarify the mechanics of cavitation damage of solid surfaces. Two approaches are being used: (1) Study of damage on standard metal specimens subjected to cavitation in the water tunnel; (2) study of damage on samples of same material in the standard magnetostriction equipment.
- (g) Further analysis of pitting rate indicates that (a) for a given guiding surface and velocity of flow, the maximum pitting rate per unit area decreases with increasing length of cavity, but that total number of pits per unit time per unit width of cavity remains constant; (b) for a given guiding surface and a given cavity length, the pitting rate increases with approximately the 6th power of the velocity. The concept of damage potential has been developed as a measure of the intensity of the mechanical attack of the cavitation process on the guiding surface. The use of the pitting rate observed on standardized aluminum specimens as a first measure of damage potential is being investigated.
- (h) "Further Studies of the Mechanics and Damage Potential of Fixed Type Cavities". Presented at Symposium on Cavitation in Hydrodynamics, National Physical Laboratory, Teddington, England, Sept. 14-17, 1955.

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

- (b) Bureau of Ships, Department of the Navy.
- (d) Theoretical and experimental; basic research.
- (e) Studies of hydrofoils.
- (h) "The High Speed Water Tunnel Three-Component Force Balance", by G. M. Hotz and J. T. McGraw, California Institute of Technology, Hydrodynamics Laboratory Report No. 47-1, Jan. 1955.  
"Pressure Distribution on a Hydrofoil Running Near the Water Surface", by Blaine R. Parkin, Byrne Perry and T. Yao-tsu Wu, California Institute of Technology, Hydrodynamics Laboratory Report No. 47-2, April 1955.

"Calculation of Hydrofoil Sections from Prescribed Pressure Distributions", by Blaine R. Parkin and Glenn H. Peebles, California Institute of Technology Hydrodynamics Laboratory Report No. 47-3, in press.

"Comparison of the Characteristics of a Hydrofoil under Cavitating and Noncavitating Operation", by T. Yao-tsu Wu and Byrne Perry, California Institute of Technology Hydrodynamics Laboratory Report No. 47-4, in press.

"Water Tunnel Tests of Two Hydrofoils in Cavitating Flow", by Robert W. Kermeen, California Institute of Technology, Hydrodynamics Laboratory Report No. 47-5, in press.

"Experiments on Circular Arc and Flat Plate Hydrofoils in Noncavitating and in Full Cavity Flows", by Blaine R. Parkin, California Institute of Technology, Hydrodynamics Laboratory Report No. 47-6, in press.

(1817) SCALE EFFECTS IN CAVITATING FLOW.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental and theoretical; basic research.
- (e) Experimental and theoretical studies are being carried out on the effect of model size on incipient cavitation.
- (h) "Mechanism of Cavitation Inception and the Related Scale-Effects Problem", by R. W. Kermeen, J. T. McGraw, and B. R. Parkin, Transactions of the ASME, Vol. 77, No. 4, pp. 533-541, May 1955.

(2051) EFFECT OF VISCOSITY ON CENTRIFUGAL PUMP PERFORMANCE.

- (b) Standard Oil Company of New Jersey; Byron Jackson Co.
- (d) Experimental.
- (e) Investigation of the effects of Reynolds number on the internal and overall flow characteristics of a centrifugal impeller with a view to improving the performance by means of design changes.
- (g) Over-all and internal flow measurements on a centrifugal impeller are being made to determine the effects of Reynolds number.

(2052) EXPERIMENTS ON SMALL SCALE PLANING SURFACES.

- (b) Office of Naval Research and Bureau of Ordnance, Department of the Navy; Consolidated-Vultee Aircraft Corp.
- (d) Experimental; basic and applied research.
- (e) Measurement of the lift on small-scale (0.5 to 3 inches width) planing surfaces have been made in the Free Surface Water Tunnel to ascertain the nature of the scale effect, if any, and to develop methods of extrapolating such force data to full scale.
- (f) Completed.

(2053) EXPERIMENTS ON STRUTS PIERCING THE WATER SURFACE.

- (b) Bureau of Ordnance, Department of the Navy.
- (d) Experimental; basic research.
- (e) The mechanism by which air ventilates down aft of a surface-piercing strut such as might be used to support a hydrofoil boat, and the resulting force system is being experimentally investigated in the Free-Surface Water Tunnel.
- (f) Inactive.
- (g) Data have been taken on rectangular and circular cylinder struts, and the resulting flow has been found to be closely related to two dimensional cavity flow. Measurements have also been made on a symmetrical airfoil shape.
- (h) "Experiments on Struts Piercing the Water Surface", by Perry, California Institute of Technology, Hydrodynamics Laboratory Report No. E-55.1, December 1954.  
"A Preliminary Experimental Study of Vertical Hydrofoils of Low Aspect Ratio Piercing a Water Surface", T. Kiceniuk, California Institute of Technology, Hydrodynamics Laboratory Report No. E-55.2, Dec. 1954.



(2054) FORCES ON UNDERWATER MISSILES RUNNING IN A CAVITY.

- (b) Bureau of Ordnance, Department of the Navy.
- (d) Experimental; basic and applied research and development.
- (e) The hydrodynamic forces on missiles and simulated missile body components are being measured in water tunnels for cavity flow. Model studies of forces on individual body components of basic geometric shapes have been correlated with studies made on composite bodies.

(2259) STUDIES OF MECHANICS OF SUB-AQUEOUS DUNES.

- (b) National Science Foundation grant.
- (d) Experimental and theoretical; basic research.
- (e) The purpose of the project is to study the behavior of aqueous sand dunes in a small laboratory flume, and to determine under what conditions they will or will not form. It is hoped that this study will lead to a better understanding of the variations in roughness of alluvial streams due to dune formation.

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

(21) STUDY OF HYDRAULICS OF SPRINKLING SYSTEMS.

- (b) California Agricultural Experiment Station.
- (c) Prof. V. H. Scott and Prof. W. A. Hall, Department of Irrigation, Univ. of California, Davis, Calif.
- (d) Experimental; operation.
- (e) Studies include water distribution and irrigation efficiency in orchards and field crops, characteristics of nozzle shapes and their effect on distribution patterns, cost analysis of sprinkler irrigation operation, and causes of aluminum pipe corrosion. A study of the effects of shape on distribution patterns for orifices is continuing. Attention is also being given to methods for minimizing pattern distortion by winds, and to plan interception and evaporation losses.
- (g) A study of the behavior of jets issuing from non-circular orifices may indicate the possibility of developing a practical means of controlling the disintegration of the jet.
- (h) "Farm Irrigation Structures --Methods of Injecting Fertilizers into a Sprinkler System", V. H. Scott and L. J. Booher, California Agriculture Extension Service unnumbered leaflet, April 1955.  
"Sprinkler Irrigation in California", California Agricultural Experiment Station Circular 388, revised by V. H. Scott. Submitted for publication.  
"Non-Circular Orifices for Sprinkler Irrigation", W. A. Hall and P. A. Boving. Submitted for publication.  
"Hydraulics of Sprinkler Systems", California Agricultural Experiment Station Bulletin 670, revised by W. A. Hall. Submitted for publication.

(23) HYDROLOGY OF IRRIGATION SUPPLIES IN CALIFORNIA.

- (b) California Agricultural Experiment Station.
- (c) Prof. R. H. Burgy, Department of Irrigation, University of California, Davis, Calif.
- (d) Experimental and field investigation; applied research and operation.
- (e) Studies are being continued on the hydrologic effects of various watershed practices in study areas established in over 30 locations on typical range and brush lands throughout California. Data are being collected on an individual storm basis to yield all possible correlations between precipitation, intensity and other factors. Small plots and watersheds have been equipped to measure precipitation, runoff, erosion and other hydrologic effects. Studies of the magnitude and scope of this modification of the hydrology of these areas are being continued.

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

- (b) California Agricultural Experiment Station.
- (c) Prof. V. H. Scott, Department of Irrigation, University of California, Davis, Calif.
- (d) Experimental; design.
- (e) Studies of farm irrigation systems for the improvement of design and efficiency of irrigation equipment are being continued. The installation, operation and maintenance of various materials used as linings for ditches and reservoirs are being evaluated under field conditions. Methods of grading land for surface irrigation have been studied in detail. The hydraulic characteristics of plastic tubing, siphons, turn-outs and gated pipe are being determined.
- (g) Information is available on the seepage control of certain prefabricated materials, on the best methods of grading land for surface irrigation, and on water spreading on agricultural lands for recharging underground water reservoirs.
- (h) "Theoretical Aspects of Water Spreading", W. A. Hall, Agric. Engineer. 36(6):394-397, 399, 1955.  
 "Materials, Equipment and Methods", W. A. Hall, Irrigation Engin. and Maintenance 5(10):19, 23-25, October 1955.  
 "Small Ditch Seepage Controlled", V. H. Scott, California Agric. 9(11):9, 14, Nov. 1955.  
 "A Practical Method for Predicting the Rate of Advance of Water Down an Irrigation Border", W. A. Hall. Submitted for publication.  
 "Prefabricated Linings for Small Irrigation Farm Ditches", V. H. Scott. Submitted for publication.  
 "Recent Developments in Irrigation Equipment", W. A. Hall and V. H. Scott. Submitted for publication.

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

- (b) California Agricultural Experiment Station.
- (c) Dr. L. D. Doneen, University of California, Davis, Calif.
- (d) Experimental and field; basic and applied research.
- (e) Studies on the permeability of different soils are being continued. Factors affecting accumulation of salines in soil from irrigation water, the effect of quality of water on infiltration of water into soils, treatment of irrigation waters to increase water penetration into soils, and cultivation in relation to soil structure and soil compaction are being investigated.
- (g) The diagnosis of poor water penetration due to soil compaction has been facilitated by the development of a core sampler for the purpose of securing undisturbed soil samples. Field application of ammonia fertilizers result in losses other than those from the jet. Keeping the  $p^H$  of the fertilizer solution as neutral as practicable seems to result in a minimum of loss. A procedure has been devised for the installation of moles to distribute water through certain soils between field ditches.
- (h) "Use of Moles for Subirrigation". D. W. Henderson, J. H. Lindt, Jr., and R. C. Pearl, California Agric. 8(8): 5-6, Aug. 1954.  
 "Ammonia Loss From Sprinkler Jets". D. W. Henderson, W. C. Bianchi, and L. D. Doneen, Agric. Engin. 36(2): 398-399, June 1955.

## (1819) DRAINAGE IN RELATION TO IRRIGATION.

- (b) California Agricultural Experiment Station.
- (c) Dr. J. N. Luthin, Department of Irrigation, University of California, Davis, Calif.
- (d) Experimental and field investigation; basic and applied research.
- (e) Field work is in progress in several areas of California for the purpose of improving drainage design. Observation wells and water stage recorders have been located in selected sites, and drainage systems have been designed on individual farms. Methods of measuring soil permeability are being investigated. Water pressures in the ground water zone are being measured by means of piezometers placed in the soil below a water table.



- (g) Some of the mathematical procedures and concepts used to obtain solutions to drainage problems have been described. Of considerable importance, as related to crop yield, will be the results of studies on the proper depth of drainage required to prevent salt accumulation on the soil surface. Information concerning water table elevations, soil permeability and effectiveness of existing drains should alleviate the varied drainage problems existing in many areas of California.
- (h) "Drainage of Irrigated Lands", J. N. Luthin, American Society of Agronomy Monograph on Drainage, in preparation.  
"The Design of a Gravel Envelope", J. N. Luthin, American Society of Agronomy Monograph on Drainage, in preparation.  
"Methods of Analysis for Solving Flow Problems", J. N. Luthin, American Society of Agronomy Monograph on Drainage, in preparation.  
"Some Techniques of Drainage Investigations", J. N. Luthin and V. H. Scott. Submitted for publication.

(2055) THE PHYSICS OF SOIL MOISTURE MOVEMENT.

- (b) California Agricultural Experiment Station.
- (c) Dr. J. N. Luthin, Department of Irrigation, University of California, Davis; Dr. Paul R. Day, Department of Soils, University of California, Berkeley.
- (d) Laboratory and theoretical studies; basic research.
- (e) Studies of the falling water table in soil columns and on the development of electronic methods of measuring and recording soil moisture tension above a water table are under way. Numerous factors involved in water entry into tile are also being investigated.
- (g) A suitable theory based on numerical solution of the differential equation of flow has been developed. Laboratory and field methods have been developed to evaluate soil hydraulic conductivity -- the basis for rational drainage design. It has been found in problems of agricultural hydrology involving lateral ground water flow at shallow depths below the ground surface that the amount of water flowing in the capillary region above the water table may represent an appreciable proportion of the total flow.
- (h) "Lateral Flow Above a Sloping Water Table", James N. Luthin and Paul R. Day, Soil Sci. Soc. Amer. Proc. 19(4):406-410, 1955.  
"A Numerical Solution of the Differential Equation of Flow for a Vertical Drainage Problem", Paul R. Day and J. N. Luthin. Submitted for publication.

(2056) THE HYDRAULIC CHARACTERISTICS OF WELL CASING PERFORATIONS.

- (b) California Agricultural Experiment Station.
- (c) Prof. V. H. Scott, Department of Irrigation, University of California, Davis, Calif.
- (d) Experimental; applied research.
- (e) Studies have been continued on the analysis of flow through well casing perforations conducted in the laboratory and field to determine (1) head loss characteristics of various perforation shapes, and (2) the influence of the gravel pack on the hydraulic performance of the perforations.
- (g) Head loss coefficients have been determined for a selected number of punched and chiselled perforations. Significant differences in the effect of the size distribution and shape of the gravel surrounding these perforations have been detected.
- (h) "Hydraulic Study of Well Casings and Gravel Envelopes", Yoash Vaadia. Submitted in partial fulfillment of the requirements for the Master's Degree in Irrigation Science.

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## UNIVERSITY OF CALIFORNIA, Division of Agriculture, Department of Irrigation and Soils.

Inquiries concerning Projects Nos. 26, 27, 1058, and 1303, should be addressed to Prof. M. R. Huberty, Chairman, Department of Irrigation and Soils, University of California, Los Angeles 24, California.

## (26) DRAINAGE INVESTIGATIONS 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, Nev.; and this laboratory.
- (d) Field investigations; applied research and design.
- (e) To develop and improve techniques for observing shallow ground water movement, for reclamation of saline and alkali soils, and for installation of drainage devices and systems.
- (g) Techniques developed have been permitting the anticipation of the need for drainage before soil salinized and crops lost. Progress is being made towards the establishment of more rational design criteria.
- (h) "Reclamation of a Saline and High Boron Soil in the Coachella Valley of California", R. C. Reeve, A. F. Pillsbury, and L. V. Wilcox. Hilgardia Vol. 24, No. 4: 69-91, September 1955.

## (27) HYDROLOGY OF WATER SUPPLIES IN CALIFORNIA.

- (b) Laboratory project, coordinated with similar work under Dr. R. M. Hagan, University of California, Davis, California.
- (d) Experimental; applied research.
- (e) Factors in watershed management that influence the disposition of precipitation and yield of water reclamation of saline waters.
- (h) "Feasibility of Using Soil as a Medium for the Reclamation of Sea Water." Mimeo.

## (1058) SOIL PHYSICAL CONDITIONS IN RELATION TO IRRIGATION.

- (b) Coordinated laboratory studies with field observations of water transfer in soils.
- (d) Continuing laboratory and field studies; basic and applied research.
- (e) Study of the soil properties and management practices which affect the flow of water into and through soils, the storage of water in soils and evaporation from soil.
- (h) "Some Factors Affecting Rates of Water Entry into Ramona Sandy Loam", A. F. Pillsbury and S. J. Richards, Soil Science 78: 211-217.

## (1303) HYDRAULIC CHARACTERISTICS OF IRRIGATION DISTRIBUTION PIPE SYSTEMS.

- (b) Laboratory project, cooperative with College of Engineering, University of California, Los Angeles 24, California.
- (d) Basic and applied research.
- (e) Analysis of the operational characteristics of float valves installed in concrete pipe irrigation systems.

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## UNIVERSITY OF CALIFORNIA, College of Engineering, Fluid Mechanics Laboratory.

Inquiries concerning Projects Nos. 35, 38, 40, 47, 280, 529, 1307, 1551, 1552, 1554, 1822, 1823, 1824, 1825, 1829, 1830, 2057, 2059, 2060, 2062, 2063, 2260 to 2266, incl., should be addressed to Prof. J. W. Johnson, Department of Engineering, University of California, Berkeley 4, Calif.



## (35) OSCILLATORY WAVES.

- (b) Laboratory project.
- (d) Experimental.
- (e) To obtain experimental information on the details of the three-dimensional problem of wind generated waves. Experiments are being conducted in a wind-wave tunnel 20 feet long, 0.5 feet deep by 4 feet wide. Wave patterns and dimensions are correlated with wind velocity and fetch length. A second study on this project was concerned with model studies of forces in mooring lines of a floating breakwater.
- (h) "A Laboratory Investigation of Short-Crested Wind Waves", by G. C. Ralls, M. S. Thesis, June 1955.  
"Mooring Cable Forces Caused by Wave Action on Floating Structures", by K. E. Beebe, M. S. Thesis, June 1955.

## (38) STRUCTURES EXPOSED TO WAVE ACTION.

- (b) National Science Foundation.
- (d) Experimental.
- (e) To obtain experimental data for the design of offshore structures. Present work involves the measurement of forces exerted on model elements subjected to wave action.
- (h) "The Design Wave in Shallow Water", by R. L. Wiegel, and K. E. Beebe, IER, University of California, Series 95, Issue 1, Oct. 1955.

## (40) FLOW CHARACTERISTICS OF GAS-SOLIDS MIXTURES.

- (b) Laboratory project.
- (d) Experimental (basic and applied research, design).
- (e) The flow characteristics of a gas-solids mixture ( $Al_2O_3$ ,  $SiO_2$  catalyst and air) are investigated in a 17 mm. I.D. glass conduit for various gas flow and solids flow rates. Pressure drops across test sections are 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. Preliminary studies on heat transfer to flowing gas-solids mixtures have been carried out and are being continued. Metering and heat transfer studies to be continued using fix size particles.
- (g) Equipment for the study of the heat transfer characteristics of flowing mixtures has been completed.
- (h) "An Investigation of the Gas-Side Heat Transfer Coefficient When Solids are Added to a Gas Flowing in a Vertical Tube", by Morgan J. Morley, M. S. Thesis 1955, University of California Library, Berkeley, California.

## (47) GRAVITY WAVES AND RELATED PHENOMENON.

- (b) Office of Naval Research, Department of the Navy.
- (d) Theoretical and laboratory investigation; basic research.
- (e) To develop methods of forecasting wind waves and swell, surf conditions and beach changes; measurement of wave characteristics; and make laboratory investigations to provide experimental checks and other information. A wave channel, ripple tank, model basin, and other facilities are used in the laboratory investigations.
- (f) Completed.
- (h) "Wave Instrumentation", by R. L. Wiegel, IER, University of California, Series 3, Issue 372, June 1955, pp. 19.

## (280) SEDIMENT TRANSPORT.

- (b) Laboratory project, U. S. Corps of Engineers.
- (d) Experimental and theoretical.
- (e) Various fundamental problems in relating to sediment transport have been studied, and efforts have been made to apply the results of research to solve practical problems.
- (g) The changes are studied experimentally and theoretically which the distributions of velocity and suspended sediment undergo if the sediment concentration near the bed becomes very high, such changes occur whenever the concentration surpasses 100 gr/lit concentration.
- (h) A progress report has been submitted to the sponsor for publication.

## (529) LITORAL SEDIMENT FLOW ON A BEACH.

- (b) Beach Erosion Board, Department of the Army, Washington, D. C.
- (d) Field, laboratory, experimental and theoretical research.
- (e) The object of this investigation is to determine the mechanism of sand transport on beaches and the water immediately off shore along the coast of California. For the past several years attention has been concentrated on the movement of sand along the coast near Santa Barbara. The particular problem attacked during the year 1954-55 was to determine the movement, if any, of sand around the rocky promontory. It was found that sand did move around the promontory. It was found that sand did move around the promontory in three well-fined zones. Coarse sand moved along the beaches where beaches were present; fine to medium grain sand moved in water up to 30 feet in depth and formed slopes that inclined 1 to 5 percent seaward. Slightly finer sand moved in water 30 to 60 feet in depth on more gently inclined slopes. Slopes beyond depth of 60 feet were more steeply inclined than in the zone immediately landward and seemed to be slowly receiving sediment. The steepness of the sea floor showed a positive relation with the quantity of sand supplied the sea.
- (h) "Movement of Sand around Southern California Promontories", by P. D. Trask, IER, Series 14, Issue 16, Feb. 1955.  
"Sediment Motion at the Vicinity of a Lattoral Barrier," by N. Chien, IER, Series 14, Issue 17, June 1955.

## (1307) DETERMINATION OF PRESSURE FLUCTUATIONS IN TURBULENCE IN LIQUID FLOW.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental.
- (e) Development of instruments and methods to measure pressure fluctuations in the free stream and at the flow boundaries.
- (g) A Rutishauser pressure gage is tested for its applicability to the problem. The frequency response is measured and calculated for various measuring arrangements. A set of wall measurements was made in a turbulent open channel flow of oil. The records are analyzed and interpreted. A flow system to measure wall pressures as well as point velocities in pipes is in operation.
- (h) "Measurement of Pressure Fluctuations at the Smooth Boundary of an Incompressible Turbulent Flow", Huon Li, University of California, I.E.R., Series No. 65, Issue 1, Dec. 1954.

## (1551) STUDY OF VERTICAL GAS-LIQUID FLOW IN PIPES.

- (b) Laboratory project.
- (d) Experimental and theoretical; basic research.
- (e) Collection of data and photographs of gas-liquid flow in glass tubes less than one inch diameter. Analytical work to help explain flow transitions.
- (g) Apparatus designed.



## (1552) EFFECT OF WAVE LENGTH ON PIPE FRICTION IN TRANSITION REGION FOR WAVED GLASS TUBES.

- (b) Laboratory project.
- (d) Experimental; basic research.
- (e) Collection of one component pipe friction data on waved glass tubes to study effect of wave length and amplitude on transition. Also to show rigid waved wall does not give exceptionally high friction factors.
- (g) Early transition shown and correlated; little increase of friction.

## (1554) SEA WATER RESEARCH.

- (b) State of California, U. S. Department of the Interior.
- (d) The several investigations for demineralizing sea water carried on during the past year are:
  - (1) Solar distillation,
  - (2) low-temperature difference method,
  - (3) use of high liquid pressures in combination with appropriate permeable membranes (osmotic pressures), and
  - (4) thermodynamic analyses of separation methods.

Solar distillation, low-temperature difference, and osmotic pressures projects are experimental. The thermodynamic analysis is a theoretical investigation. The thermodynamic analysis should be regarded as basic research only. The other three projects should be classified as applied research.

- (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 first two investigations were described in a previous report. Progress this year has yielded reliable performance data under a variety of conditions. Solar stills can reasonably be expected to utilize up to 50% of the solar energy. The new Low Temperature Difference distilling plant was operated enough to yield design information on most of the components. It is estimated that prototype plants of this type should produce fresh water at a cost between \$100 and \$200 per acre-foot. The program on osmotic membranes is being carried on at U.C.L.A. using funds from the U. S. Department of the Interior. Work during the past year has been devoted to the development of test equipment to use oil films. The first portion of this report on thermodynamic analysis has been completed and deals with the general problems to be encountered in minimizing the average expenditure in any separation process. The second part will deal with specific processes. One section of this second part, treating the vapor compression process, has been completed.
- (g) Detailed results may be obtained from the progress reports.
- (h) "Solar Distillation" by Everett D. Howe, in Solar Energy Research edited by Farrington Daniels and John A. Duffie, published by The University of Wisconsin Press, 1955, pp. 107-109.  
"Progress Report for the State of California Legislature", by Everett D. Howe, March 1955.  
"An Analysis of the Zarchin Scheme for Demineralizing Sea Water by Cold Distillation", revised by L. Shafer, S. F. Mulford, and Everett D. Howe.  
"Vacuum Distillation of Water in a Laboratory-Scale Thermal Difference Plant", by L. Akobjanoff, B. Beorse, and Everett D. Howe.  
"Research and Development of Molecular Oil Films for Use in the Large-Scale Low-Cost Demineralization of Saline Waters by a Pressure Method", by Gerald L. Hassler, Nov. 1954, April 1955, July 1955, and Sept. 1955.

## (1822) SHIP MOTION IN WAVE SYSTEMS.

- (b) David Taylor Model Basin, Department of the Navy.
- (d) Theoretical and experimental.
- (e) To make theoretical studies of ship motion on wave systems and to compare the results with experimental data.

- (h) "Experimental Determination of Pressures Exerted by Waves on a Rigidly Supported Box of Small Draft", K. E. Beebe, University of California, I.E. R., Berkeley, Series 61, Issue 8, Nov. 1954.  
 "On the Theory of Irregular Waves", R. A. Fuchs, Proceedings of the First Conference on Ships and Waves, Council on Wave Research and the Society of Naval Architects and Marine Engineers, Engineering Field Station, University of California, Richmond, Calif.  
 "A Linear Theory of Ship Motion in Irregular Waves", R. A. Fuchs, *ibid*.  
 "The Oscillation of Ships in a Solitary Wave", R. A. Fuchs and R. A. MacCamy, *ibid*.  
 "Laboratory Studies of the Motion of Freely Floating Bodies in Non-uniform and Uniform Long-Crested Waves", O. Sibul, *ibid*.

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

- (b) Beach Erosion Board, Department of the Navy.
- (d) Experimental.
- (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) Work is being done now on the determination of the turbulent velocity distribution along an oscillatory bottom.

(1824) BEHAVIOR OF AIR ABOVE MECHANICAL OCEAN WAVE MODEL.

- (b) National Science Foundation.
- (d) Experimental, basic research.
- (e) Measurement of velocity distributions in air above a mechanical model of long-and-short-crested ocean waves as a function of wind velocity, wave height and wave length. Drag forces as a function of distance from wave plane to a rigid ceiling determination.
- (g) Data being collected.

(1825) WIND WAVES IN SHALLOW WATER.

- (b) Beach Erosion Board, Department of the Army.
- (d) Experimental.
- (e) To obtain experimental information on the factors of wind velocity, wind duration, water depth, and bottom roughness as related to wave generation and wind tide produced in shallow water of limited extent. Runup and overtopping of wind waves on various levee sections also have been studied. A glass-wall channel 70 feet long, 15 inches deep, and 12 inches wide has been constructed for this study.
- (h) "A Laboratory Investigation of Short-crested Wind Waves", by Gordon C. Ralls, Jr., June 1955, M. S. Thesis.  
 "Laboratory Study of the Generation of Wind Waves in Shallow Water", by O. Sibul, Tech. Memo, No. 72, Beach Erosion Board, Corps of Engineers, Dept. of the Army, Washington, D. C., 35 pp. March 1955.  
 "Measurements of Water Surface Roughness and Wind Shear Stress by the Use of a Pitot Tube in a Laboratory Wave Channel", by O. Sibul, Oct. 1954, Series 71, Issue 2.  
 "Laboratory Study of Wind Waves in Shallow Water", by O. Sibul, Oct. 1954, IER, University of California, Series 71, Issue 3.  
 "Laboratory Study of Wind Tides in Shallow Water", by O. Sibul, Sept. 1954, IER, University of California, Series 71, Issue 4.

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

- (b) Laboratory research project.
- (d) Experimental and theoretical; basic research.
- (e) Collection and correlation of data on several diameters of tubing at inclinations from horizontal to vertical.
- (g) One inch diameter smooth and rough tubes tested. Two papers in preparation.



(1830) MEASUREMENT OF THE DISTRIBUTION OF A GAS AND TWO LIQUIDS IN A POROUS MEDIUM BY X-RAY TECHNIQUES.

- (b) Laboratory project.
- (d) Experimental; applied research.
- (e) Development of a calibration and measurement method for the distribution of three or more materials in a laboratory sample of sandstone.
- (f) Tests completed.
- (h) Paper in preparation.

(2057) PERFORMANCE OF THE PERIPHERY PUMP.

- (b) Laboratory project.
- (d) Experimental.
- (e) Experimental investigation to determine the influence of axial clearance and other features on the performance of the turbulence pump.
- (g) Laboratory investigation completed. Typical results are shown from tests of one pump with changes of total clearances (two sides) from 0.010 inches to 0.020 inches resulting in head decreases of approximately 30%.

(2058) STUDY OF EXCHANGE CHARACTERISTICS IN A TURBULENCE COLUMN.

- (b) Laboratory project.
- (d) Experimental.
- (e) Exchange of various properties are studied and compared for various properties in a column with reproducible turbulence pattern.
- (g) The column is constructed. Sediment distributions are observed for various degrees of turbulence.

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

- (b) Laboratory project.
- (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 resistance which determined the rate of sediment motion.
- (g) Experiments in progress.

(2060) ESTIMATING STREAMFLOW INTO A TIDAL ESTUARY FROM SALINITY MEASUREMENTS.

- (b) Analytical study.
- (d) Applied research.
- (e) Estimates of streamflow from the Sacramento-San Joaquin River system into San Francisco Bay are to be prepared from available salinity, tidal, current, and hydrographic data.
- (g) Computed streamflows have agreed favorably with actual channel stream-flow measurements; however, limitations of the method preclude greater accuracy for this tidal estuary.
- (h) Paper giving method and preliminary results presented before 36th Annual Meeting, American Geophysical Union; final report being prepared for publication.

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

- (b) Laboratory project.
- (d) Experimental.
- (e) The relationship is determined in an especially constructed rotating shear device for various normal pressures. The results will be used to predict the behavior of a granular stream bed subjected to high shear by a flow.
- (g) Preliminary results have been obtained.

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

- (b) U. S. Bureau of Reclamation.
- (d) Experimental; applied research; for doctoral thesis.
- (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) Studies of several of tracers passing through soil columns have been made; a literature survey of tracer and geophysical methods for studying ground-water movement has been completed.
- (h) "An Evaluation of Ground-Water Tracers", by W. J. Kaufman and G. T. Orlob, Trans. American Geophysical Union (in press).  
 "Methods of Detecting and Tracing the Movement of Ground-Water", by W. J. Kaufman and D. K. Todd, Canal Seepage Research Annual Report No. 1, Inst. of Engineering Research, University of California, Berkeley, pp. 130, 1955 (available on request).

## (2260) WAVE TRANSFORMATION.

- (b) Office of Naval Research, Department of the Navy.
- (d) Laboratory and field.
- (e) Breakers along a beach vary in height. This variation results from varying dimensions of the waves in deep water and the hydrography of the region. The purpose of these studies is to develop a practical method of predicting intervals of high and low surf from wave records at sea. The problem is very difficult as waves are dispersive, hence, they transform. Field, laboratory and theoretical studies were made.
- (f) Completed.
- (h) "Wave Transformation: Linear Least Squares Prediction", by R. R. Putz, IER Report, Series 29, Issue 58, Dec. 1954.  
 "Waves and Breakers in Shoaling Water", by H. W. Iverson Proceedings, Third Conference Coastal Engineering, Vol. 3, 1953.  
 "Prediction of Wave Motion", by R. R. Putz, Proceedings First Conference on Ships and Waves, Council on Wave Research, The Engineering Foundation, and the Soc. of Naval Architects and Marine Engineers, pp. 33-52, 1955.  
 "Travel Time for Periodic Waves on Beaches of Small Constant Slope," by R. A. Fuchs, July, 1954, Series 29, Issue 55.  
 "Wave Transformation: Field Operations", by R. L. Wiegel, Dec. 1954, Series 29, Issue 56.  
 "Laboratory Studies of Wave Transformation", by O. J. Sibul, Dec. 1954, Series 29, Issue 57.  
 "Wave Transformation: Final Report", by R. L. Wiegel, Dec. 1954, Series 29, Issue 59.

## (2261) WAVE REFRACTION RESEARCH.

- (b) Beach Erosion Board, Department of Army.
- (d) Laboratory.
- (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 engineer; 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.
- (h) "Ripple Tank Study of Wave Refraction", G. C. Ralls, Jr., IER, Series 82, Issue 1, May 1955.

## (2262) ANCHORING FORCES RESEARCH.

- (b) California Research Corporation.

- (d) Laboratory.
- (e) Model studies are being made of the forces in mooring lines of a vessel anchored at sea. Tests are being made with both uniform and non-uniform wave conditions.

(2263) MOORING FORCES RESEARCH.

- (b) Bureau of Yards and Docks, U. S. Navy, Port Hueneme, California.
- (d) Laboratory.
- (e) A model study of the forces induced in mooring cables and fender systems by water gravity waves acting on moored vessels.
- (h) "A Preliminary Study of Forces in Ship Moorings Due to Wave Action", by K. E. Beebe, IER, U. of C., Series 91 and 92, Issue 1, July 1955.  
"Ship Mooring Literature Survey", by R. L. Wiegel, IER, U. of C., Series 91 and 92, Issue 2, August 1955.  
"Progress Report on Model Study of Ship Mooring Forces", by R. W. Clough, IER, U. of C., Series 92, Issue 3, 1955, pp. 19.

(2264) WAVE ACTION OVER REEFS.

- (b) Bureau of Yards and Docks, U. S. Navy, San Francisco, Calif.
- (d) Laboratory.
- (e) This investigation was conducted for the purpose of determining experimentally the reduction of the weight of waves which pass over a reef. Both a two-dimensional idealized reef and a three-dimensional undistorted model of the reef at Subic Bay, D. I. were tested.
- (f) Completed.
- (h) "Wave Action Over Reefs", by J. W. Johnson, R. L. Wiegel, and E. G. Tickner, IER, U. of C., Series 96, Issue 1, Oct. 1955.

(2265) FORCES ON ACCELERATED CYLINDERS.

- (b) Laboratory project cooperative with Engineering Foundation.
- (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.
- (g) Constant acceleration drag forces measured for three cylinders.
- (h) Paper in preparation.

(2266) HYDROLOGIC INVESTIGATIONS OF SMALL DRAINAGE BASINS IN CALIFORNIA.

- (b) U. S. Bureau of Public Roads.
- (d) Analytic study; applied research and development.
- (e) The purpose of this investigation is to summarize streamflow records in California, to classify records on the basis of homogeneous areas for analysis, to test the adequacy of methods for estimating flood flows in California from those developed in other parts of the country, and, if required, explore new methods of estimating flood flows.
- (g) Streamflow records are being tabulated and classified by areas.

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UNIVERSITY OF CALIFORNIA, Institute of Industrial Cooperation, Department of Engineering.

(2267) PULSATING FLOW.

- (b) National Science Foundation Grant.
- (c) Mr. F. E. Romie, Associate Engineer, Institute of Industrial Cooperation, Department of Engineering, University of California, Los Angeles 24, California.
- (d) Experimental investigation.
- (e) Investigation of the unit thermal conductance between an electrically heated tube, and pulsating air flowing within the tube, the air mean flow rate extending over a range corresponding to Reynolds moduli from 3,000 to 15,000 with the frequency of the pulsations varying from a few cycles per second to several thousand.



University of California  
University of Southern California

(2268) WAVE PROPAGATION.

- (b) National Science Foundation Grant.
- (c) Prof. W. T. Thomson, Institute of Industrial Cooperation, University of California, Los Angeles 24, Calif.
- (e) Measurement of the velocity of wave propagation through hydrocarbons over specified temperature and pressure ranges ( $-30^{\circ}$  C to  $100^{\circ}$  C and 0 to 50 psi) and determination of the magnitude of any variations which may exist in the critical temperature region.

(2269) SUMP TEST.

- (b) Peerless Pump Division, Food Machinery and Chemical Corp., Los Angeles, Calif.
- (c) Prof. E. H. Taylor, Institute of Industrial Cooperation, University of California, Los Angeles 24, California.
- (e) Model sump tests on high specific speed pumps to determine optimum sump design characteristics.

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

(19) RESEARCH FOUNDATION FOR CROSS-CONNECTION CONTROL.

- (b) Laboratory project.
- (c) Dr. Kenneth C. Reynolds, Supervisor, Research Foundation for Cross-connection, University of Southern California, Los Angeles 7, California.
- (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) Department of Water and Power, City of Los Angeles, California.
- (c) Dr. K. C. Reynolds, Supervisor, Research Foundation for Cross-Connection, University of Southern California, Los Angeles 7, Calif.
- (d) The Department, in order to be advised on backflow prevention problems, has entered into a contract with the University from December 1954 to December 1957.
- (e) This contract involves the following: (a) Consulting services regarding backflow prevention installations and other hydraulic problems; (b) preparation of specifications covering the design, material, and operational requirements for backflow prevention units; and (c) maintenance of a laboratory for testing backflow prevention devices and other hydraulic equipment for the Department.
- (h) Quarterly progress reports to the Department.

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UNIVERSITY OF SOUTHERN CALIFORNIA, School of Engineering.

Inquiries concerning Projects Nos. 2271 to 2274, incl., should be addressed to Dr. K.C. Reynolds, School of Engineering, University of Southern California, Los Angeles 7, Calif.

(2271) FLOW OVER A SIDE CHANNEL SPILLWAY.

- (b) Graduate research.
- (d) An experimental study of flow over a side channel spillway and down the collecting channel.



- (e) Two models of the Pleasant Valley Dam had been built under a contract with the Department of Water and Power, City of Los Angeles. One was a 1 to 25 model of the spillway and part of the collecting channel to study their discharge capacities and design features; the other was a 1 to 35 model of the collecting channel and stilling basin to study their design features. This research was under the supervision of Dr. Reynolds of the University and Mr. W. E. Busby of the Department. For this thesis the models are being modified to conform to the final design. Complete longitudinal and transverse profiles will be taken for all possible rates of flow.
- (h) Two reports to Department of Water and Power, City of Los Angeles.  
"Report on Model Study of Side Channel Spillway for Pleasant Valley Dam", by Dr. Reynolds.  
"Supplemental Report on Model Study of Side Channel Spillway for Pleasant Valley Dam", prepared by Mr. Busby.  
The master's theses are being conducted by J. C. Dodd and J. S. Grossman.

(2272) DEFECTS AND FAILURES IN DAMS IN CALIFORNIA.

- (b) Graduate research.
- (d) A statistical analysis of the records available covering the defects and failures in dams and their appurtenances for the State of California.
- (e) The defects and failures were classified by their type and by the kind of dam on which they occurred.
- (h) "A Statistical Analysis of Defects and Failures in Dams and Their Appurtenances", James E. Ley, M.S. Thesis, 1956.

(2273) FREE OVERFALL OF A CIRCULAR CONDUIT.

- (b) Graduate research.
- (d) An experimental study of the free overfall of a partially filled circular conduit laid on a mild slope.
- (e) For various rates of flow the profile of the water surface was determined; the calculated critical depth was found; correlation between the measured depth at the drop off and the rate of flow was investigated.
- (h) Master's thesis in progress by C. A. Magnusen and R. L. White.

(2274) FLOW OVER SIDE-FLOW WEIRS.

- (b) Graduate research.
- (d) An experimental study of flow over side-flow weirs.
- (e) A rectangular channel, 9 inches wide, was built with a side-flow rectangular weir. This weir had adjustable crest lengths from 3 to 12 inches and crest heights from 1 1/2 to 3 1/2 inches. The flow data were analyzed to determine the interrelationship between the main channel velocity, the Froude number for the main channel, and other factors with the flow over the side-flow weir.
- (h) "Characteristics of Flow over Side-Flow Weirs," E. Spindel, M.S. Thesis, 1956; also another Master's Thesis by W. M. Nollac.

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CARNEGIE INSTITUTE OF TECHNOLOGY, Department of Civil Engineering.

Inquiries concerning Projects Nos. 1558, 1834, 2004, 2275, and 2276 should be addressed to Prof. F. T. Mavis, Carnegie Institute of Technology, Pittsburgh 13, Pennsylvania.

(1558) CONVERGING AND DIVERGING STREAMS.

- (b) Laboratory project.
- (d) Theoretical and experimental; for undergraduate thesis.

Carnegie Institute of Technology  
Colorado A and M College

- (e) For converging streams, the depth after the junction is a function of the common depth before the junction and the ratio of the flows in each branch.
- (f) Inactive.
- (g) Depths after a junction are smaller than the common depth before the junction; it is possible for the downstream depth to drop below the critical depth.
- (h) "The Study of Converging Streams in Horizontal Rectangular Channels", H. G. Workneh, M. S. Thesis, Carnegie Institute of Technology 1954.

(1834) AIR-WATER FLOW.

- (b) Laboratory project.
- (d) Theoretical and experimental.
- (e) An investigation to determine the amount of air that can be carried by flowing water. Experiments are conducted with free water jets and with air-water mixtures flowing in pipes at different slopes.

(2064) VIRTUAL MASS.

- (b) Laboratory project.
- (d) Experimental and analytical.
- (e) Measurement of virtual mass in bodies of fluid with free and fixed boundaries.
- (h) "Virtual Mass and Acceleration in Fluids", T. E. Stelson and F. T. Mavis. Proceedings American Society of Civil Engineers, Separate No. 670, April 1955.

(2275) FLOW OF LIQUID-SOLID MIXTURES.

- (b) Laboratory project.
- (d) Basic experimental and analytical research for doctoral thesis.
- (e) Determination of energy losses, solid and liquid velocities, concentration of solids, and characteristics of flow.

(2276) UNSTEADY FLOW THROUGH WEIRS AND ORIFICES.

- (b) Laboratory project.
- (d) Experimental and analytical for undergraduate thesis.
- (e) Analysis of steady-flow characteristics from measurements with unsteady flow.

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COLORADO A AND M COLLEGE, Department of Civil Engineering.

Inquiries concerning Projects Nos. 538, 822, 1074, 1313, 1565, 1566, 1567, 1568, 1570, 1838, 2066, 2070, 2071, 2277, and 2278, should be addressed to Dr. Maurice L. Albertson, Department of Civil Engineering, Colorado A and M College, Fort Collins, Colorado.

(53) SAND TRAPS AND SLUICeways.

- (b) Agricultural Research Service, Colorado Agricultural Experiment Station.
- (c) Mr. R. L. Parshall and Mr. Carl Rohwer, Agricultural Research Service, Colorado A and M College, Fort Collins, Colorado.
- (d) Basic research.
- (e) To develop design data for sand traps.
- (g) A siphon sand trap is being developed to handle bed loads in channels having excessive bed-load deposit. The usual practice has been to trap out the material by suitable devices placed on the bed of the channel, whereas the siphon type of sand trap removes the bed load from the top surface of the deposit. For desilting flows having a large load of sand and silt, the principal involved is that of a centrifugal action where the bed load and suspended material gravitates toward the center of a basin having a parabolic curved bottom where the material gravitates to the center to be removed either by pump or siphonic action. Model tests of the siphon sand trap indicate it should be practical in the field. Observations are being made in the laboratory of a model of the centrifugal basin.



## (55) SNOW COURSE MEASUREMENTS AND FORECAST ANALYSIS.

- (b) Soil and Water Conservation Research Branch, Colorado Experiment Station, Bureau of Reclamation, State Engineer of New Mexico, and State Engineer of Wyoming.
- (c) Mr. H. J. Stockwell, Soil and Water Conservation Research Branch, Colorado A and M College, Fort Collins, Colorado.
- (d) Field investigations; applied research.
- (e) Systematic measurements of depth and water content of snow at high elevations in Colorado 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.
- (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.

## (287) PERFORMANCE OF WELL SCREENS.

- (b) Colorado Agricultural Experiment Station, Agricultural Research Service, and various well screen manufacturers.
- (c) Mr. A. R. Robinson, Agricultural Research Service, Colorado A and M College, Fort Collins, Colorado.
- (d) Experimental; applied research; for master's thesis.
- (e) (1) Measurement of loss of head in different types of well screens for discharges suitable for each screen. (2) Determination of the size of opening in well screens, diameter of screen, thickness of gravel envelope, and size and gradation of sand or gravel for most effective control of flow of sands of different finenesses into the well with least loss of head. (3) Determination of the size of openings in well screens and diameter of screen for most efficient operation in natural sands and gravels of a given classification. An additional study is under way on the loss of head at interface of gravels of different sizes.
- (g) Tests were conducted to study the specific effect of the uniformity of gravel as a factor in controlling the movement of sand in the wells. The results of these tests have not yet been fully evaluated.
- (h) "Gravel Filters for Water Wells", Allan D. Halderman, Master's Thesis, June 1955.

## (538) HYDRAULICS OF SPILLWAYS.

- (b) Laboratory project.
- (d) Experimental; design and master's thesis.
- (e) To obtain generalized design information for spillways having the shape of the underside of the nappe from a sharp crested weir. Generalized tests are being made to determine the shape of the nappe with various negative pressures under it. Ultimately, the discharge coefficient and the pressure distribution will be obtained for all practical degrees of submergence and ambient pressures. These data will permit the designer to determine in advance the necessary shape of a spillway crest if a certain negative pressure is desired for a given head on the crest.
- (f) Suspended.
- (g) Using data reported by others, and data obtained in this laboratory, dimensionless design curves have been developed which permit solving directly for the design head, the discharge, the height of the spillway, or the shape of the spillway crest. Further data have been obtained which show the effect of downstream submergence on the discharge and the pressure distribution over the spillway. Data have also been obtained on the shape of the underside of the nappe from a sharp-crested weir for different negative pressures.

## (820) THE STUDY OF SEEPAGE LOSSES FROM IRRIGATION CHANNELS.

- (b) Agricultural Research Service, Bureau of Reclamation, Colorado Agricultural Experiment Station.

- (c) Mr. A. R. Robinson, Agricultural Research Service, Colorado A and M College, Fort Collins, Colorado.
  - (d) Experimental and field investigation; applied research.
  - (e) To study the factors influencing seepage from irrigation channels and to perfect methods for making pre-investigations of seepage for the purpose of determining the seepage from existing canals, and predicting the seepage from proposed canals. Methods of measuring seepage were evaluated to determine the limitations and advantages of each. The effect of depth to ground water as well as effect of temperature on the seepage rate was also investigated.
  - (g) A report is in progress describing the results of the experiments. Several methods of measuring seepage were evaluated and the relative merits of each method were determined. The seepage rate was found to decrease as the ground water approached the ground surface. In some cases, the seepage rate was found to vary inversely as the temperature of the water.
  - (h) Final report in progress.
- (821) GROUND-WATER FLUCTUATIONS AND THEIR RELATION TO PUMPING.
- (b) Colorado A and M Experiment Station.
  - (c) Mr. W. E. Code, Colorado A and M College, Fort Collins, Colorado.
  - (d) Field investigation; applied research.
  - (e) This is a continuing project in which semi-annual measurements are made in about 250 observation wells. The data so gathered provides information on the impact of pumping or of replenishment factors. Some indication of the magnitude of pumping is gained from the compilation of the amount of electrical energy being used. Part of the data is being gathered by the U. S. Geological Survey.
  - (g) The results of this work have served to outline the areas where pumping is causing a definite continuing decline in the water table. Similarly, those areas have become known that are reasonably certain of recovery under intensive pumping draught of a few years duration.
  - (h) Reports are included in U. S. Geological Survey Water Supply Papers.
- (822) DIFFUSION OF HEAT, VAPOR, AND MOMENTUM.
- (b) Cooperative with Office of Naval Research, Department of the Navy.
  - (d) Experimental; basic research; master's thesis.
  - (e) A controlled study in a wind tunnel of the fundamental principles describing the process of diffusion of vapor, heat and momentum from various surfaces. Eventually it is intended to use the fundamental information to aid in determining evaporation from free surfaces, land areas with various soil and crop covers, and plant surfaces, and heat and moisture losses from animals.
  - (g) A non-dimensional parameter containing the rate of evaporation is found to be a unique function of the Reynolds number in terms of shear velocity at the end of the evaporation surface. The results so presented are independent of the length of dry approach, and the regime of boundary layer flow. Sutton and Koehler-Yih solutions are found to yield identical vapor profiles, a theoretical curve for the rate of evaporation is calculated on the basis of Sutton's theory of turbulent exchange as modified by Pasquill. This curve follows the data closely.
  - (h) "The Effect of Rim Height on the Rate of Evaporation from Pans", W. W. McFarland, Master's Thesis, December 1955.
- (1074) HYDRAULICS OF STILLING BASINS.
- (b) Laboratory and field project.
  - (d) Experimental; for design and master's thesis.
  - (e) To obtain generalized design information for stilling basins utilizing a scour hole created by a jet of water as well as stilling basins utilizing the hydraulic jump together with chute blocks, floor blocks, and sills.



- (g) Studies have been completed using circular jets and two-dimensional jets. The variables considered were the depth of the pool, the fall velocity of the erodable material, the size of the jet, and the velocity of the jet. Results show that the depth and rate of scour depend upon the depth of water in the stilling basin, the size and velocity of the jet, and the size and gradation of the bed material. Studies have been completed determining the influence of size gradation and the sorting of the finer materials which leaves the coarser materials as armor plating to protect the hole from further scour.
- (h) "Scour from Jets", D. Doddiah, M. L. Albertson and R. A. Thomas, Colorado A and M College, 1953.  
"Scour at the Base of a Free Overfall", D. E. Hallmark, Master's Thesis, June 1955.

(1313) HYDRAULICS OF ALLUVIAL CHANNELS.

- (b) Laboratory project cooperative with Missouri River Division, Corps of Engineers, Department of the Army.
- (d) Experimental and theoretical; basic research and design; for master's and doctor's theses.
- (e) A part of the laboratory study on the roughness of alluvial channels has been completed. Thirty runs were made in a variable slope flume 70 feet long and 4 feet wide. The following measurements were made for each run: (1) water discharge, (2) total sediment discharge, (3) slope of water surface, (4) suspended sediment load, (5) velocity distribution, (6) average length and height of dunes, (7) depth of flow, (8) miscellaneous such as temperature, etc. The flume is now being extended to a length of 150 feet.
- (g) The variation of Chezy's resistance coefficient with Reynolds number shows that for a given size of bed material relative to depth of flow the bed is plane and smooth at a low Reynolds number but ripples and random dunes develop to create a maximum resistance as Reynolds number increases. As Reynolds number increases still farther, the dunes increase in height and spacing (and become more uniform in shape and spacing) but the resistance decreases until the bed becomes plane and rough prior to development of anti-dunes at highest Reynolds numbers.
- (h) "A Study of the Sediment Transport in Alluvial Channels", J. R. Barton and P. N. Lin, prepared for the Corps of Engineers.  
"Suspended Sediment Transport in Alluvial Irrigation Channels", D. E. Bender, Master's Thesis.

(1565) SEDIMENT CARRYING CAPACITY OF CLOSED CONDUITS.

- (b) Armco Drainage and Metal Products, Inc., Middletown, Ohio and Research Corporation, Santa Monica, California.
- (d) Experimental and theoretical; basic research; for master's thesis, and doctor's thesis.
- (e) To determine suspended load capacity of 12-inch diameter corrugated Hel-Cor, and smooth pipes carrying sand and flowing full. To determine effect of boundary form on sand transport capacity. To develop design criteria for pipelines carrying sediment. Graded sediments are being used, with mean size from 0.1 to 0.8 mm. Testing with 0.2 mm sand has been completed, and testing with 0.6 mm size is in progress. Testing with corrugated and Hel-Cor pipe is almost completed.
- (h) "Effect of Boundary Form on Fine Sand Transport in Twelve-Inch Pipes", A. R. Chamberlain, Doctor's Thesis.

(1566) DIFFUSION INTO AN AIR STREAM HAVING VARIOUS DEGREES OF STABILITY.

- (b) Air Force Cambridge Research Center, Laurence G. Hanscomb Field, Bedford, Massachusetts.
- (d) Experimental and theoretical; basic research.
- (e) By means of a horizontal, heated, metal plate placed in the floor of a wind tunnel, the effect of various artificially created lapse rates upon mean velocity profiles, turbulence structure, and flat plate heat transfer coefficients is being investigated. The effect of lapse rate upon the diffusion of gases from a point source and a line source will be studied. In addition, simultaneous measurements of evaporation, boundary shear, and heat transfer for plane rectangular surfaces with dimensions small compared to the boundary layer thickness will be conducted for a range of lapse rates.

## (1567) BEHAVIOR OF SEAPLANE HULLS IN SIMPLE SEAS.

- (b) Bureau of Aeronautics, Department of the Navy.
- (d) Experimental.
- (e) The behavior of model seaplane hulls when towed at different angles to a wave train has been studied experimentally. The model motions have been obtained from motion picture films made of the tests.

## (1568) BOUNDARY SHEAR IN OPEN CHANNELS.

- (b) Laboratory project.
- (d) Experimental; for J. Waldo Smith Fellowship of the A.S.C.E.
- (e) To supply experimental data on the shear distribution along the boundary of open channels. This information is needed in connection with the new theory conceived by E. W. Lane on the design of stable alluvial channels. The shear will be measured instead of calculated from other hydraulic measurements.
- (g) The shear measuring device has been constructed and installed in the flume and shear measurements are now in progress.

## (1570) FLOW PATTERNS ON LANDING IMPACT OF SEAPLANES.

- (b) Laboratory project.
- (d) Experimental.
- (e) To study the nature and extent of the flow field in an apparent mass of water during impact of V-wedges and ship hulls using photography by polarized lighting or other observation techniques.
- (f) Continuation of completed project "Development of a Constant-Force Bottom for Seaplane Hulls".

## (1836) EFFECT OF CANAL WATER DEPTH AND DEPTH TO WATER TABLE ON SEEPAGE FROM AN IDEALIZED CANAL.

- (b) Laboratory project.
- (c) Prof. D. F. Peterson, Jr., Colorado A and M College, Fort Collins, Colorado.
- (d) Experimental; master's theses.
- (e) Study of seepage from an idealized canal to a shallow water table using sand models and electric analogue.
- (h) "Seepage Flow From a Canal", P. V. Djanjigian, Master's Thesis, 1955.

## (1837) SEDIMENT LININGS FOR CANALS AND RESERVOIRS.

- (b) U. S. Bureau of Reclamation, Colorado Agricultural Experiment Station, various bentonite producers, chemical companies and irrigation districts.
- (c) Mr. R. D. Dirmeyer, Jr., Department of Civil Engineering, Colorado A and M College, Fort Collins, Colorado.
- (d) Experimental and field investigation; applied research; master's thesis.
- (e) To develop a truly low-cost canal and reservoir lining method--sediment linings. Briefly, sediment lining is a process involving the use of canal or reservoir water for the placement of an impervious filler or binder into the pervious or unstable materials of the canal or reservoir bed.
- (h) Monthly progress reports, and two-year progress report available upon request. "Penetration and Retention of Bentonite Suspensions in Porous Media", R. B. Curry, Master's Thesis, August 1955.

## (1838) BEHAVIOR OF MODEL SHIP HULLS IN AN OBLIQUE SEA.

- (b) David Taylor Model Basin through the Office of Naval Research, Department of the Navy.
- (d) Experimental.
- (e) A model tanker hull was towed at five different headings relative to the travel of a simple wave train. The motions of heave, pitch and roll were measured from motion picture films taken during the tests. These data were used to compute the amplitude response operators for the motions of heave, pitch and roll.



## (1839) INVESTIGATION OF REGIME THEORY OF SELF FORMED CHANNELS.

- (b) Cooperative project sponsored by Colorado A and M College, U. S. Engineers, U. S. Geological Survey, U. S. Bureau of Reclamation.
- (c) Mr. D. B. Simons, University of Wyoming, Laramie, Wyoming.
- (d) Field investigation; basic research, doctor's thesis.
- (e) This is an investigation of regime channels and of conditions related to channel stability. The field data being collected from selected straight reaches of canals having a reasonably steady discharge include the following: (1) Slope of energy gradient, (2) velocity profiles, (3) discharge, (4) shape of channel, (5) suspended sediment load, (6) total sediment load when possible, (7) samples of bed material, (8) samples of side material, (9) dune and ripple formations on the bed, (10) temperature of water, and (11) photographs of the reaches investigated for both empty and full supply conditions. The primary purpose of the study is to obtain information that will assist in establishing a more precise theory applicable to the design of stable channels in alluvium. The data collected should also be useful in the investigation of other related open channel problems. Field data have been collected and are currently being analyzed.

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

- (b) U. S. Bureau of Public Roads.
- (d) Experimental; applied research.
- (e) Models of spill-through and wing-wall bridge abutments are being studied in a rectangular variable slope flume having a variable width of 4 feet to 8 feet. Several degrees of constriction are being used with several roughnesses. Measurements are being made to determine backwater effect of the abutments. Objective of investigation is to obtain design criteria for prototype structures. Studies are also being made in alluvial channels with the same variables.

## (2067) MODEL STUDY OF A TILE INTERCEPTOR DRAIN.

- (b) Agricultural Research Service, Colorado Agricultural Experiment Station.
- (c) Mr. A. R. Robinson, Agricultural Research Service, Colorado A and M College, Fort Collins, Colorado.
- (d) Experimental; applied research; for design and master's thesis.
- (e) (1) Study the shape of the water table drawdown curve resulting from an interceptor drain installed in an area above an impermeable layer. (2) Determine the characteristics of drains placed at different levels above the barrier layer. (3) Check the results of the model study by means of an electrical analogue.
- (h) "Model Study of Interceptor Drains", J. N. Keller, Master's Thesis, August 1955.

## (2069) A COMPARISON OF IRRIGATION CANALS DESIGNED BY REGIME THEORY METHODS WITH THOSE OBTAINED BY DESIGN METHODS RECENTLY DEVELOPED IN THE UNITED STATES.

- (b) Laboratory project.
- (c) Mr. E. W. Lane, Colorado A and M College, Fort Collins, Colorado.
- (d) Office computation; applied research; master's thesis.
- (e) A comparison is being made of the cross sections for irrigation canals for a wide variety of conditions computed by various regime theory methods and the methods recently developed by the U. S. Bureau of Reclamation, to determine the extent of agreement on divergence of the results obtained by these methods.
- (f) Completed.
- (h) "Stable Channel Design", B. C. Raju, Master's Thesis, 1955.

## (2070) ROUGHNESS IN OPEN CHANNELS.

- (b) Laboratory project.
- (d) Experimental; basic research for master's and doctor's theses.
- (e) Project intended to determine the fundamental aspects of roughness in open channels. Different types of roughness are being studied to determine their influence on the resulting velocity distribution resistance coefficient, and depth and pattern of flow.



- (g) Certain results have been reported in previous issues of this publication. At present cooperating on project reported under Rocky Mountain Hydraulics Laboratory.

(2071) MANIFOLD DIFFUSER STILLING BASIN.

- (b) Larimer and Weld Irrigation Company.
- (d) Experimental, laboratory and field study; applied research.
- (e) To develop an economical structure to dissipate the energy of high-velocity flow economically and in a small space.
- (f) Completed.
- (g) A box manifold was developed with sloping bottom and cross bars spaced across the horizontal open top. Water enters at 30 fps, dissipates its energy as the two-dimensional jets move vertically upward, and comes to the pool surface at about 4 fps. No bank riprap is needed and cost is about one-fifth that of a standard stilling basin.
- (h) Report in preparation.

(2277) EVAPORATION FROM SOILS.

- (b) Laboratory project cooperative with Agricultural Research Service.
- (d) Experimental and theoretical; basic research; for master's and doctor's theses.
- (e) The rate of evaporation from soil surfaces is being determined wherein the following factors are varied: soil gradation, size and texture, ground water elevation, temperature, and treatment of soil surface. Measurements are also being made of the temperature and soil moisture and tension of the soil profile.
- (g) Preliminary qualitative results indicate that under certain conditions the soil surface will evaporate at the same rate as a free water surface even though the ground water elevation may be several feet below the surface.

(2278) METHODS OF CREATING A COMPLEX SEAWAY FOR MODEL STUDY.

- (b) Department of the Navy.
- (d) Experimental and theoretical; basic research.
- (e) A mathematical analysis is being developed for the complex sea. When this is completed, an attempt will be made to reproduce this type of sea in the wave basin for the study of models of ships and seaplanes.

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

- (b) Agricultural Research Service, Colorado Agricultural Experiment Station.
- (c) Mr. A. R. Robinson, Colorado A and M College, Fort Collins, Colorado.
- (d) Experimental; applied research; field evaluations; for design.
- (e) The project has as its purpose the compilation of data both from laboratory and field studies of the vortex tube sand trap in order to provide general design information for this type of installation.
- (f) The project is in the initial, planning stage.

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COLORADO SCHOOL OF MINES, Civil Engineering Department.

Inquiries concerning Projects Nos. 2280 to 2282, incl., should be addressed to Prof. Henry A. Babcock, Civil Engineering Department, Colorado School of Mines, Golden, Colo.

(2280) DEEP NOTCH WEIRS.

- (b) Laboratory project.
- (c) Prof. Henry A. Babcock, Civil Engineering Department, Colorado School of Mines, Golden, Colorado.
- (d) Experimental; basic research.
- (e) The purpose of the work is to determine the relationship between the discharge coefficient, and the ratio of crest length to head for sharp crested weirs with end contractions.

(2281) THE EFFECT OF GRAIN SIZE DISTRIBUTION AND VOID RATIO ON PERMEABILITY.

- (b) Laboratory project.
- (c) Prof. Henry A. Babcock, Civil Engineering Department, Colorado School of Mines, Golden, Colorado.
- (d) Experimental; basic research.
- (e) Samples of definite size distribution will be fluidized, and variation of pressure gradient and sorting action will be observed.

(2282) PULP DENSIMETER.

- (b) Laboratory project.
- (c) Prof. Henry A. Babcock, Civil Engineering Department, Colorado School of Mines, Golden, Colorado.
- (d) Design and development.
- (e) The device will measure continuously the density of liquid-solid mixtures in a pipe without being influenced by fluctuations in the velocity of flow.

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

Inquiries concerning Projects Nos. 1321, 1571, 2072, and 2283 should be addressed to Prof. Warren DeLapp, University of Colorado, Boulder, Colorado.

(1321) HYDRAULIC JUMP IN CHANNEL TRANSITIONS.

- (b) Laboratory project.
- (d) Experimental; for design and master's theses.
- (e) Profile of hydraulic jump is being studied in rectangular open channel transitions with various central angles and Froude Numbers.
- (h) "Hydraulic Jump in Rectangular Open Channel Contractions", B. Otaganonta, Master's Thesis, 1955. (Available on loan.)

(2072) FREQUENCY CURVES OF FLOW IN COLORADO STREAMS.

- (b) Laboratory project.
- (d) Analytical; for design and masters thesis.
- (e) Data for all Colorado stream stations with more than thirty years of record have been studied to determine the frequency of moderate flood peaks.
- (f) Completed.
- (h) "Flood Frequency Studies of Certain Colorado Streams.", F. A. Bertie, M. S. Thesis, 1955. (Available on loan.)

(1571) FREE OVERFALL STUDIES.

- (b) Laboratory project.
- (d) Experimental; for design and masters thesis.
- (e) Previous studies to determine the effect of channel slope and roughness on the water surface profiles and critical depth location near a free overfall have been extended to include circular sections.
- (h) "A Study of Watersurface Profiles Near the Free Outfall of Partially filled Circular Pipes", B. E. Wylie, M. S. Thesis, 1955. (Available on loan.)

(2283) GRAPHICAL SOLUTIONS FOR HYDRAULIC TRANSIENTS.

- (b) Laboratory project.
- (d) Analytical; for design and masters thesis.
- (e) Graphical methods are being developed for the solution of various types of problems encountered involving surges and waterhammer.

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COLUMBIA UNIVERSITY, Fluid Mechanics Laboratory, Department of Civil Engineering.

(62) HYDRAULIC STRUCTURES.

- (b) Laboratory project.
- (c) Prof. J. W. Delleur, School of Civil Engineering, Purdue University, Lafayette, Indiana.
- (d) Experimental and theoretical; doctoral thesis.
- (e) The growth of the boundary layer in the intake reach of an open channel is studied theoretically and in a rectangular channel in the laboratory.
- (f) Completed.
- (g) The boundary layer in a horizontal open channel develops more slowly than for comparable conditions on a flat plate in an infinite fluid. Experiments confirm the theory and also show an influence of secondary motion on the velocity distribution across the channel.
- (h) "The Boundary Layer Development in Open Channels", J. W. Delleur, Doctoral Dissertation, School of Engineering, Columbia University, New York 27, New York, April 1955.  
"The Boundary Layer Development of a Broad Crested Weir", J. W. Delleur, Fourth Midwestern Conference on Fluid Mechanics, Purdue University, Sept. 1955.  
"Boundary Layer Development at an Open Channel Inlet", J. W. Delleur, American Society of Civil Engineers, Annual Convention, Engineering Mechanics Division, Oct. 1955.

(290) HYDRAULICS OF SHORT OUTLETS IN BODIES OF DAMS.

- (b) Laboratory project.
- (c) Prof. H. R. Henry, Department of Civil Engineering, Michigan State College, East Lansing, Mich.
- (d) Experimental and theoretical; doctoral thesis.
- (e) An investigation of boundary layer development in short conduits. Pressure and velocity distributions are measured, along the pipe and entrance section.
- (f) This research is being continued at Michigan State College.

(1324) LOSSES IN TWO-DIMENSIONAL JUNCTIONS.

- (b) Laboratory project.
- (c) Mr. S. T. Tsakonas, Department of Civil Engineering and Engineering Mechanics, Columbia University, New York 27, New York.
- (d) Theoretical and experimental; doctoral thesis.
- (e) A study of flow patterns at junctions in rectangular conduits which can be considered two dimensional with particular attention to the influence of initial velocity distribution on the characteristics of the side jet.
- (g) When the initial velocity distribution is essentially uniform, the characteristics of the side jet measured in the laboratory agree very closely with theoretical results based on ideal fluid theory.

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UNIVERSITY OF CONNECTICUT, Hydraulic Research Laboratory, Department of Civil Engineering.

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

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



## (1079) STUDY OF WIND EFFECTS ON STRUCTURES.

- (b) Laboratory project.
- (c) Mr. A. L. Mirsky, Box U-37, University of Connecticut, Storrs, Conn.
- (d) Experimental; applied research.
- (e) A study of wind action and flow on the roofs of various types of buildings and structures is to be conducted in a small wind tunnel.

## (1080) STUDY OF HYDRAULIC DESIGN OF CURB INLETS.

- (b) Laboratory project; State Highway Department.
- (c) Prof. V. Scottron, Box U-37, University of Connecticut, Storrs, Conn.
- (d) Experimental; for design.
- (e) Tests are under way on influence of plan form of parallel bar gratings on hydraulic capacity. This is being coordinated with field tests on full-sized gratings.
- (g) A report has been issued to the Connecticut Highway Department on the design of parallel bar gratings. This is being abstracted for distribution.

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

- (b) Laboratory project.
- (c) Prof. V. E. Scottron, Box U-37, University of Connecticut, Storrs, Connecticut.
- (d) Experimental and analytical.
- (e) Work is being started on the hydraulics of rectangular channels with sloping bottoms and uniformly entering side flow.

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## UNIVERSITY OF CONNECTICUT, Soil Mechanics Laboratory, Department of Civil Engineering.

Inquiries concerning Projects Nos. 1574, 1575, and 1577, should be addressed to Prof. Edward V. Gant, Box U-37, University of Connecticut, Storrs, Conn.

## (1574) VARIATION IN AMOUNT OF FROST HEAVE WITH DEPTH OF GROUND WATER TABLE.

- (b) Laboratory project; State Highway Department.
- (d) Experimental; applied research.
- (e) Investigation is under way on a series of 12 test cells, 6 containing silt and 6 glacial till at depths from 2 1/2 to 6 ft. Observations taken on heave, depth-temperature variation, and water consumed from water table.

## (1575) EFFECT OF WASHED CONCRETE SAND IN INCREASING CAPILLARY RISE AND FROST HEAVING IN ADJACENT SOIL.

- (b) Laboratory project; State Highway Department.
- (d) Theoretical and experimental; applied research.
- (e) Investigations are being made of the effect of washed concrete sand in raising the ground water table in adjacent silt or glacial till.

## (1577) FILTER TESTS OF VARIOUS MATERIALS.

- (b) Laboratory project; State Highway Department.
- (d) Experimental; applied research.
- (e) Factors affecting the stability of filters are being studied.

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## CORNELL UNIVERSITY, Department of Agricultural Engineering.

- (2284) A STUDY OF FRICTION LOSS IN ALUMINUM IRRIGATION PIPE AND HEAD LOSS THROUGH IRRIGATION QUICK COUPLERS.
- (b) Laboratory project.
  - (c) Prof. H. E. Gray and Gilbert Levine, Project Leaders, Department of Agricultural Engineering, Cornell University, Ithaca, New York.
  - (d) Experimental, applied research.
  - (e) Project initiated to develop more nearly correct formulas to be used in the design of irrigation systems for head loss. Friction loss in aluminum irrigation pipe was determined in the laboratory under different rates of flow of water. Head loss measured across twelve different commercially available irrigation line quick couplers under different rates of flow.
  - (f) Have completed studies for 3-inch sizes, waiting for more pumping equipment to continue the study on larger sizes.
  - (g) Determined that Scobey's formula, now in use for irrigation pipe is not directly applicable for aluminum pipe. Aluminum pipe follows Schoder's relation for "extremely smooth" pipe. Also determined a series of values for design use for the twelve commercial couplers tested.
  - (h) "Friction Loss in Aluminum Pipe", H. E. Gray, G. Levine and M. Bogema, Agricultural Engineering, Volume 35, No. 10, Oct. 1954.  
"Head Loss in Irrigation - Line Quick Couplers", H. E. Gray, G. Levine and M. Bogema, Agricultural Engineering, Volume 35, No. 11, Nov. 1954.

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## CORNELL UNIVERSITY, School of Civil Engineering.

Inquiries concerning Projects Nos. 1849, 2287, 2288, 2290 and 2295, should be addressed to Prof. Marvin Bogema, and Nos. 2074, 2075, 2285, 2286, 2289 and 2291 to 2294, incl., should be addressed to Prof. Andre L. Jorissen, School of Civil Engineering, Department of Hydraulics and Hydraulic Engineering, Cornell University, Ithaca, New York.

## (1849) PUMP CAVITATION.

- (b) Goulds Pumps, Inc., Seneca Falls, New York.
- (d) Experimental, research for master's thesis.
- (e) Determination of required net positive suction head of 4-inch end suction and 4-inch double suction pumps when pumping hot water.
- (f) Completed.
- (h) "A Study of Cavitation in Centrifugal Pumps as Related to the Net Positive Suction Head", Master Thesis by Paul Gustav Wilhem Mayer, 1955.

## (2074) EFFECT OF INSTALLATION ON PERFORMANCE OF INFERENCEIAL FLOW METERS.

- (b) Builders-Providence, Inc., laboratory project.
- (d) Experimental.
- (e) Study of effect of 2 short-radius elbows in orthogonal planes on coefficient of discharge of Venturi Tubes and Dall Flow Tubes. Effect of straightening vanes.
- (h) Discussion by A. L. Jorissen of paper on "The Dall Flow Tube", by I. O. Miner. A.S.M.E. Paper No. 54-A-139, 1955.

## (2075) EXPANSION COEFFICIENTS FOR DALL FLOW TUBES.

- (b) Builders-Providence, Inc., laboratory project.
- (d) Experimental.
- (e) Determination of expansion coefficients for Dall Flow Tubes measuring a compressible fluid (air).
- (f) Completed.
- (h) "New Developments in Flow Measurement", Andre L. Jorissen, Kansas City Section A.S.C.E., Nov. 1955.

## (2285) QUADRANT EDGE ORIFICE STUDIES.

- (b) A.S.M.E. Research Committee on Fluid Meters, laboratory project.
- (d) Experimental, research for master's thesis.
- (e) Study of the quadrant edge orifice for discharge measurements at low Reynolds numbers.
- (h) "Discharge Measurements at Low Reynolds Numbers - Special Devices", Andre L. Jorissen, A.S.M.E. Paper 54-A-190, 1955.

## (2286) EFFECTS OF ROUGHNESS ON VENTURI TUBE COEFFICIENTS.

- (b) Builders-Providence, Inc., Simplex Valve and Meter Co.; laboratory project.
- (d) Experimental.
- (e) Study of the effects of roughness in the approach pipe and in the converging cone on the coefficient of discharge of Venturi Tubes of various characteristics.

## (2287) MODEL STUDY OF DEBRIS MOVEMENT IN RIVER.

- (b) American Gas and Electric Service Corp., New York, New York.
- (d) Experimental.
- (e) A model study of the condenser water intake of the Kanawha River Plant, Glasgow, West Virginia, to determine effectiveness of various structures in preventing bottom carried debris from entering plant intakes.

## (2288) SIX-INCH ORIFICE METER CALIBRATION.

- (b) National Valve and Manufacturing Company.
- (d) Experimental.
- (e) Accurate determination of discharge coefficient of meters to be used in boiler feed water lines during acceptance test of Milliken Station, New York State Electric and Gas Corp.
- (f) Completed.

## (2289) ORIFICE METER CALIBRATION.

- (b) Taylor Instrument Companies.
- (d) Experimental.
- (e) Calibration of 7.981" x 5.450" and 7.981" x 4.233" orifice plates.
- (f) Completed.

## (2290) TEST OF 24" BUTTERFLY VALVE.

- (b) Builders-Providence, Inc., Providence, Rhode Island.
- (d) Experimental.
- (e) Determination of Torque coefficient as function of valve angle.
- (f) Completed.

## (2291) TEST OF 30" BUTTERFLY VALVE.

- (b) Builders-Providence, Inc.
- (d) Experimental.
- (e) Pressure loss tests.
- (f) Completed.

## (2292) CHECK VALVE TESTS.

- (b) Williams Gauge Co.
- (d) Experimental.
- (e) Tests on 10", 8", 6", 4" and 2" check valves to determine pressure losses.
- (f) Completed.



## (2293) PITOT VENTURI FLOW ELEMENTS.

- (b) Taylor Instrument Companies.
- (d) Experimental.
- (e) Study of the behavior of Pitot-Venturi Elements in pipe lines of large sizes.

## (2294) FLOAT-TYPE, VARIABLE AREA FLOW METERS.

- (b) Fischer and Porter Co.
- (d) Experimental, development.
- (e) Study of tapered bodies for float-type, variable area flow meters.

## (2295) PUMP CAVITATION.

- (b) Laboratory project.
- (d) Experimental, research for master's thesis.
- (e) Determination of the effect of water temperature on required net positive suction head of a 4-inch end suction pump.

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UNIVERSITY OF FLORIDA, Department of Engineering Mechanics, Coastal Engineering Laboratory.

## (2296) INVESTIGATION OF EXISTING DATA ON TIDAL ENTRANCES.

- (b) Beach Erosion Board, Washington, D. C.
- (c) Beach Erosion Board, 5201 Little Falls Road, N. W., Washington 16, D. C.
- (d) Field investigation; basic research.
- (e) To analyze existing data on tidal inlets, including estuaries, in order to relate tidal characteristics, tidal prism, inlet area, littoral drift, and pertinent factors to the controlling depth and shoaling tendencies of tidal inlets.

## (2297) INVESTIGATIONS OF BEACH PROFILES AND SCOUR IN FRONT OF VERTICAL WALLS.

- (b) Laboratory project.
- (c) Dr. Per Bruun, 413 E and I Building, University of Florida.
- (d) Field research; basic research.
- (e) The variation of beach profiles along the Florida coast, and the fluctuation of beaches are investigated. Moreover the scour in front of sea walls is examined.

## (2298) DESTRUCTION OF WAVE ENERGY BY VERTICAL WALLS.

- (b) Laboratory project.
- (c) Dr. Per Bruun, 413 E and I Building, University of Florida, Gainesville.
- (d) Experimental and theoretical; basic research.
- (e) To study destruction of wave energy by different arrangements of permeable vertical walls.
- (h) "Proceedings of the American Society of Civil Engineers", Annual Meeting 1955.

## (2299) ENGINEERING INFORMATION ON THE BEHAVIOR OF LAKE WORTH INLET RESULTING FROM THE PROPOSED DEEPENING OF THE INLET TO ACCOMMODATE SEAGOING VESSELS OF GREATER DRAFT.

- (b) Laboratory and field project.
- (c) Port of West Palm Beach, West Palm Beach, Florida.
- (d) Experimental.
- (e) To study the water level in Lake Worth should the Inlet be deepened to accommodate sea-going vessels of greater draft.

(2300) BEACH EROSION AT FERNANDINA BEACH.

- (b) City of Fernandina Beach.
- (c) City of Fernandina Beach, Florida.
- (d) Field investigation.
- (e) To study the beach erosion and the stability of beach profiles at Fernandina Beach in order to find proper measures against the erosion.

(2301) STABILITY OF BEACH PROFILES AT DAYTONA BEACH.

- (b) Coastal Engineering Laboratory in cooperation with City of Daytona Beach.
- (c) Dr. Per Bruun, 413 E and I Bldg., University of Florida, Gainesville.
- (d) Field investigation.
- (e) To study the fluctuation of beach profiles at Daytona Beach by depth surveys every second month of 6 lines of soundings spaced 500 feet. A step resistance wave height recorder is installed on the Daytona pier by the Beach Erosion Board. Comparison is made between wave data and data from the survey.

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GEORGIA INSTITUTE OF TECHNOLOGY, School of Civil Engineering.

Inquiries concerning Projects Nos. 291, 1584, 1852, 1854, 1855, 1856, 2078, 2079, and 2302 should be addressed to Prof. C. E. Kindsvater, School of Engineering, Georgia Institute of Technology, Atlanta, Ga.

(291) FLOW OF WATER OVER HIGHWAY EMBANKMENTS.

- (b) Laboratory project.
- (d) Experimental; research for master's thesis (J. Davidian).
- (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. Limited data have been obtained on the influence of embankment height and roughness and tailwater submergence. Detailed velocity surveys have been made to define the boundary layer between the upstream edge of the upstream shoulder and the crown. Preliminary tests were made on 1:12- and 1:6-scale, two dimensional models of a typical two-lane highway embankment. Present tests are being made on a 1:9-scale model in a 3-foot wide flume.
- (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 are being sought as a means of generalizing the discharge equation for various shapes, sizes and roughnesses of embankments.
- (h) "Discharge Characteristics of an Embankment-Shaped Weir", Master's Thesis, by Gunnar Sigurdsson (1956); available on loan from Price Gilbert Library, Georgia Institute of Technology.

(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. Initial phase includes the preparation of bibliography and the collection of experimental data from all known sources. Objectives include the publication, in generalized form, of available experimental data.



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

- (b) Laboratory project.
- (d) Experimental and analytical; research for two master's theses.
- (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.
- (h) Results of initial investigation submitted in master's thesis (James R. Wells, 1954). Second thesis (R. W. Carter) in preparation.

## (1854) INFLUENCE OF BOUNDARY ROUGHNESS ON ABRUPT ENLARGEMENTS IN ENCLOSED CONDUITS.

- (b) Laboratory project.
- (d) Experimental; research for two masters theses.
- (e) An experimental investigation of the influence of boundary roughness on the total energy loss due to abrupt area-enlargements in circular conduits. Variables include discharge, expansion ratio and roughness.
- (h) One thesis complete (T. W. Fleetwood, 1955). Work on second thesis (B. J. Kittle) underway.

## (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) Preliminary 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.

## (1856) DISCHARGE CHARACTERISTICS OF CULVERTS.

- (b) Water Resources Division, Surface Water Branch, U. S. Geological Survey.
- (d) Analysis and correlation of published data, plus original research as required.
- (e) A study of the discharge characteristics of culverts. The study will be limited to culvert shapes which are common in modern highway practice. Criteria for distinguishing between full (pressure) flow and sluice (open-channel) flow based on length, roughness, bed slope, head, submergence, and entrance geometry are sought.
- (f) Completed.

## (2077) UNSTEADY FLOW IN SMOOTH PIPES.

- (b) Laboratory project; sponsored by the National Science Foundation.
- (c) Mr. M. R. Carstens, School of Civil Engineering, Georgia Institute of Technology, Atlanta, Georgia.
- (d) Experimental; basic research for three master's theses.
- (e) The mean flow characteristics in a pipe line during the time flow is being established has been studied experimentally. The flow was from a quiescent reservoir, through a rounded inlet, and thence through a straight, smooth pipe. Flow was established by instantaneously opening a downstream valve. Pressure-time and velocity-time measurements will permit calculations for shear which are to be compared with steady-state shear values. Particular attention is being given to the transition from laminar to turbulent flow.

## (2302) FLOW ANALYSIS OF WATER DISTRIBUTION SYSTEMS CONTAINING RESERVOIRS.

- (b) Laboratory project.
- (d) Analytical; for master's thesis.



- (e) The methods and principles of introducing reservoirs into a water distribution system are to be surveyed. Numerical analyses of several simple arrangements are to be presented. The rapidity of convergence of the Hardy Cross method is to be scrutinized.

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HARVARD UNIVERSITY, Department of Mathematics.

(1335) MATHEMATICAL THEORY OF WAVES AND SHIP WAVE RESISTANCE.

- (b) Office of Naval Research, Department of the Navy.
- (c) Prof. Garrett Birkhoff, Department of Mathematics, Harvard University, 2 Divinity Avenue, Cambridge 38, Massachusetts.
- (e) The purpose of present work is to perfect our methods of calculating Mitchell's Integral numerically. The methods are based on previous theoretical work (see 1954 edition Hydraulic Research Bulletin).

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UNIVERSITY OF HOUSTON, Department of Chemical Engineering.

(2303) THEORETICAL AND EXPERIMENTAL STUDY OF ENTRAINMENT IN TWO-PHASE GAS-LIQUID FLOW.

- (b) National Science Foundation.
- (c) Prof. A. E. Dukler, Chemical Engineering Department, University of Houston, Houston, Texas.
- (d) Experimental, theoretical; basic research, for master's thesis.
- (e) (1) To evaluate the variables which determine the transition from annular two-phase flow to flow with entrained liquid in the gas phase, (2) to investigate the variables which control the rate of entrainment in two-phase concurrent flow, and (3) to determine the effect of external vibration on wave motion and entrainment of the liquid phase.
- (f) Equipment near completion.

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UNIVERSITY OF IDAHO, Engineering Experiment Station.

Inquiries concerning Projects Nos. 547, 1859, 2080, and 2305 should be addressed to Prof. C. C. Warnick, College of Engineering and Projects Nos. 1860, 1861, 1862, 2081, and 2304, to Mr. V. I. Myers, Agricultural Engineering Department, University of Idaho, Moscow, Idaho.

(547) STUDY OF PRINCIPLES, DEVELOPMENT, AND USE OF HIGH ALTITUDE PRECIPITATION GAGES.

- (b) Laboratory project; cooperative with Civil Aeronautics Administration, Weather Bureau, Forest Service, Bureau of Reclamation, and Agricultural Research Service.
- (d) Experimental; design and development.
- (e) A series of wind tunnel tests have been made on movement of air around precipitation gages using sawdust to simulate snow. Qualitative catch studies on a model basis have also been made to develop proper windshielding for several types of precipitation gages. Prototype gages and shields have been installed at remote mountain locations to check field performance against the results obtained from wind tunnel tests.
- (f) Completed.
- (g) Improved windshield designs developed through testing in a wind tunnel are showing similar advantages in actual field tests at remote mountain locations. Several field gages are now in operation using designs suggested by results of this study.

- (h) "Research with Windshields for Precipitation Gages", C. C. Warnick, The Journal of Glaciology, Cambridge, England, October, 1954. Comprehensive bulletin nearing completion.
- (1859) A STUDY OF THE 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 research.
  - (e) Different types of new lining materials and methods of lining irrigation canals are being studied in special field test sections. A study is also being made of the effectiveness of chemically treated soils and soil sediments in preventing seepage.
  - (g) Three years of field testing is completed and much data have been collected on sediment carried in operating irrigation canals and on changes in seepage loss characteristics in experimentally lined laterals.
  - (h) "Experimental Studies with Canal Linings and Soil Sediments for Controlling Seepage Losses," C. C. Warnick, Progress Report No. 2, Engineering Experiment Station, University of Idaho, Moscow, Idaho, May 1955.
- (1860) APPLICATION OF ELECTRICAL RESISTANCE METHODS OF MEASURING SOIL MOISTURE IN IDAHO SOILS.
- (b) Laboratory project; under investigation in the Agricultural Experiment Station.
  - (d) Experimental.
  - (e) Laboratory and field comparisons of all the commercial types of soil moisture resistance blocks.
  - (g) Two seasons of field testing of replicated installations have been completed. Methods of improving installations and accuracy of results are being devised when possible.
  - (h) Annual progress report.
- (1861) THE IMPROVEMENT AND DEVELOPMENT OF STREAM FLOW MEASURING DEVICES.
- (b) Laboratory project; cooperative with Agricultural Research Service, being carried on under the Agricultural Experiment Station.
  - (d) Experimental; applied research.
  - (e) Study is being made in a laboratory flume and in field streams with full-size models of stage-measuring devices (primarily crest gages) under controlled conditions. Other stream-flow measuring devices are also being developed.
  - (g) A new crest gage inlet device has been developed that results in very little drawdown at velocities normally encountered in streamflow. A direct reading current meter has been constructed. Velocities are read directly from a scale.
  - (h) "The Improvement and Development of a Streamflow Measuring Device", V. I. Myers, M. S. Thesis, June 1955. (Available on loan)
- (1862) DETERMINATION OF ANNUAL RUNOFF FROM WATERSHED CHARACTERISTICS.
- (b) Laboratory project; being carried on under the Agricultural Experiment Station.
  - (d) Experimental; applied research.
  - (e) To investigate statistically the correlation between various watershed characteristics and annual runoff on gaged watersheds, for application to ungaged areas.
  - (g) Work is in progress evaluating watershed characteristics.
- (2080) A STUDY OF RIME ICE AND SNOW CAPPING ON HIGH ALTITUDE PRECIPITATION GAGES.
- (b) Laboratory project; in cooperation with U. S. Weather Bureau and Agricultural Research Service.
  - (d) Field investigation; basic and applied operational research.
  - (e) Several gages are being installed near Bogus Basin ski area to study the phenomenon of capping of gages. Measurements of temperature and wind velocity will be made as well as photographic studies of conditions that cause rime ice and snow to collect on the gage. Feasibility of heating the orifice of storage gages is being investigated.



- (g) Field gages have been in operation one year and data from various places in Western United States is being obtained. Preliminary design of heated orifice gage is completed.

(2081) THE DESIGN AND EVALUATION OF SPRINKLER IRRIGATION SYSTEMS.

- (b) Cooperative with Soil and Water Conservation Research Branch; Agricultural Research Service is being carried on under the Agricultural Experiment Station.
- (d) Field investigation; applied research.
- (e) To evaluate the engineering design of existing sprinklers, obtain field data related to design and operation of systems and to establish sprinkler design criteria that are especially applicable to Idaho conditions.
- (g) A number of evaluations have been completed and data are being assembled on IBM cards for later statistical analysis.
- (h) Annual progress report.

(2304) MECHANICS OF WATER CONTROL ON STEEP IRRIGATED LAND.

- (b) Laboratory project; under investigation in the Agricultural Experiment Station.
- (d) Field investigation; applied research for master's thesis.
- (e) To test the characteristics and effectiveness of a number of water control devices. To evaluate the resistance to erosion of irrigated soils. To develop improved devices and techniques for control of erosion and increased efficiency in application of water.
- (g) A number of water control devices have been calibrated in the laboratory and observed under field conditions. A new drop structure has been designed using prefabricated asphalt sheets and cultivation techniques for controlling erosion have been devised.
- (h) Annual progress report.

(2305) SEEPAGE LOSS STUDY OF SOUTHERN IDAHO CANAL SYSTEMS.

- (b) Laboratory and field project; in cooperation with Soil and Water Conservation Research Branch and canal companies.
- (d) Field investigation; basic and operational research.
- (e) An investigation of seepage loss from several types of canals to provide check measurements for studies being made by the Soil and Water Conservation Research Branch. Particular attention is being given seepage problems where canals are operating through basalt, through lime hardpan and where ground-water levels may influence seepage rates. Correlations with permeability data are being sought.
- (g) A summer of field testing has been completed and several new methods tried for evaluating seepage loss.

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ILLINOIS INSTITUTE OF TECHNOLOGY, Armour Research Foundation.

Inquiries concerning Projects Nos. 2082, and 2306 to 2309, incl., should be addressed to Mr. O. E. Teichmann, Manager, Heat-Power Research Department, Armour Research Foundation of Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

(2082) THREE-DIMENSIONAL FLOWS IN MIXED-FLOW COMPRESSOR.

- (b) Wright Air Development Center, Wright-Patterson Air Force Base, Dayton, Ohio.
- (d) Theoretical and experimental; basic research.
- (e) A series of mixed-flow blade cascades have been constructed in accordance with bound vortex-theory. Internal measurements of relative flow fields have been made with three-dimensional spherical pitot probe mounted on rotating impeller using mercury-type rotary seals. Relaxation techniques were applied to solve theoretical flow equations.
- (f) Completed.
- (g) Significant comparison was made between results of relaxation solutions and measurements for evaluation of design procedure and determination of effects of changes in speed and load.



- (h) "Investigations of Three-Dimensional Cascades", J. E. Ash, AF Technical Report No. 55-158, Thesis for PhD degree at Illinois Institute of Technology, 1955.  
"A Three-Dimensional Spherical Pitot Probe", J. E. Ash and J. C. Lee, ASME Paper No. 55-SA-56, prepared for presentation at the 1955 Semi-Annual Meeting of the American Society of Mechanical Engineers.

(2306) VORTEX FREE AIR THERMOMETER.

- (b) Wright Air Development Center, Wright-Patterson Air Force Base, Dayton, Ohio.
- (d) Experimental and theoretical; basic research.
- (e) An investigation has been made to study the application of a modified Ranque-Hilsch tube for measurement of free air temperature from high speed aircraft. A uniflow-type vortex tube having a tangential air inlet was developed for use in the Mach number range 0.2 to 1.5.
- (g) A vortex thermometer was developed for use in measuring the true free air temperature over the Mach number range 0.2 to 1.0. This instrument indicates the true (or static) air temperature directly with an accuracy of  $\pm 1^\circ\text{F}$  over the above mentioned velocity range.
- (h) Requests for copies of the progress reports should be directed to Equipment Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio. Attention: WCEI-6m, Department 54, Mr. R. L. Fine, Project Engineer.

(2307) INVESTIGATION OF USE OF MODELS IN SOLUTION OF HYDRODYNAMIC BEARING PROBLEMS.

- (b) Laboratory project.
- (d) Experimental; basic research.
- (e) Studies are being carried out concerning the use of enlarged clearances in model bearings for ease of measurement of bearing eccentricity. Experimental equipment has been established for simple measurement of bearing viscous torque, oil flow, and eccentricity ratios. The principal objective of the investigation is to evaluate this method of approach to bearing problems for general future application to specific conditions, especially with regard to short bearings where end effects are important.

(2308) HYDRODYNAMIC THEORY FOR PARTIAL JOURNAL BEARINGS.

- (b) Association of American Railroads, Technology Center, Chicago 16, Illinois.
- (d) Theoretical and experimental; applied research.
- (e) Solution of Reynolds' equation has been obtained for partial bearings of infinite length through use of both analytical and numerical methods. The solution is based upon assumption of the existence of cavitation in the oil film in the region where negative pressures normally are encountered. Analytical results were used as a guide to an experimental program, during which measurement of friction, oil flow and oil pressure confirmed the theory.
- (f) Completed.
- (g) Performance curves and load limits for railroad journal bearings were established for a wide range of operating conditions.
- (h) "Railroad Freight Car Hot-Boxes", 2 volumes, Sept. 1954. This work is part of final report to sponsor. Available from Association of American Railroads, Technology Center, Chicago 16, Illinois.  
"Analysis of Partial Journal Bearings Under Steady Loads", J. C. Lee, ASME Paper No. 55-Lub-1, presented at the Second Annual ASME-ASLE lubrication Conference, Indianapolis, Ind., Oct. 11, 1955.

(2309) LEAKAGE FLOW AND DIRT SENSITIVITY OF FUEL CONTROL VALVES.

- (b) Wright Air Development Center, Wright-Patterson Air Force Base, Dayton, Ohio.
- (d) Theoretical and experimental; applied research.
- (e) An experimental study was made of the effect of basic geometric parameters of fuel control assemblies upon dirt sensitivity. Trajectories and deposition of dirt particles in models of sleeve valves and piping components were studied theoretically and by means of high speed photography. Laminar and turbulent leakage of fuel through concentric, offset, and cocked positions of cylindrical and tapered spools inside a sleeve, and the effects of grooving geometry were computed and gave good agreement with experimental results.

- (f) Completed.
- (g) Recommendations are presented to avoid undesirable dirt deposition in components of fuel systems and the results of a rational theory of laminar and turbulent leakage are presented in graphical form to serve as a design guide.
- (h) "Investigation of Dirt Sensitivity of Turbo-Engine Control Components", J. E. Ash, J. C. Lee and D. Kurtovich, AF Technical Report No. 54-479, 1954.

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ILLINOIS STATE WATER SURVEY DIVISION, Champaign.

(551) RUNOFF FROM SMALL WATERSHEDS.

- (b) Laboratory project, cooperative with U. S. Geological Survey.
- (c) Mr. W. J. Roberts, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Field investigation; applied research, design.
- (e) Measurements are being made of watershed rainfall and stream flow, of stage discharge over the spillway, and municipal pumpage on five small water supply reservoirs in Illinois.
- (g) Twenty-five years of continuous measurements completed. Annual summaries 1946 to 1955 available for limited distribution.

(552) SEDIMENTATION OF ILLINOIS RESERVOIRS.

- (b) Laboratory project, cooperative with Agricultural Research Service and Illinois Agricultural Experiment Station.
- (c) Mr. J. B. Stall, Illinois State Water Survey, Box 232, Urbana, Illinois.
- (d) Field investigation; applied research.
- (e) For design of water supply reservoirs, measurements of sediment accumulation have been made on lakes in Illinois. Sediment samples are being analyzed and complete surveys of watershed soil type, slopes, land use, and conservation practices are being made.
- (g) Results at Lake Decatur, Decatur, Illinois, showed correlation between rate of sedimentation of Spring Lake, Ride Lake, Lake Chautauque, Carbondale Reservoir, Lake Bracken, West Frankfort Reservoir, Lake Calhoun, Lake Springfield, and Lake Carthage, respectively.

(553) RADAR-RAINFALL PROJECT.

- (b) Laboratory project, cooperative with Signal Corps, Department of the Army.
- (c) Mr. G. E. Stout, Illinois State Water Survey, Box 232, Urbana, Illinois.
- (d) Field investigation; basic research.
- (e) Radar is being used to track rain clouds, showing extent, movement, and intensity of each rain area. Two concentrated recording rain gage networks consisting of 10 and 60 rain gages each yield rainfall data which are correlated with photographic records of radar PPI scopes.
- (g) Results at Lake Decatur, Decatur, Ill., showed correlation between rate of sedimentation and land use on the watershed.
- (h) Reports of Investigation 13, 19, 21, and 27; Circular 49 Illinois State Water Survey. Progress reports to Signal Corps.

(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 being made of evaporation at three stations in northern, central, and southern Illinois. Vapor pressure gradients are obtained at Four-Mile Crib in Lake Michigan and at Urbana. Evaporimeters constructed and installed adjacent to pans for year-round records. Measurements are being made of reduction of evaporation by addition of substances to water in an evaporimeter. Analysis in progress.



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

- (b) Laboratory project.
- (c) Mr. Jack Bruin, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Field investigation; applied research.
- (e) To evaluate the ground water resources of the American Bottom (E. St. Louis region). Ground water levels are measured continuously. Pumpage, river stage, and rainfall data are collected. Chemical quality of ground water is measured. Areas of infiltration are determined, and all data are correlated with consideration of local conditions. Statistical studies have been made of the service lives of municipal wells.
- (h) "Preliminary Investigation of Ground Water Resources in the American Bottom", Illinois State Water Survey Division, Report of Investigation No. 17.

## (843) GROUND WATER RESOURCES IN JO DAVIESS, STEPHENSON, AND CARROLL COUNTIES.

- (b) Laboratory project.
- (c) Mr. H. F. Smith, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Field investigation; applied research.
- (e) To determine ground water resources of the area, water level contours of the sandstone aquifers, transmissibility and storage coefficients of the aquifers, and quantity of water available were obtained.
- (g) Data indicate that piezometric surface conforms generally with topography, with a 500-foot drop in about 30 miles with no apparent withdrawal. The sandstone aquifers are overlain with 100 to 300 feet and more of impervious limestone.

## (1092) HYDROLOGIC CYCLE EVALUATION.

- (b) Laboratory project; cooperative with the U. S. Geological Survey.
- (c) Mr. H. F. Smith, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Field investigation; applied research.
- (e) Data from rain gage networks (gathered under Project 553) together with information from five stream-gaging stations and five ground water level recorders are being maintained. Data will be used in analyzing storm rainfall-runoff relationships on small watersheds and effect of runoff on water table. Analysis in progress.

## (1336) DESIGN OF A 60-FOOT TILTING FLUME.

- (b) Laboratory project.
- (c) Prof. J. M. Robertson, 125 Talbot Lab., University of Illinois.
- (d) Experimental; design.
- (e) A 60-foot long, 2-foot wide, glass-walled tilting flume for hydraulic laboratory. Tests can be run at slopes from 0 to 4 percent.
- (f) Completed except for water discharge.
- (h) "Hydraulic Laboratory Research Facilities of the Illinois State Water Survey", Circular No. 48, 1955.

## (1337) DESIGN OF BUBBLER SYSTEM FOR MEASUREMENT OF WATER LEVELS IN WELLS.

- (b) Laboratory project.
- (c) Mr. H. F. Smith, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Experimental; applied research.
- (e) The bubbler system or purge method of liquid level measurement was applied to measuring well levels. The theory of operation was advanced and checked by laboratory tests.
- (f) Completed.
- (g) Laboratory accuracy obtained to 0.020 feet. Field accuracy comparable to float operated recording devices.
- (h) Published as State Water Survey Report of Investigation No. 23, 1954.

## (1341) CORROSION STUDY.

- (b) Laboratory project.



- (c) Dr. T. E. Larson, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Experimental.
- (e) A basic study of corrosion occurring at the steel electrodes under flow through a twenty foot plastic tower.

(1342) STUDY OF CORROSION AND DEPOSITION RATES WITH DIFFERENT FLOW RATES.

- (b) Laboratory project.
- (c) Dr. T. E. Larson, Illinois State Water Survey, Box 232, Urbana, Ill.
- (e) One-half inch pipes made of different material are in service. Changes in the flow due to corrosion and at constant head are being measured.

(1864) FLOW THROUGH POROUS MEDIA.

- (b) Mr. H. F. Smith, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Basic research.
- (e) Study of transition from viscous to turbulent flow in porous media.
- (f) Completed.

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

- (b) Laboratory project.
- (c) Prof. J. M. Robertson, 125 Talbot Lab., University of Illinois, Urbana, Illinois.
- (d) Experimental; applied research.
- (e) A 60-foot long, 2-foot wide, glass-walled flume for hydraulic laboratory. Tests can be run at slopes from 0 to 4 percent.
- (f) Completed except for water discharge.
- (g) Preliminary findings indicate five states of flow in drop-inlet structures.
- (h) "Hydraulic Laboratory Research Facilities of the Illinois State Water Survey", Circular No. 48, 1955.

(2310) GROUND WATER MOVEMENT DURING INFILTRATION.

- (b) Laboratory project.
- (c) Mr. Richard E. Aten, Illinois State Water Survey, Box 232, Urbana, Illinois.
- (d) Field investigation; applied research.
- (e) Analysis of data obtained from piezometer wells concerning movement of groundwater during infiltration with possible extension to watershed areal study.

(2311) GROUND WATER AQUIFER POTENTIAL STUDY.

- (b) Laboratory project.
- (c) Mr. H. Glen Rose, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Field data; applied research.
- (e) Study to determine relationship between the coefficient of transmissibility and specific capacity. Analysis in progress.

(2312) STUDY OF GROUND WATER LEVELS IN TAYLORVILLE, ILLINOIS, AREA.

- (b) Laboratory project.
- (c) Mr. H. Glen Rose, Illinois State Water Survey, Box 232, Urbana, Ill.
- (d) Correlated field data.
- (e) Study of pumpage, rainfall in Taylorville area to determine cause or causes for water level recession. Analysis in progress.

(2313) GROUND WATER INVESTIGATION AT CRYSTAL LAKE, ILLINOIS.

- (b) Laboratory project.
- (c) Mr. Robert T. Sasman, Illinois State Water Survey, Box 232, Urbana, Illinois.
- (d) Field investigation; applied research.

- (e) To study the correlation of lake levels and ground water levels in the vicinity of Crystal Lake. Ground water levels are measured continuously. Lake stage and precipitation data are collected.
- (h) "Report on Shallow Ground Water Resources in Crystal Lake and Vicinity", H. E. Romine, Illinois State Water Survey, Oct. 1947.  
"Report of Water Table Conditions in the Vicinity of Crystal Lake, McHenry County", F. X. Bushman, Illinois State Water Survey, March 1949.  
"Engineering Study of Water Level Variations at Crystal Lake, McHenry County, Illinois", H. E. Hudson and F. X. Bushman, Illinois State Water Survey, Oct. 1949.

ILLINOIS STATE WATER SURVEY DIVISION, Peoria.

Inquiries concerning Projects Nos. 556 to 560, incl., 845, 1335, 1866, should be addressed to Dr. Max Suter, Engineering Research Subdivision, Illinois State Water Survey Division, Box 717, Peoria, Ill.

(556) PERMEABILITY OF GRADED SAND MIXTURES.

- (b) Laboratory project.
- (d) Experimental; basic research.
- (e) The permeabilities of known mixtures of graded sand are measured to determine functional changes.
- (g) Sand mixtures containing 60 to 70 percent of fine material in 40 to 30 percent of coarser from 2 adjoining sieves of the 2 series have less permeability than the material of the fine screen alone. Evidence accumulates that the permeability is not much influenced by the amount of voids but greatly by the size of the smallest opening between sand grains.

(557) TURBULENT FLOW THROUGH GRANULAR MEDIA.

- (b) Laboratory project.
- (d) Experimental; basic research.
- (e) Critical flow is determined to define conditions under which turbulent flow occurs outside of well screens.
- (g) In flow through granular media, the Reynolds number cannot be calculated from ordinary formulas. By assuming a critical Reynolds number as existing at the determined critical flow conditions, the corresponding pore size can be calculated. This has been done in preliminary tests, but further work is needed to get a correlation with screen analysis.

(558) STUDY OF CAUSES AND PREVENTION OF SAND BOILS.

- (b) Laboratory project.
- (d) Field investigation; basic research.
- (e) Sand boils occurring during floods in levied districts are mapped classified, and sampled. Also sampled are river and nearby well waters.
- (g) From chemical analyses and temperature measurements, it was found that the water flowing in typical sand boils (those free from pipe connections towards the river) is different from the river water and similar to well water in neighboring wells. Such sand boils can be stopped from flowing by damming them up to a level that is below that of the river stage. They are not caused by leaks through the levee.

(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 and measuring devices, gravel pit with bottom 10 feet below river pool stage, sides and bottom covered with pea gravel. A model of 1/8 of pit (centerline to diagonal) is available to study different types of pits and variations in ground water gradients.



- (g) Pit in operation for fourth winter. Seven months of uninterrupted operation gave silting in only the top 2 inches of the 6-inch layer of pea gravel. The pea gravel gave satisfactory filtration and nearly tripled the inflow compared with using sand to give a rate of inflow of from 20 to 25 million gallons per day per acre.
  - (h) Mimeographed reports for each of the first four seasons have been issued.
- (560) GROUND WATER INVESTIGATION IN THE PEORIA, ILLINOIS, DISTRICT.
- (b) Laboratory project.
  - (d) Field investigation; basic research.
  - (e) To determine the ground water resources of the district, inventory of wells was made, including construction and logs of wells. Ground water levels are measured continuously, pumpage data collected, river stages and rainfall recorded, 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) So far conservation measures have shown more effect than artificial recharge.
- (845) EXTENSION OF THEIS' NON-EQUILIBRIUM THEORY FOR VARIABLE FLOW.
- (b) Office project.
  - (d) Theoretical; basic research.
  - (e) Development of formulas that could be used for conditions of variable flow.
  - (g) Formulas developed for most important types of variable flow, but the series obtained have not been calculated for wide ranges.
- (1335) GROUND WATER INVESTIGATION IN THE CHICAGO AREA.
- (b) Laboratory project.
  - (d) Field study on 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 determine recession and give good data for future prediction. Collection of data continued.
- (1866) GROUND WATER FORMULAS.
- (b) Office project.
  - (d) Theoretical.
  - (e) Compilation of all published ground water theories and formulas and a comparative evaluation of their range of usefulness.
  - (h) Report in preparation.
- (2314) ELECTRICAL ANALOGUE OF CHICAGO GROUND WATER CONDITIONS.
- (b) Laboratory project.
  - (d) Experimental; applied research.
  - (e) On a paraffin base is held tap water about 2" deep. The boundary of the depression cone is given by a metal band. Wells or well groups are marked geographically by metal rods. These are charged by electrical voltage in proportion to existing or planned pumpage. A separate probe measures the location of equal potential lines which correspond to equal heights of ground water levels. Variations in permeability are represented by variations in water depth and determined by comparison with the actual ground water levels as found in observation wells.
  - (f) Apparatus is being adjusted.
- (2315) INTERFERENCE BETWEEN RECHARGE PITS.
- (b) Laboratory project.
  - (d) Field investigation; basic research.
  - (e) A recharge pit is being built about 200 feet from the pit mentioned in project (559) and the mutual influence of the two pits is studied by a series of observation wells between the pits.
  - (f) Pit under construction.



Illinois State Waterways Division  
University of Illinois

ILLINOIS STATE WATERWAYS DIVISION, Springfield.

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

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

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

Inquiries concerning Projects Nos. 2316 and 2317 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 USDA.
- (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 1,000 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 25 watersheds in Champaign, Piatt, Vermillion, and Ford Counties on watersheds ranging in size from 45 to 1,400 acres. Model studies and field calibrations are made on the field structures.
- (g) Data being analyzed - period too short to report results.

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

- (b) Laboratory project cooperative with ARS USDA.
- (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.
- (h) "Drainage Investigations in the Plastic Till Soils of Northeastern Illinois", D. H. Kidder, and W. F. Lytle, Agr. Engr. Vol. 30 No. 8, pp. 384-86, Aug. 1949. (Preliminary report.)

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UNIVERSITY OF ILLINOIS, Department of Civil Engineering.

Inquiries concerning Projects Nos. 564, 1096, 1097, 1591, and 2085 should be addressed to Prof. J. J. Doland, University of Illinois, Urbana, Ill.

## (564) HYDROLOGY OF URBAN AREAS.

- (b) Laboratory project, cooperative with Illinois State Water Survey Division and U. S. Geological 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 sq mi 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 raingages strategically located in and out of the watershed. New type of evaprimeter has been developed and check studies are being made.

## (1096) FULL SCALE GUTTER TESTS.

- (b) Laboratory project, in cooperation with the Illinois Division of Highways and U. S. Bureau of Public Roads.
- (d) Experimental; applied research.
- (e) Determination of roughness coefficients for very smooth concrete gutters. Test section 120 feet long, six longitudinal slopes have been tested with maximum  $Q = 5.5$  sec-ft.
- (h) Revised report submitted to the sponsor.

## (1097) CORRECTION OF SCOUR BELOW TWO PIER HIGHWAY BRIDGE.

- (b) Laboratory project, in cooperation with Illinois Division of Highways.
- (d) Experimental; applied research.
- (e) A 1:50 scale model of an overflow bridge on flood plain of the Wabash River has been constructed as an aid in determining the cause of excessive scour just downstream from the bridge. Remedial dikes and topography changes have been tested in the model to determine their suitability.
- (h) Revised report in preparation.

## (1591) DETERMINATION OF WATERWAY AREAS.

- (b) Laboratory project, cooperative with Illinois Division of Highways.
- (d) Analytical and field investigation; applied research and design.
- (e) To determine the amount of water which will reach openings of highway drainage structures, such as bridges and culverts and provide a simple but scientific procedure for use of engineers in establishing the economical and adequate size of opening.
- (g) Three preliminary reports and two field reports were prepared. A study of rainfall-runoff relation is under way.

## (2084) HYDRAULIC CHARACTERISTICS OF FUNNEL-TYPE STREET INLET.

- (b) Departmental theses study.
- (c) Prof. J. C. Guillou, Civil Engineering Department, University of Illinois, Urbana, Ill.
- (d) Laboratory investigation; applied research.
- (e) Scale model tests of a funnel type inlet structure, discharging vertically downward into a pipe elbow. Correlation of discharge characteristics with approach channel flow.
- (f) Completed.
- (h) Preparation of report for general distribution is in progress.

## (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.
- (h) Report to sponsor is in preparation.

## (2086) A STUDY OF FISHWAYS.

- (b) Departmental graduate study.
- (c) Prof. J. C. Guillou, Civil Engineering Department, University of Illinois, Urbana, Illinois.
- (d) Laboratory investigation; basic research.
- (e) Scale model tests of a pool type fishway to determine efficient orifice design and ladder pool length.
- (h) Preparation of final laboratory report is in progress.

## (2087) EFFECTIVENESS OF SUBWAY GRATINGS FOR HIGHWAY DRAINAGE.

- (b) Department special study.
- (c) Prof. J. C. Guillou, Civil Engineering Department, University of Illinois, Urbana, Illinois.
- (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.

## (2088) DISCHARGE CHARACTERISTICS OF RECTANGULAR TYPE INLET BOXES.

- (b) Departmental study.
- (c) Prof. J. C. Guillou, Civil Engineering Department, University of Illinois, Urbana, Ill.
- (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.
- (g) The weir-orifice theory has been proved. The relation of control parameters is being investigated.

## (2318) FAUBER BRIDGE MODEL STUDY.

- (b) Departmental graduate study.
- (c) Prof. J. C. Guillou, Civil Engineering Department, University of Illinois, Urbana, Ill.
- (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 are being conducted to verify the proposed design.

## (2319) FREQUENCY STUDY OF HYDROLOGIC DATA.

- (b) Independent study.
- (c) Dr. V. T. Chow, Civil Engineering Department, University of Illinois, Urbana, Illinois.
- (d) Basic research.
- (e) A survey of existing literature and applications of the log-probability law and a theoretical interpretation of the logarithmic normal distribution of hydrologic data.
- (f) Completed.
- (g) Results include derivation of characteristic values of the log-probability law, revision of Hazen's table, verification of the extreme-value law as a special case of log-probability law, and suggestion of a new method for fitting data.
- (h) "The Log-Probability Law and its Engineering Applications", by Ven Te Chow, Proceedings, American Society of Civil Engineering, Vol. 80, Separate No. 536, November 1954, 25 pp.

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UNIVERSITY OF ILLINOIS, Fluid Mechanics and Hydraulics Laboratory, Department of Theoretical and Applied Mechanics.

Inquiries concerning Projects Nos. 1343, 1589, and 2083, should be addressed to Prof. W. M. Lansford, and Projects Nos. 2320 and 2321, should be addressed to Dr. J. M. Robertson, Talbot Laboratory, Department of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill.



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

- (b) Laboratory project.
- (d) Basic research.
- (e) Data has been collected on quantities of flow varying from 1.59 cfs to 11.5 cfs in a flood plain channel. The channel is of wood 160+ feet long. The cross-section of the channel consists of a 1' x 1' main channel with a sloped flood plain on each side.
- (f) Inactive.

(1589) OPEN CHANNEL METER.

- (b) Laboratory project.
- (d) Experimental and analytical.
- (e) Data has been collected on a meter which may be built in a sewer leading from a man hole after the sewer has been in service. The models tested were constructed of artists clay in a 6-inch lucite pipe and in a 6-inch x 6-inch lucite open channel.
- (g) Data being studied and further work being planned.

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

- (b) Laboratory project.
- (d) Basic research.
- (e) Data were obtained and a channel artificially roughened.
- (f) Completed.
- (h) Thesis on file in University Library.

(2320) TURBULENT BOUNDARY LAYER IN A DIFFUSER.

- (b) Laboratory project.
- (d) Experimental and analytical, basic research for Ph.D thesis.
- (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.

(2321) EFFECT OF ROUGHNESS ON VELOCITY PROFILE.

- (b) Laboratory project.
- (d) Analytical.
- (e) This is initially an attempt to verify the indications of the "Universal" velocity profile relations that a unique relation exists between friction factor and pipe factor. A second phase of the study is a reanalysis of rough pipe velocity profiles in terms of the more recent concepts of boundary layer flow. Thus the inner wall region and outer region will be analyzed separately.
- (g) Some anomalies in Nikuradse's rough pipe data have been found - thus the pipe factor when the pipe is acting smooth does not agree with that for a smooth pipe. All rough pipe data found to date indicate poor correlation between pipe and friction factors.

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IOWA INSTITUTE OF HYDRAULIC RESEARCH, State University of Iowa.

Inquiries concerning projects should be addressed to the following, all at State University of Iowa, Iowa City, Iowa:

Nos. 66, 1879, 2325, 2326, 2327.....to Prof. J.W. Howe.  
Nos. 69, 568, 1101, 1107, 1597, 2095.....to Mr. Emmett M. Laursen.  
Nos. 72, 73, 851.....to Dr. Philip G. Hubbard.  
Nos. 79, 1102, 1875, 2090, 2324, 2328.....to Dr. Hunter Rouse.  
Nos. 81, 875, 1871, 2091.....to Dr. Louis Landweber.

## (66) HYDROLOGIC STUDIES, RALSTON CREEK WATERSHED.

- (b) Cooperative with Department of Agriculture and Geological Survey.
- (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, ground-water 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.

## (67) COOPERATIVE SURFACE-WATER INVESTIGATIONS IN IOWA.

- (b) Cooperative with 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 Department of Agriculture and Geological Survey.
- (c) Mr. V. R. Bennion, Iowa Institute of Hydraulic Research, 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 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.

## (69) RELATION OF SEDIMENT CHARACTERISTICS TO BED EROSION.

- (b) Cooperative with Office of Naval Research, Department of the Navy.
- (d) Experimental; for doctor's thesis.
- (g) The equipment has been modified for the continuation of the study to include the effect of the grading of the bed sediments.

## (72) ELECTRICAL ANALOGY OF THREE-DIMENSIONAL FLOW.

- (b) Cooperative with Office of Naval Research, Department of the Navy.
- (d) Experimental; basic research.
- (e) Various three-dimensional flow transitions have been tested in order to provide useful design data for mechanical and hydraulic engineers.
- (f) Inactive.
- (g) A paper summarizing the work is in preparation.

## (73) MEASUREMENT OF TURBULENCE IN FLOWING WATER.

- (b) Cooperative with Office of Naval Research, Department of the Navy.
- (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) Complete analysis of the sensing element operation and the circuit performance and descriptions of finished instruments are presented in the publications below.
  - (h) "Measurement of Flow Characteristics by the Hot-Film Technique", Sung-Ching Lin, Ph.D. Dissertation, State University of Iowa, 1955, available on loan.
- (79) CAVITATION.
- (b) Cooperative with Office of Naval Research, Department of the Navy.
  - (d) Experimental and theoretical; basic research and graduate theses.
  - (e) Basic information is sought on cavitation for systematically varied boundary conditions. Tests are conducted in two variable-pressure water tunnels and a special cavitation tank. Studies of high-velocity submerged jets are being continued. Instrumentation is being 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. A slotted-throat test section has been installed in one water tunnel preparatory to an extension of previous measurements of the pressure distribution around rounded, ellipsoidal, and conical head forms to various angles of yaw. Dynamometer studies in other water tunnels are covered in Project (1871).
  - (h) "Instrumentation for the Measurement of Fluctuating Forces, Pressure Intensities, and Velocities in Studies of Cavitation", by D. W. Appel, Proceedings of Symposium on Cavitation in Hydrodynamics, National Physical Laboratory, Teddington, England, Sept. 1955.
- (81) MATHEMATICAL ANALYSIS OF PRESSURE DISTRIBUTION.
- (b) Cooperative with Office of Naval Research, Department of the Navy.
  - (d) Theoretical; basic research.
  - (e) A theory of stream functions for general three-dimensional flow has been developed and will be described in a paper to be submitted for publication. The development of a method for the determination of flow 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 completed and a description of the method will be submitted for publication.
  - (h) "Maximum Acceleration in Two-Dimensional Steady Flows of an Ideal Fluid", Chia-Shun Yih, Quarterly of Appl. Math., Vol. XIII, No. 2, pp. 202-203, 1955.  
"On a Method of Generating Three-Dimensional Potential Flows from Two-Dimensional Ones", Chia-Shun Yih, Quarterly of Appl. Math., Vol. XIII, No. 3, Oct. 1955.
- (568) SCOUR AT BRIDGE PIERS AND ABUTMENTS.
- (b) Cooperative with Iowa State Highway Commission and U. S. Bureau of Public Roads.
  - (d) Experimental; applied research.
  - (e) To investigate the effects of pier and abutment geometry, sediment properties, and stream-flow characteristics on the rate and pattern of scour, to the end of providing safe design criteria.
  - (g) Final report in preparation to be issued in 1956 as an Iowa Highway Research Board Bulletin. As well as summarizing the entire investigation the report will include means for predicting the probable local depth of scour at a bridge pier.
  - (h) "Field Measurement of Bridge-Pier Scour", P. G. Hubbard, Proceedings Highway Research Board, Vol 34, 1955.  
"Model-Prototype Comparison of Bridge-Pier Scour", E. M. Laursen, Proceedings Highway Research Board, Vol 34, 1955.
- (851) A CONSTANT-TEMPERATURE HOT-WIRE ANEMOMETER FOR THE MEASUREMENT OF TURBULENCE IN AIR.
- (b) Cooperative with Office of Naval Research, Department of the Navy.
  - (d) Experimental; instrument design.
  - (e) The earlier techniques using a hot wire have now been extended to the hot-film probe which can be used at very high temperature and in the region of sonic flow.
  - (f) Completed.
  - (h) "Measurement of Flow Characteristics by the Hot-Film Technique", Sung-Ching Ling, Ph.D. Dissertation, State University of Iowa, 1955, available on loan.



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

- (b) Cooperative with Office of Naval Research, Department of the Navy.
- (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. A critical study of the boundary layer on a smooth flat plate in zero pressure gradient has been completed and a report written, but not yet published. The boundary-layer on a smooth circular cylinder with axis parallel to the stream, in a zero pressure gradient, is now being investigated.

## (1101) MOVEMENT OF SEDIMENT IN HIGHWAY DRAINAGE SYSTEMS.

- (b) Cooperative with Iowa State Highway Commission and U. S. Bureau of Public Roads.
- (d) Experimental; for basic research and graduate theses.
- (e) A study of the movement of sediment in pipes, including the pattern of sand transport and the accompanying hydraulic energy losses for quasi-uniform flow in a circular conduit. Both full-pipe and free-surface flows have been studied.
- (f) Complete except for final report.
- (g) Final report in preparation to be issued in 1956 as an Iowa Highway Research Board Bulletin. As well as summarizing the entire investigation the report will include design recommendations for determining the maximum allowable sediment load in pipes and the efficiency of short sand traps.

## (1102) HISTORY OF HYDRAULICS.

- (b) Institute project.
- (e) To trace the historical development of the important theories of hydraulics, covering the fundamental ideas of the science, the critical periods of its development, and the personalities whose contributions were of major importance.
- (h) Has appeared during past year as French and English Supplements to La Houille Blanche. English version will now be reproduced by photo-offset for publication in book form by Iowa Institute. Requests for German, Spanish, Portuguese, and Russian translation rights are being considered.

## (1107) TRANSPORTATION OF SEDIMENT AS SUSPENDED AND TOTAL LOAD.

- (b) Cooperative with Office of Naval Research, Department of the Navy.
- (d) Experimental; basic research.
- (e) To determine the suspended and total load as a function of hydraulic and sediment parameters. A recirculating flume 3 feet wide, 15 inches deep, 100 feet long, and of variable slope has been in operation for several years (see Project 569, 1950). Distribution of sediment, as well as total load, is measured. Effect of sediment transport on velocity distribution, energy loss, and other hydraulic characteristics will also be evaluated.

## (1345) DESIGN OF HIGHWAY FILLS FOR SAFE OVERTOPPING BY FLOOD WATERS.

- (b) Iowa Highway Research Board.
- (c) Prof. C. J. Posey, Department of Civil Engineering, State University of Iowa, Iowa City, Iowa.
- (d) Experimental; applied research pertaining to design.
- (f) Completed.
- (g) Flume tests show that highway fills built of fine material can be protected by graded layers meeting requirements of Terzaghi-Vicksburg criteria for inverted filters. Binding the top layer tightly in wire sausages makes it unnecessary to carry the filter up to uneconomical rock sizes.
- (h) "Flood-Erosion Protection for Highway Fills", A.S.C.E. Proceedings Paper No. 783, August 1955.

## (1597) A STUDY OF THE EFFICIENCY OF SAND TRAPS.

- (b) U. S. Bureau of Public Roads and Iowa State Highway Commission.
- (d) Experimental; for master's thesis.
- (e) A study of the effects on the efficiency of sand traps of the geometry of the trap and the ratio of velocity of flow to settling velocity of particles. Trap proportions, sand sizes, and rates of both sediment and water transport have been varied.
- (g) Efficiency of trap shown to be a function of relative trap dimensions and ratio of conduit velocity to fall velocity of sediment. Experiments continuing to check tentative relationships. Final report to be combined with that of Project (1101).

## (1870) EFFECT OF SHAPE OF VERTICAL DRAFT TUBES ON THEIR EFFICIENCY.

- (b) Laboratory project.
- (d) Experimental; master's thesis.
- (e) Comparative study of conical, Prasil, White, and Moody draft-tube efficiency under identical conditions.
- (h) "Relative Efficiency of Draft Tube Forms", Benoyendra Chanda, M. S. Thesis, State University of Iowa, 1955, (available on loan).

## (1871) CAVITATING FLOW AROUND HYDROFOILS.

- (b) David Taylor Model Basin, Department of the Navy.
- (d) Experimental and theoretical.
- (e) Purpose is to obtain forces and moments on cavitating hydrofoils at various angles of attack. Hydrofoils are tested in a variable-pressure water tunnel on a balance which records electrically the instantaneous forces on the models. One hydrofoil of the NACA 66-series has been tested and the results compared with a linearized theory of cavitating hydrofoils.
- (h) "Theoretical and Experimental Investigation of Forces on Cavitating Hydrofoils", Michel Hug, Ph.D. Dissertation, State University of Iowa, 1956, available on loan.

## (1875) CHARACTERISTICS OF STABLE EDDIES.

- (b) Laboratory project.
- (d) Experimental; basic research for master's thesis.
- (e) Distributions of velocity, pressure, and turbulence are being measured in an air tunnel 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) Mean eddy patterns behind normal plates have most recently been investigated. Study is now being made of the flow pattern produced by a normal wind curtain.
- (h) "Flow Past a Normal Plate in Contact with a Boundary", Mikio Arie, M. S. Thesis, State University of Iowa, 1955, (available on loan).

## (2090) MODEL STUDY OF CRAWFORD STATION.

- (b) Commonwealth Edison Company, Chicago, Illinois.
- (d) Experimental; applied research.
- (e) 1:60 model of a reach of the Chicago Sanitary Canal and the inlet and outlet of the Crawford steam power plant is being used to study the recirculation of heated water. Possible changes in design of inlet and outlet to minimize recirculation are under investigation.
- (f) Completed. Continued as fundamental study under Project (2092).
- (h) Final report submitted.



## (2091) RESEARCH ON SHIP THEORY.

- (b) Cooperative with Office of Naval Research, Department of the Navy.
- (d) Experimental and theoretical; basic research.
- (e) Purpose is 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. A towing tank 10 feet wide, 10 feet deep, and 300 feet long is being constructed. Theoretical work on the added-mass coefficients and the forces and moments on bodies is under way. Equipment is being prepared for investigating the rolling of ships.
- (h) "A Comparison of the Added Masses of Streamlined Bodies and Prolate Spheroids", L. Landweber and A. Winzer, Report No. 572 of Experimental Towing Tank, Stevens Institute of Technology, June 1955.  
"On a Generalization of Taylor's Virtual Mass Relation for Rankine Bodies", L. Landweber, Quarterly of Applied Mathematics, Jan. 1956 (probably).

## (2092) STABILITY OF STRATIFIED FLOW.

- (b) Cooperative with Office of Ordnance Research, Department of the Army.
- (c) Dr. Chia-Shun Yih, Iowa Institute of Hydraulic Research.
- (d) Theoretical and experimental; basic research.
- (e) The inter-play of inertial and gravity effects in stratified flows and their stability and mixing characteristics are being investigated. The stability aspect has been studied experimentally in a small water tunnel and is being analyzed by the method of small disturbances. Experimental and theoretical work on the other phases are in progress.
- (h) "Hydraulic Jump in a Fluid System of Two Layers", Chia-Shun Yih and C. R. Guha, Tellus, Nov. 1955.

## (2095) MODEL STUDY OF WESLEY SEALE DAM.

- (b) Ambursen Engineering Corporation.
- (d) Experimental; applied research.
- (e) Pressure distribution on automatic flashboard gates and discharge coefficient for various headwaters, tailwaters, and gate settings determined from 1:20 sectional model.
- (f) Completed.
- (h) Final report submitted.

## (2320) A STUDY OF THE FLOW CHARACTERISTICS OF HIGHWAY CULVERTS.

- (b) Research Board of Iowa State Highway Commission.
- (c) Prof. D. E. Metzler, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Experimental; applied research.
- (e) An experimental study of the flow characteristics of box culverts is being made. The variation of velocity and pressure within the barrel will be determined for many different physical configurations of the barrel and inlet.
- (h) "Variations of the Kinetic Energy Coefficient at the Outlet of Square Culverts", Peter M. Smith, M. S. Thesis, State University of Iowa, 1956, available on loan.  
"Improved Culvert Inlet Design", J. E. Flack, M. S. Thesis, State University of Iowa, 1954, available on loan.

## (2321) PROBLEMS IN LAMINAR FLOW.

- (b) Laboratory project.
- (c) Dr. Chia-Shun Yih, Iowa Institute of Hydraulic Research, Iowa City, Iowa.
- (d) Basic and theoretical research.
- (e) The subjects already studied include stability of laminar flows, flows with stratification, laminar diffusion of heat, and exact solutions of the Navier-Stokes equations.
- (g) All results are either already published or under preparation for publication.



- (h) "Stability of Laminar Parallel Flow with a Free Surface", Chia-Shun Yih, proceedings of Second U. S. National Congress of Applied Mechanics, pp. 623-628, 1954.  
"Temperature Distribution in Laminar Stagnation - Point Flow with Axisymmetry", Chia-Shun Yih, Journal of Aero Sci., Vol. 21, No. 1, pp. 37-42, 1954.  
"Stability of Two-Dimensional Parallel Flows for Three-Dimensional Disturbance", Chia-Shun Yih, Quarterly of Appl. Math., Vol. XII, No. 4, pp. 434-435, 1955.

(2322) EFFECT OF RESERVOIR STORAGE UPON SUPERFLOODS.

- (b) Graduate project.
- (c) Prof. C. J. Posey, Department of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa.
- (d) Theoretical, master's thesis.
- (e) To find what effect reservoirs of various characteristics will have in decreasing the peak of increasingly greater superfloods.

(2323) FORMULATION OF STANDARDS FOR RESERVOIR SAFETY.

- (b) Graduate project.
- (c) Prof. C. J. Posey, Department of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa.
- (d) There are standard unit stresses and loadings for building used by the public, but none for the design of reservoirs that may menace populous communities. The possibility of formulating such standards will be explored.

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

- (b) Laboratory project.
- (d) Analytical and experimental; basic research for doctor's and master's degrees.
- (e) Determination of streamline configuration by means of relaxation process and electrical analog computer for various relative heights of weirs, supplemented by experimental study for relatively low weirs and sills.

(2325) PRESSURE DISTRIBUTION ON FLASH BOARDS.

- (b) Laboratory project.
- (d) Experimental; basic investigation for master's thesis.
- (e) Pressure distribution on upstream and downstream faces determined for heads up to 3 times flash-board height for level, 30° and 60° aprons.
- (f) Completed.
- (g) A bending-moment parameter and discharge coefficient are evaluated for various ratios of head to flash-board height and for different apron slopes. Results make possible the estimation of overturning moment on similar flash boards.
- (h) "Pressure Distribution on Flash Boards", Ernesto Bacci, M. S. Thesis, State University of Iowa, 1956, available on loan.

(2326) SYNTHETIC UNIT GRAPHS BASED ON TRIANGULAR CHANNEL INFLOW.

- (b) Graduate project.
- (d) Analytical, basic research for master's thesis.
- (e) Synthesis of unit graphs based on watershed characteristics; comparison with actual hydrographs.

(2327) INFILTRATION RATIO ON RAPID CREEK.

- (b) Laboratory project.
- (d) Field investigation, basic analysis of available storms, for master's thesis.
- (e) Rainfall and runoff data on 27-square mile area analyzed to determine infiltration rates. Frequency of various rates determined.

## (2328) INVESTIGATION OF SURFACE ROUGHNESS.

- (b) Cooperative with Office of Naval Research, Department of the Navy.
- (d) Experimental research.
- (e) Initial purpose is to determine effect of areal distribution of roughness elements on resistance function. Tests will be conducted on cubical elements cemented to floor of 30-foot tilting flume in varying concentration.

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IOWA STATE COLLEGE, Department of Agricultural Engineering.

Inquiries concerning Projects Nos. 2329 to 2333, incl., should be addressed to Prof. G. O. Schwab, Dept. of Agricultural Engineering, Iowa State College, Ames, Iowa.

## (2329) PREDICTION OF YIELD FROM SMALL WATERSHEDS.

- (b) Laboratory project.
- (d) Field investigation; applied research and M. S. thesis.
- (e) A rational approach for estimating annual runoff from watersheds (300 to 10,000 acres in size) is being developed. The method is dependent upon measurement and observation of five physical characteristics: climate (geographical location), land use, land slope, soil, and management and conservation practices. Factors used in estimating runoff are assigned on the basis of experimental data and general observations.
- (g) Tentative factors used in predicting median annual runoff from five small Iowa watersheds gave results within  $\pm 12\%$  of median annual runoff estimated from gage measurements.
- (h) "Water Yield Prediction Based on Watershed Characteristics", Paul Nixon and G. O. Schwab. Submitted for publication in American Geophysical Union Transactions.

## (2330) DEPTH AND SPACING OF TILE DRAINS.

- (b) Laboratory project.
- (d) Theoretical and field investigation; basic and applied research; several M.S. and Ph.D theses.
- (e) Analytical and physical approach is being studied to determine depth and spacing of tile drains by measuring soil characteristics, such as permeability. Electric and glass bead-glycerin models in addition to extensive field measurements of the rate of water table drop between tile drains are being studied.
- (g) Several field methods for measuring permeability have been developed, and many theoretical solutions have been found for the flow of water to tile drains.
- (h) "Measurement of the Hydraulic Conductivity of Soil in Place", Symposium on Permeability of Soils, Amer. Soc. for Testing Materials, Special Technical publication, No. 163, 1955, pp. 80-97, J-2505.  
 "Theory and Measurement of Anisotropic Air Permeability in Soil", Marinus Maasland and Don Kirkham, Soil Sci. Soc. Amer. Proc. Vol. 19, 1955, pp. 395-400. J-2628.  
 "Simplified Air Permeameters for Soil in Place", Don Kirkham and Ben L. Grover, Soil Sci. Soc. Amer. Proc. Vol. 19, 1955, pp. 414-419, J-2633.  
 "Physical and Mathematical Theories of Tile and Ditch Drainage and Their Usefulness in Design", Jan van Schilfgaarde, Don Kirkham, and R. K. Frevert. Sta. 1956 (in press).  
 "A Tile Drainage Field Laboratory", J. van Schilfgaarde, R. K. Frevert, and Don Kirkham. Agr. Engin. 35:474-478, 1954.

## (2331) ESTIMATION OF SURFACE RUNOFF VOLUMES FROM AN AGRICULTURAL WATERSHED.

- (b) Laboratory project.
- (d) Theoretical; applied research and doctoral thesis.
- (e) The surface runoff volume for an individual storm was estimated by superimposing an infiltration capacity curve, which had been derived for a particular soil-crop complex and antecedent rainfall condition, on the rainfall histogram. Occurrence of antecedent rainfall was studied with respect to one set of point rainfall data and probability statements were made for selected occurrences from a theoretical distribution. Also a frequency study was made for excess rainfall for the same set of point rainfall data.



- (g) The developed estimation procedure and the infiltration characteristics derived from infiltrometer data gave an estimate of surface runoff volume for an individual storm generally within  $\pm 20$  percent of the gaged volume. It was shown that infiltration characteristics derived from "wet run" infiltrometer tests simulated an overly extreme design condition.

(2332) HYDROLOGY OF A SMALL WATERSHED AND RESERVOIR.

- (b) Laboratory project.
- (d) Field investigation; basic and applied research.
- (e) Study of the relation between climatic conditions and runoff from a 20-acre watershed near Albia, Iowa. Measurement of evaporation and seepage from a 6 ac-ft. pond. Study of the effect of climatic conditions on pond evaporation. Instrumentation includes standard and recording rain gage net or watershed, water level recorder on pond and Class A evaporation station (including actinometer).

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

- (b) Laboratory report.
- (d) Field investigation; design; M.S. Thesis.
- (e) Field study is being made to determine the effect of different backfill materials on the flow of surface water to tile drains.

(2334) RUNOFF FROM SMALL WATERSHEDS.

- (b) Laboratory project, cooperative with Agriculture Research Service, United States Department of Agriculture.
- (c) Mr. R. K. Frevert, Department Agr. Engr., Iowa State College, Ames, Iowa.
- (d) Field investigation; applied research, design.
- (e) Measurements are being made of watershed rainfall and surface runoff on 10 Agricultural Watersheds. Sediment measurements are being made in 6 small reservoirs in the gaged watersheds.
- (g) Six years of measurements completed.

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THE JOHNS HOPKINS UNIVERSITY, Applied Physics Laboratory.

(1876) ANALYSIS OF DYNAMIC OPERATION OF HYDRAULIC (FORCE) AMPLIFIER TRANSFER VALVES.

- (b) Bureau of Ordnance, Department of the Navy.
- (c) Director, Applied Physics Laboratory, The Johns Hopkins University, 8621 Georgia Avenue, Silver Spring, Md.
- (d) Theoretical and experimental; applied research and development.
- (e) Designed to develop a set of linearized differential equations to describe the operation of single and double nozzle type, hydraulic force amplifier, transfer valves.
- (g) The linearization of differential equations complete. Have been completed and compare favorably with experimental results.
- (h) Second report on complete equations and their linearization in process.

(1877) ANALYSIS OF STATIC AND DYNAMIC OPERATING CHARACTERISTICS OF HYDRAULIC SERVO-MECHANISMS.

- (b) Bureau of Ordnance, Department of the Navy.
- (c) Director, Applied Physics Laboratory, The Johns Hopkins University, 8621 Georgia Avenue, Silver Spring, Md.
- (d) Theoretical and experimental, applied research and design.
- (e) Using linearized equations. Phase (3) use of describing function techniques to describe nonlinear characteristics of the transfer valve while operating in closed loop, and including effects of complex mechanical loads. This phase of work is being carried out by McDonnell Aircraft Corporation, St. Louis, Missouri, under technical cognizance of APL/JHU.



- (f) Phase two and three nearly complete.
- (g) Phase (2); system differential equations can be linearized sufficiently to allow reasonable correlation between experiment and theory for small changes in variables; the effects of complex mechanical loads are conveniently handled with the inclusion of oil compressibility. Phase (3); describing function techniques have been successfully applied to transfer valve hysteresis, spool reaction forces, and square root characteristics.
- (h) Phase (2); no unclassified report available.  
Phase (3); an unclassified report is in process.

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

- (b) Bureau of Ordnance, Department of the Navy.
- (c) Director, Applied Physics Laboratory, The Johns Hopkins University, 8621 Georgia Avenue, Silver Spring, Md.
- (d) Theoretical and experimental; applied development and design.
- (e) The application of nonlinear switching techniques to hydraulic control valves and power servo system.
- (g) The use of dual mode type of operation, possible with switch techniques, has been found to provide increased servo system performance and reliability while simplifying transfer valve requirements.
- (h) Bumblebee Report No. CM-843.

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THE JOHNS HOPKINS UNIVERSITY, School of Engineering.

Inquiries concerning Projects Nos. 855, 856, and 1111 should be addressed to Dr. John C. Geyer, The Johns Hopkins University, Baltimore 18, Maryland.

(855) HYDRAULIC BEHAVIOR OF STORM WATER INLETS.

- (b) Baltimore City, Baltimore County, and the Maryland State Roads Commission.
- (d) Experimental; basic research and design.
- (e) Model studies of curb, gutter, deflector and combination inlets for various gutter geometries. Attempt has been made to design a "best" inlet for given street conditions.
- (f) Model studies have been suspended. Final report is now in progress.
- (g) Hydraulic behavior of curb, gutter, combination, and deflector inlets have been investigated. Equations, rating curves, and a graphic method are available for determination of inlet capacities.
- (h) "Progress Report on The Storm Drainage Research Project", J. C. Geyer and P. Bock, 1955. (Available on loan).  
"Hydraulic Theory for Design of Storm-Water Inlets", W. H. Li, Proceedings, Highway Research Board, 1954 (reprints available).  
All pertinent information on inlets derived from this study to be presented in the following book to be published shortly, "The Design of Storm Water Inlets", The Department of Sanitary Engineering and Water Resources, The Johns Hopkins University.

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

- (b) Baltimore City, Baltimore County, and the Maryland State Roads Commission.
- (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 7 urban areas ranging in size from 10 to 400 acres are gaged, 4 by a newly developed flow meter, and 3 by stage measurements only. Two recording systems which simultaneously record rainfall on and runoff from 14 inlet areas provide good opportunity for detailed study. About 4 years of rainfall records now exist for a network of 10 recording gages covering an area of about 50 square miles.

- (g) Three years of data for small urban type areas show inlet times to be variable. Time to peak runoff to the inlet depends on intensity and duration of rainfall. The data support the general practice of assuming an inlet time of 5 or 6 minutes, although under certain conditions an inlet time of one minute for the immediately contributing paved areas appears justified. Further analyses are under way.

(1111) DEVELOPMENT OF FLOW GAGE FOR STORM SEWER DISCHARGES.

- (b) Baltimore City, Baltimore County, and the Maryland State Roads Commission.
- (d) Experimental; applied research.
- (e) The development of gages for measuring both depth and velocity of the debris-laden shooting flow commonly found in storm sewers. The search is for a method generally adaptable to existing storm sewers that does not require extensive alterations of the sewer channel.
- (g) Two years operational data are available for "Pigmy" type cup (Price) current meters in a special mount to give shielding against debris, installed in 3 storm sewers. The successful operation of the flow meters depends on the type and amount of debris present. Continuous maintenance is necessary. An ultra-sonic method of measuring velocities is being investigated.

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THE JAMES LEFFEL AND COMPANY.

(2336) DRAFT TUBE DEVELOPMENT.

- (b) Laboratory project.
- (c) Mr. J. Robert Groff, The James Leffel and Co., 426 East Street, Springfield, Ohio.
- (d) Experimental and applied research.
- (e) A program of testing of medium speed wheels for horsepower, efficiency, thrust, torque, runaway speed and leakage on conventional as well as newer types of draft tubes. Study of vortices or swirls in the draft tube and reliable means of preventing or breaking them up.

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LEHIGH UNIVERSITY, Fritz Engineering Laboratory.

Inquiries concerning Project Nos. 1602, 1603, 2337 to 2339, incl, should be addressed to Professor M. B. McPherson, Department of Civil Engineering, Fritz Laboratory, Lehigh University, Bethlehem, Pennsylvania.

(1602) PRESSURE DISTRIBUTION IN CONDUIT BENDS.

- (b) Laboratory project.
- (d) Experimental; applied research, for professional degree thesis, undergraduate and graduate special problem.
- (e) Electrical-analogy study of bends of circular cross-section has been initiated.
- (h) "Minimum Pressures in Rectangular Bends", by M. B. McPherson and H. S. Strausser, A.S.C.E. Proceedings, Paper No. 747, July 1955.

(1603) BUTTERFLY VALVE STUDY.

- (b) C.D.C. Controls Services, Inc., Hatboro, Pa.
- (d) Experimental; applied research, master's thesis.
- (g) Report on head loss characteristics being prepared for publication.



Lehigh University  
Louisiana State University and A and M College  
University of Maryland

(2337) GREENSBORO DAM SPILLWAY MODEL.

- (b) William C. Olsen and Associates, Raleigh, N. C.
- (d) Experimental; design.
- (e) 1:40 scale movable-bed model; bucket-type dissipator; two-dimensional model.
- (f) Completed, April 1955.

(2338) PENN FOREST DAM CHUTE SPILLWAY MODEL.

- (b) Bethlehem Authority.
- (d) Experimental; design.
- (e) 3:100 scale model; 28° deflection angle between approach channel and chute; flared-wall bucket-type energy dissipator leading to downstream canal.
- (f) Completed, August 1955.

(2339) BUCKET-TYPE ENERGY DISSIPATOR CHARACTERISTICS.

- (b) A.S.C.E. Task Force on Energy Dissipators; laboratory project; master's thesis.
- (d) Experimental; for general design.
- (f) First of three phases of study initiated November 1955.

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LOUISIANA STATE UNIVERSITY AND A and M COLLEGE, Agricultural Engineering Research.

(2340) HOSE TESTS.

- (b) Cooperative with State Anhydrous Ammonia Commission.
- (c) Mr. Harold T. Barr, Head, Agricultural Engineering Research, Louisiana State University and A and M College, Baton Rouge 3, La.
- (d) Experimental.
- (e) To determine by testing anhydrous ammonia hose the cause of failure and probable life as well as testing hose for meeting specifications. At present equipment is being re-built prior to making more thorough and complete tests due to start January 1956. A laboratory is being established for determining flow rates and pressure drops in various valves, and complete hookups for the handling of liquid ammonia and vapor in the return systems. Also being built into the equipment is a flow rate tester for vapor returns and high pressure safety valves.

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UNIVERSITY OF MARYLAND, Glenn L. Martin Institute of Technology.

(2099) TRANSITION FLOW PATTERNS IN PIPES.

- (b) Office of Scientific Research, Air Research and Development Command, U. S. Airforce. Under Contract AF 18(600)-893.
- (c) Dr. John R. Weske, University of Maryland.
- (d) Experimental (primarily) and theoretical basic research. One side of problem is being investigated by a graduate student as a master's thesis in Physics.
- (e) This project, planned by Dr. Th. Theodorsen, at that time Scientific Consultant of the Air Force, for the purpose of verifying, experimentally, his theory of the structure of turbulence, is being continued for a third year (Sept. 1, 1955 to Aug. 31, 1956). The investigation centers about the detail physical phenomena in particular the occurrence and behavior of vortices which are observed during transition from laminar to turbulent flow in pipes and also in the boundary layer along flat plates.
- (h) A 600-foot 16mm color movie completed June 1, 1954 showing discrete vortex patterns in a pipe is available on loan.



(2100) DESIGN OF LABORATORY EQUIPMENT TO STUDY FLUID FLOW BY VISUAL MEANS.

- (b) Laboratory project.
- (c) Prof. J. B. Cournyn, University of Maryland, College Park, Md.
- (d) Experimental; for design and for master's theses.
- (f) Completed.
- (g) The purpose of this project was to design and construct the apparatus necessary to convert the Chapman Photoelastic Unit into a unit with which qualitative fluid flow studies could be made using a bentonite suspension. This type of flow study utilizes a phenomenon called photoviscosity or streaming double refraction. The unit was so converted and excellent results were obtained.
- (h) "The Use of the Chapman Photoelastic Unit in Visual Fluid Flow Studies", Gerald W. Longanecker, Master's Thesis, 1955.

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

Inquiries concerning Projects Nos. 307, 577 to 580, incl., 1355, 1608, 1609, 1881, 2101, 2103, 2341, and 2342, and requests for reprints and Technical Reports should be addressed to Dr. Arthur T. Ippen, Professor of Hydraulics, Hydrodynamics Laboratory, Massachusetts Institute of Technology, Cambridge 39, Mass.

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

- (b) Laboratory project.
- (d) Theoretical and experimental; graduate research.
- (e) (1) Theoretical and experimental investigations have been made on steady-state uniform density current flows including determination of velocity distributions, resistance laws and interfacial stability. (2) Investigation of control structures for stratified flow.
- (g) Experimental work on phase (2) now in progress. Initial studies were concerned with the design of curtain walls for condenser water intakes in which the source of water consists of a warm layer overlying a cold layer. Experiments to determine the maximum rate of flow which can be discharged under the curtain wall without drawing in water from the upper layer have been completed. Experimental investigations of other types of control structures have also been made.
- (h) "Control of Stratified Flow", R. S. Gooch, M.Sc. Thesis, 1955.

(577) CHARACTERISTICS OF SOLITARY WAVES.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental; basic research.
- (e) (1) Experimental investigation of solitary wave characteristics in a horizontal channel. Measurements of attenuation for various bottom roughnesses. (2) Investigation of amplitude change, profile deformation and breaking characteristics of the solitary wave on a sloping beach. (3) Measurement of unsteady velocities in the boundary layer region. (4) Experimental investigation of wave characteristics in the transition between oscillatory and solitary waves.
- (g) Phases (1), (2), and (3) have been completed and work on phase (4) is in progress. An oscillatory wave generator with interchangeable cams has been used to generate waves of constant height and increasing wave length. Waves in the Stokian, cnoidal and solitary ranges have been obtained. Initial program is concerned with the interrelationship between celerity and wave length for waves having a constant amplitude to depth ratio. Future program includes an experimental study of the breaking characteristics of such waves.

- (h) "Attenuation and Shoaling Characteristics of the Solitary Wave", G. Kulin, Sc.D. Thesis, 1955.  
"Shoaling and Breaking of the Solitary Wave", A. T. Ippen and G. Kulin, Hydrodynamics Laboratory Technical Report No. 15, April, 1955.  
"Damping Characteristics of the Solitary Wave", A. T. Ippen, G. Kulin and M. A. Raza, Hydrodynamics Laboratory Technical Report No. 16, April, 1955.
- (578) TURBULENCE MEASUREMENTS IN FREE SURFACE FLOW.
  - (b) Office of Naval Research, Department of the Navy.
  - (d) Experimental; development of instrumentation.
  - (e) Studies of turbulence characteristics in open channel flow.
  - (g) Turbulence measurements in water with a Pitot tube-pressure cell combination have been obtained with a frequency response of the order of 150 cps. Oscilloscope records have been analyzed by means of a digital computer and auto-correlation curves, mean intensity spectra and macro-turbulence scale have been obtained. The results compare favorably with the work of other investigators in air.  
Additional experiments on the turbulence characteristics in the wake of a cylinder in supercritical open channel flow have been made. The decay of wake turbulence with distance downstream has been obtained by studying variations in the scale of macro-turbulence.
  - (h) "Some Studies of Turbulence in the Wake of a Cylinder", F. Raichlen, M.Sc. Thesis, 1955.  
"Turbulence Measurements in Free Surface Flow with an Impact Tube-Pressure Transducer Combination", A. T. Ippen, R. S. Tankin and F. Raichlen, Hydrodynamics Laboratory Technical Report No. 20, July, 1955.
- (579) INVESTIGATION OF FLOW CHARACTERISTICS IN UNSTEADY MOTION.
  - (b) Office of Naval Research, Department of the Navy.
  - (d) Experimental; basic research and development of instrumentation.
  - (e) Study of the basic flow characteristics in unsteady motion. Flows involving both frictional and separation effects have been investigated in an unsteady flow water tunnel.
  - (g) The investigations completed have included the effects of unsteady motion on the drop in potential and boundary resistance for cases of (1) surface resistance caused by boundary shear stress and (2) form resistance associated with the high shear and generation and diffusion of turbulence accompanying jet formation. These cases were obtained using uniform diameter conduits, orifices in conduits and Venturi-type restrictions in conduits.
  - (h) "Resistance Coefficients for Unsteady Flow through Fluid Meters", J. M. Jordaan, M.Sc. Thesis, 1955.  
"Resistance Coefficients for Accelerated and Decelerated Flows through Smooth Tubes and Orifices", J. W. Daily, W. L. Hankey, R. W. Olive and J. M. Jordaan, ASME Summer Meeting, June 1955, Paper No. 55-SA-78.
- (580) FUNDAMENTAL RESEARCH ON METHODS OF AIR DISPERSION IN AERATION PROCESSES.
  - (b) Federal Security Agency, Public Health Service.
  - (d) Experimental; basic research.
  - (e) Study of the mechanics of oxygen absorption by water with the purpose of increasing the efficiency of aeration processes in the treatment of sewage and industrial wastes.
  - (g) The first objective of the research program, a quantitative evaluation of the mechanism of oxygen absorption from air and oxygen bubbles has been completed. Present investigations have been concerned with a quantitative determination of the mixing coefficient in the diffusion equation which is a measure of the degree of turbulence associated with freely rising bubbles in a liquid column. The mixing coefficient is a maximum at the surface and decreases with increase in depth. At a given depth, the coefficient was observed to vary approximately directly with air-flow rate. Turbulence in the wake of the bubbles is transported toward the surface where it is subject to decay. It is concluded that this dissipation is responsible for the observed variation in the mixing coefficient with depth.



- (h) "Oxygen Absorption and Turbulence Characteristics in Bubble Aeration", C. E. Carver, Jr., Sc.D. Thesis, 1955.  
"Oxygen Absorption and Turbulence Characteristics in Bubble Aeration", A. T. Ippen and C. E. Carver, Jr., Hydrodynamics Laboratory Technical Report No. 14, April, 1955.  
"Mechanism of Oxygen Absorption", C. E. Carver, Jr., Conference on Biological Waste Treatment, Manhattan College, New York, April 1955.

(1355) CAVITATION INCEPTION FOR STEADY MOTION.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental; basic research.
- (e) Cavitation inception for steady motion is being studied for systematic variations in boundary layer development and in the turbulence level for the zone of minimum pressure.
- (g) A closed-jet water tunnel with a rectangular test section has been developed. The working section 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.  
Additional tests have also been made on the factors affecting the inception of cavitation in wall slots. It was found that the gas content of the nuclei plays an important part in determining the pressure at which cavitation will start.
- (h) "Cavitation at Offsets and Wall Slots", M. S. Slivitzky, M.Sc. Thesis, 1955.  
"The Effects of Turbulence and Gas Nuclei on the Inception of Cavitation", V. E. Johnson, Jr., M.Sc. Thesis, 1955.  
"Turbulence and Boundary Layer Effects on the Inception of Cavitation from Gas Nuclei", J. W. Daily and V. E. Johnson, Jr., Hydrodynamics Laboratory Technical Report No. 21, July 1955.  
"Turbulence and Boundary Layer Effects on Cavitation Inception from Gas Nuclei", J. W. Daily and V. E. Johnson, Jr., Proceedings, Symposium on Cavitation in Hydrodynamics, National Physical Laboratory, Teddington, England, September 1955; Hydrodynamics Laboratory Staff Publication No. 30.

(1608) FLOW CHARACTERISTICS OF SWING AND BALL CHECK VALVES.

- (b) Atomic Energy Commission.
- (d) Experimental; development.
- (e) Hydraulic characteristics of the components of a heat exchange circuit have been determined.  
Major objective of program was the testing of development models of check valves to meet strict specifications regarding head loss, magnitude of reverse flow to cause valve closure and stability of valve components.
- (f) Completed.
- (g) Test circuit consisted of an 8-inch pipe approximately 60 feet long with associated pressure measuring and flow-metering equipment. Tests on various designs of swing and ball check valves have been completed. Interior geometry of valves were modified to obtain dynamic stability of movable components. In addition, tests on a model of an electro-magnetic pump duct and a Pitot tube of special design were made.
- (h) "Hydraulic Performance of Check and Control Valves", R. E. Nece and R. E. DuBois, Journal, Boston Society of Civil Engineers, July 1955.

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

- (b) Beach Erosion Board, U. S. Army Corps of Engineers.
- (d) Experimental; basic research.
- (e) Quantitative study of the sorting action and selective transport of beach material by shallow water waves moving on a granular beach.



- (g) Equipment consists of a wave channel 30" wide, 36" deep and 100 feet in length together with a piston-type wave generating mechanism. The wave generator is controlled by a hydraulic servomechanism which permits continuous variation of both wave amplitude and frequency during operation. Beaches consist of graded materials of selected sizes and variable physical properties. The results of the sediment transport and sorting studies are related systematically to the various wave characteristics such as shape, celerity, frequency and internal velocities.

A systematic series of observations of sediment particle velocities for one beach slope and various surface roughnesses, including a smooth beach, has been completed. Size and specific gravity of the spherical particles which compose the movable sediment have been varied. An additional series of tests on a horizontal surface is now in progress.

- (h) "A Study of Sediment Sorting by Waves Shoaling on a Plane Beach", A. T. Ippen and P. S. Eagleson, Hydrodynamics Laboratory Technical Report No. 18, May 1955.  
 "A Study of Sediment Sorting by Waves Shoaling on a Plane Beach", A. T. Ippen and P. S. Eagleson, Proceedings of the I.A.H.R., Delft, Netherlands, September 1955.

(1881) WAVE FORCES ON OFFSHORE STRUCTURES.

- (b) Humble Oil and Refining Company.  
 (d) Experimental; basic research.  
 (e) Objective is the determination, by means of model tests, of the design forces to be expected on offshore structures subjected to shallow water wave action.  
 (g) Experimental equipment includes a 100-foot wave tank, an oscillatory wave generator of variable amplitude and frequency and dynamic lift and drag balances for the measurement of forces due to wave motion. Tests have been completed on a series of vertical cylinders in waves of various characteristics. Lift and drag measurements have also been made on vertical cylinders with variable submergence and on basic shapes such as spheres and cylinders. A series of tests on submerged horizontal cylinders of variable aspect ratio are now in progress.  
 (h) "Wave Forces on Semi-submerged Cylinders", W. C. Shapiro, M.Sc. Thesis, 1955.  
 "Experimental and Analytical Studies of Wave Forces on Basic Components of Offshore Structures", D. R. F. Harleman and W. C. Shapiro, Hydrodynamics Laboratory Report No. 19, May 1955.

(2101) PELIGRE DAM (HAITI) MODEL STUDY.

- (b) Brown and Root, Inc., Houston, Texas.  
 (d) Experimental; design.  
 (e) Model to study the performance of the stilling basin under all possible operating conditions of discharge through sluices and over spillway.  
 (g) A 1:40 scale model has been completed. Performance of stilling basin under varying tailwater conditions was improved by a revision of the end sill design. Optimum operating conditions for various combinations of sluices discharging into the stilling basin were obtained. Conditions at the spillway crest were also studied since the model showed pronounced contraction of the nappe at piers and end walls. Additional tests have been made to determine the effect of crest pier location and shape on the magnitude of the pier contraction coefficient.  
 (h) "Flow Transitions in Dam Sluiceways", Carl F. Seils, B.Sc. Thesis, 1955.  
 "Hydraulic Model Performance of Spillway and Outlet Works of Peligre Dam", D. R. Harleman, R. S. Gooch and A. A. Vulgaropoulos, Hydrodynamics Laboratory Technical Report No. 17, April 1955.  
 "The Effect of Location and Shape of Crest Piers on Spillway Performance", R. D. MacKay and T. A. Marlow, B.Sc. Thesis, 1955.

(2103) ENERGY DISSIPATION IN STILLING BASINS.

- (b) Laboratory project.  
 (d) Experimental; graduate research.

- (e) General study of the basic fluid mechanics associated with energy dissipation in stilling basins.
- (g) The use of a flat plate diffuser as a means of reducing bottom velocities in a stilling basin has been experimentally investigated. Particular attention was given to the stability, height and length of the hydraulic jump in the vicinity of the diffuser plate. Velocity distributions before and after the diffuser and bottom pressure distributions were also obtained.
- (h) "Effect of Baffle Piers on Stilling Basin Performance", D. R. F. Harleman, Journal Boston Society of Civil Engineers, April 1955.  
"Action of Diffuser in Stilling Basin", R. S. Hansen and C. J. Osterndorf, M.Sc. Thesis, 1955.

(2341) FLUID MECHANICS OF TURBOMACHINERY COMPONENTS.

- (b) Office of Ordnance Research, Department of the Army.
- (d) Experimental; basic research.
- (e) Investigation of problems connected with the several secondary effects in a turbomachine such as seal ring friction and leakage, rotor-to-wall clearance effects, and vane tip clearance.
- (g) The initial phase of the investigation is concerned with the effect of roughness, chamber dimensions and disk shape on disk friction. Experimental equipment consisting of a 15" diameter disk rotating in oil or water within a closed chamber is under construction.

(2342) DIFFUSION OF SUBMERGED JETS WITH DENSITY DIFFERENCES.

- (b) Laboratory project.
- (d) Experimental and analytical; basic research.
- (e) General study of the diffusion of submerged jets whose density is either greater or less than that of the surrounding fluid.
- (g) A series of experiments have been made on the characteristics of jets discharging horizontally into a reservoir. Trajectories and terminal densities of the jets were measured and compared with theory. The initial velocity of the jet was varied from 1 to 10 inches per second for jets both lighter and heavier than the surrounding medium. Additional work on instrumentation for the measurement of small salinity concentrations is in progress.
- (h) "Discharge of Submerged Jets with Density Differences", A. S. Fullerton and G. W. Schulz, M.Sc. Thesis, 1955.

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Department of Mechanical Engineering.

Inquiries concerning projects should be addressed to the following, all at Massachusetts Institute of Technology, Cambridge 39, Mass.

Nos. 1118, 1901, 1903, 2345, 2346.....to Prof. E. S. Taylor  
 Nos. 1890, 1895, 1900, 2106, 2107.....to Prof. J. L. Shearer  
 Nos. 2112, 2113, 2343, 2344.....to Prof. K. R. Wadleigh

(880) RECOVERY FACTORS AND HEAT-TRANSFER COEFFICIENTS FOR SUPERSONIC FLOW OF AIR IN A TUBE.

- (b) Office of Naval Research, Department of the Navy.
- (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 project objectives are to measure reliable heat-transfer coefficients for supersonic flow of air in a tube to study characteristics of such flow by investigation of the fundamental differential equations, and to measure boundary layer characteristics such as velocity and temperature profiles for such flows.



- (h) "Heat-Transfer Measurements in an Inexpensive Supersonic Wind Tunnel Part I--Apparatus and Results for a Laminar Boundary Layer Based on a Simple One-Dimensional Flow Model", J. Kaye, J. H. Keenan, G. A. Brown, and R. H. Shoulberg, Journal of Applied Mechanics, Trans. ASME, Vol. 22, 1955, pp. 289-296.  
 "Heat-Transfer Measurements in an Inexpensive Supersonic Wind Tunnel Part II -- Results for a Laminar Boundary Layer Based on a Two-Dimensional Flow Model", J. Kaye and G. A. Brown, Journal of Applied Mechanics, Trans. ASME, Vol. 22, 1955, pp. 297-304.  
 "Simultaneous Measurements of Velocity and Temperature Profiles for Adiabatic Supersonic Flow of Air in a Tube", J. Kaye, G. A. Brown, J. C. Westmoreland, and E. F. Kurtz, Journal of the Aeronautical Sciences, Vol. 22, 1955, pp. 575-577.
- (1118) SECONDARY FLOW IN CASCADES.
  - (b) General Electric, Westinghouse, Allison Division of General Motors, and Curtiss-Wright.
  - (d) Experimental and theoretical investigation.
  - (e) Experimental and theoretical investigation of secondary flow in cascades. Present work is concentrated on the case of a large favorable pressure gradient.
  - (g) Measurements of secondary flows in compressor and turbine cascades. Analysis of boundary layer behavior.
  - (h) "Effects of Moving Wall and Tip Clearance on Secondary Flow in a Cascade", E. M. Rex, M.S. Thesis, 1954.  
 "An Investigation of the End Wall Boundary Layer of a Turbine Nozzle Cascade", J. R. Turner, M.S. Thesis, 1955.
- (1884) EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF A CYCLONE DUST SEPARATOR.
  - (b) Laboratory project.
  - (c) Prof. Joseph H. Keenan, Mechanical Engineering Department, Massachusetts Institute of Technology, Cambridge 39, Mass.
  - (d) Effect of variation of geometry of separator on pressure drop and separating efficiency.
  - (e) Separating tests, pressure-drop measurements and various explorations of the vortex have been made with various inlet and outlet configurations.
  - (g) Analytical and experimental studies of pressure drop and separating efficiency.
  - (h) Doctor's thesis by Helmut Weber. Copies obtainable through librarian of M.I.T.
- (1890) STATIC AND DYNAMIC CHARACTERISTICS OF PRESSURIZED AIR BEARINGS.
  - (b) Laboratory project.
  - (d) Basic and applied research.
  - (e) In order to gain a better understanding of the behavior of pressurized, journal bearings having no external flow resistances, basic studies have been made of the flow between closely spaced flat plates. The results of this basic work were applied to the design of a pressurized air bearing which was used in an experimental investigation of dynamic characteristics of this type of bearing.
  - (f) Inactive.
  - (g) Non-dimensionalized graphs have been obtained showing the pressure distribution for various flow configurations between parallel and non-parallel flat plates. A design procedure has been worked out to make it possible to design a bearing to meet specified steady-state requirements, and a bearing has been built and tested which verifies the design procedure. This same bearing has been analyzed dynamically and the analysis and experimental dynamic tests indicate that this bearing is adequate for a wide range of applications.
  - (h) "A Dynamic Analysis of Externally Pressureized Air Bearings", by H. H. Richardson, S. B. and S. M. Thesis, Department of Mechanical Engineering, M.I.T., 77 Massachusetts Avenue, Cambridge 39, Mass., 1955. M.I.T. Library will furnish quotation on microfilm or photocopy upon request.  
 "Flow of a Compressible Fluid in a Thin Passage", by S. K. Grinnell. ASME Paper No. 55 SA-13.  
 "Design Study of a Hydrostatic Gas Bearing with Inherent Orifice Compensation", by S. K. Grinnell and H. H. Richardson. ASME Paper given Nov. 16, 1955 at Annual meeting of the ASME in Chicago.



## (1895) EFFECTS OF FLUID MASS AND COMPRESSIBILITY ON CONTROL VALVE STABILITY.

- (b) Bureau of Ordnance, Department of the Navy, U. S. Air Force, Wright Air Development Center.
- (d) Basic research.
- (e) A fundamental investigation has been made into the nature of the dynamic flow forces encountered in valves when the mass of the fluid in the connecting passages is significant. This work has also been extended to a study of situations that occur when both fluid mass and compressibility are both significant.
- (g) A thorough analysis reveals that the mass of the fluid in the passages of a valve-controlled hydraulic system can have an important influence on the dynamic forces exerted by the fluid on the moving member of the control valve. Experimental results were inconclusive because of insufficient instrumentation and the compromising effect of fluid compressibility. It has been found that in many cases it is necessary to consider the effects of continuously distributed fluid mass and compressibility in the lines leading to a hydraulic valve.
- (h) "Effect of a Hydraulic Conduit With Distributed Parameters on Control-Valve Stability", Sc.D. Thesis, Department of Mechanical Engineering, M.I.T., 77 Massachusetts Avenue, Cambridge 39, Massachusetts, 1955. M.I.T. Library will furnish quotation on microfilm or photocopy upon request.

## (1900) PRESSURE-FLOW CHARACTERISTICS OF PNEUMATIC VALVES.

- (b) Bureau of Ordnance, Department of the Navy.
- (d) Applied research.
- (e) Flow versus pressure curves at various valve openings have been obtained analytically for various 3-way valve configurations and experimental curves are being obtained for a number of real valves.
- (g) An experimental study of a large-scale, two-dimensional model of the flow in a slide valve has been completed which revealed that there are two possible flow regimes in this type of valve. With one regime, the flow discharge coefficient is nearly 1.0, and with the other, the discharge coefficient is approximately 0.8. Quantitative measurements have been made of the pressure-flow characteristics of a closed-center, slide-type, three-way valve. The effects of side leakage in the clearance spaces of the valve is evident at small valve opening conditions, but other wise the results seem to agree well with analytically derived characteristics. Measurements have also been made of a flapper-type three-way valve. In addition to pressure-flow characteristics, the steady-state flapper force characteristics have been measured.
- (h) "Development of a Solid-Propellant-Powered Control-Surface Actuator for Guided Missiles", G. Reethof, Thesis (Sc.D.) Department of Mechanical Engineering, M.I.T., Cambridge 39, Mass. (Partly Classified. Organizations with proper security clearance may write to the Director of the Dynamic Analysis and Control Laboratory, M.I.T. for information about how to procure copies of the thesis).  
"Study of Pneumatic Processes in the Continuous control of Motion with Compressed Air - I", ASME Paper No. 55 IRD-10, 1955, J. L. Shearer.  
"Analysis and Design of a Servomotor Operating on High-Pressure Compressed Gas", G. Reethof, submitted to ASME for presentation at the Princeton Symposium on Nonlinear Control Systems March 26-27, 1956.

## (1901) SKEWED BOUNDARY LAYER IN A VANELESS DIFFUSER.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental and theoretical for Sc.D. Thesis.
- (e) The importance of the skewed boundary layer in turbo-machinery is becoming more apparent. This research is an attempt to study the simplest problem involving the skewed boundary layer. New apparatus has been constructed.
- (g) (1) Experimental data on flow in a centrifugal diffuser, and (2) theoretical analysis of wall boundary layer flow.
- (h) "Shear Flow in Bends", H. P. Eichenberger, Office of Naval Research, Technical Report, 1952.

- "Vorticity and Vortex Sheets in Axial Turbomachines", G. L. Mellor, S. M. Thesis, Sept. 1954.  
 "Investigation of Velocity Profile Generators", L. H. Bartolink, S. M. Thesis, Sept. 1954.  
 "Potential Flow Through A Cascade of Known Airfoils", by K. H. Schneider, M. S. Thesis, 1955. GTL Report 32.  
 "A Study of the End Wall Boundary Layer in an Axial Compressor Blade Row, GTL report no. 33, October, 1955.

The following are progress reports to the ONR and may be obtained only through the ONR:  
 "Theoretical Consideration of Secondary Flow", by George L. Mellor, December 1954, Gas Turbine Laboratory, Report No. 27-2.

"Axisymmetric Solutions of the Flow Through a Single-Stage Compressor", by Raymond W. Moore, D. L. Richardson, Gas Turbine Laboratory, Report No. 27-5 December, 1954.

"Measurements of Flow Through A Single Stage Axial Compressor", by R. W. Moore, D. L. Richardson, December 1954, Gas Turbine Laboratory, Report No. 27-6.

(1903) INVESTIGATION OF ROTATING STALL IN AXIAL COMPRESSORS.

- (b) National Advisory Committee for Aeronautics.
- (d) Theoretical and experimental, for Sc.D. thesis.
- (e) Theoretical and experimental study of rotating stall in a compressor and in an apparatus especially constructed for the purpose of investigating rotating stall.
- (g) Schlieren photographs and interferometer photographs have been taken of rotating stall in an annular cascade (radial flow).
- (h) "Stall Propagation in Axial Compressors", by A. H. Stenning, Sc.D. Thesis, Gas Turbine Laboratory, June 1955, Report No. 28.  
 "An Investigation of Rotating Stall in a Single-Stage Axial Compressor", by S. R. Montgomery and J. Braun, Master's Thesis, Gas Turbine Laboratory, June 1955, Report No. 29.

(2106) DESIGN OF A POSITIVE DISPLACEMENT ROTARY AIR MOTOR.

- (b) U. S. Air Force, Wright Air Development Center.
- (d) Design and development.
- (e) A unit has been designed to operate on air at room temperature and pressures up to 500 psi with a maximum speed of about 5000 rpm with a maximum output of 1.5 lb.
- (h) "Design and Evaluation of a High-Pressure, Positive-Displacement Air Motor", H. B. Kolm, Thesis (S.M.), Dept. of Mech. Engr., M.I.T., 1955.

(2107) A STUDY OF THE STATIC AND DYNAMIC CHARACTERISTICS OF A "JET PIPE" TYPE CONTROL VALVE.

- (b) Laboratory project.
- (d) Basic research; for doctoral thesis.
- (e) A fundamental study is planned to try and discover the upper limits of performance that may be obtained with this type of flow modulating device.

(2112) STUDY OF TWO-STROKE ENGINE SCAVENGING PROCESS.

- (b) Laboratory project.
- (d) Theoretical and experimental; applied research.
- (e) A study of the effects of geometry and valve timing on the air flow characteristics of a two-stroke, uniflow-type, internal combustion engine. Equipment is complete; experimental work has begun.

(2113) Development of INSTRUMENTATION TO MEASURE PROPERTIES OF HIGH-VELOCITY GAS STREAMS CONTAINING LIQUID DROPLETS IN SUSPENSION.

- (b) Mass. Institute of Technology under Grant-In-Aid from Pratt and Whitney Aircraft.
- (d) Experimental and theoretical; applied research.
- (e) Special instrumentation is being developed to measure vapor concentration, pressure, temperature, etc. of high velocity gas streams containing liquid droplets in suspension.



- (g) Stagnation pressure probes and vapor-sampling probes, together with suitable measuring techniques, have been developed.
- (h) "A Deceleration Probe for Measuring Stagnation Pressure and Velocity of a Particle-Laden Gas Stream", by Jules L. Dussourd and Ascher H. Shapiro, Heat Transfer and Fluid Mechanics Institute, University of California, Los Angeles, June 1955.

(2343) AEROTHERMOPRESSOR PROJECT.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental and theoretical; applied research.
- (e) The Aerothermopressor is a device in which the stagnation pressure of high temperature, high-velocity gas streams is increased by evaporation cooling of injected water. A theory of operation based upon fundamental laws has been developed. Experimental work on large and small-scale devices is under way.
- (g) An Aerothermopressor has been operated successfully. Effort is now concentrated upon achieving better performance.
- (h) "The Aerothermopressor - A Device for Improving the Performance of a Gas Turbine Power Plant", A. H. Shapiro, K. R. Wadleigh, B. D. Gavril, and A. A. Fowle, ASME, Paper No. 55 SA 65.

(2344) STUDY OF THE ATOMIZATION OF LIQUIDS IN GASES.

- (b) General Electric Company.
- (d) Experimental and theoretical; applied research.
- (e) A study of the interaction between gas and liquid streams in atomization processes to determine the dependence of drop size, drop size spectrum, spatial distribution, etc. on the properties of the fluid flows.
- (g) Special drop-size measuring devices have been developed.

(2345) INVESTIGATION OF SKEWED BOUNDARY LAYER.

- (b) General Electric, Westinghouse, Allison Division of General Motors, and Curtiss-Wright.
- (d) Experimental and theoretical; applied research for Sc.D. thesis.
- (e) An apparatus has been designed and constructed which produces a three-dimensional skewed boundary layer in an unfavorable pressure gradient. The behavior of this boundary layer will be compared with that of a simple two-dimensional boundary layer.

(2346) A CASCADE FOR THE SIMULATION OF THREE-DIMENSIONAL FLOW AT STATOR ROOTS AND ROTOR TIPS.

- (b) General Electric, Westinghouse, Allison Division of General Motors, and Curtiss-Wright.
- (d) Design and development; for Sc.D. thesis.
- (e) A study of the problem of radial equilibrium in a compressor stage often indicates large changes in axial velocity through rotor and stator blades near their extremities. An apparatus to study this problem has been designed.

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UNIVERSITY OF MASSACHUSETTS, Department of Civil Engineering.

(2121) EFFECT OF AIR POCKET FORMATION AT THE SUMMIT OF A PRESSURE PIPE SYSTEM ON FLOW THROUGH THE SYSTEM.

- (b) Laboratory project.
- (c) Dean George A. Marston, Director, Engineering Research Institute, University of Massachusetts, Amherst, Massachusetts.
- (d) Experimental; applied research.
- (e) The purpose of the investigation is to correlate the amount of air pocket formation and the resultant head loss, with the angle of a vertical bend and the velocity of flow through a system.



## MICHIGAN STATE COLLEGE, Department of Civil Engineering.

## (2122) DEVELOPMENT OF THE BOUNDARY LAYER IN THE ENTRANCE TO A PIPE.

- (b) Laboratory project.
- (c) Prof. Harold R. Henry, Civil Engineering Department, Michigan State College, East Lansing, Mich.
- (d) Experimental and theoretical; basic research for doctor's thesis.
- (e) Velocity and pressure measurements obtained to determine boundary layer growth and characteristics. Also analytical study used in interpreting and analyzing experimental results.

## (2123) DEVELOPMENT OF A BOUNDARY LAYER IN A DIFFUSER NEAR THE ENTRANCE OF A PIPE.

- (b) Laboratory project.
- (c) Prof. Harold R. Henry, Civil Engineering Department, Michigan State College, East Lansing, Mich.
- (d) Experimental and theoretical; basic research.
- (e) A diffuser section increasing from two inches diameter with an included angle of  $6^\circ$  is attached to a two-inch pipe at various distances from the pipe entrance. Velocity traverses are made and pressure drop recorded. An analytical study conducted in parallel is used as a guide.

## (2124) AVAILABILITY OF GROUND WATER IN ARTESIAN AQUIFER UNDERLYING THE MICHIGAN STATE COLLEGE CAMPUS AND FARM AREA.

- (b) Michigan State College.
- (c) Mr. Norman E. Tufford, Mechanical Engineer Buildings and Utilities Department, Michigan State College, East Lansing, Michigan.
- (d) Field research for purposes of development.
- (e) Geophysical studies through use of aquifer performance testing advocated by Jacob and Theis and others, and also through use of earth resistivity methods.
- (g) Nothing definite has been concluded as yet but some very encouraging and useful tests have been conducted.

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

- (b) Michigan Agriculture Experiment Station.
- (c) Prof. E. H. Kidder, Agriculture Engineering Department, Michigan State College, East Lansing, Mich.
- (d) Field investigation; for design.
- (e) Samples of runoff water from small watersheds will be collected to determine the concentration and size of sediment in transport. Runoff gaging stations are being operated and samples obtained from two watersheds in a drainage type topography. An attempt will be made to determine the source of sediment.

## (2126) SURFACE AND SUBSURFACE DRAINAGE.

- (b) Michigan Agriculture Experiment Station.
- (c) Prof. E. H. Kidder, Agriculture Engineering Department, Michigan State College, East Lansing, Mich.
- (d) Experimental, field investigation; applied research.
- (e) To study the effect of bedding, bedding and moling, bedding and tile and tile drainage on the yields in a sub-marginal cropping area. Crop yields in a grain-grain-hay-hay rotation are measured in increments away from the drainage feature.
- (g) Sixty-foot spacing, tile and bedding, produced the highest oat yields; two-rod spacing, tile only, produced the highest hay yields.

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

- (b) Michigan Agricultural Experiment Station.
- (c) Prof. E. H. Kidder, Agriculture Engineering Department, Michigan State College, East Lansing, Mich.
- (d) Experimental, field investigation; applied research.
- (e) To study the stability and durability of subsurface drains in muck soils, four different materials and different lengths of these materials were placed in a newly cleared muck area (pH of 6.0). 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. Elevations and quality of these materials are checked periodically.

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UNIVERSITY OF MICHIGAN, Department of Civil Engineering.

(2129) DEVELOPMENT OF OPEN CHANNEL FLOW CONTROL.

- (b) Rackham Research Grant.
- (c) Prof. V. L. Streeter, 322 W. Engineering Bldg., Ann Arbor, Michigan.
- (d) Experimental and analytical.
- (e) To apply the principle of a nonlinear spring single orifice flow control to open channel flow.
- (g) Satisfactory results being obtained with flow controller designed for head range 2 to 8 inches and discharge 15 to 120 gpm. In inverted form, the device performs as a flow meter with linear head discharge relationship and adjustable capacity.
- (h) "A Quick Response Variable Flow Control Device", V. L. Streeter, Journal ISA, Vol. II, No. II, pp. 48 - 51; February, 1955.

(2130) MODEL STUDY OF BLACK RIVER HARBOR.

- (b) Michigan State Waterways Commission.
- (c) Prof. E. F. Brater, 320 W. Engineering Bldg., Ann Arbor, Michigan.
- (d) Experimental.
- (e) To determine the breakwater arrangement which will produce the most effective economical harbor.
- (f) Completed.
- (g) Two satisfactory harbor arrangements were developed, one of which was chosen for construction.
- (h) "Model Studies for Harbor of Refuge for Light Draft Vessels at Black River Harbor, Michigan", E. F. Brater and L. D. Stair, University of Michigan Lake Hydraulics Laboratory Tech. Rep., No. VII, 1955.

(2347) WAVE FORCE ON SUBMERGED STRUCTURES.

- (b) Cooperative project sponsored by University of Michigan School of Graduate Studies, Bethlehem Steel Co. and Shell Oil Co.
- (c) Prof. E. F. Brater, 320 W. Engineering Bldg., Ann Arbor, Michigan.
- (d) Experimental and analytical.
- (e) To determine and analyze wave forces on submerged barge-like structures of various shapes for various wave conditions.
- (f) Experimental work near completion. Analysis under way.

(2348) DETERMINATION OF WATER SURFACE PROFILES PRODUCED BY UNIFORM ARTIFICIAL RAINFALL ON OPEN CHANNELS.

- (b) Laboratory project for doctoral dissertation.
- (c) Prof. E. F. Brater, 320 W. Engineering Bldg., Ann Arbor, Michigan.
- (d) Experimental and analytical.

- (e) To determine water surface profiles and friction factors on channels of known roughness for unsteady flow produced by artificial rainfall. Comparison of measured and computed profiles.
- (f) Experimental work completed. Analysis near completion.

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UNIVERSITY OF MICHIGAN, Experimental Naval Tank.

Inquiries concerning Projects Nos. 585, 1127, 1128, 1378, 2132, and 2349 should be addressed to Prof. L. A. Baier, 326 West Engineering Building, University of Michigan, Ann Arbor, Michigan.

- (585) RESISTANCE OF BARGE TOWS.
  - (b) Corps of Engineers, Department of the Army.
  - (d) Experimental; design.
  - (e) To determine resistance of several formations of certain barge types relative to non-restricted straight channels and to selected channels restricted in width and depth. Each run will consist of movement of one model formation, at one draft and one depth of water for a given channel condition through a range of velocities sufficient to define a curve of functions of resistance versus velocity.
  - (f) Tank work completed.
  - (h) Report completed.
- (1127) TRANSOM IMMERSION ON HIGH-SPEED MOTORBOATS.
  - (b) Laboratory project.
  - (d) Research; design.
  - (e) Tests are being continued to determine the most efficient transom immersion for various high speed hull forms.
- (1128) COMMERCIAL VESSELS, 150 to 250 FEET IN LENGTH.
  - (b) Fairbanks, Morse, and Company.
  - (d) Experimental; design.
  - (e) A large family of hull forms is being tested in order to provide design data for the future design of commercial vessels, 150 to 250 feet in length.
- (1378) VIBRATION ELIMINATION.
  - (b) Laboratory and field projects.
  - (d) Experimental; applied research.
  - (e) Design and testing of fins fitted to both single and multiple screw hulls in way of propeller in order to control feed water flow and eliminate fantail vibration. Recent emphasis placed on twin screw stern vibration.
- (2132) SKEG DESIGN FOR CONTROL OF YAW.
  - (b) Laboratory project.
  - (d) Experimental; applied research.
  - (e) Design and testing of various types of skegs for use on towed barges where control of yaw is required. The purpose is to obtain positive operating skegs with a minimum of resistance and cost of installation.
  - (f) 80% completed.
  - (h) Report of present status was given as a paper before the Gulf Section of the Society of Naval Architects and Marine Engineers, Spring Meeting, 1955.



(2349) OIL BARGE DESIGN.

- (b) Union Industrial of Astilleros Barranquilla, Colombia.
- (d) Experimental.
- (e) Determination of best barge form for flotilla operation under local conditions.
- (f) 10% completed.

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UNIVERSITY OF MINNESOTA, Department of Agricultural Engineering.

(2350) DRAINAGE OF AGRICULTURAL LAND BY PUMPING.

- (c) Prof. Curtis L. Larson, Department of Agricultural Engineering, University of Minnesota, St. Paul 1, Minnesota.
- (d) Field investigation and theoretical; applied research.
- (e) The project has 3 phases, (a) the development of basic relations for planning pump drainage systems, (b) the study of rates of drainage, and (c) the study of factors affecting the efficiency and cost of drainage pumping plants.
- (h) "Principles of Planning Pump Drainage Outlets", by Curtis L. Larson and Evan R. Allred, has been submitted to Agricultural Engineering, St. Joseph, Michigan for publication.

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

(317) VELOCITY STUDIES IN A VERTICAL PIPE FLOWING FULL.

- (b) Laboratory project.
- (c) Prof. Clifford D. Muir, Civil Engineering Department, Missouri School of Mines and Metallurgy, Rolla, Mo.
- (d) Experimental; basic research.
- (e) Tests were conducted on vertical flow in 1/2 inch hard-drawn copper pipe to investigate flow with pipe flowing full and under positive pressure.
- (f) Reactivated for further study.
- (g) The experimental results obtained were in agreement with theoretical computations.

(319) WEIR STUDIES.

- (b) Laboratory project.
- (c) Prof. E. W. Carlton, Civil Engineering Department, Missouri School of Mines and Metallurgy, Rolla, Mo.
- (d) Experimental; basic research.
- (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.
- (f) Reactivated in order to study other weir shapes.
- (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.

(2133) CHARACTERISTICS OF COMPRESSIBLE ORIFICE.

- (b) Laboratory project.
- (c) Prof. Clifford D. Muir, Civil Engineering Department, Missouri School of Mines and Metallurgy, Rolla, Mo.

Missouri School of Mines and Metallurgy  
University of Missouri  
Montana State College  
Newport News Shipbuilding and Dry Dock Company

- (d) Experimental.
- (e) This project is primarily a study of orifice coefficients using compressed air as the test fluid. It is felt that this project will confirm some purposed orifice coefficients and serve as a basis for an enlarged study of several orifice characteristics, such as head loss, shape effect, etc.
- (g) No confirmed results to report at this time.

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UNIVERSITY OF MISSOURI, Engineering Experiment Station.

(2134) HEAD LOSSES IN STORM DRAIN JUNCTION BOXES.

- (b) Missouri State Highway Department in cooperation with U. S. Bureau of Public Roads.
- (c) Prof. Horace W. Wood, 243 Engineering Building, University of Missouri, Columbia, Mo.
- (d) Experimental; applied research, development.
- (e) Model study of junction boxes for use in urban highway construction; methods for determining coefficients by which head losses in junction boxes can be accurately predetermined for various common configurations.
- (g) Work completed for straight-through and combining flow. Effect of inflow from top grate not yet studied. Other problems to be investigated. Studies of accumulated data still under way.
- (h) "Head Losses in Storm Drain Junction Boxes", presented by Horace W. Wood at the January 1956 meeting of the Highway Research Board.

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MONTANA STATE COLLEGE, Department of Agricultural Engineering.

(2351) FORECASTING SEASONAL AND ANNUAL WATER SUPPLY.

- (b) Laboratory project.
- (c) Prof. O. W. Monson, Agricultural Engineering Department, Montana State Agricultural Experiment Station, Bozeman, Mont.
- (e) Correlations developed between water content of snow cover and subsequent runoff basis of forecasting seasonal runoff.
- (g) Accuracy of forecasts improved by application of improved statistical methods.
- (h) Snow survey summaries including forecasts prepared first of each month January through May. Write Mr. A. R. Codd, Hydraulic Engineer, Montana State Agricultural Experiment Station, Bozeman, Mont.

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NEWPORT NEWS SHIPBUILDING AND DRY DOCK COMPANY.

Inquiries concerning Projects Nos. 123, 124, 896, 901, 1132, 1133, 1136, 1634, and 2352 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 moment diagrams. The turbine load is applied by an electrical dynamometer and the gate openings are controlled by a governor. The blades adjust automatically and the blade moment is measured by a spring dynamometer.

## (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 was arranged in which the beam-draft ratio, the displacement-length ratio, and the prismatic coefficient are varied over a wide range. Towing of 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 a Strobolux light synchronized with the shaft rotation, visual observations are made to determine the location on the blade where cavitation starts.

## (1136) WAVE TESTS ON SHIP MODELS.

- (b) Laboratory project.
- (d) Experimental; for design data.
- (e) Ship models are tested with scaled waves to determine the speed reduction in waves for the pull required for various still water speeds. Pitching periods and angles are determined from light trace photographs. Wave tests were conducted for the ICSH Seaworthiness Committee and the results were reported at the Seventh International Conference on Ship Hydrodynamics in Scandinavia in August 1954. These tests were made on a Todd-Forrest Series 60, Block 0.60 model, at three radii of gyration, at five towline pulls, in four wave lengths of a single wave height. Wave tests are being made in conjunction with the ATTC Seaworthiness Committee program. The parent model for these tests is the Todd-Forrest Series 60, Block 0.60. Tests have been completed on three models of a flare series, all models having the same shear line and radius of gyration. The models were tested at five towline pulls in five wave-lengths and two wave-height ratios. Shear and other variations will be tested as time permits.



Newport News Shipbuilding and Dry Dock Company  
New York University

(1634) RESEARCH AND TEST OF MAIN INJECTION SCOOPS AND OVERBOARD DISCHARGE.

- (b) Bureau of Ships, Department of the Navy.
- (d) Experimental.
- (e) To determine the principal criteria governing the flow in ship circulating systems and to obtain some design data on the various circulating components. Model components are tested separately in a water channel. Dynamic similarity is enhanced by modeling the boundary layer thickness and shape to scale. Stagnation, secondary flow, etc, are observed through transparent plastic models.
- (f) Completed.
- (h) "Research and Test of Main Injection Scoops and Overboard Discharge", by W. F. Taylor and R. D. Douglas, 30 June 1955. Submitted to Bureau of Ships, Department of the Navy.

(2352) SHIP STABILIZER FIN TEST.

- (b) Sperry Gyroscope Corporation.
- (d) Experimental; for design data.
- (e) Hydrodynamic tests of model in circulating water channel were conducted to determine lift, drag, and torque forces under varying head conditions.
- (f) Completed.

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NEW YORK UNIVERSITY, Department of Chemical Engineering.

Inquiries concerning Projects Nos. 1138, 1165, 2135, 2136, and 2353 should be addressed to Prof. John Happel, Department of Chemical Engineering, New York University, Bronx 53, New York.

(1138) EFFECT OF VARIATION OF SOLID TO FLUID DENSITY RATIO ON FLUIDIZATION CHARACTERISTICS.

- (b) Laboratory project.
- (d) Experimental; for one doctoral and one master's thesis.
- (e) Screened particles of very light solid substances were fluidized in a 2-inch glass tube and the fluidization characteristics observed. The primary objective will be the determination of the optimum ratio of solid to gas density for smooth fluidization.
- (g) The approximate results obtained to date show good agreement with the experimental results of J. Happel and N. Epstein, Ind. Eng. Chem. 46, pp. 1187-1194, June 1954. The theoretical treatment is being carried to a higher degree of approximation.

(1635) A CRITICAL STUDY OF THE PRIME VARIABLES IN A FLUIDIZED BED.

- (b) Laboratory project.
- (d) Experimental; for doctoral thesis.
- (e) The effect of entrance conditions on the uniformity of fluidization in solid-liquid systems was studied over a range of conditions from a parabolic to a uniform flow pattern. Various calming section and bed supports were utilized. The effects of entrance conditions and the ratio of bed height to column diameter will be utilized to predict fluidized bed behavior and to compare fixed and fluidized beds.

(2135) EFFECT OF A CYLINDRICAL BOUNDARY ON STEADY VISCOUS FLOW PAST SPHERES.

- (b) Texas Company, laboratory project.
- (d) Experimental; for doctoral thesis.
- (e) A study of the effect of a cylindrical boundary on steady flow past spheres as a function of Reynolds number, sphere-to-cylinder diameter ratio, distance of spheres from axis of cylinder and void volume by simultaneous measurement of drag on the spheres and pressure drop caused by their presence.

(2136) EFFECTS OF BOUNDARY PROXIMITY IN DILUTE, FLUIDIZED AND SEDIMENTING SYSTEMS OF UNIFORM SPHERICAL PARTICLES.

- (b) Work initiated under a grant from the Research Corp. of America being continued under a grant from the National Science Foundation, laboratory project.
- (d) Theoretical; basic research.
- (e) An attempt to reconcile the theoretical and experimental discrepancies observed in the determination of pressure drop caused by slow viscous flow in bounded and unbounded media at identical voidages and velocities.
- (g) Intermediate results explain bed circulation and non-uniform spatial distributions observed in fluidized beds. Theoretical expression for pressure drop through fluidized bed agrees well with experimental results.

(2353) THE SLOW MOTION OF TWO SPHERES IN A VISCOUS FLUID.

- (b) Work carried out under grants noted in (2136); laboratory project.
- (d) Theoretical; basic research.
- (e) The Stokes-Navier equations neglecting inertial terms have been solved by a procedure of successive approximations for the case of two spheres of arbitrary size settling in a quiescent, unbounded fluid. These results will be used to establish the effect of solids concentration on sedimentation rate at low velocities.

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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.
- (d) This is an applied research project in which a theoretical analysis is being checked experimentally.
- (g) A test program has been completed that included tests of two widths of channel, two lengths of crest and two crest heights. The analysis of this data is now underway.

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NEW YORK UNIVERSITY, Department of Meteorology and Oceanography.

(2354) THE INTERACTION BETWEEN OCEAN AND ATMOSPHERE WITH SPECIAL REFERENCE TO THE HYDROGRAPHIC CIRCULATION.

- (b) Geophysics Branch, Office of Naval Research, Department of the Navy.
- (c) Dr. Gerhard Neumann, Professor of Oceanography, New York University, College of Engineering, New York, 53, New York.
- (d) Basic theoretical research including evaluation of field work.
- (e) The aim of the project is to study the interrelationships between the atmosphere and the oceans with special reference to the wind driven oceanic circulation and the stratification of the water masses. This work includes studies on the wind stress - wind relationship at the surface of the oceans and large lakes.
- (g) The results obtained for the relationship between the wind stress and the wind over larger bodies of water, such as the open sea or the Great Lakes, agree fairly well with each other. They indicate that the wind stress varies proportionally to the  $3/2$  power of the wind velocity. However, great differences are observed with wind tunnel experiments. It is conceivable that the stress values obtained from wind tunnel experiments hold only for the special flow conditions encountered with small scale models. The horizontal circulation of wind-driven ocean currents was reexamined by taking into account the average vertical density stratification and the spherical shape of the earth. The variable depth of the lower boundary of the wind driven circulation seems to play an important role in the hydrodynamic analysis of the circulation system. The analytical solution for the North Atlantic Ocean gives a mass transport of 40 million tons per second circulating in the great gyre around the Sargasso Sea which agrees well with observations.



- (h) "Notes on the Wind-driven Ocean Circulation", G. Neumann, New York University, College of Engineering, Research Division, iv + 54 pages, May 1954.  
 "On the Dynamics of Wind-driven Ocean Currents", G. Neumann. Meteorological Papers, v. 2, no. 4, 32 pages, August 1955. New York University series, New York University Press.  
 "Wind Stress on Water Surfaces", A Review prepared for publication in the Bulletin of the American Meteorological Society.  
 "The Horizontal Mass Transport of the Wind-Driven Currents in the North Atlantic Ocean." To be published (Office of Naval Research). Reprints available on request from the Office of Naval Research or in the publications cited.

(2355) OFFICE OF NAVAL RESEARCH WAVE PROJECT.

- (b) Geophysics Branch, Office of Naval Research, Department of the Navy.
- (c) Prof. Willard J. Pierson, Jr., Research Associate Professor of Meteorology, New York University, University Heights, New York 53, New York.
- (d) Experimental and theoretical; basic and applied research.
- (e) Study of the generation and propagation of waves in deep water; of wave observation techniques; and of waves as a three variable stationary Gaussian process; digital analysis of stereo aerial wave photographs to determine the two dimensional spectrum of the waves as a function of wave frequency and direction; original studies on the motions of ships in waves, conducted by this project. Study of the capillary wave spectrum in connection with radar sea return.
- (g) Univac program written and soon to be run on a grid of 5400 points representing wave heights at points 30 feet apart. The result will give information on the spectrum of the waves as a function of frequency and direction.
- (h) "On the Motions of Ships in Confused Seas", M. St. Denis and W. J. Pierson, Jr., Transactions of the Society of Naval Architects and Marine Engineers, Vol. 61, 1953, pp. 280-357.  
 "Zur Charakteristik des Seeganges", G. Neumann, Arch. Meteorol. Geophys. Biokl., A7, 1954, 352-377.  
 "Practical Methods for Observing and Forecasting Ocean Waves by Means of Wave Spectra and Statistics", W. J. Pierson, Jr., G. Neumann, and R. W. James, 1956, H. O. Pub. 603.  
 "Climatological Data on the Generation and Propagation of Waves in the North Atlantic", P. S. DeLeonibus, Proc. First Conf. Ships and Waves, Council on Wave Research, 1955. Reprints other than H. O. Pub. 603 available on request from Office of Naval Research, or in publications cited.

(2356) SHIP MOTIONS PROJECT.

- (b) David Taylor Model Basin, Department of the Navy.
- (c) Prof. Willard J. Pierson, Jr., Research Associate Professor of Meteorology, New York University, University Heights, New York 53, New York.
- (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 on the bow submergence of a ship under way in head seas, and theoretical papers on wave theory and ship motion theory.
- (h) "Certain Probabilities Associated with Bow Submergence and Ship Slamming in Irregular Seas", Leo Tick, Jr., Tech. Report No. 1 for David Taylor Model Basin, 1954.  
 "Estimation of the Cross Spectra of Stationary Vector Processes", Murray Rosenblatt. Technical Report No. 2 for David Taylor Model Basin, 1955.  
 "Short Time Prediction of Sea Surface Height: Prediction of a Degenerate Stochastic Process", Louis J. Cote, Ships and Waves, Council on Wave Research and Society of Naval Architects and Marine Engineers, 1954.  
 "A Wave Spectrum Analyzer", W. J. Pierson, Jr. and S. S. L. Chang, Ships and Waves, Council on Wave Research and Society of Naval Architects and Marine Engineers, 1954.



"Certain Problems Connected with the Short Range Prediction of Sea Surface Height",  
Louis J. Cote. Tech. Report No. 4 for David Taylor Model Basin, in press.  
Reprints available from David Taylor Model Basin, Department of the Navy, Washington 7,  
D. C.

(2357) WAVE PROJECT.

- (b) Bureau of Ships, Department of the Navy.
- (c) Prof. Willard J. Pierson, Jr., Research Associate Professor of Meteorology, New York University, University Heights, New York 53, New York.
- (d) Theoretical and experimental, and basic and applied.
- (e) Attempt to formulate the zero crossing problem of a stationary Gaussian process and solve it for spectra like those of ocean waves.
- (g) Project initiated September 1, 1955, no results to date.

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

(593) DYNAMIC SIMILARITY OF SMALL HYDRAULIC MODELS.

- (b) Laboratory project.
- (c) Prof. Leonard W. Long, Dept. of Engineering Research, North Carolina State College of Agriculture and Engineering, Raleigh, N. C.
- (d) Experimental and theoretical; basic research.
- (e) An experimental determination and theoretical study of dynamic similarity of small hydraulic models for large scale ratios.
- (f) Experimental work is completed.
- (h) Bulletin is now being prepared.

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

- (b) Laboratory project.
- (c) Prof. Charles Smallwood, Dept. of Engineering Research, North Carolina State College of Agriculture and Engineering, Raleigh, N. C.
- (d) Experimental.
- (e) The collection and analysis of data pertaining to intensity, duration and frequency of rainfall in North Carolina.

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NORTH DAKOTA AGRICULTURAL COLLEGE, Department of Agricultural Engineering.

(2358) WATER USE AND EROSION UNDER IRRIGATION.

- (b) North Dakota Agricultural Experiment Station.
- (c) Mr. Harold Holmen, Agricultural Engineering Department, North Dakota Agricultural College, Fargo, N. D.
- (d) Experimental; basic research, also for master's thesis.
- (e) The purpose of the study was to determine seasonal erosion under irrigation, effect of crops on erosion, the proper stream size to use on various grades, and the rate of erosion with these stream sizes. Equipment was built to measure water applied and to collect the runoff from plots having three different furrow stream sizes at slopes of 1% and 3%. Two moisture levels were maintained. Intake rates as well as soil losses were determined.

- (f) Completed, final report due.
- (g) Actual soil losses in tons per acre were determined under the various conditions by Marvin E. Jensen and Willis H. Sletten.
- (h) "Annual Report", Marvin E. Jensen and Willis H. Sletten, 1953.  
"The Erosion Hazard in Furrow Irrigation", Marvin E. Jensen, M. S. Thesis, May 1952.  
"A Method of Determining Water Use, Soil Loss, Intake Rate, and Length of Furrow for the Irrigated Lower Souris Basin", W. H. Sletten, M. S. Thesis, March 1954.

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NORTHWESTERN UNIVERSITY, The Technological Institute.

(326) CAVITATION DAMAGES UNDER CONTROLLED CONDITIONS.

- (b) Laboratory project.
- (c) Prof. W. S. Hamilton, Civil Engineering Dept., Northwestern University, Evanston, Ill.
- (d) Experimental; basic research; for theses and staff papers.
- (e) The pressure in a vertical column of liquid is caused to fluctuate by a motor-operated piston and bellows arrangement, thereby forming and releasing a cavity at the top of the column. The amount of damage to various materials will be related to size of cavity and proximity of material to point of cavity collapse.
- (g) Tests on mortar and many other materials were inconsistent. Carbon brushes seem to have the necessary strength properties. The damage seems to show peaks at more than one distance from point of collapse.

(2137) SPRAY DROPLET FORMATION AND VAPORIZATION.

- (b) Laboratory project, supported in part by Project SQUID, Princeton University.
- (c) Prof. W. F. Stevens, Chemical Engineering Dept., Northwestern University, Evanston, Ill.
- (e) In order to understand more fully the operation of a spray nozzle, information is being sought concerning the mechanism of droplet formation and vaporization. At present, studies include: Determination of the force and velocity distributions within the nozzle, drop-size distribution determinations, and nozzle velocity effects.
- (g) See progress reports or write direct to project director.
- (h) Project Squid, semi-annual progress reports, April 1, 1955; October 1, 1955, (direct from SQUID headquarters at Princeton University).

(2359) HEAT TRANSFER STUDIES IN THE FLOW OF FLUIDS THROUGH GRANULAR SOLIDS.

- (b) Laboratory project.
- (c) Mr. M. B. Glaser, Chemical Engineering Dept., Northwestern University, Evanston, Ill.
- (d) Experimental and theoretical; doctoral thesis.
- (e) Construction and operation of equipment to obtain experimental data pertaining to direct heat transfer phenomena involved in the transfer of heat from metallic surfaces of spheres heated electrically to fluids flowing through the voids. This particular heat transfer approach possesses some advantageous features in producing data directly pertinent to the interpretation of j-factors.

(2360) FLOW OF WATER AT ELEVATED TEMPERATURES AND PRESSURES THROUGH PIPES.

- (b) Laboratory project.
- (c) Mr. B. H. Jennings and Mr. R. L. Young, Mechanical Engineering Dept., Northwestern University, Evanston, Ill.
- (d) Experimental; basic research.
- (e) Project involves the measurement of pressure drop for water flows through pipes of commercial roughness. Of particular interest is the flow of water in such a state that a two-phase liquid-vapor flow develops as the fluid pressure decreases.

(2361) DETERMINATION OF FATE OF FISSION PRODUCTS IN SURFACE WATERS.

- (b) U. S. Atomic Energy Commission (Division of Reactor Development).
- (c) Asst. Prof. C. G. Bell, Jr., Dept. of Civil Engineering, Northwestern University, Evanston, Illinois.
- (d) Experimental; basic research.
- (e) Tests on uncontaminated streams with pure fission products; special emphasis and equipment on tracing water containing tritium hydroxide.

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UNIVERSITY OF NOTRE DAME, College of Engineering.

(2138) FOCUS ON OSCILLATING HYDROFOILS.

- (b) Office of Naval Research, Department of the Navy.
- (c) Dr. A. G. Strandhagen, Department of Engineering Mechanics, University of Notre Dame, Notre Dame, Indiana.
- (d) Basic theoretical research.
- (e) Investigation to determine the hydrodynamic focus acting on an oscillating submerged hydrofoil moving below a free surface.
- (g) A first order approximation has been found, efforts to obtain complete solution are being continued.
- (h) Progress report submitted to sponsor.

(2362) INVESTIGATION OF HYDROMETRIC (ANDERSON) SCREEN.

- (b) Laboratory project.
- (c) Dr. S. Kolupaila, Department of Civil Engineering, University of Notre Dame, Notre Dame, Indiana.
- (d) Design and experimental investigation.
- (e) A carriage with a screen is installed in a 4' x 2.5' channel for discharge measurement; compared with volumetric and weir measurements.

(2363) A STUDY OF CIRCULAR WEIRS.

- (b) Laboratory project.
- (c) Dr. S. Kolupaila, Department of Civil Engineering, University of Notre Dame, Notre Dame, Indiana.
- (d) Experimental investigation.
- (e) Two sharp-edged weirs 4" and 12" in diameter are tested in a hydraulic flume 2.25' wide by 2.75' deep.

(2364) VELOCITY DISTRIBUTION ACROSS A PIPE.

- (b) Laboratory project.
- (c) Dr. S. Kolupaila, Department of Civil Engineering, University of Notre Dame, Notre Dame, Indiana.
- (d) Experimental investigation.
- (e) A pitometer is installed in a 4" diameter pipe for investigation of velocities of water flow and pulsation.



Oklahoma A and M College  
 Pelton Water Wheel Company  
 Pennsylvania State University

OKLAHOMA A AND M COLLEGE, Agricultural Engineering Department.

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

- (b) Agricultural Experiment Station cooperative with Agricultural Research Service.
- (c) Prof. F. R. Crow, Oklahoma A and M College, Department of Agricultural Engineering, Stillwater, Okla.
- (d) Field investigation; applied research.
- (e) Measurements are being made to provide hydrologic data on total watershed runoff and peak rates of runoff from three small grass-covered watersheds (17 to 206 acres) in north central Oklahoma. Highway culverts, modified by the addition of weir sills, are being used as runoff measuring devices.
- (f) Intensive model tests of culverts equipped with weir sills completed. Four year data on precipitation and runoff completed.
- (h) "Measuring Runoff Rates with Rectangular Highway Culverts", W. O. Ree and F. R. Crow, Oklahoma Agricultural Experiment Station Technical Bulletin T-51, Nov. 1954.

(2366) CONSUMPTIVE USE OF WATER AND IRRIGATION REQUIREMENTS.

- (b) Oklahoma Agricultural Experiment Station.
- (c) Mr. James E. Garton, Department of Agricultural Engineering, Oklahoma A and M College, Stillwater, Oklahoma.
- (d) Field investigation; applied research.
- (e) To obtain basic information regarding consumptive use of water by agricultural crops, to be used to determine system capacity and irrigation management.

(2367) STUDY OF FURROW IRRIGATION WITH SIPHON TUBES.

- (b) Oklahoma Agricultural Experiment Station.
- (c) Mr. James E. Garton, Department of Agricultural Engineering, Oklahoma A and M College, Stillwater, Oklahoma.
- (d) Experimental; applied research.
- (e) To develop a system of management of siphon tube irrigation which will result in more uniform yields.

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PELTON WATER WHEEL COMPANY.

(1146) HEAD EFFECT ON IMPULSE TURBINE MODEL TESTING.

- (b) Laboratory project.
- (c) Mr. R. M. Bacchi, Pelton Water Wheel Co., 2929 - 19th St., San Francisco 10, Calif.
- (d) Experimental; applied research.
- (e) To establish model law for testing impulse turbines under various operating pressures.
- (f) Completed.

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PENNSYLVANIA STATE UNIVERSITY, Hydraulics Laboratory, Department of Civil Engineering.

Inquiries concerning projects Nos. 1917, 1918, 1919, 1920 and 2139 should be addressed to Prof. Sam Shulits, Hydraulics Laboratory, Department of Civil Engineering, Pennsylvania State University, University Park, Pennsylvania.

(1917) BED LOAD FORMULAS.

- (b) Laboratory project supported by Research Corporation and University Council on Research.

- (d) Analytical; applied research.
- (e) Analytical comparison of existing bed-load formulas to determine order of magnitude of discrepancies and their utility.
- (g) Five bed-load formulas have been studied; two of the discharge type, two of the tractive force type, and one of mixed form. The pertinent critical or inceptive discharge formulas, at which sediment movement begins, were also reviewed. The magnitude of discrepancy between formulas induces doubt about their practical reliability and usefulness.
- (h) "The Dilemma of Bed-load Formulas", Shulits, Sims and Stull, presented at 1955 Annual Meeting of American Geophysical Union.

(1918) DESIGN OF STILLING BASINS.

- (b) Laboratory project supported by Research Corporation.
- (d) Experimental; applied research.
- (e) Investigation in a plexiglass-walled flume, of rational basis of design of stilling basins, to reduce dependence on model studies.
- (f) Suspended.

(1919) EFFECT OF A DOWNSTREAM OBSTRUCTION ON AN ORIFICE METER.

- (b) Laboratory project.
- (d) Experimental; applied research; master's thesis.
- (e) Measurement of minimum distance downstream from an orifice meter at which pipe fittings may be placed without altering meter reliability.
- (f) Completed.
- (g) Five orifices of diameters, 0.500, 0.750, 1.000, 1.250 and 1.500 inches, were tested in a 2-inch pipe with a gate valve as the downstream obstruction. The minimum distance was found to be six times the diameter.
- (h) "Effect of a Down Stream Obstruction on an Orifice Meter", by Joseph R. Reed, M.S. Thesis, August 1955.

(1920) STREAM PROFILES.

- (b) Laboratory project.
- (d) Analytical; basic research.
- (e) Quantitative study of river profiles to determine whether a rational equation of the profile is attainable; and to investigate effects of river regulation on the profile.
- (g) A graphical analysis is possible of the effects of cutoffs on the river profile, based on the concepts of selective transportation and abrasion of particles. The analysis yields trend profiles which resemble the observed effects of the interplay of a series of cutoffs, for example, on the Rhine River.
- (h) "Graphical Analysis of Trend Profile of a Shortened Section of River", by Sam Shulits, Trans. AGU, v. 36, no. 4, August 1955, pp. 649-654.

(2139) RECTANGULAR-THROAT VENTURI FLUME.

- (b) Laboratory project.
- (d) Experimental; basic research; master's thesis.
- (e) Venturi flume with rectangular throat is being tested in a circular pipe, primarily to obtain flume discharge coefficients. Measured water surface profiles through the flume will be compared with theory.
- (g) Flume has been tested with one mild and one steep slope for the pipe. Good agreement so far with simplified theory.

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PENNSYLVANIA STATE UNIVERSITY, Ordnance Research Laboratory.

(921) PROPELLERS FOR OPERATION IN SYMMETRIC WAKES.

- (b) Bureau of Ordnance, Department of the Navy, (Contract NOrd 7958).



- (c) Dr. B. W. McCormick, Ordnance Research Laboratory, University Park, Pennsylvania.
- (d) Theoretical and experimental; applied research.
- (e) The problem is the design of optimum efficiency and cavitation-free propellers for operation behind bodies of revolution. It is being attacked through consideration of the mechanics of propeller action. Design methods resulting from the theory are tested by experiment on an 8-inch diameter model torpedo in the 48-inch water tunnel.
- (g) Work with propellers designed for optimum efficiency and cavitation characteristics indicated that these two parameters can be predicted with reasonable accuracy.
- (h) "The Effect of a Finite Hub on the Optimum Propeller", B. W. McCormick, Journal of the Aeronautical Sciences, Vol. 22, No. 9, September 1955, p. 645.  
"An Approximation to the Lift of a Two-dimensional Cascade of Airfoils", B. W. McCormick, Journal of the Aeronautical Sciences, Vol. 22, No. 10, Oct. 1955, p. 730.

(1386) CAVITATION STUDIES.

- (b) Laboratory project for the Office of Naval Research and Navy Bureau of Ships.
- (c) Mr. G. L. Calehuff, Ordnance Research Laboratory, University Park, Pennsylvania.
- (d) Experimental; basic research.
- (e) Investigation of cavitation scaling on two-dimensional hydrofoils. The size of the hydrofoil, water velocity, air content, surface roughness and water temperature are varied to determine their effect on the inception of cavitation.
- (g) Tests to date have not produced any significant scaling parameters.

(1387) STUDY OF TIP VORTEX CAVITATION.

- (b) Laboratory projects supported by Office of Naval Research.
- (c) Dr. B. W. McCormick, Ordnance Research Laboratory, University Park, Pennsylvania.
- (d) Experimental; basic research.
- (e) Investigation to predict the minimum pressure in the trailing vortex system behind a wing.
- (g) A semi-empirical method has been developed for the prediction of a minimum pressure in a trailing vortex system behind a wing. The magnitude of the minimum pressure coefficient is determined by the thickness of the boundary layer on the lower side of the wing at the trailing edge of the tip. Scale effects are now being investigated.

(2368) INVESTIGATION OF HYDROELASTIC PHENOMENA.

- (b) Laboratory project.
- (c) Mr. J. H. McGinley, Ordnance Research Laboratory, University Park, Pennsylvania.
- (d) Experimental and theoretical; basic research.
- (e) Investigation of the parameters affecting the hydrodynamic excitation of sympathetic vibrations of underwater vehicles including appendages and propulsers. Isolation and classification of various types of resonance such as singing, rumbling etc. The aim of the program is to determine the nature of the hydrodynamic excitation forces which cause resonance, the vibration characteristics of the objects undergoing investigation, and the laws governing such phenomena.
- (g) The "singing" characteristics of three fixed wings of different materials have been measured in a water tunnel. This type of resonance is caused by the hydrodynamic exciting forces of a Karman vortex street shed from the trailing edge of the wing. The frequency of the singing, the velocity of the flow and the trailing edge thickness of the wing correlate to each other in a Strouhal number relation. The different materials have shown that the singing is produced by resonance between the hydrodynamic excitation and the natural frequency of elastic vibration of the singing element.

(2369) TURBULENCE DETECTION THROUGH THERMISTORS.

- (b) Laboratory project.
- (c) Mr. G. L. Calehuff, Ordnance Research Laboratory, University Park, Pennsylvania.
- (d) Experimental; development.
- (e) Testing of a thermistor in the 48-inch water tunnel to explore the possibilities of using this device as a turbulence detector or as a means of measuring turbulence in water.



- (g) Tests with a thermistor in the 48-inch water tunnel indicated a change in the ac level across a dc bridge of about 30 db when the thermistor was placed in the wake of the body or in the boundary layer of the tunnel. While the thermistor response is such that it cannot indicate the structure of the wake, it definitely can detect the presence of a wake.

(2370) MASS TRANSFER DEVICE FOR MEASURING VELOCITIES AND TURBULENCE IN WATER.

- (b) Laboratory project.
- (c) Dr. W. E. Ranz, Mr. G. L. Calehuff, Ordnance Research Laboratory, University Park, Pennsylvania.
- (d) Experimental and theoretical; applied research, for doctoral thesis.
- (e) Investigation of current voltage curves at various micro indicator electrodes and flowing solutions. Variety of electroactive species, supporting electrolytes and measuring techniques will be investigated for a fundamental insight into the process at the electrode interface and transport of the electroactive species in the bulk of the solution in the boundary layers to the electrode surface.
- (g) In certain continuous experiments for a given solution and over a range of velocities up to about 300 centimeters per second the ratio between the limiting current and the square root of the velocity was quite constant.

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PURDUE UNIVERSITY, Agricultural Experiment Station.

(2371) DRAINAGE PROPERTIES AND PROBLEMS OF VIGO, CLERMONT AND STENDAL SOILS.

- (b) Laboratory project, field trials.
- (c) Prof. John R. Davis, Purdue University, Lafayette, Ind.
- (d) Field investigation; applied research.
- (e) The study involves the application of soil physical characteristics to drainage design. Ground water measurements (drawdown curves), pore space analyses, mechanical analyses, in situ and laboratory permeability measurements have been completed for three separate locations in the problem soils area. These data were then applied as recommendations for subsurface drainage systems. Future investigations will involve installation of combinations of drainage practices and their effectiveness.
- (g) In situ measurements were not successful due to unstable subsoils. The soil is relatively impervious through soil horizons investigated. Lateral spacings computed by Walker's formula varied from 18 to 32 feet, which are consistent with drawdown data.
- (h) "Physical Characteristics of Clermont Silt Loam Soil in Relation to Tile Drainage", A. F. Klinge, 144 pps, June 1955, unpublished MS thesis. Available at Purdue University library.

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PURDUE UNIVERSITY, School of Chemical and Metallurgical Engineering.

(2372) STATIC PRESSURE GRADIENT IN TURBULENT JET MIXING.

- (b) Laboratory project, cooperative with Engineering Experiment Station.
- (c) Dr. Edward W. Comings, Head, School of Chemical and Metallurgical Engineering Purdue University, Lafayette, Ind.
- (d) Basic research for doctoral thesis.
- (e) Two experimental systems were investigated. The first of these consisted of a single vertical slot nozzle discharging air at a velocity of about 80 feet per second into ambient room air isothermally. The second system consisted of a parallel pair of vertical slot nozzles joined by a solid boundary preventing inter-nozzle entrainment. The nozzle velocity was approximately the same as for the single jet. Measurements in both cases consisted of mean velocities and longitudinal turbulent intensities taken with a hot wire anemometer and static pressures taken with a specially designed static pressure probe. In the case of the dual nozzle system additional measurements included flow direction measurements in the converging flow region and several impact tube traverses in the merged flow region.

The main purpose of the investigation was to determine whether appreciable static pressure gradients exist in the turbulent mixing region, and if so, to what extent they affect the kinematics of the flow.

- (g) It has been found that appreciable static gradients do exist in the mixing region; specifically subatmospheric static pressures were found in the major portion of the single jet case and in the merged flow region of the dual jet case. The analysis of the effects of the measured gradients on the flow kinematics is now in progress and has not been completed.
- (h) A Doctoral Thesis will be filed in the Purdue University Library in 1956.

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PURDUE UNIVERSITY, School of Civil Engineering.

(1391) INVESTIGATION OF THE FUNDAMENTAL THEORIES OF SEDIMENTATION IN A TANK.

- (b) United States Public Health Service, Federal Security Agency.
- (c) Prof. D. E. Bloodgood, Civil Engineering Dept., Purdue University, Lafayette, Ind.
- (d) Experimental research of basic factors affecting sedimentation, for Doctoral thesis.
- (e) The project is an investigation of the basic factors affecting the sedimentation of solids in water and sewage. Emphasis is being given to the effect of influent turbulence on solids removal in settling tanks. If possible, a series of design curves, which take into account the effect of turbulence on solids removal in settling tanks. If possible, a series of design curves, which take into account the effect of turbulence, will be developed.
- (g) The Hazen Theory on sedimentation has been verified experimentally.
- (h) Progress Report No. 3, Purdue University, Lafayette, Indiana, Feb. 10, 1953. "Sedimentation Studies", by D. E. Bloodgood, W. J. Boegly, Jr., and C. E. Smith. Paper presented at meeting of Amer. Society of Civil Engineers, Kansas City, Mo., Nov. 22, 1955.

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PURDUE UNIVERSITY, Jet Propulsion Center.

(2373) A STUDY OF THE MECHANISM OF FILM COOLING INCLUDING MASS TRANSFER.

- (b) Project Squid, Contract N6 ori-105 T.O. III, Phase 11, Problem 11 R2, PRF 1079 - Fund 5976 M-226.
- (c) Dr. Maurice J. Zucrow, Jet Propulsion Center, Purdue University, West Lafayette, Ind.
- (d) Experimental and theoretical investigation; basic research, partially for master's and doctoral theses.
- (e) This problem is concerned with the experimental investigation of the stability of liquid films formed by injecting a liquid through spaced parallel disks into a gas stream, and the heat and mass transfer between the gas stream and the liquid film. One of the objects of the study is to obtain data which will establish the conditions for producing a stable liquid film, for cooling purposes, on the walls of the duct through which a hot gas is flowing. The criterion of film stability adopted for this investigation is the magnitude of the critical velocity of injection, defined as the maximum mean velocity of the injected liquid that does not produce separation of the liquid film from the test section wall.
- (f) Active.
- (g) A systematic investigation of the critical velocity of injection as a function of air velocity, slot configuration, duct configuration, liquid properties and gas stream properties has been undertaken. The results of the investigation showing the effects of all of the variables given above with the exception of the viscosity of the flowing gas, has been reported.
- (h) Project Squid Progress Report, October 1, 1955, and References therein.



(2374) THE MECHANISMS OF SINGLE AND TWO-PHASE FLOW OF ANNULAR LIQUID FILMS IN A VERTICAL TUBE.

- (b) Project Squid, Contract N6 ori-105 T.O. III, Phase Two, Problem 11 R3.
- (c) Dr. M. J. Zucrow, Jet Propulsion Center, Purdue University, West Lafayette, Ind.
- (d) Experimental and theoretical; basic research for doctoral thesis.
- (e) This problem is concerned with the analytical and experimental study of the mechanisms 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. In view of the complex mechanisms associated with the aforementioned phenomena the complete study has been divided into two parts. (A) A study of the downward flow of an annular liquid film on the inside surface of a vertical tube with stationary air in the central portion of the tube. (B) A study of the downward flow of an annular liquid film on the inside surface of a vertical tube under the influence of gravity and a co-current turbulent gas stream in the central portion of the tube.  
The experimental portion of Part A is concerned with the measurement of the thickness of a flowing liquid film and the recording of the profiles of the wave which occur on the free surface of the film.  
A photometric technique has been developed and employed for the aforementioned measurements. Part B has been deferred pending the completion of Part A.
- (f) Active.
- (g) Results - (A) A systematic experimental program has been completed wherein the thickness of a flowing liquid film and the associated wave profiles have been determined as functions of the liquid properties and the liquid weight flow rate. Utilizing various liquids the effects of liquid density, viscosity and surface tension have been determined over a range of liquid flow rates. These studies have been made over a range of Reynold's numbers varying from 3 to 1640. The results of the investigation indicate that the measured values of film thickness were smaller than the values calculated by the Nusselt equation for laminar film flow. The discrepancy between the measured and the calculated values of film thickness were found to be related to the nature of the wave motion on the free surface of the film, the physical properties of the liquid, and the Reynolds number of the flow. The results are reported in the publications listed below.
- (h) Project Squid Progress Report, October 1, 1955, and References therein.  
"The Mechanics of Film Flow on a Vertical Surface", A. B. Greenberg, Ph.D. Thesis, Purdue University.

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REED RESEARCH INCORPORATED.

(2375) ON THE CODIFICATION OF HYDRAULICALLY ROUGH SURFACES.

- (b) Office of Naval Research, Dept. of the Navy (D.T.M.B. Technical Supervision).
- (c) Mr. R. Taggart, Reed Research Inc., 1048 Potomac Street, Washington 7, D. C.
- (d) Experimental; applied research.
- (e) Direct measurements of wall shear stress are made on a series of 4" square plates containing controlled roughness elements (projection type). The effect on friction coefficient by parameters, such as density of elements, height and ratio of height to base diameter, is being studied. Range of Reynolds numbers in the water tunnel is from  $R = 1.1 \times 10^5$  to  $R = 7.5 \times 10^5$ .

(2376) FLOW VISUALIZATION.

- (b) Office of Naval Research, Dept. of the Navy (D.T.M.B. Technical Supervision).
- (c) Mr. R. Taggart, Reed Research Inc., 1048 Potomac Street, Washington 7, D. C.
- (d) Experimental.
- (e) By using a neutrally buoyant globule of anisole along with a fluorescent dye, a study is made of the paths traced out by these indicators when the flow in a rectangular channel changes from the laminar state to the turbulent state. The facility is a 2" x 8" x 20'-0" long plastic (lucite) channel, and the method of visualization is by photographs and motion pictures.



Reed Research Development  
Rocky Mountain Hydraulic Laboratory  
Rutgers University

- (f) Completed.
- (g) Still photographs have been taken of the flow around a half-sphere and a half-cone. A motion picture has been taken showing a bubble of anisole deforming and finally breaking up into smaller-sized bubbles simultaneously with a dye stream bursting.
- (h) Report in preparation.

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ROCKY MOUNTAIN HYDRAULIC LABORATORY.

(2140) EVALUATION OF OPEN-CHANNEL FRICTION LOSSES.

- (b) National Science Foundation, U. S. Geological Survey, State University of Iowa, Ohio State University, and Colorado A and M College Cooperating.
- (c) Prof. C. J. Posey, Director, Rocky Mountain Hydraulic Laboratory, Allenspark, Colorado (summer), State University of Iowa, Iowa City, Iowa (winter).
- (d) Experimental; basic.
- (e) Variable-slope flume long enough to permit accurate evaluation of open-channel friction losses will be tested at slopes into the steep range. Roughness and shape variables will also be investigated.
- (g) Ninety-degree V-shaped flume 400 ft. long with slope variable up to 1 1/2% has been completed, with weir box and necessary supply and waste structures.

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RUTGERS UNIVERSITY, Department of Botany.

(1662) PINE REGION HYDROLOGICAL RESEARCH PROJECT.

- (b) Cooperative with Ground Water Branch, U. S. Geological Survey, New Jersey Department of Conservation and Economic Development and U. S. Forest Service.
- (c) Mr. M. F. Buell, Department of Botany, Rutgers University, New Brunswick, N. J.  
Mr. H. T. Critchlow, Director and Chief Engineer, Division of Water Policy and Supply, New Jersey Department of Conservation and Economic Development, 520 East State Street, Trenton, N. J.  
or  
Mr. H. C. Barksdale, Ground Water Branch, U. S. Geological Survey, Room 432, Post Office Building, P. O. Box 1689, Trenton 7, N. J.
- (d) Field investigation; basic research.
- (e) Study of water relations of two watersheds, one of which will be burned according to recently developed silvicultural practices, and the other will be left to natural forest succession.
- (g) Soil survey and initial vegetation measurements completed and ready for publication.
- (h) "Pine Barrens Research Project, New Jersey", D. E. Outlaw and E. C. Rhodehamel. Completed and ready for publication:  
"Ground Water in the New Jersey Pine Barrens Area", H. C. Barksdale, Bartonian 26:36-38, 1952.  
"Origin and Development of the Pine Region Hydrological Research Project", M. F. Buell, Amer. Cranberry Growers' Assoc. Proc. for 1955, 10-13.  
"New Botanical Problems in the New Jersey Pine Barrens", M. F. Buell, Torrey Botanical Club Bull. 82:237-241, 1955.  
"Accomplishments at the Lebanon State Forest Stream-Gaging Stations", G. S. Hayes, Amer. Cranberry Growers' Assoc. Proc. for 1955, 13-15.  
"Moss Cover and Rainfall Interception in Frequently Burned Cities in the New Jersey Pine Barrens", E. T. Moul and M. F. Buell, Torrey Botanical Club Bull. 82:155-162, 1955.

## ST. ANTHONY FALLS HYDRAULIC LABORATORY, University of Minnesota.

Inquiries concerning Projects Nos. 100, 924, 1665, 1669, 1671, 1672, 1928, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2377 to 2385 incl., should be addressed to Dr. Lorenz G. Straub, Director, St. Anthony Falls Hydraulic Laboratory, Hennepin Island, Minneapolis 14, Minnesota.

Inquiries concerning Projects Nos. 111, 1168, 1398, 1929, and 2386, which are conducted in cooperation with the Agricultural Research Service, should be addressed to Mr. William G. Ackermann, Head, Watershed Hydrology Section, Soil and Water Conservation Research Branch, Agricultural Research Service, Beltsville, Maryland.

Projects Nos. 194, 985, 1206, 1977, 2189, 2424, and 2425, which are conducted at the St. Anthony Falls Hydraulic Laboratory in cooperation with the Corps of Engineers, St. Paul District, St. Paul, Minn., are listed on page 139.

## (100) AIR ENTRAINMENT RESEARCH.

- (b) Office of Naval Research, Department of the Navy.
- (d) Theoretical and experimental.
- (e) Investigation of self-aeration of high velocity open-channel flow. Air concentrations distributions in the flow have been measured for equilibrium aeration conditions in smooth channel for discharges up to 10 cfs and slopes up to 45° and in artificially roughened channels for discharges up to 15 cfs and slopes up to 75°.
- (g) Air concentration distribution in both smooth and rough channels indicates that the flow consists of two parts: (1) open channel flow in lower region with air distributed by turbulent mixing, (2) an upper region consisting of water particles or spray carried through a surface by intense transverse velocity fluctuations. Roughness coefficient for aerated flow decreases with increasing air concentration which depends primarily upon slope and less upon discharge.
- (h) "The Distribution of Air in Self-Aerated Flow in a Smooth Open Channel", by Alvin G. Anderson, St. Anthony Falls Hydraulic Laboratory Project Report No. 48, July 1955.

## (111) CLOSED CONDUIT SPILLWAY.

- (b) Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the Minnesota Agricultural Experiment Station and the St. Anthony Falls Hydraulic Laboratory.
- (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. Characteristics, performance, losses, and pressures in the hood inlet are currently being studied.
- (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. Entrained air did not invalidate the Froude model law.

## (924) FREE-JET WATER TUNNEL STUDIES.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental; applied research and design.
- (e) Tests have been conducted in a 10-in. free-jet water tunnel to determine steady-state cavity dimensions resulting from various geometries of head form under low sigma conditions. Tests are underway to determine pressure distributions on super-cavitating hydrofoils.
- (h) "Steady-State Cavity Studies in a Free-Jet Water Tunnel", by M. W. Self and J. F. Ripken, St. Anthony Falls Hydraulic Laboratory Project Report No. 47, July 1955.



## (1168) A STUDY OF CANTILEVERED OUTLETS.

- (b) Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the Minnesota Agricultural Experiment Station and the St. Anthony Falls Hydraulic Laboratory.
- (d) Experimental; generalized applied research for design.
- (e) Pipe outlet conduits for small spillways are frequently cantilevered beyond the toe of the earth dam. Attempts will be made to determine quantitatively the size of the scour hole to be expected under various field conditions.
- (f) Suspended.

## (1398) STRAIGHT DROP SPILLWAY.

- (b) Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the Minnesota Agricultural Experiment Station and the St. Anthony Falls Hydraulic Laboratory.
- (d) Experimental; generalized applied research for design.
- (e) Spillway is used as a grade control structure in ditches and streams. Study will result in general design rules for the spillway and outlet. Outlet studies have been completed. Present studies are to determine spillway performance and capacity with various approach channel shapes.
- (f) Suspended.

## (1665) LOW VELOCITY WIND INSTRUMENTATION.

- (b) U. S. Army, Signal Corps.
- (d) Experimental design and development.
- (e) Development studies on thermal anemometer for measuring speed and direction of winds from 1 to 50 fps and from ground to 1000 ft. elevation.
- (h) "Research and Development Studies for a Low-Level Wind-Measuring System", by J. F. Ripken and J. M. Killen. St. Anthony Falls Hydraulic Laboratory Project Report No. 49, Dec. 1955.

## (1669) EXPERIMENTAL INVESTIGATION OF BASIC EQUIPMENT AND METHODS ASSOCIATED WITH LABORATORY WAVE STUDIES.

- (b) David Taylor Model Basin, Department of the Navy.
- (d) Experimental; basic and applied.
- (e) Investigation of absorbers and filters for use in laboratory wave studies.
- (g) Experimental study of efficiency of absorbers as function of slope, permeability and volume, with objective of obtaining information to assist in design of absorber of minimum length. Experimental study of wave filters to determine relative merits of various types and effect of length, porosity and related variables.
- (h) "Experimental Study of Wave Filters and Absorbers", by John G. Herbick, St. Anthony Falls Hydraulic Laboratory Project Report No. 44, Nov. 1955. A limited number of copies of these reports may be made available by the sponsor.

## (1671) CAVITATION TESTING IN WATER TUNNELS.

- (b) David Taylor Model Basin, Department of the Navy.
- (d) Experimental; basic and applied research.
- (e) To study some of the factors believed to affect the pressure at which water cavitates, and to determine if a measured pressure is a better datum than vapor pressure in computing the cavitation index used to correlate test data. Incipient bubbling cavitation was of primary interest.
- (f) Completed.
- (g) Total gas content and water temperature were the only known water properties which influenced the cavitation susceptibility of the water. The cavitation index for incipient cavitation of 3- and 6- caliber ogive head forms, when tested in water of different cavitation susceptibilities, was more constant when based on an independently measured pressure than when based on vapor pressure.
- (h) "Cavitation Testing in Water Tunnels", by Reuben M. Olson, St. Anthony Falls Hydraulic Laboratory Project Report No. 42, Dec. 1954.



## (1672) SLOTTED-WALL TEST SECTION FOR WATER TUNNELS.

- (b) David Taylor Model Basin, Department of the Navy.
- (d) Experimental design.
- (e) Studies of a number of slotted-wall test sections in a 6-inch recirculating tunnel were made to determine primarily the optimum test-section geometry, the flow quality in the test section, the head losses, the cavitation characteristics, and optical properties of the transparent test-section walls.
- (f) Completed.
- (g) A design providing uniform pressures and velocities in the test section was obtained. No flow instabilities causing vibration were detected. The minimum cavitation index for the test section was 0.6 to 0.9, as compared with 0.4 and 0.03 for an open-jet and a diverging closed-jet test section. Uncorrected surface pressures on a hemispherical head form agreed with those measured in a free-jet tunnel over the upstream portion of the body, which was long compared to the test-section length.
- (h) "A Slotted-Wall Test Section for a Water Tunnel", by Reuben M. Olson, St. Anthony Falls Hydraulic Laboratory Project Report No. 45, Feb. 1955.

## (1928) DEPRESSED TEMPERATURE STUDIES.

- (b) Missouri River Division, Corps of Engineers.
- (d) Basic research; analytical and experimental.
- (e) An investigation of the effect of temperature changes on the total sediment load in natural streams. The experimental program includes the measurement in a flume of the amount and size distribution of the suspended and bed load sediment in water at various controlled temperatures.
- (g) Both sediment size and concentration of suspended sediment are notably affected by temperatures, both increasing with lowering of temperature. The effect of a temperature decrease of 40° (to about 35°F) was to increase the suspended sediment concentration by a factor of between 2 and 4 depending on the relative depth. For this same temperature range, the median sediment size increased 35 per cent or 2.5 times by weight.
- (h) "Terminal Report on Transportation Characteristics, Missouri River Sediment", by Lorenz G. Straub, St. Anthony Falls Hydraulic Laboratory Technical Paper No. 5, Series A, April 1954.

## (1929) DRAIN TILE JUNCTION LOSSES.

- (b) Minnesota Agricultural Experiment Station in cooperation with the Agricultural Research Service, U. S. Department of Agriculture and the St. Anthony Falls Hydraulic Laboratory.
- (c) Prof. Philip W. Manson, Professor of Agricultural Engineering, University of Minnesota, St. Paul Campus, St. Paul, Minnesota.
- (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.
- (g) Tests have been completed on sharp edged junctions entering the main at angles varying in 15 degree increments from 15 degrees to 165 degrees. The lateral and the main are the same size and both are completely full. The tests cover all possible combinations of discharge in the lateral and the main. The results are presented in the form of dimensionless curves. Tests are continuing using laterals smaller than the main.
- (h) "Energy Losses at Drain Tile Junctions", by P. W. Manson and Fred W. Blaisdell, Agricultural Engineering, publication pending.

## (2141) TACONITE HARBOR BREAKWATER STUDY.

- (b) Erie Mining Company.
- (d) Experimental design.
- (e) Investigate the design of the breakwater for Taconite Harbor on the Minnesota shore of Lake Superior. The breakwater is of stone construction and is approximately 1300 feet long, extending to water depths of 100 feet. Purpose of test was to determine stability of (1) the proposed design, and (2) an interim breakwater for use during construction of the harbor.

- (f) Studies indicated that the proposed final design was stable for the anticipated range of wave conditions but an improvement could be effected by extending the large armor stone farther down the lake face than was initially proposed. The model of the interim breakwater indicated that armor layer was unstable when exposed to moderate wave action.
  - (g) Report in preparation.
- (2142) THE ABSORPTION OF ULTRASONIC RADIATION BY SUSPENDED SEDIMENT IN WATER AS A MEASURE OF PARTICLE SIZE AND CONCENTRATION.
- (b) Laboratory project.
  - (d) Experimental; master's thesis.
  - (e) The absorption of a 25 megacycle plane wave of sound in water was measured for concentrations of suspended sediment of 100-2200 parts per million by volume for a size range of 44-500 microns; investigation is intended to indicate potentialities of sound absorption as an analysis technique for suspended sediments.
  - (g) Experimental work completed; thesis is in preparation.
- (2143) EXPERIMENTAL STUDIES OF SURFACE WAVE ABSORPTION.
- (b) Office of Naval Research, Department of the Navy.
  - (d) Experimental; basic research.
  - (e) Procurement of quantitative data on wave attenuation by surface current induced by jets of water and air.
  - (g) Tests have been conducted on the attenuation of both deep and shallow water waves as a result of submerged air jets; results for deep water compared favorably with theory. Tests with vertical and horizontal water jets indicated that the horizontal jets were superior. Preceding tests were conducted in a small wave channel; additional tests on horizontal water jets are underway in a larger channel, 9 feet wide, 6 feet deep and 250 feet long.
  - (h) "Experimental Studies of Pneumatic and Hydraulic Breakwaters", J. M. Wetzel, St. Anthony Falls Hydraulic Laboratory Project Report No. 46, May 1955.
- (2144) EXPERIMENTAL AND ANALYTICAL STUDIES OF HYDROFOILS.
- (b) Office of Naval Research, Department of the Navy.
  - (d) Experimental and analytical; basic research.
  - (e) Objective of the study is the determination of the principal effects of dihedral on the performance of hydrofoils, and the basic mechanism of ventilation of surface-piercing bodies, particularly with regard to scale effect.
  - (g) An approximate theory was developed whereby the lift of a surface-piercing foil at high speed can be determined as a function of the angle of attack solely from two-dimensional wind tunnel data. A theory for the trailing vortex drag was developed for both deeply submerged and surface-piercing dihedral hydrofoils. An analysis of the wave drag of surface-piercing hydrofoils was developed and compared with experimental data. An approximate theory was developed for surface-piercing dihedral hydrofoils to determine the angle of attack at which flow ventilation would occur. Fundamental studies of the ventilation of semi-submerged circular cylinders were made to determine the effect of the Weber and Froude numbers on ventilation, in an effort to arrive at a solution to the problem of scale effect that appears to be associated with this phenomenon. Spanwise and chordwise pressure measurements were made of a surface-piercing dihedral hydrofoil in subcritical and supercritical flow.
  - (h) "Experimental and Analytical Studies of Dihedral Hydrofoils", E. Roy Tinney, St. Anthony Falls Hydraulic Laboratory Project Report No. 41, November 1954.
- (2145) FLOW OF WATER THROUGH PERMEABLE MIXTURES OF SAND PARTICLES OF DIFFERENT SIZES.
- (b) Laboratory project.
  - (d) Experimental and basic; for master's thesis.
  - (e) Resistance coefficient is being measured for sieved separates of a natural sand and for various combinations of the separates such that the mean size is constant and the distribution standard deviation is varied systematically.



- (f) Completed.
- (g) Resistance coefficient can be related to an effective size involving volume and surface area. A single curve was obtained for both mixtures of various sizes and media of one size was obtained when this definition of size was used.
- (h) "Permeability Characteristics of a Common Sand", by Herbert C. Preul, University of Minnesota Master's Thesis, Dec. 1954. (Available on inter-library loan).

(2146) MODEL STUDY FOR MENOMONIE POWER PROJECT.

- (b) Northern States Power Company, Minneapolis, Minnesota.
- (d) Experimental design.
- (e) Experimental design of spillway apron. Study of gate operation.
- (f) Completed.
- (g) Satisfactory design obtained.
- (h) Report transmitted to sponsor.

(2147) TOTAL LOAD SEDIMENT STUDIES.

- (b) Missouri River Division, Corps of Engineers.
- (d) Basic research; analytical and experimental.
- (e) An investigation primarily to find a method for measurement of the total sediment load in a laboratory flume. The experimental program included the measurement of sediment concentration and size of the suspended sediment and of the total load - the bed load to be obtained by subtracting the suspended load from the total load.
- (f) Completed - to be used in depressed temperature study.
- (g) By means of sample tubes injected into the return pipe of the recirculating system, it was found that the sediment concentration profile varied in magnitude with time but that the ratio of the concentration at any two points was not variable with time. It was therefore possible to take point samples over any time period (thus integrating the total load variation with time) and to obtain the total sediment load for the period. The mean sediment size remained the same over the sample section.

(2148) AIR-WATER MIXTURES IN CLOSED CONDUITS.

- (b) David Taylor Model Basin, Department of the Navy.
  - (f) Suspended.
- Note that other information on this project may be found in the 1955 entry.

(2377) VISCOUS FLOW IN ROUGH OPEN CHANNELS.

- (b) Laboratory project.
- (d) Experimental; master's thesis.
- (e) Extension of previous thesis work on this subject. Channel was triangular of variable central angle. Roughness consisted of punched metal plates laid on previously smooth surface.
- (f) Completed.
- (g) This roughness produced a friction factor versus Reynolds curve in the lower turbulent region lying above and parallel to the smooth channel curve. The largest central angle (150)° showed the greatest roughness effect.
- (h) "Effects of Uniform Roughness on Open Channel Flow at Small Reynolds Numbers" by Murray Silverman. Master's Thesis on file at the University of Minnesota Library, Oct. 1955.

(2378) MECHANICS OF DEGRADATION OF SEDIMENT BED IN OPEN CHANNELS.

- (b) Laboratory project.
- (d) Theoretical for doctoral thesis.
- (e) An analysis of the mechanics of degradation considering rate of transportation roughness of channel in order to derive the differential equation. The solution of the differential equation to be compared to experimental measurements.
- (f) Completed.



- (g) Good agreement obtained with laboratory experiments on degradation.
  - (h) "A Study of the Mechanics of Degradation of a Bed of Uniform Sediment in an Open Channel", by E. Roy Tinney. Doctorate Thesis, University of Minnesota, April 1955. (Available on inter-library loan.)
- (2379) CRITICAL TRANSPORTING VELOCITY OF PARTICLES ON THE BED OF AN OPEN CHANNEL.
- (b) Laboratory project.
  - (d) Experimental and basic for master's thesis.
  - (e) Measurements are made of the critical velocity for initiation of movement of bodies of various shapes on the bed of an open channel.
- (2380) FLOW THROUGH POROUS MEDIA.
- (b) Laboratory project.
  - (d) Experimental, basic; for master's thesis.
  - (e) Effect of mixtures of various proportions of different sizes of particles on resistance coefficient is measured by experiment.
  - (f) Completed.
  - (g) As the proportion of smaller particles increases the resistance coefficient increases to a maximum and then decreases as the entire medium is made up of the same size particle.
  - (h) "Flow of Water Through Lead Shot Mixtures - Influence of Uniformity on Friction Factor", Sviatoslav Krochin, Master's Thesis, University of Minnesota, October 1955. (Available on inter-library loan.)
- (2381) SCOUR BY A JET.
- (b) Laboratory project.
  - (d) Theoretical and experimental; master's thesis.
  - (e) To determine relationships between rate of scour and the flow characteristics.
- (2382) COMPARISON OF A FIRST-ORDER WAVE GENERATOR THEORY WITH THE PERFORMANCE OF A PARTICULAR GENERATOR.
- (b) Laboratory project.
  - (d) Experimental; master's thesis.
  - (e) Tests were conducted on a hinged plate wave generator installed in a small wave channel. Pressures on face of plate were measured. Wave profile and height were measured near the generator as well as at several stations along the channel. Results were compared with a theory developed by F. Biesel.
  - (g) Experimental values of wave height differed from theory by an average of 13 per cent. In general the experimental data on wave height were less than the theoretical prediction. Best agreement between theory and experiment occurred for low values of wave steepness, for both wave pressure and wave height. The theory appears to offer a reasonable criteria for the design of a hinged plate generator.
  - (h) "Comparison of a First-Order Wave Generator Theory with the Experimental Performance of a Particular Generator", by James Ross, Master's Thesis, University of Minnesota, April 1955.
- (2383) DRAG FORCES ON SILLS AND BLOCKS.
- (b) Laboratory project.
  - (d) Experimental and analytical; master's thesis.
  - (e) To measure and to analyze drag forces on sills and blocks for generalized design criteria of stilling basins.
  - (g) Experimental apparatus under construction.

(2384) MAYFIELD MODEL STUDIES.

- (b) City of Tacoma, Washington Department of Public Utilities, Light Division.
- (d) Experimental; design and operation.
- (e) A 1:72 scale model of the Mayfield Power Development Project on the Cowlitz River is reproduced to study the hydraulic characteristics of the spillway, intake system and the downstream channel.
- (g) Study not completed.

(2385) RESISTANCE TO SUPERCRITICAL FLOW IN A RECTANGULAR OPEN CHANNEL.

- (b) Laboratory project.
- (d) Experimental and basic; for master's thesis.
- (e) Roughness coefficient and velocity profiles were measured for supercritical flow for slopes up to 0.11 corresponding to incipient air entrainment. Two conditions of roughness were investigated.
- (f) Completed.
- (g) The flow formulas developed for subcritical flow are also applicable to supercritical flow at high Froude numbers. Velocity profiles agreed well with the exponential form.
- (h) "Some Experiments on the Resistance to Supercritical Flow in a Rectangular Open Channel", by Alan S. Goodyear, Master's Thesis, University of Minnesota, November 1955. (Available on inter-library loan.)

(2386) GENERALIZED DESIGN OF TRANSITIONS FOR SUPERCRITICAL VELOCITIES.

- (b) Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the Minnesota 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) Apparatus under construction.

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THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

(895) THE COMPILATION OF RESISTANCE AND PROPULSION DATA.

- (b) Office of Naval Research, Department of the Navy.
- (c) Capt. W. N. Landers, Secretary, The Society of Naval Architects and Marine Engineers, 74 Trinity Place, New York 6, N. Y.
- (d) The project is concerned with the effective and systematic presentation of existing experimental data on ship model resistance and propulsion.
- (e) Ship model resistance data for models of various types are assembled on standard data sheets designed for ready reference and aimed towards further analysis to determine the influence of hull form on wavemaking resistance. Standard data sheets for reporting data on self-propelled models and model propellers are also devised, and representative data presented thereon. The dual purposes of this compilation work are to foster the adoption of standard forms for reporting model data and to facilitate the analytical analysis to determine the influence of geometry on resistance and propulsion.
- (g) One hundred and sixty resistance data sheets for models for various types have been assembled. These data have been requested by numerous shipyards, design agents, consulting naval architects, students, etc. Towing tanks in this country have unofficially adopted the form of the data sheet and are actively proposing it for international use. The self-propulsion data sheets and propulsion data sheets are still in preliminary form. Empirical analysis so far has indicated which form factors have the major effect on wavemaking resistance. The need for basic research in the hydrodynamics of ship resistance is, however, apparent.



## (h) "Model Resistance and Expanded Data Sheets",

Models 1-50	\$10.00 to members	\$11.00 to non-members
Models 51-100	\$10.00 to members	\$11.00 to non-members
Models 101-150	\$10.00 to members	\$11.00 to non-members

Single data sheets are available at \$1.00 each.

"Explanatory Notes for Resistance and Propulsion Data Sheets", Bulletin 1-13, and "Index to Model and Expanded Resistance Data Sheets, Nos. 1-150", Bulletin 1-14, are available free on request on orders of 50 or more data sheets.

## (2387) SEAKEEPING MONOGRAPH.

- (b) Sponsored jointly by The Society of Naval Architects and Marine Engineers and the Ship Structure Committee.
- (c) Capt. W. N. Landers, Secretary, The Society of Naval Architects and Marine Engineers, 74 Trinity Place, New York 6, N. Y.
- (d) The project is mainly a literature survey of both theoretical and experimental work in the field of applied research.
- (e) The project is to prepare a monograph reporting the results of a critical evaluation of the present state of the art concerning the seakeeping characteristics of ships, and is intended to establish the basis for planning further research in this field. The monograph will include essentially four parts: Waves; Forces; Rigid body response; Elastic body response.
- (f) The project is in the early stages of the survey, with the monograph scheduled for completion in December 1956.

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## STANFORD UNIVERSITY, Hydraulic Laboratory.

Inquiries concerning Projects 1171, 2150, and 2151 should be addressed to Prof. John K. Vennard, and Projects Nos. 1944, 1945, and 1946 to Prof. Ray K. Linsley, Stanford University, Stanford, Calif.

## (1171) STUDY OF MANIFOLD PORTS.

- (f) Completed.
- (h) "An Experimental Study of Fluid Flow in Outlet Manifold Ports", D. I. Dentoni. Engr. Thesis June 1954.  
"An Experimental Study of Fluid Flow in Outlet Manifold Ports", J. K. Vennard and D. L. Dentoni. Trans. A.S.C.E. Vol. 119, 1954, pp. 1136-1140.

## (1944) STUDY OF METHODS OF ESTIMATING RESERVOIR EVAPORATION.

- (b) U. S. Weather Bureau.
- (d) Field investigation, applied research.
- (e) Evaporation from a small reservoir on the campus is being compared with that measured in four different pans and that computed by mass transfer and energy balance methods.
- (f) Data collection to terminate about Jan. 1, 1956. Analysis of results will begin about that date.

## (1945) ESTIMATING RAINFALL INTENSITY FROM TOPOGRAPHIC PARAMETERS.

- (b) U. S. Bureau of Public Roads.
- (d) Statistical analysis, applied research.
- (e) Hourly rainfall intensity is correlated with various topographic and climatological parameters.
- (h) Final correlations in progress and final report nearing completion. Preliminary report out of print.



(1946) SYNTHESIS OF HYDROGRAPHS FOR SMALL AREAS.

- (b) Jointly sponsored by U. S. Bureau of Public Roads, Agricultural Research Service, and Stanford University.
- (d) Theoretical and field investigation; basic and applied research.
- (e) An attempt to develop a universal method of estimating the hydrograph of runoff from small areas for drainage design.
- (f) Field observations, theoretical study of mechanics of overland flow, and empirical analysis of field data proceeding.
- (g) Theoretical analysis of overland flow profiles at equilibrium completed.

(2150) STUDY OF FLOW FROM SLOTTED PIPES.

- (b) Laboratory project.
- (d) Experimental; engineer thesis.
- (e) Extension of manifold port problem to a continuous slot.
- (f) Experimental work completed; thesis being written.

(2151) MODEL STUDY OF PETERS DAM CHUTE SPILLWAY.

- (b) Laboratory project.
- (d) Experimental; engineer thesis.
- (e) Comparison of spillway performance and design predictions.

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STEVENS INSTITUTE OF TECHNOLOGY, Experimental Towing Tank.

(340) PLANING SURFACES.

- (b) Office of Naval Research, Department of the Navy.
- (c) Mr. Daniel Savitsky, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
- (d) Theoretical and experimental; basic research.
- (e) A continuous series of theoretical and experimental studies of the basic hydrodynamic processes involved in the planing action of seaplane hulls and high-speed surface craft. In particular, the pressure distribution, wake, and main spray formation are being studied.
- (g) Investigations have extended from elementary planing surfaces of several deadrises, through surfaces in the shape of Vee planform; also surfaces planing parallel to each other and combinations of forebody with an afterbody planing in its wake.
- (h) Fifteen papers on the results of research conducted under the subject contract have been prepared and published. Two reports are presently in preparation. One is concerned with the main spray of planing surfaces and the other with the two step planing of seaplane hulls.

(1407) SEAWORTHINESS OF SHIPS.

- (b) Society of Naval Architects and Marine Engineers.
- (c) Prof. B. V. Korvin-Kroukovsky, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Experimental; basic research.
- (e) To determine the vertical forces and pitching moments acting on a restrained ship model moving against head seas. This project supplements projects on seaworthiness model tests conducted at David Taylor Model Basin and Massachusetts Institute of Technology.
- (f) Completed.
- (g) Model tests and their analysis completed.
- (h) "Investigation of Ship Motions in Regular Waves", presented by B. V. Korvin-Kroukovsky at the November 1955 meeting of the Society of Naval Architects and Marine Engineers.

## (1410) SELF-PROPELLED TESTING.

- (b) Bureau of Ships, Department of the Navy (DTMB technical supervision).
- (c) Mr. Edward V. Lewis, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Experimental; developmental research.
- (e) To determine if successful self-propelled testing can be conducted using models of less than 12-foot length, and to determine causes of scale effect in propulsion factors.
- (f) Nearing completion.
- (g) Open-water tests have been completed on three different-sized models of a propeller designed by the Netherlands Model Basin for the Victory type cargo ship. Hull models of the Victory ship, 7-1/2 feet and 9 feet in length, have been tested self-propelled. This work is being carried out in cooperation with the Netherlands Model Basin where models 9 feet long and above are being tested.

## (1948) SYSTEMATIC INVESTIGATION OF THE TURNING CHARACTERISTICS OF A SHIP MODEL FITTED WITH VARIOUS COMBINATIONS OF APPENDAGES.

- (b) Bureau of Ships, Department of the Navy (DTMB technical supervision).
- (c) Mr. Anthony Suarez, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Experimental; applied research.
- (e) To obtain data on the influence of appendages on the turning characteristics of a twin-screw surface ship; the appendages under consideration are skegs and bilge keels, with rudders and propellers of different sizes.
- (f) Experimental work completed.
- (g) Tests have established the magnitude of the rudder-on-hull interaction effects and its variation with skeg and propeller size. Data on the rudder moments required to provide various turning radii with different sizes of skegs and propellers is believed to be of general applicability to design problems. Experiments to determine the flow conditions at the rudder provide a picture of hull-on-rudder interaction.

## (2152) PLANING SURFACES IN ROLL AND YAW.

- (b) National Advisory Committee for Aeronautics.
- (c) Mr. Daniel Savitsky, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Experimental; basic research.
- (e) To conduct an exploratory investigation to define generally the nature of the flow in unsymmetrical planing, the magnitude of steady-state forces and moments, and their variation with yaw and roll angle.
- (g) Tests have been conducted on two simple machined planing surfaces of zero deadrise and 20° deadrise. Resistance, side force, pitching moment, yawing moment, and planing area were measured simultaneously over the following range of independent variables: trim, 6° to 30°; roll, 0° to  $\pm 15^\circ$ ; yaw, 0° to 20°; speed coefficient  $C_V$ , 7.0 to 17.5; load coefficient,  $C_A$ , 2.5 to 49.0. The large amount of collected test data are presented in simplified plots. Planing conditions are defined which result in the flow clinging to the chine edges of the flat planing surface.

## (2153) EVALUATION OF WAKE FRACTION AND THRUST DEDUCTION OF A SHIP PROPELLER.

- (b) Office of Naval Research, Department of the Navy (DTMB technical supervision).
- (c) Prof. B. V. Korvin-Kroukovsky, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Theoretical; basic research.
- (e) Traditionally the wake fraction and thrust deduction for design of a ship propeller are obtained by means of model tests of a specific ship form and its propeller. The general dependence of these characteristics on ship form is known only empirically. In the attempts at rational solution, the mathematical difficulties required drastic simplifying assumptions as to physical conditions, which undermine the practical value of the results. In the present project the wake fraction and thrust deduction is obtained by computational methods as functions of the hull form and the thrust distribution over



the propeller disk. While the expression of many hydrodynamical relationships involved in the problem in a compact mathematical form proved to be prohibitively difficult, these relationships are basically simple and are amenable to computational procedure, treating one aspect of the problem at a time. In this approach to the problem the physical conditions are realistically represented.

- (g) An introductory investigation of a body of revolution with a hypothetical propeller is completed. The work is continued with calculation of the inflow velocities for a propeller of circumferentially non-uniform thrust distribution.
- (h) "Circumferentially Non-Uniform Propeller Inflow" (preliminary exposition), by B. V. Korvin-Kroukovsky, ETT Note No. 314.

(2154) INVESTIGATION OF SHIP MOTIONS.

- (b) Office of Naval Research, Department of the Navy.
- (c) Prof. B. V. Korvin-Kroukovsky, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (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) Derivation of coupled equations of motion, and computations of motions for two models in two wave lengths have been completed. This included the derivation of expressions for the forces and moments exerted on the ship by waves, taking into account the ship-wave interaction. These computations were compared with experimental measurements and good agreement was obtained. Most of the towing tank tests on models of a sailing yacht and of a fishing trawler were completed.
- (h) "Ship Motions in Regular and Irregular Seas", by B. V. Korvin-Kroukovsky and Edward B. Lewis, ETT Technical Memorandum No. 106, published in International Shipbuilding Progress, Vol. 2, No. 6, 1955, pp. 81-95.  
"The Effect of Ship Size on the Characteristics of Three Classes of Merchant Vessels", by Cedric Ridgely-Nevitt, ETT Note No. 329.  
"Planning of Towing Tank Tests of Ship Models of Widely Different Form in Head Seas", by B. V. Korvin-Kroukovsky, ETT Note No. 332.  
"Investigation of Ship Motions in Regular Waves", paper presented by B. V. Korvin-Kroukovsky at the November 1955 meeting of the Society of Naval Architects and Marine Engineers.

(2155) INVESTIGATION OF THE SEAKEEPING QUALITIES OF SHIPS, WITH PARTICULAR REFERENCE TO MOTIONS IN IRREGULAR HEAD SEAS.

- (b) Bureau of Ships, Department of the Navy (DTMB technical supervision).
- (c) Mr. Edward V. Lewis, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Theoretical and experimental; basic research.
- (e) A method of producing realistic irregular long-crested waves in the model tank is being developed and applied to the comparative study of the motions of two ship models of the same proportions but different forebody form. Results are compared with the motions calculated by recently developed methods from model performance in regular waves of a wide range of frequencies. Work is being extended to a third high-speed hull form.
- (f) First phase completed; work continuing.
- (g) Good agreement has been obtained between observed and predicted motions in moderate irregular seas, fair agreement in high irregular seas where non-linear effects become pronounced.
- (h) "Irregular Waves in Model Tanks", by Edward V. Lewis, and "Observations of Ship Motions by Models", by Professor B. V. Korvin-Kroukovsky. Both papers presented at the Conference on Ships and Waves, sponsored by Council on Wave Research and the Society of Naval Architects and Marine Engineers at Hoboken, N. J., October 1954.  
"Ship Motions in Regular and Irregular Seas", by B. V. Korvin-Kroukovsky and Edward V. Lewis (ETT T.M. No. 106), International Shipbuilding Progress, Rotterdam, Vol. 2, No. 6, 1955.  
"Ship Speeds in Irregular Seas", by Edward V. Lewis, presented at the November 1955 meeting of the Society of Naval Architects and Marine Engineers, New York.



## (2156) MOTION AND STABILITY OF HYDROFOIL SYSTEMS.

- (b) Office of Naval Research, Department of the Navy (DTMB technical supervision).
- (c) Dr. Paul Kaplan, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Theoretical; basic research.
- (e) To determine the longitudinal stability characteristics of tandem hydrofoil configurations in smooth water and in waves, both controlled and uncontrolled. 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.
- (h) Two reports are currently in preparation. One is concerned with the forces and moments acting on the system in waves and the other is a motion analysis of the unrestrained system in waves.

## (2157) WAKE AND DOWNWASH OF HYDROFOILS.

- (b) Office of Naval Research, Department of the Navy.
- (c) Dr. Paul Kaplan, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
- (d) Theoretical; basic research.
- (e) To evaluate analytical expressions for wake and downwash aft of hydrofoils in order to determine the effect of this flow field on the forces acting on a tandem foil located aft.
- (f) Completed.
- (g) The two-dimensional wake and downwash of a hydrofoil in waves has been determined in a form applicable to stability and motion analyses in waves. The complete three-dimensional flow field aft of a finite span hydrofoil in smooth water has been determined and expressions for surface wave amplitude and downwash are available.
- (h) "Evaluation of the Theory for the Flow Pattern of a Hydrofoil of Finite Span", by Paul Kaplan, John P. Breslin, and Winnifred R. Jacobs, ETT Report No. 561.

## (2158) COMPARISON OF STREAMLINED BODIES AND PROLATE SPHEROIDS.

- (b) Office of Naval Research, Department of the Navy (DTMB technical supervision).
- (c) Dr. Alice Winzer, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Theoretical; basic and applied research.
- (e) Calculations based on a theoretical analysis of the three added mass coefficients for a series of rotationally symmetric streamlined bodies; comparison of these calculations with those based on a simplified semi-empirical formula for the added mass coefficients.
- (f) Completed.
- (g) A simple semi-empirical formula is established from which the added mass coefficient  $k_1$  for longitudinal motion can be obtained for a family of bodies. This is found to be in much better agreement with the true  $k_1$  of the body than the one used thus far, namely the  $k_1$  of a prolate spheroid of same fineness ratio.
- (h) "A Comparison of the Added Masses of Streamlined Bodies and Prolate Spheroids", by L. Landweber and A. Winzer, ETT Report No. 572, June 1955, to be published in an early issue of the Schiffstechnik, Forschungshefte Für Schiffbau und Schiffsmaschinenbau, Hamburg, Germany.

## (2387) BENDING MOMENTS OF SHIPS IN WAVES.

- (b) Society of Naval Architects and Marine Engineers.
- (c) Mr. Edward V. Lewis, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Analytical.
- (e) Calculation of bending moments in waves, taking into account dynamic effects of ship motions and forward speed, for comparison with experimentally determined bending moments. Use is made of new methods developed by Prof. B. V. Korvin-Kroukovsky. Prediction of bending moments in irregular waves and comparison with irregular tank wave results.

## (2388) FORCES ON HYDROFOILS IN UNSTEADY MOTION.

- (b) Laboratory project.
- (c) Dr. Paul Kaplan, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Theoretical and experimental; basic research for doctoral thesis.
- (e) To determine the hydrodynamic forces acting on a hydrofoil moving below a free surface with time-dependent motion, with the emphasis on oscillatory motion of foil and/or fluid.
- (f) Completed.
- (g) Expressions for lift and wave drag have been found. The experimental measurements of lift found with the hydrofoil moving below regular waves indicate good agreement with theory, as compared with the usual quasi-steady derivations.
- (h) "A Hydrodynamic Theory for the Forces Acting on Hydrofoils in Unsteady Motion", by Paul Kaplan; doctoral thesis in Stevens Institute of Technology Library.

## (2389) PERFORMANCE AND DYNAMIC CHARACTERISTICS OF HYDROFOIL CRAFT.

- (b) Office of Naval Research, Department of the Navy.
- (c) Dr. Paul Kaplan, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Theoretical; applied research.
- (e) To investigate the scaling of performance of hydrofoil craft of different sizes in different seas and to develop a general method for the evaluation of the stability of various hydrofoil configurations while in the preliminary design state.

## (2390) CONTROLLED FINS FOR REDUCING SHIP PITCHING.

- (b) Bureau of Ships, Department of the Navy (DTMB technical supervision).
- (c) Mr. Edward V. Lewis, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Experimental and analytical.
- (e) To determine the most desirable action of controlled fins at bow or stern of a ship to reduce pitching in regular and irregular seas.

## (2391) THEORETICAL STUDY OF THE HYDRODYNAMIC PRESSURE FIELD NEAR A ROTATING PROPELLER BLADE AND THE FORCES APPLIED TO CERTAIN SIMPLE, NEARBY BOUNDARIES.

- (b) David Taylor Model Basin, Bureau of Ships, Navy Department.
- (c) Mr. John P. Breslin, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson Street, Hoboken, N. J.
- (d) Theoretical; applied research.
- (e) Interest in propeller excited ship vibration has led to studies of the hydrodynamic field about a propeller. Methods of obtaining fairly simple expressions for the unsteady pressure developed in the field about a rotating propeller blade are being studied with the view of correlating with measurements made at the David Taylor Model Basin. In addition, an analogous two-dimensional problem, namely that of a line vortex moving rectilinearly on a path perpendicular to the plane of a flat plate parallel to a free stream has been solved to find the instantaneous force on the plate. This has been done for orientations which correspond to the propeller-rudder configuration. It is expected that this work will be continued to include to first order the effect of a finite chord of a propeller blade on the force generated on the plate.
- (f) Preliminary report has been submitted on the two-dimensional problem.
- (g) Results obtained to date for the three-dimensional pressure field indicate that the correct order of magnitude of the pressure fluctuations can be obtained by a rudimentary representation of the propeller. However, the behavior with respect to phase and certain other characteristics peculiar to the helical wake are not well predicted and further work is required. The two-dimensional results for the forces generated on a plate (skeg or bossing forward of the propeller) are found to be in the correct order of magnitude and are therefore considered to be encouraging. The decay of the force with increasing clearance between vortex and plate is found to be relatively slow and further work, which will bring in the effect of finite propeller chord, is necessary.
- (h) "Hydrodynamic Forces on a Plate Near a Moving Vortex", ETT Preliminary Report No. 583, by John P. Breslin.



Stevens Institute of Technology  
Technical Research Group  
University of Tennessee

## (2392) FORCES AND MOMENTS ON SPINNING BODIES.

- (b) Bureau of Ordnance, Department of the Navy.
- (c) Dr. Paul Kaplan, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Experimental; basic and applied research.
- (e) To measure the forces and moments acting on spinning underwater missiles, including Magnus terms. Static and dynamic (due to angular velocity) coefficients (stability derivatives) will be obtained using the rotating arm facility at E.T.T.
- (g) A motion analysis of a spinning missile, using theoretically derived Magnus force and moment coefficients, has been made. The criteria for stability and expressions for the space trajectory were found.
- (h) "The Motion of a Non-Cavitating Spinning Underwater Missile", ETT Note No. 302, presented at the Joint Admiralty - U. S. Navy Meeting on Hydro-ballistics, 1954.

## (2393) BENDING MOMENTS OF SHIPS IN WAVES.

- (b) Bureau of Ships, Department of the Navy (DTMB Technical Supervision).
- (c) Mr. Edward V. Lewis, Experimental Towing Tank, Stevens Institute of Technology, 711 Hudson St., Hoboken, N. J.
- (d) Experimental and analytical.
- (e) Measurements of deflection of a jointed model of a high-speed naval vessel (third model in 2155) to determine external bending moment underway in regular and irregular waves; comparison with analytically determined bending moments.

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## TECHNICAL RESEARCH GROUP.

## (2394) INVESTIGATION OF THE ROLL-DAMPING OF LONG CYLINDERS, USING VARIATIONAL METHODS.

- (b) David Taylor Model Basin.
- (c) Dr. Jack Kotik, Technical Research Group, 17-19 Union Sq. W., New York 3, N. Y.
- (d) Theoretical; basic research.
- (e) The variational method is being applied, apparently for the first time, to calculate the energy radiated by a cylinder undergoing forced sinusoidal roll. Numerical calculations will be carried out for cylinders with cross-sections resembling ship-sections (U-section, V-section). The labor involved in extending the method to three-dimensional problems will be estimated.

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## UNIVERSITY OF TENNESSEE, Hydraulic Laboratory, Department of Civil Engineering.

Inquiries concerning Projects Nos. 944 and 2159 should be addressed to Dr. Harry H. Ambrose, Associate Professor of Civil Engineering, Department of Civil Engineering, University of Tennessee, Knoxville 16, Tenn.

## (944) HYDRAULIC FRICTION.

- (b) Partially sponsored by the David Taylor Model Basin, Department of the Navy.
- (d) Experimental; basic research.
- (e) A long-term investigation has been made to determine the effect of certain roughness characteristics upon the boundary resistance and the velocity distribution for turbulent flows through pipes. Tests were made in a four-inch plastic pipe which was roughened by the insertion of sleeves.
- (f) Completed. Bulletin in preparation.
- (g) The surfaces investigated contained roughness elements which were cylindrical holes or projections and which varied in size and distribution. The depression-type roughness showed characteristics quite different from those of the projection-type roughness.



A generalized relationship between velocity deficiency for the logarithmic portion of the velocity distribution and the resistance coefficient was found to apply to all roughnesses, nevertheless.

- (h) "The Effect of Character of Surface Roughness on Velocity Distribution and Boundary Resistance", by Harry H. Ambrose, Final Report submitted to the David Taylor Model Basin (Contract Nonr 811(03) ).

(2159) DISCHARGE COEFFICIENTS FOR TAINTER GATES ON SPILLWAYS.

- (b) Cooperative with the Tennessee Valley Authority.
- (d) Experimental; for master's thesis.
- (e) Discharge coefficients were determined for a generalized model of a tainter gate on a spillway. The effect of the trunnion location was investigated as well as that of the relative head and of the relative gate opening.
- (f) Experimental work completed, thesis in preparation.

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UNIVERSITY OF TEXAS, Department of Civil Engineering.

Inquiries concerning Projects Nos. 948, 1683, 1684, 2162, 2395, and 2396, should be addressed to Dr. Walter L. Moore, Department of Civil Engineering, University of Texas, Austin 12, Texas.

(948) DIFFUSION OF A TWO-DIMENSIONAL SUBMERGED JET.

- (b) National Science Foundation.
- (d) Experimental; basic research.
- (e) An investigation is being 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 feet thick and 3.0 feet wide with a plane parallel boundary at various distances from the axis of the jet.
- (g) Measurements are complete covering a range of boundary distance from 0 to 1.8 feet. Results indicate that the boundary has a stabilizing influence and tends to reduce the rate of diffusion. As the distance to the plane boundary is increased the diffusion increases. Mean flow streamlines obtained in the diffusion region defined a stable eddy between the jet and the boundary and indicated a linear spread of the jet downstream from the eddy. Velocity profiles in the zone of linear spread were all reducible to a single dimensionless curve. Measurements of static pressure in the stable eddy indicated significant negative pressures according to a systematic pattern. Checks of momentum and energy flux gave reasonable values.
- (h) Unpublished annual report to National Science Foundation is available on two weeks loan. One phase of the project is nearly complete.

(1683) THE EQUIVALENT PIPE CONCEPT IN RELATION TO THE GENERAL RESISTANCE DIAGRAM.

- (b) Laboratory project.
- (d) Theoretical; basic research.
- (e) An analytical study to clarify the conditions for the validity of the equivalent pipe concept and to modify the parameters of the conventional general resistance diagram making it more convenient for problems with pipes in series, branching pipes, and pipe networks.
- (f) Completed.
- (g) The General Resistance Diagram was modified by adding lines of constant  $m$  where  $m$  is the exponent in the equation  $h_f = KQ^m$ . A simple method was devised for evaluating  $k$  thus making  $m_1$  and  $k$  conveniently available as functions of the Reynolds number and relative roughness. The results clarify the limitations of the conventional exponential formulas yet make the convenience of this form readily applicable for a wide range of conditions.

## (1684) FLOW PATTERNS ASSOCIATED WITH VENTILATION OF A LARGE AREA.

- (b) Laboratory project.
- (d) Experimental, applied research.
- (e) The flow patterns associated with a conventional plan for the ventilation of a large area will be studied by visual observations in a model of a portion of a large underground garage. Water will be used as the fluid and colored dye to trace the flow patterns. The effectiveness of alternative flow patterns will be investigated.
- (g) The model has been completed and ventilation patterns recorded by photographing the movement of a front of dyed water sweeping through the area. Analysis of the photographic record indicated that a considerable improvement in the uniformity of the ventilation could be achieved by minor changes in the ventilation plan.

## (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. C. W. Morgan, Department of Civil Engineering, The University of Texas.
- (d) Experimental.
- (e) Experimental determinations will be made of the flow characteristics at two-dimensional channel drops and rises. The velocity distribution and surface profile will be determined (1) 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.
- (f) Temporarily inactive.
- (g) For a given entering flow condition, three different types of the hydraulic jump may form at an abrupt drop. The form of the jump, the transition between types, and the longitudinal location of the jump relative to the drop are dependent on the downstream depth.

## (2162) HYDROLOGIC STUDIES, WALLER CREEK WATERSHED.

- (b) Cooperative with U. S. Geological Survey.
- (d) Field investigation; applied research.
- (e) Measurements of rainfall and runoff for a 4 square mile and a 2 square mile portion of the Waller Creek watershed will be made to provide basic information for estimating runoff from small urban watersheds in the Southwest area. Studies of the correlation between runoff, rainfall, and the characteristics of the drainage basin will be made from time to time on the data accumulated. Two streamflow stations and a rain gage net are in operation.

## (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. Thesis in preparation.

## (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 and the available information tabulated.

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## UTAH STATE AGRICULTURAL COLLEGE, Agricultural Experiment Station.

## (151) LINING OF IRRIGATION CANALS AND RESERVOIRS.

See U. S. Department of Agriculture, Agricultural Research Service, page 115.

## (359) DRAINAGE OF IRRIGATED LANDS.

- (b) Laboratory and field project.
- (c) Mr. A. Alvin Bishop, Irrigation Department, Utah State Agricultural College, Logan, Utah.
- (d) Field studies; applied research and master's theses.
- (e) The major purposes are to find low cost, effective methods of drainage of arid-region waterlogged saline and alkali lands. In the past year work has been concentrated in Utah and Weber Counties with preliminary studies being made in Cache County.
- (g) Piezometers were used to measure the hydraulic head in the area affected by the Hooper Pilot Drain and flow patterns were constructed for conditions before construction of the drain and after the drain was completed. The effect of the drainage construction on the ground water flow pattern was significant.
- (h) "Needs for the Methods of Drainage - Logan-Hyde Park-Benson Area, Utah", O. W. Israelsen, Cleve H. Milligan and A. Alvin Bishop, Utah Agricultural Experiment Station Special Report 11, Nov. 1955.

## (1686) CONSUMPTIVE USE OF WATER AND IRRIGATION REQUIREMENTS.

- (b) Laboratory project, cooperating with Agricultural Research Service, U. S. Geological Survey and Utah State Engineer.
- (c) Prof. Wayne D. Criddle, Irrigation Department, Utah State Agricultural College, Logan, Utah.
- (d) Field investigation; applied research.
- (e) To obtain basic information regarding consumptive use of water by agricultural crops, pastures, and native vegetation; and to study methods of measurement of consumptive use of water.
- (g) Results being obtained are used currently in administration of the surface and underground waters of Utah.
- (h) "Consumptive Use Studies for Milford Valley, Utah, 1951-1954", Charles D. Busch, Thesis, Utah State Agricultural College, Logan, Utah, 1956.  
"Consumptive Use of Water and Irrigation Requirements", Wayne D. Criddle, Journal of Soil and Water Conservation, Vol. 8, No. 5, Sept. 1953.  
"Consumptive Use Studies Provide Information on Amount of Water Needed by Various Crops", Wayne D. Criddle, Farm and Home Science, Vol. 16, No. 1, March 1955.

## (1955) A STUDY OF FARM IRRIGATION EQUIPMENT AS RELATED TO OPERATION CHARACTERISTICS, COSTS, LABOR REQUIREMENTS AND TIME STUDIES INVOLVING IRRIGATION SCHEDULES AND SYSTEM CAPACITIES.

- (b) Laboratory project, cooperative with Reynolds Metals Company.
- (c) Prof. Wayne D. Criddle, Irrigation Department, Utah State Agricultural College, Logan, Utah.
- (d) Field investigation; applied research.
- (e) To evaluate irrigation equipment being used in the field and to develop criteria for the use of various types of equipment.
- (g) Results indicate that: (1) under Northern Utah conditions, farmers generally apply insufficient water by sprinklers for optimum growth and/or minimum application cost; (2) sprinkler systems must be capable of delivering about 10 gpm. continuous flow; and (3) minimum total labor requirements will be one man-hour per acre per irrigation.
- (h) "Evaluation of Sprinkler Systems in Northern Utah", Murray J. Gavel, Thesis, Utah State Agricultural College, Logan, Utah, 1955.  
"Evaluation of Sprinkler Irrigation Systems in Northern Utah", Jay M. Bagley and Wayne D. Criddle. Manuscript prepared for Technical Bulletin, Utah State Agricultural College.

## (2163) WATER RESOURCES PHASE OF INDUSTRIAL SURVEY SOUTHWESTERN UTAH, TRI-COUNTY AREA (Kane, Iron and Washington Counties).

- (b) Utah Committee on Industrial and Employment Planning.
- (c) Prof. Wayne D. Criddle, Department of Irrigation and Drainage Engineering, Utah State Agricultural College, Logan, Utah.
- (d) Field investigation; basic research.
- (e) The purpose of this study is to provide complete inventory of all water resources of the area and also to examine extent and economic value of losses, shortages, and wastes. Recommendation for more efficient utilization of the resources will be made. Findings to be integrated with other phases of the survey.

## (2164) EVALUATION OF FACTORS AFFECTING WATER YIELDS FROM HIGH WATERSHEDS.

- (b) Laboratory project.
- (c) Mr. Gregory L. Pearson, Soil Conservation Service, Salt Lake City, Utah, Mr. Cleve H. Milligan, Utah State Agricultural College, Logan, Utah.
- (d) Field investigation, statistical studies; applied research.
- (e) The purpose of the project is to improve the accuracy of prediction of summer irrigation water supplies based on snow and rainfall measurements, base stream flow, soil moisture conditions, etc. These predictions provide a basis for efficient water and farm management, including reservoir operation, cropping practices, and flood control.
- (g) As a consequence of these studies, it is now possible to estimate summer streamflow on many Utah streams within 10 percent, as compared to actual U.S.G.S. streamflow measurements.
- (h) "Federal-State Cooperative Snow Surveys and Water Supply Forecasts for Utah", published annually in mimeographed form. Available: Soil Conservation Service, Salt Lake City, Utah or Utah Agricultural Experiment Station, Utah State Agricultural College, Logan, Utah.

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STATE COLLEGE OF WASHINGTON, Division of Industrial Research and Department of Civil Engineering.

Inquiries concerning Projects Nos. 1689, 1690, 2165, 2166, 2397 to 2399, incl., should be addressed to Dr. E. Roy Tinney, Head, Hydraulic Research Section, Division of Industrial Research, State College of Washington, Pullman, Washington.

## (1689) STUDY OF FLUID FLOW IN PIPE NETWORKS.

- (b) Sponsored jointly by the Department of Civil Engineering and the Division of Industrial Research.
- (d) Experimental.
- (e) Using the McIlroy Flow Network Analyzer, the following studies are being made: 1. Effect of eliminating small pipes in a distribution system. 2. The effect of pipe roughness on pumping costs. 3. The analysis of network systems which use a compressible fluid such as natural gas.
- (h) "Pipeline-Network Problems on the McIlroy Analyzer", by Iury L. Maytin. Bulletin No. 227, Washington State Institute of Technology, 1955.

## (1690) PLACEMENT OF AIR VENTS IN IRRIGATION PIPE LINES.

- (b) Concrete Products Association of Washington.
- (d) Experimental; applied research for design.
- (e) Some of the breakages in irrigation pipelines have been shown to be the result of water hammer generated as air is released through vents. Studies on the rise velocity of air bubbles, on the minimum distance that an air vent is to be placed from the inlet of a pipeline, and on the dimensions of an air dome to relieve the water hammer have been made.



- (h) "Study of Breakage and Reduction of Flow in Concrete Irrigation Pipe", by J. A. Roberson, Bulletin No. 204, Washington State Institute of Technology, 1949.  
"Analysis of Failure in Unreinforced Concrete Irrigation Pipe", by J. A. Roberson. Bulletin No. 216, Washington State Institute of Technology, 1952.  
A third publication is in the press.

2165) THE INFLUENCE OF LOGGING OPERATIONS ON RUN-OFF FROM PRECIPITATION.

- (b) Division of Industrial Research.  
(d) Analytical with field investigation.  
(e) The run-off from water-sheds 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.

2166) NOXON RAPIDS HYDROELECTRIC DEVELOPMENT.

- (b) Ebasco Services, Incorporated for Washington Water Power Company.  
(d) Experimental design.  
(e) A 1:50 model of this development has been constructed to study cofferdam construction procedures, spillway capacity, training wall design, diversion sluice capacity, and tailrace excavation. A 1:70, two dimensional model of the spillway has been made to study various dentated sills as well as a 1:30 model of the penstock intake to study entrance losses.

2398) PIEASANT VALLEY HYDROELECTRIC DEVELOPMENT.

- (b) Ebasco Services, Incorporated for the Pacific Northwest Power Company.  
(d) Experimental design.  
(e) A 1:50 model of the 534' high arch dam has been made to study conditions at the base of the free over-fall. Of particular importance are the waves and surges along the powerhouse walls, the design of outlet works, and the rating of the free over-fall spillway. A pilot model, at a scale of 1:175, has been constructed to aid in selecting the best overall design.

2399) PRIEST RAPIDS HYDROELECTRIC DEVELOPMENT.

- (b) Harza Engineering Company for the Grant County Public Utility District.  
(d) Experimental design.  
(e) A 1:38 model of the spillway has been constructed in a 4' wide glass-sided flume. Studies of the spillway buckets and the fish-passing characteristics are being made.

2400) SEDIMENT TRANSPORTATION STUDIES.

- (b) Division of Industrial Research.  
(d) Analytical and experimental.  
(e) The roughness characteristics of movable beds are being studied. Work thus far is analytical, utilizing published data.  
(h) "A Study of the Mechanics of Degradation of a Bed of Uniform Sediment in an Open Channel", by E. Roy Tinney. Ph.D. thesis at the University of Minnesota, 1955.

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UNIVERSITY OF WASHINGTON, Department of Civil Engineering.

1692) SHORT RANGE FORECASTS OF SNOW-MELT RUNOFF IN COLUMBIA RIVER BASIN.

- (f) Completed.  
(g) Report in files of Bonneville Administration files.

## (1705) A HYDROGRAPHIC SUMMARY OF THE STREAMS IN THE STATE OF WASHINGTON.

- (b) State of Washington Department of Fisheries.
- (c) Prof. Harold K. Moritz, Hydraulics Laboratory, University of Washington, Seattle 5, Washington.
- (d) Field investigation, operation.
- (e) Comparative hydrographic study of streams in the State on basis of high year, low year, and mean year.

## (2401) SURFACE DISTRIBUTION OF FLOW FROM BURIED PIPE ORIFICES.

- (b) State of Washington Department of Fisheries, Stream Improvement Division.
- (c) Prof. Harold K. Moritz, Hydraulics Laboratory, University of Washington, Seattle 5, Washington.
- (d) Experimental.
- (e) An outdoor laboratory study of the flow through gravel to facilitate the design of salmon spawning areas.
- (f) Model equipment under construction.

## (2402) VARIATION IN KUTTER'S "n" WITH DEPTH IN AN OPEN CHANNEL WITH GRADED GRAVEL BOTTOM.

- (b) State of Washington Department of Fisheries, Stream Improvement Division.
- (c) Prof. Harold K. Moritz, University of Washington, Seattle 5, Washington.
- (d) Experimental.
- (e) Outdoor laboratory measurements on semi-trapezoidal gravel section with 3:1 side slope laid in 10 foot channel 130 feet long with slope of 0.001.
- (f) Model tests completed.
- (g) Results shown mainly on graphs enable the designers of the McNary Dam Spawning channel to proceed with confidence.

## (2403) HYDRAULIC MODEL TESTS OF FISHWAY STRUCTURES FOR COWLITZ RIVER POWER DEVELOPMENT.

- (b) City of Tacoma, Light Division, Department of Public Utilities.
- (c) Dr. E. P. Richey, Ass't. Prof. of Civil Engineering, University of Washington, Seattle 5, Washington.
- (d) Experimental; applied research for design.
- (e) One model, scale 1:10 to facilitate the design of structures for the transport of upstream migrants through the power house to a collection pool. A second model scale 1:3, for design of a screening device to safely collect the downstream migrants with the most economical use of attraction water.
- (f) Tests under way.

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## WOODS HOLE OCEANOGRAPHIC INSTITUTION.

## (2404) SHIP MOTION STUDIES.

- (b) Office of Naval Research, Department of the Navy.
- (c) Mr. Wilbur Marks, Woods Hole Oceanographic Institution, Woods Hole, Mass.
- (d) Experimental; field investigation; applied research.
- (e) Field work involved measuring the motion spectra of a thirty-six foot launch in 2-3 foot seas. Five different headings at constant speed are sufficient to characterize the heave and pitch of the vessel. In the laboratory, the motion spectra are computed by current linear theories. Comparison of the observed and predicted motion spectra should be an indication of the value of the linear theory as a ship motions predictor. The two-dimensional wave spectrum is measured via stereo-photography from a bridge. An established relationship between the spectra of small waves and large waves will show the manner in which the results of model studies in irregular seas can be extrapolated to full-scale vessels in well-developed seaways.



- (g) Observed motions have been converted to spectrum form, computed motion spectra are in final state with indications of a favorable comparison.

(2405) DEFORMATION EXPERIMENTS ON THE R/V ATLANTIS.

- (b) Laboratory project.
- (c) Mr. Wilbur Marks, Woods Hole Oceanographic Institution, Woods Hole, Mass.
- (d) Experimental; field investigation; basic research.
- (e) It is believed that the deformation of a vessel can be related to the "seaway of encounter", that is, to the waves as they tune through the vessel. The deformation is measured by the time-lapse camera, as the relative displacement of two points on the vessel. The "seaway of encounter" was measured on the hull of the R/V ATLANTIS by the National Institute of Oceanography ship-borne wave recorder. Runs were made in several directions at a variety of speeds.
- (g) The ATLANTIS is a very rigid vessel and examination of the deformation record indicated no hog or sag, in any case. There was a transverse bending which was most pronounced in beam seas and least pronounced in head seas.
- (h) "Analysis of the Performance of the NIO Ship-borne Wave Recorder Installed in the R/V ATLANTIS", Wilbur Marks, Woods Hole Oceanographic Institution, Technical Report, Reference No. 55-64. Nov. 1955. (Unpublished manuscript.)

(2406) SEAKEEPING CHARACTERISTICS OF EXTREME HULL DESIGNS.

- (b) American Bureau of Shipping.
- (c) Mr. Wilbur Marks, Woods Hole Oceanographic Institution, Woods Hole, Mass.
- (d) Theoretical; applied research.
- (e) With new concepts of powering, the possibility of very high speeds indicates that ship motions will play a greater role than resistance in the architecture of vessels of the future. It is hoped that computation of the response of some simple unconventional hull (rectangle, wedge, cylinder, ellipse) will suggest model studies in confused seas of one or more of these extreme hull designs.

(2407) TWO-DIMENSIONAL ENERGY SPECTRUM OF THE SEA SURFACE.

- (b) Department of the Navy, Office of Naval Research.
- (c) Mr. Wilbur Marks, Woods Hole Oceanographic Institution, Woods Hole, Mass.
- (d) Experimental; field investigation; applied research.
- (e) It is desired to know the energy spectrum of the waves as a function of both frequency and direction. The raw data consists of aerial stereo-photographs of the sea surface made from two airplanes flying in tandem. Elevations read from the photos at prescribed points are subjected to numerical analysis in order to determine the desired spectrum. Wave poles were used to collect supplementary data.
- (g) Wave pole records have substantiated theories of growth and decay of wave spectra.
- (h) "Aerial Stereo-photography and Ocean Waves", Wilbur Marks and F. Claude Ronne, Photogrammetric Engineering, Vol. XXI, No. 1, pp. 107-110, Mar. 1955.  
"Observation of the Growth and Decay of a Wave Spectrum", Wilbur Marks and Joseph Chase. Trans. of the Amer. Geophysical Union, Vol. 36, no. 3, p 519. June 1955 (abstract only).

(2408) OCEAN WAVE MEASUREMENTS.

- (b) Office of Naval Research, Department of the Navy.
- (c) Mr. Harlow G. Farmer, Research Associate, Woods Hole Oceanographic Institution, Woods Hole, Mass.
- (d) Field Investigations; applied research.
- (e) Measurements have been made in the open ocean of wave elevation and slopes in two directions, up-down wind and crosswind. A special buoy was used which supported, vertically, three resistance wire sensing elements. Data to be analyzed so as to indicate the average asymmetry of ocean waves under various wind conditions.

## (2409) LABORATORY INVESTIGATIONS OF THE GENERAL CIRCULATION OF THE ATMOSPHERE.

- (b) Office of Naval Research, Department of the Navy, and Geophysics Research Directorate, Air Force Cambridge Research Center.
- (c) Mr. Alan J. Faller, Research Associate, Woods Hole Oceanographic Institution.
- (d) Experimental, basic research.
- (e) An experimental attempt to reproduce the effects of rotation and heating as fundamental causes of the general circulation of the atmosphere. Isolation of the effects of seasonal variations, zonal asymmetries, topography, and external influences.
- (f) Apparatus being reconstructed.
- (g) Reproduction of character of the atmospheric circulation including fronts, cyclones, and jet streams.
- (h) "An Investigation of Fronts and Frontal Waves in Atmospheric Models", by Alan J. Faller, to be published in the Journal of Meteorology, Feb. 1956.

## (2410) LABORATORY STUDIES OF THE OCEAN CIRCULATION.

- (b) Woods Hole Oceanographic Institution, Woods Hole, Mass. under contract with the Office of Naval Research.
- (c) Dr. William S. von Arx, Woods Hole Oceanographic Institution, Woods Hole, Mass.
- (d) Experimental, basic research.
- (e) An experimental evaluation of factors influencing the oceanic general circulation. Study concerned at present with the effects of heating and baroclinity on the time of response of the ocean circulation to changes of wind stress at seasonal and higher frequencies and of the character of inertial instabilities in the flow.
- (g) The climatological mean ocean circulations have been reproduced in homogeneous water under the influence of zonal wind stresses, together with the effects of the rotation and meridional curvature of the earth. Preliminary experiments with wind-driven models of the northern and southern hemispheres have been completed.
- (h) "A Laboratory Study of the Wind-Driven Ocean Circulation", W. S. von Arx; Tellus, 4 (4): 311-318, 1952.  
 "Some Techniques for Laboratory Study of the Primary Ocean Circulation", W. S. von Arx; Proc. Conf. on Geophysical Models, Johns Hopkins Univ., Sept. 1953 (in press).  
 "On the Variation of the Coriolis Parameter and Its Simulation in Models of the Ocean Circulation", A. J. Faller and W. S. von Arx; Woods Hole Oceanogr. Inst. Tech. Rept., Ref. No. 55-13, 15 pp. (unpublished manuscript), 1955.  
 "An Experimental Study of the Dependence of the Primary Ocean Circulation on the Mean Zonal Wind Field", W. S. von Arx; doctoral dissertation, Mass. Inst. Tech., 120 pp., 1955.  
 "Experimental Approach to Problems in Physical Oceanography", W. S. von Arx; Vol. II, Recent Advances in Geophysics and Geochemistry. Pergamon Press, London (in press).

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WORCESTER POLYTECHNIC INSTITUTE, Alden Hydraulic Laboratory.

Inquiries concerning Projects Nos. 1712, 1713, 1961, 1963, 2169, 2170, and 2411, should be addressed to Prof. L. J. Hooper, Director, Alden Hydraulic Laboratory, Worcester Polytechnic Institute, Worcester 2, Mass.

## (1712) CROMBY MOVEABLE BED MODEL.

- (b) Philadelphia Electric Co.
- (d) Experimental; for design.
- (e) A distorted model (1:15 vertical scale, 1:45 horizontal scale) was constructed of a section of the Schuylkill River including provision for heating water pumped through the condensers. Studies were made of re-circulation of hot water discharged from condensers.
- (f) Inactive - work will be continued.



(1713) LITTLETON HYDROELECTRIC DEVELOPMENT.

- (b) Connecticut River Power Co.
- (d) Experimental; for design.
- (e) A 1:60 model was constructed of the chute spillway and section of the Connecticut River to study flow conditions in the chute and in the river adjacent to the chute.
- (f) Completed. Model kept in readiness to check details during construction.

(1961) HOGBACK DAM WATER SUPPLY DEVELOPMENT.

- (b) The Water Bureau, Hartford, Conn.
- (d) Experimental; for design.
- (e) A 1:50 model of the dam, spillway, diversion tunnel, Mill Brook diversion and adjacent river topography was constructed to study flow conditions for diversion and flood flows. Water surface profiles in diversion tunnel and spillway channel were determined.
- (f) Completed. Model maintained to provide information during construction.

(2169) EDGAR STATION.

- (b) Boston Edison Co., through Jackson Moreland Co.
- (d) Experimental; for design.
- (e) A 1:250 model of the Edgar Station steam plant was installed in a wind tunnel (5' x 5' x 8' test section) to determine the effect of various devices on the smoke pattern from the stacks.
- (f) Completed.

(2170) TITFLEX COUPLINGS.

- (b) Titeflex Corporation.
- (d) Experimental; for design.
- (e) A series of quick disconnect couplings in various pipe sizes up to 2 inches were tested for head loss and leakage. Several combinations of valve and check arrangements were studied.

(1963) METER CALIBRATION.

- (b) Foxboro Company, Foxboro, Mass.
- (d) Experimental; for design.
- (e) Weighing tank calibration of 2 inch, 4 inch, 8 inch and 12 inch Magnetic Flowmeters.

(2411) METER CALIBRATION.

- (b) Foster Engineering Company, Union, N. J.
- (d) Experimental; for design.
- (e) Calibration of 5 designs of 10 inch Gentile Flow Tubes.
- (f) Completed.

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THE UNIVERSITY OF WYOMING, College of Agriculture and Experiment Station.

(2412) SPRINKLER IRRIGATION STUDIES.

- (b) Laboratory research project.
- (c) Mr. W. McNab Miller, Department of Agronomy, University of Wyoming, Laramie, Wyoming.
- (e) Investigation of sampling procedure for spray pattern, interception moisture losses, and friction losses as effected by method of moving lines.

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U. S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, Soil and Water Conservation Research Branch.

Eastern Soil and Water Management Section.

(1966) SOIL AND WATER MANAGEMENT STUDIES.

- (b) In cooperation with the following State Agricultural Experiment Stations and other agencies throughout the 31 Eastern States: Alabama, Georgia, Illinois, Indiana, Iowa, Maine, Maryland, Missouri, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Virginia and Wisconsin. Hydraulic measurements are necessary for determining the effects of land management practices on runoff, soil moisture and erosion. Research is continually being carried on to improve these hydraulic measurements, since few data are available on measurement of silt and trash laden flows from small agricultural areas. Since the type of studies conducted at different locations within the many states are similar except for variations in soils, climate and cropping, they are being consolidated under a single heading.
- (c) Dr. L. B. Nelson, Eastern Soil and Water Management Section, Plant Industry Station, Beltsville, Maryland.
- (d) Field and laboratory investigations; basic and applied research for design purposes.
- (e) To determine the (1) effects of different land use and farming practices upon surface runoff, soil losses and groundwater supply and movement; (2) soil characteristics that are basically related to soil and moisture conservation principles as a basis for designing conservation practices; (3) relation of water runoff and soil erosion to the topography and to climatological conditions; (4) design of effective and economical structures and cultural practices for erosion control, water disposal and moisture conservation.
- (g) Runoff and erosion data from 280 individual plots, including different soils, slope conditions and management systems have been measured for the 1955 season.
- (h) "Using Rainfall Characteristics for Computing Soil Losses", A. P. Barnett. Agr. Eng. (in Press).  
 "Diagrams of Air, Water and Solid Space Relations in Soils", C. W. Domby and V. J. Jamison, Soil Sci. Soc. of Amer. Proc. (In press).  
 "Factors Influencing Runoff", Orville E. Hays, Ag. Eng. 36:732-736 (1955).  
 "Erosion Control Problems of the Humid Region", L. B. Nelson, Agr. Eng. 35:876-877 (1954).  
 "Punched Cards Record Runoff and Soil Loss Data", W. H. Wischmeier, Agr. Eng. 36:664-665 (1955).

(2413) DRAINAGE REQUIREMENTS AND PRACTICES FOR CROP PRODUCTION.

- (b) In cooperation with the following State Agricultural Experiment Stations and other agencies throughout the 31 Eastern States: Louisiana, Mississippi, Arkansas, Georgia, South Carolina, Florida, North Carolina, Virginia, Maryland, New York, Ohio, Illinois, Michigan, Iowa, Minnesota and Wisconsin. Determinations are made of the drainage requirements of various soils for production of important crops. Tile, mole and surface drainage systems of varying designs and materials are investigated in respect to their efficiency and effectiveness in providing adequate drainage. Studies are made of improved engineering designs and techniques for maintaining controlled water table levels under both organic and mineral soils. Relationship of drainage design to soil and crop management systems are studied. Since the type of studies conducted at different locations within the many states are similar except for variations in soils, climate and cropping, they are being consolidated under a single heading.
- (c) Dr. L. B. Nelson, Eastern Soil and Water Management Section, Plant Industry Station, Beltsville, Maryland.
- (d) Field and laboratory investigations; basic and applied research for design purposes.
- (e) To determine (1) ways to improve farm drainage systems in the Mississippi Delta area which will permit high level crop production and more effective use of modern farm machinery; (2) the relationship and effect of the physical characteristics of soils upon the drainage capabilities and drainage design requirements of soils in the Coastal Plain and in the North Central areas; (3) to investigate and define the drainage problem characteristics of Upland Valley areas and to develop pre-planning survey techniques and drainage methods;



(4) through controlled hydraulic laboratory techniques, the hydraulic design characteristics of various drainage structural forms and systems for use in making more effective and economical drainage system designs.

- (g) Work is active on each of the above objectives with data being obtained on effectiveness of various system designs upon management of excess water. Data on the hydraulics of tile junctions have been obtained.
- (h) "Drainage Problems and Principles", T. W. Edminster and J. Van Schilfgaarde, 1955 U.S.D.A. Yearbook.  
 "Changes in Drainage Properties of a Muck Soil as a Result of Drainage Practices", H. A. Jongedyk, R. B. Hickok and L. D. Mayer, Soil Sci. Soc. of Amer. Proc. 18:72-76 (1954).  
 "Surface Drainage", K. V. Stewart and L. L. Saveson, 1955 U.S.D.A. Yearbook.  
 "Losses at Drain Tile Junctions", F. W. Blaisdell and P. W. Manson (In Press).

#### (2414) IRRIGATION REQUIREMENTS AND PRACTICES FOR CROP PRODUCTION.

- (b) In cooperation with the following State Agricultural Experiment Stations and other agencies throughout the 31 Eastern States: Missouri, Mississippi, Alabama, Georgia, South Carolina, North Carolina, Virginia, Maryland, New Jersey, New York, Pennsylvania and Puerto Rico. Determinations are made of the water requirements of crops under various conditions of evapotranspiration and plant environment and of crop response and water use under different amounts, times and methods of water application and depth of water penetration. Studies are made of soil, crop and management factors that affect the sound engineering design, operation and maintenance of irrigation equipment and systems. Since the type of studies conducted at different locations within the many states are similar except for variations in soils, climate and cropping, they are being consolidated under a single heading.
- (c) Dr. L. B. Nelson, Eastern Soil and Water Management Section, Plant Industry Station, Beltsville, Maryland.
- (d) Field and laboratory investigations; basic and applied research for design purposes.
- (e) To determine the (1) water requirements for irrigation in the East; (2) best sources of irrigation water and how it may be most economically stored and applied to the land; (3) best techniques for measuring and evaluating the infiltration rates and permeability characteristics of soils throughout the East; (4) principles underlying the flow of water into and through soils and (5) essential requirements in design, operating characteristics and performance for the effective use of irrigation equipment and systems.
- (g) Work is active on each of the above objectives with data on the amount and timing of irrigation water for corn, cotton, tobacco and forages under both sprinkler and surface systems being collected, evaluated and compared.
- (h) "Designing Irrigation Systems", J. R. Carreker, Georgia Agricultural Experiment Station Service Bulletin 588.  
 "Irrigation of Pastures and Forage Crops other than Alfalfa", J. R. Carreker and J. H. Lillard, 1955 U.S.D.A. Yearbook.  
 "Crop Response to Irrigation in Mississippi Delta", Perrin Grissom, W. A. Raney and Peter Hogg, Mississippi Farm Res. 18(5):4(1955) illus.  
 "Cotton Irrigation", B. A. Krantz, K. R. Stockinger, N. W. Swanson and J. R. Carreker, 1955 U.S.D.A. Yearbook.  
 "Laboratory Determination of Infiltration Rates of Disturbed Soil Samples", T. C. Peele and O. W. Beale, Soil Science Soc. Amer. Proc. 19:429-432 (1955).  
 "When to Irrigate and How Much Water to Apply", C. S. Slater and S. A. Taylor, 1955 U.S.D.A. Yearbook.  
 "Storage Pond Design", Dwight D. Smith, Agr. Eng. 36:743-746 (1955).  
 "Irrigation of the Home Garden", Marlowe D. Thorne and Victor K. Boswell, 1955 U.S.D.A. Yearbook.  
 "Determining Whether to Use Supplemental Irrigation in Humid Areas", C.H.M. van Bavel and W. A. Raney, 1955 U.S.D.A. Yearbook.

#### Soil-Plant Relationships Section.

#### (26) DRAINAGE INVESTIGATIONS IN COACHELLA VALLEY, CALIFORNIA.

See University of California, College of Agriculture, Division of Irrigation and Soils, page 10.

## (1194) PRINCIPLES UNDERLYING THE MOVEMENT OF AIR AND WATER INTO AND THROUGH SOILS.

- (b) Laboratory project.
- (c) Mr. R. C. Reeve, U. S. Salinity Laboratory, P. O. Box 672, Riverside, Calif.
- (d) Experimental; applied research.
- (e) To investigate the factors that influence the flow of water and air into and through soils.
- (h) "The Effect of Various Exchangeable Cations upon the Physical Condition of Soils", R. H. Brooks, C. A. Bower, and R. C. Reeve, Soil Sci. Soc. Amer. Proc., 1955. (In press).

## (2172) MOVEMENT AND DISTRIBUTION OF WATER AND SALTS IN UNSATURATED SOIL.

- (b) Laboratory project.
- (c) Dr. L. A. Richards, P. O. Box 672, Riverside, California.
- (d) Field investigation; applied research.
- (e) Involves the development of a descriptive theory for water content changes in field soil following wetting. Use is made of the relation of water content to suction and capillary conductivity.
- (h) "Physical Processes Determining Water Loss from Soil", L. A. Richards, and Gen Ogata, Soil Sci. Soc. Amer. Proc., 1955. (In press).  
 "Materials for Retainer Plates and Their Use for Retentivity Measurements", L. A. Richards, Gen Ogata, Soil Sci. Soc. Amer. Proc., 1955. (In press).  
 "Sample Retainers for Measuring Water Retention by Soil", L. A. Richards, Soil Sci. Soc. Amer. Proc., 1955. (In press).  
 "Retention and Transmission of Water in Soil", L. A. Richards, Yearbook of Agriculture (USDA), 1955. (In press).  
 "Measurement of Soil Water in Relation to Plant Requirements", L. A. Richards, Sci. Monthly 78: 307, 313, illus. 1954.  
 "Diagnosis and Improvement of Saline and Alkali Soils", United States Salinity Laboratory Staff, U. S. Dept. Agr. Handbook 60, 160 pp., illus., 1954.

## (2173) MOVEMENT OF WATER AND SALTS FROM A WATER TABLE.

- (b) Laboratory project.
- (c) Dr. W. R. Gardner, P. O. Box 672, Riverside, Calif.
- (d) Theoretical and experimental; basic and applied research.
- (e) Equations describing evaporation from a water table have been formulated and solved. Data are being taken on evaporation from laboratory soil columns to test and validity of the equation.

## (2174) MATHEMATICAL THEORY FOR THE MOVEMENT OF SOLUBLE SALTS BY LEACHING.

- (b) Laboratory project.
- (c) Dr. W. R. Gardner, P. O. Box 672, Riverside, California.
- (d) Theoretical and experimental; basic and applied research.
- (e) Purpose is to derive a mathematical theory for the leaching of soluble salts from soils. The soil properties which govern the amount of leaching are determined. Mathematical results are checked experimentally in laboratory soil columns.
- (g) Tentative theory for leaching during saturated flow has been derived. Laboratory experiments to check theory are in progress.

Watershed Hydrology Section.

## (150) EXPERIMENTAL WATERSHED STUDIES.

See also Stanford University Project 1946, page 95, and U. S. Weather Bureau Project 2437, page 161.

- (b) Cooperative with State Agricultural Experiment Stations, Soil Conservation Service, U. S. Weather Bureau, U. S. Geological Survey, U. S. Bureau of Public Roads, Stanford University, University of Iowa, St. Anthony Falls Hydraulic Laboratory, Central and Southern Florida Flood Control District, and the Wisconsin Valley Improvement Company.



- (c) Mr. William C. Ackermann, Watershed Hydrology Section, Plant Industry Station, Beltsville, Maryland.
  - (d) Experimental; field and laboratory; for design of Watershed Protection and Flood Prevention Projects and general information in planning farms for soil and water conservation.
  - (e) Rainfall and runoff are measured on watersheds ranging from 1 to 40,000 acres. In addition to rainfall and runoff measurements, studies are made on small Government-operated areas of evapo-transpiration, moisture storage, moisture transmission through the soil, hydrologic effect of physiography, tillage, and ground surface conditions, vegetal covers and soils and geology, and the effect of conservation farming on runoff and erosion, as well as the characteristics of flood runoff from agricultural watersheds. Studies are being carried on at, Tombstone and Safford, Arizona; Ft. Lauderdale and Vero Beach, Florida; Edwardsville, Monticello and Alhambra, Illinois; Iowa City, Iowa; Skowhegan and Presque Isle, Maine; College Park and Hagerstown, Maryland; East Lansing, Michigan; Hastings, Nebraska; Albuquerque and Santa Rosa, New Mexico; Cohocton, Dutchess County and Arnot Forest, New York; Coshocton, Ohio; Stillwater, Oklahoma; Riesel (Waco) and Spur, Texas; Blacksburg, Staunton and Chatham, Virginia; Colby, Fennimore, LaCrosse and Madison, Wisconsin; Watkinsville, Georgia; and McCredie, Missouri. Other studies include (1) analysis of rainfall data to develop regional area-depth relationships applicable to existing point-rainfall data, (2) compilation of rainfall runoff data for watersheds less than 400 square miles in area, and (3) development of procedures for generalizing synthetic unit hydrographs for watersheds primarily under 3,000 acres in size.
  - (g) Rainfall and runoff data for 366 agricultural watersheds, ranging in size from less than 5 acres to 256 square miles, at 60 locations in 27 states, are being compiled and processed for publication during 1956.
  - (h) "The Normal Annual Pattern of Mean Daily Temperatures at East Lansing, Michigan", G. A. Crabb, Jr., Mich. Agr. Exp. Sta. Quar. Bull. 36:401-407, 1954.  
 "A Study of Some Characteristics of Kenne Silt Loam and the Muskingum Silt Loam", F. R. Dreibelbis, and W. H. Bender, Jour. Soil and Water Conserv. 8:261-266, 1953.  
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 "Water Use by Crops as Determined by Weighing Monolith Lysimeters", L. L. Harrold and F. R. Dreibelbis, Soil Sci. Soc. Amer. Proc. 17:70-74, 1953.  
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 "A Slide Rule for Soil Moisture Determinations", E. F. Rowland, T. D. Fagan, and G. A. Crabb, Jr., Agr. Engin. 35:163-164, 1954, and Amer. Soc. Agron. Jour. 46:335, 1954.  
 "Evaluation of the Accuracy of Fiberglass-gypsum Blocks for Measuring Soil Moisture Changes", John M. Stackhouse and R. E. Youker, Agron. Jour., Vol. 46, No. 9:405, 1954.  
 "Blended Solvents for Control of the Submerged Water Weed Naiad in South Florida", John C. Stephens, et al, Agr. Exp. Sta., Gainesville, Florida, Jour. Series No. 265, Weeds 3, No. 2:160-169, 1954.  
 "Notes on the Control of Water Weeds", John C. Stephens. Will appear in Ann. Proc. Fla. Park and Recreation Training Institute, Gen. Exten. Div. of Florida.  
 "Subsidence of Organic Soils in the Florida Everglades", John C. Stephens. Will appear in an early issue of the Soil Science Soc. Amer. Proc.  
 "Review of Methods and Formulations for Aquatic Weed Control", John C. Stephens, Soil Science Soc. of Fla. Proceedings, Vol. XIV: 122-125, 1954.  
 "Inventory of Available Hydrologic Data on Agricultural Watersheds", Watershed Hydrology Section, May 1955.  
 "From Ocean to Sky to Land to Ocean", W. C. Ackermann, E. A. Coleman, and H. O. Ogrosky, Yearbook of Agriculture, 41-51, 1955.  
 "Drainage of Peat and Muck Lands", John C. Stephens, Yearbook of Agriculture, 539-557, 1955.
- (1723) THE HYDRAULICS OF CONSERVATION STRUCTURES.

See St. Anthony Falls Hydraulic Laboratory Projects Nos. 111, page 87; 1168, page 88; 1398, page 88; 1929, page 89; and 2386, page 93.

- (b) Cooperative with the Oklahoma and Minnesota Agricultural Experiment Stations, the St. Anthony Falls Hydraulic Laboratory, and Colorado A and M College, Department of Civil Engineering.
- (c) Mr. William C. Ackermann, Watershed Hydrology Section, Plant Industry Station, Beltsville, Maryland.
- (d) Experimental; applied research for development and design.
- (e) Research on the hydraulics of structures used in soil and water conservation has been accelerated during the past year. 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 or devices that appear promising. Models of hydraulic structures are built and tested in the laboratory; and when the design has been developed to seemingly satisfactory operation, full-scale structures are tested before they are recommended for field use. At the Stillwater, Oklahoma Outdoor Hydraulic Laboratory tests are being made to establish friction coefficients of various crops for use in the Manning channel flow formula, and studies are being continued on the use of highway culverts for measuring flow rates. At the St. Anthony Falls Hydraulic Laboratory final tests were made to determine proportions of the straight drop spillway stilling basin; studies were initiated to determine loss of energy at junctions of drain tile; and work was initiated on a hood entrance to closed conduit spillways. At Colorado A and M tests were begun to develop the optimum dimensions of cantilever outlets for circular discharge conduits from water retardation structures.
- (g) Preliminary results of the study of drain tile junctions show, for the 90-degree junction with the lateral the same size as the main, that additional energy losses are insignificant and that there is no need for the more costly hand-placed junction with an acute angle which has been commonly used.  
Tests have shown that wheat two feet tall, and in seven-inch rows, gave a Manning's "n" of 0.180, while the tall sorghum, Hegari, planted in forty-inch rows gave a friction coefficient of 0.150 at a depth of nearly three feet.  
Initial tests of a straight conduit with hood entrance indicate that this combination is very promising as a principal spillway for small dams.
- (h) "The Box Inlet Drop Spillway and Its Outlet", F. W. Blaisdell and C. A. Donnelly, Proc. Amer. Soc. Civil Engineers 80, Separate No. 534:1-41, Nov. 1954.  
"Development and Hydraulic Design of a Straight Drop Spillway Stilling Basin", F. W. Blaisdell and C. A. Donnelly, St. Anthony Falls Hydraulic Laboratory Tech. Paper 15-B, 1954.  
"Borax Solutions Found to Inhibit Rusting", F. W. Blaisdell, Civil Engin. 24:65-66, Aug. 1954.  
"Discussion of Morning-Glory Shaft Spillways: Prototype Behavior", F. W. Blaisdell, Proc. Amer. Soc. Civil Engin. 80, Separate No. 538:41-43, 1954.  
"Discussion of Morning-Glory Shaft Spillways: Performance Tests on the Model and the Prototype", F. W. Blaisdell, Proc. Amer. Soc. Civil Engin. 80, Separate No. 538:36-37, 1954.  
"Discussion of Morning-Glory Shaft Spillways: Determination of Pressure-Controlled Profiles", F. W. Blaisdell, Proc. Amer. Soc. Civil Engin. 80, Separate No. 568:1-2, 1954.  
"Hydraulic Fundamentals of Closed Conduit Spillways", F. W. Blaisdell, Proc. Amer. Soc. Civil Engin., Separate No. 354:1-14, 1953. Closing discussion in Proceedings Separate No. 538:11-13, Vol. 80, 1954.  
"Discussion of Application of the Relaxation Technique in Fluid Mechanics", F. W. Blaisdell Proc. Amer. Soc. Civil Engin. 79, Separate No. 374:7-8, 1953.  
"Measuring Runoff Rates with Rectangular Highway Culverts", W. O. Ree and F. R. Crow, Okla. Agr. Exp. Sta. Tech. Bull. T-51, 1954.  
"Tests of Low Head, High Volume Farm Pumps", J. C. Stephens, A. L. Craig and W. H. Speir, Tech. Bull. 565, 32 pages, Univ. of Fla. Agr. Expt. Sta., 1955.  
"Evaluation of Gully Control Structures", N. E. Minshall, Agr. Engin. 36:35-37, 1955.

(2175) SEDIMENTATION IN RESERVOIRS, STREAMS AND VALLEYS.

- (b) Cooperative with State Agricultural Experiment Stations in Mississippi, Nebraska and New York.



- (c) Mr. William C. Ackermann, Watershed Hydrology Section, Plant Industry Station, Beltsville, Maryland.
- (d) Experimental; field and laboratory, for design of Watershed Protection and Flood Prevention Projects and general information in planning farms for soil and water conservation.
- (e) Field 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 stream-bank 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 on control measures to determine their effectiveness in reducing sedimentation damages. The work is oriented to meet the immediate and specific needs for information for the 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 State College, Miss.; Lincoln, Neb.; and East Aurora, New York.
- (g) In the Buffalo Creek Watershed in New York, continuing and intensive research on stream bank erosion is beginning to yield valuable results. Tentative guides were released during the year which relate the location of rip-rap and vegetal controls along the creeks and headwater streams to the geometry of the channel itself. This insures that bank protection can be more efficiently placed to anticipate the location and intensity of bank attack. A recent flood provided good verification of developed theories. Significant observations on the variation in density of reservoir sediment have been made on Sabetha Reservoir and Mission Lake, both in northeast Kansas. The dry weight of 63 samples from Sabetha Reservoir ranged from 38.5 to 80.0 pounds per cubic foot and the weight of 52 samples from Mission Lake ranged between 24.0 and 77.3 pounds per cubic foot. It is apparent that the volume of reservoir storage to be depleted by accumulated sediment depends upon the ultimate density of the deposited sediment. These observations emphasize the range in weight of deposited material and suggest that the best possible measurement of sediment density should be obtained when results of reservoir sedimentation surveys are to be used as an index to sediment yield from watersheds. Studies in Mississippi have indicated that extensive disturbance or temporary scour takes place during flood flow on sand-bed streams. Fixed position sash and log chain have recently been installed both vertically and horizontally in the channel of Big Sand Creek, in Carroll County, which will be checked after the passage of flood flows for information on depth of disturbance. Cooperative studies have been initiated with other Agencies to (1) determine trap efficiency of detention type reservoirs and (2) develop a densitometer using radio-isotope materials for measuring in-site density of under-water sediment.
- (h) "Sediment Production in Small Watersheds", Russell Woodburn, Agr. Engin. Jour. 7:467-470, Vol. 36, 1955.  
 "Studies of Sediment Yields from Watersheds", L. M. Glymph, Jr. Prepared for presentation at the Tenth General Assembly of the International Union of Geodesy and Geophysics, Rome, Italy, September 15-19, 1954.  
 "Coshocton-Type Runoff Samplers - Supplementary Laboratory Investigations", D. A. Parsons, Agri. Res. Ser., 1955.

Western Soil and Water Management Section.

(53) SAND TRAPS AND SLUICeways.

See Colorado A and M College, page 20.

(55) SNOW COURSE MEASUREMENTS AND FORECAST ANALYSIS.

See Colorado A and M College, page 21.

(151) LINING OF IRRIGATION CANALS AND RESERVOIRS.

- (b) Laboratory project; Agricultural Research Service, Utah State Agricultural College, and Bureau of Reclamation cooperating.

- (c) Dr. C. W. Lauritzen, Agricultural Research Service, Box 177, College Hill, 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) This year, emphasis has been on the use of plastic films and soil stabilizers. Linings of Polyethylene and Polyvinyl chloride film as thin as 8 mils, it appears, can be used successfully to control seepage losses from reservoirs. The indications are that these films should be employed as buried liners in most instances. Considerable care must be exercised in making the installation, but once properly installed, these film liners are extremely effective and show promise of continued effectiveness over a long period of time. Some difficulties have been encountered in the use of chemical soil stabilizers for canal linings, but the results of preliminary tests and laboratory studies are promising for stabilizer AM 955.
- (h) "Ways to Control Losses from Seepage", C. W. Lauritzen. The Yearbook of Agriculture, 311-320, 1955.  
 "Soil Stabilizers for Seepage Control in Irrigation Canals and Reservoirs", C. W. Lauritzen. Industrial and Engineering Chemistry, 47:2245-2248, November 1955.  
 "Linings for Irrigation Canals and Reservoirs, - Research and Development", C. W. Lauritzen. Proceedings, First Western Conference on Asphalt in Hydraulics, October 1955.

(287) PERFORMANCE OF WELL SCREENS.

See Colorado A and M College, page 21.

(820) THE STUDY OF SEEPAGE LOSSES FROM IRRIGATION CHANNELS.

See Colorado A and M College, page 21.

(2067) MODEL STUDY OF A TIE INTERCEPTOR DRAIN.

See Colorado A and M College, page 25.

(2176) USE OF WATER IN THE SANTA MARGARITA RIVER BASIN, CALIFORNIA.

- (b) Field project in cooperation with State of California, Department of Public Work, Division of Water Resources.
- (c) Mr. Harry F. Blaney, 1509 Post Office and Court House Bldg., Los Angeles, California.
- (d) Experimental; applied research.
- (e) To determine the consumptive use of water by agricultural crops, native vegetation and evaporation. To obtain data on irrigation practices and farm irrigation use.
- (f) Field work on consumption use complete. Evaporation, humidity, temperature and wind movement data still being recorded at three stations.
- (g) Long-term mean consumptive use of water by agricultural crops, native vegetation, and evaporation losses have been computed for the area. These values have been computed by the Blaney-Criddle method which utilizes weather records for estimating consumptive use.
- (h) "Consumptive use of Water in the Santa Margarita River Basin, California", by Harry F. Blaney and Gilbert L. Covey, Dec. 1954. (Typewritten, 45 pages, 20 tables and 2 figures, report prepared at the request of California State Engineer for inclusion as an appendix to a report on Santa Margarita River Basin Investigations to be printed by State of California.)

(2177) WATER REQUIREMENTS IN THE IRRIGATED AREAS OF THE PACIFIC SOUTHEAST.

- (b) Field project in cooperation with Western States' Agricultural Colleges, State Engineer, Soil Conservation Service, and Bureau of Reclamation.
- (c) Mr. Harry F. Blaney, 1509 Post Office and Court House Bldg., 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) Normal rates of consumptive use and water requirements have been estimated and provisional reports are prepared for several western states and Colorado River Basin. These values have been computed by the Blaney-Griddle formula;  $U = KF$ . Where  $U$  is a consumptive use in inches,  $K$  is an empirical coefficient based on experimental measurements and  $F$  is a factor determined from monthly mean temperatures and percent day-time hours.
- (h) "Consumptive Use of Water Rates by Irrigated Lands in the Colorado River Basin of Nevada", by Clyde E. Houston and Harry F. Blaney. Soil Conservation Service and State of Nevada. 1954.  
 "Consumptive Water Requirements in the Colorado River Basin", by Harry F. Blaney. Published in Proceedings of the annual meeting of the Colorado River Water Users' Association".  
 "Use of Evapo-Transpiration Data in Determining Available Water Supply in Drainage Basins", by Harry F. Blaney. Presented at the annual meeting of American Society of Agricultural Engineers, Minneapolis, Minnesota, June 1954, and published in December 1954, issue of Agricultural Engineering.  
 "Consumptive Use of Ground Water by Phreatophytes and Hydrophytes", by Harry F. Blaney. Presented at the Tenth General Assembly of the International Union of Geodesy and Geophysics, Rome, Italy. September 1954. (To be printed.)  
 "Evapo-Transpiration Measurements in Western United States", by Harry F. Blaney. Presented at the Tenth General Assembly of the International Union of Geodesy and Geophysics, Rome, Italy, September 1954. (To be printed.)

(2178) DETERMINATION OF THE CHARACTERISTICS OF THE SUSPENDED SILT LOAD OF TEXAS STREAMS.

- (f) Suspended.

(2179) EVAPORATION AND CONSUMPTIVE USE OF WATER INVESTIGATIONS IN THE SAN FRANCISCO BAY AND ADJACENT AREA.

- (b) Field study conducted as a cooperative venture with Division of Water Resources, State of California, and the Corps of Engineers, San Francisco Bay District, U. S. Army.
- (c) Mr. Dean C. Muckel, P. O. Box 180, Berkeley, Calif.
- (d) Primarily applied with some field tests.
- (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) First stage of work is now completed and a final report to the Division of Water Resources, State of California, was completed in January 1955. The project is being continued and expanded through support from Corps of Engineers to include the Delta areas of the Sacramento-San Joaquin Rivers.

(2180) EVAPORATION LOSSES FROM RESERVOIRS.

- (b) Field project in cooperation with State of California and County Flood Control Districts.
- (c) Mr. Harry F. Blaney, 1509 Post Office and Court House Bldg., Los Angeles, California.
- (d) Experimental; compilation and 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 Engineer of California. Field measurements are being made in cooperation with the State and local agencies on 15 stations ranging in elevation from -240 feet below sea level at Salton Sea to 9,194 feet at Kaiser Pass in the Sierra-Nevada mountains.
- (g) Monthly evaporation from pans, temperature, humidity, wind movement, and precipitation are being compiled 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); Florence Lake (elevation 7,345 feet); Kaiser Pass (elevation 9,194 feet). Data is being compiled to bring up-to-date California State Bulletin No. 54, "Evaporation From Water Surfaces in California (A Summary of Pan Records and Coefficients 1881-1946)".

- (h) "Evaporation from and Stabilization of Salton Sea Water Surface", by Harry F. Blaney. American Geophysics Union Trans. Vol. 36, pages 633-640. 1955.

(2181) STORAGE OF WATER UNDERGROUND FOR IRRIGATION IN CALIFORNIA.

- (b) Laboratory and field project.
- (c) Mr. Leonard Schiff, P. O. Box 513, Bakersfield, Calif.
- (d) Experimental; basic research.
- (e) To determine the factors affecting the percolation rate on water-spreading areas, and to devise ways and means to increase the percolation rate. In some soils the percolation rate decreases during spreading, and the objectives are to determine the cause of the decrease and to find practical methods of maintaining the high initial rates. Field tests are being made on test ponds and strips.
- (h) "Progress Report of Water Spreading in the North Kern Water Storage District from January 1952 - October 1954", by Kirkham W. Campbell, Jan. 1955, (mimeographed).  
 "Some Factors Involved in Groundwater Replenishment", by Eldred S. Bliss and Curtis E. Johnson, Trans. Amer. Geophy. Union, vol. 33, pp. 547-558. 1952.  
 "Report on Cooperative Water Spreading Study with Emphasis on Laboratory Phases, August 1948-December 1950", by Eldred S. Bliss, Curtis E. Johnson, and Leonard Schiff, Dec. 1950, (mimeographed).  
 "Water Spreading for Storage Underground", by Leonard Schiff, Agric. Eng. vol. 35, no. 11, pp. 794-800, Nov. 1954.  
 "The Effect of Surface Head on Infiltration Rates Based on the Performance of Ring Infiltrimeters and Ponds", by Leonard Schiff, Trans. Amer. Geophy. Union, vol. 34, pp. 257-266 April 1953.  
 "Replenishing Ground Water by Spreading", by Dean C. Muckel and Leonard Schiff, USDA Yearbook of Agriculture, Water, 1955, Pages 302-310.  
 "Pumping Ground Water so as to Avoid Overdraft", by Dean C. Muckel, USDA Yearbook of Agriculture, Water, 1955, Pages 294-301.

(2182) PAYETTE VALLEY DRAINAGE INVESTIGATIONS, GEM COUNTY, IDAHO.

- (b) Field project.
- (c) Mr. R. William Nelson, P. O. Box 835, Boise, Idaho.
- (d) Basic and applied research.
- (e) The objectives of this study are: (1) To obtain basic physical data necessary to design drainage systems and reclaim water-logged and alkaline-saline lands in the Payette Valley, and (2) to develop methods and techniques that might be applied to the solution of drainage and salt problems on the lands in the intermountain and northwestern states. Future work is dependent upon an action program directed toward construction of the drainage facilities recommended for the solution of the problem.
- (g) The sources of water causing the drainage have been determined and a plan for the removal of these waters has been formulated.

(2184) DRAINAGE OF IRRIGATED LAND IN THE UPPER COLORADO RIVER BASIN.

- (b) Field and laboratory.
- (c) Mr. Minoru Amemiya, P. O. Box 786, Grand Junction, Colorado.
- (d) Basic and applied research.
- (e) (1) To develop procedures for making drainage investigations involving the source, amount and distribution of excess water, and (2) to evaluate the effects of water logging on soil permeability and crop response. Work has been underway on field tests using a drainage well and pump tests.

(2185) SPRINKLING AS A METHOD OF APPLYING WATER TO IRRIGATED FARM LANDS, ITS PROBLEMS AND LIMITATIONS.

- (b) Field project.
- (c) Mr. Claude H. Pair, P. O. Box 835, Boise, Idaho.
- (d) Basic and applied research.



- (e) The objectives of this study are: (1) To 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; (2) to determine the effect of sprinkling upon various soils and crops; (3) to determine the economic limitations in the use of sprinkler irrigation systems; and (4) to assist in the development and testing of better sprinkler equipment and more efficient operating procedures. Work is continuing on items (1) and (2) of (e) along with testing pressure regulating valves for use in sprinkler systems.
- (h) "Annual progress report, Cooperative Surface and Sprinkler Irrigation Investigations", by Claude H. Pair, December 1954.

(2186) RELATIONS BETWEEN SOIL CHARACTERISTICS AND PROPER IRRIGATION PRACTICES.

- (b) Field project.
- (c) Mr. Claude H. Pair, P. O. Box 835, Boise, Idaho.
- (d) Basic and applied research.
- (e) The objectives of this study are: (1) To obtain more precise information on the design, layout, construction, and operation of farm irrigation systems on new and old irrigated lands; (2) to determine the irrigation efficiencies and water requirements for those irrigated lands; and (3) to determine procedures to assist in adequate land classification on proposed and existing irrigation projects.  
Work is continuing on items (1) and (2) listed in the objectives above.
- (h) "Annual Progress Report, Cooperative Surface and Sprinkler Irrigation Investigations", by Claude H. Pair, December 1954.

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U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, California Forest and Range Experiment Station.

(261) WATERSHED MANAGEMENT RESEARCH, SOUTHERN CALIFORNIA.

- (b) Laboratory project.
- (c) Dr. George M. Jemison, Director, California Forest and Range Experiment Station, P. O. Box 245, Berkeley 1, California.
- (d) Experimental; field investigations; basic and applied research.
- (e) Purposes are (1) to determine how watersheds function: what happens to the precipitation, and how water and soil movement are influenced by conditions of vegetation, soil, geology, and topography; and (2) to develop methods of watershed management, including treatment of areas denuded by fire, to insure maximum yield of usable water and satisfactory flood runoff and soil erosion control. Major work center is the San Dimas Experimental Forest situated in the San Gabriel Mountains of southern California. Here rainfall, runoff, and erosion are measured on two major drainage areas, on 10 large and 7 small watersheds within these areas, and on 24 experimental plots. Vegetation cover on the watersheds is mostly mature brush or chaparral, unburned for 36 years or more. However, in 1953 about one-third of one large watershed was burned-over by wildfire and in 1938 one-fourth of another large watershed, 3 small watersheds, and 9 plots were denuded by wildfire. Fifteen other plots are equipped to obtain detailed information on the disposition of rainfall from annual ryegrass, native scrub oak-chaparral, and a 28-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 bunchgrass association. Climatic data are obtained from several meteorological stations. Ways of improving the native vegetation cover to reduce soil movement on mountain slopes are being studied in the Los Angeles River watershed. Measurements to determine kinds, rates, and volumes of soil movement (soil, rock, and organic debris) are made on eight study sites representing typical watershed soil and vegetation conditions. After normal erosion rates have been established, the above sites will be used to evaluate effects of promising cover improvement practices upon soil stability.

- (g) An analysis to determine variations in the disposition of annual rainfall in a 740-acre watershed of the San Dimas Experimental Forest during the years 1939 through 1953 showed that total water yield (streamflow plus drainage through the root zone not appearing as streamflow) varied widely, depending upon the amount and distribution of annual rainfall. Annual yield, estimated by a bookkeeping procedure, ranged from 0.05 inch to 29.4 inches and averaged 11.3 inches depth over the watershed. Less than one-third of this yield was measured as streamflow. Annual evaporative loss ranged from 11.5 to 18.8 inches and averaged 15.3 inches. This evaporative loss varied with the number and distribution of storms and, during years of low rainfall, with the amount of water available for evaporation. Preliminary results of the plot studies, during hydrologic years 1952 through 1954, indicate that annual evapo-transpiration from the surface 4-foot depth of brush-or grass-covered soils was about the same. Thus, for soils less than 4 feet deep, little or no water would be saved by conversion from brush to grass. Below the 4-foot soil depth there was a greater carry-over of moisture each summer under grass than under the deeper rooted brush cover. Thus for soils deeper than 4-feet, conversion from brush to grass would result in a saving of water in years of sufficient rainfall to set the soil below this depth. About 10 percent of the soils in the San Gabriel Mountains of southern California are deeper than 4 feet, but these, for the most part, are in scattered areas too small to justify conversion. Results of the studies to improve the vegetation cover on rapidly eroding slopes of the San Gabriel Mountains indicated this year that growth and density of the native vegetation can be increased by increasing the amount of available nitrogen in the soil.
- (h) "Hydrologic Analysis Used to Determine Effects of Fire on Peak Discharge and Erosion Rates in Southern California Watersheds", P. B. Rowe, C. M. Countryman, and H. C. Storey, California Forest and Range Experiment Station, 49 pp., Illus. Feb. 1954.  
 "Detecting Hydrologic Effects of Changes in Watershed Conditions by Double-Mass Analysis", H. W. Anderson, Trans. Amer. Geophys. Union, Vol. 36, No. 1, pp. 119-125, Feb. 1955.  
 "Streamflow Reactions of a Fire-Damaged Watershed", J. D. Sinclair and E. L. Hamilton, Proceed. A.S.C.E., Vol. 81, Sep. No. 629, 17 pp. Feb. 1955.  
 "Temperature Requirements for Germination in Relation to Wildland Seeding", W. C. Ashby and H. Hellmers, Jour. Range Mgt., Vol. 8, No. 2, pp. 80-83, March 1955.  
 "Development of Vegetation After Fire in the Chamise Chaparral of Southern California", J. S. Horton and C. J. Kraebel, Ecology 36(2):244-262, April 1955.  
 "Soil Fertility: A Watershed Management Problem in the San Gabriel Mountains of Southern California", Henry Hellmers, James F. Bonner, and John M. Kelleher, Soil Science 80(3): 189-197. Sep. 1955.  
 "Root Systems of Some Chaparral Plants in Southern California", H. Hellmers, J. S. Horton, G. Juhren, and J. O'Keefe, Ecology 36(4):667-678. Oct. 1955.
- (2415) WATERSHED MANAGEMENT RESEARCH, NORTHERN CALIFORNIA.
- (b) Laboratory project.
- (c) Dr. George M. Jemison, Director, California Forest and Range Experiment Station, P. O. Box 245, Berkeley 1, California.
- (d) Experimental; field investigations; basic and applied research.
- (e) The aim is to develop a hydrologic base for land management decisions. The hydrologic effects of wildfires, of attempts at conversion of brushlands to grass, and of logging are to be evaluated. Present studies emphasize (1) evaluation of erosion following wildfires and "controlled" burns in brushlands, (2) study of watershed damages incident to logging operations, and (3) development of methods of management of high elevation snowpacks for maximum control and yield of water. Major work center is in Berkeley with studies being conducted throughout northern California as well as at two field laboratories: Teakettle Creek Snow Laboratory in the Kings River Basin, east of Fresno, and the Central Sierra Snow Laboratory, near Donner Summit. At Teakettle Snow Laboratory, four small watersheds are under calibration for evaluation of streamflow and sedimentation. At the Central Sierra Snow Laboratory streamflow measurements of a single watershed will be resumed, possibly this year. Work on the snow studies has been started this year, with a review of the literature on snow physics and snow hydrology, development of a research plan, and analysis of past records.



- (g) Detailed comparison of 68 burns with nearby unburned areas showed erosion accelerated by the burning in every case. Erosion following burning was heaviest where chamise cover burned, lightest where woodland-grass burned, and intermediate where other shrub and dense woodlands burned. Controlled burns had same effect in accelerating erosion as did wildfires. Observations of erosion associated with logging in the redwood-Douglas fir region showed the principal damage associated with logging was in the form of massive earth slides into roads and creeks and the choking of creeks with tangles of slash and broken logs. In that region scars of logging and erosion often were revegetated within a few years, but the streams showed excessive mudbars, cut banks, sandfilled pools, and tangles of old slash firmly bedded in the streams for many years after the logging. Sediment measurements in the reservoirs at the reactivated Teakettle Snow Laboratory showed very similar catches in three of the four small watersheds. The average rates for the 1939 to 1955 period was 0.018 AF/sq. mi./yr. (after correction for trap efficiency to a uniform reservoir capacity-drainage area ratio of 0.28 AF/sq. mi.). The fourth watershed in which a small burn occurred in 1943 had an average rate of sedimentation 0.034 AF/sq. mi./yr.
- (h) "A Guide to Erosion Reduction on National Forest Timber Sale Areas", C. J. Kraebel, et al, U. S. Department of Agriculture, Forest Service, California Region, pp. 51-62, 1954, Multi. "Annual Report - California Forest and Range Experiment Station", U. S. Department of Agriculture, Forest Service, pp. 51-62, 1954. Multi. "Water Control and Timber Management", E. A. Colman, Proceedings, 45th Annual Western Forestry Conference, pp. 24-25, 1954. "Effects of the Forest Floor on Disposition of Rainfall in Pine Stands", P. B. Rowe, Jour. Forestry 53(5):342-348, May 1955. "Watershed Damage -- Its Signs and Causes", Clark H. Gleason, Paul E. Packer, and Roy D. Hockensmith, American Forests 61(6):34-37, June 1955.

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U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Central States Forest Experiment Station.

Inquiries concerning Projects Nos. 2416, to 2418, incl., should be addressed to the Director, Central States Forest Experimental Station, 111 Old Federal Building, Columbus 15, Ohio.

(2416) WATER INFILTRATION AS RELATED TO PHYSICAL SOIL CONDITIONS AND LAND USE IN SOUTHEASTERN OHIO.

- (b) Laboratory project.
- (d) Field investigation; basic and applied research.
- (e) Infiltration measurements and associated soil conditions were measured in undisturbed hardwood forest, 10-year-old pine plantations, abandoned agricultural lands, and actively grazed upland pastures. Results will supply factual evidence concerning the soil conditions and land use practices associated with slow water infiltration and rapid water runoff in southeastern Ohio.
- (g) Analysis of data from fourteen areas shows that water infiltration rates are usually faster in soils of hardwood forests than in soils of young pine plantations, abandoned agricultural land, or in actively grazed upland pastures. Slowest rates occur in upland pastures presently being grazed. Water infiltration rates are related to bulk density, clay content, and organic content of the surface soil thus indicating that rapid infiltration rates occur with loose, coarse textured soils that contain relatively large amounts of soil organic matter.
- (h) "Water Infiltration is Related to Physical Soil Conditions and Land Use in Southeastern Ohio", W. H. Carmean, manuscript submitted for publication, Central States Forest Experiment Station, Columbus, Ohio.

(2417) SOIL MOISTURE CHANGES RESULTING FROM CLEAR-CUTTING AN UPLAND HARDWOOD RIDGE.

- (b) Laboratory project.
- (d) Field investigation; basic and applied research.
- (e) Soil moisture is measured weekly by gravimetric methods from samples taken in clearcut plots and adjacent uncut hardwood plots on ridge sites in southeastern Ohio. Results will supply factual information concerning the effects of clearcutting on soil moisture levels in this area.

- (f) Continuing. The study was started in April 1954, soon after clearcutting and will continue until November 1955.
  - (g) Preliminary analysis indicates that soil moisture levels in the clearcut plots are consistently higher during the growing season than in adjacent uncut hardwood stands. The differences are presumably caused by the large transpirational losses from the uncut forest stand.
- (2418) SURFACE WATER RUNOFF FROM UNDISTURBED AND CLEARCUT HARDWOOD FOREST LAND AND FROM ABANDONED AGRICULTURAL LAND.
- (b) Laboratory project.
  - (d) Field investigation; basic and applied research.
  - (e) Surface runoff is measured with troughs that collect water runoff from 4 x 20 feet enclosures. Replications are located in undisturbed hardwood forest, clearcut forest, and on abandoned agricultural land. Data as to amount and intensity of rainfall, and moisture content, porosity, infiltration capacity, and texture of the soils in the plots will be related to the quantity of measured water runoff.
  - (f) Continuing.
  - (g) Preliminary results from 18 months of observation indicate that runoff on all plots greatly increases as the amount of rainfall increases. Undisturbed forest land has the least amount of runoff; clearcut forest land has had four to five times more runoff than the undisturbed forest. During heavy rains surface runoff from the abandoned land has been 20 to 30 times greater than the runoff from the undisturbed forest. Soil analyses show that the abandoned land has reduced porosity and very slow water infiltration rates compared to the forest plots.

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U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Intermountain Forest and Range Experiment Station.

Inquiries concerning Project Nos. 652 to 655, inclusive, should be addressed to the Director, Intermountain Forest and Range Experiment Station, Ogden, Utah.

(652) SOIL RELATIONS (IN WATERSHED MANAGEMENT AND PROTECTION).

- (d) Experimental and field investigation; basic and applied research.
- (e) Tests on plots and small watersheds of the effects of forest, brush, and herbaceous plant cover in natural, depleted, and restored condition on the infiltration, storage, fertility, biology and stability of forest and range land soils; to determine land use practices for stabilizing eroding watershed soils and for maintaining soil stability under the impact of grazing, logging, and other wild land uses. Studies are underway on forest and range lands having coarse, granitic soils of southwestern Idaho; various soils on steep slopes of the Wasatch Mountains in northern Utah; and on heavy limestone soils in central Utah.
- (g) Obtained first year of records from 20 small watersheds in the Boise Basin Experimental Forest near Idaho City, Idaho, for evaluating effects of ponderosa pine timber cutting and logging.  
Obtained first year of records from tests of erosion control measures on logging roads and skidways of four ponderosa pine timber sale areas on the Boise and the Payette River watersheds.  
Made infiltrometer evaluation of the effects of reseeding of the hydrologic behavior of damaged range-watersheds, Manti-LaSal National Forest.
- (h) "Annual Report - 1954", Intermountain Forest and Range Experiment Station, Forest Service, U. S. Dept. of Agriculture, Ogden, Utah. pp. 30-39.  
"Watershed Damage--Its Signs and Causes", Clark L. Gleason, Paul E. Packer, and Roy D. Hockensmith, Amer. Forests, June 1955.

(653) WATER RELATIONS (IN WATERSHED MANAGEMENT AND PROTECTION).

- (d) Experimental and field investigation; basic and applied research.



- (e) Tests on watersheds of the effects of forest, brush, and herbaceous plant cover, and of mechanical soil stabilization structures, on runoff characteristics of mountain watersheds; to determine land use treatments required for flood control and for maximum yields of usable streamflow.
- (g) Continued streamflow records on experimental watersheds at the Wasatch and the Great Basin Field Research Centers.  
 Started 3-year study to evaluate the hydrologic effects of upstream flood control measures in Pleasant Creek watershed, Utah, in cooperation with Soil Conservation Service. Streamflow records from paired watersheds over 18-year period at Wasatch Research Center show contour trenching and restoration of plant cover on portions of one damaged watershed resulted in (a) prevention of summer storm mud-rock floods, (b) greatly increased quality of water, (c) reduction and delay in snowmelt runoff, and (d) no significant change in summer, fall, or winter season runoff.  
 Completed reports on soil and plant cover changes on two sub-watersheds, Davis County Experimental Watershed, Farmington, Utah, in cooperation with Botany Department, University of Utah.

(654) PLANT RELATIONS (IN WATERSHED MANAGEMENT AND PROTECTION).

- (d) Experimental and field investigation; basic and applied research.
- (e) Tests on plots and watersheds of the effects of forest, brush, and herbaceous cover on interception and evapo-transpiration losses; to determine the kind of plant cover required for producing maximum yields of useful runoff from watersheds.
- (g) Obtained first year of records from Colman soil moisture units on 16 plots in the Davis County Experimental Watershed to determine the effect of seasonal use of range forage on water available for streamflow.  
 Completed a study of soil moisture characteristics on about 150 sites in Utah, Nevada, and southern Idaho, in cooperation with the U. S. Corps of Engineers.

(655) CLIMATIC RELATIONS (IN WATERSHED MANAGEMENT AND PROTECTION).

- (d) Experimental and field investigation; basic and applied research.
- (e) Measurements and studies of climatic factors including precipitation, temperature, etc., that have a bearing on the hydrologic behavior of forest and range watershed areas at the Boise Field Research Center, Boise, Idaho; Wasatch Field Research Center, Farmington, Utah; Great Basin Field Research Center, Ephraim, Utah; and the Inland Empire Field Research Center, Spokane, Washington.
- (g) Anemometer records during one growing season show wind movement to be about 5 times greater in openings than under an aspen forest.

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U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Northeastern Forest Experiment Station.

Inquiries concerning Projects Nos. 656, 966, 1187, 1188, and 2419, should be addressed to Dr. Ralph W. Marquis, Director, Northeastern Forest Experiment Station, 102 Motors Avenue, Upper Darby, Pa.

(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 watershed covered with scrub oak. Afterwards, the cover will be converted by planting and fire protection to a commercially valuable type, and the effect on water relations will be measured. Installations have been established to evaluate all components of a water balance equation for the watershed.

- (g) Sufficient streamflow and precipitation records have been secured to permit prediction of annual and seasonal water yield to an accuracy sufficient to detect any small changes from conversion of cover. Planting the watershed to conifers will begin in 1956.
- (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.
- (1187) FROST STUDIES IN THE NORTHEASTERN UNITED STATES.
- (b) Laboratory project.
  - (d) Field investigation; applied research.
  - (e) To determine the effect of land use and condition upon type and depth of frost formation. Periodic observations of frost type and depth, snow depth, and water content are made upon a large number of plots in New England, New York, and northern Pennsylvania, selected to sample a variety of land uses and conditions within certain land use classes. A system of 186 plots were established and observations made thereon during the winters 1950-51 and 1951-52. Data are now being analyzed.
- (1188) WATERSHED MANAGEMENT RESEARCH, FERNOW EXPERIMENTAL FOREST, WEST VIRGINIA.
- (b) Laboratory project.
  - (d) Field investigation; basic and applied research.
  - (e) Studies have been started on the Fernow Experimental Forest, Tucker County, W. Va., to determine the effect of different levels of cutting practices and different logging methods upon water quantity and quality. Five watersheds have been equipped with stream-gaging stations and raingages. No logging will be done on these watersheds during a calibration period. Measurements are being made on areas adjacent to the gaged watersheds to determine erosion rates on logging roads as influenced by length and steepness of grade and various erosion control measures.
  - (h) "Integrating Timber and Watershed Management in Mountain Areas", Sidney Weitzman and G. R. Trimble, Jr., Jour. Soil and Water Conservation 10: 70-75.
- (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 on plots and experimental watersheds on the 7500-acre experimental forest in the White Mountains at West Thornton, New Hampshire.
  - (g) A geological and soil survey of the experimental forest were completed, and a survey of weir sites was made. On one site a weir was constructed to measure streamflow from a 40-acre watershed. A study was started to determine the effect of northern hardwood forest canopies and size of clear-cut opening on accumulation and rate of snow melt.
  - (h) "Watershed Research Begins in New Hampshire", George R. Trimble, Jr., Forest Notes 46:22-25. "Skid Road Erosion: a By-Product of Mechanized Logging", Richard S. Sartz, Northeastern Logger 4(1): 10-11.

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## U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Pacific Northwest Forest and Range Experiment Station.

## (969) EFFECT OF LOGGING AND OTHER FOREST OPERATIONS ON STREAM FLOW.

- (b) Laboratory project.
- (c) Mr. R. W. Cowlin, Director, Pacific Northwest Forest and Range Experiment Station, Post Office Box 4059, Portland 8, Oregon.
- (d) Field investigation; applied research.
- (e) H. J. Andrews Experimental Forest, in the McKenzie River drainage of west central Oregon. Streamflow from three small experimental watersheds in virgin Douglas-fir has been measured for three years by means of trapezoidal flume stream gages. These observations provide a pretreatment calibration which will be carried on for 4 years or more. Planned treatments will test effect of two systems of timber cutting on water yield and erosion.

## (2187) EFFECT OF CATTLE GRAZING ON EROSION.

- (b) Laboratory project.
- (c) Mr. R. W. Cowlin, Director, Pacific Northwest Forest and Range Experiment Station, Post Office Box 4059, Portland 8, Oregon.
- (d) Field investigation; applied research.
- (e) To test the effect of heavy, moderate and light grazing on erosion and sediment production, Starkey Experimental Forest and Range. 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 second year.

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## U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Rocky Mountain Forest and Range Experiment Station.

Inquiries concerning Projects Nos. 376, 377, 657, 1967 to 1971, incl., 2188, and 2420 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, and upon erosion and sedimentation, to solve problems in watershed management for the forest and range-covered watershed lands of the Rocky Mountain Front Range such as: (1) Effect of grazing intensity on the water absorption of granitic soils, (2) Runoff and erosion from natural storms on bunchgrass plots, (3) Runoff and erosion from natural storms on young pine plots, (4) Effect of type conversion on runoff and erosion from small watersheds, and (5) Characteristics of runoff from cloudburst storms on a large watershed.
- (g) The recording of rainfall, runoff, and erosion from plots and watersheds representing different complexes of soil, vegetation, and treatment have been continued in conformance with the long-term nature of the study.
- (h) "Surface Runoff and Erosion from Pine Grasslands of the Colorado Front Range", E. G. Dunford, Jour. Forestry 52: 923-927, 1954.  
"Management of Water on Western Rangelands", F. G. Renner and L. D. Love, Yearbook of Agriculture, 1955.  
Annual Report, 1954, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

## (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 for wood products on factors associated with the yield of water, largely from stored snow. The purpose is to solve problems in the management of forested watersheds of the high altitude zone of the Rocky Mountains for maximum yields of usable water. (2) To evaluate the alpine snow fields of the Colorado Rockies with respect to their contribution to summer streamflow.
- (g) Logging on one 714-acre watershed was three-fourths completed by the end of 1955. One-half of the timbered area is being cleared in a strip-wise pattern. Streamflow records from both the treated and an adjacent untreated watershed during 11 years before logging and continuing after logging will enable detection of the effects of timber removal on total water yield and its distribution in time. Streamflow gages have been built on two additional streams, putting the hydrologic aspects of four high altitude watersheds under observation. Alpine snow fields at four locations were studied during the summer of 1955 with respect to their original water equivalent, rate of depletion, and relations between depletion rates and weather factors.
- (h) Annual Report, 1954, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.  
 "How to Get More Snow Water from Forest Lands", B. C. Goodell and H. G. Wilm, Yearbook of Agriculture, 1955.  
 "The Effect on Stream Flow of the Killing of Spruce and Pine by the Engelmann Spruce Beetle", L. D. Love, Transactions, American Geophysical Union, 36: 113-118, Feb. 1955.

## (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 natural vegetation as well as vegetation modified by cultural treatment such as grazing and timber harvest, on streamflow, water use, water loss, and erosion and sediment yield; and (3) To determine for phreatophytic vegetation (water-loving plants) the amount of water used and the best methods for removing phreatophytes and replacing them with plants of as good soil-binding but of lesser water-requiring characteristics.  
 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 four watersheds in the grassland-chaparral type at intermediate elevation, and on nine small watersheds in the semidesert chaparral type at low elevation. Water use by different types of plants in different soils is studied on 11 large lysimeters. Transpiration studies of phreatophytic vegetation are being initiated using the infrared gas analyzer which gives a direct and continuous measurement of water loss.
- (g) Broad-leaf vegetation (Arizona alder and bigtooth maple) on one of the pine-fir vegetation watersheds was removed in the summer of 1953 in the interest of increasing streamflow by the removal of uneconomic plants. These plants occupied 0.6 percent of the basal area of all trees on the watershed. As yet, there has been no perceptible increase in water yield as a result of this treatment.  
 Four small watersheds in the semidesert-chaparral type were seeded to Boer and Lehmann lovegrasses (*Eragrostis chloromelas* and *E. lehmanniana*) in 1953. Measurements during the summer of the following year showed five times the density of grasses on the seeded watersheds. Sediment yield on the seeded watersheds was reduced to approximately one-hundredth of that on the adjacent protected watersheds.

## (1967) WATERSHED MANAGEMENT RESEARCH, ALBUQUERQUE, NEW MEXICO.

- (b) Laboratory project.
- (d) Applied research.



- (e) Evaluation of reseeded rangelands for infiltration, soil stabilization, and soil productivity in woodland-sagebrush zone of north central New Mexico. Rocky Mountain infiltrometer was used to measure infiltration and erosion rates from reseeded and adjacent native rangelands under grazing and nonuse. Measurement of selected vegetation and soil factors included in this study.
- (f) Field study completed. Conducted during summers of 1952, 1953, 1954, and 1955.
- (g) Compilation and analyses completed on major effects.
- (h) Publications planned: Article summarizing major findings to be released in a scientific journal in 1956.

(1968) WATERSHED MANAGEMENT RESEARCH, NORTH CENTRAL, NEW MEXICO.

- (b) Laboratory project.
- (d) Applied research.
- (e) Range and watershed condition, trend, and potential in north central New Mexico. Rocky Mountain infiltrometer was used in 1953 and 1954 to measure infiltration and erosion rates from about 20 fenced-in enclosures installed in 1939 and 1940 on native pinyon-juniper-sagebrush rangelands and from adjacent open range. Detailed soil and vegetation measurements were taken at each infiltrometer plot location. In addition, reexamination was made and quantitative measurement of vegetation taken, both inside and outside the enclosure, for comparison with measured vegetation conditions in 1939-40.
- (f) Infiltrometer studies completed in 1953 and 1954. Additional vegetation and soil remeasurements planned for 1956.
- (h) Station Paper, Rocky Mountain Forest and Range Experiment Station, summarizing findings, planned for release in the spring of 1957.

(1969) WATERSHED MANAGEMENT RESEARCH, ALBUQUERQUE, NEW MEXICO.

- (b) Cooperative study with Bureau of Land Management and Geological Survey.
- (d) Applied research.
- (e) Range-watershed evaluation of small watersheds in the San Luis drainage of the Rio Puerco. Three watersheds, ranging from 431 to 680 acres, are located adjacent to one another about 8 miles north of San Luis (Dominguez) and west of the Rio Puerco. Water inflow and sediment are measured in small reservoirs formed by earthen dams. Precipitation amounts and vegetation changes are also measured. The survey and investigation phase has been completed and individual watersheds are currently being fenced. Uniform over-winter (6-month) grazing by cattle (50 percent utilization of perennial grasses) will be practiced on all three watersheds for a 5-year period. Thereafter, treatments will be applied to obtain light and heavy utilization of perennial grasses without land treatment and light utilization combined with mechanical land treatment including gully control.
- (f) Water-level recorders installed at three reservoir sites in the spring of 1955. One recording and two standard rain gages installed in the spring of 1955 for a total of four recording and four standard rain gages. This many gages were found necessary for accurate measurement of rainfall on this small area of about 3 square miles.
- (h) Annual Reports of the Rocky Mountain Forest and Range Experiment Station.

(1970) WATERSHED MANAGEMENT RESEARCH, GRAND JUNCTION, COLORADO.

- (b) Laboratory project.
- (d) Field investigation; applied research.
- (e) Object is to determine biological and physical characteristics of the oak brush type as a guide to land capability. Research on the characteristics of the type was conducted in 1953 and 1954.
- (g) Results not reported in previous bulletins are as follows: 52 percent of oak stems observed in 1954 were in the 0-9 year age class. Each of the age classes from 10-19 years through 80-89 years contained less than 11 percent of the total number of stems. One percent of the stems were older than 90 years. The oldest tree observed was 212 years. On at least 89 percent of the sites studied Gambel oak was present prior to 1880, indicating relatively little spread into new areas since that time. However, it is believed that thickening of the original oak cover occurred on about two-thirds of the sites, largely as a result of recurrent fires. The preponderance of 0-9 year old oaks is thought to be a natural condition rather than indicative of current spread. Definite evidence of current spread was found on only 5 percent of the sites.

- (h) "Gambel Oak in Western Colorado", by Harry E. Brown. Under preparation; medium of publication not determined.
- (1971) WATERSHED MANAGEMENT RESEARCH, GRAND JUNCTION, COLORADO.
- (b) Laboratory project, in cooperation with Bureau of Land Management, Bureau of Reclamation, and Geological Survey.
  - (d) Experimental; applied research.
  - (e) To determine the effect of exclusion of livestock grazing on erosion and runoff from semidesert lands in western Colorado, eastern Utah, and southern Wyoming.
  - (g) Pretreatment measurements of infiltration and erosion as determined with the Rocky Mountain infiltrometer are summarized by soil types and data may be obtained by writing to The Director, Rocky Mountain Forest and Range Experiment Station, Room 221 Forestry Bldg., Fort Collins, Colorado.
- (2188) WATERSHED MANAGEMENT RESEARCH, ALBUQUERQUE, NEW MEXICO.
- (b) Laboratory project.
  - (d) Applied research.
  - (e) Soil moisture studies. Colman soil electrical units are installed at 3-inch depth intervals from the 1 1/2-inch soil depth to bedrock or to a depth beyond any anticipated moisture penetration. Recording and standard gages are used to measure precipitation. Moist pinyon-juniper zone (17-inch annual precipitation). -- A record of precipitation and soil moisture is 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) -- new project). -- A record of precipitation and soil moisture is 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.
  - (h) Article proposed for a scientific journal scheduled for 1956 covering the study in the moist woodland zone. Annual reports of the Rocky Mountain Forest and Range Experiment Station.
- (2420) RELATIVE WATER USE BY ASPEN, SPRUCE, OAK BRUSH, AND HERBACEOUS COVER.
- (b) Laboratory project.
  - (d) Field investigation, applied research.
  - (e) Purpose of the study is to compare the amount of soil moisture withdrawal at different depths under the following cover types: aspen, spruce, oak brush, oak brush herbaceous, Thurber fescue, and Idaho fescue. Four plots were located in each of the following types: aspen, spruce, Thurber fescue, and Idaho fescue. Three plots were located in the oak brush and oak brush herbaceous types. Four locations on each plot were sampled gravimetrically at the beginning and end of the 1955 growing season. One-foot samples were taken to depths between 6 and 8 feet on each location. In order to permit conversion of moisture content from percent by weight to percent by volume, a pit was dug near each plot and samples taken for bulk density determination. The moisture content at equilibrium under 15 atmospheres will be used as the lower limit of available moisture. Total moisture withdrawal will be the difference between the available inches of water per foot of soil at the beginning and end of the growing season. The present plan is to continue the study at least one more year.

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U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, Southeastern Forest Experiment Station.

- (380) FOREST INFLUENCES INVESTIGATIONS - WATER RESOURCE AND WATERSHED MANAGEMENT RESEARCH.
- (b) Laboratory project. For general public use and information.
  - (c) Mr. E. L. Demmon, Director, Southeastern Forest Experiment Station, U. S. Forest Service, P. O. Box 2570, Asheville, N. C.



- (d) General and complete investigation of forest influences in southeastern United States. Includes fundamental hydrologic research and applied research in water resource and watershed management.
- (e) To determine the effect of vegetation on the phases of the hydrologic cycle. To find out the effect of land use and land management practices on water yield and water quality. To develop standards and methods of watershed management so as to derive the greatest benefit from the land and water resources in the southeastern United States. Most of the actual research experiments and hydrologic data collection is carried out on the 5600-acre Coweeta Hydrologic Laboratory which is located in the zone of maximum precipitation in the eastern United States (Nantahala Range of the Southern Appalachian Mountains). Within this experimental area are approximately 35 individual watersheds whose streamflow is being continuously gaged and which are either being treated experimentally or being used as control checks. In addition to the streamflow gaging, there are 13 recording and 80 non-recording (standard) rain gages, 21 recording and 19 non-recording ground water wells, 8 recording hygrothermographs, 2 recording anemometers, and one evaporation pan. Water samples for quality analysis are collected on a weekly and storm period basis from selected experimental watersheds.  
The Calhoun Experimental Forest near Union, South Carolina, has been established and is doing basic research on how piedmont soils influence water resources and plant growth. Studies include measurement of infiltration, daily changes in field moisture, and runoff from several small watersheds.  
All projects are to be carried to completion through analysis of data, preparation of reports, and publication of technical articles. Research projects include determination of effects of: (1) permanent removal of all major vegetation and cutting all natural regrowth, (2) temporary removal of all vegetation followed by natural regrowth, (3) removal of coversite forest vegetation, (4) removal of laurel and rhododendron shrub vegetation, (5) rehabilitating a depleted steep-land agriculture watershed, (6) rehabilitating a grazed woodland watershed, (7) improved techniques for removing wood products and retaining high quality water values on mountain watersheds, and (8) removing deficient age classes in a forest stand for changing water yields.
- (g) Land use studies of woodland grazing and mountain farming have shown that changes in soil due to trampling are reflected in infiltration, permeability, total porosity, increase in storm peaks, surface drainage characteristics, changes in time of watershed concentration during storm periods, and stream turbidities. The data also shed light on the time required to alter watershed conditions when undisturbed forested lands are farmed and grazed. Results from continuing fundamental studies covering the storage and depletion of ground water, annual water balance, and control of storm water are contributing to an understanding of the hydrologic processes on small tributary watersheds having a forest cover. Thus, cutting on ericaceous understory was found to increase stream discharge by several inches the first year, with the increase declining to less than an inch by the sixth year.  
Piedmont studies are showing that the organic layers of forest soils are a valuable diagnostic tool for timber and watershed management. Also through studies of the soil moisture regime under different types of watershed cover, information is being obtained regarding consumptive use of water, percolation rates, and seasonal storage potentials of forest soils.
- (h) "A Change in Ground-Water Level After Clearcutting of Loblolly Pine in the Coastal Plain", Kenneth B. Trousdell and Marvin D. Hoover, Jour. of Forestry, 53(7): 493-498, July 1955.  
"Increasing Water Yield by Cutting Forest Vegetation", E. A. Johnson and Jacob Kovner, presented for publication in Proceedings of the Georgia Academy of Science, 1955.

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U. S. DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS, Beach Erosion Board.

Inquiries concerning Projects Nos. 399, 660, 661, 972, 975, 977, 2189 to 2195, incl., 2421 and 2422 should be addressed to the President, Beach Erosion Board, 5201 Little Falls Road, N. W., Washington 16, D. C.

## (399) DESIGN AND CONSTRUCTION OF SIX-FOOT WAVE TANK.

- (b) Laboratory project.
- (d) Experimental; design.
- (e) To design and construct a wave tank for the study of the effect of waves 6 feet high and 300 feet long. Various types of wave generating mechanisms, the power required by the generator to form the waves, and the action of the waves on a given beach slope have been studied in a 1:12 scale model.
- (f) Completed.
- (g) The large wave tank is completed and is 635 feet long, 15 feet wide and 20 feet deep. Generation of the waves is accomplished by a pusher type wave generator. The construction and installation of the wave generator was completed in October 1955.

## (660) OBSERVED WAVE CHARACTERISTICS.

- (b) Laboratory project; additional research by New York University.
- (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.
- (h) "A Magnetic Tape Wave Recorder and Energy Spectrum Analyzer for the Analysis of Ocean Wave Records", Beach Erosion Board Technical Memorandum No. 58, July 1955.  
"The Step Resistance Wave Gage", Joseph M. Caldwell, Paper presented at 1st Conference on Coastal Engineering, Univ. of Calif., Berkeley, California, Oct. 1955 (in press).

## (661) REPORTS ON BEACH PROCESSES BASED ON EXISTING MISSION, ANAHEIM, AND SANTA MONICA BAY FIELD DATA.

- (b) Laboratory project.
- (d) Field investigation; basic research.
- (e) A study of the relation between movement of beach material and natural forces such as wave, tides, and littoral currents. Fourteen million cubic yards of sand have been placed on Hyperion Beach, Santa Monica Bay, and one million cubic yards have been placed on Sunset Beach, Anaheim Bay, California. Rate of movement of this material from the placement areas is being studied and correlated to wave and tide activity.
- (f) Field work completed.

## (972) STRUCTURAL DESIGN OF SHORE STRUCTURES.

- (b) Laboratory project.
- (d) Experimental; basic research.
- (e) To aid in the preparation on and revision of a handbook on the design of shore structures. Wave run-up and overtopping tests to determine optimum design of seawalls, revetments, levees, etc.
- (f) Laboratory pressure measuring tests completed; wave run-up and overtopping tests currently in progress.
- (h) "Laboratory Data on Wave Run-up and Overtopping on Shore Structures", Beach Erosion Board Technical Memorandum No. 64, October 1955.

## (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. In connection with this project a study is being made of the sand by-passing operation carried out by the Corps of Engineers at Port Hueneme, California in 1953 and 1954. Data, including hydrographic surveys and aerial photographs before, during, and at intervals after the dredging, and records of wave height and period are being studied to obtain any pertinent information on sand by-passing which may be applicable in future operations of this type.



## (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.
- (g) Additional development of recording parallel wire resistance and capacitance gages for laboratory use has been made to obtain constant linear calibration characteristics.

## (2189) LABORATORY STUDY OF THE REFORMING OF WAVES AFTER BREAKING.

- (b) Laboratory project.
- (d) Experimental; basic research.
- (e) To determine the conditions under which waves break over an offshore bar and the amount of the original energy propagated into deeper water behind the bar for given initial wave and bar conditions.
- (f) Suspended indefinitely.
- (g) Preliminary results indicate that the portion of the original energy propagated into deeper water behind the bar varies inversely as the initial wave height.

## (2190) STUDY OF THE 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. Installation of test set-up in the Shore Processes Test Basin (973) has been completed. Initial tests consist of waves generated at a 30-degree angle to the sand beach. Measurements of material movement is being made at the down-beach end.

## (2191) SAND MOVEMENT AT MORICHES INLET, LONG ISLAND, NEW YORK.

- (d) Field investigation; basic research.
- (e) To investigate the pattern of movement and deposition of the littoral materials in the vicinity of a newly opened inlet. Movement of the littoral material is being traced by means of hydrographic surveys of both the ocean and bay sides of the inlet, and through variation in size characteristics and heavy mineral composition of the littoral material. An attempt is being made to correlate movement of the littoral material with the natural forces involved.

## (2192) REGIONAL STUDIES OF THE NEW JERSEY SEACOAST; DELAWARE SEACOAST FROM KITTS HUMMOCK, DELAWARE BAY TO THE DELAWARE-MARYLAND STATE LINE; AND THE LAKE MICHIGAN SHORE.

- (d) Field investigation; basic research.
- (e) To compile all existing factual data pertinent to shore processes on a regional scale. Report to consist of five chapters: geomorphology, littoral forces, littoral materials, shore line history, and summary and conclusions. Subject matter to include physiography, geological development of the shore region, sources of littoral materials, waves, tides or water level fluctuations, currents, physical characteristics of the littoral materials, interrelation of sedimentary properties, relation to properties of littoral materials to position in the littoral zone, changes in shore line configuration, and the volumes of accretion and erosion.
- (g) Chapter on geomorphology completed; littoral materials (chapter 2) for New Jersey and Delaware coasts completed.

## (2193) SHORE PROTECTION PLANNING AND DESIGN.

- (d) Design.
- (e) To assemble in a single volume, insofar as practicable, a manual of practice for shore protection. Attempt to include a detailed summary of applicable methods, techniques and useful data pertinent to the solution of shore protection problems.

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(2194) FACTORS EFFECTING THE ECONOMIC LIFE OF TIMBER IN COASTAL STRUCTURES.

(d) Design.

(e) The purpose is to report on the various factors that effect the economic life of timber in coastal structures. This report includes a discussion of the causes of deterioration of timber in coastal structures and protection methods to increase the economic life.

(2195) RE-EXAMINATION OF ARTIFICIALLY NOURISHED AND CONSTRUCTED BEACHES.

(d) Field investigation; applied research.

(e) The purpose of this study is to evaluate the effectiveness and economic life of beach fills through artificial nourishment. A selected number of locations where beach fills have been made are being re-examined.

(2421) DEVELOPMENT OF A SUSPENDED SEDIMENT SAMPIER FOR LABORATORY USE UNDER WAVE ACTION.

(b) Laboratory project.

(d) Experimental; basic research.

(e) To investigate the working procedures and the degree of error and reproducibility to be expected in the extraction of suspended sediment under wave action.

(g) (1) The report discusses the effect on suspended sediment concentration caused by the constantly changing configuration of local bottom irregularities (changing depth) resulting from the forces accompanying the wave action. (2) The test results indicate that the water temperature is a significant factor in the study of suspended sediment caused by wave action.

(2422) WAVE FORECASTING IN INLAND WATERS.

(b) Office, Chief of Engineers.

(d) Theoretical and field investigation.

(e) To evaluate methods of wave forecasting in reservoirs.

(h) "The Effect of Fetch Width on Wave Generation", T. Saville, Jr. Beach Erosion Board Technical Memorandum No. 70, December 1954.

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U. S. DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS, Bonneville Hydraulic Laboratory.

Inquiries concerning Projects Nos. 1198, 1462, 1464, 1465, 1466, 1728, 1729, 1974, 1975, 1976, 2196, 2197 and 2423, should be addressed to the District Engineer, Portland District, Corps of Engineers, 628 Pittock Block, Portland 5, Oregon.

(405) GENERAL MODEL STUDY OF ICE HARBOR DAM, SNAKE RIVER, IDAHO.

(b) Department of the Army, Corps of Engineers, Walla Walla District, Walla Walla, Washington.

(c) District Engineer, Walla Walla District, Corps of Engineers, Building 602, City-County Airport, Walla Walla, Washington.

(d) Experimental; for design.

(e) A 1:100-scale, undistorted, fixed-bed model reproduces 2.7 miles of the Snake River at the dam site. The proposed structures include a 6-unit powerhouse, 10-bay spillway, and a 26- x 500-foot single lift navigation lock. Studies will be made to determine flow conditions during various construction stages and with the project completed.

(f) The model, which was completed and some tests made in 1948 and 1949, was reverified and a study of flow conditions with first-step cofferdam installed was begun.

(1198) FRICTION LOSSES IN CORRUGATED METAL PIPE. (CWI-828).

(b) Office, Chief of Engineers, U. S. Army, Washington, D. C.

(d) Experimental; applied research.



- (e) Tests were conducted to determine values of Manning's "n" for corrugated metal pipe of 3-, 5-, and 7-foot diameters with velocities from 1 to 16 fps. Open-channel flow was tested with the two smaller sizes and full-pipe flow was investigated with the three pipe diameters. Similar tests were made with inverts of 5-foot diameter pipe paved with asphaltic compound covering one-fourth and one-half the circumference; the 7-foot diameter pipe was tested with one-fourth of circumference paved. Velocity distribution at various sections of the pipe and pressure distribution along the corrugations were also obtained.
- (f) Completed.
- (g) Results indicated that "n" varies between: 0.0236, 0.0245, and 0.0234 for Reynolds Numbers of  $3 \times 10^5$ ,  $9 \times 10^5$ , and  $4 \times 10^6$ , respectively, for the 3-foot pipe; 0.0238, 0.0243, and 0.0240 for Reynolds Numbers of  $1 \times 10^6$ ,  $2 \times 10^6$ , and  $4 \times 10^6$  for the 5-foot pipe; and 0.0234, 0.0237, and 0.0230, for Reynolds Numbers of  $1 \times 10^6$ ,  $3 \times 10^6$ , and  $5 \times 10^6$  for the 7-foot pipe. With the pipe circumference one-fourth paved, "n" varied between: 0.0211 and 0.0207 for Reynolds Numbers of  $1.5 \times 10^6$  and  $4 \times 10^6$ , respectively, for the 5-foot pipe; and 0.0208 and 0.0203 for Reynolds Numbers of  $2.5 \times 10^6$  and  $5 \times 10^6$  for the 7-foot pipe. With the circumference of the 5-foot diameter pipe one-half paved "n" varied between 0.0180 and 0.0174 for Reynolds Numbers of  $1.5 \times 10^6$  and  $4 \times 10^6$ .
- (h) Five preliminary or memorandum reports have been issued on results of the tests. Final report issued July 1955.

(1462) GENERAL MODEL STUDY OF THE DALLES DAM, COLUMBIA RIVER, THE DALLES, OREGON.

- (b) Department of the Army, Corps of Engineers, Portland District, Portland, Oregon.
- (d) Experimental; for design.
- (e) A 1:80-scale, undistorted, fixed-bed model reproduces 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- by 675-foot navigation lock, a rock-fill non-overflow section, and facilities for passing fish over the dam. Maximum head is 90 feet. Revised layout has a straight 23-bay spillway. Purposes are to study the structures, alignment and flow conditions affecting navigation, power generation, cofferdam placement, rock-fill dam construction, and fish passage.
- (g) Four major layout plans were tested and the most economical plan that effected satisfactory hydraulic conditions was selected. Tests indicated ability to reduce length of spillway and to reduce forebay excavation by 30 feet. Data relative to water-surface elevations and velocities in the tailrace, and the effects of excess fill placed in the forebay have been obtained. Flow conditions during various stages of construction and with the project completed have been observed with special attention given to navigation and fish migration problems.
- (h) Twenty-nine memorandum reports have been issued to date.

(1464) MODEL STUDY OF ROCK FILL, THE DALLES DAM, COLUMBIA RIVER, THE DALLES, OREGON.

- (b) Department of the Army, Corps of Engineers, Portland District, Portland, Oregon.
- (d) Experimental; for design.
- (e) The 1:40-scale model of the 600-foot-wide closure section of the rock-fill nonoverflow section of the Dalles Dam includes portions of the river channel upstream and downstream therefrom and the eight partially-completed units at the upstream end of the powerhouse through which the river flow will be diverted as the closure fill is constructed. A study of the rock sizes and placement procedure required to construct the fill at a river flow of 200,000 cfs and for stability at 300,000 cfs is being made.
- (g) The fill has been constructed by placing quarry-run rock (1000 lb and less) in 10-foot lifts or by end-dumping from the Oregon shore at river discharges of 200,000 cfs and less. Owing to the faster placing program possible with the end-dump procedure, studies have been concentrated on this method of closure. The 1000 lb and smaller material was placed without loss in bottom velocities of 17 fps and surface velocities of 24 fps. The higher velocities caused some movement of material but owing to the 250-foot width of fill the material did not move beyond the confines of the fill.
- (h) Nine memorandum reports have been issued. One summary report was issued to supply information to prospective bidders.

## (1465) MODEL STUDY OF THE DALIES DAM SPILLWAY, COLUMBIA RIVER, THE DALIES, OREGON.

- (b) Department of the Army, Corps of Engineers, Portland District, Portland, Oregon.
- (d) Experimental; for design.
- (e) Three bays of the spillway are reproduced to a scale of 1:36 to study the hydraulic characteristics of the spillway crest, piers, gates, stilling basin and baffle piers.
- (f) Tests completed.
- (g) The increased crest efficiency indicated by the model, in conjunction with a crest shape designed for 75 per cent of maximum head, permitted a reduction in the number of spillway bays. The stilling basin was shortened 50 feet to a total length of 170 feet, and one row of baffle piers, of the Bluestone type, was eliminated. The capacity of the stilling basin would not be materially reduced by erosion of the shelf located downstream from the basin.
- (h) Sixteen memorandum reports have been issued on results of tests to date. Final report is in preparation.

## (1466) MODEL STUDY OF THE DALIES DAM NAVIGATION LOCK, COLUMBIA RIVER, THE DALIES, OREGON.

- (b) Department of the Army, Corps of Engineers, Portland District, Portland, Oregon.
- (d) Experimental; for design.
- (e) A 1:25-scale model of the 86- by 675-foot lock chamber including its culvert systems and portions of the upstream and downstream approach channels is reproduced. Maximum lift is 90 feet. Studies are being made of various types of filling and emptying systems to determine the most advantageous from the standpoints of rate of operations, degree of turbulence, and economy. The several proposed plans include lateral culverts within the lock chamber combined with several locations of intake ports, longitudinal culverts, and outlet ports.
- (g) Designs have been selected for all features of the lock. A change in valve-opening schedule resulted in a filling time of 12.5 minutes and a maximum hawser force of 8 tons without supplemental use of the upstream lock tainter gate. The lock emptied in 16 minutes. Studies have shown that staggered valve operation will reduce maximum hawser stresses.
- (h) Six memorandum reports have been issued.

## (1728) MODEL STUDY OF THE DALIES DAM FISH LADDERS, COLUMBIA RIVER, THE DALIES, OREGON.

- (b) Department of the Army, Corps of Engineers, Portland District, Portland, Oregon.
- (d) Experimental; for design.
- (e) The 1:8-scale model reproduced a straight portion of a fish ladder containing ten stilling pools. Tests were made to study flow conditions with ladder slopes of 1 on 16 and 1 on 20 and to determine the most efficacious orifice sizes for ladder widths of 24 and 30 feet.
- (f) Tests completed.
- (g) Results indicated insignificant differences in flow conditions between 1 on 16 and 1 on 20 slopes. Orifices 21 by 23 inches and 25 by 26 inches have been selected for the 24- and 30-foot ladders, respectively.
- (h) Four memorandum reports have been issued. Final report is in preparation.

## (1729) MODEL STUDY OF THE DALIES DAM POWERHOUSE INTAKE, COLUMBIA RIVER, THE DALIES, OREGON.

- (b) Department of the Army, Corps of Engineers, Portland District, Portland, Oregon.
- (d) Experimental; for design.
- (e) The 1:25-scale model contains a test unit consisting of intake and scroll case, two adjacent units with intakes only, and a semi-circular forebay in which flow can be introduced from any desired direction. Tests were made to determine the effect of the direction of approach flow on velocity distribution in the intake, discharge distribution through the scroll case, and head loss.
- (f) Tests completed.
- (g) Results indicate that oblique approach flows, at an angle of 15° from the powerhouse axis, have little effect on the efficiency of the unit, as indicated by head loss and flow distribution in the intake and scroll case, when trash racks are installed on the noses of the piers to function as guide vanes.
- (h) Six memorandum reports have been issued. Final report is in preparation.



- (1974) MODEL STUDY OF THE DALLES POWERHOUSE FISHWAY DIFFUSER, COLUMBIA RIVER, THE DALLES, OREGON.
- (b) Department of the Army, Corps of Engineers, Portland District, Portland, Oregon.
  - (d) Experimental; for design.
  - (e) To determine means of baffling auxiliary flow in diffusion chambers to obtain uniform distribution into the fish collection channel by means of a 1:8-scale model of one diffusion chamber and a portion of the collection channel.
  - (f) Tests completed.
  - (g) Vertical strip baffles placed downstream from the regulating valve produced satisfactory flow distribution.
  - (h) Three memorandum reports have been issued. Final report is in preparation.
- (1975) MODEL STUDY OF THE DALLES POWERHOUSE SKELETON UNIT, COLUMBIA RIVER, THE DALLES, OREGON.
- (b) Department of the Army, Corps of Engineers, Portland District, Portland, Oregon.
  - (d) Experimental; for design.
  - (e) To design for adequate discharge capacity and to determine pressures and velocities on exposed rock surfaces in eight skeleton powerhouse units that will be used for diversion during construction of a rock-fill nonoverflow section. A 1:25-scale model reproduces one skeleton unit.
  - (f) Tests completed.
  - (g) The required size of the draft tube openings and the areas requiring protection from high velocities were determined. The effect of varied tailwater elevations and of operation with one or two of the three intake bays per unit was observed.
  - (h) Three memorandum reports have been issued on tests to date. Final report is in preparation.
- (1976) MODEL STUDY OF BONNEVILLE DAM STILLING BASIN, COLUMBIA RIVER, BONNEVILLE, OREGON.
- (b) Department of the Army, Corps of Engineers, Portland District, Portland, Oregon.
  - (d) Experimental; for design.
  - (e) A 1:36-scale model reproduces three bays of the spillway and stilling basin for the purpose of studying the need of maintaining the stilling basin baffle piers. Additional tests were made to determine the revisions required to improve pressure conditions on the baffles and to eliminate scour of the river bed adjacent to the apron downstream from the stilling basin.
  - (f) Tests completed.
  - (g) Results indicated that baffles with a sloping front face were required because of their close proximity to the spillway bucket. Placing elliptical side curves on the leading edges of the baffles and revising the second row to a solid sill of similar cross section improved pressure conditions on the baffles and eliminated the erosion of bed material downstream from the stilling basin.
  - (h) Six memorandum reports have been issued. Final report is in preparation.
- (2196) MODEL STUDY OF FISH LADDER SURGE FOR THE DALLES DAM, COLUMBIA RIVER, THE DALLES, OREGON.
- (b) Department of the Army, Corps of Engineers, Portland District, Portland, Oregon.
  - (d) Experimental; for design.
  - (e) A 1:10-scale model reproduces the 30-foot-wide, 1 on 16 slope, East fish ladder from weir 96 to weir 155. Included are 14 weirs of the downstream tangent, the 180-degree bend, the 47 weirs of the upstream tangent, the 116-degree 45-minute bend, and three weirs upstream therefrom. Provision was made for varying the slope of the fish ladder. The occurrence and best means of controlling the surge are to be investigated.
  - (g) Results to date have indicated that a bi-nodal surge occurs with or without the orifices in the weirs open. Reduction in surging has been accomplished by: (a) various designs and arrangements of baffles placed at the quarter points, normal to the downstream sides of the weirs; (b) varying the width of the ladder by changing wall widths in groups of pools; and (c) changing the curved-top weirs (design) to square-top weirs. Subsequent tests indicated that changes in flow over the curved-top, fish ladder weirs caused by variation in pressure conditions under the nappe became synchronous over several weirs and caused the surge. Weir crests with sharp-edged control at upstream edge eliminated the surge. Weir crests designed for the prototype with tops 1 1/2 in. wide at the upstream edge followed by an approximately 1 on 1 slope were found to control the surge within the operating range of the fish ladder.

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(h) Six memorandum reports have been issued.

(2197) FINGERLING MORTALITY STUDY: FISHERIES ENGINEERING RESEARCH.

(b) Department of the Army, Corps of Engineers, North Pacific Division, Portland Oregon.

(d) Experimental; applied research.

(e) The effects of reduced pressure, high velocity impingement against walls placed at various angles and turbulence on salmon fingerling, either free-swimming or encased in gossamer bags of various types, to be investigated. Results of tests will be used in evaluating studies of passage of fingerling through spillways and powerhouse turbines. Apparatus to utilize approximately 25 cfs, including device to lock the fingerling salmon into the test sections, was constructed.

(f) Tests completed.

(g) Results indicated an insignificant number of fish killed.

(h) An interim report is being prepared.

(2423) MODEL STUDY OF FISH LADDER SURGE FOR McNARY DAM, COLUMBIA RIVER, McNARY, OREGON.

(b) Department of the Army, Corps of Engineers, Walla Walla District, Walla Walla, Washington.

(c) District Engineer, Walla Walla District, Corps of Engineers, Building 602, City-County Airport, Walla Walla, Washington.

(d) Experimental; for design.

(e) A 1:10 scale model reproduces the portion of the upstream leg of the 30-foot-wide, 1 on 20 slope, Washington shore fish ladder between weirs 288 and 326. The most economical means for controlling the surge which developed in the prototype ladder was to be determined.

(f) Completed.

(g) With the original rounded weir crests the surge occurred in the model over the same range of discharges observed in the prototype. The effects of thin metal plates (38-in. prototype) placed at varying heights above the weir crest were investigated. Results indicated that plates placed on the upstream face of the weirs and extending 0.5 to 0.7 feet above the weir crest would satisfactorily control surge within the operating range of the fish ladder.

(h) One memorandum report has been issued. Final report will be combined with 2196 - Model Study of Fish Ladder Surge for the Dalles Dam.

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U. S. DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS, JACKSONVILLE DISTRICT.

(1731) WIND TIDE AND WAVE ACTION IN INLAND WATERS.

(b) Department of the Army, Office of the Chief of Engineers.

(c) The District Engineer, Jacksonville District, Corps of Engineers, U. S. Army, Jacksonville, Florida.

(d) Field investigations and analytical; for design.

(e) The program of observation and analyses of wind and wave action in inland reservoirs was initiated to develop more rational and reliable methods of estimating freeboards and slope-protection requirements for dams and levees, effect of waves on static structures, and similar problems of a practical nature. Determination of the heights to which water may be expected to rise on dams and levees as the result of wind tides, the duration of such high tides, and the accompanying wave action govern design features representing many millions of dollars.

(f) Completed.



- (g) Detailed correlative analyses were made of basic wind, pressure, wave and water-stage data recorded on Lake Okeechobee during severe hurricanes in Florida. Various wind-tide estimating procedures and theories were tested with the recorded data. A step-integration method was developed which satisfactorily reproduced observed conditions and which is considered generally applicable for determination of wind effect on large regular or irregular-shaped water bodies having non-uniform bottom configuration and extreme variations in wind velocity. A wind-shear-stress relationship was derived, using multiple-level anemometer data recorded on the lake correlated with results of model tests conducted at the University of California. Analyses of wind and pressure distribution in hurricanes gave suitable relationships enabling construction of synthetic storm patterns for transposition and use in design analysis of levees and other hydraulic structures. Empirical relationships were derived for wave heights and periods based on analyses of the factors affecting the generation of waves in shallow lakes where available depth rather than fetch controls. Those relationships were expressed in the form of dimensionless parameters and compared with similar ratios obtained by other investigators for deep-water wave generation.
- (h) "Waves and Wind Tides in Shallow Lakes and Reservoirs", summary report, June 1955.

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U. S. DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS, Los Angeles District.

Inquiries concerning Projects Nos. 1203, 1732, and 2198, should be addressed to the District Engineer, Los Angeles District, Corps of Engineers, P. O. Box 17277, Foy Station, Los Angeles 17, California.

(1203) MODEL STUDY OF LOS ANGELES RIVER CHANNEL IMPROVEMENT, RIO HONDO TO PACIFIC OCEAN.

- (b) Laboratory project.
- (d) Experimental for design.
- (e) In the reach from Rio Hondo to Spring Street (44,500 feet) the improvement proposed is a paved trapezoidal channel with 300-foot base and 1 on 2 1/4 side slopes. Normal velocity would be supercritical (25 fps) but numerous bridges would produce Class "B" flow and attendant hydraulic jumps upstream of the bridges. From Spring Street to Pacific Ocean (17,600 feet) the channel will be trapezoidal with a base width varying between 530 feet and 470 feet, the 1 on 2 side slopes will be paved, the bottom unpaved, and the velocity subcritical (12 fps). The design discharge is 140,000 cfs in the first reach and 146,000 cfs in the second reach. A 1:50-scale model was used to study flow conditions at confluences, at bridges, and at the junction of the paved and unpaved channels. The model tests were accomplished in stages.
- (f) Completed.
- (g) Tests were made to determine flow characteristics at bridges, at the confluence with Rio Hondo, at the confluence with Compton Creek, and at the drop structure which forms the junction between the paved and unpaved channels.

(1732) MODEL STUDY OF SPILLWAY AND OUTLET WORKS FOR SAN ANTONIO DAM.

- (b) Laboratory project.
- (d) Experimental for design.
- (e) Earth dam with maximum height of 160 feet and length of 3850 feet. The outlet works designed for a maximum discharge of 10,000 cfs are at right abutment and consist of an intake with 3 gated openings 5 feet 8 inches wide by 10 feet high converging into a circular conduit 14.5 feet in diameter and 621 feet long. The spillway designed to pass 54,000 cfs is in right abutment and consists of a concrete ogee 200 feet long and a concrete side channel and chute 1075 feet long which terminate in a flip bucket at streambed. Three models were used to study various designs: a 1:20-scale model of the outlet works made of transparent plastic; a 1:36-scale model of the ogee and side channel of the spillway; and a 1:48-scale general model of the spillway.
- (f) Completed.

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Army - St. Paul District

- (g) Tests were made to determine the proper design of the side channel spillway with chute and flip bucket, and to determine the flow characteristics in the transition and tunnel of the outlet works.

(2198) MODEL STUDY OF SUPERELEVATED FLOW IN CURVED OPEN CHANNELS.

- (b) Laboratory project.
- (d) Experimental for design.
- (e) Tests were made in a curved rectangular channel to determine the effectiveness of short spiral easement curves in maintaining equilibrium of flow in the curve and in the downstream tangent. A 1:20-scale model of a channel having a width of 45 feet and a radius of curve of 700 feet was tested with a discharge of 13,000 cfs and depth and velocity of flow of 7.1 feet and 41 fps, respectively.
- (g) The tests indicated that spiral easement curves with a minimum length equal to 15 times the computed superelevation would be satisfactory.

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DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS, ST. PAUL DISTRICT.

In cooperation with St. Anthony Falls Hydraulic Laboratory.

Inquiries concerning Projects Nos. 194, 985, 1206, 1977, 2199, 2424, and 2425, should be addressed to the District Engineer, Corps of Engineers, St. Paul District, 1217 U. S. Post Office and Custom House, St. Paul 1, Minn.

(194) A STUDY OF METHODS USED IN THE MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS.

- (b) Subcommittee on Sedimentation, Inter-Agency Committee on Water Resources.
- (d) Experimental; applied research and development.
- (e) Plans and specifications for point- and depth-integrating suspended sediment sampler and associated laboratory apparatus have been prepared. Sediment sampler designs include a light-weight depth sampler (4 lb) hand operated, medium-weight depth sampler (62 lb), point sampler (100 lb), and heavy point sampler (300 lb) for use in deep swift streams. Designs for a sediment sample splitter, a bottom withdrawal tube, a hand operated bed material sampler, a heavy bed material sampler (100 lb), the visual accumulation sedimentation tube and particle size analyzer for recording the sedimentation size distribution (fall or settling velocities) of sand particles have also been prepared.
- (g) Instruments and apparatus required for sampling and analyzing fluvial sediments are being manufactured in quantities sufficient to satisfy the current needs of Federal agencies. Field testing of an improved 100-pound bed material sampler and the visual accumulation tube method of determining particle-size gradations of fluvial sediments in the sand size range is progressing.
- (h) "Investigation of Intake Characteristics of Depth-Integrating Suspended Samplers at the David Taylor Model Basin", Report H, November 1954. (Available on loan.)

(985) FILLING AND EMPTYING SYSTEMS FOR HIGH-LIFT LOCKS.

- (b) Office, Chief of Engineers, U. S. Army, Washington, D. C.
- (d) Experimental; applied research.
- (e) To develop adequate criteria for the design of filling and emptying systems for high-lift locks. Tests will be conducted in prototype locks, in model locks for definite projects, and in a general lock model simulating a maximum lift of 150 feet.
- (f) General lock model was used in tests on definite projects.

(1206) CONDUIT GATE STRUCTURES AND TRANSITIONS.

- (b) Office, Chief of Engineers, U. S. Army, Washington, D. C.
- (d) Experimental; applied research.



- (e) A general model study was conducted to establish gate operating procedures for multiple gate conduits and design criteria for conduit transitions downstream from single and multiple control gates. Influence of conduit length in dampening undulating flow in the conduit was also investigated. The model included a complete outlet conduit with upper pool reservoir, multiple control gates in conduit intake, and a stilling basin.
  - (h) Report has been completed; it will be published next year.
- (1977) MODEL STUDY FOR GREENUP AND MARKLAND LOCKS, OHIO RIVER.
- (b) Huntington and Louisville Districts, Corps of Engineers, U. S. Army.
  - (d) Experimental; for design.
  - (e) The hydraulic systems of the two locks which are of similar design are being tested in a 3 to 100 scale model. The proposed locks will be 110 feet wide and 1,280 feet long with lifts of 32 and 35 feet, respectively. The filling and emptying systems are combined in two culverts, one in each wall, with lateral culvert diffusers in the lock floor and flared outlets discharging into the river below the dam.
  - (h) Final report is being prepared.
- (2199) MODEL STUDY OF FILLING AND EMPTYING SYSTEMS FOR ROBINSON BAY AND GRASS RIVER LOCKS, St. LAWRENCE SEAWAY.
- (b) Buffalo District, Corps of Engineers, U. S. Army.
  - (d) Experimental; for design.
  - (e) The hydraulic systems of the two locks, similar in design, are being tested in a 1 to 24.24 scale model. The filling and emptying systems are combined in two culverts, one in each wall, with intake in the upper gate sill, ports in the chamber walls, and diffusers in the lower approach channel. A single wall port discharging into a segment of the lock chamber was tested in a 1 to 36.2 scale model.
  - (f) Tests on the final design are in progress in the general model.
  - (g) Hawser pulls exerted by models of large and small lake vessels were less than 10 tons for filling time of 7.2 minutes and an emptying time of 7.8 minutes. Pressures in the culverts and the distribution of flow in the manifolds were measured.
- (2424) EMERGENCY VERTICAL LIFT GATE, ROBINSON BAY LOCK, ST. LAWRENCE SEAWAY.
- (b) Buffalo District, Corps of Engineers, U. S. Army.
  - (d) Experimental; for design.
  - (e) Located in the sill block upstream of the intake manifold, the vertical lift gate can be raised about 45 feet above the sill to stop the flow of water through Robinson Bay Lock in case of damage to the miter gates. The model of the emergency lift gate is built to a scale of 1 to 33.33 and simulates a 50-foot section of the 80-foot wide gate. Model tests have been conducted to determine vertical and horizontal water loads, the power required to lift the gate through flowing water and to observe the effect of varied rates of travel of the gate and the points of aeration.
  - (f) Tests have been completed.
- (2425) MISSISSIPPI RIVER NEAR AITKIN, MINN., INLET CONTROL STRUCTURE, DIVERSION CHANNEL.
- (b) St. Paul District, Corps of Engineers, U. S. Army.
  - (d) Experimental; for design.
  - (e) The diversion channel bypassing Aitkin has an inlet consisting of a trapezoidal weir drop-structure with crest 7.2 feet above the channel bottom. During the 1955 spring flood considerable scour occurred in the banks of the channel downstream from the inlet. A 1:36-scale model of the inlet structure and section of the diversion channel is being tested to determine what revisions are necessary to prevent recurrence of the scour.
  - (g) The tests indicated that 25 feet of riprap in the channel bottom and 150 feet along the banks downstream from the structure would provide the desired protection.

## U. S. DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS, Waterways Experiment Station.

Inquiries concerning Projects Nos. 211, 218, 230, 236, 425, 673, 674, 678, 682, 993, 994, 998, 999, 1000, 1002, 1004, 1207, 1210, to 1212, incl., 1467, 1470, 1472, 1474, 1475, 1735 to 1741, incl., 1979, 1980, 1982 to 1988, incl., 2200 to 2204, incl., 2426 to 2434, incl., should be addressed to the Director, Waterways Experiment Station, Corps of Engineers, P. O. Box 631, Vicksburg, Miss.

## (211) MODEL STUDIES OF OUTLET WORKS, SPILLWAY AND STILLING BASIN, GARRISON DAM, MISSOURI RIVER, NORTH DAKOTA.

- (b) The District Engineer, Garrison District, Corps of Engineers, Bismarck, North Dakota.
- (d) Experimental; for design.
- (e) Three models were used for complete investigation of the spillway and outlet works. A 1:100 model of the converging-chute spillway was used to study the hydraulic performance of the approach channel, crest, chute, stilling basin, and pilot channel, and to correct unsafe conditions. A 1:50 model of the downstream portion of the five power and three flood-control conduits was used to examine the performance of the conduits, stilling basin, and powerhouse substructure under diversion and reservoir operation conditions. A 1:25 model of the 22- and 26-foot-diameter flood-control conduits was used to investigate flow through the gated section and the conduit proper. Of special interest was the use of a tainter gate to control conduit flow. Incidental models were tested in a vacuum tank to determine the cavitation characteristics of the emergency caterpillar gate slots in the flood-control conduits and the articulated tunnel joints. Tests were conducted on a 2-foot section of the penstock gate seals to determine their operating characteristics under varying heads.
- (f) Testing completed.
- (h) Final report in preparation.

## (218) CONDUIT INTAKE MODEL TESTS.

- (b) Office of the Chief of Engineers, Department 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 for (1) rectangular conduits in which the entrance is flared in four directions, (2) a gated tunnel having a rectangular entrance with floor at same elevation as approach channel (entrance flared in three directions), and (3) a rectangular conduit in which parallel side walls are extended upstream from the entrance and only the roof flared (entrance floor at same elevation as approach channel). Tests involve determination of pressures and discharge coefficients.
- (g) Most favorable pressure conditions on an entrance flared in four directions were obtained with the upstream portion of the entrance shaped to the ellipse  $X^2/D^2 + Y^2/(0.32D)^2 = 1$ , and the downstream portion of the entrance shaped to the ellipse  $X^2/D^2 + Y^2/(0.16D)^2 = 1$ . In the above equations, D is the distance across the conduit in the direction concerned.
- (h) Report of tests with conduit flared in four directions in preparation.

## (230) MODEL STUDY OF FLOOD CONTROL, CUMBERLAND, MARYLAND.

- (b) The District Engineer, Washington District, Corps of Engineers, Washington, D. C.
- (d) Experimental; for design.
- (e) A fixed-bed, 1:60 model of the critical portions of Wills Creek and the North Branch of the Potomac River was used to study and develop proposed plans for protection of Cumberland from floods. The principal design problems centered around the determination of satisfactory side-wall alignments, satisfactory bridge pier and abutment designs, a satisfactory junction design, adequate stilling basin below industrial dam, and amount of dredging that can be eliminated below the industrial dam.
- (f) Testing completed.
- (h) Final report in preparation.



## (236) MISSISSIPPI BASIN MODEL.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; for design.
- (e) The project provides for construction and operation of a model of the Mississippi River 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 Tiptonville, Tennessee; 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 Golconda, Illinois, 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 operation of the model is determined each year by the testing programs requested by the Districts and Divisions that have operable sections on the model. Tests were conducted during the current year for the Missouri River Division, Ohio River Division, Lower Mississippi Valley Division, and the Southwestern Division. The tests consisted of studies of flood-routing methods to aid in flood forecasting and reservoir operations, verification tests of the Kentucky reservoir and Tennessee River, of hypothetical and project floods to aid in planning flood protection, the development of stage and discharge data for ungaged tributary inflow points, studies to determine the effects of rate of rise on stage-discharge relationship at certain points, and to determine the effects of levee, railroad, and highway fills in the flood plain of the Missouri River.

## (425) COMPREHENSIVE MODEL STUDY, DELAWARE RIVER, PENNSYLVANIA.

- (b) The District Engineer, Philadelphia District, Corps of Engineers, Philadelphia, Pa.
- (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-control machines. 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.
- (g) Hydraulic and shoaling adjustment and verification of a reach of the model between Wilmington, Del., and Chester Island, which had been rebuilt to conform with hydrographic surveys made in 1954-1955, were completed.

## (673) GENERAL SPILLWAY MODEL TESTS.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; applied research.
- (e) A 1:40 model is being used to study hydraulic characteristics of the standard spillway shape with heads up to 1-1/3 times the design head of the crest, including the effect of crest piers and gates, elevation of downstream floor of spillway, and downstream slope of spillway. Tests will also be made to establish general rules for design of roller-type energy dissipators. The drop from spillway crest to bucket is varied to study the effect of nappe thickness. Tests to study pressures on a flat apron-type energy dissipator, to determine the effect of tainter gate location on spillway pressures and discharge characteristics, and to study the effect on discharge coefficients of the location of the toe curve on a low ogee spillway have been completed.

## (674) MODEL STUDIES OF FORT RANDALL DAM, MISSOURI RIVER, SOUTH DAKOTA.

- (b) The District Engineer, Omaha District, Corps of Engineers, Omaha, Nebraska.
- (d) Experimental; for design.
- (e) A 1:100 comprehensive model was used to determine effects on velocities of depth and curvature of the approach channel; to investigate flow over the chute-type, tainter-gate-controlled spillway, and develop a good stilling basin design; and to study flow conditions in the exit area. A 1:50 outlet stilling basin model was used to develop a satisfactory stilling basin below the eight 28-foot-diameter conduits which were being used for diversion during construction and which will eventually be incorporated in the powerhouse substructure; to verify the design of the stilling basin for the four 22-foot-diameter flood-control conduits to insure satisfactory operation under present and future tailwater conditions; and to determine the limit of required tailrace paving and the necessity for bank protective works by study of currents and wave action. A 1:25 intake and flood-control conduit model was used to determine the character of flow for various reservoir levels; measure loss coefficients of the intake structure; investigate pressures in the transition section; and determine the effects of partial gate operation upon downpull and oscillation of the gates and upon air requirements.
- (f) Testing completed.
- (h) Final report in preparation.

## (678) CHARLESTON HARBOR MODEL STUDY.

- (b) The District Engineer, Charleston District, Corps of Engineers, Charleston, S. C.
- (d) Experimental; for design.
- (e) Tests were made to determine whether channel realignment, the provision of channel control works, or other remedial measures will be effective in reducing the present heavy rate of shoaling in certain reaches of the harbor navigation channels. The fixed-bed model had scales of 1:800 horizontally and 1:80 vertically.
- (f) Testing completed.
- (h) Final report in preparation.

## (682) HYDRAULIC CAPACITY OF MEANDERING CHANNELS IN STRAIGHT FLOODWAYS.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; applied research.
- (e) A general investigation of the hydraulic capacity of meandering channels in straight floodways. Model tests were used to study effects of radius of curvature of bends; sinuosity of channel; depth of overbank flow; overbank roughness; water-surface slope; valley slope; and ratio of overbank area to channel area. Scales were proportionate to average conditions in nature so that the data obtained can be applied to natural problems.
- (f) Testing completed.
- (h) Final report in preparation.

## (993) CAVITATION RESEARCH.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; applied research.
- (e) Cavitation characteristics of such elements as baffle piers, steps in stilling basins, and offset joints are being studied on models installed in a vacuum tank and in a variable-pressure water tunnel. Models tested to date have been generally of four types: (1) vertical offsets, into and away from flow; (2) V-notch construction joints; (3) gate slots; and (4) baffle piers. An investigation toward developing a material that would pit under model cavitation, yet would not erode under tunnel velocities, was suspended as cavitation damage could not be made to occur. The erodible material consisted of a lean mixture of sand, cement, and water. A review of existing literature is under way to evaluate the many variables that affect cavitation results.
- (g) Results of tests indicate that the point of incipient cavitation varies with the scale of the model when cavitation results from vortex- or eddy-type flow. When cavitation exists at a zone of separation, the variation in the point of incipient cavitation as a function of model scale is reduced.
- (h) A report describing studies of cavitation at baffle piers is in preparation.



## (994) EFFECTS OF MODEL DISTORTION.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; applied research.
- (e) A general study is being made to determine the effects of model scale distortion on velocity distribution and other hydraulic conditions. A series of tests has been completed in a triangular flume having an adjustable central angle and adjustable slope.
- (h) A report of the initial phase of the study is in preparation.

## (998) STUDY OF WAVE FORCE ON BREAKWATERS.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; applied research.
- (e) A general investigation of wave phenomena and resulting forces is being 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.
- (g) Development of pressure measuring and recording apparatus and a wave-tank assembly is in progress.

## (999) STABILITY OF RUBBLE-MOUND BREAKWATERS.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; applied research.
- (e) Rubble-mound structures are studied in a wave tank to determine size of cap rock and slope of mound necessary to withstand action of waves and to develop formulas, supported by experimental data, from which the action of waves on rubble structures can be determined. Test data will be presented in dimensionless form, therefore no model scale, as such, is being utilized.
- (g) Values of the coefficient  $K'$ , using Iribarren's formula, have been determined for breakwaters constructed with two, three and four layers of tetrapods on seaside slopes of 1 on 1-1/4, 1 on 1-1/2, 1 on 2, and 1 on 3 for relative depths ( $d/L$ ) of 0.10 and 0.25. It was found that tetrapods are considerably more efficient on a weight basis than rubble, and that the stability of breakwaters constructed of tetrapods would not be improved by the use of more than two layers of tetrapods. Values of  $K'$  for the different side slopes are as follows:

Side Slope	$K'$ in Iribarren's Formula for 2, 3, or 4 Layers of Tetrapods
1 on 1-1/4	0.0008
1 on 1-1/2	0.0022
1 on 2	0.0056
1 on 3	0.0105

The values of  $K'$  in this table represent the average of those obtained for the two  $d/L$  ratios tested.

## (1000) ROUGHNESS STANDARDS FOR HYDRAULIC MODELS.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; applied research.
- (e) A general study is being conducted to evaluate resistance of definite types of roughness in terms of Manning's "n" and other parameters, so that much of the trial-and-error process of adjusting the surface roughness of river models can be eliminated. Tests have been performed in three rectangular flumes and a triangular flume.

## (1002) SCALE EFFECTS IN HARBOR MODELS.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.

- (d) Experimental; applied research.
  - (e) Several representative tests of rubble-mound breakwaters which have been conducted in the large wave flume (120 feet long, 4 feet deep, and 5 feet wide) will be repeated in the small wave flume (94 feet long, 1-1/2 feet deep, and 1 foot wide), using a linear scale one-half that of the larger-flume tests, to determine the effects of different scale ratios on the results of breakwater stability tests. It also is planned to perform similar tests, using a much larger model, in the large wave tank at the Beach Erosion Board laboratory in Washington, D. C.
  - (g) Results of stability tests on breakwaters with side slopes of 1 on 1-1/4, 1 on 1-1/2, 1 on 2, 1 on 2-1/2, and 1 on 3 constructed in the small wave flume have shown that reduction of the flume width from 5 feet to 1 foot and use of a linear scale in the small flume one-half the scale used in the larger-flume tests reduces the values of the coefficient  $K'$  in Iribarren's formula about 50 percent.
- (1004) INSTRUMENTATION.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
  - (d) Experimental; development.
  - (e) Various types of instruments for use in hydraulic models are being developed to make such measurements as those of wave heights, dynamic fluid pressures, and gate vibration and downpull. Development of an improved tidal reproducing apparatus is in progress.
- (1207) MODEL STUDY OF PENSTOCK INTAKE AND SLUICE COASTER GATES.
- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
  - (d) Experimental; applied research.
  - (e) A general study of relative merits of various penstock intake and sluice coaster gate lip shapes, seals, and recesses is being conducted. The investigation 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. The 1:20 model of the sluice coaster gate is being tested in combination with a typical sluice which includes a slide gate, standard entrance curves conforming to the elliptical equation  $(x^2/D^2) + (y^2/(D/3)^2) = 1$ .
  - (g) Tests of the sluice coaster gate with various depths of the recess in back of the gate revealed downpull forces increase when the recess depth is reduced to 6 inches or less.
- (1210) MODEL STUDY OF GRAYS HARBOR, WASHINGTON.
- (b) The District Engineer, Seattle District, Corps of Engineers, Seattle, Washington.
  - (d) Experimental; for design.
  - (e) The fixed-bed model, scales 1:800 horizontally and 1:80 vertically, reproduced the Pacific Ocean area adjacent to the harbor entrance and the tidal portion of the harbor and Chehalis River. This model was used to develop a comprehensive plan to protect the existing south jetty from the undermining effects of tidal currents, and to protect Point Chehalis from erosion by current and wave action. Upon completion of this part of the investigation a portion of the model was converted to a movable-bed type to determine scour and shoal tendencies of the selected plan. Plans for reduction of shoaling in the 30-foot-deep navigation channel were also studied.
  - (f) Testing completed.
  - (g) Model tests indicated that removal of that portion of the outer 6,000 feet of the south jetty above mllw elevation (which is being rapidly accomplished by nature) would reduce current velocities in the southern portion of the entrance channel and therefore benefit Point Chehalis as a whole. The erosion rate along the northern and western shores of Point Chehalis will undoubtedly be reduced when deterioration of the south jetty has progressed eastward a sufficient distance to permit material to pass over the jetty and replenish erosion losses along those beaches; however, local protection must be provided for the northern and western shores of Point Chehalis while this additional destruction is taking place. Tests showed that training works located inside the entrance would be ineffective in reducing current velocities adjacent to Point Chehalis and the south jetty. A 58 percent reduction in local shoaling is predicted as a result of relocating 20,000 linear feet of the navigation channel. Maintenance dredging in the navigation channel between deep water in the bay and the port of Aberdeen should be materially reduced by proper selection of disposal areas and by synchronizing dredging operations with the phase of tide.



- (h) "Plans for the Improvement of Grays Harbor and Point Chehalis, Washington; Hydraulic Model Investigation". Waterways Experiment Station Technical Memorandum No. 2-417, November 1955. (Available on loan.)
- (1211) MODEL STUDIES OF HOOSIC RIVER, ADAMS AND NORTH ADAMS, MASSACHUSETTS.
- (b) The District Engineer, New York District, Corps of Engineers, New York, New York.
  - (d) Experimental; for design.
  - (e) Two models were used to verify the hydraulic design for improvement of certain sections of the North and South Branches of Hoosic River in North Adams, Massachusetts, and of the main channel in Adams, Massachusetts, and to determine whether changes should be made for safety, increased efficiency, or economy. The flow in the major portion of these channels will be below critical depth. In Phase 1 of the North Adams study a 1:30 model reproduced the lower sections of the North and South Branches and about 1,300 feet of the main stream below the confluence of the North and South Branches. In Phase 2 North Branch was extended to include the control weir at the upstream limit of the improvement works for North Adams. A 1:20 model reproduced a section of the main channel beginning in Adams approximately 8 miles above that reproduced in the 1:30 model. About 1,200 feet of Tophet Brook, which joins the Hoosic River, also was reproduced.
  - (f) Tests on Phase 1 of the 1:20 model of the main channel in Adams, Massachusetts, and of Phase 1 and Phase 2 on the 1:30 model of the North and South Branches of Hoosic River in North Adams, Massachusetts, have been completed. Tests on the initial plan of Phase 2 on the 1:20 model also have been completed. Additional tests have been undertaken for Phase 2 of the Adams model for the test of a relocated channel. Tests in the final Phase 3 of the 1:30 model of the North and South Branches of the Hoosic River in North Adams, Massachusetts, will be initiated during early 1956.
- (1212) MODEL STUDIES OF OUTLET WORKS, OAHE DAM, MISSOURI RIVER, SOUTH DAKOTA.
- (b) The District Engineer, Omaha District, Corps of Engineers, Omaha, Nebraska.
  - (d) Experimental; for design.
  - (e) Three models were constructed for complete investigation of the outlet works proposed for Oahe Dam. A 1:60 model, reproducing the downstream portion of six 18.25-foot-diameter outlet tunnels, the stilling basin, and 2,300 feet of the discharge and pilot channels, was used to investigate the performance of the outlet works and to effect revisions demonstrated to be desirable. A 1:25 model of the upstream portion of one of the flood-control tunnels, the control structure, and a short length of tunnel downstream was used to: (1) check piezometric pressures in the intake structure and transition, particularly pressure variations in the bulkhead slot area; (2) determine the effect of curvature on flow conditions in the upstream tunnel and critical areas downstream therefrom; (3) check piezometric pressures at various points in the gate chamber of the control shaft and the upstream and downstream transitions, with particular attention to pressures near the gate slots; and (4) test surge conditions in the emergency gate well. A 1:25 model of one of the regulatory tunnels consisting of a short length of upstream tunnel, the control structure, and all of the downstream tunnel is being used to: (1) check piezometric pressures in the gate slots, gate lip, transitions, and gate passage; (2) study the effects of forces acting on the service and emergency gates; (3) determine partial gate discharge ratings for the regulatory gate; (4) measure air demand characteristics; (5) determine flow characteristics in downstream transition and downstream tunnel for any condition of partial gate operation; (6) check piezometric pressures in the downstream tunnel; and (7) determine most suitable length of fillets required at outlet portal.
  - (g) A single-stage stilling basin which performed satisfactorily was developed on the 1:60 model. However, foundation problems encountered in the field made it desirable to consider use of a double-stage stilling basin located at a higher elevation. Model tests indicated that the length of the primary and secondary basins can be reduced from the lengths proposed. The height and length of the dividing piers separating each conduit also can be reduced. The 1:25 flood-control conduit model performed satisfactorily.

## (1467) ANALYSIS OF HYDRAULIC EXPERIMENTAL DATA(MODEL AND PROTOTYPE) AND DEVELOPMENT OF DESIGN CRITERIA.

- (b) Office of the Chief of Engineers, Department 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 spillway nappe and pressure profiles and pressure resultants; steel conduit friction factors and exit portal pressure gradients; and loss coefficients for miter bends. Design aid charts have been prepared for trapezoidal channels. Prototype measurements of vibration and pressures on the intake gates of the Fort Randall flood-control conduits were made. Operating forces on prototype miter-type lock gates were measured at Demopolis Lock.
- (h) "Hydraulic Design Criteria" Issues Nos. 4 and 5. (Available for purchase in limited quantities.)

## (1470) MODEL STUDY OF NIAGARA RIVER AND FALLS.

- (b) The District Engineer, Buffalo District, Corps of Engineers, Buffalo, New York.
- (d) Experimental; for design.
- (e) Use of the Niagara River for power development and other purposes is controlled by treaty between the United States and Canada which includes a specific allotment of the waters for preservation of the scenic beauty of the Falls. Proposed redevelopment of the Niagara River for power includes large increases in diversion and redistribution of flow in the Cascades to preserve the beauty of the Falls. A fixed-bed model was used to determine the effects of the proposed redevelopment and remedial works required for efficient power diversion and maintenance of adequate river flows. All features of Niagara River from Lake Erie to below the Falls were reproduced to scales of 1:360 horizontally and 1:60 vertically.
- (f) Testing completed.
- (g) Results of the study indicated that without remedial works, the future maximum diversions for power would cause reductions in water-surface elevations upstream of such magnitude as to result in lowering Lake Erie levels. Also, the time required to change the Falls flow from 50,000 cfs to 100,000 cfs (the minimum night and day flows, respectively, allowed by the 1950 Treaty between the United States and Canada), and vice versa, would be of such length that only a small part of the extra diversions authorized at night during the tourist season could be utilized. In view of these findings, consideration should be given to construction of remedial works at the head of the Cascades which would compensate for the added diversions and enable the existing range of water-surface levels to be maintained. These remedial works should consist of a gated structure, located in the Canadian channel about 250 feet below an existing submerged weir, extending 1,705 feet from the Canadian shore (only 1,550 feet of the structure to be constructed initially). Without remedial works, the 50,000 and 100,000 cfs flows over the Falls would not be sufficient to maintain the existing spectacle. Therefore, consideration should be given to construction of additional remedial works, consisting of fill and excavation on both flanks of the Horseshoe Falls, to redistribute the flow over the Horseshoe Falls.
- (h) "Preservation and Enhancement of Niagara Falls; Hydraulic Model Investigation". Waterways Experiment Station Technical Memorandum No. 2-411, July 1955. (Available on loan.)

## (1472) MODEL STUDY OF WAVE ACTION, INDIANA HARBOR, INDIANA.

- (b) Youngstown Sheet and Tube Company, and Inland Steel Company, Indiana Harbor Works, East Chicago, Indiana.
- (d) Experimental; for design.



- (e) A 1:150 fixed-bed model of Indiana Harbor and sufficient area of Lake Michigan to permit reproduction of waves from north-northwest to southeast is being used. Effects of proposed harbor structures on wave action conditions in the entrance channel and in the harbor are being studied.
- (f) Completed.

(1474) OPERATING FORCES OF MITER-TYPE LOCK GATES.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; applied research.
- (e) A general study to collect basic data on operating forces of miter-type lock gates and to determine the effect of various elements upon these forces is being conducted in a 1:20 model. A lock chamber 110 feet wide is reproduced with provisions for varying the length up to 600 feet on each side of the gate. Forces required for operation of miter gates will be 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 also will be investigated.
- (h) A combined report of test results of the Ohio River, modified Ohio River, and Panama type linkage is in preparation.

(1475) SIPHON ACTION AT PUMPING PLANTS.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; applied research.
- (e) This study is being conducted to aid in developing design criteria for pumping plants which depend upon development of siphonic action on the discharge side of the pumps in order to yield the required discharge. The investigation is to determine the minimum initial priming velocity and length of time required to expel air from (prime) the siphon. Variables to be investigated during the tests are: 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. A full size model of a 6-inch plastic discharge line with a lift of 39 feet was assembled for the investigation.
- (g) Efforts are being made to correlate model test data and recent prototype data. It is hoped that this correlation will furnish design criteria for siphonic pumping plants.

(1735) MODEL STUDY OF WAVE RUN-UP ON SHORE STRUCTURES.

- (b) The Resident Member, Beach Erosion Board, Corps of Engineers, Washington, D. C.
- (d) Experimental; for design.
- (e) Tests are being conducted in a wave flume, using a scale of 1:17, to investigate the relationship between water level, wave height, wave period, and beach slope and wave run-up on selected types of shore structures used to prevent erosion caused by wave action.
- (f) Suspended.
- (g) Tests have shown that the volume of overtopping water and height of wave run-up vary with both wave height and length. The variation is discontinuous. The volume of overtopping water and height of wave run-up vary in cycles from minimum to maximum and increase as wave height and wave length increase. A complete analysis of the results of these tests has not been completed. The Beach Erosion Board is preparing a report which will present an analysis of the test data and design criteria for various types of shore structures.

(1736) MODEL STUDY OF EFFECTS OF INLETS ON ADJACENT BEACHES.

- (b) The Resident Member, Beach Erosion Board, Corps of Engineers, Washington, D. C.
- (d) Experimental; applied research.
- (e) To determine the effects of natural or artificial inlets on adjacent beaches for various conditions of waves, tides, rate of littoral drift, and other factors, tests are being made in a basin simulating an ocean and a lagoon separated by a barrier beach of sand that can be breached to reproduce the desired inlet.

## (1737) MODEL STUDY OF CHAIN OF ROCKS PROJECT, MISSISSIPPI RIVER.

- (b) The District Engineer, St. Louis District, Corps of Engineers, St. Louis, Missouri.
- (d) Experimental; for design.
- (e) The Chain of Rocks reach, a 7-mile-long series of rock ledges, is the principal cause of navigational difficulties in the 15 miles between the mouth of the Missouri River and the city of St. Louis. An improvement plan, involving a long canal from the vicinity of the mouth of the Missouri with a navigation lock at its downstream end, was studied in a combination movable-bed, fixed-bed type model with scales of 1:400 horizontally and 1:100 vertically. Means were investigated of reducing the silting in the lower approach channel to the canal and of removing and preventing the rebuilding of a bar across the downstream canal entrance.
- (f) Testing completed.
- (g) Fixed-bed tests were concerned primarily with elimination of shoaling of fine material in the downstream end of the canal, and afforded data from which the following principal conclusions were drawn: (a) considerable deposition will occur in the downstream end of the Chain of Rocks Canal if the adjacent overbank on the lower end of Cabaret Island is not raised; (b) none of the three proposed spoil area alignments would eliminate entirely the amount of silting in the lower portion of the canal, but they would reduce it considerably; (c) installation of a system of dikes along the Missouri shore upstream from the canal entrance would tend to increase the amount of sedimentation in the lower canal entrance; and (d) operation of the vertical-lift gates of the locks near the downstream canal entrance during the 10- and 20-foot stages would not flush any appreciable amount of sediment from the lower canal entrance. Movable-bed tests were used to determine the effectiveness of various plans in eliminating or reducing shoaling of relatively coarse material at the downstream entrance to the canal. The plans investigated were of two general types: one assumed that the dike system would be so designed that the velocity of flow in the problem area would be increased sufficiently to prevent deposition of sediment in the area; the other assumed that the problem area would be protected by a dike system of sufficient height and so located as to prevent the troublesome material from entering that area. Of these two types of plans, the latter was found to be the more effective in eliminating shoaling in the downstream canal entrance.
- (n) "Shoaling in Downstream Navigation Entrance to Chain of Rocks Canal, Mississippi River; Hydraulic Model Investigation." Waterways Experiment Station Technical Memorandum No. 2-403, April 1955. (Available on loan.)

## (1738) MODEL STUDIES OF GREENUP LOCKS AND DAM, OHIO RIVER.

- (b) The District Engineer, Huntington District, Corps of Engineers, Huntington, West Virginia.
- (d) Experimental; for design.
- (e) A 1:120 model of the nonnavigable-type dam and twin parallel locks was used to determine the best arrangements of locks and appurtenant walls, to study approach conditions under various flows and methods of operation of control gates, and to demonstrate to navigation interests the acceptability of the proposed design from a navigation standpoint. Additional tests are being conducted to determine the feasibility of replacing portions of the upper and lower guard walls with pontoons and cells. A 1:25 model reproduces the proposed emergency gate and a portion of the upper approach to the lock. The purpose of the model investigation is to determine the vertical forces acting on the 110-foot-wide by 11-foot-thick emergency gate as its crest is raised from elevation 497 to above the upper pool, elevation 515, under all possible conditions of tailwater.

## (1739) MODEL STUDIES OF MARKLAND LOCKS AND DAM, OHIO RIVER.

- (o) The District Engineer, Louisville District, Corps of Engineers, Louisville, Kentucky.
- (d) Experimental; for design.



- (e) A comprehensive 1:120 model of the nonnavigable-type dam and twin parallel locks, and a 1:25 section model of the spillway and stilling basin constructed to: (1) determine the best arrangements of locks and appurtenant walls; (2) study approach conditions under various flows and methods of operation of control gates and powerhouse; (3) demonstrate to navigation interests the acceptability of the proposed design from a navigation standpoint; (4) investigate the design of the spillway and stilling basin structures; and (5) determine the hydraulic characteristics of the vertical-lift control gate.
- (f) Testing completed.
- (g) Satisfactory arrangement of lock walls, method of operation of lock gates, location for Stevens Creek diversion channel outlet, and design of spillway and stilling basin were developed. The vertical-lift control gate of original design was satisfactory for all conditions tested.
- (h) Final report in preparation.

(1740) MODEL STUDY OF OUTLET STILLING BASIN, TUTTLE CREEK DAM, BIG BLUE RIVER, KANSAS.

- (b) The District Engineer, Kansas City District, Corps of Engineers, Kansas City, Missouri.
- (d) Experimental; for design.
- (f) Testing completed.
- (h) "Flood-Control Outlet Structures for Tuttle Creek Dam, Big Blue River, Kansas; Hydraulic Model Investigation." Waterways Experiment Station Technical Memorandum No. 2-396, Dec. 1954. (Available on loan.)

(1741) MODEL STUDY OF SPILLWAY, GAVINS POINT DAM, MISSOURI RIVER, SOUTH DAKOTA.

- (b) The District Engineer, Omaha District, Corps of Engineers, Omaha, Nebraska.
- (f) Testing completed.
- (h) "Spillway for Gavins Point Dam, Missouri River, Nebraska; Hydraulic Model Investigation." Waterways Experiment Station Technical Memorandum No. 2-404, May 1955. (Available on loan.)

(1979) MODEL STUDY OF STILLING BASIN, BULL SHOALS DAM, WHITE RIVER, ARKANSAS.

- (b) The District Engineer, Little Rock District, Corps of Engineers, Little Rock, Arkansas.
- (d) Experimental; for design.
- (e) The spillway was constructed with a stepped-type stilling basin designed to spread the jets issuing from the conduits. After a period of operation the steps were damaged by cavitation. A 1:12 model was used to develop a satisfactory method of repairing the basin for conduit discharges; a 1:50 section model was used to check the performance of the modified basin with spillway discharges.
- (f) Testing completed.
- (h) Final report in preparation.

(1980) MODEL STUDIES OF TABLE ROCK DAM, WHITE RIVER, MISSOURI.

- (b) The District Engineer, Little Rock District, Corps of Engineers, Little Rock, Arkansas.
- (d) Experimental; for design.
- (e) A 1:50 section model of the stilling basin was used to determine the adequacy of the basin for spillway flow, and a 1:12 model of the stilling basin was used for tests of the basin under conduit flow. Current patterns and velocities around the training walls and in the powerhouse area were studied in a 1:100 general model.
- (g) The action of the stilling basin was improved by installing higher and wider baffles. The spacing between baffles was increased and the first row of baffles was moved 11 feet downstream without decreasing the efficiency of the basin. The spreading action of the conduit outlets was improved by installing deflector and splitter blocks in the exit portals. Flow conditions around the left training wall of the stilling basin were found to be satisfactory.

## (1982) MODEL STUDIES OF CONTROL STRUCTURE AT MOUTH OF OLD RIVER, LOUISIANA.

- (b) The President, Mississippi River Commission, Corps of Engineers, Vicksburg, Mississippi.
- (d) Experimental; for design.
- (e) The Old River 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. Tests are being made on 1:36 models to investigate the over-all performance of the proposed structure with special attention to discharge coefficients, flow conditions at the abutments, effectiveness of the stilling basin, magnitude of downpull forces on the vertical-lift gates, and relative effectiveness of various riprap placement plans.
- (g) Tests to date indicate that improved flow conditions can be obtained by realignment of the upstream and downstream training walls. It was demonstrated that the horizontal stilling basin could be raised from elevation -12.0 msl to elevation -5.0 msl, and that certain revisions to basin components produced improved stilling action. Calibration of the model resulted in satisfactory verification of the computed discharges. Downpull tests of the vertical-lift gates showed that the two lower gate leaves should be operated together in order to eliminate destructive bouncing which occurred when the bottom leaf was operated by itself.

## (1983) MODEL STUDY OF SEDIMENT DIVERSION THROUGH PROPOSED OLD RIVER, LOUISIANA, CONTROL STRUCTURE

- (b) The President, Mississippi River Commission, Corps of Engineers, Vicksburg, Mississippi.
- (d) Experimental; for design.
- (e) A 10-mile reach of the Mississippi River upstream of the mouth of Old River was reproduced in fixed-bed and movable-bed models to scale ratios of 1:400 horizontally and 1:100 vertically. Tests were conducted on the fixed-bed model to determine a suitable location and design for control structures (consisting of an overbank and a low-sill structure) that will permit the same percentage of sediment to enter the Atchafalaya River as now enters that stream through Old River, should Old River be closed with a lock and dam. Additional tests have been undertaken on the movable-bed model to determine effects of changes in design and location of structures, changes in shape and alignment of approach channel, and effect of diversion of Mississippi River Channel.
- (g) Tests were made of currents and sediment movement with the structures in operation without and with permeable dikes, and with recession of the bankline in the bend upstream. Test results indicated the general location selected for the structures to be satisfactory insofar as sediment diversion is concerned, provided that the relative positions of the overbank and low-sill structures are reversed so as to place the overbank structure upstream of the low-sill structure. The model study also indicated that velocities on the structures side of the Mississippi River channel will increase and velocities on the opposite side will decrease, which will result in some adjustment in the Mississippi River channel in the vicinity. The extent of changes in the Mississippi River channel resulting from installation of the structures and the effects of such changes on the water-sediment ratio of the diverted flow could not be determined from the fixed-bed model. The movable-bed studies indicate that operation of the structures will alter the distribution of sediment within the Mississippi River channel and tend to increase the water-sediment ratio of the diverted flow.

## (1984) MODEL STUDY OF CONTROL GATE FOR TUNNEL NO. 4, FORT PECK DAM, MISSOURI RIVER, MONTANA.

- (b) The District Engineer, Fort Peck District, Fort Peck, Montana, and the District Engineer, Garrison District, Corps of Engineers, Bismarck, South Dakota.
- (d) Experimental; for design.
- (e) Tests to study methods of eliminating cavitation on the port liner and vibration of the cylinder gate in the main control shaft of tunnel No. 4 were conducted on a 1:25 model. Discharge capacities, pressures, air demand, and gate vibration were determined for the existing cylinder gate installation.
- (f) Testing completed.
- (h) Final report in preparation.



## (1985) DEVELOPMENT OF TURBULENCE METER.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; development.
- (e) The investigation is being conducted to develop instruments that will: (a) indicate the speed and direction of fluid currents at great depths and moderate velocities; (b) indicate the speed and direction of currents at shallow depths and high velocities; (c) receive signals from (a) or (b) and separate them into (1) instantaneous velocity and direction, (2) mean velocity and direction, and (3) the root-mean-square deviations from the mean. Under the contract with the Hubbard-Ling Company, Iowa City, Iowa, three hot-film anemometers together with the necessary electronic circuits were delivered.
- (f) No tests have yet been made with the instrument. The instruments will be used in a 22-foot-diameter, steel-lined, flood-control conduit at Fort Randall Dam.

## (1986) SALT WATER INTRUSION AND RELATED PHENOMENA.

- (b) Committee on Tidal Hydraulics, Corps of Engineers.
- (c) Mr. C. F. Wicker, Chairman, Committee on Tidal Hydraulics, Philadelphia District, 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.
- (g) Tests for various conditions of tidal range, fresh-water discharge, and control salinity were made; the results are being analyzed to determine significant phenomena.
- (h) An interim report on the results of performance tests was prepared and submitted to the Committee on Tidal Hydraulics.

## (1987) MODEL REPRODUCTION OF PROTOTYPE EROSION BELOW STILLING BASINS.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; applied research.
- (e) Initially, the investigation will be conducted on a model of a selected dam with provisions for studying sands of different sizes in the channel below the stilling basin. Later, models with two or more different linear scales will be constructed to verify findings using suitable bed materials.
- (f) Preliminary design and layout in preparation.

## (1988) WATER TEMPERATURE EFFECTS ON BED FORMS AND ROUGHNESS.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; applied research.
- (e) Existing laboratory flumes, in which water temperatures can be varied to simulate normally experienced summer and winter temperatures, will be used for investigating the effects of water temperature on bed forms and bed roughness of various types of bed materials.
- (f) Preliminary design and layout in preparation.

## (2200) MODEL STUDY OF FLOOD CONTROL, ANACOSTIA RIVER, MARYLAND AND DISTRICT OF COLUMBIA.

- (b) The District Engineer, Washington District, Corps of Engineers, Washington, D. C.
- (d) Experimental; for design.
- (e) A fixed-bed model, scale 1:30, reproducing 2,100 feet of the Northwest Branch channel of the Anacostia River was used: (a) to verify conclusions, based upon theoretical computations, that the paved channel as designed will induce the supercritical velocities necessary to lower water-surface elevations to provide clearance under existing and proposed bridges, and that the hydraulic jump will be formed and retained on the paved section for the expected range of tailwater elevations; and (b) to test modifications of the original design.

- (f) Testing completed.
- (g) Results to date indicate that with the channel as originally designed, the hydraulic jump would not be retained on the paved channel for the entire range of tailwater elevations. A satisfactory plan was developed which involved: reduction of the width of the flood plain above the paved channel; superelevation of the channel floor within a curved reach; change in the shape of the transition below a railroad bridge; and raising the floor of another bridge 2 feet.
- (h) Final report in preparation.

(2201) MODEL STUDY OF LAKE REGULATION, LAKE ERIE.

- (b) The District Engineer, Buffalo District, Corps of Engineers, Buffalo, New York.
- (d) Experimental; applied research.
- (e) The existing Niagara River and Falls Model (1470) was used to determine the nature and extent of the excavation required to increase the outlet capacity of the Niagara River to permit regulation of levels of Lake Erie.
- (f) Testing completed.
- (h) Final report in preparation.

(2202) MODEL STUDY OF WAVE ACTION, TACONITE HARBOR, TWO ISLANDS (LAKE SUPERIOR), MINNESOTA.

- (b) Erie Mining Company, Cleveland, Ohio.
- (d) Experimental; for design.
- (e) A 1:150, fixed-bed model of the Taconite Harbor area was used to determine the optimum breakwater plan for the harbor.
- (f) Testing completed.
- (h) "Wave Action and Breakwater Location, Taconite Harbor (Two Islands), Lake Superior, Minnesota; Hydraulic Model Investigation." Waterways Experiment Station Technical Memorandum No. 2-405, May 1955. (Available on loan.)

(2203) MODEL STUDY OF WAVE RUN-UP AND OVERTOPPING, LAKE OKEECHOBEE LEVEE SECTIONS, FLORIDA.

- (b) The District Engineer, Jacksonville District, Corps of Engineers, Jacksonville, Florida.
- (d) Experimental; applied research and design.
- (e) Tests are being conducted in a wave flume using a model scale of 1:30 to determine the optimum levee section for Lake Okeechobee, Florida, with respect to overtopping due to wave and wind setup.
- (f) Testing completed.
- (g) Tests show that the height of wave run-up and quantities of overtopping water vary with wave height, wave period, levee slope, shape of levee face, depth of water at toe of levee slope, and depth of water at break in grade of composite levee slopes. The height of wave run-up and quantity of overtopping water decrease as the slope of the levee decreases and increase as the wave height and wave period increase. The construction of berms on the lakeside of the levee face and a decrease in the water depth at the toe of the levee slope decrease the height of wave runup. Test results showed that, excluding a levee slope of 1 on 10 which was considered impractical, a levee slope of 1 on 6 would be about as effective as any of the other levee designs tested.
- (h) Final report in preparation.

(2204) STILLING BASINS FOR OUTLET WORKS.

- (b) Office of the Chief of Engineers, Department of the Army, Washington, D. C.
- (d) Experimental; for design.
- (e) Scale models are being used for a general study of the hydraulic characteristics of stilling basins below outlet works and will involve study of such items as radii and flare of side walls as affected by the length of the curved portion of the basin immediately downstream from the conduit; shape of conduit exit portal to improve entrance conditions into stilling basin; and advantages of the use of diverging side walls as compared to parallel walls. Emphasis will be placed on the development of a satisfactory stilling basin for a simple circular outlet tunnel without any transition inside the tunnel.



## (2426) MODEL STUDY OF NAVIGATION LOCK, PORT ALLEN, LOUISIANA.

- (b) The President, Mississippi River Commission, Corps of Engineers, Vicksburg, Mississippi.
- (d) Experimental; for design.
- (e) A new channel in the Gulf Intracoastal Waterway from Indian Village to Port Allen, Louisiana, includes a navigation lock in the Mississippi River levee at that point. Several designs for the lock ports were tested in a preliminary culvert and single port model constructed to a 1:25-scale ratio. The major investigations will be conducted in a 1:25 model reproducing 150 feet of upstream approach, intake manifolds, 1,250 feet of lock chamber, culverts, lateral ports, outlet manifolds, and 1,000 feet of downstream topography. This model includes provisions for changing the arrangement of filling ports.
- (g) Satisfactory designs have been developed for the ports and intake manifold, but tests on the outlet manifold are still in progress. Upon completion of the tests on the outlet manifold, filling and emptying tests will be conducted. These tests will involve variation in port arrangement and elevation, and valve travel.

## (2427) MODEL STUDY OF OUTLET WORKS, ABIQUIU DAM, RIO CHAMA, NEW MEXICO.

- (b) The District Engineer, Albuquerque District, Corps of Engineers, Albuquerque, New Mexico.
- (d) Experimental; for design.
- (e) A 1:20 model is being used to investigate flow characteristics in the outlet of a 10-foot-diameter uncontrolled conduit and at the junction of this conduit and a 12-foot-diameter flood-control conduit. The stilling basin into which the combined flows will be discharged will also be studied. The model reproduces the uncontrolled conduit, 200 feet of the controlled conduit upstream from the control tower, the entire length of the combined-flow tunnel, and the stilling basin.
- (g) Pressures were measured and flow conditions observed through the controlled and uncontrolled conduits. A conventional stilling basin and a basin with a flip bucket were tested.

## (2428) SAVANNAH HARBOR MODEL STUDY.

- (b) The District Engineer, Savannah District, Corps of Engineers, Savannah, Georgia.
- (d) Experimental; for design.
- (e) The investigation is being conducted in a model which reproduces the following: (a) that portion of the Atlantic Ocean, adjacent to the harbor entrance, from Calibogue Sound on the north to Wassaw Sound on the south; (b) the Savannah River and its flood plain to the head of tide at Ebenezer Landing; and (c) 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.
- (g) Hydraulic adjustment of the model is in progress.

## (2429) MODEL STUDIES OF THE CORNWALL ISLAND AND BARNHART ISLAND - LAKE ST. FRANCIS REACHES, ST. LAWRENCE RIVER.

- (b) The District Engineer, Buffalo District, Corps of Engineers, Buffalo, New York.
- (d) Experimental; applied research.
- (e) Two fixed-bed models are being 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 reproduces 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 includes 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, reproduces a greater area upstream and downstream of Cornwall Island. Both models are

being used to study navigation conditions in the approach to the Grass River locks, and proposed plans for excavations in both Cornwall Island channels to effect navigation improvement in South Channel.

- (f) Tests in progress on both models.

(2430) GARY HARBOR, INDIANA (LAKE MICHIGAN), MODEL STUDY OF WAVE ACTION.

- (b) U. S. Steel Corporation, Gary Steel Works, Gary, Indiana.
- (d) Experimental; for design.
- (e) Investigation of a proposed bulkhead will be conducted in a fixed-bed type model which reproduces Gary Harbor to an undistorted linear scale of 1:150 (model to prototype). Sufficient area of adjacent shore line and hydrography lakeward of the harbor was reproduced to insure proper approach of waves from various storm directions. Model waves are generated by a movable plunger-type wave machine 40 feet in length. Design of a wave absorber will be accomplished in a wave flume, using a model scale which will be selected at a later date.

(2431) MODEL STUDIES OF STILLING BASIN, WARRIOR DAM, WARRIOR RIVER, ALABAMA.

- (b) The District Engineer, Mobile District, Corps of Engineers, Mobile, Alabama.
- (d) Experimental; for design.
- (e) Two section models will be used to determine a stable slope for dumped riprap immediately downstream from the stilling basin and to verify the adequacy of the spillway and stilling basin designs for this proposed navigation structure: (a) a 1:20 model reproducing 400 feet of the approach area, a portion of the spillway crest, left embankment, and stilling basin (2 full gate bays and adjacent half bays), and 800 feet of the exit area; and (b) a 1:60 model of the center section of the spillway and stilling basin reproducing one full gate bay and adjacent half bays.
- (g) Testing has not progressed sufficiently for determination of significant results.

(2432) MODEL STUDIES OF FORT GAINES LOCK AND DAM, CHATTAHOOCHEE RIVER, GEORGIA.

- (b) The District Engineer, Mobile District, Corps of Engineers, Mobile, Alabama.
- (d) Experimental; for design.
- (e) Two models will be used to study the hydraulic characteristics of the spillway and stilling basin, orientation of spillway and powerhouse in the river channel, and the alignment and location of the lock for this proposed navigation structure: (a) a 1:80 model reproducing the entire problem area, including 1,500 feet of the approach area, the spillway, and navigation lock, and 3,500 feet of the exit area, and (b) a 1:40 model of the center section of the spillway and stilling basin reproducing one full gate bay and adjacent half bays.
- (f) Under construction.

(2433) OLD RIVER OUTLET CHANNEL SPOIL LOCATIONS, LOUISIANA.

- (b) The President, Mississippi River Commission, Corps of Engineers, Vicksburg, Mississippi.
- (d) Experimental; applied research.
- (e) A study was made of the effects of several plans for disposal of spoil from the Old River Control Outlet Channel on flow dispersion and upon the discharge efficiency of the control structures. The investigation was conducted on a portion of the Mississippi River Flood-control model, which is of the fixed-bed type with a horizontal scale of 1:2,000 and a vertical scale of 1:100. The portion of the model used for the study included the Mississippi River in the vicinity of the Old River Control Structures, the Red-Ouachita Rivers backwater area, Old River, and the upper section of the Atchafalaya River.
- (f) Testing completed.
- (g) The model was adjusted to computed flow lines and plans were tested with the 1927, 1945, and project floods. Tests indicated that the heavy overbank growth offers considerable resistance to flow and clearing near the structures and along the outlet channel will be required. Two spoil plans were selected: one would have the least tendency to affect the discharge efficiency of the structures; and the other would have the least tendency to affect stages in the backwater area.



- (h) "Report of Model Study, Old River Outlet Channel, Spoil Bank Locations." Waterways Experiment Station Miscellaneous Paper No. 2-143, Sept. 1955. Submitted to President, Mississippi River Commission.

(2434) VERMILION BAY MODEL STUDY, LOUISIANA.

- (b) Department of Public Works, State of Louisiana.  
(d) Experimental; for design.

(e) Vermilion Bay, on the Louisiana coast, is connected with the Gulf of Mexico through the deep and narrow channel of Southwest Pass, and is part of a bay system containing, to the east, East Cote Blanche, West Cote Blanche, and Atchafalaya Bays. The Vermilion River and several smaller streams flow into Vermilion Bay, but their combined discharges are too small during the summer to prevent intrusion of saline Gulf waters into the bay through the deep channel of Southwest Pass. On the other hand, because of barrier reefs and the discharge of the Atchafalaya River, the waters of East Cote Blanche, West Cote Blanche, and Atchafalaya Bays are fresh enough for irrigation purposes during most of the year. The plan of improvement contemplates closure of Southwest Pass in an attempt to bring the salinity of Vermilion Bay into agreement with that of the other bays to the east. Should this plan not be effective, the probability exists that the shallow entrances to the other bays might also be closed, provisions being made to pass the discharge of the tributary streams over the closures.

A fixed-bed model, to linear scales of 1:100 vertically and 1:2000 horizontally, reproduces a part of the Gulf of Mexico, Vermilion, East Cote Blanche, West Cote Blanche, and Atchafalaya Bays, and portions of the tributary streams. Should it be necessary to effect a closure of West Cote Blanche Bay, the model will be enlarged to reproduce the adjacent flood plain so as to determine the effects of these closures upon the passage of floods.

- (f) Construction of the model is about 95 percent complete.

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U. S. DEPARTMENT OF COMMERCE, BUREAU OF PUBLIC ROADS.

(568) SCOUR AT BRIDGE PIERS AND ABUTMENTS.

Cooperative with Iowa Institute of Hydraulic Research. See page 49.

(1096) FULL SCALE GUTTER TESTS.

Cooperative with University of Illinois. See page 45.

(1101) MOVEMENT OF SEDIMENT IN HIGHWAY DRAINAGE SYSTEMS.

Cooperative with Iowa Institute of Hydraulic Research. See page 50.

(1597) A STUDY OF THE EFFICIENCY OF SAND TRAPS.

Cooperative with Iowa Institute of Hydraulic Research. See page 51.

(1945) ESTIMATING RAINFALL INTENSITY FROM TOPOGRAPHIC PARAMETER.

Cooperative with Stanford University. See page 94.

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

Cooperative with Colorado A and M College. See page 25.

(2134) HEAD LOSSES IN STORM DRAIN JUNCTIONS.

Cooperative with the University of Missouri. See page 72.

## (2208) EXTENSION OF FLOOD FREQUENCY RECORDS.

Cooperative with the U. S. Weather Bureau. See page 161.

## (2266) HYDROLOGIC INVESTIGATIONS OF SMALL DRAINAGE BASINS IN CALIFORNIA.

Cooperative with the University of California. See page 17.

## (2435) HYDRAULICS OF PIPE CULVERTS.

Cooperative with the National Bureau of Standards. See page 157.

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## U. S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, Fluid Mechanics Section.

Inquiries concerning Projects Nos. 159, 160, 1477 to 1479, incl., 1482, 1742, 1989, 1990, 2205, 2435 and 2436, 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) "Interface Mixing in Arrested Saline Wedges", by Garbis H. Keulegan, NBS Report No. 4442, June 1955.  
"Significant Stresses of Arrested Saline Wedges", by Garbis H. Keulegan, NBS Report No. 4267, August 1955.  
"An Experimental Study of Internal Solitary Waves", by Garbis H. Keulegan, NBS Report No. 4415, November 1955.

## (160) EFFECT OF STORM WINDS ON LAKE LEVELS.

- (b) Laboratory project.
- (d) Theoretical and experimental; basic research.
- (e) To determine frictional forces of wind on lake surfaces and the resulting setup.

## (1477) TURBULENT EXPANSION OF JETS IN WATER.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental and theoretical; basic research.
- (e) To determine experimentally the nature of turbulent expansion of jets in water with relation to Reynolds number, using jets of hot water, salt water, etc.
- (h) Report in preparation.

## (1478) WIND WAVES.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental and theoretical; basic research.
- (e) Includes mathematical and experimental studies of (1) wind tides (setup), (2) growth of wind waves, and (3) surface traction of wind on wavy surfaces.
- (h) "Laboratory Experiments on Wind Tides", G. H. Keulegan. Talk presented before the Annual Meeting ASCE, October 1955, New York City.



## (1479) ENERGY DISSIPATION IN STANDING WAVES.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental and theoretical; basic research.
- (e) To determine significance of viscous boundary layer effects in wave phenomena.
- (h) Paper in preparation.

## (1480) POSITIVE WAVES IN DRY CHANNELS.

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

## (1482) INITIAL VELOCITY DISTRIBUTIONS IN SALT WATER WEDGE.

- (b) Laboratory project.
- (d) Experimental; basic research.
- (e) To determine velocities and particle trajectories during initial motion when a gate separating two bodies of liquids of different densities is suddenly opened.

## (1742) MECHANISM OF TURBULENCE.

- (b) Office of Scientific Research, Air Research and Development Command.
- (d) Experimental.
- (e) To study with the aid of dye-tracer techniques the manner in which turbulence originates and sustains itself in shear flow.

## (1989) STABILITY OF THE INTERFACE BETWEEN TWO PARALLEL STREAMS OF IMMISCIBLE FLUID OF DIFFERENT DENSITIES.

- (b) Office of Naval Research, Department of the Navy.
- (d) Theoretical.
- (e) To determine the stability criterion of the free laminar boundary layer between two parallel streams of different densities.

## (1990) INTERNAL PROGRESSIVE WAVES.

- (b) Office of Naval Research Department of the Navy.
- (d) Theoretical and experimental.
- (e) To determine laws of propagation and dissipation of internal progressive waves.

## (2205) WAVE FORCES ON IMMERSED OBJECTS.

- (b) Office of Naval Research, Department of the Navy.
- (d) Theoretical and experimental.
- (e) Forces on submerged cylinders subjected to waves of various characteristics will be determined.

## (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 with regard to slope, length, and roughness of culvert barrel.

## (2436) FLOW OVER HYDROPHOBIC MATERIALS.

- (b) Office of Naval Research, Department of the Navy.
- (d) Experimental; applied research.
- (e) The pressure-drop coefficient for flow of water in teflon tubing is being investigated. Transitional and fully-developed turbulent flow regimes are being studied over a wide range of Reynolds numbers.

## U. S. DEPARTMENT OF COMMERCE, WEATHER BUREAU.

Inquiries concerning Projects Nos. 1010 to 1015, incl., 1744, 1745, 1750, 1751, 1992 to 1994, incl., 2206 to 2208, incl., and 2437 to 2443, incl., should be addressed to Mr. William E. Hiatt, Chief, Hydrologic Services Division, U. S. Weather Bureau, Washington 25, D. C.

## (1010) ELECTRONIC FLOOD ROUTING ANALOGUE.

- (b) Laboratory project.
- (d) Field investigation; operation and applied research.
- (e) A basic circuit for an electronic analogue computer to solve flood wave problems by the Muskingum method has been developed and its application to the solution of local stream-flow problems is being studied at the following River Forecast Centers: Cincinnati, Ohio; Knoxville, Tenn.; St. Louis, Mo.; Kansas City, Mo.; Tulsa, Okla.; Portland, Oregon; Harrisburg and Pittsburgh, Pa. (Similar analogue installations are planned for 1956 at new River Forecast Centers at Hartford, Conn. and Augusta, Ga.) A circuit for more complex routing, developed at Stanford University is being added to the analogue at Wash., D. C.

## (1011) SHORT RANGE SNOW-MELT FORECASTING.

- (b) Laboratory project.
- (d) Field investigation; operation and applied research.
- (e) To develop relations between streamflow resulting from melting snow and appropriate meteorological parameters using a statistical approach.
- (g) A reasonably adequate procedure has been established and is being refined and tested.

## (1012) AUTOMATIC RADIO REPORTING RAIN GAGE.

- (b) Laboratory project.
- (d) Experimental; development.
- (e) A simple telemetering device has been constructed for use with a standard recording rain gage. Limited field tests indicate satisfactory performance. Other telemetering units are also being tested.

## (1013) PRESSURE-ACTUATED RIVER GAGE.

- (b) Laboratory project.
- (d) Experimental; development.
- (e) To develop a more economical remote recording gage.
- (g) Satisfactorily tested for accuracy in laboratory. Experimental field installation at Williamsport, Md.

## (1014) UTILIZATION OF SOIL MOISTURE DATA IN FORECASTING STREAMFLOW.

- (b) Laboratory project.
- (d) Field investigation; operation and applied research.
- (e) Standard electrical resistance soil moisture and temperature equipment has been installed in selected areas. After sufficient data has been obtained, statistical tests will be made to determine whether such data can be used to improve forecasts of runoff from rainfall.

## (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) Test of methods and techniques at Lake Hefner, Okla, completed; and similar project being conducted at Lake Mead. Both are cooperative projects involving Bureau of Reclamation, Navy, Geological Survey as well as Weather Bureau. Another such study is underway at Felt Lake, on contract with Stanford University. Evaporation pan comparative studies also being made at Silver Hill, Md.
- (h) "Evaporation From Pans and Lakes", by M. A. Kohler, T. J. Nordensen, and W. E. Fox, Weather Bureau Research Paper No. 38, May 1955.

(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., Tennessee River Basin, Knoxville, Tenn., Columbia River Basin, Portland, Oregon, Middle and Upper Mississippi River Basin, St. Louis, Mo., Arkansas River Basin, Tulsa, Okla, New England and Hudson River Basins, Hartford, Conn., and South Atlantic and East Gulf Basins, Augusta, Ga.
- (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 (a) rainfall-runoff relations involving consideration of the physics of soil moisture, vegetative reception, transpiration, evaporation and geological features of the basins; (b) snow melt forecasting relation involving consideration of the physics of snow and heat transfer; (c) unit hydrographs; (d) streamflow routing procedures; based upon adaptations of basic hydraulic principles.
- (g) Forecasting procedures have been developed for key points; refinement of these procedures and development for other basins are underway.
- (h) "A Method of Forecasting Stages on Rivers of Little Slope", William E. Ray and Herman F. Mondschein. Presented at AGU meeting, Iowa City, Iowa, June 1955.  
"Application of Statistical Methods to River Forecasting", Donald W. Kuehl. Presented at ASCE Hydraulics Division Meeting, Berkeley, Calif., August 1955.

(1745) WATER SUPPLY FORECASTS FOR WESTERN UNITED STATES.

- (b) Work being conducted in field offices for River Forecast Center, Portland, Oreg., Water Supply Forecast Unit, Salt Lake City, Utah, River Forecast Center, Kansas City, Mo., and Weather Bureau Office, Sacramento, Calif.
- (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 over 300 points in the Western United States. These forecasts of water year 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.

(1750) CRITICAL METEOROLOGICAL ANALYSIS OF MAJOR STORMS.

- (b) Corps of Engineers, Department of the Army.
- (d) Theoretical; basic research.
- (e) Detailed hour-by-hour analysis of all meteorological data available during selected major winter rainstorms.
- (f) Continuing.

(1751) MAXIMUM STATION PRECIPITATION.

- (b) Corps of Engineers, Department of the Army.
- (d) Analysis of data.
- (e) Tabulations of maximum recorded 1-, 2-, 3-, 6-, 12- and 24-hour precipitation, for automatic recording rain gage stations, by states.
- (h) Weather Bureau Technical Paper No. 15, Part XI: North Carolina, Part XII: Oregon, Part XIII: Kentucky, Part XIV: Louisiana, Part XV: Alabama.

## (1992) IMPROVED WEIGHING RAIN GAGE.

- (b) Laboratory project.
- (d) Experimental; operation.
- (e) To construct weighing-type gage which should provide rectilinear chart record, have linear calibration, minimum maintenance, high sensitivity and accuracy.
- (g) Prototype yet to be constructed. Independent design completed for substitution of recording chart between rollers instead of on drum to avoid superposition of traces.

## (1993) PRESSURE JUMP LINES.

- (b) Laboratory project supported in part by U. S. A. F. Geophysical Research Directorate.
- (c) Dr. Morris Tepper, Scientific Services Division, U. S. Weather Bureau, Washington, D. C.
- (d) Theoretical and field investigation; basic and applied research.
- (e) Investigate the properties of and the mechanism producing pressure jump lines in the atmosphere. These lines, identified by means of discontinuities in microbarograms, have been found to be correlated very strongly with severe local storms. The study is based on (1) observational data collected from a special field program and (2) theoretical models in which the pressure jump line is interpreted as a gravity wave propagating on an inversion surface between stratified atmospheric layers.
- (g) An automatic pressure jump indicator has been developed by the Instrument Division of the Weather Bureau. Nine of these instruments have been located at volunteer stations within a network westward from Washington, D. C. This pilot project has indicated that the application of the automatic indicator to routine operations is entirely feasible. Plans for larger scale use of the automatic indicators are in progress.
- (h) "On the Generation of Pressure Jump Lines by the Impulsive Addition of Momentum to Simple Current Systems", by M. Tepper, Journal of Meteorology, August 1955. Submitted for publication in the Bulletin of the AMS: "Tornado Proximity Traces", by M. Tepper and W. E. Eggert; and "Results of the Washington, D. C. Pressure Jump Micro-Network of 1954", by J. B. Holleyman, J. M. Hand and A. Caporaso. Submitted for publication in Journal of Meteorology: "On the Impulsive Addition of Momentum to Simple Current Systems by Asymmetrical Velocity Profiles", by M. Tepper and H. Newstein.

## (1994) SHORT PERIOD FLUCTUATIONS IN GREAT LAKE WATER LEVELS.

- (b) Laboratory project.
- (c) Mr. D. Lee Harris, Scientific Services Division, USWB, Washington 25, D. C.
- (d) Theoretical and field investigation; basic and applied research.
- (e) The continuous records of lake level gages belonging to the U. S. Lake Survey and several other organizations for the year 1950 and a few other periods have been examined to learn the properties of the seiche-like phenomena observed on the Great Lakes. A theoretical model which appears to explain the observations has been derived. This work was undertaken to investigate the possibility of forecasting the floods which are due to the oscillations of the lakes.
- (f) Quiescent.
- (g) Evidence has been found which indicates that moving atmospheric disturbances may generate water level disturbances much larger than those which can be accounted for by any type of equilibrium theory.

## (2206) HYDROMETEOROLOGICAL ASPECTS OF MISSISSIPPI LEVEE DESIGN.

- (b) Corps of Engineers, Department of the Army.
- (d) Theoretical; design.
- (e) An investigation of the meteorological storm potential associated with past floods and the likelihood of various meteorological combinations of possible future flood-producing storms.

## (2207) SEASONAL VARIATION OF THE PROBABLE MAXIMUM STORM.

- (b) Corps of Engineers, Department of the Army.
- (a) Theoretical; design.



- (e) An attempt to break down the probable maximum precipitation developed in Hydrometeorological Report No. 23 to seasonal values.

(2208) EXTENSION OF FLOOD FREQUENCY RECORDS.

- (b) Bureau of Public Roads, Department of Commerce.
- (d) Theoretical and field investigation; applied research and design.
- (e) Extension of the record of peak annual discharge values through use of precipitation data and river forecasting procedures, in order to increase the reliability of frequency analyses of relatively short discharge records.
- (g) Pilot project showed differences between frequency curves based on observed and estimated flood peaks to be small and far less than between frequency curves developed from segments of observed records.

(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) construction of rainfall intensity-duration-frequency curves for 200 first-order Weather Bureau Stations for durations of 5 minutes to 24 hours and return periods of 2 to 100 years; (2) extension of Weather Bureau Technical Paper No. 24 (1749 in 1955 edition) to 24 hours and to return periods of 100 years; (3) development of a generalized relationship between depth, area, duration, and frequency for areas up to 400 square miles, durations of 1 to 24 hours, and return periods of 2 to 100 years.

(2438) STORM TIDE PREDICTIONS.

- (b) Laboratory projects.
- (c) Mr. D. Lee Harris, Scientific Services Division, USWB, Washington 25, D. C.
- (d) Theoretical and field investigation; basic and applied research.
- (e) Departures from predicted tides as shown by the records of the Coast and Geodetic Survey and other organizations are being studied to learn the extent of the meteorological effect on the tides. The goal of this work, which is just being started, is the prediction of the coastal inundations produced by hurricanes and other storms. Empirical methods of forecasting these inundations, derived within the past few months, are currently being employed by many Weather Bureau stations. Continued improvement in these forecasts is expected to result from this research.

(2439) REGIONAL FREQUENCIES OF HURRICANES.

- (b) Laboratory project plus phases sponsored by Corps of Engineers, Department of Army.
- (d) Theoretical and field investigation; applied research and design.
- (e) Determination of how often each point on the Atlantic and Gulf of Mexico coasts has been subjected to a hurricane and to the various zones of intensity during the period of record and to survey, interpret, and report on evidence and competent opinion as to long-term trends in paths or behavior of hurricanes.

(2440) SELECTED HURRICANE CHARACTERISTICS AND THEIR PROBABILITIES OF OCCURRENCE.

- (b) Corps of Engineers, Department of the Army.
- (d) Theoretical and field investigation; applied research and design.
- (e) Collection, analysis, and presentation of all available observations pertinent to hurricane movement, speed, wind-structure and other characteristics and determination of the variations of these factors with space and time, and their relationship to each other.

## (2441) HURRICANE RAINFALL AND ITS QUANTITATIVE FORECASTING.

- (b) Corps of Engineers, Department of Army.
- (d) Theoretical and field investigation; applied research and design.
- (e) Collection, analysis, and effective presentation of existing data on hurricane rainfall and evaluation of suggested methods of forecasting the intensity and quantity of rainfall from future hurricanes for design of protective works, students of quantitative precipitation forecasting, 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 winds over specific areas of the sea where the energy of the wind develops waves and tides damaging to specific coastal areas, such as Narragansett Bay, Rhode Island.

## (2443) RADAR-RAINFALL PROJECT.

- (b) Laboratory project in cooperation with University of Miami, Coral Gables, Florida.
- (d) Experimental; operation.
- (e) Integration of the instantaneous PPI scope image over time by photographic process, to provide a pattern of accumulated rainfall over areas that can be calibrated by key rainfall observations for the period of integration. To be used in flood forecasting.

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## U. S. DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY.

## (194) A STUDY OF METHODS USED IN THE MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS.

Cooperative with Corps of Engineers, St. Paul District, St. Paul, Minnesota. See Project 194, page 138.

## (439) EFFECT OF REFORESTATION ON STREAM FLOW.

- (b) Cooperative with State of New York.
- (c) Mr. A. W. Harrington, U. S. Geological Survey, Albany, N. Y.
- (d) Field investigation; basic research.
- (e) To study effect on stream flow of growing trees on abandoned farm land. Observations of stream flow, precipitation, ground-water levels, and evaporation at three small reforested drainage basins and adjacent controls were begun in 1935.
- (h) Progress reports on file.

## (445) SMALL RESERVOIRS IN ARID REGIONS.

- (b) Laboratory project.
- (c) Mr. H. V. Peterson, U. S. Geological Survey, Salt Lake City, Utah.
- (d) Field investigation; applied research.
- (e) To determine runoff, evaporation, seepage, and sedimentation in arid regions. Readings are being obtained on staff gages installed on a number of representative stock-watering reservoirs in western states.
- (h) Progress reports on file.

## (690) DISCHARGE THROUGH MULTIPLE OPENINGS.

- (b) Laboratory project.
- (c) Prof. C. E. Kindsvater, U. S. Geological Survey, Atlanta, Ga.



- (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.
- (691) COMPUTING PEAK DISCHARGES BY INDIRECT METHODS.
- (b) Laboratory project.
  - (c) Mr. Tate Dalrymple, U. S. Geological Survey, Washington 25, D. C.
  - (d) Field investigation; applied research.
  - (e) Establishment of maximum stage gages on slope-reaches or suitable contracted openings, computing flood discharges and comparing with measured discharge; to test slope-area method of computing flood discharge and to verify roughness coefficients.
- (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. Objective is to catalog flow nets for various boundary conditions identical or similar to those occurring in nature.
- (1222) INFILTRATION AND EVAPO-TRANSPIRATION STUDY.
- (b) Cooperative with State of Maryland.
  - (c) Mr. W. C. Rasmussen, U. S. Geological Survey, Newark, Delaware.
  - (d) Field investigation.
  - (e) Weekly measurement of wells, rain gages, soil moisture, runoff and pond storage in two drainage basins near Salisbury, Md., to measure all factors in hydrologic cycle to determine infiltration, evapo-transpiration and specific yield.
  - (f) Field work completed.
  - (h) Report in preparation.
- (1223) EVALUATION OF HYDROLOGIC CYCLE.
- (b) Cooperative with State of Virginia.
  - (c) Mr. D. S. Wallace, U. S. Geological Survey, Charlottesville, Va.
  - (d) Field investigation.
  - (e) Establishment of gaging station and network of observation wells on headwaters of Hudson Creek, Louisa Co., Va., for correlation of water levels and stream flow.
- (1225) STORM WATER INFILTRATION IN GROUND-WATER RECHARGE BASINS.
- (b) Cooperative with Nassau County, N. Y.
  - (c) Mr. A. W. Harrington, U. S. Geological Survey, Mineola, L. I.
  - (d) Field investigation.
  - (e) Observations are made of precipitation, evaporation, ground-water levels and storm water inflow into artificial recharge basins, to determine rate of infiltration and amount of storm water available for ground-water recharge when collected in recharge basins, and to evaluate effectiveness of these basins.
- (1227) STOCK-WATER RESERVOIR STUDIES.
- (b) Cooperative with Bureau of Reclamation.
  - (c) Mr. R. C. Culler, U. S. Geological Survey, Salt Lake City, Utah.
  - (d) Field investigation.
  - (e) Development of techniques for determination of effects of stock-water reservoirs on water supply. Detailed surveys made of number, capacity and performance of reservoirs in the Cheyenne River Basin in Wyoming, will be analyzed to determine evaporation, transpiration, and seepage losses and their effect on flow of Cheyenne River.
  - (h) Report in preparation.

## (1229) GLACIER RUNOFF.

- (b) Laboratory project.
- (c) Mr. C. S. Heidel, U. S. Geological Survey, Helena, Mont.
- (d) Field investigation.
- (e) Study of recession and accretion of Grinnel Glacier, Mont. Glacier mapped annually for some years, storage rain gage and stream gaging station installed in 1949.
- (h) Annual reports of surveys available.

## (1230) EFFECT OF LOGGING ON STREAM FLOW.

- (b) Cities of Tacoma and Seattle.
- (c) Mr. F. M. Veatch, U. S. Geological Survey, Tacoma, Wash.
- (d) Field investigation.
- (e) Operation of seven gaging stations on small streams in areas where logging operations are scheduled in several years. There are control basins where no timber will be cut.
- (h) Runoff records published in annual water supply papers.

## (1231) CATHODIC PROTECTION OF BURIED PIPE AGAINST CORROSION.

- (b) Cooperative with State of Pennsylvania and State of Louisiana.
- (c) Mr. Max Noecker, U. S. Geological Survey, Pittsburgh, Pa., and Mr. R. P. Smith, U. S. Geological Survey, Jonesboro, La.
- (d) Field investigation.
- (e) Magnesium anodes are to be installed at several gaging stations where corrosion of pipe wells or intake pipes has required frequent replacement. Anodes and pipes are to be inspected annually to determine rate of loss of magnesium and to observe extent of corrosion.

## (1233) MAGNITUDE AND FREQUENCY OF FLOODS.

- (b) Cooperative with several state agencies.
- (c) Mr. Tate Dalrymple, U. S. Geological Survey, Washington 25, D. C.
- (d) Applied research.
- (e) Analyses of flood records to determine magnitude and frequency of flood discharge at gaging stations, and at supplementary network of crest-stage gages on small streams, to determine techniques for establishing flood discharges on ungaged streams.
- (h) Reports published for Georgia, Iowa, Minnesota, Western Washington, Ohio, Western Pennsylvania, Alabama, Louisiana, and Illinois.

## (1235) SEDIMENT CARRIED AS BED LOAD.

- (b) Laboratory project.
- (c) Mr. P. C. Benedict, U. S. Geological Survey, Lincoln, Nebr.
- (d) Field measurements and observations; theoretical analyses.
- (e) Determination of the amount of sediment moving within and below the zone of suspended sediment sampling at three stations on streams in Nebraska and Wyoming; evaluation of the several bed-load formulas and basic studies of bed-load movement.
- (g) A method was developed to compute the total sediment discharge at a normal section on alluvial streams. The method was developed from a procedure advanced by Dr. H. A. Einstein in 1950. The method yields results which agree more nearly with measured total loads than do other methods that were tested.
- (h) "Computations of Total Sediment Discharge, Niobrara River near Cody, Nebraska". B. R. Colby and C. H. Hembree, Geological Survey Water Supply Paper 1357, 1955.

## (1485) EROSION AND DEPOSITION OF SEDIMENTS.

- (b) Laboratory project.
- (c) Mr. P. C. Benedict, U. S. Geological Survey, Lincoln, Nebr.
- (d) Field surveys; applied research.



- (e) Studies of the effects of climate, soil type, geology, topography, and land use on rates of erosion.
- (h) "Geomorphology of Dry Creek Drainage Basin, Nebraska", J. C. Brice, in preparation.  
"Sedimentation and Chemical Quality of Surface Waters in the Wind River Basin, Wyoming", B. R. Colby, C. H. Hembree, and F. H. Rainwater, Geological Survey Water Supply Paper 1373, in press.

(1755) CHARACTERISTICS OF SAND CHANNEL STREAMS.

- (b) Laboratory project.
- (c) Mr. Tate Dalrymple, U. S. Geological Survey, Washington, D. C.
- (d) Field investigation; applied research.
- (e) The research is conducted at a 1,900 feet reach. The following factors are being investigated; variation of value of "n" with stage; accuracy and reliability of high-water marks recovered after a rise; accuracy of slope of water surface determined by present procedures; extent of scour and fill; reliability with which scoured depths can be determined by subsequent prodding; definition of the pattern of scour and fill during floods; shapes of vertical velocity curves; and quantity of suspended sediment in transport.

(1756) WATER LOSS FROM LAKE MEAD.

- (b) Cooperative with Bureau of Reclamation.
- (c) Mr. G. E. Harbeck, U. S. Geological Survey, Denver, Colo.
- (d) Field investigation.
- (e) Evaporation from Lake Mead is being determined using mass-transfer and energy budget techniques. The Cummings radiation integrator is being used to determine the areal variability in solar and atmospheric radiation.
- (f) Field work completed.
- (h) Final report in preparation.

(1757) EVAPOTRANSPIRATION INVESTIGATION.

- (b) Cooperative with Bureau of Reclamation, Division of Hydrology.
- (c) Mr. G. E. Harbeck, U. S. Geological Survey, Denver, Colo.
- (d) Field investigation at site near Bruning, Nebraska.
- (e) Tests are to be made by mass-transfer and energy budget techniques of evapotranspiration from grass land, with comparison with water-budget control.
- (f) Field work complete, analysis in progress.

(1758) RELATION OF GROUND WATER TO STREAMFLOW.

- (b) Laboratory project.
- (c) Mr. W. E. Clark, U. S. Geological Survey, Austin, Texas.
- (d) Field investigation; applied research.
- (e) Study of hydrologic cycle in small drainage basins, in Massachusetts, Virginia, New Jersey, Connecticut, North Carolina, Louisiana, Oklahoma, New York and Tennessee to determine the relationships between ground-water levels, runoff, evapotranspiration, and the geology.

(1759) INFILTRATION STUDIES.

- (b) Laboratory project.
- (c) Mr. Irwin Remson, Seabrook, N. J.
- (d) Field investigation; applied research.
- (e) Study of the movement of percolating waters between the land surface and the water table, and water-budget studies in connection with the waste disposal project at Seabrook Farms.
- (h) Provisional reports on file.

## (1764) COMBINED PHYSIOGRAPHIC AND HYDRAULIC STUDIES.

- (b) Laboratory project.
- (c) Mr. Luna B. Leopold, U. S. Geological Survey, Washington 25, D. C.
- (d) Field and office research.
- (e) Longitudinal profiles of natural channels, relation to bed material, geologic history, and hydraulic characteristics. Problems in meanders and flood plain construction.
- (h) Progress reports in preparation.

## (1765) SONAR INVESTIGATIONS (EQUIPMENT DEVELOPMENT).

- (b) Laboratory project.
- (c) Dr. A. N. Sayre, U. S. Geological Survey, Washington, D. C.
- (d) Development; theoretical laboratory.
- (e) To adopt the sonar principle of the fathometer as method of delineating under-water sediments of moderate thickness (several hundred feet) and depth to underlying bedrock. Development work is presently in progress to modify and simplify the procedures of interpretation and use of the sonar technique for geophysical investigations on land.

## (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.

## (1996) INFILTRATION AND EVAPOTRANSPIRATION STUDY.

- (b) Laboratory project.
- (c) Mr. Irwin Remson, U. S. Geological Survey, Trenton, N. J.
- (d) Field investigation; applied research.
- (e) To determine interrelation of the various factors involved in the hydrologic cycle with special emphasis on the magnitude of evapotranspiration.

## (1997) EFFECT OF FOREST MANAGEMENT ON WATER YIELD.

- (b) Cooperative with State of New Jersey.
- (c) Mr. H. C. Barksdale, U. S. Geological Survey, Trenton, N. J.
- (d) Field investigation.
- (e) Study of effects caused by forest management practices on interception, infiltration capacity, evapotranspiration, and yield of water-bearing sands in New Jersey Pine Barrens area.
- (g) Instrumentation in process of installation.

## (1998) DEVELOPMENT OF INSTRUMENTS AND TECHNIQUES FOR SUBSURFACE EXPLORATION OF GROUND WATER.

- (b) Cooperative with State of Arizona.
- (c) Mr. H. E. Skibitzke, U. S. Geological Survey, Tucson, Arizona.
- (d) Applied research.
- (e) To adapt instruments and techniques for solving problems of the occurrence of water in alluvial fill; including electrical resistivity methods, electric logging and deep well current meters.

## (2000) GHYBEN-HERZBERG LENS.

- (b) Laboratory project.
- (c) Mr. Dan A. Davis, U. S. Geological Survey, Honolulu, T. H.
- (d) Field investigation.
- (e) Study of ground-water body in marine islands, to determine the relationship of fresh water storage to the geology of the island, rainfall, head, tidal fluctuations, leakage, and draft.



## (2001) HYDROLOGIC INVESTIGATION, LITTLE MIAMI RIVER.

- (b) Cooperative with State of Ohio.
- (c) Mr. William C. Walton, U. S. Geological Survey, Columbus, Ohio.
- (d) Field investigation.
- (e) Detailed studies of ground-water levels in various types of glacial deposits to determine effects on ground-water storage of various land use and stream improvement practices.

## (2210) THERMAL STRUCTURE OF COOLING POND.

- (b) Cooperative with Texas Board of Water Engineers.
- (c) Mr. Trigg Twichell, U. S. Geological Survey, Austin, Texas.
- (d) Field investigation at Lake Colorado City, Texas.
- (e) Observations of effect of advected heat upon thermal structure, evaporation, and radiation from cooling pond at power plant.

## (2444) REDESIGN OF PRICE CURRENT METER (INSTRUMENT DEVELOPMENT).

- (b) Laboratory project.
- (c) Mr. A. H. Frazier, Equipment Development Laboratory, U. S. Geological Survey, 1509 Hess Street, Columbus 12, Ohio.
- (d) Development.
- (e) To design a rotor for Price current meter that can be mass-produced with identical rating calibration and be affected little or not at all by vertical components of the velocity.
- (g) Models being tested.

## (2445) COLLECTION AND ANALYSIS OF WATER SAMPLES FOR RADIOACTIVE SUBSTANCES.

- (b) Field and laboratory project.
- (c) Quality of Water Branch, Water Resources Division, U. S. Geological Survey, Washington 25, D. C.
- (d) Research and field investigations.
- (e) Study of methods of collection, treatment and testing of water samples for investigations of occurrence and movement of radioactive substances in surface and ground waters.

## (2446) METHODS OF DETERMINATION OF PHYSICAL AND CHEMICAL CHARACTERISTICS OF WATER.

- (b) Laboratory project.
- (c) Quality of Water Branch, Water Resources Division, U. S. Geological Survey, Washington 25, D. C.
- (d) Research.
- (e) Continuing study and development of methods for analysis of water.

## (2447) RECORDING CONDUCTIVITY OF WATER.

- (b) Laboratory project.
- (c) Mr. J. D. Hem, U. S. Geological Survey, Denver, Colorado.
- (d) Laboratory and field study; applied research.
- (e) Study of performance and utilization of a meter for determining and recording conductivity of water in a stream under field conditions.

## (2448) RELATIONSHIPS OF SEDIMENT DISCHARGE TO STREAMFLOW.

- (b) Laboratory project.
- (c) Mr. B. R. Colby, U. S. Geological Survey, Albuquerque, New Mexico.
- (d) Analytical; applied research.
- (e) To identify and describe factors that cause areal and time variations in sediment discharge and to improve procedures for computing sediment loads from measured rates of sediment discharge.
- (h) Reports in preparation.

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## U. S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION.

Inquiries concerning Projects Nos. 453, 1495, 1498, 1499, 1502, 1769, 1774, 1775, 1777, 2002 to 2005, Incl., 2009, 2010, 2011, 2015, 2016, 2017, 2213, 2214, 2215, 2217, 2219, 2221, 2223, 2224, 2225, 2226, 2449 to 2461, incl., should be addressed to the Chief Engineer, Bureau of Reclamation, Denver Federal Center, Denver, Colo.

## (453) HOOVER DAM INTAKE CYLINDER GATE.

- (f) Completed.
- (g) Model studies indicated excessive hydraulic downpull, and prototype tests confirmed the model study. Corrective measures were developed and prototype tests proved these measures were adequate.
- (h) "Laboratory and Prototype Tests for the Investigation and Correction of Excessive Downpull Forces of Large Cylinder Gates Under High Heads", Harold M. Martin and James W. Ball, presented at the Sixth Plenary Meeting of the International Association for Hydraulic Research, The Hague, Netherlands, August 31 to September 6, 1955.

## (1495) YELLOWTAIL DAM SPILLWAY AND OUTLET WORKS.

- (b) Laboratory project.
- (d) Experimental; for design.
- (e) A 1:54 scale model of all discharge facilities and surrounding area was used to determine feasibility of entire layout, develop a low-cost tunnel spillway and energy-dissipating device, check the proposed powerhouse outlet works layout, and determine all inter-related discharge effects in river. A 1:28 scale model of the outlet works was used to develop a low-cost efficient stilling basin.
- (f) Completed.
- (h) Report in preparation.

## (1498) WEIR STANDS--IRRIGATION WATER DISTRIBUTION SYSTEM.

- (f) Completed.
- (h) Report in preparation.

## (1499) CANAL TURNOUT--METER LOCATION.

- (f) Completed.
- (h) Report in preparation.

## (1502) STABLE CHANNEL STUDIES--TRACTION FORCES REQUIRED TO MOVE NON-COHESIVE MATERIALS.

- (b) Laboratory project.
- (d) Experimental; for design.
- (e) Tests are continuing in a trapezoidal channel to determine tractive forces required to scour observed sizes of materials in a pit run gravel mixture. Information obtained will be used in design of canals in noncohesive materials and in choosing gravel blankets for protective cover for canals.
- (f) Testing and analysis continuing.

## (1769) WEIR TURNOUT.

- (f) Completed.
- (h) "Hydraulic Model Studies of Small Weir Box Turnout Structure for General Irrigation Use--Columbia River Basin Project, Washington", Report Hyd-396, by W. P. Simmons, Jr.

## (1774) KIRWIN DAM SPILLWAY AND STILLING BASIN.

- (f) Completed.
- (h) Report suspended.



## (1775) HIGH-HEAD TURNOUT WITH REGULATED VALVE AND IMPELLER-TYPE FLOWMETER.

- (f) Completed.
- (h) Report in preparation.

## (1777) SIPHON SPILLWAY STUDIES.

- (b) Laboratory project.
- (d) Combined field investigation and applied research; for design.
- (e) Purpose is to determine the operating characteristics of siphon spillways as currently designed with a view to lessening the priming time and lowering the head necessary to prime. Also, attempts will be made to design a partialization device to regulate the degree of prime through the automatic control of air intake, thereby enabling the siphon to operate more or less continually at reduced flow rather than intermittently at full capacity.
- (g) The shortcomings of present design practice have been defined, and design changes for model testing have been set up.
- (h) Report to be prepared.

## (2002) INVESTIGATION OF HYDRAULIC CHARACTERISTICS OF VERTICAL STILLING WELLS.

- (b) Laboratory project.
- (d) Experimental; applied research.
- (e) Unwatering certain structures which contain water under high pressure and supplying irrigation water from high pressure conduits to earth ditches present problems of energy dissipation. Investigations of several particular structures and operation of a completed field structure have established the feasibility of the stilling well. Area, depth, and shape of well for various discharges and entrance velocities will be obtained in a generalized form.
- (f) Inactive.
- (g) Data now available have been analyzed, indicating that design criteria can be established for the circular well.

## (2003) STUDY OF HYDRAULIC JUMP AND BUCKET ENERGY DISSIPATORS.

- (b) Laboratory project.
- (d) Experimental; applied research.
- (e) Study of hydraulic jumps, hydraulic jump stilling basins, and several other types of energy dissipators. The study also includes several types of wave suppressors for use with or without stilling basins.
- (f) Testing and analysis continuing to expand the scope of the study.
- (g) The data were analyzed, and design procedures were generalized to provide stilling basins for (1) hydraulic jumps on horizontal floors (with and without baffle piers, chute blocks and sills), (2) hydraulic jumps on sloping floors (no baffle piers but with an end sill), (3) short impact-type stilling basins for use on small drainage or canal-type structures, and (4) wave suppressors for use in open channel flow-ways.
- (h) "Research Study on Stilling Basins, Energy Dissipators, and Associated Appurtenances", Report Hyd-399, by J. N. Bradley and A. J. Peterka.

## (2004) STANDARDIZATION OF DESIGN OF SMALL CANAL STRUCTURES.

- (b) Laboratory project.
- (d) Experimental; applied research.
- (e) Canal systems contain numerous and many kinds of small structures such as drops, turn-outs, overchutes, wasteways, culverts, and bifurcation works. Many of these incorporate dissipating devices which are quite different from the conventional types. The velocity of flow is low compared to larger structures. This research will standardize designs to a large extent.
- (h) Results are being incorporated in Report Hyd-399, listed in Item (2003).

## (2005) CAVITATION EROSION OF ROUGHENED SURFACES.

- (b) Laboratory project.
- (d) Experimental; applied research.
- (e) Irregularities in surface of concrete water passages can be a source of cavitation. The purpose of this project is to explore into a method of determining the cavitation potential of various types and degrees of roughened surfaces.
- (f) Inactive.
- (g) A successful test apparatus has been designed and built, and an interpretation method evolved, from which any specific surface can be evaluated.

## (2009) NIMBUS DAM SPILLWAY.

- (f) Completed.
- (h) Report suspended.

## (2010) BOULDER SUPPLY CANAL.

- (f) Completed.
- (h) Report in preparation.

## (2011) PILOT FISH SCREEN STRUCTURE--DELTA-MENDOTA CANAL.

- (f) Completed.
- (h) "Field and Laboratory Tests to Develop the Design of a Fish Screen Structure--Delta-Mendota Canal Headworks--Central Valley Project, California", Report Hyd-401 by D. M. Lancaster and T. J. Rhone.

## (2015) DEVELOPMENT OF A LOW VELOCITY CURRENT METER.

- (f) Completed.
- (h) Report to be prepared.

## (2016) STUDIES OF AIR DEMAND OF GATES AND VALVES IN CONDUITS.

- (b) Laboratory project.
- (d) Experimental; applied research.
- (e) This project is being made to determine the size of air vents to prevent adverse effects of vibration and cavitation erosion from "in line" gates and valves. Small amount of model testing is contemplated to provide data for comparison with results of field tests.
- (f) Inactive.

## (2017) INVESTIGATION OF METHODS FOR MEASURING DISCHARGE IN LARGE CONDUITS.

- (f) Suspended.

## (2213) SEEPAGE LOSS STUDIES--GENERAL.

- (f) Completed.
- (h) Report in preparation.

## (2214) LOWER-COST CANAL LINING STUDIES--USING BENTONITIC CLAYS TO CONTROL SEEPAGE.

- (b) Laboratory project.
- (d) Experimental; for design.
- (e) Tests in a 1-foot recirculating flume will be made to determine effect bentonitic clays in water have on reducing seepage using various soil types.
- (g) Tests on fine sand and silty-type soils show large reduction in seepage by formation of a bentonite filter cake on the soil surface. Seepage resumes when filter cake is removed. Very little bentonite is retained in the soil mass without using a flocculating agent.



## (2215) GORGE HIGH DAM SPILLWAY AND OUTLET WORKS.

- (f) Completed.
- (h) "Hydraulic Model Studies of the Gorge High Dam Spillway and Outlet Works--City of Seattle, Washington", by W. E. Wagner, Report Hyd-403.

## (2217) PALO VERDE DIVERSION DAM.

- (b) Laboratory project.
- (d) Experimental; for design.
- (e) A 1:28.3 scale sectional model of one spillway bay was used to develop the design of the spillway energy dissipator. A 1:50 scale model of the diversion dam including the spillway, canal headworks, the presently used rock weir diversion dam, and the surrounding area in the reservoir and the downstream river area was used to determine the characteristics of the flow approaching the spillway and canal headworks and of the flow leaving the spillway. It was also used to determine the extent to which the present rock weir should be removed to reduce the backwater effect, and to calibrate the submerged spillway crest.
- (f) Completed.
- (g) An energy dissipator was developed. Hydraulic flow conditions were improved around left spillway approach wall and on the right side of the spillway approach in canal headworks approach improvement. The spillway discharge channel was widened to reduce its flow restriction effect. The spillway crest was calibrated for a range of tailwater elevations since channel retrogression is expected to lower the tailwater in years to come.
- (h) Report to be prepared.

## (2219) CARTER LAKE DAM NO. 1 OUTLET WORKS.

- (b) Laboratory project.
- (d) Experimental; design.
- (e) Studies made on a 1:16 scale model of the outlet works and associated measuring flume and canal to increase the capacity of the stilling basin and to reduce the wave heights and surges in the measuring flume and canal.
- (f) Completed.
- (g) Hook-shaped baffle piers added to the stilling basin floor improved the performance, and an underpass-type wave suppressor installed between the basin and the measuring flume reduced wave heights at the flume gage to enable accurate discharge measurements. The prototype structure was modified in accordance with these model developments and operated very well.
- (h) "Hydraulic Model Studies of the Outlet Works at Carter Lake Reservoir Dam No. 1 Joining the St. Vrain Canal", Report Hyd-394, by G. L. Beichley. A motion picture bearing the same title was also prepared.

## (2221) FRIANT DAM RIVER OUTLETS.

- (f) Completed.
- (h) "The Hydraulic Characteristics of the 96-inch Hollow-jet Valves Controlling the River Outlets Through Friant Dam--Central Valley Project, California", Report Hyd-388, by D. M. Lancaster.

## (2223) LOVEWELL OUTLET WORKS AND WASTEWAY.

- (f) Completed.
- (h) "Hydraulic Model Studies of the Outlet Works and Wasteway for Lovewell Dam--Bostwick Division, Missouri River Basin Project", Report Hyd-400, by W. P. Simmons, Jr.

## (2224) SHERBURNE LAKES OUTLET WORKS.

- (b) Laboratory project.
- (d) Experimental; for rehabilitation.

- (e) A 1:15 model of the outlet works control tower with control gates, the downstream tunnel, and stilling pool are being used to determine the feasibility of altering the gate structure and utilizing the tower as a combination spillway and outlet works.
  - (f) Model being altered for final test.
  - (g) Satisfactory flow conditions can be obtained by placing the new control gates within the central tower, adding a spillway crest onto the outer tower, and placing a flip-type bucket at the outlet end of the discharge tunnels.
  - (h) Report to be prepared.
- (2225) ALAMAGORDO DAM--SPILLWAY.
- (f) Completed.
  - (h) Report in preparation.
- (2226) FALCON DAM OUTLET WORKS.
- (f) Completed.
  - (h) "Hydraulic Model Tests Pertaining to the Calibration of the Hollow Jet Valves of the Falcon Dam Outlet Works", by D. Colgate, Hydraulic Laboratory Paper PAP-66, Jan. 1955.
- (2449) TIBER DAM RIVER OUTLET WORKS.
- (b) Laboratory project.
  - (d) Experimental; for design.
  - (e) A 1:15 scale model of the river outlet facilities and surrounding area was used to determine the proper placement of the 5- by 5-foot outlet gate and the 18-inch outlet butterfly valve, and the proper shape for the stilling basin that will operate over a wide range of tailwater elevations.
  - (f) Completed.
  - (g) The high pressure slide gate should be set high in the basin and must discharge at a downward angle of 15 degrees. A short basin with large blocks was developed to operate at discharge up to 1,400 cfs with a tailwater variation of 6 feet at the maximum discharge.
  - (h) Report in preparation.
- (2450) CASTAS DAM SPILLWAY AND OUTLET WORKS.
- (b) Laboratory project.
  - (d) Experimental; for design.
  - (e) A 1:30 model was used to determine the optimum approach channel shape, the effectiveness of the curved spillway crest in directing the flow into a converging spillway chute, the distribution of flow in the chute and at the stilling basin entrance, the basin performance, and the proper placement of the outlet valves in the side of the basin.
  - (f) Model studies completed.
  - (g) The approach channel was modified to greatly reduce the excavation, and the curved crest smoothly directed the flow into the converging spillway chute. Good flow distribution occurred on the chute, and a good jump with good energy dissipation took place in the basin. The outlet valves were set on downward slopes to discharge upon the surface of the basin pool without harmful effect.
  - (h) Report in preparation.
- (2451) WU SHEH DAM TUNNEL SPILLWAY.
- (b) Taiwan Power Company, Formosa (through FOA).
  - (d) Experimental; design.
  - (e) A 1:41.25 scale model was used to investigate the approach and entrance to the tunnel spillway, the flow in the tunnel, the flip bucket at the downstream end of the tunnel, and the river course downstream from the structure.
  - (f) Completed.



- (g) As a result of the model studies, an overhanging pier was developed to eliminate a severe drawdown along the right approach. The radius of the vertical curve of the tunnel was lengthened to improve the flow conditions in the tunnel. The side walls of the flip bucket were curved in order to direct the flow into the center of the river channel in order to lessen the river bank erosion in that area.
  - (h) Report in preparation.
- (2452) GLENDO DAM OUTLET WORKS.
- (b) Laboratory project.
  - (d) Experimental; for design.
  - (e) A 1:24 model was used to determine a cavitation-free downstream gate frame and to develop a satisfactory stilling basin suitable for both diversion and outlet flows.
  - (f) Completed.
  - (g) Satisfactory stilling action was attained by using baffle piers and dividing walls between the three outlets.
  - (h) Report suspended.
- (2453) TURNOUTS TO PARSHALL FLUMES--BOULDER CREEK SUPPLY CANAL.
- (b) Laboratory project.
  - (d) Experimental; for rehabilitation.
  - (e) A 1:8 model was used to improve the flow conditions between the turnout gates and the Parshall flume.
  - (f) Completed.
  - (g) Slotted walls were installed immediately upstream from the turnout gates to equalize the flow through the gates.
  - (h) No report issued.
- (2454) GATE SLOT STUDIES.
- (b) Laboratory project.
  - (d) Experimental; applied research.
  - (e) A large-scale sectional model using air as a test medium is being used to study the effect of various design changes on the pressure distribution in the vicinity of the slot.
  - (f) Active.
  - (g) The effect of upstream deflectors, downstream offsets, and guide tracks within the slot, at slot width-to-depth ratios of 0.5 to 2.0 have been investigated.
  - (h) Results will be included in a general report on gate slots.
- (2455) CASA COLORADA CHANNEL ALINEMENT--MIDDLE RIO GRANDE.
- (b) Laboratory project.
  - (d) Experimental; for design.
  - (e) Tests on a 1:140 horizontal and 1:22 vertical scale model are being conducted to determine an optimum layout of Kellner jetties to aid in channelization and levee protection. Plastics with a specific gravity of 1.06 will be used to act as suspended sediment, and a 1:16 sectional model will be used to study small areas of the jetty field.
  - (f) Model studies started.
- (2456) USE OF FLOCCULATING AGENTS TO INCREASE SETTLING RATE OF SEDIMENTS.
- (b) Laboratory project.
  - (d) Experimental; for design.
  - (e) Tests are being performed to determine the effectiveness of a small quantity of a flocculating agent to flocculate sediment in settling basins and thus permit more efficient removal of the sediment from the water.
  - (f) Tests continuing.
  - (g) Tests performed on a small scale indicate that a flocculant is very effective in increasing both the rate and quantity of sediment removal.
  - (h) Progress Report No. 1 in preparation.

## (2457) EROSION AND TRACTIVE FORCE STUDY OF UNLINED AND EARTH-LINED CANALS.

- (b) Laboratory and field project.
- (d) Experimental; for design.
- (e) Hydraulic measurements to determine tractive force distribution and soil samples are being taken on various canals with different soil types, where scour has occurred. Main stress will be on cohesive soils. Correlation of hydraulic and soils data will improve data for design.
- (f) Sites being selected, soil samples being taken, hydraulic measurements will be started during Summer of 1956.

## (2458) HEATED PRECIPITATION STORAGE GAGE.

- (b) Alaska District, Bureau of Reclamation, Juneau, Alaska.
- (d) Field investigation; development.
- (e) A heated precipitation storage gage has been developed and sent to Eklutna, Alaska, for installation where it will operate unattended during winter seasons where climatic conditions are extremely rigorous. The gage was developed so total seasonal precipitation in a drainage basin could be accumulated to aid in forecasting runoff in connection with hydroelectric power generation. The gage is 20 feet high by 18-1/2 inches outside diameter with a standard Weather Bureau intake orifice 8 inches in diameter, and is designed for a wind load of 100 miles per hour. A liquified petroleum heating system was incorporated to prevent freezing of precipitation in the catch bucket. The heating system also supplied heat to the intake orifice to prevent "snow-capping" of the intake. The gage intake is shielded to improve the quantity of precipitation catch during wind storms.
- (f) Completed.
- (h) Report to be prepared.

## (2459) FISH COLLECTING FACILITIES--INTAKE TO TRACY PUMPING PLANT.

- (b) Laboratory project.
- (d) Experimental; design research.
- (e) Purpose of the project is to determine by model studies the hydraulic performance of two structures designed to collect fish in the intake canal at Tracy Pumping Plant. In the first model, on a 1:20 scale, the flow distribution upstream of, and in, the inlet transition structure were studied. The model consisted of the river channel topography, trashracks, a trashramp, four simulated bypasses for the collection of fish, and a system of louvers to guide the fish to bypasses. The second model, on 1:4 scale, consisted of a short length of louvers and one bypass with its outlet transitions. One side of the bypass was made of plexiglas to permit studies of the flow patterns as affected by different flow guide vanes. Velocity distributions were measured with a Pitot cylinder.
- (f) Completed.
- (g) Dimensions and placement of transitions and wing walls determined in 1:20 model. Size and shape of flow guide vanes outlined from studies of the 1:4 scale model.
- (h) Report to be prepared.

## (2460) FISH COLLECTING FACILITIES--VELOCITY CONTROL DEVICE--INTAKE TO TRACY PUMPING PLANT.

- (b) Laboratory project.
- (d) Experimental; applied research.
- (e) Purpose of the project is to devise a means of sensing velocities in the intake channel and in the bypasses used to remove fish from the water to be pumped. Velocities somewhat higher than channel velocity must be maintained in the bypasses for efficient removal of fish, and the sensing device will be linked either mechanically or electrically to a system of controls that operates auxiliary valves, gates, and pumps to set up the proper velocity differential. Devices being considered include two vane designs and a magnetic flowmeter. Related to project number 2011.
- (f) Active.
- (h) Results to be included in report on Fish Collecting Facilities.



(2461) TULE RIVER PARSHALL FLUME.

- (b) Laboratory project.
- (d) Experimental; for rehabilitation.
- (e) Using a 1:18 model, corrective measures were determined to reduce turbulence and surface undulations in approach to 15-foot Parshall flume.
- (f) Completed.
- (g) Through use of baffle piers and a transition section, sufficient turbulence was eliminated to permit accurate determination of flow quantities in flume.
- (h) Report in preparation.

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U. S. DEPARTMENT OF THE NAVY, DAVID TAYLOR MODEL BASIN.

Inquiries concerning Projects Nos. 467, 470, 709 to 711, incl., 1268, 1503, 1505, 1506, 1511, 1512, 1514, 1516, 1517, 1521, 1522, 1778 to 1782, incl., 1784 to 1786, incl., 1788 to 1790, incl., 2018, 2019, 2229 to 2239, incl., and 2462 to 2474, incl., should be addressed to The Commanding Officer and Director, David Taylor Model Basin, Washington 7, D. C.

(467) DEVELOPMENT OF A HOT-WIRE INSTRUMENT FOR TURBULENCE MEASUREMENTS IN WATER.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Flow instrumentation.
- (e) Development of the hot-wire technique for measuring turbulent velocity components in water.
- (g) During the course of development of such an instrument, exchange of information was frequently made between TMB and the Iowa Inst. of Hydraulic Research. Most of the inherent difficulties associated with the use of hot-wire in water have been eliminated. However, the accumulation of dirt on the wire still prevents obtaining a stable wire calibration. To this end, Iowa has suggested the use of a hot-film plated on the end of a glass wedge. It was desired then to suspend the work at DTMB pending the outcome of the Iowa University efforts. The hot-film instrument has been demonstrated at TMB recently and shows a stable linear calibration. A report on the theoretical study of the time response of a coated wire is in preparation.

(470) ELECTROLYTIC TANK STUDIES.

- (b) Bureau of Ordnance; David Taylor Model Basin.
- (d) Potential flow research.
- (e) Investigations using the method of electrical analogy to obtain pressure measurements on and about various bodies in a fluid.
- (g) An electrolytic tank has been developed for obtaining the pressure distribution about cylindrical bodies. A single probe method is used to obtain potential differences on the body and a double probe method is used for obtaining the potential differences in the surrounding field. Refinement of instrumentation and techniques has made possible the determination of pressure coefficients at a body surface with an accuracy of better than 0.4 percent of the stagnation pressure. A technique for determining the potential distribution over the surface of a submerged body has been developed. A special probe is being designed for this purpose.
- (h) "Wall Corrections for Two and Three Dimensional Bodies in a Rectangular Electrolytic Tank", by A. Borden, TMB Report 864, December 1954.

(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 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.

(710) RESEARCH ON MAIN INJECTION SCOOPS AND OVERBOARD DISCHARGES.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Hydrodynamic 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) A study of the effect of changes in scoop geometry on scoop efficiency has been completed by Newport News Shipbuilding and Drydock Company. Full-scale tests of one of the tested condenser scoops are now being conducted to determine model prototype correlation.
- (h) "Research and Test of Main Injection Scoops and Overboard Discharge", by W. F. Taylor and R. D. Douglas, Newport News Shipbuilding and Drydock Company Report.

(711) CAVITATION RESEARCH.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Hydrodynamic 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, the growth and collapse processes of transient cavities, and the effects of cavitation on the forces on underwater bodies.
- (g) A study is being made of a linearized theory for cavity flows about hydrofoil sections at non-zero cavitation number. Research is also in progress on unsteady cavity flows about symmetric bodies.
- (h) "A Meter for Continuous Indication of Dissolved Air in Water", by H. M. Fitzpatrick and M. F. Harkleroad, TMB Report No. 867, October 1954.

(1268) STUDIES OF THE INTERACTION OF APPENDAGES AND BODIES.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Hydrodynamics of submerged bodies.
- (e) An investigation of potential flow and boundary layer phenomena associated with appendage-body combinations in order to determine the nature of interference effects. The generation of lift and moments by fins in non-uniform flows is being studied. A theoretical and experimental investigation is being made in order to determine the mutual interference effects of appendages and bodies. In addition an experimental investigation is being carried out in order to determine the effects of non-uniform flows on the lift and moments of a low aspect ratio fin.
- (f) Suspended.
- (g) A theoretical investigation is being made.

(1503) BOUNDARY LAYER TRANSITION STUDY.

- (b) Cooperative with Bureau of Ships.
- (d) Basic research.
- (e) A study of methods for stimulating predictable turbulent boundary layers to improve the reliability of model tests for resistance prediction. Tests are to be made with flat plates, ship models and bodies of revolution and will include investigations of the effects of size arrangement of stimulators and the effect of pressure gradient.
- (g) Theoretical studies have directed attention toward internal roughness stimulators. Design criteria are being developed by means of qualitative boundary layer measurements on flat plates using pin type stimulators.



## (1505) EFFECT OF TRANSVERSE CURVATURE ON FRICTIONAL RESISTANCE.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Frictional resistance research.
- (e) Studies to determine the effect of transverse curvature on the frictional resistance to motion of a body through a liquid. Shear stress measurements and velocity profiles will be obtained at 10-foot intervals along a 150-foot length of towed cylinder. Results will be extended to determine flat plate resistance without surface and edge effects normally present.
- (g) A theoretical analysis of the laminar flow case for slender cylinders has been made to determine significant parameters and the expected magnitude of the curvature effect. Equipment for the experimental phase has been completed.

## (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 studs, 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.
- (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 evaluation of the stimulators used is still continuing.
- (h) The following reports are in review:
  - "Turbulence Stimulation Tests on BSRA Model and an Evaluation of the Effectiveness of the Various Stimulators."
  - "Technique and Application of Chemical Compounds to Detect Laminar and Turbulent Flow on Surfaces of Catamaran Planes and Ship Models and Their Correlation with Other Detecting Methods."
  - "Qualitative Measurements of Effectiveness of Noise Makers for Production of Turbulent Flow."
  - "Qualitative Analysis of Effectiveness of Vibration for Production of Turbulent Flow Around Ship Models."

## (1511) SERIES 60 SEAWORTHINESS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental and theoretical.
- (e) Experimental and theoretical investigation of the effect of changes in certain features of hull shape on the seaworthiness characteristics of a series of ship models. Three single screw ship forms of 0.60, 0.70 and 0.80 block coefficient have been adopted for this purpose. Tests to determine the motion and speed reduction characteristics of the 0.60 block model were completed.
- (g) The phase between pitching and heaving motion affects the seaworthiness characteristics such as wetness, slamming, and speed reduction. Consequently this phase relationship was further studied both experimentally and theoretically.
- (h) "Apparent Pitching Axis", by V. G. Szebehely, "Forschungsheft für Schifftechnik", January 1956.

## (1512) EFFECTIVENESS OF BILGE KEELS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental testing.
- (e) Measurements of the amplitudes of roll versus rolling moment and frequency at or near resonance for a ship model with and without bilge keels; the increase in resistance of a model due to rolling and roll-induced yawing; and the lift, drag, and torque developed by fins. Data will be used in arriving at criteria for the design of fin stabilizers.

- (g) Roll tests have been made in the basin on a ship model with and without bilge keels. Also, wind tunnel measurements have been made to determine the effect of variation in fin stabilizers on lift, drag, and torque characteristics.
- (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.
  - (g) A side-force dynamometer has been designed and completed and testing is expected to begin January 1956.
- (1516) STUDIES OF RESISTANCE PREDICTION METHODS.
- (b) Bureau of Ships; David Taylor Model Basin.
  - (d) Frictional resistance research.
  - (e) The theoretical possibility of separating the viscous and wave drag for surface flows by means of wake surveys has been demonstrated. Experiments are to be performed on ship models to verify the practical possibility of using this method to improve resistance predictions.
  - (g) Instrumentation for the wake survey, including pitot rakes and traversing mechanisms are completed. The use of pressure transducers rather than manometric systems is being investigated.
- (1517) MINIATURE MODEL BASIN.
- (b) Bureau of Ships; David Taylor Model Basin.
  - (d) Facility development.
  - (e) In order to obtain data on the drag, side force, and vortex configurations of vibrating cylinders a special model basin facility was required. This facility consists of a miniature model basin with small towing carriage whereby cylinders may be towed over a range of speeds while oscillating with controllable amplitude and frequency. Measurements of the attendant forces are made by means of strain gage apparatus and vortex configurations may be studied by means of special photographic techniques.
  - (g) Preliminary tests have been conducted on a 2-inch diameter circular cylinder to determine the magnitude of vortex-induced forces. Results suggested the existence of three-dimensionality of the wake. This was subsequently verified by flow visualization of the wake on the same cylinder. A new cylinder is being constructed which will permit measuring the forces on a small segment over which the flows should be two-dimensional. Concurrent tests are being conducted in a low-turbulence wind tunnel to determine criteria for two-dimensional flow over a cylinder. Hot-wire anemometer techniques are being used to determine span-wise correlation of vortex shedding as a function of Reynolds number. Test will be conducted on two-dimensional fairings to correlate shedding frequency with shape parameters.
- (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 fps.
  - (g) Construction is expected to start in 1956.
- (1522) WAVEMAKER STUDIES.
- (b) Bureau of Ships; David Taylor Model Basin.
  - (d) Hydrodynamic research and facility development.



- (e) Theoretical and experimental studies of surface wave generators to develop criteria for the design and construction of a large-scale wavemaker installation. A program of research on wave absorbers is also underway. Prerequisite to this latter investigation is the development of practical means for evaluating the effectiveness of a given absorber.
- (f) Completed.
- (g) A small pilot model of a pneumatic wavemaker has been developed and successfully operated. Improvement has been made in the means of controlling amplitude and frequency of generated waves. A much larger pneumatic wavemaker has been installed in the 140-foot model basin, and has been in regular operation generating waves for ship model tests. A 51-foot wide pneumatic wavemaker has been installed in the deep water basin. A method of making measurements and determining wave absorption characteristics therefrom has been developed analytically. The accuracy with which wave height can be determined has been improved by the development of an electronic wave-height recorder which operates on a change of capacitance principle.

(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) "Gas Bubbles as Sources of Sound in Liquids", by M. Strasberg Journal of the Acoustic Society of America, January 1956.

(1779) TURBULENT BOUNDARY LAYERS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Frictional resistance 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 Measurement of Local Turbulent Skin Friction by Means of Surface Pitot Tubes", by E. Y. Hsu, TMB Report 957, August 1955.

(1780) BUBBLE FLOW STUDIES.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Hydrodynamic research.
- (e) Studies of bubble drag and virtual mass, and the kinematic behavior of bubbles as a function of size, pressure gradient, density, viscosity and surface tension of the media.
- (g) Theoretical solutions are being determined for the effect of container walls on the drag of rigid and fluid spheres.
- (h) "An Experimental Investigation of the Drag and Shape of Air Bubbles Rising in Various Liquids", by W. L. Haberman and R. K. Morton, TMB Report No. 802, Sept. 1953.  
"An Experimental Study of Bubbles Moving in Liquids", by W. L. Haberman and R. K. Morton, American Society of Civil Engineers Proceeding Separate 387, Jan. 1954.

(1781) ROTATING-ARM AND MANEUVERING BASIN.

- (b) Cooperative with Bureau of Ships.
- (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 wave-makers for the purpose of making maneuvering tests on ship models.

- (g) Functional specifications for the facility have been prepared and a Phase I Advance Planning Engineering Report completed. It is expected that bidding plans and specifications will be completed by early 1956 and a construction contract awarded by the middle of 1956.
- (1782) SHIP MOTIONS.
- (b) Bureau of Ships; David Taylor Model Basin.
  - (d) Basic research.
  - (e) Determination of ship motions in a regular seaway when coupling exists between heave and pitch. The work is to be based on the linear theory and is a continuation of work on uncoupled motion. It is intended to extend the applicability of the linear theory to a larger number of vessels of various type.
- (1784) RESEARCH ON UNSTEADY FLOW PROBLEMS - UNSTEADY EFFECTS ON STABILITY DERIVATIVES.
- (b) Bureau of Ships; David Taylor Model Basin.
  - (d) Theoretical and experimental.
  - (e) Studies of the effect of oscillation frequency and amplitude, speed of advance and geometry on the stability derivatives of an oscillating body in a fluid.
  - (g) The effect of the various parameters has been studied with a spheroid of 7 to 1 fineness ratio. It was shown that unsteady effects may be of importance especially when combined with non-linearity.
- (1785) RESEARCH ON UNSTEADY FLOW PROBLEMS - GENERAL THEORY.
- (b) Bureau of Ships; David Taylor Model Basin.
  - (d) Theoretical research.
  - (e) A general theoretical study of the field of time-dependent hydrodynamic phenomena.
  - (g) Flows with d'Alembert type unsteadiness, unsteady jet problems, decay of vorticity, d'Alembert flows, Gerstner's waves, potential waves, have been studied. It was shown that the dimensionless parameter which describes the unsteadiness of general fluid motion reduces to the conventional Strouhal number (or dimensionless frequency ratio) for oscillatory flows under certain conditions.
- (1786) STUDIES OF THE SLAMMING OF SHIPS.
- (b) Bureau of Ships; David Taylor Model Basin.
  - (d) Experimental and theoretical.
  - (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) "Preliminary Experimental Investigation of Slamming", by V. G. Szebehely and S. H. Brooks, TMB Report No. 812, July 1952.  
"Hydrodynamics of Slamming Ships", by V. G. Szebehely, TMB Report No. 823, July 1952.  
"Hydrodynamic Approach to the Slamming of Ships", by V. G. Szebehely.  
Second Midwestern Conference on Fluid Mechanics, Proceedings, page 89-97, 1952.  
"Slamming Due to Pure Pitching Motion", by M. A. Todd, TMB Report No. 883, January 1955.  
"Ship Slamming in Head Seas", by V. G. Szebehely and M. A. Todd, TMB Report 913, Feb. 1955.  
"Model Experiments of Slamming of a Liberty Ship in Head Seas", by V. G. Szebehely and S. M. Y Lum, TMB Report 914, February 1955.  
"Slamming Pressures on Series 60 Forms", by Margaret D. Bledsoe, TMB Report No. 994, (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 feet on water-line length.
- (f) Completed.
- (g) The blend developed is entirely suited to the climatic conditions existing in Washington, 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 (91) models, varying in length between 19 and 24 feet and in weight between 1,000 and 4,500 lbs., and four 30 foot 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) "Wax Model Construction at the David Taylor Model Basin", by J. Hadler and W. Hinterthan, TMB Report No. 930, June 1955.

## (1789) PRESSURE DISTRIBUTION ON SHIP MODELS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Frictional resistance research.
- (e) Measurements of pressure distribution and resistance with photographs of wave profiles and flow lines for a series of ship models. Data are to be used for the design of turbulent boundary layer stimulators and the improvement of resistance prediction technique.
- (g) A bank of diaphragm type pressure gages has been constructed to determine the pressure distributions and tests on a specific model are in progress.

## (1790) PROPELLER THEORY, ARBITRARY DISTRIBUTION OF CIRCULATION.

- (b) Cooperative with Bureau of Ships.
- (d) Theoretical; applied research.
- (e) Studies of moderately loaded propellers with a finite number of blades and an arbitrary distribution of circulation. Comparison is made between the theory based on "induction factors" and the theory assuming the condition of normality for the induced velocity.
- (f) Application to basic theory of propellers.
- (g) Problems have been solved both for a free running and wake adapted propeller.
- (h) "A Propeller Design Method", by M. K. Eckhardt and W. B. Morgan, Society of Naval Architects and Marine Engineer, 1955.

## (2018) SERIES 60-RESISTANCE OF VARIOUS RELATED HULL FORMS.

- (b) Bureau of Ships; Maritime Commission; David Taylor Model Basin.
- (d) Experimental testing.
- (e) The dependance of resistance upon the coefficients of hull form for a practical range of single-screw ship forms is to be determined. The history of the project, the scope of the proposed series is given in (h) for Series 57. The resistance results of the original Series 57 models were somewhat disappointing and therefore careful thought was given to the problem of improving the original parents. As a result, new parent forms have been drawn out, together with necessary contours and models run for resistance. The new family was designated number Series 60.
- (g) It is believed that the new Series 60 contours now are such as to justify their use as a starting point for future research in a number of fields. Suggestions as to such systematic research were made in the earlier paper, and include the evaluation of the effect of LCB position, L/B and B/H ratios etc.

## (2019) PROPELLER EXCITED VIBRATION.

- (b) David Taylor Model Basin and Society of Naval Architects and Marine Engineers.
- (d) Experimental; basic research.
- (e) Investigation, measurement and prediction of propeller excited vibratory forces on ship models.
- (g) Development of the instrumentation and testing technique for single screw vessels has been completed. An investigation of the principal main hull, propeller and rudder parameters is being conducted in order to determine the effect of such parameters on the vibratory force.

## (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.

## (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 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) "A Procedure to Impart Specified Dynamical Properties to Ship Models", by Howard R. Reiss, TMB Report 986. (Being Printed).

## (2231) HYDRAULIC ROUGHNESS STUDIES.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Frictional resistance 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 for issuance in a TMB report.
- (h) "The Frictional Resistance and Turbulent Boundary of Rough Surfaces", by P. S. Granville, TMB Report, (in preparation).

## (2232) PRESSURE AND VELOCITY DISTRIBUTIONS ON TWO-DIMENSIONAL AND AXI-SYMMETRIC THREE-DIMENSIONAL FORMS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Potential flow 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 UNIVAC computation.



- (g) An iterative solution has been developed and coded for the UNIVAC. The pressure distribution for a number of bodies whose pressure distribution is known have been completed and verified. Some difficulty is experienced however, with convergence in certain portions of the calculations.

(2233) THE STRUCTURE OF TURBULENCE IN BOUNDARY LAYERS AND WAKES.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Turbulence research.
- (e) A study to investigate the behavior of the basic turbulence quantities in boundary layer and wake flows.
- (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.
- (h) "Exploratory Investigation of the Turbulent Wakes Behind Bluff Bodies", by R. D. Cooper, TMB Report 963, October 1955.

(2234) SURFACE WAKES BEHIND TOWED STRUTS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Hydrodynamic research.
- (e) Research on the mechanism of plume and wake formation of surface piercing struts, including the determination of wave drag, spray drag, and induced drag for geometrically varied series.
- (g) The geometric characteristics of the strut plume and the associated wave drag have been determined for a series of ogives of varying thickness ratio. The induced drag of a 6:1 ogive surface piercing strut has been determined for varying submergences.

(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. The aspects of this investigation includes speed reduction, ship motion, and slamming. Model experiments have been conducted with 5-foot models in waves. This work will be extended to 20-foot models and full-scale sea trials.

(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.
- (g) Experimental results are being obtained.

(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 is temporarily inactive.
- (g) The available results are being applied to propeller design methods.

(2238) THE EVALUATION OF THE EFFECT OF SHIFTING THE LONGITUDINAL CENTER-OF-BUOYANCY (LCB) UPON THE RESISTANCE AND PROPULSIVE CHARACTERISTICS OF VARIOUS RELATED HULL FORM OF SERIES 60.

- (b) David Taylor Model Basin.
- (d) Experimental testing.
- (e) Four models for each of the five block coefficients, to which the parent models were built, were constructed from the Series 60 contours. Resistance tests were conducted for each of these hulls to find the effect on resistance of varying the LCB. Concurrently, the relation between the propulsion coefficients and LCB position was obtained from propulsion tests.
- (f) Active.
- (g) The effect of the LCB positioning on the propulsive coefficients has been obtained. Also an optimum location of LCB for each block coefficient, of this series, has been established from the resistance characteristics of this hull.
- (h) A paper will be prepared for presentation to the Society of Naval Architects and Marine Engineers.

(2239) PROPULSIVE CHARACTERISTICS OF VARIOUS RELATED HULL FORMS SERIES 60.

- (b) Bureau of Ships; Maritime Commission; David Taylor Model Basin.
- (d) Experimental testing.
- (e) The dependence of propulsion characteristics upon the coefficients of hull form and propeller diameter for a practical range of single-screw ship forms are to be determined. Series 60 parent models are used for this project.
- (g) The dependence of wake, thrust deduction, propulsive coefficient, etc. upon the block coefficient, propeller diameter, trim etc. has been obtained.

(2462) PITCH REDUCTION STUDIES.

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

(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.

(2464) THE EVALUATION OF THE EFFECT OF CHANGING THE LENGTH TO BEAM (L/B) AND BEAM TO DRAFT (B/H) ON THE RESISTANCE CHARACTERISTICS AND PROPULSIVE COEFFICIENTS FOR THE VARIOUS RELATED HULL FORMS OF SERIES 60.

- (b) David Taylor Model Basin.
- (d) Experimental testing.
- (e) Models are to be built from the offsets of the model with the optimum location of the longitudinal center-of-buoyancy. This model will have been established by the program - "The Evaluation of the Effect of Shifting the Longitudinal Center-of-Buoyancy upon the Resistance and Propulsive Characteristics of Various Related Hull Forms of Series 60."
- (g) This work has just begun and should require about two years to complete.



## (2465) CROSS FLOW AT THE STERN OF A MODEL IN A TURN.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental testing.
- (e) The relationship between the drift angle and direction of flow at the rudder of a cruiser-type model was investigated during free turns. The direction of flow was measured by flags at mid-height of the upper and lower portions of the horn-type (semi-balanced) rudder.
- (f) Completed.
- (g) The flags in the lower position assumed approximately the same angle as the drift angle. In the upper position the direction of flow was not uniform, varying from parallel to the centerline behind the inboard propellers to the magnitude of the drift angle between the propellers.
- (h) "An Investigation of the Flow in the Region of the Rudder of a Free-Turning Model of a Multiple-Screw Ship", by W. G. Surber, Jr., TMB Report 998, dated October 1955.

## (2466) TOWING EQUIPMENT AND MOTION RECORDING INSTRUMENTATION FOR SHIP MODEL TESTS IN WAVES.

- (b) David Taylor Model Basin Laboratory Project; specifically for TMB's proposed Maneuvering Basin.
- (d) Experimental and theoretical.
- (e) The purpose of the equipment and instrumentation is, respectively, to tow models in waves and to measure and record various types of model motions. Surface models will be tested under partially-restrained conditions, the restraints being those of yaw and sway; or, of yaw, sway, and roll. Model tests will be conducted in head and following seas.
- (f) Specifications were completed while the design of the equipment and instrumentation is being done presently.

## (2467) DEVELOPMENT OF OCEANOGRAPHIC RESEARCH VESSEL.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental and theoretical.
- (e) Prediction and experimental determination of the motion of research vessel in seaway.

## (2468) EFFECT OF WAVES ON STANDARDIZATION TRIALS.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental.
- (e) To establish a method for determining the conditions under which standardization trials might be adversely affected. Experimental studies are underway on models of three typical vessels of varying block coefficients to determine the combination of speed, wave length and wave height which influence smooth water speed. As a by product, this work will furnish general information on factors governing speed reduction in a seaway. A theoretical method has been developed to determine added resistance due to waves. It is intended to compare experiment with theory.
- (f) Active.

## (2469) INTERNATIONAL COMPARISON TESTS - SEAWORTHINESS.

- (b) Bureau of Ships; David Taylor Model Basin laboratory project.
- (d) Experimental and theoretical.
- (e) To obtain seaworthiness information for comparison purposes by means of a 10 foot fiber glass plastic self-propelled model of the Series 60, 0.60 block coefficient form. The effect of self-propulsion on the motion and speed reduction characteristics of this model is compared with the effects previously studied by means of a gravity type towing arrangement. Comparison between results obtained in three large basins (DTMB, Wageningen, Haslar), equipped to handle 10 foot self-propelled models, will also be made.

## (2470) HELMHOLTZ RESONATOR.

- (b) Bureau of Ships; David Taylor Model Basin.
- (d) Experimental and theoretical investigation of the excitation of Helmholtz Resonator by fluid flow.
- (e) Studies to determine the mechanism of excitation of the Helmholtz Resonator by fluid flow past orifice will be undertaken. The experimental investigation will employ the Low-Turbulence Wind Tunnel. The amplitude of pressure fluctuation 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. It is hoped that design criteria for orifices and cavities on ships may be formulated.

## (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) "Contra-Rotating Optimum Propellers Operating in a Radially Nonuniform Wake", by H. W. Lerbs, TMB Report No. 941.

## (2472) CO-OPERATIVE 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 co-operative 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 program is in the status of testing.
- (h) Results will be published before the coming International Towing Tank Conference.

## (2473) FRICTIONAL RESISTANCE OF GEOSIM MODELS.

- (b) David Taylor Model Basin; Skin Friction Committee of the International Towing Tank Conference.
- (d) Theoretical; basic research.
- (e) Representatives of the various towing tanks of the ITTC have been unable to agree on a friction line. The Skin Friction Committee of the ITTC was therefore directed to develop a universally acceptable "Engineering Line" for use in extrapolating from ship models to full-scale. Model resistance data for geosim series are therefore being assembled and analyzed according to each of several currently proposed friction lines. Resistance data for geosim models tested at TMB are being distributed to other basins for analysis and TMB will analyze all model data from other tanks using the Schoenherr formula.
- (g) According to present status, the Schoenherr line seems to represent a reliable average friction line.
- (h) Results will be published by the Skin Friction Committee.

## (2474) CALCULATION OF GOLDSTEIN FACTORS FOR 3, 4, 5 and 6 BLADED PROPELLERS.

- (b) Co-operative with Bureau of Ships, Department of the Navy.
- (d) Theoretical; applied research.
- (e) Calculation of Goldstein factors, particularly for the case of large advance ratios where the approximations made in the original equations are not valid.
- (g) Application to propeller design.



U. S. DEPARTMENT OF THE NAVY, NAVAL BOILER AND TURBINE LABORATORY.

Inquiries concerning Projects Nos. 1523 and 1524 should be addressed to Mr. James W. Murdock, Instrument Division, U. S. Naval Boiler and Turbine Laboratory, Philadelphia Naval Base, Philadelphia 12, Pa.

(1523) HIGH PRECISION POWER INSTRUMENTS.

- (b) Bureau of Ships and Office of Naval Research, Department of the Navy.
- (d) Experimental; applied research.
- (e) For improvement of fluid flow measurement. Work is currently being undertaken to determine the effect of two phase flow. Data to date have been obtained for moisture contents in the order of 20 percent.
- (g) Preliminary results indicate that additional correction for wet steam is essential over and above compensation for density.

(1524) DETERMINATION OF HYDRAULIC CHARACTERISTICS OF SHIP PIPING SYSTEM COMPONENTS (I-25).

- (f) Completed.
- (h) "Determination of Hydraulic Characteristics of Ships Piping System Components and Design Criteria", NBTL final test report I-25, January 1955.

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U. S. DEPARTMENT OF THE NAVY, NAVAL ORDNANCE TEST STATION.

Inquiries concerning Projects Nos. 1531 and 2475 to 2478, incl., should be addressed to the Commander, U. S. Naval Ordnance Test Station, Pasadena Annex, 3202 E. Foothill Blvd., Pasadena 8, Calif., Attn: Code P807.

(1531) MECHANISM OF CAVITATION.

- (b) Laboratory project.
- (d) Experimental and theoretical; basic research.
- (e) The rates of growth of vapor bubbles in water near equilibrium size are being obtained in order to understand the initial behavior of cavitation bubbles in terms of liquid properties and air content.
- (g) High-speed photographs have been obtained of bubbles in superheated water which indicate rough agreement with theory.  
A NAVORD report describing previous work on the growth of vapor bubbles in various superheated liquids and the present work is in preparation.

(2475) WATER ENTRY ACCELERATION.

- (b) Laboratory project; cooperative with Office of Naval Research.
- (d) Experimental and theoretical; basic and applied research.
- (e) Vertical broadside impact of a rigid circular cylinder on a flat surface of incompressible fluid has been considered theoretically. In addition to some simpler methods of approximation, an analysis based on the potential flow about a sectorially growing circular-arc shell is made.  
Measurements of highly resolved axial and transverse accelerations vs. time at oblique water entry are being made, using 2-inch-diameter models with hemisphere and disk-cylinder noses. A 1-inch-diameter model will be used to measure transverse accelerations and results will be compared with the 2-inch-diameter model results to test the adequacy of one-to-one Froude and cavitation-number scaling for modeling transverse water-entry acceleration.
- (g) A manuscript, "Experimental Determination of Axial Deceleration at Oblique Water Entry of 2-Inch-Diameter Models with Hemisphere and Disk-Cylinder Noses", by G. G. Mosteller, is being typed for review. (A preliminary report on this research has been published in the Torpedo Quarterly, NAVORD Report 3425 P18, February 1955. CONFIDENTIAL).

- (h) "Some Theoretical Calculations on the Impact of Circular Cylinders on Water", by Andrew G. Fabula, China Lake, Calif., NOTS, 25 May, 1955. (TPR III, NOTS 929).  
"Vertical Broadside Impact of Circular Cylinder: Growing Circular ARC Approximation", by Andrew G. Fabula and L. D. Ruggles, China Lake, Calif., NOTS, 12 October 1955.

## (2476) HYDROBALLISTICS RANGE DEVELOPMENT.

- (b) Bureau of Ordnance.
- (d) Experimental; applied research.
- (e) Development of a technique for determining the detailed fully wetted motion of free-flying momentum-propelled models as a function of time. From these data the hydrodynamic coefficients are to be determined.
- (g) The horizontal and vertical components of model motion in the vertical range plane and model pitch and roll (four degrees of freedom) are being measured. Stereoscopic photography to measure all six degrees of freedom of motion is being tested.

## (2477) WATER ENTRY MODELING.

- (b) Cooperative with Bureau of Ordnance and Office of Naval Research.
- (d) Experimental; basic research.
- (e) Measurement of water-entry pitch vs. time will be made with 2-inch-diameter models with varied angle of attack and one-to-one Froude and cavitation-number scaling. This extends the pitch modeling tests to the case in which the model has angle of attack. Measurements will be made to evaluate the effects of cavitation-number and gas-density scaling where model velocities are Froude-scaled on water-entry pitch and water-entry cavity behavior modeling. Models of 4-, 2-, 1-, and 1/2-inch diameter will be used.
- (g) A report, IDP 22 (see (h) below) has been issued. This report shows good agreement of model pitch vs. time with that of 22.4-inch-diameter prototypes when the angle of attack is small, using one-to-one Froude and cavitation-number scaling.
- (h) "Water Entry Pitch Modeling with One-to-One Froude and Cavitation Number Scaling", by John G. Waugh, China Lake, Calif., NOTS, 8 July 1955. (IDP 22.)

## (2478) COMPRESSIBILITY EFFECTS DURING WATER ENTRY.

- (b) Laboratory project; cooperative with ONR.
- (d) Theoretical; basic research.
- (e) A review was made of recent theoretical and experimental work at the U. S. Naval Ordnance Test Station. Three theoretical approaches were made to the problem of determining the pressures on a missile at water entry and involving the compressibility of water.
- (f) Completed.
- (g) Mathematical techniques previously used only in supersonic aerodynamics are applied.
- (h) "Compressibility Effects During Water Entry", by Paul Dergarabedian, China Lake, Calif., 23 June 1955. (NAVORD Report 3523, NOTS 1159.)

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## U. S. DEPARTMENT OF THE NAVY, OFFICE OF NAVAL RESEARCH.

For sponsored projects see the following:

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(16) Hydrodynamic forces on submerged bodies.	3
(279) Flow in rotating channels.	3
(803) Dynamics of cavitation and cavitation damage.	4
(804) The effect of physical characteristics of liquid on the inception of cavitation.	4
(1301) Hydrodynamics of free-boundary flows.	5
(1548) Special problems in hydrodynamics.	5



(1815)	The correlation of the mechanics of cavitation with that of physical damage.	5
(1817)	Scale effects in cavitating flow.	6
(2052)	Experiments on small scale planing surface.	6
(47)	Gravity waves and related phenomenon.	11
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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, Tenn.

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 (3) the operational characteristics of 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.

## (732) WATAUGA DAM, BED LOAD STUDY.

- (d) Experimental; for design.
- (e) A fixed-bed 1:70 model of the river near the powerhouse was tested to determine whether bed load moved by the spillway discharge would be deposited in the powerhouse tailrace, and, if so, how it could be prevented.
- (f) Model studies completed.
- (g) A small wall located along the upstream edge of the tailrace channel was found sufficient to keep the bed load from depositing in the draft tubes and the tailrace.
- (h) "Watauga Project Hydraulic Model Studies Tailrace Channel and Bridge Piers", 1955.

## (739) CHEROKEE DAM, SLUICE RATING.

- (d) Field investigation; operation.
- (e) Measurement of discharges and differential pressures in the sluices, supplemented by model test data, will be used to establish the discharge ratings for the eight sluices. Tables of discharge for any gate opening at any headwater elevation within the operating range are to be prepared.

## (742) DOUGLAS DAM, SLUICE RATING.

- (d) Field investigation; operating.
- (e) Correlation of the measured differential pressures in the sluice with discharges obtained at a downstream river discharge gage will be used to establish the discharge ratings for the eight sluices. Tables of discharge for one half and full gage openings at any headwater elevation within the operating range are to be prepared.
- (f) Completed.
- (h) Sluice tables issued.



## (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 operating purposes will be prepared.
- (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 11 years.

## (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 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 10 years.

## (760) FONTANA DAM, PROTOTYPE CHECK TESTS.

- (d) Field investigation; applied research.
- (e) Plaster surface impressions of carefully located sections are taken after each extended period of tunnel operation to obtain evidence of damage. Entire tunnel is examined for erosion, cavitation damage, or structural failure.
- (g) Inspections made in Sept. 1946, Oct. 1949, and May 1950.

## (761) KENTUCKY DAM, PROTOTYPE CHECK TESTS.

- (d) Field investigation; applied research.
- (e) Measurements are made of lateral pressures on the face of the spillway piers and on the submerged baffle piers on the spillway apron to be compared with the results of the model tests.
- (g) Field measurements of crest and baffle block pressures were made in 1946 and 1950.

## (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) Initial tests made in Feb. 1950.

## (763) HIWASSEE DAM, PROTOTYPE CHECK TESTS.

- (d) Field investigation; applied research.
- (e) Measurements of pressure in sluices are being obtained for comparison with pressures measured in model tests.
- (g) Field measurements of sluice pressures were made in 1943 and 1954. The sluice barrels and apron were inspected in 1954.

## (1038) HALES BAR DAM, SPILLWAY APPROACH STUDIES.

- (d) 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.
- (f) Model tests completed.
- (h) Report in preparation.

## (1277) WATAUGA DAM, PROTOTYPE CHECK TESTS.

- (d) Field investigation; applied research.
- (e) Outlet tunnel surfaces are inspected after completion and after extended periods of operation to determine erosion, cavitation damage, or structural failure.
- (g) Initial inspection in Dec. 1949.

## (1283) STEAM PLANT AIR POLLUTION STUDIES.

- (d) Field investigation; design and operation.
- (e) To obtain information for use in studies of air pollution and its control. Measurements of air temperatures, wind velocities and directions, and atmospheric sulphur dioxide are being obtained at Johnsonville, Shawnee, Widows Creek, and Kingston Steam Plant areas. Air temperature, wind velocities, and wind directions are being measured at Gallatin, John Sevier, and Widows Creek Steam Plant areas.

## (1534) FORT PATRICK HENRY DAM, SPILLWAY MODEL STUDIES.

- (d) Experimental; for design.
- (e) Tests are being 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.
- (h) Report in preparation.

## (1536) VHF RADIO GAGES FOR REPORTING RAINFALL AND RIVER STAGES.

- (d) Experimental; development.
- (e) Standard FM tone modulated 169 - 172 Mc. radio equipment has been modified to transmit pulsed signals produced in a specially designed electro-mechanical converter unit (keyer). This keyer can be directly operated for river stage measurement by the conventional float system. By use of an electrical servo system, rainfall caught in a standard weighing type gage can be transmitted to the keyer unit. Standard VHF radio station transmitter-receiver units have been modified for use as automatic repeater units. A printing type recorder operated by a standard VHF, FM receiver suitably modified, records and prints all transmitted signals on a 5-inch tape. All transmitting units are supplied with at least 3 days emergency power in case of AC power failure. Suitable signals indicate when any gage is on emergency power.
- (g) Seven receiving systems which include 19 stream gages, 22 rainfall gages, 13 repeater stations, and 7 receivers have been installed. Some units have operated for three years very satisfactorily. Keyer unit has been patented.

## (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 May 1952.
- (h) Reduction of data is being completed.

(1795) HALES BAR DAM, PROPOSED LOCK LOCATION STUDIES.

- (d) Experimental; for design.
- (e) To determine the most expeditious location for the proposed 110 by 600 foot lock tests are being made on a 1:65 scale model. Effect of changes is determined by measurement of bow and stern forces on model tows and by measurement of wave heights in the navigation channel.
- (f) Completed.
- (g) The study showed that any of the proposed locations were satisfactory and that only the minimum length of lower guide wall was required. An upstream guide wall set on spaced cells without connecting diaphragms provided satisfactory approach flow conditions.
- (h) Internal report issued.

(1796) KINGSTON STEAM PLANT, CONDENSER WATER INTAKE TEMPERATURE STUDIES.

- (d) Theoretical and field investigation; design.
- (e) The condenser water intakes and outlets draw water from and discharge into Watts Bar Reservoir (Tennessee River). During the warmer portions of the year this reservoir becomes stratified and the inflowing waters pass through the reservoir as density currents. By means of theoretical considerations and field observations, the proper location and shapes for the intakes and outlets were determined and the probable intake temperature calculated.
- (g) Six-point recording temperature gages were installed on the Tennessee, Clinch, and Emory Rivers and data obtained during the period of stratification in 1953 and 1954. Velocity and temperature profile measurements were made at eight sections in the Clinch and Emory Rivers for periods of steady flow to define thermal density underflow. Theoretical analyses were made to show the benefits that could be derived by the installation of a submerged dam in the Clinch River below the mouth of the Emory River to divert the density underflow up the Emory River. Studies indicate that temperature reductions effected by the structures will result in coal savings of \$100,000.00 annually. The cost of the structures is about \$400,000.00.

(1797) GALLATIN STEAM PLANT, CONDENSER WATER INTAKE TEMPERATURE STUDY.

- (d) Theoretical and field investigation; design.
- (e) The condenser water intakes and outlets are to draw water from and discharge into the proposed Old Hickory Reservoir (Cumberland River). The entire setup is to be analyzed to determine the type of flow conditions to be expected in the reservoir; the temperatures to be expected at the inlets; and the best design for the inlets and outlet structures.
- (g) Single-point temperature recorders were installed at six stations which, in combination with turbine intake temperature recorders at three upstream dams, will be used to determine temperature increases between points on the Cumberland River for various conditions. Data are being collected and evaluated.

(2029) APALACHIA POWER TUNNEL, PROTOTYPE CHECK TESTS.

- (d) Field investigation; operation.
- (e) Periodic inspections of the power tunnel will be made to determine change in subsurface roughness. Field test measurements will be made to determine the change in friction and roughness coefficients.
- (g) The tunnel was inspected in 1953 after 10 years of continuous operation. Field pressure measurements were made in March 1954 to determine change in friction coefficients as compared to those obtained as reported in Project 757 in Hydraulic Research in the United States, Vol. 14, 1950. These tests are now being analyzed.
- (h) "Friction Measurements in 10-year-old Apalachia Tunnel", by Rex A. Elder. Presented at meeting of ASCE, August 1955.

## (2031) FORT PATRICK HENRY DAM, SPILLWAY RATING.

- (d) Experimental; operation.
- (e) Model tests, checked by field measurements, are to be used in determining discharge ratings for all anticipated operating conditions. A 1:15 scale model of one bay and its associated Tainter gate was used to determine discharges for gate openings below crest level and up to five feet above crest level. Discharge tables for operating purposes will be issued.
- (f) Completed. Rating tables issued.

## (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.

## (2243) OCOEE 3, 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 on the structures and the effect of operation on the structures.
- (g) The power tunnel to the powerhouse was inspected in 1953 and found to be in good condition. A partial inspection was made of the spillway apron and sluice channel.

## (2244) WAYNESVILLE WATERSHED, RATING OF SAN DIMAS FLUME.

- (d) Experimental; applied research.
- (e) A steel 1.5 foot wide San Dimas Flume was rated in the laboratory for heads up to 2.16 feet.
- (f) Completed.
- (g) Rating issued.

## (2479) WILSON LOCK HYDRAULIC MODEL STUDIES.

- (d) Experimental; for design.
- (e) The new Wilson lock will be 110 feet long, 675 feet center-to-center pintles with a 100-foot maximum lift. Three models are projected: a 1:36 scale model of a single transverse lateral with 12 ports to determine proper lateral and port designs; a 1:16 scale model of lock chamber, intakes, culverts, gates, and other details to determine overall design; and a 1:10 scale model of the river and navigation channel confluence to study navigation problems.
- (g) Models under construction.

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 Tennessee 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.

## (777) RUNOFF-EROSION INVESTIGATIONS ON SMALL WATERSHEDS.

- (b) Certain projects involve cooperation with North Carolina State College of Agriculture and Engineering and The University of Tennessee.
- (d) Field investigation and office analysis; basic and applied research.
- (e) To evaluate, hydrologically, existing and changed land-use practices or management. Data are obtained on rainfall and runoff on watersheds, and in some instances include ground-water levels, soil moisture storage and transmission, potential evapo-transpiration, vegetal covers, and soils as well as characteristics of runoff from agricultural and forested watersheds.
- (g) During the 10-year period 1941-1950 the cover improvement and erosion control in the Pine Tree Branch watershed (formerly Henderson County project) have 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) "Influences of Reforestation and Erosion Control upon the Hydrology of the Pine Tree Branch Watershed - 1941 to 1950", Technical Monograph No. 86, Knoxville, Tennessee, 1955. TVA, Treasurer's Office, Knoxville (\$1.50). Report on sediment load reduction by forest cover improvement in White Hollow watershed is in preparation.

## (778) EFFECT OF ALTITUDE UPON RAINFALL.

- (f) Completed.
- (h) "Precipitation-Altitude Study--Snowbird Mountains, North Carolina", Report No. O-5620, December 1955. TVA, Hydraulic Data Branch, Knoxville, Tenn.

## (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. Weather Bureau and cooperating agencies.

## (780) MONTHLY EVALUATION OF GROUND-WATER STORAGE.

- (d) Theoretical; operation.
- (e) By analysis of current records of stream discharge, the volumes of runoff in ground-water and channel storage are determined for use in operation of multi-purpose reservoirs.
- (g) Results reported monthly within the organization.

Procedures Development Section.

## (1801) RAIN GAGE LOCATION STUDIES--SOUTH CHICKAMAUGA CREEK WATERSHED.

- (d) Field investigation; applied research.
- (e) A study to learn the most applicable location and necessary density of rain gages to obtain an accurate record, particularly for river forecasting purposes, in a basin having numerous parallel ridges, and to compare several methods of computing average rainfall and of estimating runoff. Three recording and 11 nonrecording rain gages, in addition to 4 existing nonrecording gages, were established in the South Chickamauga Creek watershed, which has a drainage area of 428 square miles.
- (f) Completed.



- (h) "South Chickamauga Creek Watershed Rainfall Station Location Study", condensed paper submitted for publication in Trans. Amer. Geophysical Union. Report completed for internal use.

(2032) DEVELOPMENT OF RIVER FORECASTING METHODS.

- (d) Experimental; applied research.
- (e) Studies to develop improvements to river forecast procedures with particular application to streams and local inflows into reservoirs operated by the TVA. Procedures include (1) rainfall-runoff relations involving the effect of soil moisture, evapo-transpiration and interception losses, geological features of the watersheds, and seasons; (2) unit surface-water and ground-water hydrographs; (3) streamflow routing procedures; (4) coordinated studies with an established unit of the U. S. Weather Bureau for determination of natural flows at pertinent river points.

(2248) RAIN GAGE LOCATION STUDIES--FLINT RIVER WATERSHED.

- (d) Field investigation; applied research.
- (e) A study, similar to that on the South Chickamauga Creek watershed (1801), to determine the most advantageous location and necessary density of rain gages to obtain the desired accuracy in storm rainfall for river forecasting purposes, on a watershed having in general a gently rolling topography. In addition to one existing nonrecording rain gage and two existing recording rain gages in or adjacent to the area, eight nonrecording gages were established on the watershed, which has a drainage area of 342 square miles. These gages were located to provide approximately uniform distribution throughout the watershed.
- (f) Daily observations beginning November 1, 1954, and will be continued through April 30, 1956.

(2480) FONTANA RESERVOIR BANK STORAGE.

- (d) Experimental; applied research.
- (e) Bank storage is indicated if during the annual operation of a storage reservoir more water enters into or is withdrawn from storage than is determined from the topographic storage curve. This bank storage is defined as the water that is stored in the bottom and sides of the reservoir. A study is being made to evaluate the amount of bank storage in Fontana Reservoir during the large annual fluctuations of 1953 and 1954. Reservoir storage volumes will be computed from inflows and outflows by using U. S. Geological Survey average daily flows and making proper allowance for rain falling directly on the reservoir surface, evaporation from the reservoir surface, leakage, and diversion. The difference between these computed storage volumes and those indicated by the topographic reservoir storage curve will represent the bank storage.
- (f) Study nearing completion.

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## UNIVERSITY OF ALBERTA, Hydraulics Laboratory.

## (2481) A REGIME THEORY ANALYSIS OF SEDIMENT TRANSPORT.

- (b) Laboratory project.
- (c) Prof. T. Blench, Department of Civil Engineering, University of Alberta, Edmonton, Alberta, Canada.
- (d) Theoretical; basic research, master's thesis.
- (e) A mathematical analysis in terms of the concepts of regime theory derived from observation of the self-adjustment of mobile-boundaried canals in the field, of the data of bed-load transport in laboratory flumes. The theoretical objective was to discover possible generalizations in a complementary range of the independent variables. The practical objectives were (1) to obtain a design relation between bed-factor and bed-load charge, (2) to test the need for introducing bed-load charge into regime relations that had been derived from very small charges, and (3) to reconcile regime methods with those based on transport.
- (f) Completed.
- (g) (a) Present laboratory flume data are inadequate for relating bed-factor to bed-load material size, or for obtaining practically accurate formulas relating bed-factor to bed-load charge for natural river-bed materials, (b) the bed-factor of regime theory is significant for dunes, sheet flow, and antidunes. (c) The regime slope formula, applied to appreciable bed-load charges, has to include a term containing charge, but does not lose its dynamically significant form; for lack of adequate data the included term cannot be given with good practical accuracy. (d) Regime theory outlook is now reconciled with the transport outlook by the regime slope formula becoming a transport one. (e) The field for future experiment is now defined.
- (h) "A Regime Theory Analysis of Sediment Transport", by R. Bryan Erb. Part requirement for degree of M.Sc. from University of Alberta, 1955. Limited number of mimeographed copies from University.  
"Regime Formulas for Bed-Load Transport". T. Blench. Proc. of 1955 Meeting of International Association for Hydraulic Research.

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## UNIVERSITY OF BRITISH COLUMBIA, Hydraulics Laboratory.

## (1044) FRASER RIVER MODEL.

- (b) Hydraulic model studies cooperative with the Department of Public Works of Canada.
- (c) Prof. E. S. Pretious, Department 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 and represents the tide-water reaches of the lower Fraser River from the 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), being tidal are included. Natural tides and river discharges can be simulated on the model and are controlled by self-balancing electronic servo-systems. Sand injection can be automatically controlled as a function of river discharge. Instantaneous water surface slopes can be obtained for the whole model by automatic electrically-recording point gauges situated at controlling points. Natural river sand is used for the bed material. Auxiliary projects carried out in the University hydraulics laboratory on new designs for low-velocity current meters suitable for models, and flume studies of critical tractive velocities for various grades of bed sand in order to obtain criteria for choosing model scales.
- (h) Progress and technical reports submitted periodically to the Department of Public Works of Canada.



(2482) SURGE TANK INVESTIGATION.

- (b) Laboratory project, assisted by National Research Council grant.
- (c) Dr. A. W. Marris, Department of Civil Engineering, University of British Columbia, Vancouver, Canada.
- (d) Model test to check theory, applied research.
- (e) The hydraulic oscillations occurring in a simple surge tank operating under the condition of constant hydraulic power input to the turbine are investigated by means of a model. Of particular interest are the criteria for the critical conditions for (1) the perpetuation of oscillations of constant amplitude, (2) dead-beat translation of water level, and (3) drainage. The criteria for the successive amplitudes of stable oscillations to exhibit given degrees of damping are obtained, and the variation of the frequency of the oscillation with friction. The data obtained from the model are compared with the criteria prophesied by theory based on the solution of the linear part of the differential equation describing the motion, with a view to determining the range of validity of this approximate theory.
- (f) Completed.
- (h) Article being prepared for submission to Canadian Journal of Technology.

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ÉCOLE POLYTECHNIQUE DE MONTREAL, Hydraulics Laboratory.

(266) HYDRAULIC MODEL STUDIES OF DIFFERENT SPILLWAY PROFILES.

- (b) Laboratory project.
- (c) Professor Raymond Boucher, Ecole Polytechnique, Montreal 18, Canada.
- (d) Experimental; applied research.
- (e) To establish a comparison between the discharge capacities of different spillway designs. Studies are made on concrete models of existing and recommended spillway profiles. Pressure distribution on spillway faces and coefficients of discharge are determined for various heads up to the designed head. The effect of gate piers of various design is also investigated. Eight different profiles have been studied, including two modifications of the Creager profile upstream of crest line.
- (f) Suspended.

(268) CALIBRATION TESTS OF A SHARP-CRESTED PARABOLIC WEIR.

- (b) Laboratory project.
- (c) Professor Raymond Boucher, Ecole Polytechnique, Montreal 18, Canada.
- (d) Experimental; applied research.
- (e) To obtain the head-discharge curves and head-discharge coefficient curves for a sharp-crested parabolic weir (21-inch maximum width by 18-inch maximum height) having a capacity of 3 cfs. The influence of viscosity is also being investigated. This weir is to be used in a flume for model testing and open channel studies.
- (f) Completed.
- (g) Report in preparation.

(2483) MODEL STUDY OF ENERGY DISSIPATOR FOR THE CITY OF MEGANTIC DEVELOPMENT ON THE CHAUDIERE RIVER, QUEBEC, CANADA.

- (b) Cote, Lemieux, Carignan, Bourque, consulting engineers, City of Sherbrooke, P. Q., Canada.
- (c) Professor Andre Leclerc, École Polytechnique of Montreal, 1430 St. Denis, Montreal, P. Q. Canada.
- (d) Experimental; for design.
- (e) The spillway channel consists of a concrete flume (bottom slope 8%) the velocity at the lower end being 65 feet per second. The soil and foundation downstream is a very thick layer of varved clay. Tests were made on a 1:40 scale model to design a dissipation structure and some kind of protection for the earth canal which extends past the concrete flume.

- (f) Completed.
- (g) A deeply submerged upturned bucket was adopted together with some rip-rap for a short distance past the bucket.
- (h) Report in preparation.

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NATIONAL RESEARCH COUNCIL, Division of Mechanical Engineering.

Inquiries concerning Projects Nos. 1806, 2041, 2042, 2250, 2484 to 2491, incl., should be addressed to Mr. J. H. Parkin, Director, Division of Mechanical Engineering, National Research Council, Montreal Road, Ottawa, Ontario, Canada.

(1806) ST. LAWRENCE RIVER MODEL - PRESCOTT-CARDINAL REACH.

- (b) Department of Transport.
- (d) Experimental; for design and development.
- (e) A 1:240 x 1:48 scale model of the St. Lawrence River between the towns of Prescott and Cardinal has been constructed to study the effect of engineering works on the water level relationships throughout the reach.
- (g) Verification tests are virtually completed.

(2041) ST. LAWRENCE RIVER MODEL - CORNWALL ISLAND REACH.

- (b) St. Lawrence Seaway Authority.
- (d) Experimental; for design and operation.
- (e) A 1:480 x 1:96 scale model of about five miles of the St. Lawrence River in the vicinity of Cornwall has been constructed to study the design of proposed engineering works in connection with the seaway.
- (g) Testing programs in connection with the power and navigation problems in this area of the river have been underway for over a year.
- (h) Reports have been submitted to the sponsor.

(2042) LOCK MODEL - GENERALIZED STUDY.

- (b) St. Lawrence Seaway Authority.
- (d) Experimental; for design.
- (e) A 1:30 scale model of an 800 foot by 80 foot navigation lock, having a lift of 40 feet, has been constructed to study the design of side port filling systems upon filling time and turbulence in the lock chamber.
- (f) Completed.
- (g) Tests were made on variation of lock filling time and hawser stresses on several ships for a range of lift. The results will be correlated and published.

(2250) LOCK CULVERT JUNCTION.

- (b) St. Lawrence Seaway Authority.
- (d) Experimental; for design.
- (e) A 1:30 scale model of a lock supply culvert was constructed, consisting of two parallel conduits connected by a short tube.
- (f) Completed.
- (g) Several practical designs have been evolved such that flow in one conduit was divided equally to each half of the conduit.
- (h) A report has been issued to the sponsor.

(2484) MODEL OF COTE STE. CATHERINE LOCK.

- (b) St. Lawrence Seaway Authority.
- (d) Experimental; for design.



- (e) The model was constructed to 1:30 scale and represents a lock 800 feet by 80 feet with a lift of 38 feet. It has been constructed to supply design data.
- (g) Tests on various configurations of side ports and conduit sizes have been completed. It has been found that the largest forces on the ships are due to the axial momentum of the conduit flow being carried through the ports to the lock chamber.

(2485) MODEL OF BEAUHARNOIS LOCK.

- (b) St. Lawrence Seaway Authority.
- (d) Experimental; for design.
- (e) A 1:30 scale model of an 800 foot by 80 foot navigation lock is to be constructed to evaluate a design of a side port filling system using very short ports.
- (f) The model is now under construction.

(2486) LOCK SECTOR GATE MODEL.

- (b) St. Lawrence Seaway Authority.
- (d) Experimental; for design.
- (e) A 1:20 scale model of a pair of sector gates, used for either filling or emergency gates in navigation locks, has been constructed. Tests have been run to determine the discharge coefficient and torque required to hold the gate open for a range of gate openings, headwater and tailwater levels. The gates represent a height of 45 feet and a radius of 50 feet.

(2487) POWERHOUSE INTAKE MODEL.

- (b) Shawinigan Engineering Company, Limited, Montreal.
- (d) Experimental; for design.
- (e) A small scale model of an intake canal for a proposed powerhouse was constructed for the purpose of evaluating various designs. Consideration had to be given to costs, head loss, and streamlines, such that logs could be diverted to a mill now in operation.
- (f) Completed.
- (h) A report was issued to the sponsor.

(2488) HARBOUR MODEL.

- (b) Department of Public Works, Canada.
- (d) Experimental; for design.
- (e) For the purpose of investigating wave agitation in a harbour on the East Coast of Canada, a 1:128 scale model is being constructed.

(2489) ST. CHARLES ESTUARY STUDY.

- (b) National Harbours Board of Canada.
- (d) Field investigation.
- (e) A study is being made of the current directions and composition of the bed material in this estuary. It is desired to ascertain the source of sediment now creating a hazard to navigation.
- (g) The sediment was shown to be the result of transport by the tidal currents.
- (h) Two reports have been issued to the sponsor.

(2490) FLOW OF FIBRE SUSPENSIONS.

- (b) National Research Council.
- (d) Experimental and theoretical study for basic research.
- (e) The mechanics of flow of fibre suspension, such as used by the pulp and paper industry, are being studied in a specially constructed pipeline. It is hoped to evaluate the shear field from velocity and turbulence measurements.

## (2491) INSTRUMENT FOR MEASUREMENT OF TURBULENT PRESSURES.

- (b) National Research Council.
- (d) Experimental; for basic research.
- (e) An instrument is being developed for the measuring of turbulent pressures in water. It is designed to resolve eddys 4" in diameter and larger, and to be used within one foot of the water surface.
- (g) Static calibration has proved satisfactory and the instrument is now undergoing dynamic calibration.

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ONTARIO AGRICULTURAL COLLEGE, Department of Agricultural Engineering.

## (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 20 acres each under various land use practices is being evaluated.
- (g) Winter surface runoff from watersheds with good grass-legume cover is greater than from watersheds plowed the previous fall.
- (h) Publication in press.

## (2493) THE EFFECT OF SLOPE AND TILLAGE TREATMENT ON DEPRESSION STORAGE AND SURFACE DETENTION.

- (b) Laboratory project.
- (c) Prof. H. D. Ayers, Ontario Agricultural College, Guelph, Ontario.
- (d) Experimental; basic research, master's thesis.
- (e) By simulated rainfall on an impermeable concrete surface mounted on a variable slope carriage, depression storage and surface detention are being measured for the different conditions of micro-topography resulting from soil tillage.

## (2494) EFFECT OF THE UPPER END OF SUBSURFACE DRAINS ON THE WATER TABLE.

- (b) Laboratory project.
- (c) Mr. R. W. Irwin, Ontario Agricultural College, Guelph, Ontario.
- (d) Field investigation, applied research.
- (e) By the use of water table pipe the drawdown curves axially and normal to field tile are being determined in relation to time.

## (2495) SURFACE DRAINAGE OF TIGHT SOILS.

- (b) Laboratory project.
- (c) Mr. R. W. Irwin, Ontario Agricultural College, Guelph, Ontario.
- (d) Field investigation; development.
- (e) Land smoothing and land grading with parallel surface ditches are being evaluated as methods for the surface drainage of an area of heavy clay soil of very low permeability.

## (2496) TILE DRAINAGE DEPTH AND SPACING FORMULA EVALUATION.

- (b) Laboratory project.
- (c) Mr. F. R. Hore, Western Ontario Agricultural School, Ridgetown, Ontario.
- (d) Field investigation; applied research.
- (e) The purpose of this study is to determine the validity of existing tile drainage depth and spacing formulae for Brookston Clay Soils, by measuring the factors used in the formulae.



(2497) HYDRAULICS OF SAND POINT BATTERIES.

- (b) Laboratory project.
- (c) Mr. F. R. Hore, Western Ontario Agricultural School, Ridgetown, Ontario.
- (d) Field investigation; applied research.
- (e) This project was to determine the hydraulic characteristics of yield and drawdown in relation to soil permeability, for a complete battery of well points and combinations of well points.
- (g) For the conditions at the study site it was determined that there was negligible interference between wells in a battery when spaced at forty feet.
- (h) "The Hydraulic Characteristics of Well Point Batteries", F. R. Hore, Printed report available from author.

(2498) THE USE OF INFILTRATION DETERMINATIONS FOR RUNOFF ESTIMATES.

- (b) Laboratory project.
- (c) Prof. H. D. Ayers, Ontario Agricultural College, Guelph, Ontario.
- (d) Experimental; basic research, development (one phase for master's 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.

(2499) IRRIGATION WATER SUPPLY SURVEY.

- (b) Laboratory project.
- (c) Mr. F. R. Hore, Western Ontario Agricultural School, Ridgetown, Ontario.
- (d) Field investigation, applied research.
- (e) The purpose of this survey was to evaluate by survey the water supplies on presently irrigated farms and to assess the irrigation potential in the southern townships of Essex County, Ontario.
- (f) Completed.
- (g) Of one hundred farms presently irrigating, those depending upon locally available water had inadequate supplies from streams in 42 percent of the cases, from shallow wells in 38 percent of the cases and from excavated ground water ponds in 67 percent of the cases.
- (h) "Summary of Irrigation Water Supply Survey, South Essex County", 1954, F. R. Hore and H. D. Ayers, printed report available from author.

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QUEEN'S UNIVERSITY, Hydraulics Laboratory.

(2044) ECONOMICAL CONSTRUCTION OF SAFE PULPWOOD HOLDING GROUNDS.

- (b) Pulp and Paper Research Institute of Canada Limited, 3420 University Street, Montreal, Quebec, Canada.
- (c) Prof. R. J. Kennedy, Department of Civil Engineering Queen's University, Kingston, Ontario, Canada.
- (d) Applied research; experimental field and laboratory investigation.
- (e) Field and laboratory model investigation of forces acting on various types of pulpwood holding grounds.

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