Water-Supply and Irrigation Paper No. 146

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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

PROCEEDINGS

OF

SECOND CONFERENCE OF ENGINEERS OF THE RECLAMATION SERVICE

WITH ACCOMPANYING PAPERS

COMPILED BY

F. H. NEWELL

CHIEF ENGINEER

WASHINGTON

GOVERNMENT PRINTING OFFICE

1905

CONTENTS.

LETTER OF TRANSMITTAL.

Department of the Interior,
United States Geological Survey,
Washington, D. C., April 26, 1905.

Sir: I transmit herewith a manuscript relating to the conference of the engineers of the Reclamation Service held at El Paso, Tex., November 14 to 18, 1904, and adjourned to Washington, D. C., where the conference was continued from January 9 to 14, 1905.

This second conference was in continuation of the general policy of holding annually a meeting of the principal engineers of the Reclamation Service, largely for the purpose of discussing matters of administration and economies of work. The first conference was held at Ogden, Utah, September 15 to 18, 1903, in connection with the Eleventh Irrigation Congress, held at that time and place. The first session of the second conference was held at the time of the meeting of the Twelfth Irrigation Congress, at El Paso, Tex., at which place were gathered citizens representing all of the Western States and Territories interested in the development of irrigation. The bringing together at El Paso of the principal engineers of the Reclamation Service and of prominent citizens from the West made possible an interchange of views and a discussion of data leading to results of very great value in the furtherance of the purposes of the reclamation act.

At El Paso the engineers took part in the proceedings of the engineering section of the Irrigation Congress, and also held meetings of a more or less executive character to consider and make recommendations concerning important details of the work. Various conditions were pointed out and discussed; methods of expediting and economizing the various operations were presented; and engineers from various sections of the country compared experiences and exchanged views regarding matters of common interest.

The conference adjourned to meet in Washington in January, in order to allow opportunity for other engineers to take part in the discussions and to give additional time for consideration of important details. At the adjourned meeting in Washington a number of prominent public men met the engineers and exchanged views concerning matters in various States. A partial stenographic report was made of the various meetings, and short papers were submitted, some being read by title and others presented in full and discussed. This material is of great value to the men who are working on similar lines. The printed report of the proceedings of the first conference, that at Ogden, has been distributed as Water-Supply and Irrigation Paper No. 93, and has been found to be of great assistance to the various men engaged in reclamation work. I recommend, therefore, that the second report be printed as a water-supply and irrigation paper, in order that it may be convenient for reference.

Very respectfully,

F. H. NEWELL,
Chief Engineer.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

PROCEEDINGS OF SECOND CONFERENCE OF ENGINEERS OF RECLAMATION SERVICE,

AT EL PASO, TEX., NOVEMBER 14–18, 1904, AND WASHINGTON, D. C., JANUARY 9–14, 1905.

ORGANIZATION.

The following schedule exhibits the organization of the hydrographic branch of the United States Geological Survey and of the Reclamation Service:

HYDROGRAPHIC BRANCH.

DIVISION OF HYDROGRAPHY.

Washington office.—N. C. Grover, engineer, hydrographer in charge, assisted by A. H. Horton, engineer; J. C. Hoyt, engineer in charge of computations, assisted by Robert Follansbee and Roy H. Bolster, assistant engineers, George F. Harley, engineering aid, and others; E. C. Murphy, engineer, inspector of hydrographic methods; E. G. Paul, engineer in charge of instruments.

New England.—H. K. Barrows, engineer, 6 Beacon street, Boston, Mass., hydrographer in charge, assisted by F. E. Pressey, assistant engineer.

New York.—Robert E. Horton, hydrographer, 75 Arcade, Utica, N. Y., hydrographer in charge, assisted by Clermont C. Covert, assistant engineer.

Southeastern States.—Maxcy R. Hall, resident hydrographer, Temple court, Atlanta, Ga., assisted by J. M. Giles, assistant engineer, Warren E. Hall, engineering aid, and others.

Central States.—Frank W. Hanna, assistant engineer, 263 Dearborn street, Chicago, Ill., hydrographer in charge, assisted by Sidney K. Clapp and Robert W. Pratt, assistant engineers.

Texas.—Thomas U. Taylor, resident hydrographer, Austin, Tex.

DIVISION OF HYDROLOGY.

Eastern section.—M. L. Fuller, Washington, D. C., geologist in charge, assisted by Isaiah Bowman, E. F. Lines, and E. E. Ellis, geologic aids, and others.

Western section.—N. H. Darton, Washington, D. C., geologist in charge, assisted by W. C. Mendenhall, geologist; George B. Richardson, Willis T. Lee, Cassius A. Fisher, and Claude E. Siebenthal, assistant geologists, and others.

DIVISION OF HYDRO-ECONOMICS.

Marshall O. Leighton, Washington, D. C., hydrographer in charge, assisted by Horatio N. Parker, assistant hydrographer; Richard B. Dole and Samuel J. Lewis, assistant engineers; Herman Stabler, engineering aid; and Sheldon K. Baker, hydrographic aid, and others.

RECLAMATION SERVICE.

Created by law on June 17, 1902, authorizing the survey and construction of irrigation works for reclaiming arid lands in Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Washington, and Wyoming from the proceeds arising from the sale and disposal of public lands.[a] Under the hydrographic branch, but distinct and separate from that body.

Hon. E. A. Hitchcock, Secretary of the Interior; approves all matters and signs all contracts.

Charles D. Walcott, Director of the Geological Survey and of the Reclamation Service; initiates action and reports to the Secretary.

Carl Ewald Grunsky, consulting engineer in the Reclamation Service.

EXECUTIVE AND CONSULTING STAFF.

F. H. Newell, chief engineer, U. S. Geological Survey, Washington, D. C.

Arthur P. Davis, assistant chief engineer, Washington, D. C.

George Y. Wisner, consulting engineer, 34 West Congress street, Detroit, Mich.

J. B. Lippincott, supervising engineer, Braly Building, Los Angeles, Cal.

J. H. Quinton, supervising engineer, Montrose, Colo.

W. H. Sanders, consulting engineer, 915 Grand View avenue, Los Angeles, Cal.

H. N. Savage, supervising engineer, Billings, Mont.

D. C. Henny, supervising engineer, Portland, Oreg.

Charles H. Fitch, supervising engineer, Denver, Colo.

O. H. Ensign, consulting engineer and electrical expert for Pacific coast, 437 South Cummings street, Los Angeles, Cal.

H. A. Storrs, electrical and mechanical expert for Atlantic slope, Chamber of Commerce Building, Denver, Colo.

Morris Bien, supervising engineer (on land and legal matters), Washington, D. C., assisted by J. M. McKinney, examiner, E. H. Peery, law clerk, H. L. Holgate, C. A. Mansuy, and O. G. Cowhick, assistant examiners, and others.

L. H. Taylor, supervising engineer, Hazen, Nev.

Charles E. Wells, supervising engineer, Casper, Wyo.

Charles S. Slichter, consulting engineer, Madison, Wis.

A. J. Wiley, consulting engineer, Boise, Idaho.

T. H. Means, engineer of soils, Salt Lake City, Utah.

B. M. Hall, consulting engineer, El Paso, Tex.

N. H. Darton, geologist, Washington, D. C.

E. T. Perkins, engineer and traveling auditor, Braly Building, Los Angeles, Cal.

George A. Hammond, superintendent of borings, Salt Lake City, Utah.

E. G. Paul, engineer in charge of instruments, Washington, D. C.

C. J. Blanchard, statistician, Washington, D. C.

N. E. Webster, jr., accountant, Washington, D. C.

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[a] Extended to Texas by act of February 25, 1905.

DISTRICT ENGINEERING FORCE.

Arizona.—Louis C. Hill, supervising engineer in charge, Phoenix, Ariz. Chester W. Smith, constructing engineer, Salt River project, Roosevelt, Ariz. Assistants: E. Duryee, cement expert; B. R. Harrison, tunnel expert; F. Teichman, designing engineer; Robert De Large, construction foreman; J. D. Stannard, A. L. Harris, O. T. Reedy, A. M. Sprigg, H. G. Stokes, Hugh Redmond, and W. A. Farish, assistant engineers; A. H. Demrick, electrician; O. L. McIntyre, engineering aid, and others.

California.—J. B. Lippincott, supervising engineer in charge of operations in California and adjacent areas, 1108 Braly Building, Los Angeles. Assistants: D. W. Murphy and Richard Doerfling, engineers; J. R. Prince, draftsman; J. W. Spencer, disbursing agent; C. H. H. Stone, assistant analyst, and others. Homer Hamlin, engineer in charge of Colorado River project, Yuma, Ariz. Assistants: J. C. Clausen, engineer; Paul McGeehan, R. S. Hawley, L. M. Lawson, and M. D. Williams, assistant engineers; J. C. Avakian, draftsman; L. B. Brainard, A. C. Hansen, W. D. Smith, Edward Riesbol, and T. J. Strickler, engineering aids, and others. S. G. Bennett, engineer in charge of Sacramento Valley investigations, 431 Rialto Building, San Francisco. Assistant: Edward Johnson, jr., engineer. W. B. Clapp, assistant engineer in charge of California hydrography, 431 Rialto Building, San Francisco. Assistants: Eugene C. La Rue, O. W. Peterson, and R. J. Taylor, engineering aids, and others. T. H. Humpherys, assistant engineer in charge of Klamath investigations. Assistants: F. W. Huber, assistant engineer, and others.

Colorado.—J. H. Quinton, supervising engineer, Montrose, Colo. C. H. Fitch, Chamber of Commerce Building, Denver; G. H. Matthes, engineer; C. R. Steiner, assistant engineer; J. C. Gawler, disbursing agent; L. F. Kinslow, topographic draftsman; T. E. Brick and Mrs. J. K. Gawler, clerks. I. W. McConnell, engineer in charge of Uncompahgre Valley project, Montrose; J. A. Sargent and C. T. Pease, engineers; E. E. Sands, H. A. Howe, J. L. Lytel, J. T. Keenan, J. M. Roberts, and J. H. Miner, assistant engineers; J. O. Ambler, engineering aid; H. E. Essley, and R. E. Furstenfeld, bookkeepers. M. C. Hinderlider, engineer, Denver, in charge of hydrography in Colorado and adjacent States, and in charge of La Plata Valley project; R. I Meeker, and Oro McDermith, engineering aids.

Idaho.—D. W. Ross, engineer in charge, Boise. Frank C. Horn, constructing engineer, Minidoka project, Minidoka. Assistants: D. G. Martin, engineer; J. L. Savage, Charles B. Smith, Gilbert H. Hogue, Fred Stockton, and J. T. Burke, assistant engineers; R. M. Conner, Leon L. Gay, Ernest A. Bailey, Robert J. Newell, engineering aids, and others.

Kansas.—Charles H. Fitch, supervising engineer, Washington, D. C. Charles S. Slichter, consulting engineer; W. G. Russell, hydrographer, Russell, Kans.

Montana.—H. N. Savage, supervising engineer, Billings, Mont. C. C. Babb, engineer in charge of operations connected with the Milk River project. Assistants: L. E. Granke, engineer; C. T. Prall, A. E. Place, and L. R. Stockman, assistant engineers; W. B. Freeman, engineering aid, and others. R. S. Stockton, engineer in charge of Crow Reservation surveys. Assistants: George E. Stratton and Ernest D. Hendricks, assistant engineers; L. M. Hatch and J. S. Swan, engineering aids, and others. William E. Swift, engineer in charge of Huntley project. Assistants: H. R. Evans, assistant engineer, and others. S. B. Robbins, engineer in charge of Sun River project, Great Falls, Mont. Assistants: F. F. Prendergast, assistant engineer; W. R. Ewing, Gordon Edson, and A. P. Porter, engineering aids, and others.

Nebraska.—C. E. Wells, supervising engineer, Casper, Wyo. John E. Field, engineer in charge of operations in western Nebraska, Chamber of Commerce Building, Denver, Colo. Assistants: Andrew Weiss, B. E. Hayden, and J. D. Stannard, assistant engineers; P. D. Simpson, W. L. Gorton, E. C. Woodward, and Sam G. Porter, engineering aids; James Dopson, drillman, and others.

Nevada.—L. H. Taylor, supervising engineer in charge of operations in Nevada, Hazen, Nev. Assistants: William Sargeant, A. V. Saph, and Ferd. Bonstedt, engineers; L. M. Holt, assistant engineer; B. B. Smith, engineering aid; C. F. Carpenter, messenger, and others in Hazen office. R. R. McGregor, engineer, and B. E. Forbes, assistant engineer, in charge of construction of divisions 1 and 2 of Truckee canal. Assistants: I. W. Huffaker, assistant engineer; A. H. Schadler, engineering aid, and others. W. S. Russell, engineer in charge of location and construction of lateral canals in Carson Sink Valley. Assistants: D. W. Hays, C. V. Taylor, W. A. Keddie, H. T. Paterson, A. C. Redman, C. H. Southworth, and Walter N. Frickstad, assistant engineers, and others. F. A. Temple, engineer in charge of location of Alkali Flat reservoir supply canal and outlet. Henry Thurtell, State engineer, in charge of hydrography. Assistant: B. E. Corlett, engineering aid. J. C. Coniff, field assistant in charge of topographic survey of irrigable lands. Assistants: A. T. Philips, M. Hayes, and others.

New Mexico.—B. M. Hall, supervising engineer, Carlsbad, N. Mex. Assistant: J. L. Rhead, assistant engineer. W. M. Reed, engineer, Roswell, N. Mex., in charge of operations connected with the Hondo project. Assistants: E. W. Myers, assistant engineer; H. L. Eames and F. S. Dobson, engineering aids, and others. M. C. Hinderlider, engineer in charge of La Plata Valley project, Chamber of Commerce Building, Denver, Colo.

North Dakota.—H. N. Savage, supervising engineer, Billings, Mont. F. E. Weymouth, engineer in charge of Fort Buford project. Assistants: Charles H. Paul and E. C. Bebb, engineers; J. N. Kerr, C. K. Hosford, and H. S. Morse, assistant engineers, and others. H. A. Storrs, electrical engineer, Chamber of Commerce Building, Denver, Colo., in charge of pumping from Missouri River. Assistant: P. M. Churchill, assistant engineer. J. A. French, assistant engineer, in charge of surveys near Bismarck, N. Dak. E. F. Chandler, assistant engineer, University of North Dakota, in charge of hydrography.

Oklahoma.—James G. Camp and W. W. Schlecht, assistant engineers on reconnaissance surveys, under B. M. Hall, supervising engineer, Carlsbad, N. Mex.; Charles E. Gordon, Lawton, Okla., assistant engineer in charge of operations under town-lot fund; G. L. Warner, assistant engineer; L. E. Johnson, engineering aid.

Oregon.—D. C. Henny, supervising engineer. John T. Whistler, district engineer, Pendleton, Oreg., in charge of operations. Assistants: J. H. Lewis, Herbert D. Newell, I. S. Voorhees, Edmund I. Davis, and W. C. Sawyer, assistant engineers; G. Stubblefield, R. S. Hall, W. R. Saxton, and H. S. Williams, engineering aids; N. S. Hamilton, draftsman, and others.

South Dakota.—Charles H. Fitch, supervising engineer, Denver, Colo. Raymond F. Walter, engineer in charge of Belle Fourche project, Belle Fourche, S. Dak. Assistants: H. E. Green, engineer; Frank C. Magruder and Francis M. Madden, assistant engineers; H. D. Comstock, engineering aid, and others.

Utah.—J. H. Quinton, supervising engineer, Montrose, Colo. George L. Swendsen, district engineer, P. O. Box "S," Salt Lake City. Assistants: W. D. Beers, W. P. Hardesty, and Caleb Tanner, assistant engineers; H. W. Sheley, L. L. Hunter, H. S. Kleinschmidt, W. T. Carpenter, T. C. Callister, W. J. Spalding, and W. G. Swendsen, engineering aids, and others.

Washington.—D. C. Henny, supervising engineer. T. A. Noble, engineer in charge, Yakima project, North Yakima, Wash. Assistants: Christian Anderson, engineer; L. J. Charles, F. H. Tillinghast, Charles E. Hewitt, George H. Bliss, assistant engineers; C. C. Fisher, Charles B. Cox, O. Laurgaard, and Calvin Casteel, engineering aids, and others.

Wyoming.—H. N. Savage, supervising engineer for northern portion, Billings, Mont. Jeremiah Ahern, district engineer, Cody, Wyo., in charge of Shoshone project. Assistants: C. P. Williams, designing engineer; D. W. Cole, engineer; W. E. Young, H. J. Saunders, E. S. Ela, and E. F. Tabor, assistant engineers; A. C. Downey, R. S. Sargent, and Carroll Paul, engineering aids, and others. Charles E. Wells, supervising engineer for southern portion. E. H. Baldwin, constructing engineer in charge of Pathfinder reservoir. Assistants: L. V. Branch, assistant engineer, and others.

ACCOUNTS AND PROPERTY.

The hydrographers and engineers named in the following list are authorized to certify accounts for approval by the chief engineer, and are responsible to the chief engineer for the property purchased in the field:

DIVISION OF HYDROGRAPHY.

Eastern section.—N. C. Grover, R. E. Horton, H. K. Barrows, E. G. Paul, M. R. Hall, and F. W. Hanna.

DIVISION OF HYDROLOGY.

Eastern section.—M. L. Fuller.
Western section.—N. H. Darton.

DIVISION OF HYDRO-ECONOMICS.

M. O. Leighton.

RECLAMATION SERVICE AND WESTERN SECTION OF HYDROGRAPHY.

Arizona.—Louis C. Hill.
California.—J. B. Lippincott.
Colorado.—J. H. Quinton.
Idaho.—D. W. Ross.
Kansas.—Charles H. Fitch.
Montana.—H. N. Savage.
Nebraska.—John E. Field.
Nevada.—L. H. Taylor.
New Mexico.—B. M. Hall.
North Dakota.—H. N. Savage.
Oklahoma.—Gerard H. Matthes.
Oregon.—John T. Whistler.
South Dakota.—Charles H. Fitch.
Utah.—George L. Swendsen.
Washington.—Theron A. Noble.
Wyoming.—H. N. Savage, northern portion; J. H. Quinton, southern portion.

REPORT OF THE CONFERENCE.

ATTENDANCE AT EL PASO CONFERENCE.

The following members of the Reclamation Service were present at the conference at El Paso, November 14 to 18, 1904:

Bien, Morris, engineer and legal adviser.
Chandler, A. E., State engineer for Nevada.
Chandler, Elwyn F., State engineer for North Dakota.
Darton, N. H., geologist.
Fellows, A. L., district engineer.
Hall, B. M., supervising engineer.
Hewitt, C. E., assistant engineer.
Lee, W. T., assistant geologist.
Lippincott, J. B., supervising engineer.
Matthes, G. H., engineer.
Means, Thomas H., engineer of soils.
Mendenhall, W. C., geologist.
Newell, F. H., chief engineer.
Perkins, E. T., engineer.
Reed, W. M., engineer.
Rhead, J. L., assistant geologist.
Savage, H. N., supervising engineer.
Slichter, C. S., consulting engineer.
Storrs, H. A., electrical engineer.
Taylor, Thomas U., hydrographer.

In addition to these there were in attendance at several of the meetings the following: Gifford Pinchot, chief, and E. A. Sterling, assistant chief, Bureau of Forestry; C. W. Dorsey and J. G. Holmes, of Bureau of Soils, Department of Agriculture; Senator W. A. Clark, of Montana; Senator F. G. Newlands, of Nevada; Governor George C. Pardee, of California; Governor J. T. Morrison, of Idaho; Governor Ahumada, of Jalisco, Mexico; A. J. McCune, ex-State engineer of Colorado; M. K. H. Bakhati, engineer of the Nile, Egypt; F. C. Finkle, consulting engineer, and many other prominent persons.

MINUTES OF EL PASO CONFERENCE.

November 14.—The engineers of the Reclamation Service convened at the Angelus Hotel, El Paso, Tex., at 8.30 a. m. A brief address was made by the chief engineer on the operations of the past year and plans for the future. Administrative details were discussed informally and a number of short papers presented.

In the afternoon the session was resumed and a delegation of citizens from Oklahoma was received and the prospects of early construction of reclamation projects in that Territory were discussed. A brief statement was made by Mr. M. K. H. Bakhati concerning irrigation in Egypt. In the evening a conference was held with Hon. Francis G. Newlands and with various delegates from the arid States.

November 15.—A conference was held with Representatives Smith and Stephens of Texas, and the situation on the Rio Grande was discussed by B. M. Hall and Thomas U. Taylor. Adjournment was had to the general meeting of the Twelfth Irrigation Congress. At noon the engineers met Governor George C. Pardee, of California.

In the afternoon the engineers attended the general meeting of the Irrigation Congress, addresses being made by the chairmen of the various sections.

November 16.—The engineers met in the county court room, various papers being presented and discussed. Among these were the following: Reclamation in the State of Washington, by H. N. Savage, supervising engineer; Construction Work in Oklahoma, by Gerard H. Matthes, district engineer; Underground Waters of Southern California, by W. C. Mendenhall, and discussion by F. C. Finkle; River Floods and Water Resources of North Dakota, by E. F. Chandler.

In the afternoon the session was resumed at 2 p. m., and a general discussion on a State irrigation code was opened by Morris Bien. This was followed by a paper on the Klamath project in Oregon and California, by J. B. Lippincott. A short address was given by Governor Ahumada, of Jalisco. In the evening delegations from New Mexico, Utah, and Arizona were received and the reclamation projects in each important locality were discussed.

November 17.—A general public meeting was held in the large convention hall, papers being read by H. A. Storrs on Irrigation Development in North Dakota; by Thomas U. Taylor on Texas; and by Robert Gayol, of the City of Mexico. The principal discussion was on the paper by B. M. Hall on Water Storage on the Rio Grande. This was followed by a brief paper by Charles S. Slichter on the Underflow of the Rio Grande.

At the afternoon session papers were read by Thomas H. Means on the Necessity of Draining Irrigated Lands; by A. L. Fellows on Estimates of Tunnel Work; and by H. A. Storrs on Sources of Power for Pumping Plants.

The conference then adjourned to meet at Washington, D. C., at the call of the chief engineer.

MINUTES OF WASHINGTON CONFERENCE.

The following are minutes of the various meetings held during the conference of the engineers of the Reclamation Service at Washington from January 2 to 14, 1905. The results will be found in the reports of the various committees (pp. 160–215).

January 2.—Reception by the President at the White House.

January 3.—General meeting of engineers and hydrographers at the Geological Survey Building. This meeting was for the purpose of organization and announcement of plans for the succeeding two weeks. The following members of the hydrographic branch were either present at that time or reported later in the conference:

Babb, Cyrus C., engineer.
Baker, S. K., hydrographic aid.
Barrows, H. K., engineer.
Bien, Morris, engineer and legal adviser.
Blanchard, C. J., statistician.
Bliss, George H., assistant engineer.
Bolster, R. H., assistant engineer.
Branch, L. V., assistant engineer.
Burnham, W. W., hydrographic aid.
Cass, F. H., traffic agent.
Clapp, S. K., assistant engineer.
Comstock, H. D., engineering aid.
Covert, C. C., assistant engineer.
Darton, N. H., geologist.
Davis, A. P., assistant chief engineer.
Eames, H. L., engineering aid.
Fellows, A. L., engineer.
Field, J. E., engineer.
Fitch, C. H., engineer.
Follansbee, R., assistant engineer.
Fuller, M. L., geologist.
Giles, J. M., assistant engineer.
Grover, N. C., engineer.
Hall, M. R., hydrographer.
Hall, W. E., engineering aid.
Hanna, F. W., assistant engineer.
Harley, G. F., engineering aid.
Hawley, R. W., assistant engineer.
Hill, Louis C., supervising engineer.
Horton, A. H., engineer.
Horton, R. E., hydrographer.
Hoyt, J. C., computer.
Johnson, Edward, jr., engineer.
Kastl, A. E., engineer.
Leighton, M. O., hydrographer.
Lemenager, H. V., draftsman.
Lewis, S. J., assistant engineer.
Lippincott, J. B., supervising engineer.
McConnell, I. W., engineer.
Means, Thomas H., engineer of soils.
Morse, H. M., engineering aid.
Murphy, E. C., engineer.
Newell, F. H., chief engineer.
Noble, T. A., engineer.
Olberg, C. R., assistant engineer.
Parker, H. N., assistant hydrographer.
Paul, E. G., engineer.
Perkins, E. T., engineer.
Prall, C. T., engineer.
Pressey, F. E., engineer.
Quinton, J. H., consulting engineer.
Richardson, G. B., assistant geologist.
Robbins, S. B., engineer.
Ross, D. W., engineer.
Sanders, W. H., consulting engineer.
Savage, H. N., supervising engineer.
Schlecht, W. W., assistant engineer.
Slichter, Chas S., consulting engineer.
Stabler, Herman, engineering aid.
Steward, W. G., assistant engineer.
Storrs, H. A., electrical engineer.
Taylor, L. H., engineer.
Taylor, Thos. U., hydrographer.
Tillinghast, F. H., assistant engineer.
Walter, R. F., engineer.
Webster, N. E., jr., accountant.
White, T. B., assistant engineer.

The chief engineer appointed the following committees:

Personnel and assignments.—Davis, Fitch, Savage.

Water laws and forms of water users' associations.—Bien, Ross, Chandler, Field, Noble.

Duty of water, alkali, and drainage.—Means, Sanders, Leighton, Slichter.

Methods of reconnaissance and survey.—Savage, Wisner, Fitch, Noble, Lippincott.

Standard plans and specifications.—Quinton, Wisner, Davis, L. H. Taylor.

Costs and results.—L. H. Taylor, Fellows, Webster, Olberg, McConnell, Paul.

Cement and concrete.—Wisner, Duryee, Kastl, Eckel, Wells, McConnell.

Electric power development and pumping.—Ensign, Storrs, Sanders, L. H. Taylor, Horton.

Stream measurements.—Grover, Murphy, Hinderlider, T. U. Taylor, Horton.

Auditing.—Fitch, Perkins, Paul.

Organization.—Kastl, Wells, Lippincott, Ross, Walter, Sanders, Ensign, Quinton, McConnell.

Transportation.—Davis, Bien, Storrs, Cass, Perkins.

Fiscal.—Newell, Davis, Webster.

The chief engineer directed that the committees confer immediately and prepare reports to be presented to the conference, and finally come to conclusions and make definite recommendations with reference to the various features of the work which they were appointed to consider.

During the remainder of the day the engineers attended the American Forest Congress.

January 4.—The day was set apart for conferences of standing committees for consideration of the matters assigned and the methods of presenting the same to the general conference.

In the afternoon the section of costs and results took up the discussion of methods of preparing engineering estimates of the actual cost of work accomplished and the consideration of the details of the original records for the purpose of obtaining the facts. The report of this committee will be found on pages 162–173.

January 5.—Mr. Asa Phillips, engineer of the District of Columbia sewage department, described the work which had been carried on in connection with the construction and maintenance of the trunk sewer for the city of Washington. Mr. Phillips exhibited detailed plans of the pumping station and discussed some of the interesting problems concerning the great work. The subjects of cement and concrete construction and of pumping were also discussed, great interest being manifested in them.

A conference of the committee on water laws and forms of water users' associations was held, but was not concluded at the expiration of the period allotted.

A conference was held with Messrs. Person, Ray, and Swift, auditor and assistant auditors of the Department of the Interior. Mr. Person and associates explained the distinction made between suspensions and disallowances, and advised concerning the best methods of procedure in each case. Further information was given with reference to contracts, railroad freights, and passenger rates.

A brief address was also made by Representative J. M. Dixon, of Montana, who spoke of the great importance to his State of the work of the Reclamation Service.

Representative Robert W. Bonynge, of Colorado, also met the engineers, and Mr. Howard Elliott, chief engineer of the Northern Pacific Railroad, called with Mr. Thomas Cooper, land commissioner.

In the section meetings the principal topics discussed were the limits of accuracy in reporting discharge measurements, in constructing rating tables, and in applying gage heights. This subject was introduced by Mr. R. E. Horton, of New York.

Another matter carefully considered was that of methods of counting seconds and revolutions in making low-water measurements. The discussion was opened by Mr. John C. Hoyt, chief computer.

At 3 p. m. the conference adjourned to attend the session of the American Forest Congress.

January 6.—The morning session was given over largely to the discussion of the subject of transportation of materials and laborers in connection with the great irrigation works now under way or proposed.

An important subject of discussion was "Contracts," with a view to simplifying present methods of advertising to secure the largest publicity and the greatest number of bids for Government contracts. There was a meeting of hydrographers at 11 a. m. to listen to a discussion of "Bench marks" by Mr. E. Johnson, jr., hydrographer in charge of the Mississippi River district. This meeting was continued over into the afternoon, when it was addressed by Mr. E. C. Murphy, inspector of stream gaging, on the subject of "Equipment for cable stations."

At the afternoon session Mr. C. C. Babb discussed the Milk River project in Montana and its engineering complications.

January 7.—The morning session was given over principally to the discussion of the work of the service in Snake River Valley, in Idaho. The entire Idaho delegation, composed of Senators Dubois and Heyburn and Representative French, were present and addressed the engineers.

District Engineer Ross, who is in charge of the Government's work in that State, briefly outlined the plans for reclamation, explaining in detail the location and extent of the irrigable lands and the character of hydraulic works required.

Following Mr. Ross's discussion, Senator Dubois spoke briefly on the subject of irrigation development in Idaho.

Senator Heyburn explained that, although a resident of the Panhandle of the northern part of Idaho, which has an abundant rainfall, he was none the less deeply interested in the material development of the southern, or arid, portion of his State. He said he believed that the plans of the Reclamation Service as outlined are safe, and had no patience with the complaints of those not informed as to the character of these works who criticised the engineers for proceeding slowly.

Representative French, of Idaho, called attention to the extreme need of modification of our present homestead laws where they pertain to areas embraced in the Government's projects.

The morning session was concluded by an interesting address by Mr. H. E. Williams, of the United States Weather Bureau, representing Mr. Willis L. Moore, who could not be present.

In the afternoon conference the hydrographers were addressed by E. C. Murphy, inspector of gaging stations, on the subject of "Cost of stream gaging,"[a] and Mr. J. C. Hoyt, computer, on the "Study of data by local men."

District Engineer L. H. Taylor, in charge of Nevada work, addressed the conference on the subject of the Truckee-Carson project and its recent developments.

S. B. Robbins, engineer, described the plans for the Sun River project, Montana. This contemplates the irrigation of bench lands lying between Sun and Teton rivers.

January 9.—The morning was devoted to a discussion of the Belle Fourche project, South Dakota, led by Raymond F. Walter. Senators Kittredge and Gamble and Congressmen Burke and Martin took part. The Government will probably begin actual construction by the 1st of next April. The Secretary of the Interior has set aside the sum of $2,100,000 for the construction of this work. The plans and detailed estimates have been prepared and finally approved by the consulting board of engineers.

The committee on duty of water, alkali, and drainage called attention to the importance of these points as viewed from the past history of irrigated lands in the West.

The chief engineer, in executive session with the supervising, consulting, and district engineers and experts, discussed the broad principles of construction and cost, and the relations which the coordinate branches of the service bear to each other.

At the afternoon meeting of the hydrographers the chief engineer spoke of the Bureau of Forestry and called attention to the intimate relations its work bears to that of the Survey. Computer Hoyt discussed the work of the computing section.

The committee on cement and concrete took up the subject of the materials which enter so largely into the construction of the Government's great dams and headworks. An interesting feature of the discussion was a description of the cement mill erected by the Government to manufacture 200,000 barrels of cement for the Roosevelt dam, in Arizona, which is to be one of the highest dams in the world.

January 10.—T. A. Noble, in charge of work in Washington State, spoke of the Big Bend irrigation project, saying that owing to the

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[a] See pp. 121–123.

enormous area involved, and the great cost, it has not been found practicable to proceed with its construction.

Supervising Engineer J. B. Lippincott discussed the Klamath irrigation project.

Mr. Lippincott also told of the project known as the Yuma on the Colorado River.

By invitation of Chairman Mondell, the chief engineer and a number of supervising and constructing engineers of the Reclamation Service met the members of the House Committee on Irrigation on this date, the principal topic of discussion being the Klamath project in California and Oregon. Mr. J. B. Lippincott described the important features of the project, which involves the irrigation of 300,000 acres, about half of which is Government land. The Klamath project possesses many unusual features of engineering, among which are the lowering of several lakes and the drying up of others. Two of these lakes are interstate bodies of water and both are navigable. It is necessary to have a special act of Congress to divert these waters, as such diversion will affect their navigability.

In the afternoon the supervising engineers met the committee and discussed the reclamation work for the past season.

The committee was desirous of securing all the information obtainable concerning the present status of the work, and took advantage of the opportunity of receiving the facts from the engineers in direct charge.

The adjourned conference with the committee on water laws and forms of water users' associations was continued.

January 11.—Thomas H. Means, engineer of soils, presided at the conference. The topic of discussion was the duty of water, or the amount of water required to properly irrigate the lands under project. Under the terms of the irrigation act it is necessary for the Reclamation Service to determine as closely as possible the amount of water which may be allowed per acre, and as this varies with the character of the soil and the actual demands of the various crops, it is usually a matter of dispute even among engineers who have had the best opportunity to precisely determine the question. A set of rules bearing on the subject were finally adopted at the conference.[a]

A conference was held with the committee on standard plans and specifications.[b]

Shortly after noon the engineers called on President Roosevelt, to whom they were introduced by Director Walcott and Chief Engineer Newell. The President said:

"No measure of public importance except the Panama Canal is of

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[a] See committee report, pp. 173–177. [b] See committee report, pp. 189–206.

deeper interest to me than the work of the Reclamation Service. I am greatly pleased to enjoy this opportunity of meeting with the engineers who are engaged upon this very important work of developing our country's resources."

Those who called on the President were:

Cyrus C. Babb, engineer: S. K. Baker, hydrographic aid; H. K. Barrows, engineer; Morris Bien, engineer and legal adviser; C. J. Blanchard; F. H. Cass, traffic agent; C. C. Covert, assistant engineer; A. P. Davis, assistant chief; A. L. Fellows, engineer; J. E. Field, engineer; J. M. Giles, assistant engineer; N. C. Grover, engineer: M. R. Hall, hydrographer; R. W. Hawley, assistant engineer; R. E. Horton, hydrographer; Edward Johnson, jr., engineer; A. E. Kastl, engineer; M. O. Leighton, hydrographer; H. V. Lemënager, draftsman; J. B. Lippincott, supervising engineer; I. W. McConnell, engineer; Thomas H. Means, engineer of soils; F. H. Newell, chief engineer; T. A. Noble, engineer; C. R. Olberg, assistant engineer; E. T. Perkins, engineer; C. T. Prall, engineer; J. H. Quinton, consulting engineer; S. B. Robbins, engineer; D. W. Ross, engineer; H. N. Savage, supervising engineer; W. W. Schlecht, assistant engineer; H. A. Storrs, electrical engineer; L. H. Taylor, engineer; R. F. Walter, engineer, and N. E. Webster, jr.

January 12.—Mr. John E. Field, engineer in charge of the North Platte investigation in Wyoming and Nebraska, discussed at length the Pathfinder project. Members of the Nebraska delegation in Congress—Senator Dietrich, Representatives Hitchcock, McCarthy, Norris, and Hinshaw, former Senator Manderson, and Mr. B. A. Fowler, of Arizona—were present.

Following Mr. Field's address Supervising Engineer H. N. Savage gave a description of the Shoshone project in Big Horn County, Wyo.

Later a conference was held with the committee on reconnaissance and survey,[a] and another with the committee on transportation.

January 13–14.—Mr. J. J. Hill, president of the Great Northern Railroad, addressed the engineers, speaking of the great work of irrigation, its progress under individual efforts, and its splendid future under the irrigation law. He promised his hearty cooperation in the Government work in the territory tributary to his lines.

By invitation of Senator Bard, chairman of the Senate Committee on Irrigation, the chief engineer and principal supervising and constructing engineers of the Reclamation Service appeared before the committee and discussed several bills of importance to the reclamation work. Chief Engineer Newell explained the exigency which has arisen necessitating the proposed legislation, the discussion being taken up by Supervising Engineer Lippincott and Mr. Bien, legal adviser.

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[a] See committee report, pp. 187–189.

ADDRESS BY THE CHIEF ENGINEER AT EL PASO.

At 8.30 a. m. on Monday, November 14, the chief engineer called the conference to order at El Paso, Tex., and made an informal address upon the organization of the Reclamation Service and the principal changes that had taken place since the meeting at Ogden. An informal discussion followed, questions being answered and the details referred to committees. The principal topics of discussion are given in the following pages, various details being amplified as the result of subsequent proceedings.

PURPOSE OF THE MEETING.

The principal engineers of the Reclamation Service have been brought together for the second time in a general meeting for the purpose of discussing matters of interest to all and of strengthening the work through a larger comprehension of its scope and an interchange of ideas. In the two and one-half years which have elapsed since the reclamation act went into effect the Reclamation Service has grown rapidly and has approached nearer the maturity of a permanent organization.

The report of the first conference, held at Ogden, has been printed as Water-Supply and Irrigation Paper No. 93, and has been distributed to all members of the Reclamation Service. This has served to bring to the attention of all of the men the relation of one part of the work to another and has served in many ways as a text-book or manual of instruction on many points that have needed explanation. It is proposed to embody in a similar pamphlet the results of the second conference and to insert discussions of details supplementing those given in paper No. 93.

In the general discussions which are to follow it is hoped that the various engineers present will bring forward the results of their experience during the past year, show what improvements in methods have been successfully tried, and point out difficulties which may be avoided by others. In particular, attention should be given to all matters of economy, both large and small. It must be continually borne in mind that although the Reclamation Service is a part of the administrative branch of the Government, yet it must at the same time be a strictly business organization and display sound financial judgment in seeing that there is received for every expenditure the equivalent value.

It is not sufficient in the operations carried on under the reclamation act to merely expend the reclamation fund for good works, but these must be financially successful and must return to the Treasury their original cost. In this respect our work differs from that of almost every other operation under governmental auspices, in that, while we do not consider interest and profit, yet we must get back the investment within relatively few years. The fund must be preserved for future use again and again in the many large projects which are now known to be feasible.

The definition of an American engineer is a man who, for $1, can produce results that another man can for $2. This idea must be kept prominently in the minds of all of our men. Advancement in the Reclamation Service, as well as standing in the judgment of the world at large, is dependent upon each man showing that he can and is producing substantial and permanent results at a relatively small outlay of time and money. As employees of the Government we have no excuse for not doing good work and completing permanent structures; but the credit which is properly attached to these is largely modified by considerations of their cost. Extravagance can not be tolerated. At the same time it is understood that the Government is not parsimonious nor niggardly, but that the higher officials and the public require that the returns shall be commensurate with the outlay.

There is one direction in which in the future larger expenditures should be made, and this is in the matter of complete records of expenditures and of costs. This general matter of bookkeeping and cost keeping should be discussed very thoroughly at this conference, and ideas developed along the most effective lines of recording essential facts.[a]

It is necessary to know not merely how much has been paid out for various purposes, but also to record from time to time the facts which will enable careful estimates to be prepared of the exact unit cost of each class of work or kind of operation. These facts are needed, not merely to show what has been accomplished, but for guidance in preparing future estimates.

The reclamation act was signed by the President on June 17, 1902, or twenty-nine months ago. During that time work has been energetically pushed in all parts of the arid region in the survey, examination, and beginning of large works. The engineering corps, which has been gradually created to meet the needs of the service, consists of well-trained and experienced men, selected through the Civil Service Commission. The gathering here is for the purpose of bringing representative men together and of affording opportunity for the principal engineers of the Reclamation Service to meet with each other and with citizens and statesmen interested in the future development of the arid region.

The foundation of success is in securing good men and in giving them every opportunity and encouragement to do good work. The

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[a] See report of committee on costs and results, pp. 162–173.

occasional bringing together of the principal men should serve as a means of stimulating all to effective effort, and this stimulus should be transmitted to the men in the field who can not be conveniently brought together at a conference of this kind. It is incumbent upon each of the engineers not only to assist in the conference, but to take back to his assistants or subordinates the good results of contact with men in similar lines of work.

PERSONNEL OF THE SERVICE.

During the past year a considerable number of new men have been added to the Reclamation Service, most of these being young assistants, men fresh from college with good education, ambitious, and eager to enter upon active work. These young men should be given every reasonable opportunity to obtain breadth of experience, as from among them are to come the strong engineers of the future. Much of the success in constructing and operating great irrigation works rests upon giving these men a thoroughly practical training in details.

There has also been added a number of more experienced men and a few constructing engineers of large reputation. From time to time other constructing engineers will be added, these men being selected, as is the case of all others, through competitive civil-service examination, in which, however, experience is given greater weight than in the case of the younger men.

ORGANIZATION.

Next in importance to the actual character of the men engaged in the Reclamation Service is that of the organization or relation of the various men to each other. This subject is one which has been frequently discussed, and, while in a broad way the details have been outlined, yet there are many important matters for further discussion. A committee on organization, to be designated in the future, will probably make a report as to the present views on the subject.

ENGINEERS AND ASSISTANTS.

The engineers, assistants, and aids of our various classes or grades are, as a rule, systematically grouped in field parties, and the organization should be such that no confusion can arise as to the responsibility of each man. Great care must be taken in selecting chiefs of field parties to see that each has an adequate force of assistants, and that tact and discretion is displayed by the chiefs of independent parties in placing the assistants where they will be most effective. To a certain extent the reputation of the entire Service rests upon the parties operating more or less independently away from central offices.

DISTRICT ENGINEERS.

The district engineers, located at central or convenient points in the district, are responsible for all of the engineers and assistants under them, and as the work develops should have their headquarters at or near the point where most men are employed and where a general oversight of the work can be most expeditiously had. District offices can be rented when in or near towns or cities, but during the past year there has been a tendency to move the district offices to the point of construction if ordinary facilities for mail and supplies can be had there.

FIELD ASSISTANTS.

The conditions of employment in the Reclamation Service are discussed in Water-Supply Paper No. 93, pages 24–35, and details relating to subsistence are shown on page 85. The underlying law and theory has, however, not been fully presented, and it is essential for a full comprehension of the subject to go back to the fundamental principles.

The reclamation act does not bear directly upon the matter of employment and subsistence of men, but by inference this is implied in the second section, authorizing and directing the Secretary of the Interior to make investigations and surveys and to give estimates of cost of all contemplated works. This, of course, necessitates the employment of a large number of men, and, as in the case of all surveys in distant regions, requires that certain equipment, including subsistence, shall be furnished. Since, therefore, the reclamation act does not define these matters, it is necessary for further details to consider the general laws, practices, and rulings governing similar operations of the Government, and reference should be made to the Revised Statutes and more recent acts of Congress and to decisions of the Comptroller as well as those of other law officers of the Government.

As illustrated by current practices, there are numerous ways in which employment is had. These may be conveniently classified as follows:

(*a*) Appointment by the Secretary after competitive civil-service examination to permanent or statutory places.

(*b*) Appointment by the Secretary after competitive civil-service examination to temporary positions.

(*c*) Employment by subordinate officials as required by exigencies.

At the present time there are no appointments under the first category, as the reclamation act and subsequent acts of Congress have not created any statutory places or salaries; hence all appointments are officially designated as "temporary" to distinguish them from appointments which are made to fill definite positions. This matter is explained in Water-Supply Paper No. 93, page 27.

The regular employees of the Reclamation Service fall under the second category, viz, those appointed by the Secretary after competitive civil-service examination. The various grades and classes are briefly described in Water-Supply Paper No. 93, page 36.

The occasional or field employees are hired for the time being by engineers in the field as exigency arises, under the general authority given by the Secretary to employ field assistants. Their places should be filled as soon as possible through certification from the Civil Service Commission.

In the employment of field assistants care must be taken to distinctly state and record the essential facts as to terms of employment, transportation, and subsistence, and to ascertain that these terms are in accordance with the law and authority given.

Each person employed should be furnished with a written statement covering all of these terms, and a copy should be forwarded immediately to the office of the chief engineer for record there. This statement should give the dates of the letters of authority for such employment and state the rate per day or month, the fact whether transportation is to be furnished, and particularly the terms of subsistence, the date of service, and the times when subsistence is to be begun or discontinued.

SUBSISTENCE.

The general conditions relating to subsistence of all employees are given on page 85 of Water-Supply Paper No. 93. Under the head of subsistence are included the necessary expenditures made for furnishing food and suitable shelter or space for sleeping accommodations. Where men are employed, as the majority in the Reclamation Service are, on work remote from human habitations, provision must be made, not merely for transporting the men to these remote localities, but for furnishing them food and shelter while there. Two divergent and apparently contradictory opinions have been presented concerning the legal basis for furnishing subsistence. On the one hand, it has been held that field subsistence is furnished, not as a perquisite or emolument, but solely as a necessity in facilitating work in the same way that horses, wagons, and tools are provided. On the other hand, arguments have been presented to show that the legal basis is to be found in the fact that subsistence in the field is a part of the compensation paid for services. This latter is probably the correct view.

KINDS OF SUBSISTENCE.

Subsistence may be considered as being furnished under one of several heads:

(*a*) Subsistence in kind; that is to say, the issuance of rations to the members of a party in camp, and their preparation by persons employed for this purpose.

(*b*) Repayment for actual and necessary expenses incurred when traveling, when supported by vouchers executed in the required form.

(*c*) Payment of a per diem allowance in lieu of traveling expenses or of subsistence, this allowance being sufficient to cover the usual cost of such subsistence.

LAWS GOVERNING SUBSISTENCE.

The fundamental act governing subsistence is that of March 3, 1875 (18 Stat. L., 452), as follows:

That hereafter only actual traveling expenses shall be allowed to any person holding employment or appointment under the United States * * * and all allowances for mileage and transportation in excess of the amount actually paid * * * are hereby declared illegal; and no credit shall be allowed to any of the disbursing officers of the United States for payment or allowances in violation of this provision.

In a letter from the Comptroller of the Treasury, dated April 11, 1905, the following statement has been made:

Relative to the field men of the Reclamation Service and the payment of actual traveling expenses incurred, or a per diem in lieu of their subsistence and lodging, it is usual in all branches of the Government service to pay field men either their actual and necessary traveling expenses (act of March 3, 1875, 18 Stat. L., 452) up to the maximum departmental limit, if actually incurred when traveling in the field, or a per diem as commuted when such expenses are commutable and commuted under the law.

Government employees are not in a traveling status when either at their homes, domiciles, or at their stations. A station is a place the opposite of the field. Stationed men, when paid from a lump sum, have the fact taken into consideration in fixing their compensation, that while at their official stations they are not in a traveling status, and are not allowed traveling expenses or a commutation in lieu thereof.

Where the duties of a person in the Reclamation Service require him to be in a particular place for a long period of time performing what is usually known as station work, such person can not be considered as in the field in the absence of being officially stationed at some other place.

LOCATION AS AFFECTING SUBSISTENCE.

The question of subsistence is evidently dependent upon the location of the employee. Four distinct conditions appear to be contemplated by the law and regulations:

(*a*) Home.

(*b*) Station.

(*c*) Field.

(*d*) Traveling.

Subsistence at home.—When an employee is at home no subsistence is furnished. The question, therefore, as to what constitutes a home is one which has to be considered. In the case of a married man the test is as to the location of his family. If a man is so located that his wife is with him, he is assumed to be at home, even though this home is located in a camp. As a rule no quarters or subsistence are allowed under these conditions.

Subsistence at station.—A station is a definite place or location where a man or body of men is habitually employed, such, for example, as at a local office of the Reclamation Service or at the point of construction of a large work.

The local offices, as a rule, are in or near towns, and subsistence is not furnished. On construction work, however, quarters are, as a rule, provided, as is customary in such cases, as there are no lodging places near by and the work is facilitated by having the men live close at hand. In other words, lodging is provided for the reason that without it the work would suffer, because the men could not otherwise live in the vicinity. Food is not furnished at stations, excepting during the preliminary stages of establishing a construction camp, when the party is virtually on a field basis and has not definitely assumed a permanent position. It is necessary to draw an arbitrary line between the field condition, where the location of individuals and of parties is unsettled, and the comparatively permanent station, when facilities for procuring food have been established.

Subsistence in the field.—Field location, as such, is distinguished by the fact that operations are not at any one particular place. The equipment is designed for mobility and the operations are carried forward, moving habitually from place to place, generally in unsettled regions. The fact that the party must be continually on the move and that there is no way of effectively carrying forward the work without furnishing lodging and food necessitates furnishing these. This condition is well recognized in all surveys and explorations, and individuals or corporations carrying on such work habitually furnish the means of transportation, tents, if needed, and all of the usual food materials in the raw state, together with a cook to prepare and serve the food. Subsistence is thus furnished as a matter of course, and it practically goes without saying that when an assistant is employed on a surveying party he is furnished with the necessary transportation, equipment, and food. This is not generally recognized as an emolument or perquisite, but as a necessary prerequisite to carrying on the work.

Any gain to the individual in the reduced cost of living is considered as being offset by the arduous labor and exposure of outdoor life.

Subsistence when traveling.—In the ordinary course of travel subsistence is obtained in an entirely distinct manner from the usual methods in the field work. A person traveling can rarely be furnished with crude or raw food materials and with implements for cooking it. As a rule, lodging is obtained at hotels or public houses and food at restaurants or lunch rooms. In this case payment must be made from day to day for meals and lodging, and the method recognized by law and custom is to refund these costs upon the presentation of the customary vouchers. Each person, as a rule, pays his own way and submits separate vouchers, while in the case of a field party being subsisted on rations, these are purchased by the chief of party and the individual does not keep separate account of the cost chargeable to him.

The laws and decisions applying to subsistence seem to be drawn with particular reference to traveling expenses, and it is believed that the act of March 3, 1875, relates wholly to this condition and not to field subsistence furnished to parties engaged in surveys. Under this view it is possible to reconcile the two distinct opinions above noted, and to regard allowance for subsistence as an emolument or perquisite to be covered by the appointment of each person. On the other hand, the subsistence furnished in the field may be considered, not as a perquisite, but as a necessary incident to the work in hand.

PER DIEM ALLOWANCES FOR TRAVELING EXPENSES.

Construing the act of March 3, 1875 (18 Stat. L., 452), the Comptroller has held that "the allowance to an officer whose compensation is fixed by law of a fixed sum in lieu of all expenses, exclusive of transportation and sleeping-car fare, is not authorized by law" (7 Comp. Dec., MS. 17). But in another instance it was held that "this act refers to actual traveling expenses, and does not prohibit the head of a department, having discretion to contract for the services of an employee, from agreeing with such an employee upon an amount to include compensation and all expenses." So, also, may the contract be for a fixed sum as compensation *and an amount per day as additional compensation when absent from headquarters.* If actual cost of transportation is given also, it should be clearly stated, as, for instance, "Actual cost of transportation, exclusive of sleeping- and parlor-car fares" (5 Comp. Dec., 107).

Under date of January 30, 1905, the Interstate Commerce Commission adopted an order "that on and after the 1st day of February, 1905, inspectors of safety appliances will be paid at the rate of $1,500 per annum, and in addition thereto will be allowed the sum of $4 per day, including Sundays and legal holidays, while away from home and actually on duty, etc." This order was adopted after the matter had been approved by the Comptroller.

It may, therefore, be possible to allow a per diem to the engineers and other traveling employees of this Service as additional compensation for each day, including Sundays and legal holidays, while on official duty away from their homes and headquarters. When such a per diem is authorized and allowed the engineer should not approve any claim for reimbursement for the expenses of official travel other than those for the actual cost of transportation, including regular fares for railroad, steamboat, and stage travel, inclusive of sleeping- and parlor-car fares and necessary livery hire. When the expense of steamboat travel is claimed it must be shown whether meals were included in the passage rate, and if so, the per diem will not be allowed.

In computing the per diem allowance fractions of a day should be disregarded. When travel or duty away from home begins before noon or ends after noon, the full per diem for that day should be allowed; when such travel or duty begins after noon or ends before noon, no per diem for that day should be allowed. The day and hour of beginning and ending travel or duty and any absence from or suspension of duty while away from home and headquarters should be plainly and fully stated in the employee's report.

No per diem should be allowed to an employee for days when at home or at his headquarters nor when at any camp or station of this Service where he is lodged and subsisted at a table or mess conducted for the employees of this Service. No per diem should be allowed while on annual leave or other absence from duty, whether at his home, headquarters, or elsewhere.

Should an employee be absent from his home and headquarters on official duty under circumstances not entitling him to a claim for per diem, as upon departure from his home or headquarters after noon of one day and return before noon of the day following, he will be entitled to reimbursement for his actual expenses upon submission of a voucher properly prepared showing the actual expense incurred, with subvouchers for the various items, according to regulations now in force.

PAPERS READ AT THE CONFERENCE.

PROPOSED STATE CODE OF WATER LAWS.

By Morris Bien.

INTRODUCTION.

The simplest form of regulation of the use of water is best exemplified by the present laws of the State of California. These declare the principles of priority and beneficial use and provide that claims to the use of water shall be recorded in the form of a notice of appropriation and shall be perfected by application to a beneficial use.

The form and theory of these laws has been developed by several of the States, which have followed in general the California laws and elaborated upon the methods established in that State.

The operation of these laws places no restraint upon appropriations of water. Formerly the courts, in passing upon the claims of the appropriators, having scanty information concerning the amount of water available for use, with no guide to the quantities which should be applied in the cultivation of crops, and confronted with the excessive claims of the parties, often adjudicated rights to the use of water many times in excess of the amount carried by the stream. During recent years, however, the knowledge obtained concerning the discharge of streams and the use of water has caused such decrees to become exceptional. Nevertheless, the need for a more careful regulation of the appropriation and use of water has been apparent for many years.

In 1890 the State of Wyoming enacted a code of water laws providing for a thorough supervision of the utilization of the water supply of the State through a State engineer and State board of control, who adjudicate rights to the use of water in the first instance, and division superintendents and water masters, who have immediate charge of the distribution of the water in the various water divisions.

Nebraska subsequently adopted a code of water laws substantially the same in principle as those of Wyoming. Idaho, Utah, and Nevada in 1903 adopted codes of water laws based upon those of

Wyoming, with, however, a number of important modifications dictated by the experience of Wyoming and the development of irrigation practice.

At the sessions of the legislatures of Oregon and Washington in 1903 the governors were directed to appoint commissions to prepare and submit drafts of a code of irrigation law.

At a joint session of the two commissions with the chief engineer and other members of the Reclamation Service, held last August, the fundamental principles of a modern irrigation code were discussed. There was also some consideration of the provisions which should be incorporated in such a code to facilitate the operations of the Federal Government in carrying on the work of constructing the irrigation systems contemplated by the act of Congress approved June 17, 1902 (32 Stat. L., 388), known as the "reclamation act."

As the conditions in the two States were similar, it was deemed advisable for the two commissions to work in harmony and to prepare codes which should be as nearly identical as the conditions would permit in the hope that by cooperation the commissions would be able to submit to the respective legislatures a code which should be an expression of the most advanced development of irrigation law.

At the conclusion of the joint session of the two commissions I was requested to prepare a draft of a code of water laws to form a basis of discussion by the commissions. The draft was prepared in a few weeks and widely distributed among those interested for comment and criticism.

A number of valuable comments and suggestions have been received, enabling me to formulate amendments which a subsequent careful study of the draft had shown to be advisable, besides suggesting important changes and improvements.

I desire particularly to express my obligations in this matter to Messrs. F. I. Dunbar, secretary of state of Oregon; A. E. Chandler, State engineer of Nevada; Clarence T. Johnston, State engineer of Wyoming; L. G. Carpenter, State engineer of Colorado; D. W. Ross, engineer in charge of the work of the Reclamation Service in Idaho, and T. A. Noble, engineer in charge of the work of the Reclamation Service in Washington.

PROVISIONS OF A WATER CODE.

A State code of water laws should provide for the appropriation, adjudication, and apportionment of the waters of the State, and divides itself naturally into four branches:

First. A declaration of the fundamental principles on which the right to use water shall be based.

Second. The adjudication of rights to the use of water claimed under the laws previously in force, thus determining the unappropriated public waters.

Third. The regulation, control, and determination of the rights to water to be subsequently acquired.

Fourth. The regulation and control of the distribution of the water, rights to the use of which have been established.

In discussing these branches of the subject the important features of procedure in the code proposed for Oregon and Washington will be described.

Basic principles.—Under the first heading the fundamental principles are few and well established—namely, that all the waters within the limits of the State belong to the public and are subject to appropriation for beneficial use, except from sources of supply which are navigable; that the beneficial use of water shall be the basis, the measure, and the limit of the right; that the use of water is a public use, and private parties may exercise the right of eminent domain for the utilization thereof, and that water used for irrigation shall be appurtenant to the land on which it is used.

Adjudication of prior rights.—Under the second heading, providing for the adjudication of rights claimed under prior laws, it is now generally conceded that the final adjudication must be by the courts. The codes of the different States contemplate various forms of procedure. In the code proposed for Oregon and Washington a State engineer, appointed for six years by the governor, subject to confirmation by the Senate, is to make a complete hydrographic survey of a stream system, obtaining all the data necessary to determine the amount of water available and the rights of the parties entitled to the use of it. This material is turned over to the attorney-general of the State, who is required to enter suit promptly for the determination of the rights of all parties and to prosecute the same diligently to a conclusion. In all suits for the determination of the right to the use of the waters of any stream system all who claim the right to use such waters shall be made parties. In all suits involving the determination of water rights the attorney-general is required to intervene on behalf of the State if in the opinion of the State engineer the public interest requires it.

Establishment of new rights.—The third subject—namely, that of the regulation, control, and determination of rights to the use of water to be acquired—is placed in the hands of the State engineer. The procedure proposed is substantially the same as that adopted in the other States having a modern irrigation code, with some differences of detail.

The principal feature to be noticed is that before any work looking to the construction of an irrigation system is commenced, and after the State engineer has passed upon the form and substance of the application, the intention to appropriate the water shall be published in a newspaper circulated in the community. After such publication the State engineer will approve the application if no valid objection is presented.

When the construction is completed, the works are to be inspected and approved by the State engineer, who will then determine their capacity, which will limit the amount of the appropriation. Afterwards, when the water is applied to a beneficial use, the State engineer will make a further inspection, whereupon he issues a license for the appropriation of the amount of water which has been applied to a beneficial use. A time limit is fixed for completion of construction and for beneficial use.

Distribution of water.—For the distribution of the water, which comes under the fourth branch, the States are divided by the law into four water divisions by drainage areas, each under the supervision of a water commissioner appointed by the supreme court of the State. The functions of these commissioners are the distribution of water under judicial decree or appropriation, and they may therefore be regarded as, in a sense, officials of the court. The four water commissioners, with the State engineer, constitute a board of water commissioners, of which the latter is president. The water commissioners each serve six years, their terms being so arranged that a new one is appointed every two years. This board has general supervision over the waters of the State.

The actual work of distributing the waters to those entitled to use them is done by water masters appointed by the water commissioners, with the approval of the State engineer. Each water master has charge of a water district set apart by the State engineer as found necessary from time to time. The operations of the water master are under the supervision of the water commissioner, and his acts are subject to appeal to the State engineer.

The cost of the water distribution is borne by the water users. The general expenses of the State engineer and the water commissioners are paid by the State. The greater part, if not all, of this expense will be returned to the State treasury by the fees collected by the State engineer and by the repayment of the cost of hydrographic surveys by the parties to the suits for adjudication.

The States and the Reclamation Service.—Special reference should also be made to the features of the draft relating to the work under the Federal reclamation act.

In order that the State may obtain the full benefit of this work and prevent serious interference with and perhaps the entire abandonment of the projects to be investigated, it is provided that the water supply for such projects shall be reserved from general appropriation until the investigations of the Reclamation Service shall determine the precise amount required for the project, the remainder being then released from such reservation.

It is also provided that State lands coming under such project shall be disposed of in harmony with the plans for the disposition of the lands of the United States, and that lands required by the Reclamation Service for irrigation works shall be transferred to the United States without charge.

In all future sales of State lands the conveyance is to reserve a right of way for ditches or canals constructed by authority of the United States.

The theory of these provisions is that the State regulates the appropriation of the water, exercising this power and holding the land in trust for the public, and that when the interests of the public are so directly involved as in these large irrigation projects, and when, further, there is no element of individual speculation or profit in the construction of the works, which are for the purpose of establishing the maximum number of homes on the land, it is the duty of every State to which the reclamation act is applicable to assist with every resource under its control.

Other provisions.—It will be of interest to review several of the other provisions of the draft.

Units of measurement are established: the cubic foot per second for the flow of water and the acre-foot for volume. The miner's inch is fixed as one-fiftieth of a cubic foot per second, unless a different ratio has been agreed upon by contract or established by actual measurement or use.

The amount of water which may be appropriated for irrigation is limited to 1 cubic foot per second for 70 acres or its equivalent.

While it is conceded that water used for irrigation must be appurtenant to the land, the fact must be recognized that conditions may arise to make it impracticable or uneconomical to continue to irrigate a particular tract. Provision is made so that the use of water may be severed from the land after application to the State engineer, due publication of notice of such intention, and approval by the State engineer. Similar provision is made for a change in the nature of the use to which the water is applied, or a change in the place of diversion, storage, or use.

The subject of seepage water is one that has given much trouble, and provision is made for the appropriation thereof in the same manner as other waters, with the requirement that the appropriator must pay reasonable charges for storage or carriage to the owners of the irrigation works from which it comes, provided that the seepage can be traced to such works beyond reasonable doubt.

All decisions of the State engineer or water commissioners affecting a substantial right are subject to appeal to the courts.

The commissions of the two States prepared drafts of codes upon substantially the principles herein outlined. The legislatures did not, however, adopt them, but passed certain laws governing the general procedure in regard to the adjudication of rights to the use of water.

In Oregon the office of State engineer was established and provision was made for a system of filing and adjudicating water rights.

An irrigation code without material change from that herein discussed was adopted early in 1905 by the legislatures of North Dakota, South Dakota, and Oklahoma.

During the legislative sessions of 1905 acts were passed in Colorado, Idaho, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Washington, and Wyoming, providing for cooperation with the work of the United States in the construction of reclamation projects in regard to one or more of the following:

(*a*) Necessary water supply.
(*b*) Rights of way over State lands.
(*c*) Condemnation of private property.

HYDROGRAPHIC INVESTIGATIONS IN NEVADA.

By A. E. Chandler.

There are four important river systems in Nevada, three of which—Truckee, Carson, and Walker rivers—rise in the high Sierra of California and flow through fertile valleys to inland lakes in Nevada. In the high mountain country tributary to the three rivers there are numbers of beautiful, tree-fringed lakes. The largest of these are in the Truckee basin, Lake Tahoe, with its area of 195 square miles, being by far the greatest in size. The Truckee empties into Pyramid and Winnemucca lakes, the Carson into Carson Lake and Carson Sink, and the Walker into Walker Lake.

The fourth river of importance is the Humboldt, which has the distinction of being entirely a Nevada river. It rises in the high mountains in the extreme northeast corner of Nevada and flows in a general southwesterly direction for 350 miles to Humboldt Lake. Twice within the last fifty years the flood waters of the Humboldt have reached Carson Sink.

The lowest reaches of all four rivers vary but little in elevation—the lowest, Lake Winnemucca, possessing an altitude of 3,825 feet, and the highest, Humboldt and Carson lakes, 4,100 feet. It is worthy of note that the Truckee-Carson project now being constructed by the Reclamation Service will utilize the waters of the Truckee in the Carson basin, and may carry the commingled waters of the two rivers to Lovelock Valley, the lowermost valley of the Humboldt basin. When it is added that it is practicable to connect the Walker with the Carson, the close proximity of the four streams in their lower basins must be apparent.

Besides the four rivers mentioned above there are several smaller rivers and a multiplicity of mountain streams. Salmon, Bruneau, and Owyhee rivers rise in the extreme northern part of Nevada and flow northerly into Snake River in Idaho. Virgin River rises in southwestern Utah and flows across the southeast corner of Nevada to join the Colorado. Muddy River has its source in springs on the Moapa Indian Reservation, in Lincoln County, Nev., and flows for 30 miles through the same country to its confluence with Virgin River. Quinn River and its tributary, Kings River, rise north of the Oregon line and flow southerly and westerly a distance of 80 miles, to sink in the Black Rock Desert of northwest Nevada.

Throughout the central portion of Nevada there are numerous high mountain valleys, the waters of which belong to none of the systems enumerated above. The small streams have their source in the snow-capped peaks of the neighborhood or in springs at the base of the range. The scattered mining camps make the produce of their valleys very valuable, and, as irrigation is absolutely necessary, all the water is utilized.

The first systematic stream measurements in Nevada were made by the United States Geological Survey on Truckee and Carson rivers from 1889 to 1892. Gaging stations were established by the same agency on Humboldt River in 1894 and have been continued to the present time. Measurements were also made at stations on Walker, Carson, and Truckee rivers during part of the year 1905.

The Congressional appropriations for hydrographic work made possible the establishment of a number of new stations in the basins of the four rivers in 1899–1900, and the scope of the work has been extending ever since. In 1903 the Nevada legislature created the office of State engineer and provided that among his duties should be the measurement of streams and ditches. In order to avoid duplication in work the United States Geological Survey has made the Nevada State engineer its district hydrographer, and all gaging stations are maintained according to Survey regulations.

At present there are maintained three gaging stations on the main Humboldt and one on each of three tributaries—North Fork, South Fork, and Pine Creek. There are four stations on the main Truckee, one on the inlet to Lake Winnemucca, and four on tributaries in California. On each of the two branches of Carson River, East and West forks, stations are maintained, and a third is situated on the main Carson River below upper Carson Valley, in which the two forks converge. Permanent stations have also been established on East and West forks of Walker River, and on the main river at the lower end of Mason Valley, in which the two branches join.

In 1903 the State engineer was asked by the people of Muddy River Valley to report on a reservoir site existing immediately above the valley. The site is undoubtedly good, but the water supply is questionable. In order to intelligently report upon the matter a gaging station was established upon the river immediately above the reservoir site and has been maintained since January 1, 1904.

The small and scattered population of Nevada make the maintenance of good stations a very serious problem. It does not suffice to find the point which is the best physically for a station, but rather a habitation must first be found and then some point in the vicinity selected at which to establish a gage rod. At the majority of the stations the gage rod and cable from which measurements are made have to be separated by long distances, often one-half mile. For gage readers there is little choice; every type is engaged, from the small schoolboy to the uneducated but faithful Italian farmer. There are a number of important tributaries to Humboldt River on which it is desired to conduct a series of measurements, but on which no practicable station can be found within miles of a residence.

The following remarks will show the fluctuations and average discharge at a number of Nevada stations. The flow of the Truckee at Vista, at the lower end of the largest irrigation valley in the basin, has varied between 7,510 second-feet in May, 1890, and 61 second-feet in August, 1900. The mean annual discharge for the year 1891 and for the years 1900 to 1903, inclusive, was 571,446 acre-feet.

The station on the Humboldt at Oreana is immediately above the lowermost valley of the basin. In May, 1897, the flow was 3,047 second-feet and in October, 1903, but 8 second-feet. The mean annual flow for the period 1896 to 1903, inclusive, was 169,390 acre-feet. The station at Golconda, on the Humboldt, is about 100 miles above the one at Oreana. The records show that the fluctuations at Golconda were from 3,100 second-feet in May, 1897, to nothing in the fall months of a few years. The mean annual discharge for the and for the years 1900 to 1903, inclusive, was 571,446 acre-feet.

The station on South Fork of Humboldt River is about 6 miles above its confluence with the main river. In June, 1899, the flow was 1,370 second-feet and the stream is often dry in September. The mean annual discharge for the period 1897–1903, inclusive, was 130,057 acre-feet.

Carson River, at Empire, has varied from 6,278 second-feet in

May, 1890, to 15 second-feet in September, 1902–3. The mean annual discharge for the period 1901–1903, inclusive, was 323,547 acre-feet.

The present stations on Walker River and its branches were not established until late in 1902. The discharge for 1903 of the main river at Wabuska, Nev., was 122,888 acre-feet; of East Walker, near Yerington, Nev., 79,562 acre-feet; and of West Walker, near Coleville, Cal., 225,091 second-feet.

Besides the work at regular stations, miscellaneous measurements of mountain streams and ditches have been made during every summer since 1900. It is proposed to continue these measurements in the future with special reference to the determination of the return waters after irrigation and to the duty of water.

During the season 1903–4 a number of rainfall stations were maintained at points in the Sierra Nevada. These stations are now being cared for by the United States Weather Bureau. A series of such records will be of the utmost importance to those interested in irrigation, as it is to the mountains we must look for our water supply. Until these stations were established but few rainfall records were obtainable for the higher altitudes.

POWER ENGINEERING APPLIED TO IRRIGATION PROBLEMS.

By O. H. Ensign.

In a paper treating of the growth of the use of power applied to irrigation work some statement concerning the history of the development and transmission of power by electrical means will not be out of place.

BEGINNINGS OF POWER TRANSMISSION.

In 1893 there was started in Mill Creek Canyon, above Redlands, Cal., the first three-phase alternating-current power-transmission plant in the United States. This plant utilizes the waters of Mill Creek under a head of 530 feet, using impulse water wheels directly connected to three-phase generators. This was one of the first plants in which the water wheel was directly connected to the generator, and, while it was essentially crude as compared with later development, it has been in continuous service down to the present time; from it was built up a system of power transmission which now covers a territory 150 miles long by 50 miles wide, supplying power for all manner of uses; and from the possibilities demonstrated by it, confidence was created and similar transmission systems have sprung into existence all over the country. As a direct object lesson in irrigation it is probably one of the most interesting developments in the West.

Since the first plant was constructed the same company undertook and brought to a successful conclusion the installation of the first long-distance line in the world, transmitting power from Santa Ana Canyon, another stream of the San Bernardino Mountains, to the city of Los Angeles, 83 miles away; when constructed this line was nearly three times the length and carried three times the voltage of any existing system, being constructed for 33,000 volts.

From an operating standpoint, as well as any other, this system has been a perfect success from the very beginning, and within the last two years there has been constructed, also in Mill Creek Canyon, another power plant feeding into this transmission system, operating under a hydraulic head of 1,960 feet. This plant has been in operation for eighteen months without a shut down from any cause due to the plant, and when it is considered that this is the highest pressure under which a large water wheel is operating anywhere in the world, the results may be regarded as truly phenomenal. Since this high-head plant has been in operation a similar one in the northern part of the State has been started which has single units, developing 7,500 horsepower in a single jet under a 1,700-foot head.

Owing to the fact that the demands had grown beyond the immediate practicable development of further water power in this section there has been recently installed as an addition to this system a steam turbine plant which feeds into the same transmission lines and distributing systems formerly supplied by the water-power plants alone; this plant has been in entirely successful operation without interruption for nine months. There is also being constructed a plant of 20,000-horsepower transmission to tie into this system from an entirely different watershed 116 miles away.

We have here, then, in a single system, an example of the development of power transmission through all its phases. Still operating on the system, too, is the first three-phase induction motor, the first three-phase synchronous motor, the first large unit on extremely high heads, the first four-stage vertical steam turbine in the United States, and the first 33,000-volt line of the world to be successfully operated.

This little historical sketch is given because in this system are exemplified the possibilities of development of irrigation systems along similar lines, and because in it there is afforded an opportunity to study the development step by step and to profit by mistakes as well as by improvements.

IRRIGATION AND POWER TRANSMISSION.

The promoters of this system little dreamed when they started the small plant in 1893 that one of its greatest sources of revenue would come from pumping water for irrigation, but to-day the waters which flow down the canyons of Mill Creek and Santa Ana River are made through this means to furnish power for pumping water from wells in sufficient quantity to irrigate a section of country nearly four times as great as that which the water from the streams themselves irrigates. There are 107 of these pumping plants, with 3,050 total motor horsepower.

EFFICIENCY OF TRANSMISSION SYSTEMS.

A common error into which laymen are often led is in regard to the all-around efficiency of a hydro-electric transmission pumping system as usually installed. Most of the pumps operated on this system are of the vertical-shaft, centrifugal type, placed at the bottom of a shaft whose depth corresponds to the original level of the water plane. The pump is equipped with a suction pipe lowered into a driven well and supplying water through a discharge pipe to the surface of the ground or reservoir or perhaps to an elevation some distance beyond the location of the well. Taking the average of these conditions, the water horsepower to be created in the pumped water delivered to the irrigation ditch will not, as a rule, exceed 22½ per cent of the all-around efficiency from the water on the water wheels, and will often fall below that figure. On the other hand, a system could be built up for a special purpose, with short transmission in large units, whose efficiency would be as high as 32 per cent; and, according to the claims of certain manufacturers, in a system where the pumping plants required high-lift pumps, as high as 42 per cent.

The above efficiencies are all based on the use of the centrifugal pump, and it does not appear that with the average condition of the water which would be used for irrigation it would be at all practicable in considering any large irrigation project in which pumping was the main feature to use anything but a centrifugal pump. The maintenance account on plunger pumps, cylinders, valves, etc., where water carried mud and silt, would be so great as to make operating costs excessive, and, where motors are to be used, gears and the wear and annoyance, as well as the extra care for the whole device, would largely operate to make their serious consideration a matter of doubt.

The efficiency of the centrifugal pump has been increased to such an extent in the last few years that serious consideration of the plunger type of pump is unnecessary.

On the California system discussed, besides the style of pumps mentioned above, there are deep wells of the plunger type, systems of pumping from a large number of wells by means of compressed air, low-lift centrifugals operating out of streams or canals, and almost every other conceivable device for lifting water to which electric motors could be attached. But the methods first referred to seem to be the most practical.

HEIGHT OF LIFTS.

Over a great section of this country the water is being lifted to a height of nearly 100 feet, and in some places more than that, but the large number of plants lift the water to such a height as would come within the limit of a single centrifugal pump. Since the beginning of the construction of this system great advance has been made in the construction of the impulse water wheel, and it is the belief of the writer that there will be seen here water wheels of the highest efficiency operated anywhere in the world, and not far from them wheels of a type which have now become obsolete and are being changed to the new types. All of the wheels are of the impulse type, as the lowest head of any of the plants is 480 feet.

USE OF STEAM TURBINES.

In the recent development which has occurred along the line of power generated by steam, the steam turbine has demonstrated its reliability, and its rapid introduction has convinced both investor and engineer of its practical adaptability to the problems of generating electric power. Along with the development of the steam turbine has come the development of the superheater in connection with boiler practice, and as the steam turbine reaches its highest economical working conditions with the use of superheated steam, the successful development of the superheater is a most fortunate circumstance.

Steam turbines operating under a vacuum of 28 inches and superheated steam, as above mentioned, have shown an economy equal to that obtainable by the best triple-expansion condensing engines; while in the matter of continuous operation through long periods without shut downs they are eminently suited to the work of generation of power for directly driving pumps for irrigation work.

In this connection the centrifugal type of pump in its recent developments and improvements has kept pace with the demands for improved machinery for purposes described in this paper, and the turbine type, with its more flexible properties in connection with special designs, both as to high head and speed of rotation, is available for use at an opportune time.

There has recently been under serious consideration a plant where it is intended to use the turbine pump directly connected to steam turbines in units which will be the largest pumping units in the world, considering the lift, the capacity being 80,000,000 gallons in twenty-four hours in a single unit, the lifts approximating 100 feet, while the economy expected is very close to that of the most economical waterworks pumping engines of which any authentic tests have been made. Thus fields may be opened up, in some localities where fuel is sufficiently cheap for handling water from rivers where the water may not be perfectly clean, and hence entirely debarred from being handled by any form of plunger pump.

PUMPS IN DRIVEN WELLS.

Another irrigation development consists in sinking wells in many localities where the gravel strata contain no large bowlders by driving well casings, 20 inches or more in diameter, and lowering into them high-lift centrifugal pumps and bearings for the vertical shaft. There are many places which have come to the writer's knowledge where this method appears to be practicable, and if a demand for this style of construction were once created, no doubt methods for driving well casings of such large diameters would be developed, and would be the means in many localities of obtaining water from underground sources at moderate expense.

GAS ENGINES.

There are many localities where gas engines of various types, in sizes from 5 to 30 horsepower, form one of the readiest means of obtaining power for small irrigation plants. But the great difficulty which the average man not skilled in mechanics has in handling the gas engine is liable to produce dissatisfaction with it as a reliable machine and to create a general impression of its lack of economy, although in the hands of those who are thoroughly familiar with these small units it is very efficient for the purpose desired.

Large engines, developing thousands of horsepower, have been eminently successful on the European Continent, especially where they could use the waste gases from blast furnaces. In this country they have not been generally used in the past, but at the present time greatly increased interest is being displayed in their use, recent contracts calling for units as high as 5,000 horsepower. In one case, with units of this size, it is necessary to manufacture the gases purposely for the engine.

Close observation of the success of these plants may warrant the adoption of such large units for large irrigation works, where fuel cheap in price and high in gas-making qualities can be obtained.

The gas engine is necessarily an expensive unit to install, and the greatest advantage that can be claimed for it is its fuel economy, but it yet remains to be thoroughly demonstrated that in all-around economy of investment, fuel consumption, etc., it will obtain a higher net economy than other forms of heat engines already perfected and demonstrated. In the case of all these new developments there are special localities for which they are especially fitted and where they could be used to decided advantage.

WATER POWER.

In many places throughout the West the rivers carrying large quantities of water have rapids or falls which can be utilized for power purposes, both electrically and by direct means. Some preliminary plans have been made for plants of this kind where the banks of the river and the lands adjacent thereto are too high for water to be taken to them by gravity, but where there is plenty of power. A high-lift centrifugal pump may be mounted directly on the shaft of a vertical turbine water wheel, both the wheel and the pump receiving their water from the same source, the water flowing down through the turbine wheel and up into the base of the pump, there being no external shafts or stuffing boxes. With a water-balanced step bearing and suitable screens provided, this device will work practically continuously, with very little attention and at small expense for wear and tear.

SUMMARY.

With the rapid demand for means of obtaining water upon lands out of reach of gravity systems, the developments such as have been treated in this short article will undoubtedly continue, and improvements both as to cost and economical operation will advance with the demand and with the demonstration of the feasibility of bringing under cultivation lands now utterly useless. It is the belief of the writer that the future holds the most encouraging prospects for such development, and that those interested in irrigation have only to create the demand and it will be supplied in such measure as will bring about a satisfactory income from the development of our great West.

ESTIMATES ON TUNNELING IN IRRIGATION PROJECTS.

By A. L. Fellows.

INTRODUCTION.

I first became intimately concerned with tunnel construction about eighteen years ago in connection with an irrigation project in southwestern Colorado. In this project the lands to be reclaimed were separated from the river which was expected to furnish water for their irrigation by a divide several hundred feet high. The tunnel forming a part of the irrigation system as constructed was 5,400 feet in length, with a cross section of 7 by 9 feet. My connection with this project was that of assistant engineer, and there I learned principally what not to do.

As is common with corporate enterprises, the amount of money available was very limited, and it was generally considered that money that could be saved in surveying was economy for the project. As a matter of fact, in this particular case, I have estimated that three-fourths of the actual cost of the project would have been saved by careful and thorough engineering.

The tunnel as constructed was of considerably greater length than necessary and was left unlined, in spite of my protest, on the theory that it was more economical to give it a heavy grade and to leave the tunnel unprotected than to construct lining that might serve as protection.

This tunnel may to-day serve as a typical horrible example. The roof has caved in until there are in places rooms of from 16 to 30 feet in height. The finer material has been washed out to some extent, but the bulk of the material broken down from the roof is left as a menace to the maintenance of the tunnel and an impediment to the flow of the water. It would cost more to-day to put this tunnel in good repair than to construct a new one. I cite these conditions simply as instances of things to be avoided in tunneling, or, in fact, any other kind of engineering work.

My attention was first drawn to the Uncompahgre Valley project, of which the Gunnison tunnel is an integral part, by its similarity to the project which I have just instanced, and in the surveys every effort was made to avoid the mistakes that had been made in the first project.

PRELIMINARY WORK.

The importance of thorough surveying, with reference to any class of engineering, can not be overestimated, and this importance is particularly well illustrated in the survey of the Gunnison tunnel project, which I am now discussing. As a matter of fact, mistakes did creep into the early part of the work, and had the project been constructed as at first contemplated, and as the earlier surveys seemed to indicate was the proper method, it would have been done at an increased cost of several hundred thousand dollars. In my opinion it is safe to say that surveys amounting, at the outside, to not over $8,000 in cost effected a saving of not less than $200,000 in construction. This refers to the construction of the tunnel alone and not in any way to the increased efficiency of the project as a whole, with reference to which it is estimated that the cost has also been lessened by at least another $100,000, and perhaps by twice that sum, through the change.

Location.—The best location for a tunnel having been decided upon in a general way, the details must be worked out with the greatest of care. The amount of water to be carried, the amount of fall available, the best alignment for the tunnel from both topographic and geologic standpoints, the cross section, coefficients of friction and velocity of flow, are all to be determined as exactly as possible.

The alignment may depend upon a variety of both topographic and geologic conditions. The shortest line may be the best, but it may also be affected by the character of the formation to such an extent that a longer line through better formation may be preferable. It is true that one can not tell what conditions he may meet with in a long tunnel, but with a fair amount of care the probabilities may be ascertained and many uncertainties done away with, at least within reasonable limits.

At first thought it would seem that the natural location for a tunnel was always where the line is the shortest, but the very causes which have made such a location the shortest line may also be of such a character as to prevent easy construction, and possibly provide contingencies which will very materially increase the cost of construction. A saddle between hills often owes its existence to the fact that the erosion which has taken place has been caused by the softness of the rocks at that particular point, or possibly to the fact that there is a fissure at this location which has rendered erosion easy, but tunneling difficult.

Grade.—The grade to be given the tunnel, as is the case in the grading of canals, siphons, etc., will depend upon the conditions. If there is sufficient flow available the tunnel should be given enough grade to carry the amount of water desired at the maximum velocity that will not erode the tunnel lining, this being, of course, for the purpose of decreasing the cross section to as great an extent as possible.

The coefficients of friction depend upon the surface of the tunnel, and will range from 0.010 to 0.012 for smooth concrete up to 0.030 to 0.035 for the ordinary rough-rock walls in machine-bored tunnels.

The velocity is dependent upon the grade which can be given. In my plans I have assumed that the lining can withstand a velocity of approximately 12½ feet per second without injury. This high velocity would not be possible if it were expected that the water to be conveyed through the tunnel would carry a great amount of silt, but in the project which I am now considering the amount of silt carried is usually inconsiderable.

ESTIMATES OF COST.

General principles.—Assuming that the location of the tunnel has been made with the necessary care, an estimate of the cost of construction may be made. In the course of my investigations with regard to this subject I have compiled considerable data concerning the cost of construction of tunnels in different localities, much of which, however, I regret to state I am unable to incorporate in this paper, as it was given to me confidentially and is therefore not to be disclosed. It is sufficient to say, in this connection, that the cost per cubic yard of material to be removed may vary from a very small sum, amounting to perhaps not more than $2, up to almost any figure. My suggestions with regard to estimates can be, therefore, only general, the details necessarily being worked out separately for each individual project.

The kind of estimate to be made will depend very largely upon the stage of investigations. For example, in the earlier stages when general knowledge only as to cost of construction is desired, it is quite common to accept figures concerning cost shown by actual construction under as nearly similar conditions as possible in the region in which the project is located. This estimate may be based either upon the cubic yard or linear foot. I have found no very clearly defined idea as to the proper cost per cubic yard in making estimates. Some authorities state that $5 per cubic yard in long tunnels is the time-honored basis for estimate; others state that $6 is more nearly correct, and still other figures are given by other authorities.

Probably the more usual practice is to determine as nearly as possible the cost of similar structures in the vicinity; for example, in the preliminary investigation with reference to the Gunnison tunnel, I found that tunnels of about the same size and in conditions apparently more unfavorable than those surrounding the construction of the Gunnison tunnel had cost, for excavation alone, from $20 to $30 per linear foot. In the two tunnels most nearly like the proposed Gunnison tunnel of which I have knowledge the proprietors, who had done the construction work themselves without the intervention of contractors, informed me that while the excavation had cost them somewhat more than $20 per linear foot, they were certain that under as favorable conditions as they knew to exist with reference to the proposed Gunnison tunnel $20 per linear foot would be ample. Later investigations have demonstrated to my satisfaction that these estimates were not too high, but, in general, those made in this way can be considered as approximate only.

As investigations proceed more nearly to completion and final estimates, before letting contracts, are desired, it becomes necessary to consider the probable cost much more in detail, and then the only proper way of making an estimate, in my opinion, is on the basis of a contractor's bid. Plans must be drawn showing the different varieties of cross section to be used, and the amount of lining necessary for different degrees of hardness of the geologic formation; and the probabilities with reference to the finding of water in great or small amounts must be determined. In the specifications for the Gunnison tunnel an effort was made to do away with all uncertainties, so far as the water to be encountered was concerned, by incorporating proposals with reference to the amount of water to be pumped, thus putting the burden directly upon the Government, and not upon the contractor and thence indirectly to the Government.

Power.—The first details to be worked out with care are those relating to the furnishing of power for construction. A water power, if available, may often be preferred to power derived from the use of coal or oil unless these are extremely low in cost. This subject has been most ably treated by Mr. H. A. Storrs in his valuable paper, and need not be gone into at this time. I desire to say, however, that in general I am sure that the Government would save money by constructing the power plant itself instead of leaving this for the contractor to do. It would lose nothing thereby, as the cost of establishing a power plant is well known among contractors, and they would almost invariably allow for the cost of such a plant, with probably some additional allowance, if they were satisfied that sufficient power would be furnished.

In the matter of the establishment of a water-power plant, a number of instances which have come under my observation have led me to believe that the saving to the contracting party may be several times the cost of the power plant; in other words, the contracting party is practically losing nothing and may have considerable to gain by itself establishing the power plant. In making the estimate the cost of depreciation upon the plant must, as has been shown by Mr. Storrs, depend upon whether the plant will be entirely used in the construction of this individual project or whether there will be considerable salvage. In most cases there should be a salvage of from one-half to one-third of the original cost of a new plant. This has an important bearing upon the estimates, as the cost of the plant is a very considerable proportion of the entire cost of construction. Estimates with reference to the cost of a power plant may generally be determined with reasonable accuracy through the aid of the engineering supply companies, which are always glad to furnish preliminary estimates.

Labor.—The next item to be considered in detail is that of labor, and here, too, conditions will vary widely in different localities. It is usual for contractors, in making their estimates, to determine the cost of operation per day as the first step, the amounts paid for labor being different in different localities. In estimates for a 12 by 12 tunnel which I have in my possession I find the following items in computing the cost of excavations at one heading for one day, the number of employees varying with the number of shifts:

Number of employees required in tunnel work.

Rating.	Number employed.	Rating.	Number employed.
Compressor engineers	2 to 3	Trackmen	2 to 3
Compressor firemen	2 to 3	Dump men	2 to 3
General foreman	1	Light men	2 to 3
Shift foremen	2 to 3	Nippers	2 to 3
Timekeepers	1 or 2	Stable men	2 to 3
Machinists	1 or 2	Pump men	2 to 3
Blacksmiths	2 to 3	4-horse team	1 or 2
Drillers	8 to 12	2-horse team	1 or 2
Helpers	8 to 12	Locomotive engineers	4 to 6
Muckers	14 to 21	Brakemen	4 to 6

To these are to be added the cost, varying in the different localities, as before stated, for fuel, water, powder, oil, repairs, carbons, depreciation of plant, insurance on men, pumping water, bond, and incidentals not otherwise accounted for, the last item amounting usually to about 10 per cent of the total cost.

The estimates made by the contractors will probably not vary widely, generally, as to cost per day. The crucial question is as to the amount of work that can be done in one day. For example, in two bids in my possession, the contractor who made the higher estimate of cost per day has assumed that he could do not to exceed 12 feet of work at each heading per day, while the other makes his estimate on the assumption that he can complete, on an average, 18 feet per day in each heading, this decreasing the cost per linear foot in the second case very considerably.

Lining.—The lining will naturally depend upon many different conditions. In some localities, where material for making brick is at hand, it may be thought best to line the tunnel with brick. In others, where construction is intended to be temporary only, the lining may be of timber, with a board surface to facilitate the flow of the water. In the project under consideration it was decided that concrete should be used, and in making the estimates with this end in view the following items were taken into account, the cost of a cubic yard of material in place being computed: Labor, crushing stone or transportation of gravel, or both, as the case may be, sand, forms, placing forms, cleaning bottom of tunnel, drayage, cement sheds, and depreciation on equipment. To the sum of these items should be added also the cost of cement, although where, as in this case, the cement is furnished by the United States Government, its cost will not be included in the contractor's estimate.

Timber.—The amount of lumber used per linear foot may be easily computed and is to be added where timbering is necessary.

SUMMARY.

The summing up of the various items enumerated above, reduced according to the best judgment of the engineer, into cost per linear foot for different classes of work, will give his estimate of the actual cost of construction. Where it is expected that bids will be asked, however, a profit to the contractor must be added. Few contractors will estimate on less than 20 per cent profit, and ordinarily 25 per cent will be accepted as a reasonable basis.

It is not expected that in a general discussion upon such a subject as this it would be possible to cover all conditions that may arise. Only general rules can be laid down and all details must be worked out separately for each individual project. Where the plan outlined above is followed, however, it will in general give a close approximate idea of what should reasonably be expected as bids by contractors. The engineer must use his best judgment in making these estimates and endeavor to cover all details. Difficulties of an accidental nature that may arise should not be included, excepting in the insurance and contingencies as above provided for. The contractor may perhaps make an additional allowance for unforeseen emergencies, but the fact is generally recognized that although a contractor may possibly make his estimates on the worst possible conditions, the contracting party may do the work himself and thus avoid the extreme conditions on which the contractor's basis is estimated.

In conclusion I desire to deprecate a too common tendency to overestimate. It appears to me to be as much of an error to overestimate as it is to underestimate cost, and while reasonable allowance for contingencies should be made, it is not, in my opinion, good engineering to make an additional allowance after the allowance for contingencies has once been made. I have known of instances where estimates had to pass through several different hands and each individual felt it incumbent upon him, even after expressing himself as satisfied with the details, to add some lump sum for unexpected emergencies "so as to be on the safe side." I appreciate the fact that engineers are often criticised for underestimating, and I deprecate this fault as fully as anyone can, but the point which I desire to make is that after the engineer has stated what, in his opinion, is the proper estimate, that amount should be adhered to and neither added to nor subtracted from, unless some good reason for the change is shown.

REPORTS AND ACCOUNTS.

By A. L. Fellows.

INTRODUCTION.

Of the many difficulties confronting the engineer in the Reclamation Service, none causes more annoyance, probably, than the necessity for frequent reports to his superior officers and for keeping the necessary accounts connected with his work. This condition applies to everyone connected with the Service, from the field assistant of the lowest grade to the chief engineer and the Secretary of the Interior.

It is not my purpose, in this short paper, to go extensively into details, but I desire to submit for consideration a few suggestions along broad lines.

That reports are absolutely necessary evils no one will deny; but to those who, like many of us now in the Reclamation Service, have been engaged for any length of time in private practice, where they were responsible only to themselves and to the individuals or firms employing them, the necessity for reports concerning all kinds of details is particularly trying. Nevertheless, the ever possible investigation, when every item is to be sifted out of the sum total of expenditures and when every act is to be scanned, must be always present before us.

But, more than this, every engineer must wish to have his records and accounts in such shape that he can, for his own satisfaction, lay his hands immediately upon any data or transaction in which he is interested; and, in order to do this, his records must be arranged systematically and be kept strictly up to date.

CHARACTER OF REPORTS.

It is clear, first of all, that there must be a definite system to be followed, and that this system must be so simple as to be readily understood, not only by the engineer himself, but by any other engineer who may be obliged to follow him and to carry on his work. While it must be thorough, so as to cover all essential details, it should not be involved nor should it permit of reduplication. It must not be encumbered with dead branches, making it so overloaded that it may fall of its own weight, but it must, on the other hand, be based upon records showing what the details of cost and methods employed in operation have been, and be sufficiently comprehensive to give a clear conception of the facts.

This system, while it must be complete enough to satisfy the conditions for which it is evolved, must yet not take the time of the engineers unnecessarily, but must present in concise form, for the consideration of the higher authority, those facts which are essential, leaving out nonessentials.

The Secretary of the Interior wishes to have before him reports from the Director, and reports from the chief engineer, showing. briefly and concisely, work accomplished and progress made in all of the different projects and classes of work contemplated and carried on by the Reclamation Service. He desires to have these reports made in as few words as possible consistent with giving a clear idea, in the broadest possible way, of the situation.

The chief engineer requires from his subordinates reports somewhat more frequent and more detailed in character. He wishes to know at stated intervals the progress made along all lines of work carried on under his jurisdiction. At the same time, he desires that these reports should be free from unnecessary details, such as the cost of individual items, and such events as moving camp and similar trifling matters; but it is highly essential that he have a clear idea of the situation at all times, so that he may talk intelligently concerning projects under his general direction with those who may be interested.

The fact must be remembered that the chief engineer is to a very great extent the one who stands between the public and those who are doing the field and office work. He is, in fact, almost the court of last resort in important matters and sometimes with regard to matters that are relatively unimportant. He, moreover, must take upon himself the sins of omission and commission of his subordinates when discussing matters pertaining to the Reclamation Service with members of Congress and public men generally, as well as with private individuals who may be concerned. He must, therefore, be kept well informed not only by means of monthly reports, but by personal letters relating to important matters whenever conditions requiring them arise. At the same time, the tendency to annoy him with descriptions of petty details can but brand the correspondent as incompetent to satisfactorily fill his office.

The assistant chief engineer and supervising engineers, who are to render decisions in regard to the less important matters not relating to public policy and administration, should be kept informed in much the same way as the chief engineer concerning work being carried on under their supervision.

The consulting engineers should similarly be kept informed concerning those matters over which they have jurisdiction.

The district engineers in order to make the necessary reports to their superior officers must be kept informed concerning the work of each party within their respective territories, and must have within their grasp details of work done and cost of same, with reasons for the prosecution of such work if called upon to give them. The district engineer is concerned both in the results and in the methods adopted to secure them. He must be both initiative and referendum.

The project engineer, in turn, must have all details within reach, including costs, methods adopted, and, in general, everything needed in case of detailed investigations. His office is the depository, temporarily, of accounts which will be looked into, notebooks used upon the project, detailed reports of assistants, plans and estimates connected with his project, whether the same originated in his own office or in other offices. He must receive reports from his chiefs of parties as often as he may need them, to keep him thoroughly informed as to operations in the field and to see that his orders are being carried out and to plan for future contingencies.

Finally, chiefs of parties must have reports from their instrument men and heads of subparties, in order that they may be able to compile intelligible reports concerning all work, whether carried on by individuals or by heads of subparties.

To review the conditions from the other side, the chiefs of parties must be able to report to the project engineer, in such form as he may prescribe, concerning the most minute details of the work carried on under them. He, in turn, after boiling down the details before him until he has those most essential for a clear comprehension of the situation, reports to the district engineer, who, again, reports the sum and substance of all that has been accomplished within his territory to the consulting, supervising, and chief engineers, who report the broader facts for the use of the director and secretary, who may make these facts public through the medium of his report to Congress.

BASIS OF REPORTS.

In devising any system of reports, some well-established principle, upon which all can agree, must be adopted as a starting point. There is in the Reclamation Service one definite and necessary foundation upon which any system must be based, namely, the voucher. This is the final referendum in investigation, and upon this is based the charge sheet which has been adopted in the Service for convenience in bookkeeping. In order to simplify the processes of keeping accounts and of making reports, so far as is possible, it is clear that the same terms should be generally employed as those used in the charge sheet and in the accounting department of the Washington office.

The various divisions made, if it is desired, may be somewhat further subdivided by the district and project engineers, but these subdivisions should readily group themselves under the main divisions used on the charge sheet. It would be difficult, and probably impossible, to find two engineers who, offhand and without concerted action, would use the same terms for facilitating their bookkeeping and in describing their work. The charge sheet has, however, been adopted as the result of careful study on the part of several of the engineers who have had the most experience in the Service, and will probably, with possible modifications as developments may from time to time require, serve permanently as a basis upon which accounts are to be kept and rendered. Reports should, therefore, so far as possible, make use of the same terms as those used in the charge sheet.

SYSTEM OF ACCOUNTS.

With reference to reports to be submitted covering both details of work done and accounts there is a wide divergence of opinion among engineers. One class believes that the keeping of accounts and the rendering of reports should be eliminated from field work, and that all of this work should be done, so far as practicable, in the office; the other class believes, to a greater or less degree, varying with the individual, in making each engineer directly responsible for the purchases made under his direction and for his use, and, in order to bring this as closely home to him as possible, he requires his assistants to make out detailed reports both of the work done and the expenditures incurred.

The former method will undoubtedly result in the best sets of accounts, both in appearance and accuracy. They will be made up most nearly according to the requirements of the Washington office, and will not, in all probability, contain the irregularities that may be shown in reports made up in the field. This method has the advantage, too, of giving the field man more time to devote to the field work, and does not distract his attention by the petty details connected with the field accounts. For the reason that the work may be done more expeditiously, as well as better, in the central office, this method is probably cheaper, and, in some respects, more satisfactory to the project and district engineers, and perhaps more particularly so to the chief engineer and the army of accountants ranging through the various departments of the Washington offices.

On the other hand, the second method suggested has the advantage of schooling the assistant to the various methods of keeping accounts of expenditures and records of his work in detail, and it is to be borne in mind that the field assistant may, at some future time, and in many cases certainly will, be called upon to take charge of the keeping of accounts and to assume the responsibilities connected therewith. The argument in this connection is that, in the end, more is gained by having the field assistants thoroughly trained in the methods of keeping accounts and making reports than in the temporary advantage of having the accounts in better form and appearance. This case is nearly parallel to that of the engineer who has gone through all of the different branches of field work in making surveys. He is a better engineer who has actually, by experience, learned all of the details of chaining, using the ax, rodding, marking stakes, leveling, running transit, plane table, etc., than he who has started with the transit at the beginning and has never gone through any or all of the preliminary steps.

It is true, on the other hand, that this routine work and devotion to details may be carried too far, and, as previously suggested, the system may fall of its own weight. For this reason the processes gone through should be as simple and as little onerous upon the field man as is possible.

The system used by myself was devised for my own needs and without particular reference to the work of other engineers. Later, however, at the request of the chief engineer, I sent samples of the different forms used by me in my survey work (but not as yet with regard to construction work) to all of the different district and supervising engineers. I may say, in passing, that the comments which have come to me have, in general, been commendatory, although a number of valuable suggestions have been made with reference to possible desirable changes.

The system adopted is, briefly, as follows:

The chief of a party or head of any particular class of work, whether he have a dozen men under him, or be doing all of the work with only one assistant, or even by himself alone, is furnished with a time book, consisting of—

First. Instructions to chief of party.

Second. The usual return penalty blank.

Third. Title-page, with blank space for month, State, project, etc.

Fourth. Personnel of party, comprising name, classification, occupation, rate per day, name of person to be notified in case of injury to employee, and permanent address.

Fifth. Monthly time record in the usual time-book form.

Sixth. Several pages for daily record, which are nothing more nor less than a form of journal intended simply to help the assistant to keep track of important incidents and to furnish him with a regular place for keeping memoranda of purchases, etc., space being provided also for an estimate of the salary expenses for the day upon the several classes of work under his direction. Some would make this even more extensive.

Seventh. The last two pages of the book are devoted to a monthly summary, using the subjects for secondary and tertiary division used in the charge sheet, subdivided to some extent, but grouped under the classifications shown therein, this monthly summary being for the purpose of familiarizing the assistant with the terms used and with the nature of the work which has to be done in the accounting division. Some of my correspondents would prefer to leave this out entirely.

Experience has shown that it takes but a few minutes' time on the part of the chief of the party each evening, and two or three hours at the end of the month, after he has become familiar with what is expected of him, to keep his book in satisfactory condition. He may, if he desires, keep a duplicate for his own use and records, but the original is to be turned in as his report promptly at the end of the month to his superior officer. It is to be accompanied by such written statements as he may wish to give in describing the work done under his direction, which statements should refer to the orders of his superior officer, and give such details as the assistant may conceive to be of importance in connection with his work. It should, in some cases, be accompanied by sketches, which in the work under my supervision are expected to be made upon progress maps, compiled in the office for use in the field.

The chief of each party is expected, moreover, at the end of each week, to keep both the project engineer and the district engineer informed as to the progress of his work, by means of Form 9–512, which consists simply of a journal of the week's work, with space for comments concerning work and for a forecast of the work to be done during the ensuing week. I find these forms of considerable value in keeping me in touch with the work going on. It is expected, of course, that the chief of party will also write detailed letters in case there is anything requiring particular attention or in case there is not enough space on the form. His reports, however, are all to be on sheets of the same size as the form, which is of the ordinary letter size.

At the end of each month each chief of party or individual having direct charge of important work is expected to send in a summary for the month on Form 9–518. It is intended that but little time should be required in filling out this form, which, in the main, is arranged on the plan of the charge sheet. Instructions are given on the back of the same for its use, and thus far those who have made use of it have expressed satisfaction with the results obtained.

Form 9–514 is intended as a means of grouping together the reports from the chiefs of parties, so that they may be submitted as a whole to the project engineer. It is not essential that copies of Form 9–518 be sent to the district engineer with the summary, although it is desirable at points where there are auditing departments capable of going over the various reports and checking the results.

In general, it may be said that Forms 9–515 and 9–512 would be almost universally accepted among the engineers, while 9–514 and 9–518 are forms which some engineers would not have made up in the field, but the information upon which would be gleaned from the office records. Much could be said upon both sides of this question, but the main point is that records of this character should be available from some source, whether made up in the office or in the field, and these forms have thus far seemed easily comprehended and to require but little labor. To make their use possible, that must be done which I assume is done in every well-organized office, namely, purchases must be made upon requisition and the purchaser must be furnished with an itemized statement showing each purchase made, with cost of same. In all of my work I have these requisitions made in duplicate—that is, with an original and carbon copy, the original being left with the merchant from whom the goods were purchased and the carbon copy being retained in the office.

REPORTS ON CONSTRUCTION WORK.

The system devised for reports upon construction work is somewhat more extended, although simpler in its nature. It proceeds along two lines—first, on the supposition that the office must be kept informed concerning the work actually done by the contractor, and, second, that the office must have as definite information as possible concerning the actual cost of construction to the contractor.

In the first group the field quantity book is naturally the basis. From the quantity book quantity sheets are made, showing the amount of material removed and the amount of work done. These are to be made up by the division engineers and forwarded to the project engineer, in whose office they will be kept on file. Next is a form for the purpose of showing the total amounts of work done by the contractors, this being compiled from the quantity sheets. Last is a form for the purpose of making a statement of the amount to be paid the contractor, a copy of which is forwarded to the district engineer, and, after being checked and approved by him, to the chief engineer. With this statement is a graphic representation of work actually accomplished and payments to the contractor.

The second group is based upon the time book and is for the purpose of determining, as far as possible, the cost to the contractor and his consequent profit or loss. The timekeeper keeps a time book of the kind ordinarily used in similar work, and at the end of each week or month makes his report upon a suitable form, showing the amount of labor and materials paid for by the contractor. These reports are forwarded to the project engineer, in whose office a more detailed report is compiled, showing the cost to the contractor. These reports are filed away as matters of record and are not necessarily sent to higher authorities until summarized at the conclusion of the work. They show, however, more or less roughly, whether the contractor is making money or losing, and as such are frequently to be referred to. The results obtained from these sheets may usually be summarized in one or two sentences upon the report to the chief engineer.

SUMMARY.

Regarding these forms in general, I should state that they have not yet been definitely decided on in all details, but that, if the tentative forms now on trial in construction work prove satisfactory and receive the indorsement of the chief engineer, it is expected that they will be printed—the time books and quantity books in the usual way and upon ordinary paper, but the more extended forms on a tough quality of tracing paper, which may be reproduced by the blueprint process, as copies must be furnished to the contractors, as well as to the district, supervising, and chief engineers when called for.

It only remains to state that whenever any class of work has been completed or construction finished a detailed report, showing all essential facts, must be made by the district engineer to the higher authorities. These reports should cover the ground fully, so that it will not be necessary to go back to the original records at any later time, except in case of detailed investigations. If they are found by the chief engineer to be in satisfactory form they will greatly lessen the labor of compiling annual reports, as they may be referred to by date of letter of transmittal, and may, if in suitable form, be printed in the annual report of the Reclamation Service or disposed of as may seem most desirable.

PUMPING UNDERGROUND WATER IN SOUTHERN CALIFORNIA.

By F. C. Finkle.

INTRODUCTION.

The climate of southern California is quite variable as regards rainfall. The maximum annual rainfall in years of abundance is about 5 times the minimum which occurs in years of deficient precipitation. In some localities the difference is even greater than this, but the above is a fair statement of the average in the great valley of southern California, by which is meant the valley extending from the San Bernardino Mountains to the sea near Los Angeles. From an inspection of the records of rainfall it also appears that the greater number of years have a rainfall which either approaches the average or is below it; that the rule is to expect a rainfall below the average, which is made rather large owing to the occurrence of a very great precipitation in certain scattered seasons. Under such climatic conditions as these it is but natural to expect that the discharge of streams during the irrigation season is variable. The difference in this respect is so great that the principal flowing streams in southern California, which have their origin from the mountain watersheds, will discharge during years known as "wet seasons" from ten to fifteen times as much water as they do during other years known as "dry seasons."

The opportunities for storage of water are also limited, owing to the precipitous character of the country and the few available reservoir sites. Agriculture, which depends on irrigation, would therefore be limited to the supply of water which could be obtained in minimum years were it not that nature has provided in the different valleys many large subterranean gravel reservoirs, from which can be obtained, by pumping, a considerable amount of water for limited periods of time. This has been the principal reliance in the extension of agricultural areas in southern California.

UNDERGROUND RESERVOIRS.

NATURE OF THE BASINS.

The gravel reservoirs referred to consist of the fill of drift which covers the bed-rock floor in the different valleys lying between the ranges and spurs of mountains throughout the section. Each of these valleys is filled with material, consisting of large bowlders, gravel, sand, and earth, sometimes to a depth of several thousand feet, and the basins are bounded either by the terranes of rock of an older geologic formation than the drift in the valleys or by dikes that have been silted up from the action of streams while the deposit in these valleys was being formed.

The character of the drift fill in different localities varies greatly in density, owing to the fineness or coarseness of the material. This variation is very important, as on it depends the amount of water which can be yielded when pumping is applied to any basin. Where the deposits are extremely fine, or of graduated sizes, so that the finer particles nearly fill the voids in the coarser, although the absolute amount of water contained in the mass may be great the quantity which can be withdrawn by pumping will be very small. The water contained in these masses of earth may be divided into two classes—that which may be withdrawn by the force of gravity and that which can be extracted only through capillary action. The writer has made experiments in many localities which have shown that although the total fill of a basin contained as much as 33 per cent of its mass in water, not more than an average of 5 to 8 per cent could be withdrawn by the application of pumps or other gravity force. Again, in other localities, where the fill is of coarser particles and more uniform in size, although the amount of water contained would not be more than 25 per cent it would be possible to extract four-fifths of this, either through pumping or by tapping the deposit at a lower level.

SOURCES OF SUPPLY FOR UNDERGROUND RESERVOIRS.

The sources of supply which have filled these reservoirs of drift material are three in number—(1) the precipitation on the mountain watershed bounding the basin where the water is to be found; (2) the precipitation upon the valley land itself, part of which enters the ground, and (3) the return waters from irrigation on areas lying above the basin.

By an inspection of the United States Geological Survey maps of the Redlands and San Bernardino quadrangles it will be seen that San Bernardino Valley, for example, has a number of large gravel washes running from the various rivers, creeks, and mountain canyons into and across the valley. These gravel washes comprise a considerable area of the land adjacent to the foothills, and where they enter upon the valley lands are designated by engineers as "débris cones." This title is derived from the fact that they are fan-shaped deposits of coarse drift, which bear something of a resemblance to the side of a cone. When the flood waters from the mountains are deposited at the mouth of a canyon, they pass over these débris cones, permitting a certain amount of the flowing water to sink below the surface. The water thus sinking is not again drawn to the surface and evaporated, but percolates gradually until it enters the valley or basin below, where it furnishes by far the most important source of supply of the underground valleys of southern California.

Next in importance, viewed from the state of nature, but not in volume, under the present artificial conditions produced by irrigation, is the rainfall upon these valley lands. The water falling upon the surface penetrates to various depths, depending upon the nature of the ground and the amount of annual precipitation. Where the ground is porous, and in years of good rainfall, a considerable quantity of water is added to these underground reservoirs in this manner; on the other hand, where the ground consists of fine clay, very little, if any, is added to the supply. Since the extension of irrigation and the diversion of all the normal flow of streams in the valleys of southern California, another source of supply has been added to these underground reservoirs. It is well known that when water is applied to the surface for irrigation purposes a certain percentage of the water is evaporated, another part is consumed by plant life, and the remainder absorbed by the ground. As in the case of rainfall, if the water absorbed by the ground reaches a depth below the surface from which capillary attraction can no longer draw it up and cause it to be evaporated, it descends and becomes a part of the supply in the underground valley reservoir.

EXTENT OF UNDERGROUND WATER SUPPLY.

Much investigation has been carried on to determine the extent of the underground water supplies in southern California. All investigators have reached about the same conclusion, that the supply produced by nature annually for the replenishment of these reservoirs is limited. While it is considerable in years of abundant rainfall, it becomes almost nothing in years of minimum precipitation, and a mean must be drawn so that the reserve supply is not withdrawn to such an extent as to imperil this resource. Up to the present time this has been much neglected, and the haphazard and reckless way in which promoters have attacked the underground water supply of southern California has demonstrated the necessity of future retrenchment. A great number of cases may be cited where one company has obtained a supply of water by underground development, soon to find that some one else would follow them and either take away a portion or all of their supply. Cases of this kind became so numerous that the matter had to be brought to the attention of the courts, and much expensive litigation has been the result.

LEGAL PROTECTION OF UNDERGROUND WATER.

At first the courts were inclined to treat the subject in the same manner as the law regarded it in regions of abundant rainfall, permitting to each man the right to take as much of the water percolating in his own land as he could use, regardless of the purpose to which it might be put or the locality where it would be applied to the desired use. The defects of this rule, however, became so apparent that the supreme court of California saw the necessity of so interpreting the common law as to adapt it to the conditions prevailing in that State.

The first important case in the State of California on this subject was the now famous case of Katz *v.* Walkinshaw, reported in California Reports, vol. 141. The decision in this case established the rule that underground percolating waters, even when existing in the soil of a proprietor, could only be devoted to reasonable use on the freehold itself. Under this rule it will be possible to protect all legitimate uses of the percolating waters in the land and to prevent speculators from indulging in the practice heretofore too often carried out. Some of these practices have consisted in buying small tracts of land in a valley and sinking thereon a number of wells, from which could be drawn practically the entire underground water supply in the whole valley. The water thus withdrawn would, in the majority of cases, be carried outside of the valley itself and sold for use in other watersheds than the one from which the water was derived. Cases of this kind have led to the impairment of property values in many localities in southern California, and have reduced lands which were originally productive to a desert condition by taking the water to distant localities.

Another and greater evil was the overdevelopment of the underground water, by which the water plane would gradually decline in elevation until the expense of pumping would become greater than the profits from agriculture could support.

Although much has already been accomplished looking to the rational use of the subterranean water supplies, much still remains to be done. There is still a great amount of litigation which must be determined before the question as to who has the best right to the use of the underground waters can be settled. The effect of the ruling of the supreme court in the case of Katz *v.* Walkinshaw, however, has become very apparent and is working for the good of all southern California. New promoters are not coming into the field in the numbers they did formerly and other sources of water supply are being sought for and developed. Those already using the underground water are becoming more careful of its use, and the effect in restraining former operations is beginning to be felt in some localities. No hardship will ensue from the new rule applied to the underground-water question, as ample time will be given to all localities wrongfully using water in which to make other arrangements. There are undoubtedly many projects which will have their rights curtailed when the questions are presented to the courts, and in some cases the proprietors, realizing this, are making preparations for the future.

DECLINE OF THE UNDERGROUND WATER SUPPLIES.

A table of water elevations existing in Perris and Menifee valleys prior to the beginning of pumping operations and subsequent thereto shows a very rapid decline in the water plane in these valleys under the action of pumping, the effect being greatest near the points where the pumping plants are located and, radiating outward, becoming less perceptible at greater distances from the pumps. The pumping from this valley has been carried on for about three years for the purpose of taking the water away to a distant locality. The average amount withdrawn during that time is equivalent to a constant flow of from

8 to 9 second-feet. As the water-bearing gravels of this valley are limited in depth and much of the deposits are of a compact nature, the decline has been more rapid than in any other case of record. The opportunity for flood water to penetrate the surface and replenish the subterranean supply is also more limited in this locality than in many other places, owing to the fact that the surface more nearly approaches a state of imperviousness. The only conclusion which can be drawn from the tabulation showing the decline of the water levels in Perris and Menifee valleys is that this supply has been greatly overdeveloped, and at the present rate of use will soon become unprofitable owing to the great depth from which it must be lifted.

Another example of overdevelopment of water is that exhibited in San Bernardino Valley. Lines have been drawn on the map of the Redlands and San Bernardino quadrangles showing the limits of the artesian area in San Bernardino Valley at different periods. Four different limits of the extent of artesian water are shown, all of which are from observations made by the author during these different years. While it is not likely that all of the decline is attributable to the excessive use of water from San Bernardino Valley, it is certain that the greater part of the effect is due to this cause. An inspection of rainfall diagrams representing graphically the rainfall at San Bernardino and at Riverside—these being the two principal towns in the San Bernardino basin—shows that this conclusion is inevitable. Although the precipitation in later years has been somewhat below the average, except in two seasons, these rainfall charts show that this condition has occurred previously, and even to a more marked degree, without producing the very radical effect on the underground water supply which is now apparent.

REPLENISHMENT OF UNDERGROUND WATER SUPPLY.

A consideration of the condition in the two valleys referred to shows the necessity for careful consideration of this question by the people interested in these respective localities and the adoption of measures which will remedy the condition now existing.

Diminution of the draft.—The first thing to be done will be to diminish the amount of water being withdrawn from these two valleys. As the water taken out is not being applied to the ground in the valleys themselves, no opportunity is afforded for the return of any part of the water extracted to the underground strata. This creates an absolute loss to the underground reservoirs of the entire supplies being withdrawn. As above outlined, the only method by which this reform can be brought about, unless the users consent to a reasonable diminution of their supply, is by recourse to action in the courts on the part of the property owners suffering injury. Such actions are now pending, and until they are decided no relief is likely to come from this source. It is possible, however, for the users of the water being pumped from these valleys to increase the supply in another way.

Replenishment by floods.—As has already been pointed out, the principal source of supply for this underground water is the flood water which is discharged from the mountain watersheds adjacent. When these flood waters enter the valley they issue forth in a narrow and contracted channel at some point across the débris cone immediately below the mouth of the mountain canyon. The opportunity for percolation from the stream when flowing is limited to the area of surface over which it passes. The material being porous, a considerable amount of water percolates down into the strata, even in the narrow channel occupied by the water. But, on the other hand, it is undisputed that when heavy floods occur the greater part of the flood run-off passes over the surface, down the various stream channels, and eventually into the Pacific Ocean. If some means can be adopted whereby a greater percentage of the flood water may enter the débris cones along the upper margin of the valleys, it follows that the supply to the underground reservoirs can be increased correspondingly, and this is an ideal which is not impossible of realization. The areas of these gravel washes are very extensive, and if the flood waters, instead of running in a narrow channel, were spread out over the débris cones the result would be to feed the underground reservoirs much more rapidly than is possible in a state of nature. In order to accomplish this it will be necessary for those interested in the water supply of these underground reservoirs to construct regulating works at the mouth of every mountain canyon of sufficient importance, by means of which the flood waters can be controlled and uniformly distributed over the large areas of gravel wash immediately below each canyon. Such works would have to consist of a dam or dams, with outlets at a sufficient number of points to discharge the water on the gravel wherever desired.

In addition to the dams, shafts or wells might also be excavated at points lower down, into which streams of water might be run, thus affording the infiltration of water into the gravel débris cone under pressure. These dams should be so constructed that the water might be shifted from place to place as required.

This feature is extremely important, because when flood water heavily charged with silt flows over the débris cone in one place for a considerable period the fine silt carried by the water fills up the pores and prevents rapid percolation into the detritus.

In connection with such works for controlling and distributing the flood waters over the débris cones it is, of course, important that they be so constructed as not to direct the floods upon the agricultural areas adjacent, thereby causing damage to improved property.

While the accomplishment of this method of recharging the underground areas of southern California seems a very simple one, it involves problems in hydraulics which are possibly more important than have heretofore been encountered by the engineering profession. Not only is the question of designing these works so as to make them commercially economical a very important one, but the question of so designing them as not to damage adjacent improved property is one of still greater importance. These floods are sometimes so enormous that to divert them from their accustomed channel might be a serious menace to many localities, for which reason the works must not only be substantially built, but must be so designed as to allow complete control of the water discharged during the heaviest floods.

PUMPING FROM UNDERGROUND RESERVOIRS.

When some of the ideas above outlined are put into practice, as can without doubt be accomplished successfully, the fears now existing as to the giving out of the underground water supply in southern California and the abandonment of localities now under cultivation will be wholly dissipated. The subject of pumping water in southern California is, therefore, not one of mere passing importance, but one which will engage the attention of the people in this section for all time. It is an industry which will forever flourish and be extremely important, becoming more so as the question is solved whereby the right to the use of this water is definitely decided and the quantity which can be obtained from this source is definitely determined. When this period is reached the troubles incident to the interference of one locality with another, or one company with another, will be eliminated, and the whole industry will be founded upon a fixed and conservative basis.

The question of methods and extent of pumping operations is therefore a very important one and merits thorough description.

EXTENT OF PUMPING OPERATIONS.

In the part of southern California lying south of Tehachapi Pass, and embracing the great valley of southern California having its outlet to the ocean below Los Angeles, as well as a large number of smaller valleys, the number of horsepower devoted to pumping water for irrigation and other purposes approximates 10,000. At times the number of horsepower employed is even greater, but the average is not far from the figure stated.

As to the amount of water being pumped by this power it is difficult to state exact figures, owing to the fact that so many of the pumping plants are in operation only for short periods when the owners require the water. Plants operated by large companies and municipalities are in operation most of the time, but individual plants are used as the exigencies of the owner may demand. The average quantity of water pumped has been variously estimated by different authorities to be the equivalent of anywhere from 350 to 550 second-feet, continuous flow. The making of such an estimate, however, is attended with considerable difficulty, owing to the fact that pumping operations are governed to such a large extent by climatic conditions. In some seasons, which we denominate "dry years," the pumping of water is carried on during almost every month of the year, while in other years, of more abundant rainfall, it is confined principally to about six or seven months. The estimate of the author is that an average quantity of about 450 second-feet of water has been pumped during the last few years from the various underground-water sources of southern California. This, as will be shown by the reports of stream gagings in southern California, is a much greater volume than the combined flow of all the running streams during the summer season of an average year.

METHODS EMPLOYED IN PUMPING WATER.

The means by which this large volume of water is pumped vary greatly. The type of pump employed is probably more uniform than any other feature, as the centrifugal pump is principally used. Some other types of pumps are in operation in places where the water is to be lifted a considerable height, but these are the exception rather than the rule.

The kind of power employed in driving these pumps varies considerably, being, in the order of their importance, as follows: Electric motors, gasoline engines, and steam plants. The application is either by direct connection or by belting, the latter being at present the most popular and most widely used. In the case of electric motors the author is convinced that the efficiency can be increased by a direct connection of the motor to the pump, particularly in the case of centrifugal pumps.

Efficiency of pumps.—A method of pumping which has been employed to some extent is to drive an air compressor by means of either of the three kinds of power above stated, forcing down into the well the compressed air, which, upon escaping, throws the water out of the casing. This method is known as the direct air-lift or Pohle system. The economy of power with the direct lift is very low, as the efficiency of an air compressor is usually as low as somewhere from 50 to 60 per cent, and the air discharged in the water only exerts about one-half of its useful energy in lifting water, the balance escaping in the form of bubbles to the surface. The result is that the direct air-lift method of pumping shows an efficiency of only from 20 to 30 per cent of the actual power applied. This makes the method undesirable where a first-class pump can be operated to advantage; but it has its use in the case of a large number of wells scattered over a radius of half a mile or thereabouts, which may be operated from one central station without individual plants at each well. In a case of this kind the compressor can be installed in the central station and the air piped to each of the wells from this point. The loss due to inefficiency in the use of power is, therefore, in such cases overcome to a great extent by avoiding a multiplicity of small plants and attendants to look after them.

As to the efficiency obtained from the power applied to other pumps, it has been found to vary from 40 to 75 per cent. The worst cases of installation which have come under the observation of the writer were where centrifugal pumps have been used and show an efficiency of about 40 per cent, the best being about 75 per cent. This range also applies to other pumps, such as the Downey double-acting deep-well pump, as well as to triplex and quadruplex pumps of various makes. With proper installation there is no reason why the efficiency should ever be below 65 per cent in case of any of these types of pumps, and with the very best design it should in three-fourths of the cases be up to 75 per cent. The faults which account for the inefficiencies in most cases are in selecting the size of pump required and the method of arranging the installation of the apparatus. These plants are frequently installed either by agents, who are not themselves familiar with points relating to the operation of such machinery, or by the owners of wells themselves, who go ahead without any technical assistance. However, the people are gradually learning that economy in operation is a very important essential, and that the investment of a few less dollars in the initial cost is not so important as the securing of a continuously high efficiency.

Electric power for pumping.—While streams in southern California are not large in volume during the season of normal flow, they possess another feature, viz, that of having steeply inclined beds. The grades of the streams flowing from the mountain watersheds vary from 100 feet to 400 feet per mile. This fact makes it possible to obtain high falls in the mountains, from which electric power can be developed. The result is that there is not at present a stream of any importance on which there has not been constructed one or more hydro-electric power plants. In the development of these powers the Edison Electric Company, of Los Angeles, has been the leader up to the present time, having developed and put in operation 6 plants of this kind and being engaged at present in the construction of several more. The output of these plants is largely used for pumping water for irrigation and other purposes, and a description of the methods of constructing them is therefore of great value in this connection.

Of the plants which the Edison Electric Company has in operation at the present time, the first was installed on Mill Creek, near Redlands, in the year 1893. This plant has a net fall of 510 feet, and the water is carried through a 30-inch steel force main 10,250 feet in length. This is the only plant that may be termed a "valley" plant, the diversion of the water being at the mouth of Mill Creek Canyon and the pipe line and power house being entirely in the valley. The fall of the valley at this point, however, being more than 250 feet per mile, made the construction of the plant easily possible. The apparatus installed in the station of Mill Creek No. 1 is three 250-kilowatt generators, driven by Pelton water wheels. These generators at their estimated full load develop 1,000 horsepower, but have frequently been loaded 30 or 40 per cent over their rated capacity. At the time of its installation this plant was considered large and important, being the first commercial three-phase plant in the world. Later developments of the company, however, have made this plant appear small and insignificant.

Two other plants have been installed higher up on the same stream and are known as "Mill Creek No. 2 and No. 3." The former of these was constructed in the year 1898, the fall available at the water wheels being 627 feet. This plant derives its water from a tributary of Mill Creek known as "Mountain Home Stream" and from certain other water rising in the bed of Mill Creek itself below the next diversion, known as "Mill Creek No. 3."

The water is carried in a cement-concrete pipe line along the side of the mountain and through numerous tunnels to a fore bay, from which point the force main of steel pipe, 18 inches inside diameter and 1,400 feet in length, delivers the water to the power station. The machinery installed in this plant consists of two 250-kilowatt generators, also driven by means of Pelton water wheels.

The plant on Mill Creek known as Mill Creek No. 3 is remarkable on account of its high pressure at the wheels. The net fall from the fore bay to the power-house floor is 1,960 feet, being through a steel force main about 8,000 feet in length and varying from 28 inches to 24 inches internal diameter. The water is diverted from Mill Creek at a point near Akers Narrows, which is situated nearly 5,000 feet above sea level, and carried through a cement-concrete pipe 31½ inches in diameter, laid on a grade of two-tenths of a foot per 100 feet. This pipe is buried in trenches or laid through tunnels. These tunnels, of which there are 19 on the line, vary in length from 300 feet to 1,100 feet.

The method of making the cement-concrete pipe referred to is by using a form consisting of two parts, the inside being known as the core and the outside as the jacket. The core when expanded has an outside diameter equal to that required for the inside of the pipe section, and the jacket when closed has an inside diameter equal to that required for the outside diameter of the pipe section. The space between the two when placed in position constitutes the thickness of shell for the concrete pipe, which in case of 31-inch pipe is $2\frac{3}{4}$ inches. The forms when set up and in position for making pipe are placed upon a cast-iron ring, which gives the lower end of the pipe section an ogee form. The core is expanded by means of a locking device, by loosening which it can be contracted to a lesser diameter. The reverse is true of the jacket, which is contracted by means of a similar device, the loosening of which allows the jacket to be expanded.

The making of the pipe is accomplished by mixing sand and finely crushed rock in equal proportions, and again mixing this, in the proportion of 1 to 3, by measurement, with hydraulic Portland cement. This is shoveled into place between the core and jacket through a hopper and tamped thoroughly until the entire space is filled. The hopper is then removed and a heavy shaping ring is placed on top of the jacket, which shapes the upper end of the pipe section to correspond in reverse to the lower one. The core is then pulled while the shaping ring is still in place, after which this is removed, but the outside jacket is not taken off for about thirty or forty minutes, or until the concrete has taken on its initial set. The pipe section is then left on the cast-iron ring for two or three days until it can be lifted off with safety.

To render them impervious these sections are later coated with a wash of neat cement dissolved in water to cover the entire interior surface.

The method of laying these pipes is to place them together, so that the recess in the end of one section fits the projection of the other. A collar of cement mortar, mixed with 1 part cement to 2 parts sand, is then applied, by means of rubber gloves, around the entire outside and underneath the pipe. This collar varies in size, depending upon the diameter of the pipe; the general rule being that it should be twice as wide as the thickness of the pipe shell and not less than one-sixth as deep at the point of juncture of the two pipes as the thickness of the pipe shell. The crack formed on the inside of the pipe where the two sections are joined is carefully plastered with a trowel to make a smooth and continuous surface. Great importance attaches to having the ends of the pipe section well cleaned and thoroughly wet before the mortar for making the outside collar or plastering the interior is applied, and also to covering carefully the collar or band after it is completed.

After the pipe joint is well set, the trench is then back filled with earth, covering the pipe to a depth of about 18 inches. It is not desirable to cover the pipe any deeper than this with fresh earth, owing to the danger of the external pressure cracking or disturbing the concrete, but later on, after the earth has thoroughly set around the entire outside circumference of a pipe section from natural rainfall on the surface, it may be covered to any depth. This method of constructing a hydraulic conduit for power plants has been found very economical and efficient, as the conduit is buried under the ground where no slides, washouts, or rolling bowlders can injure it.

The Edison Electric Company has also constructed its hydraulic conduit for the power plant owned by it on Lytle Creek, in San Bernardino County, in the same manner, using in this case a 36-inch diameter pipe having a shell 3 inches thick.

These three plants, the two on Mill Creek above referred to and the one on Lytle Creek, have been in operation a long time and no accidents of any kind have occurred to the pipe. They are in a condition which warrants the belief that they will last indefinitely.

The company has, in addition to the three plants on Mill Creek and the one on Lytle Creek, two other plants, located on the Santa Ana River, also near Redlands. These plants are known as Santa Ana River No. 1, which was constructed in 1898, and Santa Ana River No. 2, constructed during 1904. The volume of water for these plants is so much larger than for the others already discussed that it was impossible to adopt the type of construction already described. It was therefore decided to drive tunnels through the sides of the mountain. These tunnels are lined with concrete and when finished are 5 feet wide on the bottom and 6 feet high, the sides being run up straight for 4½ feet, after which an arch is sprung over the middle. The capacity of these tunnels is 100 second-feet of water; the fall at the upper power plant being 728 feet, and at the lower one, or No. 2, 310 feet.

The most remarkable installation yet completed by the company is the No. 3 plant on Mill Creek, owing to its extremely high head, the pressure at the nozzle of the Pelton wheel being 840 pounds to the square inch. The pipe used at the lower end of this force main is of the lap-welded pattern, with solid steel flanges welded to each pipe section. As the thickest pipe—of 24-inch diameter—which could be made by the National Tube Company was three-fourths of an inch, it became necessary to wrap the lower end of this pipe for the force main to give it the requisite strength. This was done with crucible-steel wire three-sixteenths of an inch in diameter, applied under tension while the pipe was being turned in a lathe, and securely clamped at both ends of the pipe section. The pipe was then dipped in a bath of asphaltum to cover the surface of the wrapping thoroughly.

The total capacity of the six power plants of the Edison Electric Company above referred to is 15,000 horsepower, nearly one-third of which is being used for the pumping of water for irrigation and domestic purposes. The remainder of the power is distributed for lighting and street-railway operation in the various cities of southern California.

Another large electric-power plant, to be located on Kern River, is now in course of construction by the company, which will have a total output of 28,000 horsepower. This plant will consist of a line of tunnels (8 miles in length), divided into 19 sections and worked from 38 headings. The size of these tunnels in the rough is 9 feet by 9 feet, the sides being 7 feet vertical with an arch overhead. The entire bottom and sides up to 7 feet will be lined with concrete, reducing the section to 8 feet by 7 feet in depth. Overhead lining, in the form of a concrete arch, will be used only where the rock is not sufficiently solid to be self-supporting. Over half of these tunnels, or about 4½ miles, were completed January 1, 1905.

The force main for this power plant will be an inclined underground tunnel, which will be lined with a steel tube 7½ feet internal diameter, the space between this steel lining and the sides of the tunnel being filled with concrete well rammed into place. The grade of the tunnels leading to the head of the force main is at the rate of 7.92 feet per mile, giving the lined section a capacity of about 460 cubic feet per second. The water thus carried will have a net fall of 872 feet from the head of the force main to the water wheels in the station.

The development of this large plant was made necessary by the enormous expansion of business in the part of southern California over which the lines of the company extend, a great deal of this business being occasioned by the amount of power used for pumping water.

The lining of the tunnels with concrete, as above stated, has been found to be the most economical method of constructing them, because the section of a tunnel of given carrying capacity is reduced by smoothness of interior. Taking Kutter's formula as the method of calculating the capacity, the tunnels driven in the rough by means of machine drills will give a coefficient of roughness from 0.028 to 0.035, while the lined and plastered section has a coefficient not exceeding 0.012. It is therefore cheaper to provide the concrete lining and plaster than to excavate the much larger section required for carrying the same quantity of water through a tunnel in the rough.

Other powers used for pumping.—Largely because the electric development has not been able to supply the demands for power a great many individuals and companies have had to resort to the use of gasoline and steam plants to lift their water. The gasoline engines used are operated with distillate, which is a crude oil having the heavier ingredients removed. The cost of this fuel is not excessive, but the amount of attendance required for small plants makes the operation quite expensive. In the case of an electric motor the machinery will run without an attendant after being started, but with a distillate or gasoline engine some one has to be in attendance to guard the operation of the plant. This is also true where steam plants are used, as in that case a fireman and engineer must be in constant attendance, both night and day.

It is likely that as the development of electric power progresses the supply will be sufficient to displace most of these less economical plants with electric motors. Although the electric companies supplying power for motors do not usually make a rate which is lower than the cost of fuel for other plants, the saving in other directions is so great that the change will be adopted by users of power.

Not only is the saving of attendance above cited an important item, but the greater durability of electric machinery is really still more important. An electric motor is a piece of machinery which, if not abused, will endure for an indefinite time, while all types of engines are limited in their life to only a few years. Particularly is this true when they are operated (as is usually the case) in pumping plants by men who are not skilled in handling power machinery.

PUMPING IN CENTRAL CALIFORNIA.

The counties of central California from Fresno County to the Tehachapi Pass, including the counties of Fresno, Tulare, Kings, and Kern, are usually classed with southern California when the State is considered in only two geological divisions. These counties include what is the best part of the San Joaquin Valley, which needs greater irrigation facilities alone to make it a real empire. All the waters of the rivers flowing into this portion of the San Joaquin Valley are now being used for irrigation, but the supply is sufficient to irrigate only a small part of the available land. The whole valley, however, is underlaid with an abundant supply of water, which in most localities is suitable for irrigation purposes if pumped to the surface. A beginning has already been made in this direction, and the Mount Whitney Power Company, in Tulare County, is now supplying large quantities of power for pumping water to irrigate land in that locality. This power plant is constructed on East Fork of Kaweah River, and more than half its output is applied to pumping water at the present time.

In Kern County a plant owned by the Bakersfield Power, Transit and Light Company is constructed, from which a great part of the output is used for pumping wells in the vicinity of Bakersfield. The water from these wells is used largely for growing alfalfa and for irrigating deciduous fruits, which grow luxuriantly in that neighborhood.

With a greater available supply of power for pumping purposes the extension of irrigation in Kern County, by means of pumping, will be greatly increased. In Fresno County there are large areas of land on what is known as the King River delta, which can be reclaimed by means of wells and electric power developed from the Sierras.

The King River Power Company, a corporation under the Edison Electric Company, of Los Angeles, is the owner of the power rights on King River near Fresno, and the development of these powers will create endless possibilities for the irrigation of land from subterranean water in this part of San Joaquin Valley. The amount of water power which can be developed at normal flow of the streams from the King River Canyon, at Fresno, south to Tehachapi Pass, will approximately equal 200,000 horsepower, and unquestionably there will be a market for all of this power, as a great part of it is needed in southern California, south of Tehachapi, and another large part will be required for pumping water in San Joaquin Valley in the counties above referred to. It is hard to realize what will be the condition of the population in this part of the San Joaquin Valley when these developments are completed to their fullest extent.

No danger need be apprehended from the decline of the subterranean water supply even if used in large quantities in this manner, as the water taken out will be applied to the surface of the valley itself, and a very large percentage will again enter the ground, the only loss being from evaporation and the consumption of the crops grown on the land.

The cases in which the underground water supply is seriously impaired by its being pumped for use are those where the water is carried out of one basin or valley for use in other localities, so that the return waters from irrigation do not reenter the same strata from which the supply was derived.

SUGGESTIONS AND CAUTIONS.

In concluding these observations it is important to state a few facts relating to the proper method used in deciding on projects where lands are to be reclaimed by the use of underground water.

First, it must be definitely ascertained that the supply is ample for the purpose intended and will not give out as soon as the locality built up from its use has become large and prosperous. This is particularly important where the water taken from one valley is to be carried to another distant from it. In this case it must be carefully ascertained that the supply entering the basin from which the water is taken is sufficient to replenish the voids created by the water being pumped out. It is also important to determine that the proposed pumping operations will not interfere with other vested water rights in the streams or springs in the vicinity, and that they will not draw away the water belonging to other landed proprietors in the vicinity. Where the water is taken out and used on the land under which it is discovered, these considerations are not so important, as but a small part of the supply can be consumed at the most. In such cases the percentage consumed will of course depend upon the nature of the soil, the kind of crops grown, and other natural conditions in the vicinity.

Another important consideration is the character of the water, because injurious salts, if contained therein, may result in the infertility of the land to which such water is applied. This subject must, of course, be investigated by careful analyses of the water and of the soil to be irrigated.

The proper construction of the plants for lifting the water and distributing it to the points needed is equally important and requires careful attention from men skilled in this class of engineering.

COLLECTION OF STREAM-GAGING DATA.

By N. C. Grover.

A general study of the records of stream gaging brings to the attention the fact that the degree of accuracy varies much for different river stations and sections of the country. Measurements made for several years at carefully maintained stations have been consistent, and the measured discharges when plotted have defined closely for each station the discharge curve. Such records indicate that the laws of river hydraulics are definite and that inconsistencies in measured discharges are due to causes which can be determined and eliminated.

In contrast with these stations are many at which the physical conditions are just as good, but for which the discharge measurements, even in a single year, are glaringly inconsistent. For many such stations, with practically stable conditions of bed and banks, as many as 30 to 60 meter measurements of discharge for each station have been made without defining the curves of discharge.

It therefore becomes a matter of importance to determine the reasons why the records for some stations are good and for other stations poor. Causes for such differences have generally been found to be either (1) inaccuracy in the determination of areas, (2) changes in the datum of the gage, (3) inaccuracy in the determination of velocity, or (4) poor conditions at the gaging station.

Probably the most frequent source of error is in the determination of the area of cross section of the streams. At high stages of the river, particularly, accurate soundings are difficult and expensive to obtain, and even if sufficient lead is used to insure its position on the bed vertically under the point of observation, the bowing of the sounding line, due to the force of the moving water, will frequently cause errors of several tenths of a foot in the soundings. Errors as great as 30 per cent have not uncommonly been introduced in high-water measurements through errors in the determination of area.

If the bed and banks are permanent, the profile of the cross section should be accurately determined during a low stage of the river, and in computing the results of all meter measurements area should either be determined from this standard cross section or be checked by comparison with it.

Whenever possible the station should be so located that the conditions of flow will be permanent—that is, the conditions of bank and bed should be practically permanent, not only at the station, but within such limits above and below that there will be no appreciable change in the relation between gage height and discharge. In some sections of the country this may be practically impossible, but in others such conditions are not uncommon. Results of gagings at such stations should always be consistent.

If the beds change only during freshets a succession of cross sections, determined at the low-water stages and each applicable for a limited time, can probably be used to advantage. If the bed is constantly changing, soundings must of course be made at each gaging, but exceptional care must be used in order to insure even passably good results. Particular attention is here called to the fact that in order that the areas may be readily checked by comparison with others the total area of both still and moving water must be included.

Next to errors in determination of area are those due to changes in the datum of the gage. A score of cases can be easily cited where several years' records have been rendered almost worthless by carelessness in maintaining a constant datum. Frequent checking of the gage with a permanent bench and an exact and detailed record of just what and when changes have been made is absolutely essential to good results.

Inaccuracies in the determination of velocity may be divided into two classes, (1) those that are due simply to erroneous observations and which are as likely to be positive as negative and are consequently compensating, and (2) those due to defects in the meter or its rating, which may persist through many measurements. These latter are by far the more important and should receive consideration. They are due to either original inaccurate rating of the meter or to injury of the meter after rating, usually the latter. In order that these errors may be reduced to a minimum, care should be exercised that the meter receives no blows, is properly adjusted, and that the pivot point is protected and oiled. Results should occasionally be compared with those obtained by another meter. If at any time the mean velocities when platted throw suspicion on the meter, it should either be rerated, or compared directly with another meter. If the instrument must be used after injury or when in poor condition, it should be rated before repair and the rating table so obtained applied to previous measurements.

A large Price meter should not be used when the velocity of the current is less than 1 foot per second, nor a small Price when the velocity of the current is less than 0.05 foot per second.

It is worth noting also that at many stations where conditions are permanent, as outlined above, the growth of grass in the stream at the gaging station may decrease the flow as much as 25 per cent from the normal, and this one fact would doubtless explain why many current-meter measurements do not plat well on the curve. Such conditions should be noted in all cases.

At gaging stations where conditions are permanent, therefore, the rating curve may be constructed from measurements made in several years, and should be good for all time. As a result of this investigation the writer has come to believe that if more time had been expended in maintaining the station, in making, computing, and checking each measurement, better estimates could have been made at a smaller ultimate cost. In other words, the careless and hastily made meter measurement is believed to be more expensive in the end. It is therefore suggested that after a meter measurement of flow has been made and computed it should be tested by the man who made the measurement before the results are transmitted, by platting the computed discharge, area, and mean velocity, and by comparing these platted results with others obtained at the same station. If discrepancies are found, the causes should if possible be at once located. An early study of each measurement will insure that mistakes in area and datum of gage shall not be carried forward indefinitely and that reasons for erratic data shall be determined if possible. If a few months or years elapse before any study of these errors is made the results must generally remain uncorrected and frequently will be much in error. It is good business to spend a few dollars in carefully checking and reporting records which cost many more dollars to collect.

RIO GRANDE PROJECT.

By B. M. Hall.

The writer prepared and read at the El Paso Irrigation Congress a paper on "Plans for irrigation of the Rio Grande Valley," which has been published in full in the Third Annual Report of the Reclamation Service. As a supplement to that paper it has been thought desirable to epitomize the unique conditions and engineering facts brought out by it and some of the results that would naturally follow from the completion of the Engle dam and the irrigation of 180,000 acres in New Mexico, Texas, and Mexico.

WATER SUPPLY.

Engle, N. Mex., is about 100 miles up the river above El Paso, Tex., and the annual discharge of the river is much larger at the upper station than at the lower station, as shown by the following table, which gives the discharge at each point in acre-feet:

Discharge of Rio Grande.

Year.	Discharge at San Marcial, above Engle.	Discharge at "The Pass," above El Paso.
	Acre-feet.	*Acre-feet.*
1897	2,225,257	1,374,745
1898	964,677	669,298
1899	239,835	73,503
1900	484,324	169,751
1901	656,274	363,968
1902	200,729	57,768
1903	1,272,069	1,032,844
1904	689,069	473,141
Total for eight years	6,732,234	4,215,018
Average per year	841,529	526,877

These figures show that in flowing from San Marcial to El Paso the river suffers an average annual loss of 314,652 acre-feet, or more than 37 per cent of its water, by irrigation, evaporation, and percolation.

The records also show for San Marcial a minimum annual discharge of 200,729 acre-feet and a maximum annual discharge of 2,225,257 acre-feet, while those for El Paso show a still greater discrepancy between the minimum and the maximum flow. In order, then, to get a uniform annual supply of 600,000 acre-feet for irrigation, the reservoir at Engle must be very large and must present a surface for evaporation that is as small as possible, the evaporation being 84.8 inches per annum in that dry atmosphere. It has also been demonstrated by a long series of tests that the amount of silt carried in suspension by the water of this river is phenomenal, being sufficient to produce a deposit of solid mud that is 1.8 per cent by volume of the total discharge of the river. The reservoir site at Elephant Butte, near Engle, has been chosen with reference to these conditions. The proposed reservoir will be long, narrow, and deep, having a maximum depth of 175 feet, a length of over 40 miles, and a storage capacity of 2,000,000 acre-feet. Sixty per cent of its capacity will hold all the mud that can come down the river in eighty years, but its deep, narrow form will present ideal conditions for sluicing out this mud as opportunity presents itself, advantage being taken at times of an empty reservoir and a flood in the river, or a supply of water from a storage dam above constructed for the purpose.

CONSTRUCTION FEATURES.

At the dam site the bed rock is 65 feet below the present river bed, and the proposed dam will be 255 feet high from bed rock to crest. The crest will be 15 feet above the level of the spillway. A gap 1½ miles west of the dam site forms a natural spillway at the proper level, but this gap is in soft material and will require masonry and riprap. The bed rock is firm sandstone, dipping upstream, and it outcrops on both sides of the river to a height far above the crest level. The dam is to be of cyclopean concrete. There is an unlimited quantity of hard, tough, heavy trap rock near at hand that will be excellent for the broken stone and large bowlders necessary in the structure.

In drawing out the water for irrigation it can pass through water wheels and produce an immense amount of power. The main irrigation canals will also have drops in them that can be utilized for power. The soil in which the canals will be excavated is tight and the silt from the river will make them practically impervious.

It is estimated that the dam, the spillway, the various diversion dams, and the necessary system of canals will cost $7,200,000, or $40 per acre for the land irrigated.

The surveys and tests made by Prof. Charles S. Slichter at "The Pass," a narrow gorge just above El Paso, where the bed rock is 90 feet below the river bed, show that there is practically no underflow at that point, and demonstrate that there is no necessity of going to bed rock with low diversion dams to prevent underflow. Professor Slichter's work also shows that submerged dams from bed rock to river bed, which have been often proposed on this river in order to bring up the supposed underflow, would be of no use, as there is practically no underflow to bring up. At ordinary stages of river there is very little percolation, except at points where the understratum of silt has been recently eroded by floods or the river has taken a new channel.

IRRIGABLE LANDS.

The 180,000 acres of land to be irrigated are in a long, narrow valley, and the return water from the irrigation of the upper valley can be rediverted on lands lower down the valley. This feature, and other favorable conditions, coupled with the fact that the whole area to be irrigated has an average annual rainfall of 9.3 inches, make it entirely safe to estimate on a duty of 3⅓ acre-feet per acre at the outlet of the reservoir. In other words, it is considered safe to estimate that 600,000 acre-feet per annum drawn from the reservoir will irrigate 180,000 acres of land. This estimate is on average crops, including alfalfa, orchards, corn, grain, vegetables, etc.

Under present conditions the river bed is often dry from four to six months in a year, while disastrous floods come at other times. It is expected that the Engle Dam and the proposed irrigation will change these conditions for the better. The storage dam will hold back all the floods and distribute them over the irrigation period of ten months. The water will be let out as needed and there will be no more disastrous floods below the dam. The river bed will never be dry at any time of year, as the return water from such a large irrigated area will form constant springs along the whole course of the river. Lastly, the supply of ground water for pumping will be greater and more constant than it now is, as the water entering the ground from the irrigated lands will form a constant source of supply.

The valley of the Rio Grande is remarkably fertile. The section under consideration is from 3,500 to 4,000 feet above sea level, and the climate is healthy and delightful. The crop season is long, and the whole region is tributary to El Paso, with its numerous railroads, thus insuring a good market for all products.

INTERSTATE AND INTERNATIONAL QUESTIONS.

This project is peculiarly interesting, not only because it will irrigate so large an area of valuable land, but because it will supply water to settle an interstate question between New Mexico and Texas, and an international question between the United States and the Republic of Mexico.

In making the plans for this Rio Grande project the engineers of the Reclamation Service have recognized the existence of these interstate and international questions, and have provided as much water for the El Paso Valley in Texas and Mexico as would have been supplied by the proposed international dam at El Paso, but they have not stated how this El Paso Valley water should be divided between Texas and Mexico; neither have they expressed any opinions as to the sovereign rights of the Territory of New Mexico, the State of Texas, or the Republic of Mexico.

DIAMOND-DRILL METHODS.

By G. A. HAMMOND.

After a reconnaissance has been made and the feasibility of the project determined, it is necessary to look into the matter of suitable foundations for the proposed dam; or, in the case of a natural reservoir, to ascertain whether its bottom will hold water. For this purpose the diamond drill is employed.

The drill man usually finds that he has arrived before the road makers. In this case provision must be made for hauling the drill to the site of operation. In some cases a hand drill may be transported on pack animals to the reservoir site and lowered over the cliff to the river below.

It is also necessary to ascertain whether the water is fit for boilers. If it is found to be of good quality, the question of fuel is next to be considered. It has been the experience of the writer that good water and fuel are seldom found together. When salty water is found and the contemplated borings are not too extensive, hand drills are employed, water being used only for washing the material out of the bore holes. The motive power is obtained by hand cranks. In hand drilling progress is slower than where steam is employed, but when the cost of fuel and the hauling of water long distances are considered it may be found cheaper.

On most projects hand drills have been used, since, owing to their light weight, freight charges are saved in railroad shipments. In some localities it has been found impracticable to use steam drills on account of the bad water for boilers, and the scarcity of fuel.

In one instance the work was started with hand-power drills, but encountering granite bowlders 26 feet thick, which were too hard and large for hand work, a steam drill was employed to drill and ream the bowlders so that the casing could be put through and driven to bed rock. In another instance the project was 12 miles from water, and much farther from fuel, so that the use of steam drills was impossible.

Diamond drills are now used extensively in all parts of the world. The idea was brought out in the year 1863 by a French engineer, who built and operated the first drill and introduced the carbon to the professional world. Carbons are found in Brazil. Borts also are found in Brazil and in South Africa. Borts are used in soft rock, but they are not of proper structure for hard rock, as they have a cleavage plane which is not found in the carbon. The cost of bort is about one-fourth that of carbon.

In commencing drilling operations, efforts are made to equip all the parties with casing and rods of standard size, so that if work should not progress satisfactorily on any project, owing to some unforeseen contingency, such as encountering of harder material or finding the depth to rock being greater than anticipated, part of another outfit could be sent in and used with the one already on the project, and in that way a saving in freight charges effected by not having to ship a complete outfit.

The Service equipment has not yet been entirely standardized, owing to the fact that many of the appliances are comparatively new and valuable; but as the objectionable material wears out it will be replaced by standard equipment. For the work now in hand, the standard drill will consist of $2\frac{1}{2}$-inch extra heavy flush-joint casing, $1\frac{7}{8}$-inch drill rod, and $2\frac{1}{16}$-inch diamond bit. The large bit is found to be more satisfactory in the rock encountered in the lava country.

A wooden derrick is employed, which can be trailed behind a wagon; this can be taken down, moved, and set up ready for work in a few minutes. Six or eight hours would be required to make the same move with a steam drill. After the derrick is set up on the plank foundation and guide for casing, the casing is lowered through the hole in the plank, and the rod is put in the casing with a steel X or cross bit on the bottom. Two men take hold of the rope, which passes through a pulley at the top of the derrick and is hooked in a water swivel screwed in the top of the rod, and pull until the rod is raised the distance required by hardness of material; the rod is then let fall and the bit cuts the earth. The rods are hollow, and water is forced through them by means of a hand pump and a hose attached to the water swivel. The earth which has been loosened by the bit is thus forced up and out over the top of the casing. The foreman then clamps a pair of tongs to the casing and by slowly moving it back and forth the casing cuts the side of the bank and follows the bit down.

If a bowlder is encountered, loose material is forced out by the pump, the rods are withdrawn, and a piece of dynamite with exploder attached is lowered by wire to the bowlder, the casing is pulled 2 or 3 feet, and the dynamite is exploded by battery.

When rock is found, the drill is set over the casing, a diamond bit is lowered to the bottom, rods are connected to the drill, and boring is commenced.

Prior to March 1, 1904, some machines were equipped with sleeve pipe and heavy iron hammers, the method employed being to force the pipe by driving. The result in hard material was very disastrous to the pipe, and several hours were required to pull for blasting or to pull out when the borings were finished. By using flush-joint casing and powder, progress is much more rapid, and the casing can be pulled in a very short time.

In the drilling department are four steam drills and six hand drills, which will be employed when to advantage in the work. The foremen are provided with blank forms of daily and monthly reports which they are required to make out and send to the superintendent of borings at Salt Lake City. In that way a very close watch is kept on the work, and by referring to the daily reports the superintendent can at any time tell where his presence is most needed.

Parties are made up, when convenient, of a foreman who understands the driving of casing and the handling of a diamond drill. Foremen receive from $90 to $100 per month. The diamond bits are set by the superintendent on his regular visits. On projects where the rock is very hard or where more than one drill is in use, a diamond setter is employed as chief of party, at $150 per month.

MEAN-VELOCITY AND AREA CURVES.

By F. W. Hanna.

FACTORS OF STREAM DISCHARGE.

Inasmuch as the discharge of any river is the product of the cross-sectional area and mean velocity for that stage, the most convenient and logical place to seek for guidance in the construction of a discharge curve is in these related functions. It is easier to follow changes in these variables individually than as product. Any study, therefore, that will throw light upon the nature of either of these functions will give valuable knowledge as to the location and nature of the discharge curve. By plotting for varying stages of water the discharges, mean velocities, and areas for any river cross section as abscissæ and the corresponding gage heights as ordinates a general curvilinear relation between any one of these functions and the gage height can be seen to exist. Moreover, where conditions of curvature, slope, cross section, and bed are similar for the same or different streams, an equal resemblance is noted in all of the above like curves. This concomitant similitude of channel and curves indicates clearly the source for investigation, but it also indicates the impossibility of deriving an exact, and at the same time general, equational law. Of the four determining elements—(1) channel curvature, (2) channel bed, (3) channel slope, and (4) channel cross section—the problem of curvature effect may be omitted, as all gaging stations should be so located as to eliminate this element. Of the remaining three elements the area is affected only by the latter, while the velocity, and consequently the discharge, are affected by all of them.

CROSS-SECTION AREA CURVES.

In order to find some approximate law governing the area curve it will be necessary to make some assumption as to the character of the cross-section curve of the stream. To meet this necessity, in order to be strictly accurate, it should be assumed that the profile of any stream cross section consists of a series of arcs of parabolas whose axes are vertical. As the arcs may be taken long or short, and as each parabola may have a different parameter or may be convex outward or inward, and as a straight line is a limiting condition of a parabolic arc, the above statement, while having the quality of being very general and comprehensive, has the merit also of being capable of very close approximation to the actual conditions. From this principle the degree, variability of degree, and direction of the area function may be developed. However, the results are very complicated, and as the intention of the formulæ here developed is for the purpose of showing the impracticability of using them, rather than suggesting them for use, less elaborate and at the same time just as useful information may be obtained by assuming the profile of the river cross section to be composed of a series of short straight lines. Under this assumption the cross-sectional area will be made up of a series of rectangles and trapezoids, promiscuously placed one on top of the other. Since the lengths of the straight lines may be assumed to be very short, no very great error will be involved in formulæ based on this rectilinear assumption.

If C represents the area below the base of any one of the cross-sectional trapezoids, B the width of its base, θ and φ the complements of the slopes of its sides, x its varying area, y the height of water above its base, and A, $\frac{1}{2}$ (tan θ + tan φ), then it may be shown by calculus that the area equations for the rectangular, trapezoidal, and complex channel are, respectively:

1. $x=By$.
2. $x=Ay^2+By$.
3. $x=\frac{1}{2}(\tan\theta+\tan\varphi)\,y^2+By+C$.

In these equations A, B, and C are all positive quantities (excluding cases of overhanging banks) from the imposed conditions in the hypothesis. B, C, θ, and φ are, however, periodical variables in the third equation, changing for each trapezoid. An examination into these equations reveals the following facts: First, that when a channel is perfectly rectangular the area curve is a straight line; second, that when a channel is perfectly trapezoidal the area curve is a parabola with a horizontal axis extending to the right; third, that when a channel is a promiscuous series of rectangles and varying trapezoids the area curve consists of a series of parabolic arcs with varying parameters and with horizontal axes, which extend to the right, except that when the expresssion ($\tan\theta + \tan\varphi$) becomes negative from an overhanging bank or banks the direction of the axis is reversed. As an overhanging bank is a rare occurrence, the condition will be excluded from the discussion hereafter and the expression ($\tan\theta + \tan\varphi$) will, therefore, be positive.

By differentiating the area equations 1, 2, and 3 with respect to x and y as variables, there result the following expressions:

$$4.\quad \frac{dy}{dx}=\frac{1}{B}.$$

$$5.\quad \frac{dy}{dx}=\frac{1}{2\,Ay+B}.$$

$$6.\quad \frac{dy}{dx}=\frac{1}{(\tan\theta+\tan\varphi)\,y+B}.$$

In these differential equations $\frac{dy}{dx}$ is the tangent of the angle that any tangent to the area curve makes with the x-axis. Now, since $dx>dy$ always, this tangent must always make an acute angle with this axis. Assuming that the gage increments are all taken equal, if the area increment receives any sudden increase in value, as it would where there is a sudden decrease in the slope of the banks, the tangent $\frac{dy}{dx}$ becomes suddenly smaller, and there is a corresponding change in the direction of the curve to the right. If this increase is due to a horizontal line the change in the curve is a sharp angle, if to a gradually sloping line the angle will be rounded off. Again, if the area has been increasing rapidly, caused by one or both banks becoming more nearly perpendicular, the degree of curvature will suddenly be decreased and the curve will become flatter. If at any place in the curve the banks become perpendicular, $\frac{dy}{dx}$ becomes constant and the curve proceeds on a straight line.

By differentiating equations 4 to 6 and multiplying by x there are obtained the following relations:

$$7.\quad \frac{d^2x}{dy^2}\,x=0.$$

$$8.\quad \frac{d^2x}{dy^2}\,x=2\,Ax.$$

$$9.\quad \frac{d^2x}{dy^2}\,x=(\tan\theta+\tan\varphi)\,x.$$

Now, by the theory of curvature, when the expression $\frac{d^2x}{dy^2}x$ is positive the curve is convex toward the y-axis. Inspection of equations 7 to 9 shows that this expression is in every case positive, whence the area curve is always convex toward the y-axis, and, therefore, always concave toward the x-axis.

From the above deduction the following facts concerning the area curve must logically be inferred: The construction of any area curve must be preceded by a careful study of a complete profile of the river cross section. If the cross section is perfectly rectangular or trapezoidal the area curve may be drawn by plotting a few salient points and by drawing through them a straight line or a parabola, as the case demands. However, if the channel is irregular, varying from one form to the other, as is almost invariably the case at all gaging stations, the construction of a reliable area curve can be made only by computing from the elevations of the cross-section profile the area for numerous heights of gage throughout its range of variation, plotting these results and drawing through them the resulting curve.

MEAN-VELOCITY CURVES.

The matter of determining the nature of the mean-velocity curve is not an easy task. The fact that so many varying and doubtful elements, such as roughness of bed, slope, area of cross section, and wetted perimeter, enter into its composition makes it to a large degree indeterminate. The Chezy formula, $V=c\sqrt{rs}$, with Kutter's value for c, is probably the best formula from which to obtain information.

Let this formula be written in the following manner: $V^2=c^2s\frac{x}{p}$, where x is the cross-section area and p its wetted perimeter. Now, by substituting the values of x from equations 1, 2, and 3 in this expression, there result the following equations of the mean-velocity curve for the respective conditions of cross section represented by the value of x substituted:

10. $V^2=c^2s\,\frac{By}{p}.$

11. $V^2=c^2s\,\frac{Ay^2+By}{p}.$

12. $V^2=c^2s\,\frac{\frac{1}{2}(\tan\theta+\tan\varphi)\,y^2+By+C}{p}.$

If s be considered constant, which it is for uniform channel cross section and permanence of flow; if c be considered constant, which is practically the case where changes in gage height do not cause increase of roughness of bed and where there is permanence of flow; and if the increase in p be considered negligible, which may be assumed with little error for small rises in a wide, steep-banked stream of uniform depth, then equation 10 is a parabola with its axis vertical, equation 11 is a hyperbola with a vertical axis, equation 12 represents a series of hyperbolas with varying eccentricities and usually with vertical axes, but the axes of which are horizontal when $B^2 - 2(\tan\theta + \tan\varphi)C$ is negative. This is equivalent to saying that when the area below any trapezoid base, multiplied by twice the sum of the tangents of the angles that the banks make with the vertical, is greater than the square of the base of that trapezoid the curve is reversed and the axis of the hyperbola is horizontal. Owing to the properties of these curves and the direction of their axes, if c, s, and p be regarded as constants, it may be expected that the mean-velocity curve will always be concave toward the V-axis when the channel is rectangular or trapezoidal, and will or will not be so when the channel consists of a series of trapezoids, accordingly as $B^2 - 2(\tan\theta + \tan\varphi)C$ is positive or negative.

Evidently these parabolas and hyperbolas will be considerably modified by variations in the channel roughness, slope, and wetted perimeter, but the modifications will rarely upset the similitude. The effect of p, since it is always an increasing quantity for increasing gage heights, will be to throw the curve inside of the theoretical curve; that is, to make it closer to the velocity axis. The effect of s is both positive and negative in action, as it may either increase or decrease for increasing values of y. Its changes depend upon the slope of the channel above and below the gaging station and upon the rising and falling condition of the river. Increases in gage height usually increase the coefficient of channel roughness, and, therefore, usually decrease the value of c. Its effect on the theoretical graph, or curve, is usually conjoined with that of p. The complicated effects of wetted perimeter, slope, and roughness of channel on the theoretical curves make a careful study of the gaging-station conditions absolutely necessary to an intelligent construction of the mean-velocity curve. Such a curve may be drawn by keeping in mind the theoretical curves here deduced, and by studying carefully the cross-section profile for increase in area and in wetted perimeter, by considering the condition of the banks of the river as to growth of grass and trees and as to other obstructions affecting the coefficient of roughness, and by inspecting the conditions of channel both above and below the station for slope influences, and by investigating each measurement to see whether the stream was in a state of permanent flow when it was made.

EQUATION OF DISCHARGE.

Since the discharge of a stream for any stage is the product of the area and mean velocity for that stage, then the equations for discharge become:

13. $Q=\frac{c\sqrt{s}}{\sqrt{p}}(By)^{\frac{3}{2}}$.

14. $Q=\frac{c\sqrt{s}}{\sqrt{p}}(Ay^2+By)^{\frac{3}{2}}$.

15. $Q=\frac{c\sqrt{s}}{\sqrt{p}}[\frac{1}{2}(\tan\theta+\tan\varphi)\,y^2+By+C]^{\frac{3}{2}}$.

All of these discharge equations are of a complicated degree, unsuited to practical application, but they serve to show the following important facts: (1) The discharge curve for a rectangular or trapezoidal channel could be determined were it possible to get entirely satisfactory values for c, p, and s. (2) The discharge curve for the irregularly cross-sectioned channel, which is about the only kind used in stream gaging, is a very complicated equation of the sixth degree with respect to Q and y, and contains in addition the varying quantities c, s, p, $\tan\theta$, $\tan\varphi$, B, and C, thus making it impossible to obtain any tangible method of applying it. (3) The first derivative, $\frac{dQ}{dy}$, of equations 13, 14, and 15 shows that the tangent to the discharge curve makes an acute angle with the y axis and is always an increasing function for increasing gage heights unless influenced by unusual fluctuations in s, p, and c. (4) The second derivative, $\frac{d^2Q}{d^2y}$, of these equations shows that the curve is always convex toward the y-axis, and therefore concave toward the Q axis. Fluctuations in s, p, and c are probably never so great as to upset these conditions. (5) The chief and controlling factor in shaping the progress of the discharge curve is the condition of channel.

APPLICATION OF CURVES.

So far there have been considered only the nature and method of construction of the cross-sectional area and mean-velocity curves. It yet remains, therefore, to point out their practical utility. Evidently, neither of them would be of much use in and of itself, as there is little need for the determination of river cross-sectional area or mean velocity as ultimate results. Their sole function in the problem of hydrography is as auxiliary components of discharge determination, the discharge being the simple product of these two values. Anything that tends to more accurate results in obtaining these functions increases, therefore, the precision of discharge estimates.

The standard profile and area curve of the river cross section are very important for every permanent gaging station. This profile should be very carefully determined by means of soundings at low water and levels up the banks to the high-water limit. The standard area curve can be determined from this standard cross-section profile. If the area is computed for various gage heights which have been selected at the critical points in the cross section, a reliable curve can be constructed by using the areas as abscissæ and the gage heights as ordinates. This curve once constructed for a permanent station becomes a criterion whereby computed areas obtained at the time of measurements may be checked. Also, when on account of high water or any other hindrance soundings can not be obtained, the depths may be obtained directly from the standard cross section and the area taken directly from the standard area curve. In nonpermanent stations this standard area curve will serve to show the amount of scour or fill of the channel and the standard cross section will show its location. The standard area curve should be kept on file and every area computation should be compared with it as soon as it is made. The very important additional use of the area curve in determining the discharge curve will be mentioned in connection with the remarks on that curve.

While the area curve may be obtained immediately for any gaging station, the mean-velocity curve can be constructed only after a series of discharge measurements has been made. As soon as a few fairly well distributed gagings have been obtained the velocities should be plotted and the most probable curve drawn. This curve when kept on file will serve to check subsequent velocity determinations, and will, therefore, disclose back-water conditions, errors in computation, and current-meter defects. When all the yearly measurements are made, or at any time that it is desirable to make a discharge curve, this mean-velocity curve can be drawn to correspond to the whole data and then used in connection with the area curve in constructing the discharge curve.

Owing to the fact that close checks have been kept by the hydrographer on the area and mean-velocity computations, the discharge measurements will probably make a very reasonably smooth curve, and may, therefore, give no further trouble. However, if the measurements are somewhat at variance with one another, or are not well distributed, it is a comparatively easy matter to draw or extend the mean-velocity curve, which is much less complicated than the discharge curve. By using the standard area curve and the mean-velocity curve so constructed a satisfactory discharge curve may almost invariably be constructed. This discharge curve is obtained by taking the products of the abscissæ of these curves for the corresponding abscissæ of the discharge curve for various gage heights. These products should be obtained for every foot or half foot of gage height where the degree of curvature is high, but where the curvature approaches zero these intervals may be increased somewhat.

IMPORTANCE OF GENERAL HYDROGRAPHIC DATA CONCERNING BASINS OF STREAMS GAGED.

By Robert E. Horton.

The publications of the Survey on streams and gagings are largely utilized by persons familiar with and especially interested in some particular stream. They are also used by persons desiring to compare adjacent catchment basins, and gross errors may be and often are committed in attempting to estimate the yield of a drainage basin from that of an adjacent stream or from the yield of the same stream at some point where it has been gaged.

Consider, for example, a stream flowing out of a rocky, forested mountain region and over a broad plain with deep soil under cultivation. Suppose that the stream has been gaged at the foot of the mountains, but it is desired to estimate its run-off at the foot of the plain. A very common method in such cases is to increase the discharge in proportion to the increased drainage area. This method is legitimate in some cases, and unless the person making the estimate had a knowledge of the hydrographic features of the two sections of the basin and of their effect on the run-off and regimen of the stream he might easily infer that such a method was applicable in this case. As a matter of fact, in the case cited it is probable that the use of such a method would result in an estimated discharge at the foot of the plain considerably in excess of the truth. An error of this kind which cost perhaps $100,000, and which resulted in the complete failure of a large project, has come under the writer's observation.

In the reports of the Survey as hitherto published but little data have been given regarding the character of the drainage basins. To persons unfamiliar with the conditions, the fact that gagings at two points on a stream show widely different run-off may be taken as evidence of inaccuracy of the gagings, whereas the real reason for the difference may be in the physical character of the basin.

As the records continue from year to year, conditions in the catchment basins as to forestation, culture, drainage, evaporation, etc., may progressively change, causing a change in the run-off and in the rainfall–run-off relation.

It is important that the state of each drainage basin as regards the above-named features shall be early recorded, so that when changes occur in the future their relation to the streams may be rationally traced. The physical data which it appears most important to include in descriptions of gaging stations may be classified as follows:

(*a*) Shape of drainage basin and description of tributaries—whether sparse or numerous, with branches or without, etc. This has an important bearing on the flood discharge.

(*b*) Topography. Especially that of the upper reaches of the stream as compared with the intermediate and lower drainage areas.

(*c*) Soil and underlying rock. The relative location of portions of the area having rock and soil surface, respectively, should be noted. It is also well to know whether the rock is impervious, as slate or granite, or porous and fissured, as sandstone and limestone. The character of the soil, whether sand or clay, porous or impervious, deep or shallow, moist or dry, should also be noted.

(*d*) Lakes and marshes. Their location, area, and range of variation in stage are important as modifying both the flood discharge and the low-water regimen; the existence and extent of flood plains and overflowed areas may also be noted.

(*e*) Culture. The location of the larger forest areas. The percentage of forest and tilled land. The area of barren rock surface, etc. It is also desirable to state the extent of sodded meadows and pasture lands, as such areas afford maximum evaporation losses.

(*f*) Springs and ground water. The depth of the ground-water table below the surface. The seasonal fluctuation in level to which it is subject, and general facts as to the presence or absence of springs. It may also be of great value in interpreting gaging records to know whether the topographic drainage basin receives water from or yields water to adjacent basins through ground water.

(*g*) Diversion and storage. Irrigation, drainage, and other artificial influences modifying the stream regimen should be noted in the records.

(*h*) Rain and snow. The regimen of a stream in a northern climate may differ widely from that of a similar southern drainage basin, owing to the fact that a large part of the northern winter precipitation is held for months as surface storage in the form of snow.

Peculiarities in the distribution or occurrence of precipitation in each locality should be noted, even if details as to the amounts of such precipitation can not be entered into.

If such data as those above outlined are carefully collected and published, the gaging records may become of greatly increased value and may be safely utilized by those not familiar with the character of the streams in question.

With such data before him, one could compare the gaging records for streams on the plains with those for streams in the Central States, and, for example, reasons would at once appear why it is that one river may yield but 2 inches run-off per year from 15 inches rainfall, while another yields 10 inches run-off from an equivalent precipitation.

Conditions such as above described are frequently brought to light in the reports of the Survey, yet it is not always possible to find in the published reports the underlying reasons for them. Such physical data as have been outlined form properly a part of the subject-matter of hydrography, and the above notes are given not as a criticism of the work done, but in the hope that they may suggest what auxiliary data are needed to render the stream-gaging records themselves most complete and useful.

EFFECT OF AQUATIC VEGETATION ON STREAM FLOW.

By Robert E. Horton.

Three principal classes of aquatic plants that influence stream flow may be mentioned. The first, algæ, has been found to give little trouble, usually growing in small brooks or on rocks in rapids and shallows. The second class, a fine long wiry grass, sometimes called "eel grass," has been observed by the writer, notably in Saratoga Lake outlet, or Fish Creek, in New York. It is accompanied by the third form, the common dark-green fronded water plant, or eel grass, of New England rivers, in which, however, the fine wiry grass seems to be the chief source of interference.

Fish Creek is a smooth-flowing stream with sandy bed and a very steady regimen, its principal supply coming from Saratoga Lake. It is utilized by important water powers near its mouth. The grass is so scattered that its effect on the stream would at first appear doubtful or unimportant. An examination shows, however, that the stream is filled with swirls and eddies, and its current is very hard to measure with a meter. As the season advances and the grass growth increases the slope and flow become so decreased that cleaning is necessary, and a boat is sent through to cut the grass. Aside from the grass, the conditions are favorable to accurate measurement.

Discharge measurements of Fish Creek, New York, in 1904, showing effect of grass in stream.

Date.	Gage height.	Discharge.	Condition.
		Second-feet.	
August 25	1.46	283	Much grass.
October 5	1.47	311	Some grass.
November 11	1.25	381	Grass mostly gone.

On many Michigan rivers fronded water grass is so common and prolific than a suitable site for current-meter work can hardly be found in the course of the stream. Upper St. Joseph River, a flat, winding, smooth-flowing stream, affords an interesting example. A gaging station was established in 1902 at Mendon, at a highway bridge, where apparently measurements could be made with an excellent degree of accuracy. There is no artificial influence disturbing the stream for many miles above or below and no back water from dams. A descent of over 20 feet slope of stream surface intervenes between the gaging station and the nearest dam below. The gage is located in the open stream channel one-half mile above the bridge where measurements are made. It was soon found that there was a wide variation in the discharge at a given stage, and this could only be attributed to the effect of back water from aquatic vegetation growing below the place of measurement.

Measurements made in early spring, before the growth of grass began, showed a maximum discharge for a given stage. It was proposed, therefore, to develop a maximum or normal discharge curve showing the conditions in the absence of vegetable growth in the stream. The station has been continued three years, and each season, as the summer advances and the growth of aquatic vegetation increases, the discharge measurements fall short farther and farther from the normal discharge curve.

Ultimately a series of discharge curves will be drawn parallel to the normal curve showing "contours" of discharge with varying degrees of grass obstruction, and in this way an approximate estimate of the summer discharge may be arrived at, somewhat after the method used in estimating discharge of western rivers having continually shifting beds.

SANITARY REGULATIONS GOVERNING CONSTRUCTION CAMPS.

By M. O. Leighton.

NEED FOR SANITATION.

Sanitation, according to the popular idea, is a science which has no pecuniary utility—that is, the purposes are entirely humanitarian and have little or no relation to money values. This idea is erroneous. There are phases of the sanitary question which are quite as important from the financial as they are from the purely social standpoint. Almost nowhere is this better exemplified than in connection with great construction camps.

The physical condition of the laborer is the measure of his day's work. Whether his occupation be active or sedentary, his achievements are finally controlled and limited by his relation to physical ills. The difference between the achievements of a person in good and in poor physical condition is a matter of common observation. When this difference applies to a whole community, its total is increased in direct ratio to the number of persons, and in a camp of several hundred workmen it becomes a serious item. It may represent the difference between success and failure in the completion of a piece of work within a specified period, in the character of the work, or in its permanence after completion.

It is only a step from the poor physical condition that is responsible for indifferent labor to the acute illness, during which all productive labor ceases. A general epidemic of acute disease in a construction camp is disastrous. Disease rather than engineering difficulties has been the cause of absolute failure in a few great projects. The earlier attempt at the construction of the Panama Canal is a notable instance. In short, sanitation is one of the vital necessities in construction camps.

Construction camps maintained in connection with the various irrigation projects afford exceptionally favorable ground for the dissemination of disease. There the men mingle more intimately than in almost any other walk of life. Culinary and toilet utensils are used in common, and every other feature favorable to the rapid dissemination of disease is provided. This is true, of course, of all construction camps, but there are in these arid lands additional hazards which no human foresight can provide against. Camps are invariably remote from bases of supplies, and food must therefore be inferior to that which could be provided in more favorable locations, but most important of all is the fact that water is often scarce. The very conditions which make irrigation construction necessary also add to the dangers attendant upon that construction. In arid countries the desire for water on the part of workingmen is far more acute than in humid regions. It is natural that under such circumstances men consider quantity of water rather than quality. Too often there is no choice to be exercised—the one available supply must be used, whether it be good or bad. Thirsty men give little thought to any characteristic of water save that of wetness.

The above considerations make it practically incumbent upon those in charge of reclamation construction to provide against all conceivable conditions or circumstances which might result in an outbreak of disease among the engineers or laborers. To this end it is proposed to incorporate into the specifications of each contract advertised under the reclamation law the following clause:

The use and sale of intoxicating liquor will be absolutely prohibited on the work except under the direction and supervision of the engineer in charge or his agent, and then only for medicinal purposes; and it is furthermore hereby understood and agreed that the chief engineer may establish rules for sanitary and police regulations in all forces employed under this contract, and should the contractor fail to enforce these rules the engineer may police working gangs and camps and assess the proper proportion of the cost against the contractor, the amount so assessed to be deducted from any sum due said contractor.

SANITARY CODE FOR RECLAMATION WORK.

The following code has been promulgated to govern the location, construction, and maintenance of camps. In drafting these regulations it has been necessary to bear in mind the limitations which prevail in the region covered by the work. The natural conditions and the remoteness of camps from bases of supplies, as well as the widely varying necessities attendant upon the different branches of the work, render it impracticable to attempt to establish and enforce finely definite regulations. In this code it has been the intention to express general principles, with the purpose of having them carry the details by implication.

Camp sites.—Especial care should be exercised in the location of camp sites. They should be placed upon well-drained ground where sun and air may have free access, and as far as possible from bodies of quiescent water, such as bog holes, seepage ponds, and sinks. Low places along river bottoms should be avoided whenever possible, and in case it becomes necessary to establish a camp at any point where the ground-water table is close to the surface each camp structure should be surrounded at its base by a trench of from 1 to 2 feet in depth and an outlet provided for emergency use to drain off water which may collect there.

Camp structures.—Camp sites should always be selected convenient to some source of water supply, but the camp structures should not be placed in close proximity thereto. The slope and nature of the soil should be considered, and no structure should be erected at a point from which effete matter may filter through the ground and infect the water supply.

Lavatory arrangements.—Arrangements should be made for the rapid and complete disposal of water from wash basins, tubs, etc. In the case of permanent camps, a sink should be provided with pipe connection to a covered cesspool, located at a point from which there will be no drainage to a well or other stored water supply. Whenever the conditions are such as to make this arrangement impracticable, the lavatory should be placed at a point similar to that described in the case of the cesspool. Where the nature of the ground is not such as to readily absorb all wash water, an excavation of proper dimensions should be made and filled with loose material to a level with the ground surface.

Water supply.—The water supply for all camps, especially that used for drinking and cooking, should be absolutely free from all suspicion of dangerous organic contamination. Old wells in questionable positions with reference to surface or outbuilding drainage should be avoided, and wherever there are no wells free from such suspicion upon the site of a permanent camp new ones should be sunk at unquestionable points. Whenever it is necessary to erect a camp at which the only water available is open to suspicion or is known to be contaminated with animal wastes, such water should be purified by boiling or by filtration. If the former course is taken, great care should be exercised to maintain at all times a sufficient quantity of stored water which has been cooled after boiling. In many cases where boiling has been resorted to for water purification this rule has not been observed, and the members of the camp, finding no water or only that recently boiled, have been induced to drink raw water. Such an act destroys the value of all previous precautions. Filtered water is far more palatable and generally as safe as that which has been boiled. The Berkefeld or some similar filter is best adapted for such uses. It can be provided in various sizes and should be installed with a suitable container to store filtered water. The pressure should be developed either by pumping direct through the filter or by placing a small reservoir at some point higher than the filter and allowing the filtration process to go on continuously into the clear-water reservoir.

Flies and mosquitoes.—The most important sanitary provision in connection with camps is that of exclusion of flies from cook tents, mess tents, and privy vaults; yet this is the very provision which is most frequently overlooked. According to the report of the commission appointed by President McKinley to investigate into the occurrence of typhoid fever among the soldiers during the Spanish war, almost every outbreak which occurred was due to the lack of sufficient protection against flies. Therefore special care should be taken to exclude flies from all places in which food stuffs are exposed, and, if necessary, in the large camps a man should be detailed to accomplish this purpose.

Mess and cook tents or houses should be provided with screens at all windows, and each door which leads into the outer air should be provided with a vestibule about 4 feet square, constructed in the following manner: The dividing partition and the door between the cook or mess tent and the vestibule should be of wood, as well as the side walls of the vestibule, for a distance of about 1 foot from the dividing wall. The door and walls should be painted black or some dark color. The remainder of the vestibule should be of durable wire netting and the door leading out from the vestibule of the same material. With such a provision the flies which enter the outer screen door during the time when people are passing through will be caught in the vestibule and will congregate upon the wire part of the vestibule in preference to the dark-colored wood next to the cook or mess tent, and only a very small proportion of the flies entering the vestibule will under such conditions escape into the larger apartment. If the cook and mess tents or houses are not built under a common roof the passage between the two should be thoroughly screened, and if an entrance is made from the passage to the outer air vestibules should be provided as above described.

Of equal importance is the thorough screening of privy vaults and vault apartments, for it is from such places that flies carrying upon their bodies effete material diffuse throughout the camp an epidemic by coming in contact with foods. Without proper screening a disastrous epidemic of typhoid may be easily spread through a camp if one of the members of the camp, or, indeed, a transient guest, should be in the prodromal stage of the disease. It is at these times that the discharges are most virulent. Vaults should therefore be built of tight material and be provided with a vestibule at the entrance similar to that above described in the case of cook and mess apartments. A box of dry earth should be kept in each closet and the contents liberally sprinkled in the vault after using.

Wherever it is possible to do so sleeping apartments should be thoroughly screened, not only for the comfort of the members of the camp, but to protect them from mosquitoes, which transmit the malarial infection. The genus *Anopheles*, which transmits the malarial infection through its proboscis, does not commonly fly about during the day, but is active at night and should be excluded from sleeping apartments.

Camps should be well supplied with sticky fly paper in cook and mess apartments, and all flies, mosquitoes, etc., should be excluded, so far as it is possible to do so, before food stuffs are exposed.

Garbage.—Garbage should not be allowed to remain upon camp premises for any length of time, but should be removed as frequently as conditions will allow. While it is necessarily stored upon premises it should be kept in metal containers and protected from flies and other vermin.

Privy vaults should always be placed at a considerable distance from other camp structures, should be kept as dry as possible and should not be so placed that the drainage therefrom will infect the local water supply.

KLAMATH PROJECT.

By J. B. Lippincott.

INTRODUCTION.

The basin of Klamath River was visited in October, 1903, by John T. Whistler, engineer, who reported on it under date of November 2, 1903. H. E. Green, engineer, also visited this basin in October, 1903, and reported thereon in a communication entitled "Report of reconnaissance of the country lying on either side of the boundary line between California and Oregon in the Klamath and Ashland Atlas Sheets of Oregon, and the Shasta and Modoc Lava Beds Atlas Sheets of California." Both reports were transmitted to the Secretary of the Interior in November, 1903, and were printed in the Second Annual Report of the Reclamation Service. They were preliminary and were considered sufficient justification for a further investigation of this section.

In the latter part of June, 1904, the writer made an extended trip through a portion of the basin of Klamath River and Lost River with T. H. Humpherys, assistant engineer. No extensive surveys had been made at that time, Mr. Humpherys having spent his time in acquainting himself with the general situation. The basin of Williamson River, which lies largely in the Klamath Indian Reservation, has not yet been explored, but it is stated currently that there are large areas of excellent land in this reservation that may be reclaimed. This report is therefore based very largely on general information received from Mr. Humpherys and on a personal reconnaissance by the writer, aided by the topographic maps of the Geological Survey. The data based on the surveys now being made are not yet available.

Permanent gaging stations are being established by Mr. Humpherys at Keno, on Klamath River, at the Horse Fly reservoir site on Miller Creek, at the Clear Lake reservoir site on Lost River, a gage rod and evaporating pan in Tule Lake, near Merrill, and a gage rod in Klamath Lake, near Klamath Falls. Measurements of the flow of Link or Klamath River at Klamath Falls will be continued. Mr. Whistler's gaging station on Lost River, in Langells Valley, will be abandoned, as will the gaging station on Lost River at Olene.

GENERAL LOCATION.

The general location is in Klamath County, Oreg., and in Modoc and Siskiyou counties, Cal. The State line to a singular extent divides this basin between the two Commonwealths. For instance, the Clear Lake reservoir site lies in California, but the water impounded therein can best be used in Oregon. The Horse Fly reservoir site is situated in Oregon, and this water can best be used in Oregon. A diversion conduit from Upper Klamath Lake will serve lands both in Oregon and California. The falls of Klamath River are in both California and Oregon, and this power can best be used for the pumping of water onto lands in California. Klamath River is navigable in a portion of its course and is so used commercially.[a] Upper and Lower Klamath Lakes are commercially navigable and are cut in half by the State line. Tule Lake is navigable, but is so used only to a slight extent; it is cut by the State line. We therefore have an interstate situation, both as to water supply, power, and irrigable lands.

This immediate region has no railroad, the nearest station being Pokegama, from which a stage drive of some 24 miles is made to Keno, from which point Klamath River may be navigated by means of a gasoline boat to Klamath Falls, which is the county seat of Klamath County. Two railroads are now being projected into this region, one from Pokegama and the other, known as the Weed road, from California. Both these railroads are built primarily for lumbering purposes.

DRAINAGE.

The principal streams of the Klamath basin are Wood, Williamson, Sprague, and Lost rivers. The drainage is quite singular. Lost River at present does not flow into Klamath River, but into Tule Lake, which has no outlet.

Klamath River.—Wood and Williamson rivers are the two principal tributaries of the Klamath. Wood River is fed by some very large springs, the water supply apparently coming in large part from the country around Crater Lake; Williamson River drains the region northeasterly from Klamath Lake.

These streams flow into Klamath Lake, which covers 67,220 acres, and, if the marginal swamp lands are included, 94,000 acres. The river is therefore regulated by this large area of lake and swamp. From Upper Klamath Lake the stream falls abruptly about 56 feet, and is called Link River. At Keno the lower rapids of Klamath River begin. Link River also supplies Lower Klamath Lake, which covers 29,400 acres with water and 88,300 acres of water and marginal swamp. The lower lake acts as an additional regulator, and the fluctuation in river height at Keno probably does not vary over 2 or 3 feet.

On October 25, 1903, Klamath River was measured at Klamathon by Mr. H. E. Green at its low-water stage, and its volume found

[a] An act of Congress approved February 9, 1905, authorizes the Secretary of the Interior to interfere with these navigable waters by constructing irrigation works. Similar permits have been granted by the States of California and Oregon.

to be 2,000 second-feet. It was stated at the time that the river was lower than at any previous time for twelve years. The low-water flow of Link River in 1904 was 1,773 second-feet. Upper Klamath Lake may be used as a storage reservoir, if desirable.

The elevation of Klamath River near the Southern Pacific crossing at Klamathon, according to the topographic sheets of the Geological Survey, is less than 2,200 feet. The elevation of the river at Keno is 4,086 feet, as determined by levels run from Klamathon, which indicated a fall of about 1,900 feet in a distance of 40 miles. Near the mouth of Falls Creek there is a drop in the river of 400 feet in 2 miles, as indicated by the topographic map on the Shasta quadrangle. With a low-water flow of 2,000 second-feet, this 400-foot drop would develop 91,000 theoretical horsepower. Beginning at a point about 6 miles below Keno the map indicates a drop in the river of 800 feet in a distance of 10 miles—sufficient to produce 181,000 theoretical horsepower, with a flow of 2,000 second-feet. From this it will be seen that the opportunities for power development on the river are very great, and it will be shown later that there is the possibility of using this power for irrigating arid lands.

It appears to be feasible to make an excavation near Keno in the channel of the river at the head of the rapids, where the river drops 60 feet in a short distance, by means of which the water can be drawn off of the marshes surrounding Lower Klamath Lake, as well as from Lower Klamath Lake itself. This difference in elevation probably could be made sufficient so that the flood waters of Lost River which are not impounded in the reservoir sites on Lost River could be turned into Klamath River and away from Tule, or Rhett. Lake. The advantage of such a proceeding will be treated later.

Lost River.—Lost River is an interstate stream, which flows to a material extent through Clear Lake. Horse Fly reservoir site, on Miller Creek, tributary to Lost River, has a drainage area above it roughly estimated at 200 square miles. Its elevation is 4,792 feet. The basin is fairly well timbered and apparently has a fall rainfall and winter stream flow. The reservoir basin is very flat and swampy and it is estimated that the area of the valley is about 3,500 acres, and that a dam 50 feet high would give a capacity of 100,000 acre-feet. The river flows through a narrow canyon of basaltic rock at the dam site. The land in this reservoir site is largely public and has been withdrawn for a reservoir. The site is of very substantial importance.

Clear Lake reservoir site is situated on the southern branch of Lost River, and above Clear Lake the stream is known as Willow Creek. The drainage area of Willow Creek, above Clear Lake dam site, as obtained from the topographic sheets, is 577 square miles. The area of this lake as shown on the topographic sheet is 12½ square miles, or 8,000 acres. A dam 40 feet high at dam site below the lake would probably hold half a million acre-feet. The dam site is in a canyon of volcanic rock. Apparently there are excellent spillway opportunities and probably the dam could be best constructed of earth and loose rock. There is a very pronounced public opinion to the effect that the principal supply for Lost River comes down Willow Creek. The grades into Clear Lake are very singular. Willow Creek in flood discharge overflows into Clear Lake, but at the same time a large portion of this water passes down Lost River. When the creek falls Clear Lake begins draining into Lost River and discharges through its intake channel. The area of Clear Lake, according to land-office surveys, is 9,200 acres. The area of adjacent swamps, according to survey, is 15,000 acres. The drainage basin above the lake is covered by a sparse growth of pine trees. The elevation of the lake is 4,533 feet, according to the contour maps. The rise of the lake during the past winter would indicate an inflow of about 150,000 acre-feet additional to the discharge of Lost River, which was continuous during the inflow period.

Lost River discharges into Tule Lake, the area of which is 90,000 acres. During the past winter the lake had a net rise of 7 feet, indicating an inflow of 830,000 acre-feet. The past winter, however, was one of unusual rainfall. The evaporation in this region is believed to be about 3½ feet. As this lake maintains an area of about 90,000 acres, this would indicate a mean annual net flow of Lost River of 315,000 acre-feet. This agrees with a statement as to the usual annual rise of Tule Lake. There is the opportunity, both at Clear Lake and Horse Fly Valley, to hold over water from wet to dry years. It would seem reasonable to expect that 200,000 acre-feet annually might be obtained from these two reservoir sites. The water from these reservoir sites would naturally be used on Langells Valley, which contains about 12,000 acres of irrigable land; Poe Valley, containing 10,000 acres; Swan Lake Valley, 30,000 acres; Alkali Valley, 20,000 acres; 72,000 acres in all. These areas are gross and only roughly approximate, and probably will be increased by a detailed investigation. It would seem reasonable, however, to consider that these two reservoir sites can irrigate all the underlying agricultural lands in the valleys named. There is practically no public land in Poe Valley, some public land in Langells Valley, and quite a large amount of public land in Alkali and Swan Lake valleys.

As previously stated, the flood waters not impounded in Horse Fly and Clear Lake reservoirs could be diverted into Klamath River and away from Tule Lake.

IRRIGABLE LANDS.

Butte Valley.—Butte Valley is in Siskiyou County, Cal., adjacent to the northern line of the State. It is roughly estimated that it contains over 100,000 acres of agricultural lands, including some 10,000 or 15,000 acres of Government land in the southern portion. The elevation is about 4,200 feet, between 150 and 200 feet above the level of Lower Klamath Lake. Butte Creek and Antelope Creek flow into this valley. The midsummer water supply, however, is quite small and is used for irrigation. There would be an abundant water supply for pumping from Lower Klamath Lake, and a great abundance of power obtainable from Klamath River for lifting this water into Butte Valley. The question as to whether it is commercially feasible to do this is not yet ascertained, but the withdrawals of public land along Klamath River for the purpose of generating power pending this investigation are believed to be justified.

Tule Lake.—Tule, or Rhett, Lake has an area of 90,000 acres, supplied from the inflow of Lost River. Tradition states that at times in the past the lake has been almost dry, that teams have crossed over very considerable portions of its area, and that sagebrush stumps are found in the lake. If Lost River water can be mostly impounded in reservoirs and the surplus diverted into Klamath River by lowering the outlet of the river at Keno and by throwing a levee across Lost River, there practically will be no other supply into Rhett Lake, and with an annual evaporation of $3\frac{1}{2}$ feet, it is believed that the lake would rapidly shrink in area and uncover a large area of land. It is a fresh-water lake. This lake is interstate and navigable, but is only slightly so used. The margin of the lake is meandered by the land office. If the lands that are uncovered are public lands that could be disposed of under the reclamation act, they could be very easily irrigated by means of a diversion canal, either from Klamath River or from Lower Klamath Lake. This is a subject that will require legal opinion. Tule Lake is an interstate navigable lake, and could only be drained by Congressional permission. In January, 1905, the States of California and Oregon, by legislative act, relinquished to the United States any right or title that they might have had to lands in these lake beds, with a proviso that these lands are to be disposed of under the terms of the reclamation act.

Lower Klamath Lake.—Lower Klamath Lake has a water surface of 29,400 acres and a swamp and water surface of 88,300 acres. If the outlet from the lake at Keno can be lowered, as previously suggested, the greater portion of this swamp land can be drained, and probably a large portion of the lake bed itself. This lake is interstate and navigable, and used commercially for navigation. The situation is a duplicate of that at Tule Lake, and if these lands can be drained they can be readily irrigated from Klamath River. The swamp lands are all in private ownership, title having been conveyed by the State.

The areas of the beds of these two lakes that might be uncovered, as suggested, are not definitely known as yet, and are being determined by survey, but it would seem within reasonable limits to say that there might be from 50,000 to 75,000 acres of public lands so reclaimed.

Klamath Indian Reservation.—Klamath Indian Reservation has not yet been investigated, but it is reported that there are large areas of irrigable lands therein, and this will be made a subject of future study. Particular attention is called to the fact that the State of Oregon has a claim pending in court for the swamp lands shown as the Klamath Marsh on the Klamath quadrangle, which lands are in the Indian reservation.

Land withdrawals.—It was deemed advisable to withdraw, at least temporarily, all public lands in the Clear Lake and Horse Fly reservoir sites, the public lands along Klamath River, and such townships as contained public irrigable lands. If the beds of these navigable lakes are public lands, as is believed to be the case, it will probably be possible to reclaim 100,000 acres of public land in addition to over 150,000 acres of private land under this project.

Summary.—The following is a very rough estimate of the gross irrigable areas:

Irrigable from Clear Lake and Horse Fly reservoirs.

	Acres.	Acres.
Langells Valley	12,000	
Poe Valley	10,000	
Swan Lake Valley	30,000	
Alkali Valley	20,000	
Total		72,000

Irrigable from Klamath River.

Between Klamath and Merrill	60,000	
From Merrill to Carrs	10,000	
Bed of Tule Lake	50,000	
Bed of Lower Klamath Lake	20,000	
Total		140,000
Butte Valley, irrigable by pumping		100,000
Total		312,000

The water supply is believed to be adequate for this irrigation.

EXISTING CANALS.

A canal has been constructed from Lower Klamath Lake, near the State line, for the irrigation of the north shore of Tule Lake. This is the largest canal in the district. Its manager is Mr. Frank Adams, post-office address, Merrill. The writer has talked with Mr. Adams and with other owners of the canal, and they state that all they wish is water for their lands, and that they will be pleased to have the Government enter this field and to turn over their canal systems to it.

Another canal, diverting between 600 and 1,000 inches of water, near Klamath Falls, irrigates some 5,000 or 6,000 acres of land between Klamath Falls and Lost River. The ditch was constructed some years ago, and has passed through bankruptcy; the United States has an option for its purchase for $50,000. There are also one or two small irrigation ditches in Poe and Langells valleys.

About January, 1904, the Klamath Canal Company was organized for the purpose of constructing a canal from Upper Klamath Lake toward Tule Lake, paralleling the largest existing canals in this region at some 10 or 15 feet higher elevation. W. K. Brown is manager. The company entered into contracts to furnish water to land owners southeasterly from Klamath Falls and along the existing canals at $10 an acre, with $1 per acre annual rental. Their water contracts are severe. At present this corporation is constructing a tunnel 4 by 7 feet in section out of Upper Klamath Lake, the intention being to widen this tunnel to such dimensions as may be required by the contracts that are ultimately entered into. They have purchased some land and succeeded in signing up for water for about 29,000 acres of land, their field of operation covering some 60,000 acres. This canal company at present is very active along promotion lines, and is working a large force of men on the tunnel in question. They began work about August 1. They express very great dissatisfaction and regret over the fact that the Reclamation Service is making investigations in this section, as it will interfere with their programme, and have endeavored to have orders issued by the Secretary of the Interior to suspend the surveys. The principal men of this region, however, outside of this corporation, seem to be of the opinion that public irrigation works are desirable, and have presented numerous petitions to this effect to the Service. The Reclamation Service will not proceed unless the people of the region desire it. The withdrawals made were only for the purpose of giving the Reclamation Service an opportunity of investigating the country sufficiently to determine whether there was any occasion for the construction of public works. These withdrawals were considered necessary, as the

Klamath Canal Company were filing on streams and endeavoring to file on the Horse Fly and Clear Lake reservoirs, which filings, if perfected, might prevent the Federal Government, or, for that matter, any other irrigation enterprise, from doing business in this region.

It would hardly seem reasonable that the Reclamation Service should have stood aside for a corporation that was not irrigating an acre of land, and that did not have a mile of ditch or canal constructed, and leave to this corporation the reclamation of over 300,000 acres of land lying in 3 counties and 2 States, the source of water supply being both interstate and navigable, and a large part of the land being in the beds of navigable lakes.

TRAINING ASSISTANTS IN OFFICE AND FIELD.

By G. H. Matthes.

That much of the future success of the Reclamation Service depends upon the ability of its engineers and the manner in which the younger men are trained hardly needs to be pointed out. The question which arises in this connection may be propounded as follows: When and to what extent are we to train our men? While the question is not one which admits of a direct answer, and I would not presume at this time to outline a definite procedure, I desire to review a number of points of particular interest in this connection, drawn from my personal experience and observation.

In the organization of the Reclamation Service a vast corps of men have been taken into the Service, most of whom have received a more or less technical training, some being graduates of universities and technological schools, while others are self-made engineers. It may be assumed from their statements of past experience and from the civil-service examinations which these men have passed that they are qualified to do certain kinds of work. The examination papers furnish little or no clue, however, as to ability and personal merits, and when the men enter the Service they can only tentatively be assigned to such work as they seem to be best fitted for. The next step is to bring out their best qualities, advance them, and make better employees of them. From my personal observation I find that the younger men are most easily molded into something better. They are generally quick to grasp new things and adapt themselves to their new environment with its many rules and regulations. Their schooling, if it has been of the modern university standard, enables them to study out problems and new features in a scientific manner, independent and unconscious of the routine and stereotyped methods of older engineers.

With the older men it is a different matter. Previous experience gained elsewhere and the practice and methods with which they have been in contact for years have caused them to form definite conclusions as to engineering and business practice, as well as a multitude of preconceived ideas regarding the new work before them, which in many, though not all, cases may be regarded as obstacles preventing them from readily falling in line and adjusting themselves to the routine of the new order of things. That their past experience has been in many ways of great value to the Reclamation Service is not here denied. The fact remains, nevertheless, that, other things being equal, the younger the man the better the chances for developing him into an engineer specially adapted for our particular class of work. To repeat an old saying, "It is easier to learn than to 'unlearn.'"

It sometimes happens that an engineer who has entered the Service and previously had a good experience in a certain class of work is placed on similar duties in the Reclamation Service as a natural outcome of his peculiar fitness for that particular work, and that he is given practically no opportunity for branching out in other directions and generally broadening himself. Conspicuous cases of this kind have come under my notice, and they are usually to be ascribed to inevitable conditions which can not be readily remedied except as opportunity offers. The men in such cases have not been able to improve and advance themselves, and promotion has, of necessity, been slow, or has not been made. Cases of this kind are unquestionably a detriment to the Reclamation Service as well as to the individuals themselves.

In order that an employee may be promoted and become a valuable man to the Service it is necessary that he should be trained to do more and more advanced work, and be given opportunity for study and self-improvement. The Reclamation Service is not a technological institution, nor are the principal engineers teachers dispensing free information. Yet to train men right requires personal attention. Those who are in charge of work and in more or less immediate contact with the younger men have a duty to fulfill in this respect which requires thought and judgment. Probably among the first things that the new man turns his attention to is the book of regulations, and it may be said here that it is beyond the average human intellect to remember regulations from the mere reading of them and that practical application is after all the only means for impressing them permanently on the mind. The sooner new men are made acquainted with matters pertaining to vouchers, reports, etc., through actual practice the sooner will they become proficient in the use and knowledge thereof. I find that after a man has spent some time on the book of regulations and the large number of circulars issued by the Washington office they cease to make an impression on him unless, as stated above, he has occasion to keep up his interest through practical application.

In a measure it is, therefore, useless to try to make the younger men familiar with all regulations, and only the more important ones should be brought to their attention as occasion requires. Well-equipped bulletin boards posted in conspicuous places in the western offices and kept up to date will be found great aids in this direction. Regulations of local importance, issued by the district engineer, can also in this manner be brought to the attention of the men, who should be held responsible for reading and noting all matter so posted. A place on the bulletin board should be reserved for press bulletins and weekly programmes.

Text-books, reports of the Reclamation Service, Water-Supply Papers, special reports, and plans prepared for other projects are very useful and constitute the best information that can be brought before our men. But here will be found a serious stumbling block; the men as a rule have not time to study or read to any great extent, this being especially true of the field men. At the close of a long day's work out of doors they are tired, and after supper no desire is manifested to settle down to hard studying. Men who are out on surveys during six months of the year do not improve much intellectually, excepting in so far as the details of their field work is concerned. It is further true that the more men are brought together in camps, socially, the less the opportunity for study. This is a serious drawback to field work and camp life.

The men who are located at points where offices are being maintained have a great advantage in this respect over the field men, and get much opportunity for studying. This is particularly true of the Washington office, where the library, map collections, magazines, and office files present an almost inexhaustible source of information, and where the young engineer possessed with ambition and love for his profession will find study a pleasure. This pleasure, or more strictly speaking opportunity, is denied the men working in the field, and there exists, therefore, a necessity for shifting the latter from the field to the office and back again whenever the nature of their work and circumstances warrant this. Many of our field men who have never served an apprenticeship in the Washington office have a most hazy conception of what constitutes a Government office, its relation toward the public on the one hand and toward Congress on the other. Their lack of knowledge of office routine, insight into administrative work, and the necessity for system and so-called " red tape " sometimes borders on blissful ignorance. Yet these are matters that should be instilled into men from the start, as they constitute the kind of knowledge which can be assimilated by small degrees only.

Doubtless it devolves upon the district engineers, who are constantly in touch with the younger men, to train them and in a measure to teach them. They are in a position to tell the men what books to read, what authorities to consult, and, last but not least, they can lay out the work of their assistants in such a manner that they may gradually be made familiar with a variety of duties, broadening their minds and rendering them more and more valuable to the Service. It appears to me that district engineers should have in mind the education of their assistants if for no other reason than that upon their recommendation depends in a large measure the promotion of the assistants. Briefly stated, the district engineer should be best fitted to judge of his assistant's capacity and ability by knowing what studies that assistant has been pursuing in connection with his regular work.

At Lawton, Okla., I made it a point to install electric lights sufficient to enable my assistants to study evenings. The various text-books owned by the different men formed an excellent nucleus of a library of engineering knowledge. Several of the irregular employees have taken up courses of study in engineering subjects with leading schools of correspondence, and I have always encouraged work of this kind as being to the best interests of all concerned. Even with these advantages the amount of studying done after hours has been comparatively little, and during the hot summer evenings it was practically nil. In summary it may be said that the average man can not study unless he is in the right mood, and to obtain the latter the conditions should be favorable, in providing which the district engineer can be instrumental to a large extent. Much will depend on local conditions, of course, and I realize that my remarks as drawn from my own observations may not be applicable in all cases and may require modification.

In conclusion, I desire to submit for consideration and criticism a list of text-books which, it is believed, should be owned by every engineer or assistant in the service who aspires to a higher position.

Useful text-books for engineers.

Trautwine's Civil Engineer's Pocket Book.
Searle's Field Engineering.
Carnegie's Hand Book.
Wilson's Topographic Surveying.
Merriman's Hydraulics.
Baker's Masonry Construction.

Baker's Roads and Pavements.
Folwell's Sewerage.
Folwell's Water Supply Engineering.
Molitor and Beard's Manual for Resident Engineers.
Vega's Logarithms.
Wilson's Irrigation Engineering.
Weston's Tables of Friction of Water in Pipes.
Johnson's Engineering Contracts and Specifications.
Merriman and Jacoby's Text-Book of Roofs and Bridges.
Allen's Railroad Curves and Earthwork.
Frizell's Water Power.
Foster's Electrical Engineer's Pocket Book.
Patton's Foundations.
Johnson's Materials of Construction.
Byrne's Inspection of Material and Workmanship.

NECESSITY OF DRAINING IRRIGATED LAND.

By THOS. H. MEANS.

The necessity of draining agricultural lands has long been felt, and in many places drainage is extensively carried on. Drainage is the rule rather than the exception on the better farms in the States of Ohio, Indiana, and Illinois. In irrigated districts practically no drainage works have been built, and the necessity of drainage is not generally recognized, despite the loss of large areas of land by seepage waters and rise of alkali in many places.

Aside from the necessities of drainage, which every engineer appreciates, there are a number of reasons from the standpoint of the plant which are not so well known. As we are building works for irrigation of land on which to grow plants, it is well to consider how these are affected by drainage and what reasons they advance for drainage.

The majority of plants in common use by American farmers have been developed from wild species through long years of selecting the most desirable individuals. Agriculture has developed on dry lands, using the term in contradistinction to swamp lands. Very few plants can grow with roots in standing water; the greater number attain their most satisfactory development in soils containing a moderate amount of moisture. This quantity of water varies from 5 per cent to 30 per cent by weight, depending upon the character of the soil. This amount never exceeds that which will be retained by a well-drained soil; all moisture remaining above that which will drain away is in excess of the requirements, and is detrimental to proper plant growth.

Plant roots need water and air. If either is excluded, or if either is difficult for the plant to obtain, growth is checked and there is likely to be a shortage in the harvest. Roots not only need air, but they need fresh air, and consequently ventilation is desirable. All of us know how difficult it is to ventilate a room from one opening. Drainage provides a second opening and permits the more ready "breathing" of soils and the consequent ventilation of the spaces around roots.

Bacteria play an important part in the growth of plants by living in the soil around and on roots and assisting in the chemical changes which are needed to prepare the plant food for the roots. In many cases the bacteria do not seem necessary to plant growth; in other cases their presence and activity is essential. The best-known example of this is in the case of the leguminosæ, a family of plants including alfalfa, clovers, beans, peas, peanuts, locusts, vetches, and others. Bacteria which develop on the roots of the leguminosæ have the faculty of obtaining nitrogen from the atmosphere and combining it in such form as to be available for the higher plants. The importance of these minute organisms can not be overestimated, for nitrogen is the most costly and the least abundant of the essential plant foods in soils. To foster these helpful organisms, therefore, becomes the duty of every farmer. The nitrifying organisms can only live in an aerated soil. Stagnant air or excess of moisture prevents their forming the nutritive nitrogen compounds and frequently encourages the development of other species of bacteria, which act in the opposite way and decompose nitrogen compounds, liberating the nitrogen.

Wet soils are colder than those well drained, for the evaporation from the surface uses up heat and the presence of an excess of water filling the soil pores prevents the circulation of warm air. Cold soils retard germination of seed and prevent the most rapid growth of plants. Drainage removes the excess of water, allows the pores to drain, and permits a more rapid warming of the soil in the spring. Experiments have shown drained soils to be as much as two weeks in advance of adjacent undrained fields.

Aside from these general reasons for drainage, there are in the arid regions other important reasons why soils should be drained. It is almost impossible to apply exactly the right amount of water. If too much is applied, the subsoil becomes saturated unless the natural drainage is perfect. If the natural drainage under one field is good, the water drained away from it may run underground to rise at the surface of some field lower down.

In its movements water dissolves and carries with it alkali, which accumulates where the water evaporates. Drainage lowers the water surface so that it can not evaporate at the surface of the land and deposit alkali; drainage removes from each field the excess of water applied and prevents drainage to lowlands by those higher up.

Besides the actual moving and concentrating of alkali salts, which so often occurs in undrained fields, there is brought about a very harmful chemical change. Stagnant soils poorly aerated frequently become charged with black alkali or sodium carbonate. Drainage and aeration produce the opposite reaction and change the sodium carbonate to less harmful salts. It is frequently possible to reclaim black-alkali lands by simple aeration and removal of the excess of water. Where the formation of black alkali has gone on for a great length of time, drainage alone can not speedily accomplish the reclamation, but must be assisted by washing out the excess of soluble matter.

Many other reasons why irrigated lands should be drained can be given, but these are considered the most important. One familiar with western soils and agriculture needs no further reasons to show the value of drainage.

ALKALI SOILS.

By Thos. H. Means.

The term "alkali" or "alkali soils," as commonly used in the Western States, has reference to soluble matter within the soil and does not refer to the chemical properties of the soluble matter. The choice of the term is unfortunate, as many think it refers to soils which are alkaline in a chemical sense. Thus frequently one is told that the soil contains not "alkali," but common salt, while as a matter of fact the majority of western farmers include all soluble salts in the general term "alkali."

OCCURRENCE OF ALKALI.

There are two kinds of alkali popularly recognized—black alkali, consisting solely of sodium carbonate (washing soda, or sal soda), and white alkali, including all other soluble salts found. The most common white-alkali salts are sodium chloride (common salt), sodium sulphate (Glauber's salt), sodium bicarbonate (baking soda), magnesium sulphate (Epsom salt), magnesium chloride (bittern). Small quantities of potassium and calcium salts are found, but the more abundant calcium salts are relatively insoluble and the amount which is in solution at any one time comparatively small.

This soluble matter occurs in western soils as the direct result of rock weathering. In many places the soluble matter has been carried by water and accumulated in poorly drained spots. In other localities the alkali is distributed throughout the soil where it originated. Practically all rocks contain small amounts of sodium, potassium, and magnesium, held in insoluble form in the mineral constituents. The weather influences acting upon the rock bring about disintegration and decomposition or a change in the chemical arrangement of the atoms. Certain portions of the minerals during decomposition yield soluble salts. These are taken up by percolating waters and in the humid States almost entirely removed. In arid regions the amount of percolating water is so small that the soluble salts are left in the soil, while in many cases that which is removed from its place of formation is deposited by the evaporation of the waters in some stream channel or alkali-lake bed.

EFFECT UPON PLANTS.

To have any effect upon plant growth matter must be in solution. One frequently hears the statement that there are deleterious substances in a soil which are not soluble and which can not be removed. Fears on this score are groundless, for a plant can only absorb through the roots materials dissolved in water. Our study of the action of alkali salts within a soil is therefore limited to that portion soluble in water.

Certain soluble salts are poisonous to plants in very small quantity. In this respect they act very much as poisons do toward animals in bringing about some physiological change which results in disease or death. Copper salts have this action. Fortunately they are almost unknown in waters or soils in agricultural communities, though cases have been known where water coming from mines, mills, or chemical works was harmful to both plant and animal life.

Other salts, those commonly occurring in western waters and soils, are deleterious to plant growth only when present in appreciable quantities. The effect upon plants of matters in solution is well known to all who have studied western agriculture. The mode of action of these salts is unfortunately not so well known, and the principles can therefore be stated only in the most general terms. As is known, the roots of plants are made up of cells whose walls are absorptive of water and to a limited degree of mineral salts in solution. These walls are what is termed "semipermeable"—that is, they are enabled to absorb water and small quantities of certain salts, but can not absorb other salts. The solution inside a cell must be of greater concentration than that outside in order that absorption of the water can occur; so it follows that when the soil moisture or water around the root cells is of greater concentration than that inside, the cells can not absorb the moisture and the plant actually dies. This fact can be easily illustrated by immersing the roots of a growing plant in a strong 5 per cent solution of common salt. The plant will in a few minutes wilt; the roots, instead of taking up water, actually give off water. Some such action as this occurs in soils. If an alkali spot in a field is observed, there will be seen certain plants stunted, hardly alive, others yellowed and looking as though water was scarce and they were suffering from a drought, while a little farther away from the edge of the spot plants are flourishing.

There is a great range among individual plants of one species and between different species. Certain plants, such as sorghum, sugar beets, date palms, and pears, have the faculty of withstanding larger amounts of alkali salts in solution than others and are for that reason termed "alkali resistant."

Sodium carbonate, or "black alkali," has a different action to that of white alkali. This salt is alkaline in a chemical sense, or caustic, and corrodes the vegetable tissues. Its action is most severe at the surface of the ground, where it corrodes the bark, killing the plants in much the same way a forest is destroyed by "ringing" the trees.

AMOUNT OF ALKALI ALLOWABLE IN SOILS.

The amount of alkali which is allowable in any soil varies with the soil, the plant to be grown, and the kind of alkali. To state accurately, therefore, the amount allowable all of these factors should be known. In practice the most general figures are given, with alfalfa as the basis—that is, the soils are graded according to their ability to grow alfalfa. The following figures may be given:

Allowable percentage of alkali in soils.

Effect.	White alkali salts, principally sulphates.	White alkali salts, principally chlorides.	Black alkali (sodium carbonate).
	Per cent.	*Per cent.*	*Per cent.*
Good for all crops	0.0 -0.50	0.0 -0.25	0.0 -0.10
Good for alkali-resistant crops	.50-1.00	.25- .60	.10- .20
Too alkaline for crop growth	1.00- +	.60- +	.20- +

Upon this basis maps showing the various grades or degrees of alkali are constructed. These maps can of course have only the most general interpretation, as soils in the field are so spotted in character that complete detail is impossible.

In the classification of lands, as pursued by the Reclamation Service, soils are examined in the field to determine the amount of alkali present. The total amount of alkali is determined by taking the electrolytic resistance of a portion of the soil saturated with water.

Pure water is almost a nonconductor of electricity, its conductivity depending upon the amount of soluble matter present. Thus by knowing the conductivity of the soil and the effect of the solid soil grains it is possible to determine approximately the per cent of alkali. This method is admittedly not exact, but by using certain easily applied corrections the results are sufficiently accurate for all practical purposes. One especial advantage of this method is that the results are arrived at on the field.

The amount of sodium carbonate or black alkali and the amount of chlorides present can also be determined by simple methods in the field. A measured sample of the saturated soil is mixed with a measured quantity of water and an aliquot part filtered of the suspended matter. The amount of sodium carbonate is determined by dropping in tablets containing sodium acid sulphate. The presence of sodium carbonate is indicated by the purple color which appears on adding a drop of phenol phthalein; the tablets are added until this color disappears. In a similar manner the amount of bicarbonate and chlorides is determined.

MOVEMENTS OF ALKALI IN SOILS.

In virgin soils the bulk of the alkali salts occur at about the maximum depth penetrated by moisture. This depth varies somewhat with the kind of soil and the amount of rainfall. Where the land is, however, very wet during a portion of the year, as in undrained swales and lake beds, the salt is brought to the surface and left as a white crust.

The alkali hidden below the surface is the most dangerous kind, for it is frequently hidden so as to be unsuspected. In many places it is down 10 or 12 feet below the surface and comes to the top only after a long series of years. In the early days around Fresno, Cal., there were few or no evidences of alkali on the surface of the land; water was from 60 to 100 feet below the surface. After a number of years of irrigation the water rose until now under many thousands of acres water is within 3 to 6 feet of the surface and during parts of the irrigating season closer. In its rise the small amounts of alkali scattered through the subsoil were accumulated and brought to the surface and left there by the water brought to the surface by capillary action. In many other districts the same story may be told.

The alkali in a soil can move only when in solution, and so its movements are governed and measured by the movements of the soil moisture. Two kinds of movement occur in a soil, movements caused by gravity and movements caused by surface tension (capillary movements). Gravity movements occur only when a soil contains an excess of water above that required by plant growth. The movement occurs in the larger pores, root holes, insect, and animal burrows and to a much smaller extent through the small pore spaces which make up the bulk of the soil. It is a well-known fact that almost any soil can be made more impervious by puddling. This can be explained by saying that in the puddling the large gravity pores are broken up and only the smaller capillary pores are left.

To illustrate the movements of water and alkali in a soil, let us assume a typical case of a soil filled with both gravity and capillary spaces. Irrigation water is applied at the surface. The water sinks in the soil, going most rapidly down the gravity spaces and being carried laterally into the smaller pores by capillary action. With these once filled all motion in the capillary spaces ceases, while water continues to pass down through the gravity spaces. In the aggregate these gravity spaces occupy but a small per cent of the space in a soil, and in washing them the surface cleansed of alkali is but a small per cent of the total surface of the soil grains. If the supply of water at the surface continues, the movements downward go on and only a small percentage of the alkali is washed out; continued washing only serves to carry off the alkali which diffuses out from the fine pores into the spaces where movement is taking place.

When the supply is cut off from the surface and the gravity spaces drain free of excess water, the surface tension acts upon the water held in the capillary spaces and movement in them commences. As the surface dries the upward movement continues almost entirely through the capillary spaces, and as the water moves so does the alkali upward to the surface.

Consideration of the above makes it plain why alkali seems to move upward easier than downward, and why after repeated washing alkali yet remains within a soil. The example illustrates the importance of drainage to rapidly remove any excess of water, which might otherwise be brought back to the surface by capillary movements and as it comes return the alkali to the zone of root action. The depth to which drainage should be carried depends upon the kind of soil; the object should be to lower the water to such a depth that surface tension is unable to draw the water back to the surface.

RELATION OF DRAINAGE TO ALKALI.

Drainage solves the alkali problem. The removal of alkali is accomplished in two ways: (1) By withdrawing from a soil the water which has washed through the surface soil and thus removing part of the alkali. Each irrigation removes a small amount of alkali and the soil continues to improve as long as irrigated. The second method of improvement is the prevention of the rise of alkali salts which lie below the drainage plane. In other words, the drains cut off the active upward movement and prevent the rise of the alkali.

The Bureau of Soils has been experimenting for several years upon drainage as a method of reclaiming alkali salts. The work of the Bureau has clearly demonstrated that drainage will accomplish the reclamation and permit the farming of our most sterile alkali flats.

UNDERGROUND WATERS OF SOUTHERN CALIFORNIA.

By W. C. MENDENHALL.

The greatest population and the highest cultural interests in southern California are concentrated within a wide diversified valley that extends inland 80 miles from the Pacific coast at Santa Monica, and is effectually screened from the Mohave and Colorado deserts by the San Gabriel and San Bernardino mountain ranges. These high groups protect the land on their Pacific slope from the climatic extremes of the deserts, and at the same time wring from the ocean winds the moisture with which they are laden, and which, in the form of perennial streams, makes possible the high state of cultivation that has given some of the adjacent agricultural lands values of from $500 to $2,000 per acre. Yet the rainfall is low—from 10 to 20 inches in the valleys—and this and its concentration within a few months of the year are conditions which demand irrigation to insure crops even of grain and hay, and make it imperative for the much more valuable citrus lands, walnut groves, and gardens.

EARLY IRRIGATION.

The practice of irrigation was begun early in the century by the missions, before a general settlement of the country by the Mexicans or the Americans. Short and simple ditches, which usually took their water from the perpetual springs and served a small acreage about the ranch houses, sufficed for the simple agricultural needs of this pastoral period. The construction of permanent works of a better character began before the civil war, and was most actively carried out during the seventies and eighties. The famous Riverside colony was founded in 1870, its existence depending entirely upon the successful construction of a large canal, which carried the flowing waters of the San Bernardino basin to a strip of desert mesa north of Santa Ana River. By the construction of other canals built about this period the mountain waters as they came down the canyons to the margin of the low-lying tillable lands were gradually diverted and the acreage under cultivation extended. Such flourishing colonies as Anaheim, Pasadena, Pomona, Ontario, Cucamonga, Highlands, and Santa Ana owe their foundation to the diversion of these surface waters.

By 1880 the available flowing waters had been generally diverted and utilized, and the limit of the amount of land reclaimable seemed to have been reached; but the stimulus of the very high values reached by the California citrus lands, and the comparatively small acreage under cultivation as compared with that reclaimable if water were available, combined to induce a most thorough examination of all possible sources. After the appropriation of the normal stream flow, there remained two additional possibilities sufficiently inviting to enlist the attention of capital and skilled service. Because of the high gradients of the California river beds, and the steep slopes of the mountains where the greater part of the rainfall occurs, as well as because of the fact that a large part of the annual precipitation falls during heavy storms of moderate duration, there has always been a heavy loss of water through run-off during floods. If this could be saved by impounding reservoirs, a great gain would be effected. But the generally constricted character of San Bernardino and San Gabriel mountain canyons has been unfavorable to the construction of reservoirs, and actually but two important projects have been completed—the Bear Valley dam, whose stored waters have added the flourishing Redlands colony to the reclaimed areas, and the Hemet dam, less favorably situated as regards rainfall and less successful, therefore, in the matter of acreage redeemed. Another project, the Arrowhead, is under way after years of patient observation of rainfall and run-off; hence eventually there will be a further addition to the waters conserved in this way.

ARTESIAN-WELL DEVELOPMENT.

Underground water supply.—The second attractive possibility for securing additional water lay in the development of the great underground reservoirs. It had been found in the sixties and early seventies that the boring of wells in certain moist-land areas was followed by flowing water, and when the surface supplies had all been appropriated engineers turned their attention to these lands and to the storage sites as the two remaining sources which promised most in the way of increasing the available supply.

The Gage canal system, completed in 1886, has depended from the first almost entirely upon underground waters, and its 7,500 acres of splendid citrus lands are an example of what may be done with them. Since this experiment the development of underground waters in southern California has continued, until now there are nearly 3,000 artesian wells and about 1,600 pumping plants, representing a capital of about $4,500,000 and a combined production of at least 400 to 500 second-feet continuous flow.

This development, although under way for thirty years, was given a great forward impulse by the series of dry years which began a decade ago. The previous ten years had been years of abundant rainfall, the precipitation being well above the average, although this vital fact was not generally recognized by water users. As a consequence, the acreage brought under cultivation during those years exceeded the amount which the ditches depending upon surface streams could serve when the dryer period came on. The most important and valuable of California crops are perennial plants—citrus and deciduous fruits and walnuts—which can not be rapidly adjusted to fluctuations in the water supply. A grove which does not come into profitable bearing until five years after planting represents by that time considerable capital. If the water fails it for a season, that capital is lost. Hence great energy has been displayed in the development of water as the surface supplies have dwindled under the influence of the drought. There are few important irrigating systems whose supply has not been augmented during the ten years past by the boring of wells, whose flowing or pumped water is used to make up the deficiency in stream flow. In addition much independent irrigation has been undertaken whose supply is well water entirely. A large part of this is new land, not under cultivation previous to the beginning of irrigation from wells. A smaller proportion was moist land cultivable without irrigation before the dry period and retained in the cultivated class since only by the installation of wells. The reclamation of lands in this way has been most extensive, naturally, in the artesian areas, and in those other low-lying lands bordering the artesian basins, where water could be obtained near the surface and at but slight cost by pumping, but it has been practiced in a more limited way where higher, warmer, and more valuable lands have enabled the horticulturist to lift water to greater heights and to pay the resulting higher charges.

It has been fortunate, indeed, for southern California that she has had large bodies of subterranean waters on which to draw. This fact has enabled her to come safely through so trying and generally fatal a combination of circumstances as a decade of heavy rainfall, and consequent exaggeration of her most fundamental asset, accompanying such a rapid industrial development as to constitute a boom of the first order. The reaction from such a combination is usually utter stagnation. The worst fault of our western American business character is its cheerful, careless optimism. It will believe any tale, however false, that flatters its community pride and promises fortune; it will have nothing of any fact, however absolute, that sets a limit to its resources. In the Southwest it might well parody the well-worn motto of the court of Louis XV and say, "After us the drought." But southern California has not as yet lost any extensive areas of her reclaimed lands, although the deficiency of rainfall at Los Angeles for the past eleven years has aggregated 26 per cent of the average, and during that time and at present she has been steadily increasing her acreage.

Origin of underground water.—The geologic relations which have made this condition possible may be briefly outlined. The valley of southern California is not a normal stream valley, carved by stream action and adjusted in width, depth, and alignment to the volume and course of the stream. It owes its character entirely to other agencies, those agencies being crustal movements. This diversified lowland may be best described as a series of deep, irregular, crustal troughs, parallel to each other and to the Pacific shore line, plunging to the northwest and abutting in this direction against the granitic San Gabriel Range. At the foot of this range the ridges separating the troughs are lowest, and a practically continuous valley extends from Santa Monica to San Bernardino. Farther south the separating ridges rise higher and the valley is broken by mountain chains and groups. As these troughs and their separating ridges have formed by geologic processes, the previously existing rivers have maintained their way across them from the higher mountains where they rise to the sea, and in maintaining these courses have cut canyons in the ridges and have filled the troughs with the sands, gravels, and clays that are due to their erosive action. The result is a series of deep bed-rock valleys filled with alluvium, across which the rivers flow. These conditions give rise to certain peculiarities in the habits of the rivers, peculiarities which it happens adapt them in a wonderful way to man's needs as an irrigator.

Santa Ana River is the most important of these southern California streams, has the largest drainage basin, the longest course, and exhibits these beneficent peculiarities in great perfection. It will therefore be briefly traced as an example of the type. It rises in the higher San Bernardino Mountains, where rainfall is abundant, and has attained a volume of from 25 to 50 second-feet when it reaches the first of the filled geologic troughs at the mouth of its upper canyon. Here it promptly sinks in the coarse débris and percolates slowly below the surface, protected perfectly from evaporation and contamination until it reaches the lowest point in the rim of this depression. This rim forces it to the surface, and it flows across it as a living stream, the waters which escape diversion sinking again in the gravel filling of the second trough. After a short subterranean course it is forced out again by the impervious rock at Riverside Narrows and continues to flow over the surface through the Santa Ana Mountains until beyond these it reaches the inner edge of the greatest of the troughs, the Coastal Plain, in which it sinks. Below Santa Ana it rises once more in a series of strong scattered springs and escapes to the sea.

This hide-and-seek habit is characteristic of the rivers of this valley and is as ideal an adaptation to the needs of the arid-land horticulturist as though definitely planned by man for his own benefit. The lower rims of the rock folds force the water to the surface at very convenient intervals for diversion, and meanwhile not only is the water in its underground passage saved from loss by evaporation, but the irregular spasmodic supply at the canyon mouths is converted into a uniform flow which is unaffected by individual storms and responds but slowly to prolonged wet or dry periods. These basins are, therefore, not only storage reservoirs, but are most effective regulators as well, and go far to bring about that most important desideratum in irrigation practice—uniformity of supply. An additional important economic factor is introduced by the presence of artesian conditions along the lower margin of each of these storage basins.

The material with which the rock basins are filled is alluvial, river-deposited sediment. Each stream issuing from its mountain canyon carries with it the products of its erosional activity there. Debouching upon the plain, its velocity is checked and the heavier fragments are dropped. At the lower margin of any particular basin, where the velocity of flow is least, the finest materials are laid down as clay sheets. These have the original slope of the stream bed and are limited in their extent upstream. In this direction they gradually become coarser until they are no longer impervious. The waters entering the valley at the canyon mouths and percolating seaward below the surface through the more porous strata are entrapped beneath these sloping clay blankets, where under the weight of the waters behind them they accumulate pressure. Then when the impervious clay cap above them is pierced they flow.

Distribution and character of supply.—These cheap artesian waters are well distributed in southern California, and have been important elements in its development. The original area of the lands under which they were found was about 375 square miles, but it has suffered a shrinkage of 33 per cent during the last fifteen years and now measures only about 250 square miles.

Since these artesian basins are unlike the normal synclinal folds in porous rock, which have come to be regarded as the type, so they have special characteristics which bear directly upon their usefulness.

In the first place, being in wholly unconsolidated and generally coarse material, they have a high transmission capacity. So freely does the water flow through them that individual 10-inch wells have in a few cases yielded 6 or 8 second-feet of water. Such wells do not fail because the water supplied at the head of the alluvial fan can not reach the boring, as has been the case in the Denver basin, for example. On the other hand, flowing so freely they draw down the supply at a very rapid rate, but can be restored if closed for a time, while a new supply is allowed to accumulate.

The fact that the water-bearing strata lie approximately parallel to the surface, and that the highest are very near it, facilitates development to such an extent that ranchers in many instances have found it more economical to sink a well for each 10-acre lot than to distribute from a single central well. This condition encourages the multiplication of wells and the drafts upon the artesian supply.

It is these great rock basins, with their filling of saturated alluvial wash, which constitute the important underground reservoirs that have not only tided the region over a long period of low rainfall, but have actually made possible constant additions during the dry period to the reclaimed lands. These great natural reservoirs more than compensate for the lack of sites for effective artificial storage. Their actual capacity is to be expressed in cubic miles rather than in smaller units. The San Bernardino basin has been explored by the auger for over 1,000 feet, and is roughly estimated to attain a maximum depth of 3,000 or 4,000 feet. The alluvial filling about Pomona and Chino, and that east of Pasadena, above the Paso de Bartolo, is known to extend below sea level. The great Coastal Plain basin has been explored for 1,300 feet, and its depth, were it known, would probably be found to run well up into the thousands. With a surface area of 775 square miles and on the basis of 30 per cent of voids, a very impressive but utterly valueless estimate might be made of the amount of water stored in it.

Reduction of supply.—But while the underground reservoirs have proved of incalculable value to southern California during the decade just passed, and have not only carried the country through this period, in spite of the fact that the greater part of its earlier development was carried out during and upon the basis of a decade of excessive rainfall, but have actually permitted a continual increase of acreage under irrigation, it is not to be expected that this result has been attained without affecting the water level in the reservoirs.

Water levels have, in fact, declined notably, artesian areas have shrunk, and pressures in wells still flowing have decreased markedly. The thing which causes most surprise is that these shrinkages have not been more violent. The underground supplies have been attacked in front and rear. The summer and a part of the winter flow of the mountain streams is diverted at the canyon mouths and used for irrigation, where formerly all of it sank into the gravels and joined the underground supply. A few storage reservoirs have been built which hold a part of the winter flood waters that are now and always have been the chief source from which the ground waters are replenished. Thus not only has the supply been less during the past decade because of drought, but it has been further curtailed because of diversion and storage. In addition to this indirect attack, the great number of artesian wells and pumping plants which have been put in have directly attacked the quantity of stored waters. It is estimated that of the 225,000 acres under irrigation in the valley of southern California at present, two-thirds are dependent upon developed underground waters, of which about 400 to 500 second-feet are used, while the surface streams supply but 200 or 250 second-feet. These relations are not fixed, there being a large acreage which is irrigated with surface water when this is abundant, but with well water when the streams are low. But the irrigation from developed water alone is increasing, while that from streams is at a standstill or is shrinking, the flow of certain important streams which are due to rising ground waters having diminished during recent years. One great water company, all of whose supply of 40 second-feet except about 6 second-feet was originally artesian, now pumps at least 75 per cent of the total. The water levels in wells in important water-bearing lands tell the same story. Maximum declines of 60 or 70 feet within the past four years are of record. Declines of 25 or 30 feet are not at all rare.

Cause of fluctuations of supply.—These of course are phenomena to be expected during a period of drought. The critical point with the California irrigator who is dependent upon underground waters is to determine how much of it is due to the dry period and how much to development. Obviously this is a difficult point. The amount of water returned to the gravels each year is scarcely capable of direct estimate, at least with the data now available. The greater part is contributed of course during the winter floods, but the measurements of these are difficult, and but few attempts have been made to estimate them.

Observations upon the fluctuations of the ground-water level are perhaps of more value. A system of such observations has been begun by the Survey, but it will have to be continued for a considerable period before its results furnish a safe basis for conclusions. At present we have only two or three sets of observations within the valley which extend far enough back to be valuable. Fortunately for our thesis, their evidence is harmonious. I have selected for discussion the water-level fluctuations in a well near Anaheim, on the inner edge of the Coastal Plain. Pumping plants are numerous in this vicinity and are being rapidly increased in number, so that the phenomena exhibited by this profile may be accepted as typical of those neighborhoods where most pumping is being done. For direct comparison with it a rainfall table has been prepared in which the departures from the average are shown for each year, since it is with the relation of each year's rainfall to the normal that we are especially concerned.

From these records it appears that from the time when the observations began in 1898 the declines were continuous and regular throughout the dry period, which was interrupted during the winter of 1900–1901 by an excess of rainfall. During this winter the water level rose 2 feet, but the gain was more than lost before the beginning of the next rainy season. The decline then continued, although irregularly, until the winter of 1902–3, another year of excess in precipitation. Here again the profile shows a rise, but again it was more than lost before the end of the year. Since that time the decline has been rapid.

The significant thing about these fluctuations is that years in which the rainfall has exceeded the average have failed to stop the decline, although they have checked its rate. With present developments then, the decline will continue, rapidly through years of deficiency, less rapidly through years of average rainfall, slowly through years of slight excess, and will cease only with an amount of excess greater than any that we have had in a decade. This is a sufficiently serious showing to call for a halt in the development of underground waters. It does not necessarily mean loss of land now reclaimed, because it is recognized that the proportion of water available for the restoration of the underground supplies increases at a rapidly accelerating rate as the rainfall itself increases—that is, where a precipitation of 15 inches may add little to the underground supplies, a fall of 20 inches may add nearly all of the last five, and a precipitation of 25 inches, well distributed throughout a long wet winter, may restore the continuous declines of half a dozen years of deficiency.

Need of moderation.—But the evidence is quite sufficient to show that it is time to stop increasing indiscriminately the number of wells for the reclamation of virgin lands. There is grave danger that the splendid subterranean reservoirs which have carried communities through the past decade without distress, and have responded so fully to every demand made upon them, may be overestimated. Such supplies are everywhere peculiarly liable to overvaluation for several reasons. Among them is the fact that if the total quantity of stored water be estimated the figures are so great that thoughtless users immediately conclude that such supplies are inexhaustible. They forget that actually it is only a very small part, often no doubt only 1 or 2 per cent of this great amount, which is, or with present methods can become, available. Again, the fact that these great bodies of gravel are efficient regulators of the supply through rainfall, responding but slowly to periods of drought or periods of excessive precipitation, and showing but slowly the effects of overuse, leads many to suppose them wholly independent of these controlling factors, and so encourages them in their campaign of overdevelopment. As a matter of fact, close, careful, and continual observations should be made of fluctuations in ground-water levels as development proceeds, and these, when compared with rainfall measurements, will give a safe, scientific basis for the regulation of the acreage irrigated from ground waters.

Meanwhile, development must proceed with extreme caution, for obviously nothing worse can happen to a community than to be forced to abandon lands which have been reclaimed at a great expenditure of time and capital.

COST OF STREAM-GAGING WORK.

By E. C. Murphy.

The cost of obtaining the data on which the monthly and annual estimate of flow of a stream are based is made up of four items, namely, cost of equipment of station, cost of gage records, cost of each gaging, and number of gagings a year.

The cost of equipping a bridge station will generally be from $10 to $25; the cost of equipping a cable station will generally be from $25 to $500, depending on the length of span of the cable and the accessibility of the location.

The gage readers are generally paid from $3 to $5 per month for from eight to twelve months per year. In some States, as, for example, Maryland, the gage readers are paid by the State. The records of a number of stations, especially in the South, are obtained from the Weather Bureau free of charge. In some States, notably New York, gage records are furnished by private parties free of charge. Some of the railways cooperate in stream-gaging work by furnishing the resident hydrographer with free transportation to his station.

The cost of a gaging depends mainly on the time required to reach the station and the cost of transportation. In some sections of the country, notably New Jersey, two or three stations per day can be visited; in other sections, as Wyoming and Oregon, two or three days' travel are necessary to reach a single one.

The number of gagings that are necessary per year after a station is once rated depends on the character of the bed of the stream, not only at the station, but also for a considerable distance above and below it. Two or three measurements a year are sufficient at some of the New England stations, whereas from four to twelve measurements a month are necessary on some of the streams of changeable bed in the West. The following table shows the estimated cost of stream-gaging work at some of the gaging stations in 1903:

Estimated cost of stream-gaging work in 1903.

[Prepared from reports on Form 9-237.]

District or State.	Hydrographer.	Number stations included in estimate.	Number of visits.		Cost per visit.			Total yearly cost.		
			From—	To—	From—	To—	Mean.	From—	To—	Mean.
New England	N. C. Grover.	23	2	6	$7.00	$31.00	$13.88	$34.00	$169.80	$116.57
New York [a]	R. E. Horton.	[b]27	1	4	4.00	25.00	12.40	15.00	150.00	63.37
Do.[a]	do	26	3	16	4.00	15.00	8.20	50.00	150.00	144.00
Michigan [c]	do	[b]5	1	2	10.00	30.00	24.00	30.00	75.00	51.00
Do.[c]	do	11	1	6	10.00	20.00	11.90	25.00	175.00	94.10
Pennsylvania, Maryland, Virginia, and West Virginia.	E. G. Paul	16	....	6	11.00	16.00	12.88	66.00	132.00	[d]100.00
North Carolina, South Carolina, Virginia, and West Virginia.	E. M. Myers	23	4	10	7.50	18.00	10.95	79.00	174.00	116.74
North Carolina, South Carolina, Tennessee, Georgia, Alabama, and Mississippi.	M. R. Hall	[e]34	4	10	7.50	17.75	10.79	68.00	136.50	97.90
Washington	Geo. H. Bliss.	10	4	6	15.00	45.00	28.38	125.00	275.00	......
South Dakota	R. F. Walter.	9	4	5	5.50	30.00	11.33	45.00	185.25	79.13
Chicago	E. Johnson, jr.	26	9	12	5.35	22.50	17.69	107.00	330.00	243.51

[a] The gage records for 21 of these stations are fnrnished free.
[b] Stations at weirs and dams.
[c] The gage records for 11 of these stations are furnished free.
[d] No allowance for office work.
[e] The records of 29 of these stations are furnished free of charge, and the cost of gage records of the other stations at from $1.50 to $3 per month.

This table shows in a general way the cost per gaging and the total cost of a gaging station per year in different parts of the country. The total cost depends on so many items that differ so widely in different sections of the country that it is very difficult to make a just comparison.

The mean cost per visit to a current-meter gaging station in the districts east of the Mississippi varies from $12 to $17.75, the latter being for the Chicago district, where the stations are widely scattered, and the former in New York State, where the stations are not far distant from headquarters.

The yearly cost per visit is less for stations at dams and weirs than for current-meter gaging stations. This difference is partly due to the fact that the gage records at most of the former are furnished free of charge.

The following table, prepared from the annual reports of M. C.

Hinderlider, gives the actual cost of stream-gaging work in the Denver, Colo., district for 1904 and a part of 1903:

Cost of stream-gaging work[a] in the Denver, Colo., district, 1903.

[Prepared from reports of M. C. Hinderlider, engineer.]

State.	1903.							1904.					
	Gaging regular stations.				Miscellaneous.		Average cost of all gagings.	Regular gaging stations.			Miscellaneous.		Average cost of all gagings.
	Number of stations.	Gagings per station.	Number of gagings.	Average cost of gaging.	Number of gagings.	Average cost of gaging.		Number of stations.	Number of gagings.	Average cost of gaging.	Number of gagings.	Average cost of gaging.	
Colorado	45	3 to 22	456	$6.84	401	$1.20	$2.89	58	419	$7.63	72	$7.82	$7.68
Wyoming[b]	16	1 20	64	6.86	3	1.13	6.61	12	109	13.68	9	5.92	13.07
Nebraska[b]	16	1 11	13	6.30	13	3.34	5.80	10	69	7.33	30	2.17	5.76
Kansas[b]	12	1 4	21	9.39	4	12.65	9.94	11	75	10.75	5	10.82	10.76
South Dakota								13	90	11.09	49	1.20	7.60
New Mexico								16	78	7.93	2	7.03	7.90
Oklahoma and Indian Territory								8	17	12.69			

[a] Not including gage readings. [b] For the period July 1 to December 31, 1903.

The cost per gaging at regular gaging stations in 1903 varied from $6.30 to $9.39 and in 1904 from $7.33 to $12.69.

The average cost per gaging in Wyoming in 1903 is about one-half that in 1904, on account of the work being done in 1903 by local men. The results obtained by these local men were not found satisfactory, and the work was done in 1904 by the resident hydrographer.

The cost of miscellaneous gagings is generally much less than of those made at regular gaging stations.

The actual cost of carrying on the stream-gaging work at 15 gaging stations in Idaho for the year 1904 was $2,422.97; the cost per station varied from $83 to about $255, the mean being $161.53. The amount spent on the equipment of 11 of these stations during this year varied from $14 to $92, the mean being $39.86. The number of visits made during the year varied from 2 to 9, and the cost per visit varied from $2 to $25, the mean being $6.80.

The actual cost of stream-gaging work at 34 gaging stations in New York State from July 1 to December 31, 1904, was $2,114.69, the cost ranging from $13 to $110, the mean being $66.08. The number of visits made during these six months varied from 1 to 6. The cost per visit varied from $3.50 to $29, the mean being $13.16, the larger of these values being for visits when repairs were made to the station. The cost of some of these New York stations includes the cost of computing two years' records.

EQUIPMENT OF A CABLE GAGING STATION.

By E. C. MURPHY.

The equipment of a cable gaging station consists essentially of the cable with its turn-buckle for increasing or decreasing the sag, the supports for keeping the cable at the proper height, the anchorages for holding the ends of the cable in place, the car or box from which the measurements are made, the tag line and its tags marking distances across the stream from an initial point, and the stay line for keeping the meter in place in the water when the flow is rapid.

The cost of erection of a cable is generally so large, compared with the cost of any part of the equipment, that it is wise to make the parts abundantly strong and durable. Failure of the cable frequently results from drift (parts of floating trees) catching on it during flood, and hence the supports must be long enough to keep the cable above any drift that may come down the river, and also to permit the highest floods to be measured from the car.

Galvanized steel wire cable is preferable to ungalvanized cable on account of its greater durability. The sizes of the galvanized cable given below will be found safe for different spans or lengths between cable supports:

Proper diameter and sag of galvanized steel cable, with live load of 450 pounds, for spans of 100 to 800 feet.

Span.	Diameter in inches.	Sag in feet.	Stress.
100 feet	$\frac{1}{2}$	4	2,938
200 feet	$\frac{9}{16}$	6	4,167
300 feet	$\frac{5}{8}$	8	5,061
400 feet	$\frac{3}{4}$	10	6,300
500 feet	$\frac{3}{4}$	12	7,813
600 feet	$\frac{7}{8}$	12	10,125
700 feet	1	14	12,626
800 feet	$1\frac{1}{8}$	15	16,660

The diameter is computed for a live load of 450 pounds (car and two men) on the cable, at center of the span, and an initial tension due to the sag (given in the table), using a factor of safety of about 5. The sag given in the table is the least allowable. If it is increased, the factor of safety is increased. The cable should not be bent in making connections to a shorter radius than 2 inches; and the turn-buckle and connections should have a safe working strength of an amount given in the last column of the table.

It occasionally happens that a tree can be found on one or both sides of the stream at the place selected for the station that can be used to support the cable. If such trees can not be found, then for spans less than 300 feet a single post, such as a telephone or telegraph pole, or sawed timber 10 or 12 inches on a side, can be used, with the lower end firmly set in the ground and notches cut in the upstream side for sustaining the cable. Two pieces of 6 by 8 inch timber crossed and bolted together near the upper end, called "shear legs," can be used instead of a single post, if desired. High supports for long spans are made of two inclined heavy timbers connected by horizontal timbers with diagonal bracing.

The form and size of anchorage depends on the length of span and the material of the bank. For spans of less than 200 feet and earth bank a log or sawed timber 12 inches in diameter and 5 or 6 feet long buried at least 4 feet in the ground will answer. For longer spans it is necessary to place cross timbers on top of the timber to which the cable is attached and to bury them more deeply in the earth than for the shorter spans. Old iron rails can be used to advantage instead of timber in the anchorage, and rock in place of earth on top of the timbers is desirable.

The end of the cable is wrapped a couple of times around the deadman and fastened to the cable with clips. A block and tackle and a team of horses are necessary in the erection of long cables.

If there is solid rock on one or both banks that can be used for an anchorage, a hole 12 to 18 inches in depth and of one-eighth inch larger diameter than the cable can be drilled into it. A bolt slightly less in diameter than the hole, having a loop in the upper end and a slit and wedge in the lower end, can be leaded into it. The end of the cable is fastened with Crosby clips to this loop on the end of the bolt. A right-and-left turn-buckle of sufficient length to take up the sag of the cable should be placed between the anchorage and the support on one side of the stream.

The car from which the measurements are made should be about 4 feet long, 3 feet wide, and 1 foot deep. Each end is fastened to a pulley on the cable, either by galvanized steel wire cable or by a 2 by 4 inch timber at a height such that the car can easily be pulled along by a man in it. The pulley should be at least 8 inches in diameter and made so that it can be easily taken off the cable.

Barbed wire can be used as a tag line. It is not likely to be stolen, and the tags can easily be fastened to it and replaced if they drop off. The ends of the line are fastened to the cable supports.

A single heavy galvanized wire or a three-eighths inch or one-fourth inch galvanized steel wire cable can be used as a stay line. A pulley with a swivel on it is placed on this line, to which a sash cord is attached during the measurement of the flow of the river. This stay line must be placed at a sufficient distance upstream so that it will exert only a small upward pull on the meter. If the stay line is too near the cable, it will not permit the lowering of the meter to the bottom of the stream directly underneath the cable.

SILTING OF RESERVOIRS.

By W. M. Reed.

The matter of silt deposit in storage reservoirs is one that will be encountered in many of the projects to be undertaken by the Reclamation Service.

Those who have had to deal with the silt-laden streams of the West have long known that the silt question is an important one. But little of a definite nature has been written upon this subject, the question having been dodged in the hope, perhaps, that by some mysterious process the silt would not become the trouble that is often predicted and toward which all indications point.

The writer has had opportunity to study this question somewhat during the present year, and the results have been quite satisfactory from an educational standpoint, even if they do not offer a solution of the problem.

Pecos River is a typical southwestern stream, always carrying some silt in suspension, and at flood time carrying large quantities; it does not, however, carry any such amount as does the Rio Grande. A comparison of the sediment in the two streams was made by Prof. Arthur Goss, of the New Mexico Agricultural Experiment Station, and the results published in Bulletin No. 34 of that station, which gives the sediment in the Pecos as 180 parts of suspended matter to 100,000 parts of water, and in the Rio Grande as 831 to 100,000.

During the winter of 1903–4 a board of consulting engineers of the Reclamation Service visited Lake McMillan, the principal storage reservoir of the Pecos Irrigation Company, and instructions were issued that should this reservoir become empty a survey should be made to determine the amount of sediment that had been deposited during the ten years that the reservoir had been in operation.

The drought of 1903 continued into the summer of 1904, and on June 1, 1904, the reservoir was empty of all stored waters. A survey was at once begun and the work was pushed almost to completion, when on June 17 a rise in the river brought to an end all operations along this line; not, however, before nearly all the data sought had been obtained.

This reservoir had been in operation for ten years, and therefore the sediment found represents the amount deposited in that period. The reservoir had never been accurately surveyed and it was necessary to determine its capacity before the silting commenced as well as its capacity at the time of this examination.

The original capacity was found to have been 28,732 acre-feet and its capacity June 1, 1904, was 16,500 acre-feet. This shows a loss of storage capacity in ten years of about 42 per cent, or a little more than an average of 4 per cent per annum.

It had been contemplated originally to construct a reservoir of much greater capacity, but, owing to some trouble from floods in the early existence of the reservoir, the western spillway was cut down several feet below the spilling point and was not reconstructed until during the past winter, when, at a very small expense, the capacity was increased to about 46,000 acre-feet.

One cause of the rapid silting up of this reservoir can readily be understood. The flow of the river probably averages ten times the capacity of the reservoir, and as nearly all the silt is taken out of the water at this reservoir the process of silting up is very rapid. Had the storage capacity been equal to the entire flow of the river the per cent of silt would have been small. This indicates that small reservoirs on streams of great flow have a very low ultimate efficiency.

One of the points not satisfactorily determined by the investigations was the amount of silt deposited outside of the storage area of the reservoir. The amount is known to be large, the depth of silt increasing rapidly as the intake end of the lake is approached, and a few hurried borings outside the real storage area showed a greater depth of sediment than at any point within that area. It is a positive fact that a large proportion of the entire silt deposit is outside the storage area, but exact information could not be obtained on account of the high water.

It seems that when the reservoir is full, or nearly so, and a flood comes down the river, meeting with the level surface, the silt begins to drop and for several miles above the reservoir the banks overflow and the topography is entirely changed. This would indicate that where small reservoirs are constructed on streams of great flow and little fall a large part of the silt will be deposited outside the reservoir.

A more detailed report of this investigation has been submitted to the chief engineer and published in the Third Annual Report of the Reclamation Service. One of the most important of the conclusions reached as a result of the investigation is that in silt-laden streams, when the valley of the river must be used for the storage of the floods, thereby accumulating all the suspended matter, reservoirs of capacity as nearly as possible equal to the entire flow of the river will be the most economical.

The writer has not put much faith in the theory that any considerable part of a large silt deposit in a reservoir can be removed by ordinary flushing. The current through a reservoir is not sufficiently strong to pick up much of the silt, and in cases that have come under personal observation the sluice gates have operated only to cut out a small narrow channel, not materially increasing the storage capacity.

It is possible that when the value of water becomes much greater, as perhaps it may at no very distant time, mechanical appliances may be used to aid the current to take a large proportion of the silt again into suspension and remove it through the sluiceways that are almost invariably placed in reservoirs; but considering the present value of water, mechanical methods of removing silt seem to be without the bounds of economy, except in rare cases.

FARM-UNIT CLASSIFICATION.

By D. W. Ross.

PROPOSED PLANS FOR CLASSIFICATION.

A circular letter on farm-unit classification issued by the chief engineer under date of October 29, 1904, invites discussion by the engineers of the service of the subject of farm-unit classification, particularly in relation to apportioning the cost of reclamation over the lands to be reclaimed, keeping in mind the character of each farm unit.

The letter referred to submits three plans for settling this difficulty which are thought to be worthy of consideration, and invites comment on the same. The following are the alternative plans suggested:

(1) That the classification sheets should contain in each area the equivalent acreage of first-class irrigable land, distinguished from the total acreage by being placed within a circle. The charge will be uniform per acre of first-class land or its equivalent.

(2) Assuming that the standard area is 80 acres, the charge should be made for that acreage, regardless of the actual area of the farm unit. In case a smaller subdivision has been made under the project near the towns the charge to be for the actual area in each farm unit, on the theory that in such cases both the land and the crops would have a value as great as the land and the crops of the larger area farther from the towns.

(3) That the charge per acre should be made proportional to the quality and value of land. For example, if a 40-acre tract, specified as first-class land on account of quality or location, is charged at $25 per acre, another tract of second quality containing 80 acres would be charged at $12 or $15 per acre, etc.

Commenting on these plans, the letter states that No. 1 would probably call out the least objection from the settler; No. 2 would be simpler to manage and involve the least danger of error, and No. 3 would give opportunity for criticism on the part of the larger portion of the settlers.

Plan No. 1.—Where the tract to be reclaimed is public land and is open to entry while the construction of the works is in progress, full consideration will likely be given all matters relating to the quality and location of lands open to entry by the intending entrymen; that is, in entering a given tract each entryman will first consider its location and quality, and knowing the price per acre which he will be called upon to pay for his water right, he will naturally decide whether or not the land is worth entering at that price. Those who are fortunate enough to make the first filings will, of course, select the best land, and each succeeding entryman will select the best land remaining, until the poorest land of the tract remains to be entered, when the same question arises as before—is the land worth what it costs to reclaim it? If it is, it will be entered; if not, it will remain vacant, but probably for only a short time. So it is my opinion that but very little attention need be paid by the Reclamation Service to the relative value of farm units where entrymen are at liberty to exercise their own judgment in selecting their claims. I do not believe that the first plan proposed is necessary.

Plan No. 2.—Regarding plan No. 2, considerable importance seems to be attached to the location of the tract. If it is close to a town, it is proposed to charge a greater amount for the water right, so as to place it on an equality with perhaps a larger tract situated farther from a center of population. The principal objection which I see to this plan is that where a large area of public land is to be reclaimed there is nothing settled regarding centers of population; such matters are to a very large extent in the future, so that if an attempt should be made to place the entryman who is remote from a townsite on an equality with one whose land may join a townsite the result may be entirely upset in a few years' time through the development of towns in unexpected localities. For this reason I do not believe the plan proposed is a sound one.

Plan No. 3.—Plan 3 proposes to make the charge per acre proportional to the quality and value of the land. This involves the same principles that it is sought to apply to plans 1 and 2.

ALTERNATE PLAN FOR ASSESSING COST.

It would appear that the principle adopted in fixing the price of a water right should be one which will have general application not only to public lands, but to private lands as well. If the question could be approached on the theory that what is paid for by the irrigator is a proportional interest in the works the problem would be comparatively easy of solution. What the settler pays for is called a "water right," acquired by him by virtue of stock held in an association. It means primarily a proportional interest in the works constructed, and under the provisions of the reclamation act it seems to be contemplated that the settlers shall, at some future time, be given control of the works constructed; so that whatever payments may have been made for so-called "water rights" would, as a matter of fact, represent certain equities in the works themselves. Where these water rights or equities are purchased through a water users' association it is proposed that each water right purchased shall be represented by a share of stock issued by the association. This places water users' associations in practically the same class as community irrigation companies, which are so common all over the West. On this basis, then, one share of stock would be worth as much as another. The land, of course, will not be all of the same quality, but the shares will likely cost the same.

While it is a fact that desert land owes its first real value to the construction of irrigation works, and every acre of land is, or should be, worth what it costs to reclaim it, the productive value of the land, or its value after it is improved, very soon exceeds this first outlay, which is finally lost sight of entirely, and the poorest land upon which water is applied is usually worth a great deal more than the average cost of reclamation.

The quality and lay of the land, however, is an important factor in determining the amount of water necessary for irrigation, which in turn frequently determines the amount of the annual charge or tax, which runs perpetually. But the amount of water needed is not necessarily proportional to the first cost. Land which appears to be of the very best quality and which, according to the principle set out in the circular letter, would pay the highest price for a water right, might require a comparatively small amount of water, and if the cost of service is based on the quantity of water delivered, the charges running against this land perpetually might be very low. But lands which are inferior in quality, and which as a result would pay a smaller charge to begin with, might in the end pay an exceedingly high annual maintenance tax, owing to the great amount of water required for irrigation. Or these two cases might be entirely reversed; that is, the superior land require an exceedingly large amount of water, while the inferior might require but very little. In this case it might with reason be held that the owner of the inferior land should pay a larger proportion of the first cost of reclamation.

It is my opinion, therefore, that if we hold that the irrigator is purchasing a proportional interest in the works for which the money is expended no one will be done an injustice when the charge is made uniform over all the land, unless extraordinary expense has been incurred in carrying water to a certain tract, in which case the entire tract involved might with justice be made to pay a greater price per acre.

I am of the opinion that the distribution of the cost of an irrigation system should be allotted to certain natural subdivisions of the territory involved rather than to separate farm units, since greater expense may be incurred in reaching one natural subdivision than another, but all the lands in each subdivision should be assessed the same—that is, the shares of stock or water rights should cost the same.

The benefits to be derived from the use of water can not, in my opinion, be very accurately estimated. The cost, however, of conducting water onto certain lands can be definitely determined, and it seems to me that this should be the basis for equitably proportioning the amount expended in the construction of works.

COST OF POWER FOR PUMPING IRRIGATING WATER.

By H. A. Storrs.

Many factors must be considered in determining the feasibility of pumping water in large quantities for irrigation uses, and no factor is more important and more variable than the cost of power and of operating the pumping plant.

ELECTRICALLY TRANSMITTED WATER POWER.

In many sections of the arid West water power may be developed and the power transmitted electrically from the mountains, where the power plants are usually located, to the valley lands, where the water is to be pumped and used. The commercial cost of electric power so obtained may be as low as 1 cent per horsepower hour delivered to the pump motor. On this basis the cost of power for pumping water to any required height would be about 2¼ cents per acre-foot for each foot of height to which the water had to be lifted. And if, for instance, each acre of land to be irrigated required a total depth of 3 feet of water during the irrigation season and the water had to be pumped a total height of 50 feet, the total annual cost per acre for the power required for operating the pumps would be about $3.40.

Commercial electric-power companies usually find it necessary to charge more than 1 cent per horsepower hour—frequently 5 cents or more. These higher rates are not, however, prohibitive where the lift is not great or a small auxiliary supply is required whenever the main supply proves inadequate or the value of the crops is relatively high.

On the other hand, the actual cost of supplying power to the motors will often be less than 1 cent per horsepower hour, depending on the first cost of the hydraulic works—such as the dam, flume, canal or pressure pipes, etc.—the size of the power plant, the length of the electric transmission line, etc.

In the case of national irrigation works, minimum costs may be expected for electric power developed and used for pumping purposes, since no interest is charged by the Government on the money advanced for installing the plant, and the item of profits involved in commercial enterprises is here eliminated, the users of the power being themselves the owners of the power plant.

Still another reason for expecting a low cost for electric power for pumping irrigation water should be noted in the case of combined gravity and pumping systems. Here it often happens that one dam serves the double purpose of securing storage or diversion for the gravity supply and water power for generating the electric power required for pumping.

Again, a power plant may sometimes be placed in the main canal of a gravity system where the nature of the country requires the water to descend suddenly to a lower level, making the additional cost for the power development little more than the bare cost of buildings, water wheels, and generators. In such cases it may be possible to deliver electric power to motor-driven pumps at less than one-half cent per horsepower hour.

STEAM POWER.

But many sections of the West where water for irrigation must be pumped are not so fortunate as to possess water-power possibilities. It then becomes necessary to hunt for a cheap fuel supply.

Coal.—Coal and oil are found in many parts of the arid regions and may often be delivered at the pumping plants at very low cost. Western coals are, however, as a rule, poorer steam producers than coals from the Eastern or Middle States. Tests to determine relative evaporative power have been made at the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition at St. Louis, which when worked out will afford reliable data for comparing the steam-producing qualities of varieties of coals from all parts of the United States. These tests will be of special value as regards western coals, which differ greatly in their characteristics and about which much less has been learned by practical use than is known regarding the coals of the East, which have been longer in use.

The results of various commercial tests indicate that under similar conditions 1 pound of the bituminous coals of Pennsylvania or West Virginia will evaporate about 10 pounds of water into steam; 1 pound of Illinois or Missouri coal will evaporate about 7 pounds of water into steam, and 1 pound of western lignite will evaporate about 5 pounds of water into steam.

Many grades of coal besides the lignites are, however, found in different sections of the West, Colorado alone producing coals ranging all the way from lignite to anthracite. On account of these extreme variations in the character of western coals, the cost per horsepower for the fuel required in steam-pumping plants will vary widely in the different sections of the arid regions.

Hence, in order to estimate closely the probable annual cost of coal for a given pumping plant, it is as important to know the steam-producing power of the coal to be used as to know its cost per ton.

In designing steam-pumping plants care should be exercised in selecting the boiler and in designing the boiler setting to adapt these to the peculiarities of the kind of coal to be used. A plant that would give excellent results with anthracite or bituminous might be very inefficient in burning lignite.

Engines.—Having determined how many pounds of steam may be expected with the kind of coal to be used it becomes necessary to determine how many pounds of steam will be required by the engine to produce a horsepower hour. This will depend upon the size and type of engine used, as shown by the fact that while a 500-horsepower simple, high-speed, noncondensing engine may require 32 pounds of steam per horsepower hour, and a compound, slow-speed, noncondensing engine about 25 pounds, a compound, high-speed, condensing engine of the same size will require only about 20 pounds of steam per horsepower hour, and triple-expansion engines, steam turbines, and large, slow-speed, direct-connected steam pumping engines may require less than 12 pounds of steam per horsepower hour.

In view of all these variable factors it is evident that pumping plants of various designs and sizes, using varieties of coals which differ widely in their steam-producing values, will show great differences in the annual cost for fuel.

Sometimes it may happen that a large and efficient plant will burn bituminous coal and be able to produce one-half of a horsepower per hour per pound of coal consumed, whereas a smaller plant using boilers and engines of cheaper and less efficient design and burning lignite may be able to produce not over one-eighth of a horsepower per hour per pound of coal consumed.

The above are not extreme cases, but merely serve to show that some plants may use four times as many tons of coal as others in doing the same amount of work.

EFFICIENCY OF PUMPS.

Pumps.—Moreover, the efficiency of the pumps would naturally be lower in the smaller than in the larger plant, and losses by friction and leakage in the suction and pressure pipes may further vary the ratio of coal used in the several plants. For comparison, take a plant using coal which costs $3 per ton and requiring 5 pounds of coal burned under the boilers for each horsepower delivered to the pumps per hour. Assuming an efficiency for pumps, suction and discharge pipes of 60 per cent, the fuel cost per acre-foot per foot of lift would be about 2 cents. To this must be added the cost of labor for operating the plant and depreciation and repairs to machinery, which would bring the cost to 3 cents per acre-foot per foot of lift, or a total cost of $4.50 per acre per year, based on a duty of 3 acre-feet per acre per year and a lift of 50 feet. In general, the larger the pump units and the higher the lift the smaller will be the cost per acre-foot per foot of lift.

As a practical illustration of what is now being done, consider the pumping plants in use for supplying water for irrigating sugar-cane plantations in Hawaii. Ninety-five per cent of the pumps are steam-driven, direct-connected, reciprocating pumps of Worthington or Riedler type. The lifts are usually from 100 to 500 feet. These steam plants contain the most efficient equipment obtainable. The price of coal averages about $12 per ton.

The cost of pumping irrigating water under these conditions is reported by Mr. Jared G. Smith, special agent of the agricultural department in Hawaii, as follows: The cost for coal for two steam-driven, direct-acting, plunger pumps, with a combined capacity of about 22 acre-feet per day, pumping against heads of 95 and 100 feet, respectively, averaged about 4.2 cents per acre-foot per foot of lift; the cost for coal for three Riedler pumps, having a combined capacity of about 66 acre-feet per day, pumping against heads of 200 and 300 feet, averaged a trifle over 1½ cents per acre-foot per foot of lift.

This is an excellent showing for the Riedler pumps, considering the high price of coal. The cost per acre per year, assuming a duty of 3 acre-feet per acre and a pumping lift of 200 feet, would be about $9. This, and much greater annual costs, can easily be paid from the yearly receipts from an acre of sugar cane, since the average yield is about 11 tons of sugar per acre and its selling price $60 per ton.

In general, the higher the lift the less the cost per acre-foot per foot of lift. For comparison, consider the costs for two large pumping plants in Egypt, where the pumping lift was only 6½ feet. The cost of coal being $9 per ton, the cost per acre-foot per foot of lift was in one case 7.2 cents and in the other 8.5 cents, including fuel and labor. Compound condensing engines were used, and presumably the whole plant was designed for high efficiency.

Oil.—Crude oil burned under steam boilers is an ideal fuel when its cost is not too high. Oils from the wells of the principal oil fields of the country vary little in their steam-producing qualities as compared with the variations in different coals.

Oil usually gives better efficiency than coal under steam boilers, as shown by tests made by the Engineers' Club, of Philadelphia, giving the following results: 1 pound anthracite coal evaporated 9.7 pounds of water; 1 pound bituminous, 10.14 pounds; 1 pound fuel oil (36° gravity), 16.48 pounds water, indicating that a pound of oil will evaporate 60 per cent more water than will a pound of coal. Tests made in 1893 by the Twin City Rapid Transit Company, of Minneapolis and St. Paul, showed that in their plant it was equally economical to burn Lima oil, costing 95 cents per barrel, as to burn coal costing $3.85 per ton, the evaporation of the coal being 7½ pounds water per pound of coal; these results include the difference in the cost of handling the coal, ashes, and oil. A test made by the Illinois Steel Works showed that one week's work required 2,731 barrels of oil against 848 tons of coal to do the same work, a ratio of 3.22 barrels of oil to 1 ton of coal, or about 2½ pounds of coal to 1 pound of oil; Indiana block coal was used. In this case the cost for oil, at 93 cents per barrel, would equal the cost of coal at $3 per ton to do the same work. On the basis of 2 pounds of oil burned under the boiler for each horsepower hour delivered to the pump shaft, the cost for oil would be about 2 cents per acre-foot per foot of lift with oil at 95 cents per barrel, or a total cost of about $4.50 per acre per year, assuming a duty of 3 acre-feet per acre and lift of 50 feet.

INTERNAL-COMBUSTION ENGINES.

Oil may be used with greater efficiency, however, in internal-combustion engines, and these cost less than a steam boiler and engine of the same capacity, besides requiring less labor to operate.

These engines, if designed to burn crude oil, are provided with an attachment called a generator, in which the heat of the exhaust from the engine is applied to the oil, thus raising its temperature sufficiently to separate the volatile matter from the residue. The gas thus formed is burned in the engine cylinder with a high thermal efficiency. The residue, which may amount to 50 per cent of the crude oil used, is suitable for many purposes, such as lubrication, road surfacing, etc.

The thermal efficiency of steam plants ranges from about 5 per cent to 10 per cent; that is, only 5 per cent to 10 per cent of the heat energy in the coal or oil burned is transformed into useful work, the remaining 90 per cent or 95 per cent being lost in the boiler and engine. The thermal efficiency of internal-combustion engines is not often less than 20 per cent, and is frequently more than 30 per cent. A recent test of a 240-horsepower Diesel oil engine showed a thermal efficiency of 42.8 per cent.

To illustrate, assume that an oil engine, using crude oil of which the calorific value is 18,000 heat units per pound, producing a residue amounting to one-half of the quantity of oil used, shows a thermal efficiency of 25 per cent. Then about 1.2 pounds of crude oil would be required per horsepower hour, costing about 0.4 cent, if oil costs 90 cents per barrel. The cost of oil would then be nearly 1 cent per acre-foot per foot of lift, if, as before, pump efficiency be taken at 60 per cent. Adding one-half cent per acre-foot to cover labor, repairs, and depreciation, the total cost per year, assuming a duty of 3 acre-feet per acre and a pumping lift of 50 feet, would be about $2.25 per acre.

The small gas or oil engines used for pumping usually burn distillate, gasoline, or kerosene, and require about half the quantity that would be required if crude oil were used to do the same work. The cost per gallon varies from about 10 to 20 cents in different sections, but at 15 cents per gallon the cost per acre-foot per foot of lift would be about 3½ cents. If, as before, we add one-half cent for labor, etc., making 4 cents per acre-foot per foot of lift, the total cost, based on a duty of 3 acre-feet per acre and a 50-foot pumping lift, is approximately $6 per acre per year.

Some of the results actually obtained in portions of California are reported as follows: Five engines, rated at 5, 6, 12, 16, and 20 horsepower, all burning distillate which cost 10 cents per gallon, cost, respectively, 4.3 cents, 7.6 cents, 2 cents, 1.1 cents, and 1.9 cents per acre-foot per foot of lift for fuel and operation. Two engines rated at 20 and 22 horsepower, burning crude oil which cost 3½ cents per gallon, cost, respectively, 0.9 cent and 0.8 cent per acre-foot per foot of lift for fuel and operation.

In general, large engines are more economical than small, and the statement of costs given above seems to bear this out, with some exceptions. Two items enter into statements of this kind which are not always clearly defined and so affect comparative results unaccountably. One indefinite item is, how much is charged to the plant to cover operating expenses, in some cases practically nothing being charged, it being claimed that the man who ran the pumping outfit had to be employed anyway and the amount of time given to this work did not appreciably lessen the amount of other work he was able to perform. The other uncertain element is the efficiency of the pump as affected by the relation between the speed of the pump and the pumping lift. It is often inconvenient to change pulleys so as to keep the speed of the pump right for the varying lifts sometimes encountered; consequently the plants are operated sometimes for long periods at comparatively low efficiency.

GAS ENGINES.

All internal-combustion engines really operate as gas engines, since even when crude oil, distillate, gasoline, or kerosene are burned in the engine this liquid fuel is transformed into a gas prior to combustion either before or after entering the engine cylinder. It is therefore but a step from oil engines, so called, to gas engines proper. This distinction simply implies that the latter type of engine receives the gas consumed by it from an independent source, namely, some kind of gas producer.

Natural gas.—On irrigation works it will not often happen that natural gas or illuminating gas can be supplied to gas engines for operating pumps, but the possibilities of producing in an economical way some kind of fuel gas for pump engines are worth considering.

Producer gas.—The fuel gas known as "producer gas" is probably best suited to the conditions met in irrigation problems. The design of the producer-gas plant will depend upon the character of the fuel available. The best results may be expected when anthracite or coke are used, yet excellent gas can be produced with good economy from lignites or very poor grades of bituminous coals. Anthracite coal yields in producer-gas plants of 100 to 400 horsepower capacity about 75 to 80 cubic feet of gas per pound of coal consumed, and the calorific value of the gas is about 125 to 140 heat units per cubic foot. A gas engine having a thermal efficiency of 25 per cent and a mechanical efficiency of 85 per cent, if supplied with this gas, would consume 90 to 100 cubic feet of gas per horsepower hour. This corresponds to 1.1 to 1.3 pounds of coal per horsepower hour. Either with lignite or other grades of coal having only two-thirds the heating value of anthracite, a combined plant of this kind would require less than 2 pounds of coal per horsepower hour, which is less than half the amount required for steam plants of similar size.

Makers of gas engines and producer plants will guarantee that the coal consumption will not exceed 1¼ pounds per brake horsepower hour for sizes above 100 horsepower, and undoubtedly better results than this have been frequently obtained commercially. On this basis, with coal at $5 per ton, assuming as heretofore a net efficiency of 60 per cent for pumps, suction and discharge pipes, the cost per acre-foot per foot of lift is about 0.7 cent. The same results would be secured by using a poorer coal, like lignite, costing $3.20 per ton, if about 2 pounds were required per horsepower hour. In either case the cost for the coal required for pumping would be about $1.05 per acre, on the basis of 3 acre-feet per acre and a lift of 50 feet.

Where pumps take their water from wells, smaller engines than 100 horsepower are usually required, and a single gas-producer plant will have to supply several small pumping plants, which may be considerably scattered. It thus becomes necessary to extend gas pipes from the gas producer to the pumps, thus increasing the first cost of the pumping system somewhat. This additional first cost might, however, be more than offset by the saving in fuel and operating expenses. By this plan a considerable number of pumps, located at wells scattered over several square miles, might be more economically operated by gas engines supplied from a central gas plant than in any other way.

The first cost of gas engines and producer plants would be somewhat more than that of the usual steam engines and boilers of the same rated horsepower, and the depreciation and repairs would perhaps be slightly greater. On the other hand, the cost of fuel and labor for operation might be reduced 50 per cent or more.

Wherever large pumping plants are required, as for lifting water from a canal, reservoir, or stream to land too high to be reached by gravity systems, a combination of gas engines and a fuel gas plant would probably effect a very great saving over steam equipment or oil engines as regards fuel, besides being quite as reliable, safer, and requiring less skilled labor in their operation.

SUMMARY.

As a résumé of the above outline of the principal sources of power available for pumping purposes and the relative costs involved, the following statement seems warranted:

That the cheapest power in those localities where the conditions for developing and transmitting the power are favorable, will be derived from water-power plants; that steam boilers and engines should be selected only for large plants and in localities where fuel, whether coal or crude oil, is exceptionally cheap; that for small plants internal-combustion engines should generally be used, wherever crude oil, distillate, gasoline, or kerosene can be obtained at reasonable prices, and that the greatest economy may be expected where crude oil is used; that in the majority of cases, where fuel of some kind must be the source of power, the combination of gas engines with fuel gas-producing plants should give the most satisfactory results.

IRRIGATION DEVELOPMENT IN NORTH DAKOTA.

By H. A. Storrs.

Surveys and examinations of the entire arid portion of North Dakota have been pushed systematically and energetically by the Reclamation Service in the effort to discover a locality where the natural conditions offer a fighting chance of working out a feasible irrigation project. The topographic features of the State are, however, distinctly unfavorable to the storage and diversion of water from its streams, and North Dakota seems to possess few, if any, possibilities of large irrigation projects.

The Missouri affords an abundance of water, but the irrigable lands along its banks exist either in small tracts at low elevations, or in extensive plains at high elevations above the river. The lower lands are not sufficient in extent at any location to warrant the enormous expense involved in damming and diverting the waters of the Missouri. The higher lands could be reached only by dams of great length and height or by large canals several hundred miles long. Neither of these methods is considered feasible, in view of the unfavorable topographic features presented and the enormous expense involved.

The smaller streams are flat in slope, variable in flow, devoid of favorable reservoir sites, and hemmed in by high banks of earth, all of which conditions are unfavorable to storage or diversion of irrigating water on a large scale. The conditions, however, on most of the streams west of the Missouri are distinctly favorable to small dams and pumping plants which private enterprises will no doubt utilize in the near future.

During the past season it was determined to ascertain whether it would be feasible to pump water from the Missouri for irrigating the inviting bench lands which extend for many miles along its banks. The Reclamation Service has been unwilling to resort to this method of securing irrigating water, on account of its presumed high cost, if any cheaper or simpler method could be discovered. The feasibility of any pumping project is not assured until it is demonstrated that the value of the lands and crops will warrant the necessary expenditure for pumping machinery, canal system, and annual operating expenses.

The engineer can determine the natural conditions, the cost of irrigation works and their maintenance and operation, and can present figures showing the cost per acre for irrigating a proposed tract of land. It then rests with the land owners to decide whether they will agree to pay what is required to install and operate the proposed irrigation works.

The people of North Dakota have much to learn regarding the value of irrigation. Almost no irrigation has been attempted thus far, and the majority of farmers have had no opportunity to see what has been accomplished in other States. Undoubtedly when the facts as to the increase in the amount and value of crops to be secured by means of irrigation are presented to and understood by the people they will be as ready to accept the conditions and secure the benefits resulting from reclamation projects as have been the farmers in Montana and other Western States.

As a result of preliminary investigations not yet completed, the Reclamation Service will soon present to landowners in the vicinity of Bismarck, Buford, Trenton, and possibly some other localities, the proposition to erect pumping plants at these places, provided the people will agree to cooperate in the enterprises.

The costs promise to be but little if any higher than for many of the projects in other States, where an annual charge of $3 to $4 per acre is required during the first ten years. This amount pays for the irrigation works in ten annual installments, in accordance with the terms of the reclamation act, and also pays the cost of operating expenses during the first ten years. During subsequent years the annual charge covers only maintenance and operating expenses.

In projects involving steam or gas-engine pumping plants the operating expenses will probably be greater than on gravity systems. These operating expenses, however, will be approximately proportional to the amount of water actually pumped. Consequently, in years of heavy rainfall the operating expenses will be small. The pumping plants are really a reserve, to be called upon to supply the deficiencies of rainfall and run-off. By storing all the flood waters of small streams within the area covered by the project the run-off may materially lessen the quantity of water which has to be pumped.

In general it may be stated that the pumping works and canal systems for the two projects examined would be paid for in ten annual payments not exceeding $2 per acre each. The maintenance charges would involve an additional annual payment of about $1 per acre and would be practically constant, whether much or little irrigating water was used. The operating expenses would, however, vary according to the amount of water actually used, and would amount to little or nothing during years of abundant rainfall. During dry years, when as much as 2 acre-feet per acre might be used, the total for maintenance and operation would approximate $2 per acre. The pumping plants will have a capacity of 2 acre-feet per acre for the entire tract during an irrigation season one hundred days in length. On this basis the probable annual operating expenses have been estimated. This amount is probably the maximum that will be required if economy is exercised in the use of water.

The Buford-Trenton project includes about 18,000 acres and the Bismarck project about 15,000 acres. Both projects are on the left bank of the Missouri, the former near the Montana State line and the latter south and east of Bismarck. The latter may be considerably extended after the surveys are completed and the results studied. Possibly it will be thought advisable to erect a central power station convenient to the coal supply and transmit the power electrically to the pumping plants, thus saving transportation of coal to pumping plants located at a distance from the railroads or coal mines. In any event the landowners along the Missouri, and possibly other rivers in the State, will soon have an opportunity to signify their desires regarding the construction of national irrigation works within the confines of the State.

RECORDS OF FLOW AT CURRENT-METER GAGING STATIONS DURING THE FROZEN SEASON.

By F. H. Tillinghast.

GENERAL WINTER CONDITIONS.

In the determination of the volume of flow of rivers for conditions of open channel at the ordinary current-meter gaging stations, the methods of the United States Geological Survey are well defined and the limits of accuracy are known to be reasonable. For ice conditions, on the other hand, records of gage heights are not uniform, knowledge of the relation of gage height to discharge is meager, and estimates of flow are often much in error.

Throughout the Northern States the most severe droughts occur in the winter months. Whenever the streams are closed by ice with a low condition of ground water, if the period of cold is long continued, there is sure to result a period of extremely low stages of the rivers; for during the frozen season no surface water finds its way to the streams, the precipitation being all stored in the form of snow. One or two such periods of low water have been known in which there has been a draft upon the ground water covering a period of nearly six months, and the streams have discharged a smaller amount than has been recorded with open-channel conditions.

It is, therefore, very desirable that a full investigation should be made of the whole subject of flow of water under ice, in order to determine the best methods for making discharge measurements, the gage height to be used, and the probable accuracy of the results. None of these matters have received adequate attention and there are comparatively few data bearing upon the subject.

The winter conditions in many rivers vary through a large range, from those which may be called normal, in which the ice remains practically in the position in which it has formed and the stream is quickly closed by a uniform cover of ice, to those where the ice has been broken and is either flowing in large blocks, often practically filling the whole section of the river, or has been gorged to form temporary dams. To these latter cases no general rules can apply; each must be considered as a problem by itself.

With unbroken ice, fair estimates of flow are possible. There is, however, a wide range in so-called normal conditions of ice through all stages in ice development, from the first fringe along the shore to the solid cover of smooth ice varying in thickness to a maximum of 30 or even 40 inches. With a falling stage of the river the ice cover may not rest entirely on the water, but may act in part as a bridge supported on the banks; on the other hand, with a rising stream the pressure of the water under the ice may be greater than that due to the weight of the ice.

FLOW UNDER ICE.

There have been made several series of current-meter measurements of flow under ice by the hydrographers of the United States Geological Survey. The measurements have been tabulated according to increasing gage heights and compared with discharges as obtained from the open-section rating table, as shown below:

Discharge measurements, with ice conditions.

Gage height to water surface.	Thickness of ice, in feet.	Average depth of water below ice.	Actual discharge (closed section).	Discharge from rating table (open section).	Coefficient for reducing open section to ice conditions.
WALLKILL RIVER AT NEWPALTZ, N. Y.					
7.14	1.1	5.4	332	805	0.41
7.23	2.0	4.6	288	855	.34
7.68	1.1	6.0	597	1,105	.54
8.75	1.0	7.2	945	1,765	.54
8.97	1.0	7.4	1,167	1,910	.61
10.80	1.0	9.2	2,028	3,250	.62
11.10	.8	9.2	2,293	3,494	.66
[a] 11.40	----------	----------	3,040	3,746	----------
[b] 13.60	----------	----------	3,277	5,660	----------
[a] 15.75	----------	----------	5,985	7,650	----------
17.23	.9	15.5	6,063	9,170	.66

[a] Partly open channel. [b] Ice piled along banks.

Discharge measurements, with ice conditions—Continued.

Gage height to water surface.	Thickness of ice, in feet.	Average depth of water below ice.	Actual discharge (closed section).	Discharge from rating table (open section).	Coefficient for reducing open section to ice conditions.
RONDOUT CREEK AT ROSENDALE, N. Y.					
[a] 6.63	0.3	5.6	222	302	0.73
[b] 6.83			423	434	
[c] 7.43			772	910	
[b] 7.50	.7	6.0	342	971	.35
7.93	1.5	5.7	543	1,402	.39
7.96	.5	6.8	676	1,432	.47
8.61	.2	7.7	1,185	2,120	.56
ESOPUS CREEK AT KINGSTON, N. Y.					
[a] 5.25	0.3	2.9	245	322	
[a] 5.47	.3	3.1	337	376	
6.30	.1	4.4	476	631	0.75
[a] 6.43	.1	4.2	522	675	
6.60	.8	4.0	425	741	.57
6.70	.3	4.3	530	782	.68
[a] 6.80	.4	4.6	654	823	
[a] 9.01	.3	6.8	1,687	1,947	
12.70	.4	10.8	3,461	5,008	.68
FISHKILL CREEK AT GLENHAM, N. Y.					
[d] 4.25	0.4	3.5	100	300	0.33
4.87	.5	4.0	202	554	.37
5.00	.5	4.0	261	615	.43
CATSKILL CREEK AT SOUTH CAIRO, N. Y.					
[a] 3.30	0.4	2.5	110	120	0.91
[a] 3.50	.8	3.0	148	152	.97
4.72	1.0	3.0	363	660	.55

[a] Partly open channel.
[b] Anchor ice.
[c] Ice piled up along banks.
[d] Water backed up.

Discharge measurements, with ice conditions—Continued.

Gage height to water surface.	Thickness of ice, in feet.	Average depth of water below ice.	Actual discharge (closed section).	Discharge from rating table (open section).	Coefficient for reducing open section to ice conditions.
CONNECTICUT RIVER AT ORFORD, N. H.					
4.03	2.0	5.0	799	1,765	0.45
4.03	2.0	5.0	790	1,765	.44
4.08	2.0	5.0	785	1,800	.44
4.12	1.9	5.0	876	1,820	.48
4.15	1.9	5.0	884	1,845	.48
4.20	2.0	5.0	792	1,880	.42
6.60	1.2	7.0	2,620	4,120	.63
6.90	1.4	7.0	2,690	4,450	.61
7.20	1.2	7.0	2,970	4,780	.62
7.40	1.4	7.0	2,980	5,000	.60
7.45	1.4	7.0	2,990	5,055	.59
7.45	1.4	7.0	3,030	5,055	.60

VELOCITY OF FLOW.

The results of these measurements have been studied to ascertain the effect of the ice cover upon (1) the vertical distribution of velocity, especially upon the position of the point of mean velocity, and (2) the ratio of gage height to discharge as compared with that ratio for open-channel conditions.

Observations were taken through holes cut in the ice at regular distances across the stream. Velocities were obtained at ten or more points in the vertical and were plotted on cross-section paper, the depths as ordinates and velocities as abscissæ. A curve was drawn through the points so determined and divided into ten parts. The center velocities of each part, taken from the curve, added and divided by 10 gave the mean velocity in that section.

When the holes were cut the water rose nearly flush with the surface of the ice, showing that it was flowing under pressure. A study of the tables and curves showed that the flow of water under such conditions was somewhat similar to its flow in pipes and in closed flumes. The mean velocity occurred at two points in the vertical, the average of 101 curves (see table below) being at 0.11 depth and 0.71 depth; the maximum velocity occurred at 0.36 depth. The curves dragged more for shallow depths and became more concave, and consequently the error of observation increased if the meter was not held at the proper point in a vertical.

Position of mean and maximum velocities in a vertical plane under ice.

Depth from under surface of ice, in feet.	Number of curves.	Depth of mean velocity.		Depth of maximum velocity.	Coefficient to reduce maximum to mean.
WALLKILL RIVER, NEWPALTZ, N. Y.					
[a]4 to 12	20	0.12	0.71	0.38	0.85
[b]4 19	26	.13	.74	.38	.86
ESOPUS CREEK, KINGSTON, N. Y.					
[a]2.3 to 7.4	16	0.08	0.68	0.36	0.80
[b]5 8	8	.11	.73	.37	.85
RONDOUT CREEK, ROSENDALE, N. Y.					
[a]4 to 8	5	0.08	0.68	0.35	0.82
[b]5 7	8	.13	.71	.35	.86
CONNECTICUT RIVER, ORFORD, N. H.					
[c]2.5 to 7.7	18	0.11	0.69	0.35	0.85
MEAN.					
----------------	--------	0.11	0.71	0.36	0.84

[a] By F. H Tillinghast. [b] By W. W. Schlecht. [c] By C. A. Holden.

ICE-RATING COEFFICIENTS.

Results of the discharge measurements, given in the first table, have been platted on the sheet which contains the rating curve for open-channel conditions, using first the gage height to the surface of the water and second the gage height to the bottom of the ice. The results when platted with gage heights to the surface of the water have been more consistent among themselves and have located a curve approximately parallel to the curve for open-channel conditions, and lying always to the left of it. The results when platted with the gage height at the bottom of the ice have not been consistent among themselves and the curve, which is not so well defined as in the first case, crosses the rating curve for open-channel conditions, falling to the right of it in the lower part and to the left of it in the upper part.

From the data at hand, therefore, it appears to be best to use gage heights to the surface of the water as it rises in the hole cut in the ice, and a comparison of the ice-rating curve so platted with the open-channel rating curve is given in the following table:

Relation between discharges from open-section and ice-rating curves.

Gage height.	Discharge from ice-rating curve.	Discharge from open-section rating curve.	Coefficient for reducing open section to ice conditions.	Mean coefficient.	Greatest range from mean coefficient.	Weight given results.
WALLKILL RIVER AT NEWPALTZ, N. Y.						
8.0	650	1,290	0.50	0.63	0.13	3
9.0	1,125	1,930	.58			
10.0	1,640	2,630	.62			
11.0	2,180	3,410	.64			
12.0	2,760	4,250	.65			
13.0	3,360	5,120	.66			
14.0	3,980	6,020	.66			
15.0	4,610	6,940	.66			
16.0	5,240	7,890	.66			
17.0	5,920	8,930	.66			
18.0	6,575	10,000	.66			
RONDOUT CREEK AT ROSENDALE, N. Y.						
8.0	688	1,472	0.47	0.55	0.08	2
8.5	1,040	2,000	.52			
9.0	1,425	2,539	.56			
9.5	1,840	3,102	.59			
10.0	2,290	3,700	.62			
ESOPUS CREEK AT KINGSTON, N. Y.						
6.0	320	527	0.61	0.71	0.10	1
7.0	625	905	.69			
8.0	1,010	1,373	.74			
9.0	1,470	1,940	.75			
10.0	1,980	2,642	.75			
11.0	2,520	3,440	.73			
12.0	3,075	4,340	.71			
13.0	3,650	5,305	.69			

Relation between discharges from open-section and ice-rating curves—Continued.

Gage height.	Discharge from ice-rating curve.	Discharge from open-section rating curve.	Coefficient for reducing open section to ice conditions.	Mean coefficient.	Greatest range from mean coefficient.	Weight given results.
FISHKILL CREEK AT GLENHAM, N. Y.						
4.2	140	284	0.49	0.53	0.04	1
4.5	210	380	.55			
4.8	280	521	.54			
5.0	330	615	.54			
5.2	400	737	.54			
CATSKILL CREEK AT SOUTH CAIRO, N. Y.						
4.72	363	660	0.55	0.55	0.55	1
CONNECTICUT RIVER AT ORFORD, N. H.						
4.0	800	1,740	0.46	0.57	0.11	1
4.5	1,100	2,110	.52			
5.0	1,400	2,520	.56			
5.5	1,700	2,970	.57			
6.0	2,050	3,470	.59			
6.5	2,400	4,010	.60			
7.0	2,750	4,560	.60			
7.5	3,100	5,110	.61			
8.0	3,500	5,660	.62			

Total mean coefficient, 0.595, or about 0.6.

In the table above are given the values of the coefficient, which must be applied to the rating curve for open-channel conditions in order to give an estimate of discharge under ice when the gage is read to the top of the water. It will be noticed that the coefficient to be used varies between 0.46 and 0.75, with a mean of 0.60. Isolated measurements have been made with thicker ice and comparatively small depths which give coefficients as low as 0.30. If ice conditions are not known in detail, therefore, an estimate based on a coefficient of 0.60 would probably be most nearly correct. It seems probable that further investigations will enable us to determine upon a sliding coefficient, varying between 0.30 and 0.75, the value of which for each case shall be determined by the thickness of the ice or by the ratio of the thickness of the ice to the depth of water, and from which we can obtain more reliable estimates.

CONCLUSIONS.

It is urged that in making measurements of flow under the ice in the future the record be made as complete as possible. The vertical velocity method should be used and data accumulated in regard to the nature of the ice at the section and above and below it, the gage height of the water as it stands in a hole cut in the ice, the gage height of the bottom of the ice, the thickness of the ice, and any other attendant conditions which may even remotely affect the discharge, in order that in further study of this subject all possible information may be at hand.

BOOKKEEPING FOR RECLAMATION SERVICE.

By N. E. Webster, Jr.

GENERAL CONDITIONS.

In the matter of a system of bookkeeping for the hydrographic branch, study has first been given to the problems presented in the reclamation fund because of the unusual conditions which attach to it and which make necessary such methods as will enable the Service to report at any time the amount of expenditures and liabilities along certain lines. It has also been thought that any plans which would succeed with the accounts of the Reclamation Service could easily be adapted to those of the appropriation for gaging streams, eliminating such features as would be inappropriate or undesirable.

But while it seems wise to have the accounts of the two appropriations as similar in forms and method as possible, because they are so largely prepared and handled by the same persons, it seems also that they should be made readily distinguishable, and for this purpose that all blank forms affecting the accounts of the Reclamation Service, as vouchers, charge sheets, debit and credit notices, bills of lading, etc., should be issued on paper of a distinctive color.

In the report of the committee on costs and results [a] such reference has been made to the bookkeeping of the Service as was necessary to make clear the operations required of the engineers in the field. The local accounts and those in the Washington office should be designed upon the same general plans, the former showing in greater detail for what features of the various projects the expenditures have been made, and the latter giving a comprehensive exhibit of the resources, expenditures, and liabilities of the entire Service. In attempting the latter especial attention should be given to the language of the reclamation act, that the accounting may follow the lines therein laid down. The law states that the fund is derived, first, from the sales of

[a] See pp. 162–173.

public lands, etc., and, second, from the return of construction charges; that it is to be distributed so as to expend the major portion in the State where it arose; and that it is to be applied in "examination, survey, preparation of maps and plans (designing), limiting area of entry (subdividing), acquisition of rights and property, construction, maintenance and operation of irrigation works," and in other expenditures provided for (executive). There are, besides, the departmental and bureau regulations relative to accounts, which must be observed.

BOOKKEEPING IN WASHINGTON.

STATE RECORD.

As section 9 of the reclamation act declares it "to be the duty of the Secretary of the Interior, in carrying out the provisions of this act, so far as the same may be practicable and subject to the existence of feasible irrigation projects, to expend the major portion of the funds arising from the sale of public lands within each State and Territory hereinbefore named within the limits of such State or Territory: *Provided*, etc.," it is necessary to keep a record of the reclamation fund by States and Territories.

In this will be entered temporarily the approximate amounts arising from the sale of lands and the collection of construction charges in the reclamation States as reported annually, following the close of each fiscal year, by the Commissioner of the General Land Office, subject to such correction as may be necessary when the public-land accounts have been audited by the accounting officers of the Treasury Department and reported on by them. Of these amounts 51 per cent is restricted to each State as the "major portion" of such fund.

As charges against such credits will be entered the estimated costs of the distinct projects which have been determined upon and authorized by the Secretary of the Interior, the amount being subject to revision upon completion of the project, so as to equal the actual costs.

PROJECT RECORD.

As section 4 states that "the charges which shall be made per acre upon the said entries, and upon lands in private ownership which may be irrigated by waters of the said irrigation project, * * * shall be determined with a view of returning to the reclamation fund the estimated cost of construction of the project," and as section 5 states that "the entryman upon lands to be irrigated by such works * * * shall pay to the Government the charges apportioned against such tract as provided in section 4," a record of the charges against each project is required.

For this there should be a project ledger in which shall be segregated all the credits and charges to and against individual projects and all charges against reconnaissance in States where no project has yet been developed, the several accounts under one State being grouped together and the States arranged alphabetically. The accounts for the various projects within a State should be entered, not alphabetically, but in the order of their adoption as definite projects, and for convenience in cross reference should be given a number indicating the order in which they have been taken up. The Washington office should be treated as a State, and its cost finally distributed over the entire Service.

On the title-page of each project account should appear the name of the State under which the account is being carried, the name of the project, its number and the date of its adoption, its location and extent, the estimated acreage to be reclaimed, and if the work undertaken or the lands to be reclaimed lie in two or more States the name of each of such States, with its estimated proportion of expense and benefit, should be given. The contracts let for construction, etc., may here be recorded, thus showing in a concise form what are to be the larger items of expenditure on the project.

As credits to the several projects will be entered the authorization of the Secretary of the Interior for the construction of the works at the estimated costs, and subsequently any amounts arising from the charging to other projects of equipment, material, or supplies transferred, or of the expense of Washington office administration previously prorated against the then existing projects. All credits which do not increase the total amount available, but decrease the expense incurred, should be entered in red ink and deducted from debit totals, which will then show the actual cost of the project.

As charges against the several projects will appear the expenditures thereon for which vouchers have been approved, the ledger showing the number of the charge sheet for the voucher and the amount thereof.

Following the sheets on which are entered the charges against the project should be others with the titles of the secondary charges of the charge sheet—examination, survey, design, subdivision, rights and property, construction, maintenance, operation, and executive; and these auxiliary sheets should have nine vertical subdivisions in which to enter the tertiary charges of the distribution of the expense under the headings services, traveling, subsistence, equipment, materials, supplies, rent and storage, forage, and construction contracts, each subdivision having two columns for charge-sheet number and amount.

All the columns of this project ledger should be totaled separately in order that any necessary corrections of the vouchers or the distribution thereof, made after entry in this ledger, may be corrected on the original entry without changing every subsequent footing.

VOUCHER RECORD.

There should be a voucher record in which the approved vouchers should be entered each day under the proper headings, date, charge sheet, and voucher numbers, in whose favor drawn, amount, to what project chargeable, and how payment was made—as by whom, date, and check number. Every voucher should be accompanied by an appropriate charge sheet. Vouchers paid by local disbursing officers will be received in Washington with their accounts therefor, and the only entries necessary under payment will be name of disbursing officer and date of payment. Vouchers to be paid by the disbursing officer in Washington will be indicated as sent to him. Vouchers to be paid by warrant from the Treasury Department will be noted "Treas."

CHARGE SHEETS.

A separate charge sheet should be prepared for and accompany each voucher to the Washington office. If a voucher is received without a charge sheet, the clerk examining the voucher should prepare a "dummy," inserting all the information obtainable from the voucher, and write the engineer to forward a proper charge sheet, which may be substituted when received. It should show the number and date of the voucher, in whose favor drawn, amount, and by whom payable, and be signed by the officer approving the account.

When these sheets are received in the Washington office the clerk examining the voucher should, before passing it, give both voucher and its charge sheet a serial office number, with a numbering stamp set to "duplicate," this number to be the one under which the voucher is to be entered in the voucher record before described, and to be used in the ledger postings referred to under the project ledger. When the postings from the charge sheet have been made, the clerk making them should initial it, thus indicating what work has been done on it.

The postings to the project ledger, both to the general project account and to the distribution sheets therewith, are to be made from the charge sheets, which should then be bound in books of probably 500 sheets, each arranged in the order of the numbers thereof, the book to be so labeled as to show the numbers of the charge sheets contained in it and the dates when the first and last vouchers covered by them were entered in the voucher record.

DEBIT NOTICE.

Whenever a debit upon a paid voucher arises against a definite project from without the office of the resident engineer, or against the reconnaissance account of a State from without the office of the engineer in charge, debit sheets should be prepared in the Washington office, showing the amount of such charge, how it arose, to whom payable, and the distribution as far as possible, and one each be sent the engineers whose accounts are affected and one retained in the Washington office and filed with the charge sheet covering the voucher to which it pertains.

CREDIT NOTICE.

Whenever a credit arises to a definite project from without the office of the resident engineer, or to the reconnaissance account of a State from without the office of the engineer in charge, credit sheets should be prepared in the Washington office, showing the amount of such charge, how it arose, from whom repayable, and the distribution originally made of the charge when vouchered, and one each be sent to the engineers whose accounts are affected and one retained in the Washington office and filed with the charge sheet covering the voucher to which it pertains.

TRANSFER SHEETS.

Whenever charges made against one account are to be reentered against other accounts, as upon the shipment from one project to another of equipment, materials, or supplies, or upon the prorating against various projects of the general accounts of a State or of the Washington office, transfer sheets in triplicate, or in quintuplicate if necessary, should be prepared in the office where the new debit originates, showing the amount of such charge, how it arose, a description of the subject-matter of the transfer, and the distribution originally made of the charge when vouchered, and one each be sent to all the offices affected and one to the Washington office.

In the Washington office such a transfer sheet should be given the same serial number as that of the charge sheet it follows in the file, and the postings should show this number preceded by the letter " T."

JOURNAL-DAYBOOK.

It is believed that the charge sheets, debit notices, credit notices, and transfer sheets when assembled and bound together will constitute a complete journal-daybook and be the book of original entry.

BOOKKEEPING AT PROJECT OFFICES.

On June 7, 1904, a circular letter was sent to all engineers regarding methods of bookkeeping. This letter contemplated bookkeeping based on the charge sheet then in use (Form 9-272) and provided that each secondary charge should be given a page of the ledger. It showed how any ordinary ruled blank book could be adapted to this use by ruling additional columns. The tertiary charges for which columns were thus provided were " services, traveling, subsistence, equipment, office, supplies, storage," and there was a column for totals and two blank columns. It was intended that a portion of the ledger should be set aside for each of the secondary charges.

Under the new charge sheet (Form 9-501) there are two more tertiary charges than under the former one, but two of these, " materials " and " construction contracts," apply to the secondary charge of construction only, so that a ledger which would carry the former distribution can be readily adapted to the new one, placing the charges to " office " against " services, equipment, or supplies," according to the nature of the expense, and using that column for " forage."

If the books as already ruled provide for nine columns, that will take all the tertiary charges now used. If only seven were provided, another blank page, following the one provided for the secondary charges of construction should be used for the tertiary charges of " materials and construction."

The secondary charges of " topography, testing, and design " under the former analysis are now united in the one charge of " survey," and the totals of the three accounts should be taken as the initial balance when beginning with the new distribution.

For " maintenance and operation " no accounts need be opened until some portion of a project is completed and being operated.

Attention is called to the instructions for keeping accounts of stores (Form 9-508) which will require that all vouchers for stores be charged first to an appropriate account of the stores ledger, as " equipment," " materials—cement," " supplies—fuel," " supplies—lumber," " subsistence—heat," etc., and then charged to the proper secondary charge as issued. The balance of these stores accounts at any date will represent the stocks on hand and must be taken, together with the totals of the several secondary charges, to equal the total of the vouchers approved for payment.

As stores are purchased it will be necessary to prepare a charge sheet covering the voucher, in which the whole amount of the voucher will be placed against one or more of the secondary charges. At the project, however, a more accurate record can be made by placing the charge for such vouchers to accounts in the stores ledger and making the debit to the proper secondary charge only as issued.

This will admit also of subdividing a project into its principal features, and keeping, at the project, an account with each, as in Washington an account is kept with each project.

A GOVERNMENT ACCOUNT.

By N. E. WEBSTER, JR.

The disbursement of public moneys in settlement of accounts against the Government is variously made throughout the several Executive Departments upon vouchers, certificates, reports, claims, etc., but in every case it must be in accordance with an appropriation previously made and after the proper administrative officers have certified to its correctness as to payee, subject-matter, and amount.

AUTHORIZATION.

The authority for all expenditures must proceed from the official in whom the control of an appropriation has been vested by Congress. By the second section of the reclamation act the disposition of the reclamation fund is committed to the Secretary of the Interior, and his authorization of contemplated expenditures is required before expense may be incurred. Such authorization may be specific for a single purchase, or more often general, covering a class or group of proposed conditions. It is manifestly impracticable to submit to any one person each contemplated purchase, but certain general authority may be given which will be sufficient for all transactions coming within the limits of such authorization. An example of such general authority is that given for the renting of necessary office rooms for the engineers of the Reclamation Service, and the submission of the leases to the Secretary for his approval.

The more common method, and a more satisfactory one, is the submission quarterly, on the 10th of December, March, June, and September, of plans for the ensuing quarter, and estimates, setting forth the amounts which will probably be required for the execution of these plans in the various localities where work is proceeding, and showing the purpose and character of the contemplated expenditures. These estimates should be sufficiently definite to indicate that vouchers for expenditures made in pursuance thereof were properly authorized. They should be tabulated in a way to show clearly what will be the probable payments.

To ———, contractor for construction of ———	$------
To ———, contractor for delivery of ———	------
To ———, contractor for transportation of ———	------
To laborers, for construction by "force account" of ———	------
For purchase of equipment, tools, wagons, animals, etc	------
For purchase of cement, lumber, steel, and other materials	------
For purchase of subsistence, forage, and other supplies	------
For purchase of lands and rights of way	------
For miscellaneous engineering expenses	------
For miscellaneous administrative and office expenses	------

CLASSES OF ACCOUNTS.

All expenditures can be divided into two general classes, those for individual personal services and those for purchases, under the latter heading being included accounts for rentals and for miscellaneous services. There is also a class of accounts in which the above classes may be mixed, as in what are known as traveling or field accounts; but these are, in fact, only for the reimbursement to employees of outlay on behalf of the Government, and the original expenditures were for one or the other of the two general classes.

There are important differences to be noted between the two classes of accounts. Section 3709, Revised Statutes, expressly excepts personal services from the general requirement that "all purchases and contracts for supplies or services shall be made by advertising," etc., and section 3744 does not apply to the engagement of personal services. For all other agreements on behalf of the Government advertising is a necessary preliminary except when an exigency of the service will not admit of delay, when the statute permits purchase in the open market, and in certain other cases where it is impracticable to secure competition. Such cases are: The necessity for additional work arising as work progresses under a formal contract for construction; the articles wanted being patented or copyrighted, and not obtainable from the trade generally; there being only one dealer within a practicable distance from whom the articles are obtainable; previous advertising for the identical purchase having been followed by the receipt of no proposals, or only such as were unreasonable, and under circumstances demonstrating that further advertising would not alter results; and the prices or rates being fixed by legislation, Federal, State, or municipal, or by competent regulation, as in many lines of public service.

VOUCHERS.

Whatever the character of the account against the reclamation fund, whether for services, traveling or field expense, purchases, rent, etc., it is shown upon duplicate voucher forms, which may be for the salary of a single person or for a pay roll covering the several amounts due to a number of individuals, or upon blanks suitable for showing the details of the traveling or field expenditures or the purchases made.

Every voucher, except those submitted for settlement by the Treasury Department, should be receipted in full payment of the account which the payee certifies to be correct. If the payee be an individual, he must receipt in person; if the payee be a partnership or an unincorporated or incorporated company, the receipt should be in the usual firm or company name, followed by the autograph signature, with his title, of the partner or officer authorized to receive the money.

The vouchers should bear the certificate of the engineer incurring the expense that the account is correct and just; that the articles specified have been received by him, or the services stated have been performed; that they were necessary for and have been or will be applied to the purposes contemplated by the reclamation act; and, in the case of other than personal services or reimbursements for expenses, that to the best of his knowledge and belief the prices charged are reasonable and just, and that they were supplied in such and such a way, with reference to methods of contract and of securing competition. This last must show whether the purchase was under contract or under an informal agreement, with immediate delivery or performance. It must also show whether the purchase was upon competitive proposals in accordance with and after advertising in so many newspapers, or by circular letter sent to so many dealers and posted in so many places; or upon noncompetitive quotations without advertising, under an exigency of the service existing prior to the order, which would not admit of delay incident to advertising, or by reason of impracticability to secure competition because of certain specified causes.

Vouchers for reimbursement for traveling expenses should contain a certificate showing that the travel was made upon competent orders. They should also be supported by subvouchers, as provided in Regulations of the United States Geological Survey, 1903, section 45, paragraph 3 (1), as amended January 18, 1905.

Vouchers for payment in pursuance of contract for construction should show in detail the estimates of all work done or material delivered to the date of the voucher. The items should be listed in the order and under the designations given in the contract. A summation of these items will show the value of the work done or material delivered to date, from which there should be deducted the percentage which the contract provides as a holdback and the amount of previous payments.

If extra work is to be paid for, that portion of the voucher should be prepared in the following form:

EXTRA WORK.

Labor and materials, as per attached itemized statement:

Actual cost of labor and materials, ———, $———; —— per cent added, as per paragraph —— of contract, ———, $———.

To the voucher should be attached:

1. Itemized statement of labor and materials, with engineer's certificate as follows:

I hereby certify that the above statement of cost of labor and materials is correct, and that the said extra work was performed in accordance with my instructions, dated ———, 190—, and that the same has been satisfactorily performed.

2. Copy of letter to contractor authorizing the extra work.

Accounts for amounts due contractors for construction should bear the certificate of the engineer immediately in charge of the work done that—

I have inspected for the Reclamation Service the work and materials described in the foregoing, and find that the same are in conformity with the contract and specifications and are of the value stated. I further certify that the stipulations thereof have been complied with up to the present time.

Also, the following certificate of the supervising or district engineer in executive charge of the project:

I certify on honor that the foregoing account is correct and just; that the work and materials have been carefully inspected by ——— ———, who signed the preceding certificate; that the stipulations of the contract and specifications have been complied with, as is stated in the foregoing certificate; and that there is now due upon this claim the sum of $———, no part of which has been paid.

When properly prepared, all vouchers should be forwarded through superior engineers for payment.

PAYMENT.

This will be effected in one of three ways: First, by a local disbursing officer located at the project or in the office of the supervising engineer; second, by the chief disbursing clerk of the Geological Survey at Washington; or, third, as in the case of vouchers for amounts found due for freight, etc., by a warrant drawn by the Secretary of the Treasury on the certificate of the Auditor for the Interior Department.

In the first case the local disbursing officer retains one voucher as evidence of payment and forwards the other to the chief engineer, either with his abstract at the end of the quarter or with a request for a renewal of his credit to the amount of such vouchers should his balance become so low as to necessitate such action.

In the second and third cases, where the account is to be paid from Washington, both vouchers after being approved by the supervising engineer are forwarded to the chief engineer. In the Washington office all vouchers are carefully examined for mistakes and informalities, and if found correct are certified by the chief engineer and approved by the Director, and go to the chief disbursing clerk of the Geological Survey. All vouchers which have not already been paid by local disbursing officers are paid from the latter's office, except those for amounts due for freight and express on Government bills of lading; for passenger fares on Government transportation requests over bond-aided railroad lines; for cartage in Washington on contract with depot quartermaster, United States Army, and for amounts due for purchases or construction so large as to make it inadvisable to so greatly exhaust his credit balance. He retains one of the duplicate vouchers as evidence of payment.

All three classes of vouchers are then sent to the chief disbursing officer of the Department of the Interior, whence all go to the office of the Auditor for the Interior Department. This is a bureau of the Treasury Department, and here all the accounts are audited and allowed, suspended, or disallowed. The accounts not previously paid, as for freight, etc., are examined, and if approved are certified to the Secretary of the Treasury, who draws warrants in payment therefor upon the Treasurer of the United States. For each disbursement from the reclamation fund or other appropriation a voucher must be submitted to the Auditor for his permanent record. When necessary, such vouchers may be consulted upon proper application, as may also those in the possession of the several disbursing officers.

SUSPENSIONS AND DISALLOWANCES.

Exception to the propriety of any account may be noted by any of the various officers who pass upon it, but any such objection will fall in one of two general classes—those made by administrative officers and those made by auditing officers.

Should any certifying or approving officer object to the subject-matter or amount of any voucher which is submitted to him, he will call upon the payee or certifying officer for explanation, suspending the entire account or that portion covering the items questioned. If the account is not satisfactorily explained, the objectionable items must be withdrawn, and any payments made thereon must be refunded to the disbursing officer.

Should the Auditor in his examination of the accounts of any disbursing officer take exception to any of the payments for which credit is claimed, such objections will be made in one of two ways. The first method is by a suspension of the items questioned, when the disbursing officer is called upon for an explanation of these items. In order to reply to such a notice of suspension the disbursing officer will usually have to call upon the engineer approving the account for the necessary information. Such explanations should be made promptly, and in any event within six months from the date of suspension, for if no explanation of the suspended items is made within that period they are subject to disallowance. The second method of noting exceptions to an account is by a disallowance of the items questioned, and for this an explanation to the Auditor is not sufficient. To secure a revision of such disallowance request should be made to the Comptroller of the Treasury, and within one year from the date of the Auditor's settlement. The Comptroller's decision is final upon executive branches of the Government, but an appeal therefrom on behalf of the claimant will lie to the Court of Claims.

TIME REQUIRED FOR AUDITING.

From the foregoing it is evident that a period of several months must elapse after the approval of account before final action will have been taken thereon. This period will vary greatly in different cases, and no certain date can be fixed in advance when an account will be closed. When a voucher is complete and apparently correct, there will be but little time required in the offices of the project, supervising, or chief engineers. It may remain in the disbursing offices after payment from a day to three months, but should be received in that office by the 20th of the month following the end of the quarter, and must in any case reach the office of the Auditor by the 20th of the last month of the succeeding quarter. It will be from three to fifteen months in this office before a report may be expected from the Auditor, and in the case of suspensions or disallowances thereafter no period of time can be stated.

REQUESTS FOR RULINGS.

In order, therefore, to avoid delay in settlement of accounts and their subsequent disallowance upon revision, it is important to see to it in advance that all vouchers are for proper and authorized expenditures. Whenever there is doubt, an opinion can always be obtained, either in advance by the engineer upon application through his superiors and the chief engineer to the Secretary of the Interior or by the disbursing officer upon the presentation to him of the account for payment, by application through the proper channels directly to the Comptroller. So far as possible the former course should be followed in order to avoid the incurring of unauthorized or improper expense, but when this is impracticable the disbursing officer, when called upon for payment of an account containing charges for unprecedented or questionable items, should always submit the account to the Comptroller for an opinion as to its propriety under existing law.

REPORTS OF COMMITTEES OF THE CONFERENCE.

The following are the reports of the various committees, practically as rendered by the committees, the modifications, if any, being only such as to enable the chief engineer to approve the reports as a whole.

COMMITTEE ON CEMENT AND CONCRETE.

REQUIREMENTS AT THE SALT RIVER PROJECTS.

The cement specifications prepared by the committee at its meeting in Los Angeles December 26, 1903, have been followed by the Department in purchasing cement for the several projects in Nevada, Idaho, and Arizona, and the particulars may be found in the proposals and contracts for cement used in the constructions under way in those States.

In the summer and fall of 1904 the Service established laboratories for testing cement at Berkeley, Cal., Denver, Colo., Roosevelt, Ariz., and Washington, D. C. Mr. F. W. Huber has had charge of the Berkeley laboratory and has tested the cement used on the Truckee-Carson project. Mr. J. Y. Jewett has conducted the Denver laboratory and has passed on the cement shipped from Portland, Colo., to Arizona and from Salt Lake to the Minidoka project. The Roosevelt laboratory has been under the direction of Mr. E. Duryee, assisted by Mr. H. A. Tobleman, chemist. This laboratory is equipped for general analytical work and in addition to testing cements has made many analyses for various survey projects and trial burns of cement materials. Some investigations have been conducted in all the laboratories on natural and crushed rock sands that have been of much interest and are likely to lead to economies in the use of cements. Mr. Duryee is prepared to make investigations in several lines as to means of reducing the cost of cement for the various projects. This may sometimes be accomplished by grinding sand cement at the site of the project, or by requiring specially fine grinding of the Portland or by making the cement at the site. The chief engineer called upon Mr. Duryee for additional details as to methods followed by him in testing cement and received the following suggestions supplementing the specifications referred to:

In preparing the specifications and conducting tests of cements the aim has been to ascertain, before shipment, the quality of the cement offered by the contractor. The requirements of the specifications as to aging for a period of two months, and sampling and testing at the cement works before shipment, may appear to be rather exacting, but in the long run these provisions work to the advantage of both manufacturer and purchaser. The cement manufacturers generally claim that they plan to hold all cement for sixty days before shipment, and the contractor should provide sufficient warehouse capacity to permit storage of the sacked cement for one month, during the period of sampling and testing.

Sampling.—The samples are kept separate. Every fortieth sack is opened and a fair sample, weighing about 2 pounds, is extracted with a sampler. On retying the sack a tag, numbered and dated and having the car number noted thereon, is securely attached to the sack by means of wire and lead seals, fastened with a car sealer. The sample of cement is put into a paper sack numbered to correspond with the sample tag.

In bulk, in a bin, cement cures very slowly and may vary considerably in quality. On this account it is better to have the cement sacked before sampling. The tester can then sample more fairly, the cement will cure better, and the shipments can be more surely identified when the sealer is used. The Service sealer has the initials U. S. R. on the die.

Tests.—In a general way the rules for testing adopted by the American Society of Civil Engineers and the American Society for Testing Materials, which can be found in the transactions of those societies, are followed. It is advisable for the tester to submit his opinions of the cement as tested, with his report, the judgment to be based on the results of his tests, and he should not allow any cement to be shipped that is not sound, safe, and high-grade Portland.

Screening.—A screening test of a mixed average sample from each car is made in the laboratory. The cement from some factories varies greatly in fineness as well as in strength, and on that account it is well when time permits to make screening tests on individual samples instead of on a mixed sample, so as to show if there is much variation.

Consistency.—A preliminary and approximate test is made by mixing a small quantity of cement with a measured portion of water; the mortar is then worked for three minutes, molded with the hands into a ball, and dropped from a height of 20 inches. If the proper proportion of water is used, the ball will not crack. The test is confirmed by using a Vicat needle in the manner described in manuals on cement testing.

Making pats.—Three ounces of cement are mixed with sufficient water to give a paste of normal consistency. The cement is weighed but the water is usually gaged in a glass graduate, the quantity used being approximately 25 per cent. The water is added to the cement in one dose and the mortar is then worked with a trowel for two minutes. Standard specifications usually mention five minutes, but two minutes is about as long as laboratory practice allows. One pat is made from each sample. As soon as made the pat is put in a moist atmosphere. This can be obtained by suspending wet crash towels over a light wooden frame, if no better arrangement can be made. As often as necessary the pat is removed and tested with a one-fourth pound Gilmore needle for the initial test. After standing twenty-four hours these same pats are put in a pan and water of the temperature of the room is poured over them and gradually raised to the boiling point and kept at that temperature for six hours. The pats should not soften or crack.

RECOMMENDATIONS OF THE COMMITTEE.

The committee has to report that Mr. Duryee's recommendations have been carefully considered and are recommended for approval.

In the matter of long-time tests of cement and cement mortar, the committee recommends that a series of such tests be undertaken in connection with the construction of the more important dams. The aim should be to undertake only such tests as it is desired to cover a period of one year or more. However, it would be well to keep constantly on hand a limited number of briquettes for short-time tests to be utilized for explanatory and educational purposes.

In addition to the regular tests of neat cement and cement mortar using standard sand, a similar series of tests of cement mortar using samples of sands and broken-stone screenings actually used in the construction should be undertaken in order to determine the relative strength of mortars made with ordinary sands and with broken-stone screenings.

Finally, it is recommended that as far as practicable all tests should be conducted in accordance with rules adopted and recommended by the American Society of Civil Engineers and by the American Society for Testing Materials.

COMMITTEE ON COSTS AND RESULTS.

At the Washington conference there was appointed a committee on costs and results, to which was referred the entire subject of costs, both estimated and actual, and which was instructed to consider the necessary records and methods of collecting information, and to recommend forms for such a system. On January 14, 1905, the committee reported as follows, after having received various reports, suggestions, and forms from the chief engineer, from other engineers, and from former committees:

ACCOUNTING.

There are three closely related but distinct operations to be considered:

(1) Preparation of estimates in advance of execution of work.

(2) Bookkeeping, or records of expenditures and liabilities.

(3) Cost keeping, or summation of actual costs of work done.

Section 2 of the act of June 17, 1902, requires that the Secretary of the Interior shall report to Congress at the beginning of each regular session, giving estimates of cost of all contemplated works, also the cost of works in process of construction, as well as those which have been completed. In short, it requires that the Reclamation Service shall make public these important details of actual cost and go clearly on record on these vital matters.

ADVANCE ESTIMATES.

The law thus requires a report on the estimated cost of all contemplated works. There is opportunity for debate as to what constitutes contemplated work, and experience has shown that judgment must be used in not disclosing these estimates in advance of actual receipt of bids from contractors. It is to be assumed that the law does not compel the divulging of information which good business principles require should be kept confidential. The items, therefore, which go to make up the details of the cost of various parts of the project should not be given publicity until after the matter has been approved by the Secretary and bids received.

In the preparation of advance estimates the items of cost which enter into the estimates should be stated in such a way that it will be practicable in the future to check these against the actual expenditures. It is to be assumed that, as a rule, all estimates are to be prepared upon the basis of a unit price for earth excavation, rock work, concrete, etc. This being the case and the units being given it will be possible when the work is built to make direct comparison.

While it is desired to have the assumed cost ultimately borne out by the facts obtained in construction, yet, at the same time, it should be borne in mind that in case of doubt the estimates should be high rather than low. The results upon the public mind are far better if the work is executed within the original estimates, and great credit is usually given to the man or organization executing the work within the limits originally set. If, however, the actual cost exceeds the estimates, either in unit prices or quantities, it is usually difficult to give a satisfactory explanation. The advance estimates on which the Secretary is asked to authorize construction of a project should therefore be prepared with a view to covering the project's proportion of the State and Washington general charges.

The principle stated above should also be observed in the preparation of the quarterly estimates.

The three amounts given under the heading of each project or account of the quarterly estimates should represent the following:

(1) Total expenditures to end of previous quarter, including all expenses for which vouchers were approved during that period.

(2) Expenditures during expiring quarter, including all expenses for which vouchers will be approved during the quarter, without regard to the time when the expense was incurred.

(3) Estimated expenditures for succeeding quarter, which should be an amount sufficient to cover all expense which it is expected will be incurred and all unpaid liabilities of previous quarters.

BOOKKEEPING.

Vouchers.—In the operations of the Reclamation Service, as in all public matters, expenditures are made solely upon vouchers properly approved. Each individual voucher, whether large or small, constitutes a unit and is handled and considered as such. The items in the vouchers may be distributed or grouped, but the voucher itself and all that relates to it is a distinct entity and should be so treated. In other words, the step from the voucher to the entry or series of entries in the books must be direct, and all further steps consecutive, so that, starting with the voucher at the beginning or with the final statement at the end, it will be possible for a person of ordinary training to follow forward or backward and trace out or check over all intermediate steps. A method of bookkeeping which does not permit this rapid and definite verification will not answer the purpose for which it is intended.

The voucher is ultimately deposited in some safe place, but, though forming the foundation upon which the bookkeeping rests, is not always available for quick reference. The first entry or series of entries made from the voucher must be sufficiently clear to enable all future distributions of accounts to be effected. This distribution can only be made in most cases by the person incurring the expense or certifying primarily to its propriety. After the first certification is made the voucher usually passes into the hands of other persons, who are less and less qualified by personal knowledge to verify the matter. It is therefore required that the person originally certifying to the account should indicate at that time, while the matter is fresh in mind, the item or items to which charges are to be made.

Charge sheet.—The first step in the bookkeeping is the preparation of a charge sheet (Forms 9-501, 9-502, 9-503) covering the amount of each voucher and showing its distribution into several elements of expense. A new form is recommended, having nine subdivisions of secondary charges and nine of tertiary charges. The definitions of the secondary charges are as follows:

Examination: Reconnaissance and all preliminary investigation.

Survey: Topography, testing, and location.

Design: Preparation of plans and detail drawings.

Subdivision: Limiting area of land per entry in the determination of farm units, including examination of the soil.

Rights and property: Acquisition of lands and rights, abstract of title, and recording.

Construction: Building of the project works and of structures, etc., incidental to such building.

Maintenance: Depreciation and repairs on the irrigation works of such a character as to be separable from operating costs.

Operation: Services and supplies for operating the irrigation works and incidental repairs made by operatives.

Executive: Administration and "all other expenditures provided for."

Each secondary charge has nine subdivisions, or tertiary charges, as follows:

Services.—All charges for salaries, annual or monthly, wages by the day or hour, and any other expenditures for personal services only, or for services of men with teams, or horse hire not classed as livery, where the employment is a continuing one at a unit rate.[a] (See Regulations U. S. G. S., 1903, sec. 43, p. 31.)

Traveling.—All charges for railroad fare, street-car fare, stage fare, livery and keep thereof, ferriage, tolls, sleeping- and parlor-car fare, porterage, checking parcels, hotel bills, meals, laundry, telegrams, and other necessary and incidental expenditures directly the result of a journey, and the jurat fee. (See Regulations U. S. G. S., sec. 45, p. 33.)

Subsistence.—All charges, including freight, for meals, rations, food, water, lodging, etc., for men only, when not traveling.[a] (See Regulations U. S. G. S., sec. 62, p. 48.)

Equipment.—All charges, including freight, for nonexpendable property, including public animals. (See Regulations U. S. G. S., sec. 54, p. 41.)

Materials.—All charges, including freight, for expendable property entering into construction and remaining a part thereof.

Supplies.—All charges, including freight, for expendable property used in preliminary and construction work, and wholly consumed therein, fuel, explosives, lubricants, illumination, repairs (including services when combined with "job" charges for repair supplies), stationery, advertising, telephone, telegrams, and miscellaneous expenses not classified elsewhere.[a]

[a] The wages of cooks, which are a part of the cost of subsistence; of men in Government employ engaged in repairs, which are a part of the cost of supplies; of janitors, which are a part of the cost of rent; and of hostlers and stablemen, which are a part of the cost of the care of animals, are all to be entered under "Services."

Rent and storage.—All charges for rent of offices and other buildings, and storage of equipment, material, and supplies, but not pasturage of public animals.[a] (See Regulations U. S. G. S., sec. 51, p. 40.)

Forage.—All charges, including freight, for feed and care of public or hired animals, pasturage, etc.[a] (See Regulations U. S. G. S., sec. 45, p. 33, and sec. 64, p. 49.)

Construction contracts.—All charges for payments to contractors on account of completed portions of construction work (Voucher Form 9–268). This includes both materials furnished and work done, and covers amounts which, if the work were done directly by the Government, would be spread over the preceding eight charges.[a]

A charge sheet should be prepared for and accompany to the Washington office each voucher approved for payment from the reclamation fund. It should not be prepared for transportation requests, bills of lading, or other unpaid liabilities, but the coupons of transportation requests and bills of lading should have indicated thereon to what projects and to what secondary and tertiary accounts they are chargeable.

Transfer sheet.—Whenever charges made against one primary account are to be reentered against other accounts, transfer sheets (Form 9–504) showing the amount of such charges, the subject-matter thereof, and its distribution should be prepared by the office entitled to the credit.

Debit and credit notices.—Appropriate debit and credit notices (Forms 9–505, 9–506) should be prepared in the Washington office and sent to the resident engineers or to the proper engineers in charge, covering all charges and allowances to the project arising from without the office of such engineers.

All vouchers made by the several experts and specialists of the Service for purchases which are to be applied to the various projects should, after approval by the engineers incurring the expense, be sent to the resident engineers for record and should be accompanied by appropriate charge sheets. Such action will avoid discrepancies in the accounts and give the resident engineers fuller information regarding the nature of the expenditure than can be given in other ways.

Vouchers for services and for traveling and field accounts of men under their direction need not be so transmitted, but should be sent on direct for payment. When such men are detailed to a project for any considerable period and are to be paid there, notice of the salary to

[a] The wages of cooks, which are a part of the cost of subsistence; of men in Government employ engaged in repairs, which are a part of the cost of supplies; of janitors, which are a part of the cost of rent; and of hostlers and stablemen, which are a part of the cost of the care of animals, are all to be entered under "Services."

be paid them and of the date from which such payment should be made should be sent to the resident engineer (Form 9–507).

General charges.—Work done in one State for the benefit of the entire Service (as tests of certain methods of doing work or of certain materials) should be charged to appropriate accounts under the head of the Washington office, that the expense thereof may be apportioned to the entire Service, as are all the accounts under Washington.

The general charges for a State having one principal project under construction or about to be entered on should be charged to that project; reconnaissance charges should be placed against definite projects, either those under way or those being considered.

It appears that there will not be need of any account outside of the Washington office other than those for distinct projects, except reconnaissance in those States where no definite project has yet been developed.

Unpaid liabilities.—In the matter of salaries and of the greater portion of its miscellaneous purchases the Government is not a credit purchaser. But in certain lines of business, particularly transportation, where the purchases are large in number and relatively small in amount individually, the charges are allowed to remain on account until such time as a statement of account or "bill" therefor is rendered, when charges, often covering a large number of items, are vouchered and paid. Such charges are mainly for passenger fares, freight, express, and telegraph tolls.

There should be kept in each district or project office a "record of liabilities incurred for which vouchers have not been approved."

Herein should be recorded all transportation requests and bills of lading issued to transportation companies, giving date, number, railroads, etc., affected, points from and to, amount, and accounts chargeable.

When transportation requests and bills of lading are delivered in blank, a record should be made of the number, etc., and a pencil memorandum be made of the date and name of person to whom delivered, until such time as the other information can be supplied.

Charge sheets should not be prepared for such unpaid liabilities until the accounts therefor have been vouchered and approved, nor should entries therefor be made in any of the various ledgers at project, district, or Washington offices, as such entries are to be made only on charge sheets based on paid or approved vouchers.

When notice is received of the approval of the voucher covering an item of this record, the date of approval should be entered in the last column.

All items of this record for which the vouchers have not yet been approved are outstanding liabilities.

COST KEEPING.

Definition.—Cost keeping, or the summation of actual cost of work done, is founded on the expenses incurred, but is largely dependent upon engineering data. It is important to carefully observe the distinction between bookkeeping in general, which consists in keeping the record of expenditures, liabilities, etc., and cost keeping as above defined. There is a wide distinction to be observed between the amount of money which is spent, for example, on a contract for the construction of a canal and the amount which that canal actually costs the contractor. The first is of general interest from the financial standpoint mainly; the second is of most value to the engineers, not only for comparison with the original estimates of cost, but as a guide in the preparation of future estimates.

The keeping of a record of the contract cost is relatively a simple matter. This can be ascertained from the contract itself or record of expenditures. The actual cost of the work is determined, however, with considerable difficulty, since it involves the recording daily of facts concerning number of men employed, material used, and miscellaneous expenditures.

The item of cost keeping is largely an engineering function, and all estimates of the actual or net cost of construction must be made under the supervision of an engineer concerned immediately with the execution of the work. The record books should be simple yet explicit, and the dates noted should be collated and arranged according to some uniform system susceptible of checking and verification.

For the cost accounts three classes of records are necessary—stores books, showing purchases and how the articles are applied to the project and giving inventories of stocks on hand; time books, showing the entire force account of the Government and of contractors; and reports or estimates of quantities of work done. As very different conditions exist during the preliminary period of survey and the later period of construction, two sets of time books and reports are provided, intended, respectively, for use in collecting and reporting the costs of survey and the costs of construction.

Stores accounts.—For stores records ordinary blank books with ledger ruling may be used, with the following instructions inserted in each book (Form 9–508):

All stores should be divided into five general classes corresponding to the subdivisions of the charge sheet relating to stores.

Equipment: All nonexpendable property, including public animals. (See Regulations U. S. G. S., sec. 54, p. 41.)

Materials: All expendable property entering into construction and remaining a part thereof.

Supplies: All expendable property used in preliminary and construction work, and wholly consumed therein, fuel, explosives, lubricants, illumination, repairs (including services when combined with "job" charges for repair supplies), and stationery.

Subsistence: All rations, food, water, etc., for men only. (See Regulations U. S. G. S., 1903, sec. 62, p. 48.)

Forage: All feed for public or hired animals, etc. (See Regulations U. S. G. S., 1903, sec. 45, p. 33, and sec. 64, p. 49.)

For equipment use the property account blanks of the United States Geological Survey, retaining a duplicate and indicating thereon not only the name of the person in possession of the property, but also the feature of the work on which it is then used.

For each of the other divisions of the stores accounts, there should be a separate book or division of the book in which there should be opened an account with each general kind of stores handled. There may be one miscellaneous account in each general class, to which will be entered single purchases for specific purposes, showing how the articles were applied.

The accounts under "Subsistence" should conform to the ration list, and where different articles are grouped under one heading of that list, as fresh meat, which includes fish, poultry, and eggs, the substitute articles should be entered to appropriate accounts following the principal one.

Indicate all debits in number of units, as pounds, gallons, etc.; enter description and whence procured, with voucher number, if possible; show unit price thereon and gross cost.

Indicate all credits in like manner and state the purpose to which the stores are applied; state feature of the work rather than the person to whom delivered.

Balances should always agree with the inventories of stores on hand.

All purchases, whether for the general store or for field parties, and all requisitions for stores made by field parties on the general store should be made on requisition blanks in duplicate (Form 9-509), and one copy be retained by the person ordering, the other, in the case of purchases from outside suppliers, to accompany the invoice rendered for the goods. When stores are furnished by the general stores keeper on such requisitions, an invoice in duplicate (Form 9-510) should be prepared by him for the articles supplied, showing, in case of failure to complete the order, when the other articles will be furnished.

Analyses of costs.—A logical report upon costs requires the following procedure, which should be as nearly uniform as possible in all work of this Service:

(1) The collection of data in the field.

(2) The arrangement and tabulation of these data in the local offices.

(3) The transmission to superior officers of the results of such collation as fully as required to be clearly understood, but not in such detail as to defeat the purposes of the reports by rendering them cumbersome.

Costs of surveys.—For the Government executive and the engineering force in the prosecution of surveys, both during the preliminary stages and the construction periods, the following forms are provided:

(1) Time book (Form 9–511), containing blanks in which to record the names and permanent addresses of members of the parties; a daily time record of men and teams, daily memoranda, and a monthly summary.

(2) Weekly report (Form 9–512) from chiefs of party to resident engineers.

(3) Monthly report (Form 9–513) from chiefs of party and others in charge of specific classes of work to the resident engineers for approval and transmission to the supervising engineers.

(4) Monthly summary (Form 9–514) of operations from resident engineers to superior officers.

All of these forms are based upon the distribution provided for on the charge sheet.

Costs of construction.—For the collection and transmission of information concerning work on construction, whether under contract or on force account, the following forms are provided:

(1) Time book (Form 9–515), similar to the one prepared for use on surveys except that the blanks for daily memoranda and monthly summary are omitted. All engineers or inspectors having relations with contractors or in direct charge of any portions of construction work on force account should keep journals, and should record fully the daily operations, instructions, and information furnished to contractors or foremen and lists of the expenditures made.

(2) Field engineering record (Form 9–516), for use by the assistant engineer in charge of a section of construction work.

(3) Engineering summary (Form 9–517), on which is to be collected the data recorded on the previous form, and a copy of which is to be prepared for the resident and supervising engineers.

(4) Monthly statement (Form 9–518), to be printed on translucent paper. This statement is to be prepared at the same time as the voucher (Form 9–268), and should show all the data on the voucher. Sufficient copies should be prepared to furnish at least one copy each to the offices of the resident, supervising, and chief engineers and one to the contractor.

Cost summary.—For the working out of contractors' prime costs

(i. e., costs of labor, materials, and supplies, and excluding equipment in use and general charges at distant offices "not in sight"), a cost summary or statement of force employed, material delivered, and work done (Form 9-519) is prepared on translucent paper. This is divided into vertical sections, which should be supplied with appropriate headings to indicate the character and class of the excavation, masonry, etc. Under excavation, there should also be reported the kind of earth, the method of excavating employed—whether by machinery or hand labor—the mode of transportation, and the length of haul. Under masonry, if for concrete in place, there should be reported the method of mixing, the proportions and materials used, the mode of transportation, and the length of haul. It is divided horizontally into sections headed "labor," under which should be entered all man or team labor, irrespective of whether teams are owned or hired by the contractor, at the current rates for such service, and "materials and supplies furnished by contractor," under which should be entered all stores furnished by the contractor which have been applied to or consumed upon the work done.

The cost to contractor obtained by a summation of the charges for labor, materials, etc., will be a prime cost, and will not, excepting indirectly, include depreciation of equipment or executive charges.

Below are spaces for the contract price, for "materials and supplies" furnished by the Government, and "engineering expenses," the last two supplied with sufficient blank lines to permit them to be divided into their principal elements, as are the force and material accounts of the contractor above.

A summation of these last three items will furnish a prime cost to the Government, which again does not otherwise than indirectly include depreciation of equipment or State or Washington charges.

Report of costs.—For a concise statement to the chief engineer a report of costs (Form 9–520) is prepared which will present on one sheet of letter size the kind and quantity of work done on each division of the project work and the cost thereof to the contractors. Also the cost to the Government for amounts paid to contractors, for materials and supplies furnished, for engineering expenses, and the total cost to date. The unit costs shown are the contractors' prime cost, the unit price per contract, and the Government prime cost. A statement of the whole number of men employed on contract work and on engineering work is provided for.

PROGRESS DIAGRAMS.

Progress maps or diagrams showing graphically the work accomplished should, whenever practicable, be prepared by engineers in charge of specific work to accompany their reports to the supervising and chief engineers.

Such maps and diagrams must necessarily be drawn specifically for each project, but they should be as nearly uniform in plan and details as possible. It is recommended that, whenever practicable, these diagrams be prepared in the Washington office, under the direction of the resident subcommittee hereinafter referred to, in accordance with data and suggestions furnished by the supervising engineers, the plans to be photographed and as many prints as may be required to be sent to the supervising engineers having jurisdiction. These plans must be simple, so that they may be readily understood at a glance by members of Congress and others not engineers, and must show the character, amount, and locality of the work and the cost thereof.

Whenever it is not practicable for such maps and diagrams to be made in the Washington office, they may be prepared in the office of the project or supervising engineers, but in such cases they should, if possible, be sent at once to Washington for reproduction and return. In all such progress maps and diagrams standard colors showing the work accomplished in each month should be used, sheets of such standard colors being furnished from the Washington office.[a]

All such maps and diagrams should be of such size that they may be folded to letter size, and in no case should they be larger than 4 times letter size—i. e., 16 by 21 inches.

The maps and diagrams of progress and the reports of cost and other operations should be properly collated and filed in the Washington office, convenient for ready reference. The information to be obtained from such statistics as they are gradually accumulated can then be tabulated and put in such shape as to be available for the benefit of the entire Service.

PREPARATION OF FORMS.

All blanks of the Reclamation Service having relation to accounts and reports, including vouchers, charge sheets, debit and credit notices, bills of lading, property returns, weekly and monthly reports, and circulars of instructions, should be printed on paper of distinctive color.

It is recommended that the preparation and final approval of the forms which are herein proposed and which further experience may show to be essential for the keeping of accounts and reports of progress shall be intrusted to the members of this committee residing in Washington (Messrs. Webster, Olberg, and Paul), but that suggested forms be submitted for suggestion and criticism to the other

[a] See p. 230.

members of this committee before final action is taken. All such forms should be procured from Washington.

It is recommended that prior to the establishment of further local accounts the Washington office be consulted in order to bring about a uniform system of accounts throughout the Service.

OPERATIONS IN WASHINGTON OFFICE.

In the Washington office the complete books of the Reclamation Service are to be kept in simple yet explicit form, showing resources, liabilities, and expenditures. The charges made and the totals of expenditures are to be sent from time to time to the engineers interested, and the books in the local offices should be kept in accord with those in the Washington office.

OPERATIONS IN LOCAL OFFICES.

In each local office the books should be kept on the same general system as those in the Washington office, but in addition the local office should keep all of the original notebooks and other records which go to show both the original estimates and the cost-keeping records. As nearly as possible a uniform system should be employed in the latter operations, so that assistant engineers accustomed to cost keeping in one locality can on being transferred continue the work at another point.

The committee recommends that duplicate copies of this report, if approved, or of so much of it as may be adopted, be prepared and, with a complete set of the forms referred to, be sent each engineer having charge of local accounts.

REPORT OF COMMITTEE ON DUTY OF WATER, ALKALI, AND DRAINAGE.

The work of the Reclamation Service in the construction of irrigation works of magnitude involves a series of investigations and experiments whose object is to determine the practicability of irrigating certain lands. Such experiments and investigations are an essential part of the work which the Secretary of the Interior is authorized to undertake in section 2 of the reclamation act, and are necessary in order for him to determine "all the facts relative to the practicability of each irrigation project." Among such investigations and experiments are those on the duty of water, soil investigations, experiments upon the reclamation of alkali land, drainage experiments, etc. Each and in some cases all of these should be investigated during the progress of the surveys leading up to the building of a project,

DUTY OF WATER.

The duty of water under a stream should be known before a project is approved, in order that canals can be designed so as to carry the amount of water proper for the irrigation of the farms lying under them. While it is true that the duty will vary with every kind of plant grown under every variety of soil in every climate, and even with the man using the water, yet some average duty should be determined and the canal cross sections and grades based thereon.

The importance of the exact determination of the duty of water can not be overestimated. Where a figure too low is taken, the plants grown will suffer, low yields will result, and the farmers will not receive the full benefit of their labors. On the other hand, where too high a duty is taken, the area of land which can be irrigated by a given water supply is underestimated, valuable land is often left dry, and too much water is used, the farmer thereby not only damaging his own lands and crops but those of his neighbors lower down.

Many observations have been made upon the duty of water in various parts of the United States, and it is proposed that this information be collected and digested for the use of engineers.

There are, however, many districts where little or nothing has been done in this connection, and it becomes necessary to observe irrigated fields in the vicinity to determine this quantity. This has been done in the past and should be encouraged in the future. It is hoped, however, that methods for this work can be made uniform in all districts.

Where markedly different types of soil or methods of farming occur in sufficiently large areas to be irrigated by independent canals, the duty of water should be determined for each type; but where, as is usually the case, the types are intermixed and it is not possible to find large areas of one type of soil or of farming, the piece of ground selected should be nearly an average of the types and should have the crops of the locality in about the same proportion as in the whole district. If it is possible to do so, an arrangement should be made by which the engineer in charge may have some control of the amount of water in the experiment. That is, he should endeavor to determine the best practice rather than that ordinarily followed in the vicinity.

All water used should be measured through a weir, or, in case of muddy waters, through a flume, the records being kept by recording weir gage. The yield of the crops grown under the experiment should be determined.

As a further check upon the duty of water, it is well, where possible, to measure the duty under a large canal if any exist in the community or near by. A recording gage should be placel at the head of the canal and the area irrigated determined, together with all possible facts regarding the yield and quality of the crops grown.

While the primary object of the work is to determine the capacity of the irrigating canals and the area to be irrigated, and one year's record might be sufficient for this, still, as the actual amount needed for each acre need not be stated until applications for water rights are filed, it is thought well to continue the records for at least five years, so as to overcome discrepancies caused by unusual seasons and to determine as accurately as possible the best practice and to start each district right.

The question of the rate and time of delivery of the water is of especial importance and one which has unfortunately received but little attention. When pumping plants are to be built, it is of prime importance to know the maximum rate of delivery needed, and the same considerations apply to canals.

ALKALI AND DRAINAGE.

The alkali problem is one of vital interest to the irrigation farmer. One-eighth of the land which has been irrigated in the United States has been damaged by alkali to such an extent that its cultivation is no longer profitable. Such a loss is serious, amounting to nearly $50,000,000, and indicates something very unsound in the practice heretofore pursued. Our observations clearly indicate that this loss is largely due to lack of drainage, and the success in adequately drained regions indicates the fact that drainage prevents such loss.

To prevent any loss of land in the projects irrigated by the Service it becomes necessary for some study to be made of the question, and preventives applied.

Experimental work so involved falls under two classes: (1) Methods of preventing damage from alkali, and (2) methods of reclaiming lands already alkaline. It is the sense of this committee that the Service should carry on certain experimental work on the drainage and management of alkali lands. This work might be done by the Department of Agriculture by request from this Service, but the committee recommends, after careful consideration, that it be taken up and entirely carried out by the Reclamation Service.

Investigations in drainage and alkali reclamation work should be carried on on tracts of 10 or 20 acres. Where possible the land should be in private ownership, and the Service should arrange with the owner to do all necessary farm work, and possibly to pay for the material used, as he can not well benefit thereby. Where such an arrangement is not possible, a tract should be reserved from entry for use in these investigations (see sec. 7, reclamation act).

Crop introduction.—The introduction of suitable crops for each project becomes the duty of the Service. The majority of farmers in the new projects will be inexperienced, and, in order that they be enabled to return the cost of irrigation, they should be advised regarding the best crops to grow and the best ways of growing and marketing them. Work of this sort involves farming operations and seems to fall within the scope of the Department of Agriculture and the experiment stations.

It is suggested that upon the approval of a project the Secretary of Agriculture be informed of the location, extent, and probable time of completion of the project, and asked to suggest crops and methods of farming adapted to the country.

Farm-unit maps.—The report of the El Paso committee, consisting of Messrs. Savage, Bien, and Means, on farm units is as follows:

The principle on which the dealings with the settler should be based is that he shall pay for what he gets and know for what he pays. Accordingly, he should know the number of acres of irrigable land he receives and the amount of water to be furnished for each acre per annum. It is recommended—

(*a*) That the farm-unit classification sheets shall show in each farm unit the boundary of the irrigable land and the area of irrigable land, in acres.

(*b*) That a water-right application shall state the number of acre-feet per annum to be furnished per acre.

(*c*) That the charge for water rights shall be the same per acre of irrigable land.

(*d*) That the land be classified into two grades—irrigable and nonirrigable—and that all farm units contain the same area of irrigable land as nearly as practicable, except in the case of areas near towns and those susceptible of growing more valuable crops, thus providing for two sizes of irrigable areas in the farm units. The maximum number of acres of irrigable land fixed for each class in a project shall be adhered to as closely as possible.

(*e*) That the charge per acre for water rights on private land be the same as for public land, and that the irrigable area in each tract be determined in the same way as for public land, the irrigable area allowed one man in no case to exceed 160 acres.

RECOMMENDATIONS.

After discussion of the above subjects in committee meetings and in general conference with the engineers, the following specific recommendations were reported for approval:

(1) That the report of the El Paso committee on farm units be adopted and made the rule of the Service.

(2) That determinations of the duty of water be made by engineers in all projects where reliable figures are not at hand. In all such investigations the object shall be to determine the best practice in use of water, the total amount of water per acre per year, and the amount

used each month during the season, with the maximum delivery needed at any one time.

(3) That drainage of all lands to be irrigated be considered in detail, and that drainage ditches be considered an essential part of the irrigation works.

(4) That investigation upon the best methods of reclaiming and managing alkali or other lands is essential to the success of the reclamation work in certain projects.

(5) That the introduction of suitable crops and agricultural industries is important, and engineers in charge of projects are urged to give all possible aid and assistance in investigations leading to the solution of these problems. The details of these investigations are to be worked out as each arises.

REPORT OF COMMITTEE ON ORGANIZATION.

Three meetings of the committee on organization were held, at which a number of engineers, notably Messrs. Ross, Sanders, Fellows, and Storrs, not members of the committee, attended and materially assisted in the discussion.

The committee believes that it is undesirable to establish absolute rules of procedure, as conditions and circumstances may change so as to require other methods.

Chief engineer and assistant chief engineer.—It is especially desirable that the Washington office, and particularly the chief engineer, should keep in close personal touch with conditions in the field.

The committee believes that the present practice of providing for visits to the various projects by the chief engineer and assistant chief engineer, alternately, should be continued for the benefit of the Service and of the executive engineers in the field.

Consulting engineers.—For the protection of the Service the present practice should be continued of having all vital points relative to the policy and construction of the work passed upon by a board of consulting engineers. The success of the chief engineer in securing the services of eminent consulting engineers is cause for congratulation. Consulting engineers should act in an advisory capacity and should not issue instructions in an executive capacity to the men who are the assistants on a project. After consideration of a question, the finding of a majority of the board should constitute a final decision so far as the board is concerned. This report should then be presented to the chief engineer.

Project board meetings.—The district or supervising engineer should, when necessary, request the chief engineer to convene a board of consulting engineers. Because of the intimate knowledge of the project in question which is had by the executive engineers it is due to them, as well as to the chief engineer, that they should be represented in such conference.

The chief engineer or the assistant chief engineer may, in his discretion, convene a board of consulting engineers to act on any question where consultation is deemed necessary, and the chief engineer and assistant chief engineer may be members of the board when they so desire.

In order that the construction work may be expedited, the decision of the project board should be accepted by the supervising engineer as final, and he should issue instructions in accordance therewith. This action should be presented to the chief engineer for his review. The action of the project board involving the acceptance or rejection of a project should, however, be submitted to the chief engineer for his decision before action is taken by the supervising engineer.

Executive engineers.—In order that the related duties of the various engineers may be clearly defined and the work thus expedited, the supervising or district engineers should be considered as the executive heads and in charge of the management of their respective sections as the representatives of the chief engineer.

The chief engineer should place supervising or district engineers in charge of certain specific territories. Under the district or supervising engineer may be placed project engineers. These executive engineers should prepare and present all data relative to any particular project or section thereof. The constructing engineer should, if possible, prepare plans and specifications, or assist in their preparation, when they relate to work which he is to build.

The positions of district engineer and supervising engineer apparently are not well defined. It would appear advisable to have but one intermediate engineer between the project engineer and the chief engineer, and it is immaterial whether such engineer be called a district or supervising engineer.

The field of the supervising engineer should not be so large that he can not have an intimate, detailed knowledge of all the work being performed within the territory over which he has jurisdiction. His report to the chief engineer should be based on full and personal knowledge.

Construction engineers.—The construction engineer should be definitely assigned to some important construction. He should reside near the work and be responsible for its construction and completion. He should report through the supervising engineer to the chief engineer. The construction engineer should be a member of the board when his work is under discussion. He should be available for consultation work in the immediate vicinity.

Power engineers.—The power engineers appointed by the chief engineer should be available as experts on all matters pertaining to the generation and transmission of power and its application to pumping, and as such should be freely consulted by the other engineers.

The power engineers should be called on by the supervising engineer to assist in the preliminary investigations of such projects as have power possibilities, and in such cases should furnish estimates of first cost and operation of proposed power plants to the supervising engineer and forward a copy to the chief engineer. It would be advisable for the investigation of apparatus and devices to be left entirely to the power engineer wherever possible.

After any project is approved for construction the power engineer should have executive charge of all matters concerning design and construction of power plant and pumping system and should issue specifications, on approval by the project board, for the apparatus needed; and when bids have been accepted on the principal units he should prepare designs for the plant as a whole. In a water-power plant the power engineer should be guided by the supervising engineer in the laying out of the delivery of the water to and its discharge from the plant.

All accounts connected with the power and pumping work should be kept with the other accounts on the project, but in such a manner that the cost can be segregated and be subject to the approval of the supervising engineer.

The engineer of any project and the power engineer should confer together in all matters where their work meets, and each on request should furnish the other any information necessary to the completion of the plan of the project as a whole.

Owing to the peculiar nature of the work of the power engineer, it is essential that his office should have a fixed location or headquarters. The larger part of the study and design of a power project is made in the office, and that office will require frequent communication with manufacturers or their agents, and should be located with that in view as centrally as possible in the district the engineer is to cover.

The power engineer should have charge of the operation of the power plants in his district.

The power engineer should be a member of the project board when questions involving his work are under consideration.

REPORT OF COMMITTEE ON POWER AND PUMPING.

GENERAL STATEMENT.

The applying of transmitted water power to the uses of irrigation, whether to operate large pumps from lakes or streams or to pump water from underground sources, offers a very wide field for consideration and may be divided into several classes, according to whether the transmission is short or long (it may be extended up to 75 miles and used to distribute power over a large area), and according to whether the pumping is from wells or from streams or canals.

COST OF INSTALLATION AND OPERATION.

Specific example.—The thing which at this time is of the utmost importance to the Service is the probable cost of such installations. Estimates are being worked up on several projects, from which perhaps some idea can be gathered. In one case, where power is derived from water already stored for a canal system, and where only such hydraulic construction as water mains for delivering the water to the water wheels is charged, the cost works out about $25 an acre. The transmission in this case is about 75 miles, covering an extended area; the average lift on the pumping plants is about 50 feet, using centrifugal pumps directly connected to motors; and the pumps are to be run not more than 200 days a year and to be given a rest during such periods as there is rain or an unusual supply of water due to rise of the natural streams supplying the gravity system.

The cost of operation of a plant of this character, this one being laid out for 40,000 acres, will approximate about 40 cents an acre-foot, allowing for depreciation, salaries, wages, and repairs; but if a portion of the care of this system can be merged under the management of the operation of the gravity canals this can be somewhat reduced.

In another case, where the transmission is short and the pumping units are large, and no step-up transformers nor step-down transformers are required, the cost amounts to about $10 an acre, and the operation to about 25 cents per acre-foot. The distance here is within 15 miles and the power derived is an incident of the construction of a diversion dam for a gravity system. These two cases illustrate what may be done along these particular lines.

In general, if a power plant is to be constructed solely and purely for the operation of such a system, the hydraulic work connected with it must not be the greater feature of the cost, for the electrical and mechanical appliances have practically a fixed cost for a given amount of power. The varying costs are the cost of hydraulic development and the cost of the transmission line controlled by its length. It can be very readily seen also that the lift on the pumps cuts a very large figure in all such cases.

A problem similar to the long-distance transmission above has been worked out very well in Water-Supply Paper No. 58, relating to the land around Fresno, and is very similar in cost of installation and operation to the one above mentioned. As a rule, if a high head can be obtained without too great an expenditure for a canal line (by high head is meant heads above 500 feet), the cost of the hydraulic work does not become, as a rule, excessive.

It can also be shown that in a project where land is lying reasonably level and the water plane is within 2 or 3 feet of the surface and is renewed by floods every year, and where coal or its equivalent has an average value not to exceed $2 a ton, a steam plant can be installed, power transmitted 10 miles either way, and by pumping from wells irrigate as much as 40,000 acres from one plant at an installation cost of about $25 per acre and an operation cost not to exceed $2 per acre per annum, with a water duty of about 3 feet. The above is based on a lift on the pumps not to exceed 30 feet.

CHARACTER OF POWER.

Steam turbines.—There are some localities in which cheap fuel can be obtained where water can be advantageously lifted from streams or canals to heads not exceeding 100 feet by direct-connected apparatus, using steam power. For this purpose the steam turbine, directly connected to a centrifugal pump, offers many advantages, especially if the water to be used in the boilers carries much mineral water, for with the turbine it can all be returned and reduce the cost of cleaning and repairs of boilers.

In some localities where fuel is extremely cheap and the irrigation season short, economy would indicate that the construction of a cheaper class of plant would be best, if other conditions, such as head, etc., would permit, but as a rule the serious question of the price of fuel through long terms of years, beyond the time of those who are planning the construction of these plants, would cause us to be very careful whether or not we build pumping plants to be operated by steam or by any power requiring fuel.

Gas engines.—The gas engine is claiming our consideration in large units to no small degree, but in this country it has not been in operation sufficiently long to warrant extensive recommendations for its use, unless several of the controlling conditions are extremely favorable.

There are now under contract in this country for driving electric generators some large gas-engine units, having a capacity of 5,000 horsepower in a single unit. From the operation of these no doubt sufficient data as to the reliability and economy and the other costs which enter into successful operation may be obtained which will warrant their use for this class of work.

The small gas engine in its many forms and types is undoubtedly one of the best means of obtaining power in units up to as high as 30 horsepower for irrigation work for the individual farmer. In all cases where the power for pumping water for irrigation is to be derived from the consumption of fuel, used in any form of heat engine, the nature of the crops and the value of the crop per acre per annum will have a great deal to do with the solving of the question of whether they will be used at all or not. But there are some cases where the lift is very light and the water supply plentiful, where undoubtedly they could be applied to crops of a moderate value.

Water turbines.—Another point where we should look for the practical use of pumping plants is in connection with canals across some sections of the country. In building these it is often necessary to overcome a rapid grade by a sudden drop. In numerous cases of that kind there lies, immediately above the canal, land in relatively small areas which could be reached by water elevated to their level by pumping plants. In such cases a simple water wheel of the vertical-shaft turbine type, direct-connected to centrifugal pump mounted on the same housing, submerged in the stream, the water dropping through the turbine wheel, furnishes the power to raise a portion of the water to the high level. In all cases where it is desired to connect the pump and the turbine water wheel together there should be a fall in the canal equal to at least one-quarter of the head against which the water would be lifted.

SUBMISSION TO SPECIAL ENGINEERS.

Wherever a power project is contemplated it would be well that the project engineers, as soon as they are satisfied there is sufficient power and sufficient land to be benefited thereby to make a power plant seem feasible, should put the problem up to those engineers who will eventually become responsible for the design of the power plant.

The nature of the data required will be, first, a diagram of stream flows throughout the year, expressing the flow in second-feet; also a diagram of gage heights, giving the elevation to which the water is to be lifted, and the amounts of water to be pumped each month during the year, showing it by maximums for the month. These data apply to cases where the pump is direct-connected to the water wheel. The other problems are much more complex, and it is well for the engineers interested to have a conference and go over the work together at as early a date as possible.

There have been within the past two years centrifugal pumps designed and placed in operation, working against heads as high as 700 feet, and there may be localities where it will be practical to raise the water for irrigation in large quantities as high as 300 or 400 feet by units direct-connected to water wheels. This type of pump has an efficiency very much higher than the low-lift pumps.

It is desirable in all cases where power is to be used for pumping water that the engineers who are responsible for the power development should be consulted as early in the investigations as is practical, and that the responsibility should be placed on them for furnishing the estimates and preliminary plans. Confusion is quite likely to arise should several engineers be working on the same problem, and the best results are likely to be obtained where some individual engineer is responsible for presenting to the chief engineer the estimates which refer to his particular class of work.

WITHDRAWAL OF UNDEVELOPED WATER POWERS.

On some projects which require the diversion and storage of water for irrigation purposes difficulties arise in dealing with private interests, owing to the presence of water-power plants claiming prior rights to the natural flow of the streams from which the water for irrigation purposes must be taken. Water-power plants designed to supply commercial uses require, as a rule, a nearly uniform stream flow throughout the year, whereas irrigation systems require the largest flow during the irrigation season, and, where possible, complete storage of the water during the remainder of the year. For this reason the presence of a water-power plant on a stream whose waters are desired for storage in order to be used for irrigation purposes would necessitate permitting a certain amount of water to pass the storage reservoir in order to supply the water-power plant, thus depriving the irrigation system of that amount.

To avoid complications of the kind above described it is suggested that control of all necessary water powers be secured as early as possible by withdrawing, under the first form, such lands along the streams as will control the situation so far as power development is concerned. It will be much better for the Government to release to private parties those water powers which it is not prepared to utilize itself than to leave them open to be filed on for speculative purposes. When the Government finds it necessary to release to private parties a water power which has been withdrawn, it will be an advantage to be able to make this release under certain conditions as to the use of the water-power privilege, reserving the right to control the natural flow of the stream to such extent as may be necessary to serve the needs of irrigation. It may sometimes happen that the presence of an irrigation storage reservoir on a stream will greatly improve the stream flow for power purposes for commercial plants situated below the reservoir, in which case the power company should pay a part of the expenses of the storage works by which they are benefited.

There are other reasons why the Reclamation Service should secure control over the necessary water powers in the arid regions. For instance, any undeveloped water existing within, say, 100 miles of an area of land might at some later period be found useful for supplying water by electric transmission for pumping irrigation water for this land. No definite limit can be stated for which power can be economically transmitted, since this is entirely a matter of the relative expense of producing and transmitting the power and the value of the same when applied to beneficial uses. The land on which it is proposed to use the power need not be definitely specified when the withdrawal is requested, but any area that may sometime be reclaimed will serve as the reason for requesting withdrawal.

Another consideration which should not be lost sight of is that some of these water-power possibilities may be found valuable in providing power for construction work on some reclamation projects that will be undertaken later on in this section of the country.

TEMPORARY POWER PLANTS FOR CONSTRUCTION WORK.

The construction of large structures, such as dams and canals, demands the use of large amounts of power, involving the consumption of much fuel, the cost of which is often high on account of the inaccessibility of the work. This power could often be furnished by installing temporary hydraulic or steam plants, where water power or fuel could be cheaply secured, and transmitting electric power for use in the work. Hydraulic power may sometimes be cheaply developed in connection with the diversion of the stream to permit the building of a proposed dam, or at some point on a canal above the point where the storage dam is to be constructed, or on any stream within a radius of a few miles of the proposed construction work. A steam-generating plant may sometimes be warranted to save haulage of fuel over rough mountain roads, the plant being placed at a convenient delivery point on a railroad or at a coal mine. When the construction work is finished the plant can often be sold at nearly full valuation for commercial uses if the Government has no further use for it. If the transmission line can no longer be of use in place, the wire can be sold or shipped to other projects and the pole line will usually be found useful for telephone purposes.

To meet the objection that the Government can not well arrange to put in these temporary power plants, since the actual construction work on the large dams, tunnels, etc., will be done almost entirely by contract, it is suggested: (1) That the temporary plant, after being erected by the Government, might be turned over to the contractors for operation under the supervision of the engineer in charge and under the agreement to maintain the plant in satisfactory working condition to the completion of the work. (2) That the Government retain control and operate the power plant, supplying power to the contractors at a reasonable rate.

If this matter were carefully considered and decided on before the bids were called for, all the prospective bidders could be informed that the Government proposed to install the power plant, thus relieving all bidders of the necessity of determining the cost of producing the power necessary for construction work, which is always an important and very uncertain item in these estimates. Then all bidders could give due weight to the advantage they would derive from having power supplied to them from a power plant constructed by the Government.

In view of the above, the committee recommends that the possibility of furnishing electric power for the construction of large works from temporary steam or hydraulic plants erected by the Government be fully considered by the engineers of the Service prior to drawing specifications and letting contracts for these large structures.

CHARGES FOR PUMPED WATER.

On pumping projects it seems reasonable that the water user should pay for his irrigating water on the basis of the amount of water actually delivered to him. This is unquestionably the proper method to follow on those projects where oil, coal, or other fuel furnishes the power for pumping, since in such cases the operating expenses depend so largely upon the quantity of water pumped. Hence it is proposed that the articles of incorporation for water users' associations, in projects where pumping is to be done by the use of fuel of some sort, include a provision that the annual charge for the cost of maintenance of the works be the same for each share, but that the charge for cost of operation be proportional to the quantity of water actually delivered to each shareholder.

Under this provision a minimum annual payment per share will be made, which will cover the fixed charges and upkeep of the plant. In addition to this, each water user will pay annually for water in proportion to the quantity actually used by him, a price per acre-foot being determined by dividing the total operating expense of the entire system by the total acre-feet of water delivered to all consumers.

One of the strongest arguments in favor of this plan is that it tends to foster economy in the use of water. Another is that the annual payments can be adjusted from year to year to correspond with the varying quantity used, depending upon whether the season is wet or dry.

On pumping projects depending upon water power, the operating expenses will not vary with the quantity pumped to so great an extent as on projects involving the use of fuel for pumping. But in such cases it is a question whether a minimum annual charge for maintenance and operation should not be made on the basis of the least quantity of water that would under any circumstances be sufficient to irrigate the farm unit, and permit additional water to be purchased by individual users at a certain price per acre-foot. This price per acre-foot would be figured on the actual cost of delivery, and might be different for different parts of the irrigating season. On some projects where water power is utilized for pumping, the power is available throughout the year, but the machinery would usually be idle except during the irrigating season. The system might, however, be operated an additional month or two at merely nominal expense, and where the water and power are available and would otherwise go to waste it would seem desirable to make a very low price for water delivered outside the regular irrigation season in order that the plant and the water might be utilized to the greatest possible extent. Water so applied to land intended for certain crops, such as alfalfa and grain, might greatly lessen the amount of water required during the irrigating season and thus increase the acreage which the pumping plant could serve.

POWER DEVELOPMENT AT DROPS IN MAIN CANALS.

On the main canals of many projects the topography of the country requires an abrupt drop in grade which affords an opportunity for the development of power. It seems certain that this amount of power will not be allowed to go to waste indefinitely, and in most cases will be developed in the course of a comparatively few years. For this reason it would seem advisable in most cases to prepare for the erection of the future power house, when the canal is being constructed, by extending the concrete work, which will usually be required to provide a safe drop for the water from the higher to the lower level, and by constructing the tailrace and foundations for the power house. This additional work can be done at less cost, and with less danger of unequal settlement, if done at the start; otherwise, if the tailrace and foundations for the power plant are built after the canal has been in use for several years, it will be necessary to excavate for the new works in saturated ground, possibly endangering the whole structure, and with some difficulty in securing a perfect bond between the new work and the old. Moreover, this work would have to be done between two irrigating seasons, which would frequently make it necessary to do the work more rapidly than was consistent with economy, and in some locations would necessitate laying concrete in freezing weather.

DUTY OF WATER.

Estimates of probable costs of power and pumping plants necessitate a knowledge of the several factors peculiar to each project—

for instance, of the duty of water, of materials for construction which can be secured locally, of the character of the water to be pumped, and of the ground on which the power and pumping plants are to be built.

In regard to the duty of water, for instance, the essential factor in determining the necessary capacity of the power and pumping plants is the maximum demand for water which will occur during the irrigating season. Since the use of water for irrigation will be prescribed by regulations, it is safe to assume that the maximum demand will not be confined to a single day, but will cover at least a week or ten days. It is suggested that the greatest quantity of water to be used during any ten days of the irrigation season be taken as a maximum by the engineers in determining the capacity of the pumping stations.

Whenever it is possible to provide storage for pumped water, the size of the plant may be materially affected by that fact, since the storage reservoir, even if comparatively small, might serve as an equalizer and enable the system to supply during a period of one or two weeks a much larger quantity of water than the pumping plants alone would be able to deliver in the same length of time.

REPORT OF COMMITTEE ON RECONNAISSANCE AND SURVEYS.

Reconnaissance.—As the development of projects has progressed the imperative necessity for thorough reconnaissance and investigation, conducted along parallel lines as to time of initiation and progress, for every feature of the work, is increasingly manifest, primarily to develop the controlling factors of a project and also their relative and time importance for determination.

In addition to the general and detailed engineering and hydrographic investigations and surveys, many other important matters—some of them possibly controlling—should receive careful consideration early in the investigation of a project.

It is imperative that all branches of the investigation be carried out in a thorough manner and every feature possible to anticipate be given consideration. Investigations of existing records, filings, and statistics, and of available data of any and every kind should be given special attention before initiating field surveys.

It is recognized that the preliminary engineering field investigations should be carried on by men who by natural ability, training, and experience have demonstrated efficiency in this line of work. Detailed instructions should be given them, setting forth the controlling conditions of the reclamation law and other points governing the development of each project to which they are assigned.

Careful consideration should be given to the general project as a business investment for the capital to be involved.

Irrigable lands.—If the area of unpatented lands is nearly sufficient to require the available supply of water, or if a majority of all the available land is unpatented, the situation is much simplified.

In many cases a choice of lands to be irrigated is possible. For example, lands suitable for market gardening located near cities and towns have a much greater value when irrigated than lands located at considerable distance from market, and it is necessary to decide whether water supply shall be developed for lands of comparatively low productive ability located tributary to and near to the source of development, or shall be conducted for long distances to lands which can apparently afford to pay a large price for water supply.

Railway lands.—In the case of railway-grant land it is reasonable to expect that in order to secure the development and settlement of the lands tributary to their lines, with the consequent freight and passenger traffic, the various railway companies will cooperate to the extent of subdividing the lands and offering them for sale under such terms and at such prices as may properly be required in accordance with the reclamation act.

In consideration of the large and perpetual revenue accruing to the transportation companies from the irrigation development, it is expected that a very low selling price per acre will be arranged. It is necessary, however, to have a definite agreement drawn up and properly executed with the railway companies. The attitude of the Reclamation Service toward railroads is a matter for careful consideration, especially where it may be necessary to frequently cross a main trunk line with a main distributing canal. The benefits accruing to the railroad in most cases will be very large, probably $3 or more per acre in annual freight revenue alone, without considering the additional large passenger traffic, which may amount to nearly as much more; and while it seems that they may be expected to cooperate consistently, it is necessary that the Service should have a consistent and uniform basis for dealing with them.

Private lands.—Where private lands, located tributary to the proposed irrigation-supply development, are held in large tracts for investment or otherwise, the owners should be expected and required to enter into agreement and contract guaranteeing to dispose of their holdings over 160 acres, in compliance with the reclamation act, prior to the time when water is to be furnished from the irrigation works.

Borings.—Diamond drill or other borings should be made where required at a timely period in the investigation of a project.

Water users' association.—Where any considerable portion of the irrigable lands under consideration is in the hands of settlers, the attitude of these owners should be definitely determined before undertaking expensive surveys.

Careful attention should be given at the proper time to the organization of a water users' association. Cordial cooperation and every assistance should be given by the Reclamation Service, but undue effort to promote or hasten such an organization is not advisable.

Rights of way.—Investigations of all records should be made at an early time to determine the existence of rights of way for railways, and also to determine ownership of lands required for reservoir purposes, whenever preliminary surveys have determined the necessity for and location of desirable storage sites. The acquisition of right-of-way and flowage rights where reservoir sites have to be obtained is one of considerable importance.

Water rights.—Investigations should, of course, be made to determine the existing water rights. The laws already enacted and in operation in some States provide for the determination and adjudication of water rights. It is expected that other States will soon enact laws for the same purpose.

Before a project can safely be put under construction, or even be finally declared feasible, it is necessary that a complete study of all water rights from the contemplated source of water supply be made, and that an adjudication of such rights be assured.

It has been the policy of the Reclamation Service not to acquire title to the water rights held and used by the private landowners previous to their subscribing their lands and taking irrigation water supply under a reclamation project, but to take over only such portions of existing distribution systems as can be utilized to advantage in connection with the more comprehensive project works, awarding the owners a fair price based on actual cost to reconstruct the ditches or portion of ditches so taken. All the existing private water rights are left intact, with title remaining permanently vested in the present holders to revive automatically and be of full force and effect in the basis of the adjudication previously made, in case circumstances should ever develop requiring their identification and use the same as before reclamation project.

REPORT OF COMMITTEE ON STANDARD PLANS AND SPECIFICATIONS.

STANDARD PLANS.

The general opinion of the engineers assembled at the first conference with this committee was that plans of some of the smaller structures might be standardized. For the present, however, it is recommended that no effort be made to standardize the plans for the larger and more important structures. The territory covered by the reclamation works extends over more than 20 degrees of longitude, and from the Canadian to the Mexican boundary. In this region a great diversity of soil and climate is found, the elevations varying from 200 feet below to 6,000 or 7,000 feet above the level of the sea. Every structure has a purpose to fulfill, and the design must be influenced more or less by local conditions. The conduit which would answer the conditions in Arizona might be a total failure in Montana. The dam which would successfully hold back the warm waters of the Colorado might be carried off by ice floes in the cold waters of the upper Missouri. A great deal must be left to the judgment of the engineer designing the works, and it may be noted that there is a vast difference in men's ideas. Two engineers might design entirely different structures for the same purpose, and they might both answer that purpose, or they might both be failures. Engineers must be given great latitude in designing of structures, as long as well-recognized scientific principles are observed. No two leaves on any tree or on any number of trees are exactly alike; no two dam sites, no two bridge sites, and no two headworks sites are exactly alike.

Any tendency to standardize the work of the engineer must result in restricting improvements, which are largely a matter of growth, based upon trial and performance in actual practice. Nothing is made perfect at first. The standardizing of our plans must be a matter of growth. Many of the structures which we think are about perfect on paper may upon trial develop weakness which must be provided against in future. We therefore recommend that a beginning be made on the standardization of the smaller structures by selecting from the drawings of the different project engineers now in the Washington office such as appear most suitable for types, and that one of the assistant engineers now in the Washington office be given charge of the work. His duty will be to examine and compare all the drawings now in the office bearing on each structure and design a type of this structure which can be easily modified to suit a particular locality.

STANDARD SPECIFICATIONS.

In the matter of specifications it is recommended that the present "general conditions" be modified so that they will suit the following three contracts:

Contracts for construction work, including canals and all the necessary structures mentioned in the schedule (Form 9–294).

Contracts for machinery and installation (Form 9–294A). This form would apply to all kinds of machinery and manufactured appliances needing special mechanics for installing.

Contracts for furnishing materials only (Form 9-294B). The three amended forms follow.

SPECIFICATIONS FOR CONSTRUCTION (FORM 9-294).

INSTRUCTIONS TO BIDDERS.

1. *Form of proposal and signature.*—The proposal must be made on the form provided for that purpose, inclosed in a sealed envelope, and marked and addressed as required in the notice to bidders. It must state in writing and in figures the unit prices and the sum of money for which the bidder proposes to supply the materials and perform the work called for in the proposal and schedules. If the bid is made by an individual it must be signed with the full name of the bidder, whose address must be given; if it is made by a firm it should be signed with the copartnership name by a member of the firm, and the name and full address of each member should be given; and if it is made by a corporation it should be signed by an officer in the corporate name, and the corporate seal should be attached to such signature. No telegraphic proposal or telegraphic modification of proposal will be considered.

2. *Proposals.*—All blank spaces in the proposal must be filled in, and the phraseology of the proposal shall not be changed and additions shall not be made to the items mentioned therein. Any conditions, limitations, or provisos attached to a proposal will be liable to render it informal and may cause its rejection. Alterations by erasure or interlineation must be explained or noted in the proposal over the signature of the bidder. If a bidder wishes to withdraw his proposal he may do so before the time fixed for the opening, without prejudice to himself, by communicating his purpose in writing to the officer who holds it. No bids received after the time set for opening the proposals will be considered. The right is reserved to reject any or all bids, to accept one part and reject the other, and to waive technical defects, as the interests of the Service may require. Bidders are invited to be present at the opening of proposals.

3. *Certified check.*—Each bidder must submit with his proposal a certified check for the sum stated in the notice to bidders, drawn to the order of the Secretary of the Interior. The proceeds of said check shall become the property of the United States if, for any reason whatever, the bidder withdraws from the competition after the opening of the bids or refuses to execute the required contract and bond if his bid is accepted. Checks will be returned to the unsuccessful bidders after the approval of the contract and bond executed by the successful bidder.

4. *Award.*—The bidder to whom award is made will be required to enter into a written contract with the United States, and to furnish good and approved bond as herein specified, within ten days after receiving such contract for execution. The contract shall be, in its general provisions, in the form adopted by the Reclamation Service, copies of which can be inspected at its offices and will be furnished, if desired, to parties proposing to bid. If the bidder to whom the first award is made fails to enter into a contract as herein provided, the award may be annulled and the contract let to the next most desirable bidder in the opinion of the Secretary of the Interior: and such bidder shall be required to fulfill every stipulation embraced herein as if he were the original party to whom the award was made. A copy of the advertisement and of the general conditions and detail specifications will be attached to and form part of the contract. A corporation to which a contract is awarded will be required,

before the contract is finally executed, to furnish certificate as to its corporate existence and evidence that the officer signing the contract is duly authorized to do so on behalf of the corporation.

5. *Contractor's bond.*—The contractor will be required to give a bond in the sum of 20 per cent of the amount of the contract, unless a different sum is specified in the notice to bidders or proposal, conditioned upon the faithful performance by the contractor of all the covenants, stipulations, and agreements in the contract. If at any time during the continuance of the contract the sureties, or any of them, shall die, or, in the opinion of the Secretary of the Interior, become irresponsible, the Secretary shall have the right to require additional and sufficient sureties, which the contractor shall furnish to the satisfaction of that officer within ten days after notice, and in default thereof the contract may be annulled by the Secretary of the Interior and the work carried to completion in the manner provided in the contract.

6. *Transfers.*—Transfer of a contract, or of any interest therein, is prohibited by law.

GENERAL CONDITIONS.

7. *Eight-hour law, and foreign and convict labor.*—In all construction work eight hours shall constitute a day's work, and no Mongolian labor shall be employed thereon. The importation of foreigners and laborers under contract to perform labor in the United States or the Territories or the District of Columbia is prohibited. (Sec. 3738, Rev. Stat., U. S.; act Aug. 1, 1892, 27 Stat. L., 340; sec. 4, act June 17, 1902, 32 Stat. L., 388; acts Feb. 26, 1885, and Feb. 23, 1887, 23 Stat. L., 332 and 414.) On all construction work the employment of persons undergoing sentences of imprisonment at hard labor which have been imposed by courts of the several States, Territories, or municipalities having criminal jurisdiction is prohibited. (Executive order May 18, 1905.)

8. *Engineer.*—Where the word "engineer" is used in the general conditions or detail specifications, or in the contract, it shall be and is mutually understood to refer to the chief engineer of the Reclamation Service, or any of his authorized assistants or inspectors, limited by the particular duties intrusted to them. The engineer will give the locations and the grades for the work, and no work depending on such locations and grades will be commenced until these have been established. The engineer shall point out to the contractor any neglect or disregard of the plans, specifications, and general conditions of the contract. Upon all questions concerning the execution of the work, the classification of the material in accordance with the specifications, and the determination of costs, the decision of the chief engineer shall be binding on both parties. When two or more contractors are engaged on work in the same vicinity the engineer shall be authorized to direct the manner in which each shall conduct his work so far as it affects other contractors.

9. *Contractor.*—Whenever the word "contractor" is used it shall be held to mean the party, firm, or corporation with whom the contract is made by the United States for the construction of the work, the agent of this party who may be appointed to represent him in the execution of the work, or the legal representatives of the contractor. The foreman in charge of the work will be held to represent the contractor during the absence of the latter or his designated agent.

10. *Foreman and copy of plans, etc.*—The contractor shall at all times keep upon the work a copy of the plans and specifications, so that reference may be made thereto by the engineer, in case of misunderstanding or misconstruction. Instructions given by the engineer to the contractor's foreman or agent on the work shall be considered as having been given to the contractor himself.

11. *Transportation.*—The contractor will afford opportunity to the engineer to obtain copies of the expense bills for transportation charges on all machinery, materials, and supplies shipped to or from the project for use in connection with the work under this contract. On most of the western railroads reduced rates are applicable for the transportation of laborers employed by the contractor traveling in parties of five or more to or from the locality of the work, and allowance should be made therefor in submitting bids; full information concerning these rates can be obtained by application to the engineer in charge of the project.

12. *Local conditions.*—Bidders must satisfy themselves as to the nature of the material and as to all local conditions affecting the work, and no information derived from the maps, plans, specifications, profiles, or drawings, or from the engineer or his assistants, will in any way relieve the contractor from any risks or from fulfilling all the terms of his contract.

13. *Mortgaging of plant, etc.*—The contractor shall not, under any circumstances, give or execute any mortgage, deed of trust, or other conveyance or instrument of any description, affecting or intended to affect his right, title, interest, or property in or to any plant, machinery, tools, appliances, materials, or animals which may at any time be used in the prosecution of this contract.

14. *Damages.*—The contractor will be held responsible for and be required to make good, at his own expense, any and all damages, of whatsoever nature, to persons or property caused by carelessness, neglect, or want of due precaution on the part of the contractor, his agents, employees, or workmen. He will not allow any of his agents, employees, or workmen to trespass upon the premises or lands of persons in the vicinity of the works, and will discharge, at the request of the engineer, anyone in his employ who may be guilty of committing such damage.

15. *Drawings and specification requirements.*—Any drawings or plans which may be listed in the detail specifications shall, together with such detail specifications, be regarded as forming part hereof and of the contract. The engineer will furnish from time to time such detail drawings, plans, profiles, and special specifications as may be necessary to enable the contractor to complete the work in a satisfactory manner. The general conditions and detail specifications shall apply to all work done or material furnished, and shall control the special specifications where the latter are silent. In case of conflict in the general conditions, the detail specifications, and the special specifications the last shall control in the particular work to which they apply.

16. *Experience.*—Bidders must, if required, present satisfactory evidence that they have been regularly engaged in the business of constructing such work as they propose to execute, and that they are fully prepared with the necessary capital, machinery, and material to begin the work promptly and to conduct it to the satisfaction of the Department.

17. *Character of workmen.*—The contractor shall discharge from his service, when required by the engineer, any disorderly, dangerous, insubordinate, or incompetent person employed on or in the vicinity of the works under construction by the United States. None but skilled foremen or workmen shall be employed on work requiring special qualifications. as tunnels, concrete work, etc.

18. *Methods and appliances.*—The methods and appliances adopted by the contractor must be such as will secure a satisfactory quality of work and will enable him to complete the work in the time agreed upon. If at any time such methods and appliances appear inadequate, the engineer may order the

contractor to improve their character, or increase their efficiency, and the contractor must conform to such order; but the failure of the engineer to order such improvement of methods or increase of efficiency will not relieve the contractor from his obligations to perform good work or finish it in the time agreed upon.

19. *Material and workmanship.*—All materials must be of the specified quality and fully equal to approved samples, when samples are required. All work must be done in a thorough, workmanlike manner by mechanics skilled in their various trades, notwithstanding any omission from the drawings or specifications; and anything mentioned in the specifications and not shown in the drawings, or shown in the drawings and not mentioned in the specifications, must be done as though shown or mentioned in both. All materials furnished and all work done shall be subject to rigid inspection, and if not in accordance with the specifications, in the opinion of the engineer, shall be made to conform thereto. Unsatisfactory material will be rejected and shall be immediately removed from the premises, at the cost of the contractor, if so ordered by the engineer.

20. *Samples.*—The contractor shall submit samples of any or all materials proposed to be used in the work if required to do so by the engineer.

21. *Delays.*—The contractor shall not be entitled to any compensation for delays or hindrances to the work from any cause whatever. Extension of time will be allowed for unavoidable delays, such as may result from causes which, in the opinion of the engineer, approved by the Secretary of the Interior, are undoubtedly beyond the control of the contractor, such as acts of Providence, fortuitous events, or the like. If any delay or hindrance is caused by specific instructions on the part of the Secretary of the Interior or the engineer, or by their failure to provide material sufficient to carry on the work, or to give such instructions as may be necessary for the same, or to provide necessary right of way, then such delay will entitle the contractor to an extension of time equivalent to the time lost by such delay. The engineer must receive from the contractor a written notice of claim for such delay before any extension of time will be allowed. Any extension of time, however, shall not release the sureties from their obligation, which shall remain in full force and effect until the discharge of contract. Any application for an extension of time must be accompanied by the formal consent of the sureties thereto, or other sufficient sureties must be furnished by the contractor. In case the contractor should fail to complete the work in the time agreed upon in the contract, or in such extra time as may have been allowed for delays as herein provided, the engineer shall compute and appraise the direct damages for the loss sustained by the United States on account of further employment of engineers, inspectors, and other employees, including all disbursements on the engineering account, properly chargeable to the work. The amount so appraised and computed is hereby agreed upon as liquidated damages, and shall be deducted from any money due the contractor under his contract, and the contractor and sureties shall be liable for any excess. The decision of the chief engineer as to the appraisal of such damages shall be final and binding on both parties. Any provisions in the detail specifications concerning deduction for delay shall be held as modifying or revoking the provisions herein.

22. *Suspension of contract.*—Should the contractor fail to begin the work within the time required, or fail to begin the delivery of material as provided in the contract, or fail to prosecute the work or delivery in such manner as to insure a full compliance with the contract within the time limit, or should any question arise as to whether or not the contractor is properly carrying out the

provisions of his contract in their true intent and meaning, at any time during the progress of the work, notice thereof in writing shall be served upon him, and upon his neglect or refusal to provide means for a more energetic and satisfactory compliance with the contract within the time specified in such notice, then and in either case the Secretary of the Interior shall have the power to suspend the operation of the contract, and he may take possession of all machinery, tools, appliances, and animals employed on any of the works to be constructed under the contract and of all materials belonging to the contractor delivered on the ground, and may use the same to complete the work, or he may employ other parties to carry the contract to completion, substitute other machinery or materials, purchase the material contracted for in such manner as he may deem proper, or hire such force, and buy such machinery, tools, appliances, materials, and animals at the contractor's expense as may be necessary for the proper conduct of the work and for finishing it in the time agreed upon. Any excess of cost arising therefrom over and above the contract price will be charged against the contractor and his sureties, who shall be liable therefor. The failure to order improvement of methods or increase of force, plant, or efficiencies will not relieve the contractor from his obligation to perform good work or finish in the time agreed upon.

23. *Climatic conditions.*—The engineer may order the contractor to suspend any work that may be damaged by inclemency of the weather or other climatic conditions (as, for example, excessive cold or heat), and due allowance shall be made to the contractor for the time actually lost by him on account of such suspension.

24. *Quantities.*—The quantities given in the proposal are for the purpose of comparing bids, and are approximate only, and no claim shall be made against the United States on account of any excess or deficiency, absolute or relative, in the same.

25. *Changes.*—The Secretary of the Interior reserves the right to make such changes in the specifications of work or material at any time as may be deemed advisable, without notice to the surety or sureties on the bond given to secure compliance with the contract, by adding thereto or deducting therefrom, at the unit prices of the contract, or at such allowances for changes of materials as shall be deemed just and reasonable by the engineer, whose decision shall be binding on both parties. The right to make material changes in the quantities listed in the proposal is an essential part of the contract, and bidders must make their estimates accordingly. Should any change be made in a particular piece of work after it has been commenced, so that the contractor is put to extra expense, the engineer shall make reasonable allowance therefor, which action shall be binding on both parties. Extra work or material will be paid for as hereinafter provided.

26. *Extra work or material.*—Extra work or material of a character not provided for in the specifications, if ordered in writing by the engineer, will be paid for at actual necessary cost, as determined by the engineer, plus 15 per cent for profit, superintendence, and general expenses. The cost of extra work shall include all materials, labor, and fuel furnished by the contractor, but shall not include use of tools or machinery, office expenses, general superintendence, or other general expenses. Demand for payment must be made in writing by the contractor promptly upon the completion of the extra work or furnishing of the extra material. The account including the same must be accompanied by the certificate of the engineer that such work has been satisfactorily performed or the material furnished, stating the amount to be allowed therefor.

27. *Structural difficulties.*—Should structural difficulties prevent the execu-

tion of the work as described in the plans and specifications, necessary deviations therefrom may be permitted by the engineer, but must be without additional cost to the United States.

28. *Inspection of work.*—The engineers and inspectors appointed by the Secretary of the Interior shall at all times have the right to inspect the work and materials. The contractor shall furnish such persons reasonable facilities for obtaining such information as they desire respecting the progress and manner of the work and the character of the material, including all information necessary to determine the cost of the work, such as the number of men employed, their pay, the time during which they worked on the various classes of construction, etc. He shall, when required, furnish the engineer and his assistants meals and camp accommodations at reasonable prices at any camp under his control Whenever the contractor shall be permitted or directed to perform night work, or to vary the period during which work is carried on each day, he shall give due notice to the engineer so that proper inspection may be provided for. Such work shall be done under regulations to be furnished in writing by the engineer, and no extra compensation shall be allowed therefor.

29. *Removal of defective work.*—The contractor shall remove and rebuild, at his own expense, any part of the work which has been improperly executed, even though such work should have been already allowed for in the monthly estimates. The engineer shall give to the contractor written notice of such defective work when found. If the contractor refuses or neglects to replace such defective work, it may be replaced by the United States at the contractor's expense.

30. *Protection of finished work and cleaning up.*—The contractor will be held responsible for any material furnished to him, and for the care of any finished work until final completion of the work, and will be required to make good, at his own cost, any damage or injury it may sustain from any cause. He shall take all risks from floods and casualties of every description and make no charge for detention from such causes. He may, however, be allowed a reasonable extension of time on account of such detention, as provided herein. The contractor shall remove all rubbish and unused material upon completion of the work, and place the premises in a condition satisfactory to the engineer.

31. *Errors and omissions.*—The contractor will not be allowed to take advantage of any error or omission in these specifications, as full instructions will always be given should such error or omission be discovered.

32. *Roads and fences.*—All roads crossing the work and subject to interference therefrom must be kept open until proper bridges or crossings are provided, if necessary, and all fences crossing the work must be kept up by the contractor until the work is finished.

33. *Bench marks, stakes, etc.*—All bench marks, witness and side-slope stakes must be carefully preserved by the contractor, and in case of their destruction or removal by him or any of his employees such stakes shall be replaced by the engineer at the contractor's expense.

34. *Right of way.*—The right of way for the works to be constructed and for all necessary borrow pits, channels, spoil banks, ditches, roads, etc., will be provided by the United States.

35. *Sanitation.*—The chief engineer may establish rules for sanitation and police regulations for all forces employed under this contract; and should the contractor fail to enforce these rules, the engineer may enforce them and assess against the contractor the cost thereof, which will be deducted from any sum due on the contract.

36. *Use of liquor.*—The use and sale of intoxicating liquor will be absolutely prohibited on the work except under the direction and supervision of the engineer or his agent, and then only for medicinal purposes.

37. *Claims for work and material.*—The contractor shall promptly make payments to all persons supplying labor and materials in the prosecution of the work, and a condition to this effect shall be incorporated in the bond to be given by the contractor, in pursuance of the act of Congress approved August 13, 1894 (28 Stat. L., 278), and acts amendatory thereof.

38. *Payments.*—The payments due shall be made to the contractor upon the presentation of proper accounts, prepared by the engineer and approved by the chief engineer, in accordance with the provisions made therefor and pertaining to the contract. When the work has been completed or all the material has been delivered, to the satisfaction of the chief engineer, and when a release of all claims against the United States on account of the contract shall have been executed by the contractor, final payment of the balance due will be made.

SPECIFICATIONS FOR MACHINERY AND INSTALLATION (FORM 9-294A).

INSTRUCTIONS TO BIDDERS.

1. *Form of proposal and signature.*—The proposal must be made on the form provided for that purpose, inclosed in a sealed envelope, and marked and addressed as required in the notice to bidders. It must state in writing and in figures the unit prices and the sum of money for which the bidder proposes to supply the materials and perform the work called for in the proposal and schedule. If the bid is made by an individual, it must be signed with the full name of the bidder, whose address must be given; if it is made by a firm, it should be signed with the copartnership name by a member of the firm, and the name and full address of each member should be given; and if it is made by a corporation, it should be signed by an officer, in the corporate name, and the corporate seal should be attached to such signature. No telegraphic proposal or telegraphic modification of proposal will be considered.

2. *Proposals.*—All blank spaces in the proposal must be filled in and the phraseology of the proposal shall not be changed and additions shall not be made to the items mentioned therein. Any conditions, limitations, or provisos attached to a proposal will be liable to render it informal and may cause its rejection. Alterations by erasure or interlineations must be explained or noted in the proposal over the signature of the bidder. If a bidder wishes to withdraw his proposal, he may do so before the time fixed for the opening, without prejudice to himself, by communicating his purpose in writing to the officer who holds it. No bids received after the time set for opening the proposals will be considered. The right is reserved to reject any or all bids, to accept one part and to reject the other, and to waive technical defects, as the interest of the Service may require. Bidders are invited to be present at the opening of proposals.

3. *Certified check.*—Each bidder must submit with his proposal a certified check for the sum stated in the notice to bidders, drawn to the order of the Secretary of the Interior. The proceeds of said checks shall become the property of the United States if, for any reason whatever, the bidder withdraws from the competition after the opening of the bids or refuses to execute the required contract and bond if his bid is accepted. Checks will be returned to the unsuccessful bidders after the approval of the contract and bond executed by the successful bidder.

4. *Award.*—The bidder to whom award is made will be required to enter into a written contract with the United States and to furnish good and approved bond, as herein specified, within ten days after receiving such contract for

execution. The contract shall be, in its general provisions, in the form adopted by the Reclamation Service, copies of which can be inspected at its offices, and will be furnished, if desired, to parties proposing to bid. If the bidder to whom the first award is made fails to enter into a contract as herein provided, the award may be annulled and the contract let to the next most desirable bidder in the opinion of the Secretary of the Interior; and such bidder shall be required to fulfill every stipulation embraced herein as if he were the original party to whom the award was made. A copy of the advertisement and of the general conditions and detail specifications will be attached to and form part of the contract. A corporation to which a contract is awarded will be required, before the contract is finally executed, to furnish certificate as to its corporate existence and evidence that the officer signing the contract is duly authorized to do so on behalf of the corporation.

5. *Contractor's bond.*—The contractor will be required to give a bond in the sum of 20 per cent of the amount of the contract, unless a different sum is specified in the notice to bidders or proposal, conditioned upon the faithful performance by the contractor of all the covenants, stipulations, and agreements in the contract. If at any time during the continuance of the contract the sureties, or any of them, shall die, or, in the opinion of the Secretary of the Interior, become irresponsible, the Secretary shall have the right to require additional and sufficient sureties, which the contractor shall furnish to the satisfaction of that officer within ten days after notice, and in default thereof the contract may be annulled by the Secretary of the Interior and the work carried to completion in the manner provided in the contract.

6. *Transfers.*—Transfer of a contract, or of any interest therein, is prohibited by law.

GENERAL CONDITIONS.

7. *Eight-hour law, and foreign and convict labor.*—In all construction work eight hours shall constitute a day's work, and no Mongolian labor shall be employed thereon. The importation of foreigners and laborers under contract to perform labor in the United States or the Territories or the District of Columbia is prohibited. (Sec. 3738, Rev. Stat., U. S.; act Aug. 1, 1892, 27 Stat. L., 340; sec. 4, act June 17, 1902, 32 Stat. L., 388; acts Feb. 26, 1885, and Feb. 23, 1887, 23 Stat. L., 332 and 414.) On all construction work the employment of persons undergoing sentences of imprisonment at hard labor which have been imposed by courts of the several States, Territories, or municipalities having criminal jurisdiction is prohibited. (Executive order May 18, 1905.)

8. *Engineer.*—Where the word "engineer" is used in the general conditions or detail specifications, or in the contract, it shall be and is mutually understood to refer to the chief engineer of the Reclamation Service or any of his authorized assistants or inspectors, limited by the particular duties intrusted to them. The engineer shall point out to the contractor any neglect or disregard of the plans, specifications, and general conditions of the contract. Upon all questions concerning the execution of the work in accordance with the specifications, and the determination of costs, the decision of the chief engineer shall be binding on both parties. When two or more contractors are engaged on work in the same vicinity the engineer shall be authorized to direct the manner in which each shall conduct his work so far as it affects other contractors.

9. *Contractor.*—Whenever the word "contractor" is used it shall be held to mean the party, firm, or corporation with whom the contract is made by the United States, the agent of this party who may be appointed to represent him in the execution of the work, or the legal representatives of the contractor.

The foreman in charge of the work will be held to represent the contractor during the absence of the latter or his designated agent.

10. *Foreman and copy of plans, etc.*—The contractor shall at all times keep upon the work a copy of the plans and specifications, so that reference may be made thereto by the engineer in case of misunderstanding or misconstruction. Instructions given by the engineer to the contractor's foreman or agent on the work shall be considered as having been given to the contractor himself.

11. *Transportation.*—The contractor will afford opportunity to the engineer to obtain copies of the expense bills for transportation charges on all machinery, materials, and supplies shipped to or from the project for use in connection with the work under this contract. On most of the western railroads reduced rates are applicable for the transportation of laborers employed by the contactor, traveling in parties of five or more to or from the locality of the work, and allowance should be made therefor in submitting bids. Full information concerning these rates can be obtained by application to the engineer in charge of the project.

12. *Local conditions.*—Bidders must satisfy themselves as to the nature of the material and as to all local conditions affecting the work, and no information derived from the maps, plans, specifications, profiles, or drawings, or from the engineer or his assistants, will in any way relieve the contractor from any risks or from fulfilling all the terms of his contract.

13. *Damages.*—The contractor will be held responsible for and be required to make good, at his own expense, any and all damages, of whatsoever nature, to persons or property caused by carelessness, neglect, or want of due precaution on the part of the contractor, his agents, employees, or workmen. He will not allow any of his agents, employees, or workmen to trespass upon the premises or lands of persons in the vicinity of the works, and will discharge, at the request of the engineer, anyone in his employ who may be guilty of committing such damage.

14. *Drawings and specification requirements.*—Any drawings or plans which may be listed in the detail specifications shall, together with such detail specifications, be regarded as forming part hereof and of the contract. The engineer will furnish from time to time such detail drawings, plans, profiles, and special specifications as may be necessary to enable the contractor to complete the work in a satisfactory manner. The general conditions and detail specifications shall apply to all work done or material furnished, and shall control the special specifications where the latter are silent. In case of conflict in the general conditions, the detail specifications, and the special specifications, the last shall control in the particular work to which they apply.

15. *Experience.*—Bidders must, if required, present satisfactory evidence that they have been regularly engaged in the business of constructing such work as they propose to execute, and that they are fully prepared with the necessary capital, machinery, and material to begin the work promptly and to conduct it to the satisfaction of the Department.

16. *Character of workmen.*—The contractor shall discharge from his service, when required by the engineer, any disorderly, dangerous, insubordinate, or incompetent person employed on or in the vicinity of the works under construction by the United States. None but skilled foremen or workmen shall be employed on work requiring special qualifications.

17. *Methods and appliances.*—The methods and appliances adopted by the contractor must be such as will secure a satisfactory quality of work and will enable him to complete the work in the time agreed upon. If at any time such methods and appliances appear inadequate, the engineer may order the con-

tractor to improve their character or increase their efficiency, and the contractor must conform to such order; but the failure of the engineer to order such improvement of methods or increase of efficiency will not relieve the contractor from his obligations to perform good work or finish it in the time agreed upon.

18. *Material and workmanship.*—All materials must be of the specified quality and fully equal to approved samples, when samples are required. All work must be done in a thorough, workmanlike manner by mechanics skilled in their various trades, notwithstanding any omission from the drawings or specifications; and anything mentioned in the specifications and not shown in the drawings, or shown in the drawings and not mentioned in the specifications, must be done as though shown or mentioned in both. All materials furnished and all work done shall be subject to rigid inspection, and if not in accordance with the specifications, in the opinion of the engineer, shall be made to conform thereto. Unsatisfactory material will be rejected and shall be immediately removed from the premises, at the cost of the contractor, if so ordered by the engineer.

19. *Samples.*—The contractor shall submit samples of any or all materials proposed to be used in the work if required to do so by the engineer.

20. *Delays.*—The contractor shall not be entitled to any compensation for delays or hindrances to the work from any cause whatever. Extension of time will be allowed for unavoidable delays, such as may result from causes which, in the opinion of the engineer, approved by the Secretary of the Interior, are undoubtedly beyond the control of the contractor, such as acts of Providence, fortuitous events, or the like. If any delay or hindrance is caused by specific instructions on the part of the Secretary of the Interior or the engineer, or by their failure to give such instructions as may be necessary, then such delay will entitle the contractor to an extension of time equivalent to the time lost by such delay. The engineer must receive from the contractor a written notice of claim for such delay before any extension of time will be allowed. Any extension of time, however, shall not release the sureties from their obligation, which shall remain in full force and effect until the discharge of contract. Any application for an extension of time must be accompanied by the formal consent of the sureties thereto, or other sufficient sureties must be furnished by the contractor. In case the contractor should fail to complete the work in the time agreed upon in the contract, or in such extra time as may have been allowed for delays as herein provided, the engineer shall compute and appraise the direct damages for the loss sustained by the United States on account of further employment of engineers, inspectors, and other employees, including all disbursements on the engineering account properly chargeable to the work. The amount so appraised and computed is hereby agreed upon as liquidated damages, and shall be deducted from any money due the contractor under his contract, and the contractor and sureties shall be liable for any excess. The decision of the chief engineer as to the appraisal of such damages shall be final and binding on both parties. Any provisions in the detail specifications concerning deduction for delay shall be held as modifying or revoking the provisions herein.

21. *Suspension of contract.*—Should the contractor fail to begin the work within the time required, or fail to begin the delivery of material as provided in the contract, or fail to prosecute the work or delivery in such manner as to insure a full compliance with the contract within the time limit, or should any question arise as to whether or not the contractor is properly carrying out the provisions of his contract in their true intent and meaning, at any time during the progress of the work, notice thereof in writing shall be served upon him, and upon his neglect or refusal to provide means for a more energetic and satisfactory compliance with the contract within the time specified in such notice,

then and in either case the Secretary of the Interior shall have the power to suspend the operation of the contract, and he may take possession of all machinery, tools, appliances, and animals employed on any of the works to be constructed under the contract, and of all materials belonging to the contractor delivered on the ground, and may use the same to complete the work, or he may employ other parties to carry the contract to completion, substitute other machinery or materials, purchase the material contracted for in such manner as he may deem proper, or hire such force and buy such machinery, tools, appliances, materials, and animals at the contractor's expense as may be necessary for the proper conduct of the work and for finishing it in the time agreed upon. Any excess of cost arising therefrom over and above the contract price will be charged against the contractor and his sureties, who shall be liable therefor. The failure to order improvement of methods or increase of force, plant, or efficiencies will not relieve the contractor from his obligation to perform good work or finish in the time agreed upon.

22. *Climatic conditions.*—The engineer may order the contractor to suspend any work that may be damaged by inclemency of the weather or other climatic conditions (as, for example, excessive cold or heat), and due allowance shall be made to the contractor for the time actually lost by him on account of such suspension.

23. *Changes.*—The Secretary of the Interior reserves the right to make such changes in the specifications of work or material at any time as may be deemed advisable, without notice to the surety or sureties on the bond given to secure compliance with the contract, by adding thereto or deducting therefrom, at the unit prices of the contract, or at such allowances for changes of materials as shall be deemed just and reasonable by the engineer, whose decision shall be binding on both parties. The right to make material changes in the quantities listed in the proposal is an essential part of the contract, and bidders must make their estimates accordingly. Should any change be made in a particular piece of work after it has been commenced, so that the contractor is put to extra expense, the engineer shall make reasonable allowance therefor, which action shall be binding on both parties. Extra work or material will be paid for as hereinafter provided.

24. *Extra work or material.*—Extra work or material of a character not provided for in the specifications, if ordered in writing by the engineer, will be paid for at actual necessary cost, as determined by the engineer, plus 15 per cent for profit, superintendence, and general expenses. The cost of extra work shall include all materials, labor, and fuel furnished by the contractor, but shall not include use of tools or machinery, office expenses, general superintendence, or other general expenses. Demand for payment must be made in writing by the contractor promptly upon the completion of the extra work or furnishing of the extra material. The account including the same must be accompanied by the certificate of the engineer that such work has been satisfactorily performed or the material furnished, stating the amount to be allowed therefor.

25. *Structural difficulties.*—Should structural difficulties prevent the execution of the work as described in the plans and specifications, necessary deviations therefrom may be permitted by the engineer, but must be without additional cost to the United States.

26. *Inspection of work.*—The engineers and inspectors appointed by the Secretary of the Interior shall at all times have the right to inspect the work and materials. The contractor shall furnish such persons reasonable facilities for obtaining such information as they desire respecting the progress and manner of the work and the character of the material, including all information necessary to determine the cost of the work, such as the number of men employed,

their pay, the time during which they worked on the various classes of construction, etc. He shall, when required, furnish the engineer and his assistants meals and camp accommodations at reasonable prices at any camp under his control. Whenever the contractor shall be permitted or directed to perform night work, or to vary the period during which work is carried on each day, he shall give due notice to the engineer, so that proper inspection may be provided for. Such work shall be done under regulations to be furnished in writing by the engineer, and no extra compensation shall be allowed therefor.

27. *Removal of defective work.*—The contractor shall remove and rebuild, at his own expense, any part of the work which has been improperly executed, even though such work should have been already allowed for in the monthly estimates. The engineer shall give to the contractor written notice of such defective work, when found. If the contractor refuses or neglects to replace such defective work, it may be replaced by the United States at the contractor's expense.

28. *Protection of finished work and cleaning up.*—The contractor will be held responsible for any material furnished to him, and for the care of any finished work until final completion of the work, and will be required to make good, at his own cost, any damage or injury it may sustain from any cause. He shall take all risks from floods and casualties of every description and make no charge for detention from such causes. He may, however, be allowed a reasonable extension of time on account of such detention, as provided herein. The contractor shall remove all rubbish and unused material upon completion of the work, and place the premises in a condition satisfactory to the engineer.

29. *Errors and omissions.*—The contractor will not be allowed to take advantage of any error or omission in these specifications, as full instructions will always be given should error or omission be discovered.

30. *Sanitation.*—The chief engineer may establish rules for sanitation and police regulations for all forces employed under this contract; and should the contractor fail to enforce these rules, the engineer may enforce them and assess against the contractor the cost thereof, which will be deducted from any sum due on the contract.

31. *Use of liquor.*—The use and sale of intoxicating liquor will be absolutely prohibited on the work except under the direction and supervision of the engineer or his agent, and then only for medicinal purposes.

32. *Claims for work and material.*—The contractor shall promptly make payments to all persons supplying labor and materials in the prosecution of the work, and a condition to this effect shall be incorporated in the bond to be given by the contractor, in pursuance of the act of Congress approved August 13, 1894 (28 Stat. L., 278), and acts amendatory thereof.

33. *Payments.*—The payments due shall be made to the contractor upon the presentation of proper accounts, prepared by the engineer and approved by the chief engineer, in accordance with the provisions made therefor and pertaining to the contract. When the work has been completed or all the material has been delivered, to the satisfaction of the chief engineer, and when a release of all claims against the United States on account of the contract shall have been executed by the contractor, final payment of the balance due will be made.

SPECIFICATIONS—MATERIAL (FORM 9-294B).

INSTRUCTIONS TO BIDDERS.

1. *Form of proposal and signature.*—The proposal must be made on the form provided for that purpose, inclosed in a sealed envelope, and marked and

addressed as required in the notice to bidders. It must state in writing and in figures the unit prices and the sum of money for which the bidder proposes to supply the materials called for in the proposal and schedules. If the bid is made by an individual, it must be signed with the full name of the bidder, whose address must be given; if it is made by a firm, it should be signed with the copartnership name by a member of the firm, and the name and full address of each member should be given; and if it is made by a corporation, it should be signed by an officer in the corporate name, and the corporate seal should be attached to such signature. No telegraphic proposal or telegraphic modification of proposal will be considered.

2. *Proposals.*—All blank spaces in the proposal must be filled in, and the phraseology of the proposal shall not be changed, and additions shall not be made to the items mentioned therein. Any conditions, limitations, or provisos attached to a proposal will be liable to render it informal and may cause its rejection. Alterations by erasure or interlineation must be explained or noted in the proposal over the signature of the bidder. If a bidder wishes to withdraw his proposal he may do so before the time fixed for the opening, without prejudice to himself, by communicating his purpose in writing to the officer who holds it. No bids received after the time set for opening the proposals will be considered. The right is reserved to reject any or all bids, to accept one part and reject the other, and to waive technical defects, as the interests of the Service may require. Bidders are invited to be present at the opening of proposals.

3. *Certified check.*—Each bidder must submit with his proposal a certified check for the snm stated in the notice to bidders, drawn to the order of the Secretary of the Interior. The proceeds of said check shall become the property of the United States if, for any reason whatever, the bidder withdraws from the competition after the opening of the bids or refuses to execute the required contract and bond if his bid is accepted. Checks will be returned to the unsuccessful bidders after the approval of the contract and bond executed by the successful bidder.

4. *Award.*—The bidder to whom award is made will be required to enter into a written contract with the United States, and to furnish good and approved bond, as herein specified, within ten days after receiving such contract for execution. The contract shall be, in its general provisions, in the form adopted by the Reclamation Service, copies of which can be inspected at its offices, and will be furnished, if desired, to parties proposing to bid. If the bidder to whom the first award is made fails to enter into a contract as herein provided, the award may be annulled and the contract let to the next most desirable bidder in the opinion of the Secretary of the Interior; and such bidder shall be required to fulfill every stipulation embraced herein as if he were the original party to whom the award was made. A copy of the advertisement and of the general conditions and detail specifications will be attached to and form part of the contract. A corporation to which a contract is awarded will be required before the contract is finally executed to furnish certificate as to its corporate existence and evidence that the officer signing the contract is duly authorized to do so on behalf of the corporation.

5. *Contractor's bond.*—The contractor will be required to give a bond in the sum of 20 per cent of the amount of the contract, unless a different sum is specified in the notice to bidders or proposal, conditioned upon the faithful performance by the contractor of all the covenants, stipulations, and agreements in the contract. If at any time during the continuance of the contract the sureties, or any of them, shall die, or in the opinion of the Secretary of the Interior become irresponsible, the Secretary shall have the right to require additional

and sufficient sureties, which the contractor shall furnish to the satisfaction of that officer within ten days after notice, and in default thereof the contract may be annulled by the Secretary of the Interior and the work carried to completion in the manner provided in the contract.

6. *Transfers.*—Transfer of a contract, or of any interest therein, is prohibited by law.

GENERAL CONDITIONS.

7. *Eight-hour law, and foreign and convict labor.*—In all construction work eight hours shall constitute a day's work, and no Mongolian labor shall be employed thereon. The importation of foreigners and laborers under contract to perform labor in the United States or Territories or the District of Columbia is prohibited. (Sec. 3738, Rev. Stat., U. S.; act of Aug. 1, 1892, 27 Stat. L., 340; sec. 4, act June 17, 1902, 32 Stat. L., 388; acts Feb. 26, 1885, and Feb. 23, 1887, 23 Stat. L., 332 and 414.) On all construction work the employment of persons undergoing sentences of imprisonment at hard labor which have been imposed by courts of the several States, Territories, or municipalities having criminal jurisdiction is prohibited. (Executive order May 18, 1905.)

8. *Engineer.*—Where the word "engineer" is used in the general conditions or detail specifications, or in the contract, it shall be and is mutually understood to refer to the chief engineer of the Reclamation Service, or any of his authorized assistants or inspectors, limited by the particular duties intrusted to them. The engineer shall point out to the contractor any neglect or disregard of the specifications and general conditions of the contract.

9. *Contractor.*—Whenever the word "contractor" is used it shall be held to mean the party, firm, or corporation with whom the contract is made by the United States, the agent of this party who may be appointed to represent him in the execution of the work, or the legal representatives of the contractor. The foreman in charge of the work will be held to represent the contractor during the absence of the latter or his designated agent.

10. *Expense bills.*—Contractors shall afford opportunity to the engineer to obtain copies of the expense bills for transportation charges on all machinery, materials, and supplies shipped to or from the project for use in connection with the work under this contract.

11. *Damages.*—The contractor will be held responsible for and be required to make good, at his own expense, any and all damages, of whatsoever nature, to persons or property caused by carelessness, neglect, or want of due precaution on the part of the contractor, his agents, employees, or workmen. He will not allow any of his agents, employees, or workmen to trespass upon the premises or lands of persons in the vicinity of the works, and will discharge, at the request of the engineer, anyone in his employ who may be guilty of committing such damage.

12. *Specification requirements.*—The general conditions and detail specifications shall apply to all material furnished, and shall control the special specifications where the latter are silent. In case of conflict in the general conditions, the detail specifications, and the special specifications the last shall control in the particular work to which they apply.

13. *Character of workmen.*—The contractor shall discharge from his service, when required by the engineer, any disorderly, dangerous, insubordinate, or incompetent person employed on or in the vicinity of the works under construction by the United States.

14. *Material.*—All materials must be of the specified quality and fully equal to approved samples, when samples are required. All materials furnished shall

be subject to rigid inspection, and if not in accordance with the specifications, in the opinion of the engineer, shall be made to conform thereto. Unsatisfactory material will be rejected and shall be immediately removed from the premises, at the cost of the contractor, if so ordered by the engineer.

15. *Samples.*—The contractor shall submit samples of any or all materials to be furnished if required to do so by the engineer.

16. *Delays.*—The contractor shall not be entitled to any compensation for delays or hindrances from any cause whatever. Extension of time will be allowed for unavoidable delays, such as may result from causes which, in the opinion of the engineer, approved by the Secretary of the Interior, are undoubtedly beyond the control of the contractor, such as acts of Providence. fortuitous events, or the like. If any delay or hindrance is caused by specific instructions on the part of the Secretary of the Interior or the engineer, or by their failure to give such instructions as may be necessary, then such delay will entitle the contractor to an extension of time equivalent to the time lost by such delay. The engineer must receive from the contractor a written notice of claim for such delay before any extension of time will be allowed. Any extension of time, however, shall not release the sureties from their obligation, which shall remain in full force and effect until the discharge of contract. Any application for an extension of time must be accompanied by the formal consent of the sureties thereto, or other sufficient sureties must be furnished by the contractor. In case the contractor should fail to complete the contract in the time agreed upon, or in such extra time as may have been allowed for delays as herein provided, the engineer shall compute and appraise the direct damages for the loss sustained by the United States on account of further employment of engineers, inspectors, and other employees, including all disbursements on the engineering account, properly chargeable to the contract. The amount so appraised and computed is hereby agreed upon as liquidated damages, and shall be deducted from any money due the contractor under his contract, and the contractor and sureties shall be liable for any excess. The decision of the chief engineer as to the appraisal of such damages shall be final and binding on both parties. Any provisions in the detail specifications concerning deduction for delay shall be held as modifying or revoking the provisions herein.

17. *Suspension of contract.*—Should the contractor fail to begin the delivery of material as provided in the contract, or fail to prosecute the delivery in such manner as to insure a full compliance with the contract within the time limit, or should any question arise as to whether or not the contractor is properly carrying out the provisions of his contract in their true intent and meaning, at any time during the progress of the delivery, notice thereof in writing shall be served upon him, and upon his neglect or refusal to provide means for a more energetic and satisfactory compliance with the contract within the time specified in such notice, then and in either case the Secretary of the Interior shall have the power to suspend the operation of the contract, or he may employ other parties to carry the contract to completion, substitute other machinery or materials, or purchase the material contracted for in such manner as he may deem proper. Any excess of cost arising therefrom over and above the contract price will be charged against the contractor and his sureties, who shall be liable therefor.

18. *Inspection.*—The engineers and inspectors appointed by the Secretary of the Interior shall at all times have the right to inspect the materials.

19. *Errors and omissions.*—The contractor will not be allowed to take advantage of any error or omission in these specifications, as full instructions will always be given should such error or omission be discovered.

20. *Claims for work and material.*—The contractor shall promptly make payments to all persons supplying labor and materials in the prosecution of the work, and a condition to this effect shall be incorporated in the bond to be given by the contractor, in pursuance of the act of Congress approved August 13, 1894 (28 Stat. L., 278), and acts amendatory thereof.

21. *Payments.*—The payments due shall be made to the contractor upon the presentation of proper accounts, prepared by the engineer and approved by the chief engineer, in accordance with the provisions made therefor and pertaining to the contract. When all the material has been delivered, to the satisfaction of the chief engineer, and when a release of all claims against the United States on account of the contract shall have been executed by the contractor, final payment of the balance due will be made.

REPORT OF HYDROGRAPHERS ON STREAM MEASUREMENTS.

INTRODUCTION.

The second annual conference of eastern hydrographers was held in Washington January 3 to 12, inclusive, 1905, in connection with the conference of the reclamation engineers. It was attended by the men named below:

Hydrographers.—R. E. Horton, M. R. Hall, T. U. Taylor.

Engineers.—H. K. Barrows, A. H. Horton, E. Johnson, jr., John C. Hoyt, E. C. Murphy, N. C. Grover.

Assistant engineers.—S. K. Clapp, F. W. Hanna, Robert Follansbee, F. E. Pressey, J. M. Giles, W. G. Steward, C. C. Covert, R. E. Bolster, G. H. Bliss.

Engineering aids.—W. E. Hall, H. L. Eames, F. H. Harley, H. M. Morse, H. D. Comstock.

The following subjects were discussed:

Winter records for current-meter gaging stations.

Gages.

The maintenance of permanent river stations.

Effect of grass on stream gagings.

Curves of mean velocity and of area.

Secondary or " bench-mark " stations.

Limits of accuracy in reporting discharge measurements in constructing rating tables and in applying gage heights.

Methods of counting seconds and revolutions in making low-water measurements.

Bench marks.

Equipment for cable stations.

Cost of stream gaging.

The study of data by local men.

The work of the computing section.

Evaporation.

Hydrographic gazetteer.

During one session of the conference Dr. H. C. Frankenfield, of the Weather Bureau, explained the river work carried on under his direction.

RECOMMENDATIONS.

As a result of the discussion the conference made the following recommendations:

Watch for use in stream gaging.—It is recommended that an effort be made to obtain a watch having a second dial of the full size of the watch face and subdivided into 50 parts, the second hand making one complete revolution in 50 seconds, and the advisability of introducing such a timepiece in our work be considered.

Meters and meter ratings.—Inasmuch as the results of our work depend so largely on the meter used, and considering the large cost of the work done with the individual meter compared with the cost of constructing and rating the same, it is the opinion of the conference that too great care in studying these instruments and in maintaining them can not be taken. In this connection the conference has been especially interested in Mr. Steward's ball-bearing meter and in the designs for the rating-station recording device.

It is believed that the meter is capable of giving consistent results at stations where the velocity is less than 0.50 foot per second, which is admitted to be as low as the meters are now rated, with a fair degree of accuracy.

It is therefore recommended that each meter be accurately rated to as low a velocity as the wheel is capable of turning with an even motion. In order that this may be properly done, it is further recommended that steps be taken to construct in the near future at Washington a new meter-rating station, and that it be equipped with Mr. Steward's recording device. It is believed that if possible this station should be so constructed as to be of use both during the summer and winter periods, and that a special channel should be built of sufficient size to serve for this purpose, so that the rating can be made under constant conditions.

The ball-bearing meter, designed by Mr. Steward, will probably be a step toward the improvement of our current-meter work, and it is urged that steps be taken to have constructed for experimental purposes at an early date a meter of this type.

Furthermore, it is believed that a careful study of the behavior of current meters should be made and that they should be rated as they come in from the field, in order to determine the change which has taken place during their use. It is therefore recommended that steps be taken to facilitate the continuance of this work so that the above-mentioned results may be obtained. It is further recommended that an electric meter be constructed that will record 5, 10, or 20 revolutions, for use in making flood measurements.

Annual report.—The general attitude as regards the annual report on the progress of stream measurements should be one of greater conservatism in publishing estimates. All facts collected during the year should be published in the annual report for that year.

No estimates of discharge at a station for any unit of time should be published until sufficient current-meter measurements have been made to cover the ordinary limits of gage heights.

No estimates of discharge, as outlined above, should be published, except in the case of stations with changeable beds.

Until estimates of discharge can be made, as outlined above, the data published regarding a gaging station should be substantially as follows:

(*a*) Description of station, bench marks, etc.

(*b*) List of discharge measurements to date.

(*c*) List of daily gage heights for the year.

The general outline for data regarding stations at which rating curves are suitably developed should be substantially as follows for the first year:

(*a*) Description of station, bench marks, etc.

(*b*) List of discharge measurements to date.

(*c*) List of daily gage heights for the year.

(*d*) Rating table for station.

(*e*) Daily discharge for the two or more years, where such estimates appear to be desirable.

(*f*) Table of mean monthly discharge, etc., for the two or more years.

After the first year of publishing discharge estimates data for a station shall be substantially as follows:

(*a*) Description of station, bench marks, etc.

(*b*) List of discharge measurements to date.

(*c*) List of daily gage heights for the year.

(*d*) Rating table for station, indicating changes or additions.

(*e*) Daily discharge for the year, where such estimates appear to be desirable.

(*f*) Mean monthly discharge, etc., for the year.

It is recognized that there will be exceptional cases where it will be inadvisable to adhere closely to the foregoing requirements—for example, where temporary stations are maintained for special purposes—and it is intended that the course of procedure in such cases be left to the judgment of the various district hydrographers.

The annual report of progress of stream measurements should hereafter be published in several volumes, each one of which should be devoted to one or more adjacent and complete drainage basins, but, as far as possible, divided so as to make the work of each district hydrographer in a separate volume or volumes. Each part of the annual report should be published under the name of the hydrographer whose work comprises the greater portion of said part and the name of the party who has charge of the editing and computations in the Washington office.

It is furthermore recommended that arrangements be made whereby parties asking for stream-measurement data shall be supplied, when such requests are made, with the gage heights and discharge measurements to date. Furthermore, that a circular letter be prepared stating that owing to the large amount of work carried on in the hydrographic branch it will be impossible for the office to furnish advance estimates of rating tables and flow.

Maintenance of stations during winter months.—Wherever possible the permanent stations of the Survey should afford continuous records, both winter and summer, and no estimates of discharge should be made for ice-covered streams without discharge measurements made during the ice season.

Especial care should be taken in selecting meter stations to secure sites where as good winter records as possible may be obtained.

The hydrographers may profitably record and report at the end of the present winter certain general facts regarding ice conditions in their territory, so that we may better understand the nature and magnitude of the ice problem. A brief statement should be made for each gaging station, stating—

(*a*) The duration of the ice season.

(*b*) Whether the stream freezes clear across.

(*c*) Whether the ice is persistent, or comes and goes.

(*d*) Whether anchor ice forms; and if so, how it occurs.

(*e*) Whether the ice surface is smooth underneath.

(*f*) Whether winter gage readings are made daily or weekly.

(*g*) What is the maximum ice thickness.

(*h*) Whether it is feasible to measure the discharge through the ice at this station.

(*i*) Whether the water rises to uniform depth in ice.

It is recommended that observers take winter gage readings to water level as it rises in a hole chopped in the ice.

A rubber stamp bearing the words "Report thickness of ice at gage" may be used and a special heading stamped on the regular weekly gage cards for stations where there is but little ice.

Where weekly readings only are required in winter, or, supplementary to the regular cards, a card form as follows may be used:

OBSERVATIONS OF RIVER HEIGHT, ETC., DURING THE FROZEN SEASON.

Made on the ....River,

near.................post office, State of...........

Day of week.	Month. 190.....	Day.	Time of day.	Gage height to—		Thickness of ice at gage.
				Water surface.	Top of ice.	

In space below put remarks as to anchor ice, condition of ice, etc. Mark on the sketch the extent to which the river is frozen, both at the station and above and below the station. Put figures on sketch, showing ice thickness at other places than at gage.

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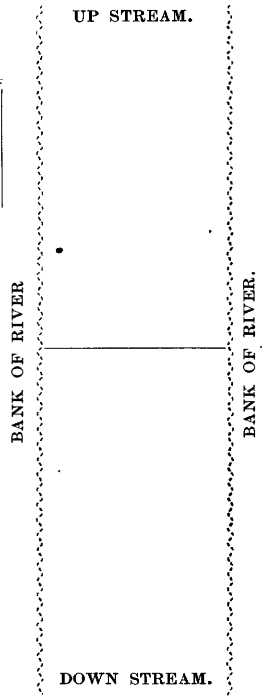
................(Sign).......................Observer.



It is recommended that the northern hydrographers make careful observations on one or two important rivers the present winter, with special reference to determining:

(*a*) Practical methods of ice measurements.
(*b*) The nature of flow under ice.
(*c*) The vertical velocity curves under ice.
(*d*) The relation between ice flow and free flow at various stages.
(*e*) Whether a constant or any general deductions can be made.
(*f*) The limitations of successful ice measurement.

It is recommended that a committee, consisting of Messrs. Barrows, Horton, and Murphy, be appointed and empowered to compile at the end of the present winter season the data above outlined and formulate plans for next season's work.

Accuracy of computations.—The following rules relative to accuracy of computations were adopted:

The highest degree of precision consistent with the rational use of time and money is imperative.

All items of computation should be expressed by at least 2 and by not more than 4 significant figures.

Any measurement in a vertical velocity, mean velocity, or discharge curve whose per cent of error is 5 times the average per cent error of all the other measurements should be rejected.

In reducing the number of significant figures, or the number of decimal places, by dropping the last figure, the following rules apply:

(*a*) When the figure in the place to be rejected is less than 5, drop it without changing the preceding figure. Example: 1,827.4 becomes 1,827.

(*b*) When the figure in the place to be rejected is greater than 5, drop it and increase the preceding figure by 1. Example: 1,827.6 becomes 1,828.

(*c*) When the figure in the place to be rejected is 5, and it is preceded by an even figure, drop the 5. Example: 1,828.5 becomes 1,828.

(*d*) When the figure in the place to be rejected is 5, and it is preceded by an odd figure, drop the 5 and increase the preceding odd figure by 1. Example: 1,827.5 becomes 1,828.

In constructing and applying rating tables a maximum limit of one-half of 1 per cent error should seldom be exceeded.

REPORT OF COMMITTEE ON WATER LAWS AND FORMS OF WATER USERS' ASSOCIATIONS.

The committee held several sessions with other engineers present, and discussed the subjects within their province at several general sessions. Various phases of the water laws under consideration by the several States were discussed and suggestions made as to the most desirable forms, so far as the operations of the Reclamation Service are concerned.

Among the questions presented were forms of water users' associations and the forms for application for water right under the provisions of the reclamation act.

Amendments to the printed form of articles of incorporation of water users' associations were considered by the committee and discussed in general sessions of the engineers. An amended copy of these articles was submitted to the chief engineer, with the recommendation that a new edition be printed.

The main subject of discussion was the form of water-right application under the provisions of the reclamation act. This discussion was based largely upon the report of a committee, consisting of Messrs. Savage, Bien, and Means, to the conference at El Paso, upon the classification of lands into farm units and the water supply to be furnished.

A form of application for water right was presented to the committee and to the general sessions of the engineers and freely discussed. Copies of two forms of water-right application, drawn so far as possible to meet the views of the engineers present at the conference, are hereto appended, and have been submitted to the Secretary of the Interior for his approval.

The question of what should be regarded as residence in the neighborhood of the land received special attention at a number of meetings, as well as the method of meeting this condition in the applications. As a guide for such limit the distance of 10 miles seemed, in the opinion of most of the engineers present, to be a reasonable maximum for a country comparatively flat and in which travel is easy. For rougher country the distance should be shorter.

The general opinion seems to be that the distance could not be specified for all projects, and, accordingly, the forms of application have been prepared upon the supposition that the distance for each project will be specified by the Secretary of the Interior on recommendation of the chief engineer, and that the applicant should state the distance of his residence from the land, which would be acceptable if within the limit fixed by the Secretary, and if not, would be the subject of special consideration in each of such cases.

Among the matters which it would be necessary for each engineer to report when his work had progressed to such point that applications for water rights should be made are the following: The amount of water to be furnished in acre-feet per annum per acre, measured at the land; the limit of distance of residence which is to be regarded as in the neighborhood in the contemplation of the Reclamation Act.

The amount of water to be furnished per acre per annum can not, of course, be fixed for all projects. The general view seemed to be that the limit should be fixed for each project. The details concerning the furnishing of this supply are to be made a matter of regulation by the Secretary of the Interior, presumably under a few general regulations applicable to all projects, with special regulations for the separate projects as may be found necessary.

The present situation does not permit of drawing up any regulations upon this subject, but the experience of the Reclamation Service in this branch of the work will develop the need of regulations covering the various phases of this subject.

FORM A.

Homesteads under the reclamation act.

Application No. ——.
Water right ———. Project ———.

Act of June 17, 1902 (32 Stat., 388).

DEPARTMENT OF THE INTERIOR,
LAND OFFICE AT ———,
——— ——, *190—*.

I, ——— ———, do hereby apply for a water right under the ——— project, subject to the provisions of the act of Congress approved June 17, 1902 (32

Stat. L., 388), known as the reclamation act, and the rules and regulations established thereunder; the water supplied in pursuance hereof to be used for the irrigation of and to be appurtenant to ——— acres of irrigable land, as shown on plats on file in this office, approved by the Secretary of the Interior, within the area described as follows:

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section ——, township ——, range ——, ——— meridian, an area of ——— acres; the said land having been entered by me under the said reclamation act by homestead application No. —— on the —— day of ———, 190—.

The amount of water to be furnished hereunder shall be ——— acre-feet of water per annum per acre of irrigable land aforesaid, measured at the land; or so much thereof as shall constitute the proportionate share per acre from the water supply actually available for the lands under said project: *Provided*, That the supply furnished shall be limited to the amount of water beneficially used on said irrigable land.

I agree to pay for said water right the sum of $——— per acre for the said area of irrigable land, in ——— annual installments, and to pay promptly when due the annual installments and the maintenance and operating charges duly assessed against said land on account of said water right.

I further agree that upon my failure to comply with the terms of the said reclamation act this application shall be subject to cancellation with the forfeiture of all rights acquired thereunder and of all payments made thereon.

This application must bear the certificate, as hereto attached, of the water users' association under this project, which has entered into contract with the Secretary of the Interior.

If the Secretary of the Interior has made no contract with a water users' association under this project, I agree to file, upon his direction, evidence of membership in the water users' association organized under the said project; in default of which this application shall be subject to cancellation with the forfeiture of all rights acquired thereunder and of all payments made thereon.

And being duly sworn, I further depose and say that I have made no other application, now uncanceled, for a water right under said act of Congress, appurtenant to land now owned or claimed by me except as follows:

Application No. ——, ——— project, ——— of ——— ———, for ———, section ——, township ——, range ——, ——— meridian, an area of ——— acres, and containing ——— acres of irrigable land as determined by the Secretary of the Interior; and that the present application is made in my own behalf and not at the instance or for the benefit of any other person or any association or corporation, either directly or indirectly.

———, *Applicant.*

STATE OF ———, *County of* ———, *ss:*

Subscribed and sworn to before me this —— day of ———, 190—.

My commission expires ——— ———, 190—.

——— ———,

——— ———.

[This affidavit may be sworn to before any officer authorized to administer an oath.]

If the Secretary of the Interior has entered into a contract with a water users' association under the project, the following certificate must be filled out:

——— ——, *190—.*

I hereby certify that the applicant for this water right has duly subscribed for the stock of this association, for the lands described herein, and that all assessments levied against said stock by this association have been fully paid up to date.

[CORPORATE SEAL.] ——— ———,

Secretary of the ——— Water Users' Association.

FORM B.

Lands in private ownership.

Application No. ——.
Water right ———. Project ———.

Act of June 17, 1902 (32 Stat. L., 388).

DEPARTMENT OF THE INTERIOR,
LAND OFFICE AT ———,
——— ——, *190—.*

I, ——— ———, do hereby apply for a water right under the ——— project, subject to the provisions of the act of Congress approved June 17, 1902 (32 Stat. L., 388), known as the reclamation act, and the rules and regulations established thereunder, the water supplied in pursuance hereof to be used for the irrigation of, and to be appurtenant to, ——— acres of irrigable land, as shown on plats on file in this office approved by the Secretary of the Interior, within the area described as follows:

---

section ——, township ——, range ——, ——— meridian, an area of ——— acres.

The amount of water to be furnished hereunder shall be ——— acre-feet of water per annum per acre of irrigable land, as aforesaid, measured at the land; or so much thereof as shall constitute the proportionate share per acre from the water supply actually available for the lands under said project: *Provided,* That the supply furnished shall be limited to the amount of water beneficially used on said irrigable land.

I agree to pay for said water right the sum of $——— per acre for the said area of irrigable land, in —— annual installments, and to pay promptly when due the annual installments and the maintenance and operating charges duly assessed against said land on account of said water right.

I further agree that upon my failure to comply with the terms of said reclamation act this application shall be subject to cancellation with the forfeiture of all rights acquired thereunder and all payments made thereon.

This application must bear the certificate, as hereto attached, of the water users' association under this project, which has entered into contract with the Secretary of the Interior.

If the Secretary of the Interior has made no contract with a water users' association under this project, I agree to file, upon his direction, evidence of membership in the water users' association organized under the said project; in default of which this application shall be subject to cancellation with the forfeiture of all rights acquired thereunder and of all payments made thereon.

And, being duly sworn, I further depose and say that my post-office address is ———; that I am a bona fide resident upon said land (or an occupant thereof, residing in the neighborhood, namely, upon section ——, township ——, range ——, ——— meridian, a distance in a direct line of —— miles therefrom); that I hold the following interest in the said tract:

———————————————————————————————

———————————————————————————————

———————————————————————————————

———————————————————————————————

as duly shown upon the records of ——— County, ———; that I have made no other application, now uncanceled, for a water right under said act of Congress, appurtenant to land now owned or claimed by me except as follows: Application No. ——, ——— project, ——— of ———, for ——— section ——, township ——, range ——, ——— meridian, an area of ——— acres and containing ——— acres of irrigable land as determined by the Secretary of the Interior; and that the present application is made in my own behalf and not at the instance or for the benefit of any other person or any association or corporation, either directly or indirectly.

It is further understood and agreed that the evidence of ownership of this water right shall not be issued by the United States unless fee-simple title to said land is vested in me at the time when the final payment hereon is due, in default of which this application shall be subject to cancellation with the forfeiture of all rights thereunder and of all moneys paid thereon.

——— ———, *Applicant.*

STATE OF ———, *County of* ———, *ss:*

Subscribed and sworn to before me this —— day of ———, 190—.

[SEAL.] ——— ———,

——— ———.

(My commission expires ———.)

[This affidavit may be sworn to before any officer authorized to administer an oath.]

If the Secretary of the Interior has entered into a contract with a water users' association under the project, the following certificate must be filled out:

——— ———, *190—.*

I hereby certify that the applicant for this water right has duly subscribed for the stock of this association for the lands described herein, and that all assessments levied against said stock by this association have been fully paid up to date.

[CORPORATE SEAL.] ——— ———

Secretary of ——— Water Users' Association.

CIRCULARS.

From time to time, as regulations are promulgated or decisions rendered affecting the conduct of work under the reclamation act, circulars embodying the information are prepared in the office of the chief engineer and sent out to the various men in the field.

It is important that these circulars be carefully read and preserved for reference. A separate book should be kept for the purpose by engineers, and the circulars should, after reading, be pasted therein, and a subject index made and kept up to date.

In the following pages the substance of recent circulars of importance is repeated for convenience of reference and in order that the information may be thus brought to the attention of new employees.

RAILROAD TRANSPORTATION RATES.

The act of Congress of March 3, 1905 (Public, No. 192), provides that any moneys refunded in connection with the operations under the reclamation act shall be covered into the reclamation fund; therefore any refund of freight rates that may be obtained will reduce the cost of construction and promote the development and settlement of the lands under the projects.

It has therefore been possible to enter into contracts with a number of railroad companies providing for the transportation at reduced rates of machinery, materials, and supplies used on the projects. The form of construction contract now in use by the Reclamation Service provides that contractors shall afford to the engineer opportunity to obtain copies of the expense bills on all machinery, materials, and supplies shipped to or from the project for use in connection with the work. These expense bills are transmitted to the railroad company by the engineer in charge of the project, and the railroad company pays to the engineer, by check drawn to the order of the Secretary of the Interior, the difference between the amount paid by the contractor and the charges at the rate contracted for between the railroad company and the United States.

The contracts do not cover transportation of provisions, clothing, or supplies for laborers or others engaged on the work, nor articles produced or carried in stock in the local market.

Question having arisen as to whether the provisions of the interstate-commerce law, which forbid common carriers to grant concessions from their published rates, affect certain agreements between the United States and various railroad companies in which the latter promise to transport, at one-half their published rates, materials and machinery required by the United States or by parties contracting with the United States, for use upon the irrigation systems under construction in the arid West, the opinion of the Attorney-General was requested, and the following is quoted from his letter of April 20, 1905, upon the subject:

It is perfectly plain, I think, that the intention of section 22 of the act to regulate commerce was to give express sanction to any arrangements between the United States, State, or municipal governments, and railroad companies by which those governments might relieve themselves of the cost of transportation in whatever form it might assume, and the section should be construed to give effect to that intention. It is, therefore, immaterial whether the property transported belonged to the United States at the time of shipment or whether it have subsequently become the property of the United States in the particular shape in which it was shipped. It is sufficient that it entered into the construction of a public work of the United States, and that the cost of its transportation was a part of the final cost of that work to the United States.

The issue, then, narrows down to this: Does the United States, in point of fact, receive in the end the whole of the concession in freights granted under these contracts?

It can not, of course, be stated in advance, as a presumption of fact covering all cases which may arise under this arrangement, that the United States will receive the whole of the concession and the contractor none, for that would be to presume not only that the contractor's bid will be less than it would have been if he had had to pay the published rates, but that it will be less by an amount equal to the freight reductions allowed him. On the other hand, however, it certainly can not be presumed that under no circumstances will the United States receive the whole concession; that is to say, that in no case will the contractor make full allowance in his bid for the reduced freight rates. The strong probability is that he will not leave any advantage from that source in the hands of his competitors. In other words, then, whether or not the United States receives the whole of the concession and the contractor none is a question of fact which must be decided in each case especially, as the answer may differ in different cases. My conclusion upon the questions you propound, therefore, is this: That in those cases where the fact is that the United States receives the whole of the concession and the contractor none, then neither the spirit nor the letter of the act to regulate commerce has been violated, but that in those cases, if any, where that is not the fact the operation of the agreements which have been drawn in question would result in the violation of section 2 of the act. Being a question of fact, and one that, if it shall ever properly arise it must arise in the administration of your Department, your determination of the question will be binding so far as the executive branch of the Government is concerned.

TRANSPORTATION AGENT.

It is desired that all matters relating to transportation and the handling of bills of lading be referred to F. H. Cass, transportation agent, 876–877 Federal building, Chicago, Ill.

When possible, the transportation agent will be required to attend personally to all shipments of freight, especially material purchased f. o. b. at any point on the Missouri River or east thereof. Engineers making purchases in this territory should furnish Mr. Cass with copy of orders and such memoranda as will enable him to properly prepare the bills of lading and to ship in accordance with the wishes and needs of the engineer. When it is not possible for this business to be attended to from the Chicago office, the engineer should furnish the transportation agent with memoranda of the shipping orders when they are placed, so the shipments may be expedited.

LAND AND LEGAL MATTERS.

Engineers in charge of projects should keep the chief engineer advised of all work relating to land or legal matters which may be necessary. They should give notice as long in advance as possible concerning assistance required in work of this character, in order that men regularly in the service may be detailed, or that instructions may be given for the employment of field assistants. Detailed instructions concerning this phase of the work will be found on pages 96 to 104 of Water-Supply Paper No. 93. Later instructions modifying part of the procedure there outlined are printed in the late edition of "Blank for report on negotiations for purchase of lands," Form 9–281, and are as follows:

PURCHASES OF LANDS.

The proper method of procedure in making purchases of lands under the reclamation act, in pursuance of the various rulings made by the Department of the Interior and the Department of Justice, is substantially as stated below. In some cases, however, deviations may be necessary in certain details.

1. As soon as possible after it has been ascertained that the property will be required, the engineer in charge should forward to the office of the chief engineer the following papers:

(*a*) Form 9–276, contract of sale, or memorandum of terms of proposed purchase.

(*b*) Form 9–281, report on land agreement.

(*c*) Certificate that the land is necessary for the purposes authorized by the reclamation act and that the price agreed upon is reasonable, together with a recommendation that the purchase be made. This certificate should also contain other available information relative to the purchase not given in Form 9–281.

These papers will be submitted to the Secretary of the Interior for approval, as to the price and terms of purchase.

2. When the agreement to sell has been approved by the Secretary, the engineer will notify the vendor thereof that he should, pursuant to said agreement, procure and have recorded, where proper for record, any assurances of title and affidavits which may be necessary and proper to show clear, unincumbered title in him. This will fix the date from which time may be counted in favor of the United States for extension of the option as provided in the agreement, in case it be found necessary to do so. An abstract of the title should be procured, together with proper certificates as to the status of the records concerning lands, judgments, and taxes. The abstract, certificates, and form of deed which it is proposed to execute, referred to in next paragraph, should be submitted to the United States attorney for the district, after the engineer has

received notice that instructions have been issued to the former by the Attorney-General to examine and report on the subject of titles. These instructions will be requested by this office after the receipt of information from the engineer that the purchase of lands has become necessary.

3. The ordinary form of warranty deed or its equivalent in general use will be acceptable to the Department, only one material change being required, viz, the insertion of the italicized words in the clause to the following effect usually found in such deeds: "for and in consideration of ——— dollars to him in hand paid *in pursuance of the provisions of the act of June 17, 1902 (32 Stat. L., 388)*, by the said party of the second part," etc. The grantee or second party must be the United States, and the words "heirs, executors, administrators, successors," etc., when referring to the second party, should be stricken out, and the sentence should read "the party of the second part and its assigns." One copy of the proposed form of deed should be transmitted with the abstract to the United States attorney, and one copy should be retained by the engineer, to be executed by the vendor when the purchase is authorized by the Secretary of the Interior. A quitclaim deed will be acceptable in case title in fee is not vested in the vendor.

4. The United States attorney will forward the abstract and form of deed to the assistant attorney-general for the Interior Department, with his opinion thereon, in accordance with instructions from the Attorney-General.

5. The engineer in charge will notify the chief engineer as soon as the abstract and form of deed have been forwarded to the assistant attorney-general, and will state, if possible, the tenor of the report made by the United States attorney.

6. The assistant attorney-general will render an opinion upon the title, and upon approval thereof by the Secretary of the Interior the purchase will be authorized, if the title is found satisfactory. In case the title is found to be imperfect, the papers will be returned for the necessary corrections, and the abstract should then be brought up to date and again submitted for reexamination.

7. Upon notice of authorization, the payment can be made by a local disbursing officer, if one is available, taking vouchers in the usual way. In other cases payment will be made through the Treasury Department, for which purpose there should be forwarded to the Washington office the executed deed, duly recorded, and certificates that nothing has been placed on record adversely affecting the title as to conveyance, judgments, or taxes since the date of the abstract; in other words, the abstract should be brought up to the date of the record of the deed to the United States. No voucher is needed if payment is made through the Treasury Department. The described certificates and the recorded deed must be transmitted with the local disbursing officer's accounts if the payment is made by him.

8. In the case of the desert-land entry, when the Secretary has approved the purchase of the possessory rights of an entryman, the certificate of the recorder of land titles in the county where the land is situated should be obtained, showing that he has searched the records of his office, and stating whether any instrument of conveyance, assignment, or mortgage of the right obtained by the entry referred to there appears.

9. In the case of land covered by a homestead of desert-land entry a relinquishment to the United States is sufficient, and a certificate should be obtained from the register and receiver of the local land office, showing that the entry was valid and subsisting at the time of the relinquishment, and that it has been relinquished and canceled on the records of the land office.

10. In the public-land States improvements by entrymen are generally regarded as personal property, subject to taxation, and before paying for land

to be acquired by relinquishment, the certificate of the officer having charge of the tax records in the county should be obtained showing the condition of the property in respect to levy and payment of taxes for the years since the entry.

11. This form (9–281) may be used as far as it is applicable in making a report of negotiations not concluded, all necessary additional information being given under heading No. 6, when for any reason it is advisable that the matter be further considered by the engineer in charge before final agreement. In this case it should be noted conspicuously on the first page and in the brief on back that it is a report of pending negotiations.

12. The person engaged in right-of-way negotiations or in negotiations for the purchase of lands will make monthly reports to the engineer in charge of the particular project, to be forwarded to the chief engineer at Washington, D. C.

13. An agreement of sale may be made with any person owning the land in his own right, or with a trustee under a power in a deed, or with a person holding a power of attorney from the owner authorizing him to do so, or with an executor under power in a will. Certified copy of the evidence of authority must accompany the papers.

14. The husband and wife must join in the agreement except where the local land laws or the conditions under which the property is held do not require it. It is better, however, to obtain in every case the signatures of both husband and wife. The agreement must state whether the vendor is married or single, a widow or widower.

15. An administrator or an executor without a power to sell in the will has no authority to make a contract for the sale or conveyance of land or of a right of way thereon. In case of the death of the owner without a will, the real estate descends to the heirs; if he dies leaving a will, the real estate goes to the devisees, subject in both cases to the payment of debts of the decedent. The heirs or devisees must all join in the agreement.

16. Neither the guardian of a minor nor the guardian of an insane person has a right to contract to sell or convey the real estate of his ward without special authority from the proper court.

17. Before negotiations for the purchase of any tract are begun it is important to learn whether the land has been offered for sale, and at what time and price; also what price the present owner paid for the land.

18. Special conditions and limitations may be added, when necessary, to the printed forms of contract in reference to possession of premises, growing of crops, etc., pending final conveyance, but these conditions should be avoided as far as possible, and the time limit of the contract should be fixed with reference to these matters. Ample time should be given in the contract for the preparation of an abstract of title and for consideration of the same by the officials at Washington, D. C.

19. For a general discussion of this subject, see pages 96 to 100 of Water-Supply Paper No. 93.

PURCHASE OF POSSESSORY CLAIMS ON PUBLIC LANDS.

Attention is called to the following quotation from a letter of the Secretary of the Interior, dated January 25, 1905, regarding settlement or possessory rights of parties who have made entries or filings under the public-land laws:

> As the legal and equitable title is in the United States to all public lands to which a mere inchoate right has attached, there is no outstanding legal or equitable title in such lands to purchase; but the improvements of the settlers

made upon such lands under authority of the public-land laws are a property right which can not be taken without compensation, which probably may include the enhanced value of the land by reason of the settler's cultivation and improvement.

The legal title passes from the United States only upon the issuance of patent; but an entryman, if he has complied with the law, acquires by his final certificate an equitable right, which is the equivalent of a patent so far as it affects his rights and interest. Such title or right can not be divested and acquired by the United States under the act of June 17, 1902 (32 Stat. L., 388), except by purchase or by condemnation in the manner provided by law. The effect of this ruling is that to acquire any rights asserted under the public-land laws, prior to the issuance of final certificate, it is necessary to pay only for the improvements—which probably may include the enhanced value of the land due to the claimant's cultivation and improvement—as there is no outstanding title to the land to be acquired.

RIGHTS OF WAY FOR CANALS AND DITCHES.

Engineers and others authorized to acquire rights of way for canals and ditches under the reclamation act should proceed as follows:

1. They should examine the lands and prepare a general map showing the position of the canals with reference to the land lines.
2. They should ascertain the essential facts as to ownership.
3. Owners of lands entered subsequent to October 2, 1888, should be served with notice (Form 9-263) in accordance with instructions on page 101, Water-Supply Paper No. 93, which should be carefully followed. In such cases no agreement or abstract of title is required. Where the lands are needed for other purposes than for canal or ditch right of way, they must be purchased or donated.
4. Where lands were entered prior to October 2, 1888, the owner or his representative should be seen and a fair and reasonable price agreed upon, or, if possible, a free grant should be obtained.
5. In cases under paragraph 4, Form 9-276 should be used. Where no payments are to be made, Form 9-277 should be used.
6. In all cases Form 9-281 should be filled out and should accompany Forms 9-276 and 9-277. The report should state all the facts, in order that the details of the purchase or agreement may be fully understood by the chief engineer.
7. When the purchase is decided upon, an abstract of title must be secured. An abstract must also be obtained when the land is donated, because the risk of construction can not be undertaken without the assurance that the consent of the actual owner and all parties interested has been secured. Abstracts may be paid for by the Reclamation Service when they are to be used in connection with purchases,

but not when they are to be used in connection with condemnation. Appropriate arrangements may be made with the vendor as to furnishing abstract of title, either by him or by the Government.

8. Form of deed which the vendor proposes to execute should be submitted.

9. In proceedings under paragraphs 7 and 8 the printed instructions given in Form 9-281 (see p. 218) should be followed.

10. The agreement and report must be accompanied by a certificate from the district engineer as to the necessity of the right of way and the reasonableness of the price, and must contain a definite recommendation as to the purchase.

APPROPRIATION OF WATER.

On page 103 of Water-Supply and Irrigation Paper No. 93 directions are given for the proper filing of notices of appropriation of water. Engineers are therein advised—

> to submit a copy to the United States district attorney, calling his attention to the instructions of the Attorney-General, dated September 14, 1903, providing for giving advice to the engineers of the Reclamation Service concerning the preparation of such notices, and requesting any suggestion which he may have to offer in regard to the form submitted.

It has been found necessary to caution engineers to follow this advice.

In several of the reclamation States laws were enacted in 1905 granting special privileges to the United States when appropriating water for the purpose of carrying out the provisions of the reclamation act. These, together with the statutory law governing appropriations in the other reclamation States, are summarized below.

It is important to follow strictly the provisions of law and the local regulations in filing notices of appropriation.

In the States where special laws have been enacted to govern appropriations by the United States the specific language of the law should be utilized and followed in giving the required notices.

The work required under the various statutes after filing notices differs under the various laws, and it is essential that the requirements in each case shall be followed as closely as possible.

Nothing will be gained by filing these notices unless their form and the subsequent proceedings comply with the provisions of the law, and, accordingly, these matters must be so ordered as to conform to the law and the regulations in all particulars so far as it is possible under the operations of the reclamation act.

In Arizona a notice [a] of the proposed appropriation must be posted at the place of intended diversion. A copy of the notice must be

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[a] Water-Sup. and Irr. Paper U. S. Geol. Survey No. 93, 1904, p. 103.

filed for record in the office of the recorder of the county or counties in which the diversion and other works are situated, and a copy of the notice must also be filed in the office of the secretary of the Territory. The works must be constructed within a reasonable time after posting and filing the notice.

In California a notice [a] of the proposed appropriation must be posted at the point of intended diversion, and a copy must be recorded in the office of the recorder of the county in which it is posted within ten days. Work must be begun within sixty days and prosecuted diligently and uninterruptedly to completion.

In Colorado, within sixty days after commencing construction, statements and maps in duplicate must be filed with the State engineer for his approval. After approval by the State engineer the claimant must file duplicate map and statement thus approved in the office of the county clerk and recorder of the county in which the headgate of the canal or the reservoir is situated. Blank forms for this statement and directions for preparing maps can be obtained upon application to the State engineer. Engineers are requested to keep copies of such forms and directions on file in their office and to follow them carefully in making an appropriation of water.

In Idaho an application must be made to the State engineer for permission to make an appropriation. Engineers are requested to keep on file in their office copies of printed forms and directions furnished by the State engineer, and are cautioned to abide by all the rules and regulations of the State engineer's office in making an appropriation.

In Kansas a notice [a] of the proposed appropriation must be posted at the point of intended diversion, and within ten days thereafter a copy of the same must be posted in a conspicuous place in the office of the county clerk of the county in which the diversion is situated and be recorded by the county clerk. Work must commence within sixty days and be prosecuted diligently.

In Montana a notice [a] of the proposed appropriation must be posted at the point of intended diversion, and a verified copy must be filed within twenty days with the county clerk of the county in which the diversion is made.

By an act of the Montana legislature approved February 27, 1905, all appropriations made in behalf of the United States by persons duly authorized by the Secretary of the Interior shall be held valid for the period of three years after the filing of the notice as above described, and no part of the waters designated in the notice shall be subject to other appropriation for three years unless a notice of abandonment of the irrigation project is filed under authority from

[a] Op. cit., p. 103.

the Secretary of the Interior with the county clerk and recorder of the county in which the original notice was filed.

In Nevada the same procedure must be followed as in Idaho.

In New Mexico, by an act approved March 16, 1905, it is provided that whenever the proper officer of the United States shall notify the State engineer that the United States intends to utilize certain specified waters, such waters shall not be subject to further appropriations, except in so far as formally released in writing by a duly authorized officer of the United States.

In North Dakota, by an act approved March 1, 1905, it is provided that whenever the proper officer of the United States shall notify the State engineer that the United States intends to utilize certain specified waters, such waters shall not be subject to other appropriation for a period of three years from the date of said notice, except in so far as formally released in writing by the proper officer of the United States. Before the expiration of the three-year period plans of the proposed work must be filed in the office of the State engineer.

In Oklahoma the statutory provisions covering this subject are the same as those in North Dakota, stated above.

In Oregon, whenever the proper officer of the United States shall file in the office of the State engineer a written notice that the United States intends to utilize certain specified waters, such waters shall not be subject to further appropriation for a period of three years from the date of filing such notice, within which time final plans of the proposed works must be filed with the State engineer. Construction must be authorized by the United States within four years of the date of the original notice. No part of the waters so appropriated shall be subject to other appropriation within the period stated above, unless formally released in writing by a duly authorized officer of the United States, which release shall be filed in the office of the State engineer.

In South Dakota the statutory provisions covering this subject are the same as those in North Dakota, stated above.

In Utah the same procedure must be followed as in Idaho.

In Washington, by an act approved March 4, 1905, it is provided that whenever a duly authorized officer of the United States shall notify the commissioner of public lands that the United States intends to make examinations or surveys for the utilization of certain specified waters, the waters so described shall not be subject to other appropriation for a period of one year from the date of receipt of such notice by the commissioner of public lands, unless formally released in writing by a duly authorized officer of the United States. If, before the expiration of the one-year period, a duly authorized officer of the United States shall certify in writing to the commissioner of public lands that the project contemplated in such notice appears to be feasible and that the investigation will be made in detail, the waters specified in such notice shall not be subject to other appropriation for the further period of three years following the date of receipt of such certificate, and such further time as the commissioner of public lands may grant upon application of a duly authorized officer of the United States and notice thereof first published once a week for four consecutive weeks in a newspaper published in each county in which the works are to be constructed.

In Wyoming the same procedure must be followed as in Idaho.

INFORMATION CONCERNING LANDS UNDER RECLAMATION PROJECTS.

The following is a copy of a letter from the Secretary of the Interior, dated March 3, 1905, addressed to the Director of the Geological Survey, relative to the establishment of bureaus where information may be had concerning public lands subject to disposal under the provisions of the reclamation act:

On the 10th ultimo you reported to the Department on a letter of January 26, 1905, from George H. Maxwell, who urged the establishment of bureaus of information in connection with irrigation projects, to answer inquiries relative to the location of lands subject to disposal to actual settlers under the provisions of the reclamation act of June 17, 1902 (32 Stat. L., 388).

Your report has been duly considered and in a letter of even date to the Commissioner of the General Land Office I have directed him to instruct the registers and receivers of the several land districts in which the projects are located to give full information relative to public lands included in the projects and subject to disposal under the act mentioned to all parties making inquiry with a view to actual settlement and to keep the engineers of the Reclamation Service fully informed by correspondence of the conditions pertaining to such lands.

In view of the fact that the work of construction of several of the projects under the act is well advanced I direct that you instruct the engineers of the Reclamation Service in charge of the various projects to keep the registers and receivers of the land districts in which the projects are located fully informed by correspondence respecting the condition and progress of the work of construction and to inform inquirers that, without cost, full and reliable information respecting the public lands to be disposed of under the act may be obtained from the register and receiver of the land district in which the lands are located.

You are also directed to authorize the chief engineer of the Reclamation Service to announce with each project that information concerning lands to be irrigated thereunder will be given officially by the register and receiver of the land district on request therefor addressed to them at the proper time.

By this cooperation of the officers of the Reclamation Service and the registers and receivers of the local land offices it is believed that all persons desiring to make entries of lands to be irrigated will be enabled to secure all necessary information respecting such lands.

CONTRACTORS' BONDS.

The Secretary of the Interior, in letter dated April 26, 1905, states that—

Every corporation authorized to transact business as sole surety under the terms of the act of August 13, 1894, is required to file in the office of the Secretary of the Interior the following papers:

(1) Evidence that it has obtained authority from the Attorney-General under the act above mentioned to act as sole surety on bonds in matters affecting the United States.

(2) Evidence of the election of general officers of the company for each year, with their names.

(3) Names of the persons in the several judicial districts of the United States authorized to accept service of process on behalf of the company.

(4) Names of the parties, however designated, authorized to execute bonds for and on behalf of the corporation in places other than its home office.

(5) A copy of its quarterly financial statement as filed in the Department of Justice.

In cases where surety companies have already filed with the Department the evidence and statements above mentioned, duplicates need not be furnished, but in lieu thereof a certificate may be appended to the bond stating that the papers are on file in the office of the Secretary of the Interior.

LIABILITY TO SUBCONTRACTORS.

The question of withholding final payment due under a contract in connection with the Truckee-Carson project, in Nevada, by reason of a claim preferred by a subcontractor for supplies and labor furnished, was the subject of an opinion rendered by the assistant attorney-general for the Department of the Interior, dated February 6, 1905, and approved by the Secretary the same day, wherein it was held that a mechanic's lien would not attach in favor of the subcontractor on work completed under the contract; that the Government incurred no liability by paying to the contractor the balance due under his contract; and that there is no obligation on the part of the Government to aid in the collection of such claims other than as provided by the act of August 13, 1894 (28 Stat. L., 278).

The said act provides that the bond required of parties entering into contracts with the United States in the prosecution of public works shall contain an additional obligation to make prompt payment to all persons furnishing supplies and labor in the conduct of the work, and that such persons may bring suit in the name of the United States, for their benefit, against the contractor and sureties, and prosecute the same to final judgment.

The opinion cited rulings of the United States Supreme Court to the effect that the United States can not be subjected to legal proceedings at law or in equity without its consent, and then only within the authority granted by some act of Congress; and that such exemption extended to the property of the United States, there being no distinction between suits against the Government directly and against its property.

EXTENSION OF TIME ON CONTRACTS.

The following is a copy of a letter to this office from the Secretary of the Interior, dated April 1, 1905, which is self-explanatory:

> With respect to existing and future contracts in connection with reclamation projects under the act of June 17, 1902 (32 Stat. L., 388), I direct that you instruct the engineers in charge of the various projects that whenever it becomes evident that the work covered by a contract can not be completed within the time fixed therein, they notify the contractor that any application for extension of time must be accompanied by the formal consent of the sureties thereto and lodged with the Department in ample time for the allowance of the application, if such action may be determined on, prior to the expiration of the contract.

PAYMENTS FOR EXTRA WORK.

Vouchers for extra work should be prepared and the items entered thereon in the following form:

EXTRA WORK.

Labor and materials as per attached itemized statement:

Actual cost of labor and materials	$——
Fifteen per cent added, as per paragraph —— of contract	——

To the voucher should be attached two papers:

(1) Itemized statement of labor and materials, with engineer's certificate as follows:

> I hereby certify that the above statement of cost of labor and materials is correct, and that the said extra work was performed in accordance with my instructions of ———, and that the same has been satisfactorily performed.

(2) Copy of letter to contractor authorizing the extra work.

In case the contract makes no provision for the added 15 per cent, or makes it necessary to insert other items, the voucher should be modified accordingly.

RENT OF OFFICES.

The Comptroller of the Treasury having held that no payments for rent should be made unless based upon a formal lease, forms of lease for office buildings for the Reclamation Service have been prepared, differing only in regard to the lessor, the forms being applicable, severally, to the cases of an individual, a firm, and a corporate lessor. Copies of these forms may be obtained on application to the chief engineer.

Each engineer of the Reclamation Service in charge of an office is authorized by the Director of the Geological Survey to sign such a lease, subject to the approval of the Secretary of the Interior.

PURCHASE OF ARMY STORES.

By authority granted by the Secretary of War, April 27, 1905, chiefs of parties are permitted to purchase commissary stores and quartermaster supplies, including officers' supplies, for official, camp, and for personal use, at any of the garrisoned posts enumerated below, provided such stores can, in the opinion of the commanding officers, be spared. Cash is to be paid for both classes of supplies in order that the proceeds received by the post commanders from such sales may be returned and again expended by the War Department for additional purchases during the same fiscal year. The price of quartermaster supplies will be contract price plus 10 per cent. The price of commissary stores will be contract price plus 10 per cent to cover waste in transit and an additional amount to cover cost of transportation. Party chiefs applying for such stores at garrisoned posts will show cards of identification, signed by the Secretary of the Interior and countersigned by the Director of the Geological Survey.

Quartermaster stores include practically all articles used in camp and personal equipment, such as tents, harness, vehicles, shovels, axes, cots, blankets, leggings, gloves, cutlery, tableware, forage, etc. Commissary stores include all varieties of subsistence supplies and such toilet articles as towels, soap, etc.

The following garrisoned posts are most accessible:

Adams, Fort, Newport, R. I.
Allegheny Arsenal, Pittsburg, Pa.
Apache, Fort, Arizona.
Assinniboine, Fort, Mont.
Barrancas, Fort, Fla.
Bayard, Fort, N. Mex.
Bliss, Fort, El Paso, Tex.
Boise Barracks, Boise, Idaho.
Brady, Fort, Sault Ste. Marie, Mich.
Brown, Fort, Brownsville, Tex.
Casey, Fort, Port Townsend, Wash.
Caswell, Fort, Southport, N. C.
Clark, Fort, Brackett, Tex.
Columbus Barracks, Columbus, Ohio.
Crook, Fort, Nebr.
D. A. Russell, Fort, Wyo.
Davis, Fort, Nome, Alaska.
Des Moines, Fort, Des Moines, Iowa.
Douglas, Fort, Utah.
Duchesne, Fort, Utah.
Du Pont, Fort, Delaware City, Del.
Egbert, Fort, Eagle, Alaska.
Ethan Allen, Fort, Vt.
Gibbon, Fort, Tanana, Alaska.
Grant, Fort, Ariz.
Hamilton, Fort, N. Y.
Harrison, Fort, Mont.
Hot Springs, U. S. Gen. Hosp., Ark.
Huachuca, Fort, Ariz.
Jackson Barracks, New Orleans, La.
Jay, Fort, New York City.
Jefferson Barracks, St. Louis, Mo.
Keogh, Fort, Mont.
Lawton, Fort, Interbay, Wash.
Leavenworth, Fort, Kans.
Lincoln, Fort, Bismarck, N. Dak.
Liscum, Fort, Alaska.
Logan, Fort, Colo.
Mackenzie, Fort, Sheridan, Wyo.
Madison Barracks, Sackett Harbor, N. Y.
Mason, Fort, San Francisco, Cal.

McHenry, Fort, Baltimore, Md.
McIntosh, Fort, Laredo, Tex.
McKinley, Fort, Portland, Me.
McPherson, Fort, Ga.
Meade, Fort, S. Dak.
Missoula, Fort, Mont.
Monroe, Fort, Va.
Morgan, Fort, Mobile, Ala.
Moultrie, Fort, Moultrieville, S. C.
Myer, Fort, Va.
Niobrara, Fort, Nebr.
Oglethorpe, Fort, Dodge, Ga.
Plattsburg Barracks, Plattsburg, N. Y.
Porter, Fort, Buffalo, N. Y.
Presidio of Monterey, Cal.
Presidio of San Francisco, Cal.
Reno, Fort, Okla.
Riley, Fort, Kans.
Robinson, Fort, Nebr.
Rosecrans, Fort, San Diego, Cal.
Sam Houston, Fort, Tex.
Sheridan, Fort, Ill.
Sill, Fort, Okla.
Snelling, Fort, Minn.
Stevens, Fort, Oreg.
St. Michael, Fort, Alaska.
Thomas, Fort, Newport, Ky.
Vancouver Barracks, Wash.
Walla Walla, Fort, Wash.
Washakie, Fort, Wyo.
Washington Barracks, D. C.
Wayne, Fort, Detroit, Mich.
Whipple Barracks, Prescott, Ariz.
W. H. Seward, Fort, Haines Mission, Alaska.
Wingate, Fort, N. Mex.
Yellowstone, Fort, Mammoth Hot Springs, Wyo.
Wright, Fort, Spokane, Wash.

REPORTS ON OPENING OF BIDS.

In order to secure uniformity and completeness in the reports of boards of engineers designated to open bids for work or materials in connection with reclamation projects, the following suggestions should be adhered to as closely as possible:

The report should be in duplicate and should include a statement that the bids were opened at a certain time and place (being the time and place mentioned in the advertisement), and that all the bids then received are transmitted with the report.

All the papers received with the proposals should be transmitted to the chief engineer, including the envelopes in which the bids were received.

On the outside of each envelope should be indorsed the amount of the certified checks submitted by the bidder, and the number, if more than one.

The report should also be accompanied by an abstract, in duplicate, of all the proposals received. The names of the bidders and the information given concerning each bid should be entered on this abstract in the order of the amounts of the bids—the lowest first, then the second lowest, and so on.

The report should also contain a specific recommendation as to the award of the contract, and if deemed advisable to let the contract to the next lowest bidder in case the lowest fails to qualify, an alternative recommendation should be made.

If recommendation is made that the contract be awarded to any other than the lowest bidder, the reason for such recommendation should be stated.

The report should be in such form that it can be submitted to the Secretary with the Director's letter of recommendation in regard to action to be taken, if deemed advisable.

It is desirable that the board prepare extra copies of the abstracts of the bids and forward them to the technical papers which published the advertisements and which make a practice of printing abstracts of bids, unless there is some reason for temporarily withholding the information. The chief engineer should be informed of the names of any publications to which this information is sent.

All bids withdrawn in the manner contemplated by the specifications and all bids not received within the time and at the place advertised should be promptly returned by the board unopened.

Water-Supply and Irrigation Paper No. 93, pages 71–82, contains regulations of the Indian Office concerning the opening of bids, which should be of assistance to the boards of engineers in preparing their reports.

STANDARD PROGRESS REPORT COLORS.

In the preparation of progress maps and diagrams, Winsor-Newton water colors, according to the following table, are the standard progress colors for the Reclamation Service, and should be used:

Colors for progress drawings, by months.

Months.	Colors.
January	Sepia.
February	Vermilion.
March	Prussian blue.
April	Deep chrome.
May	Emerald green.
June	Indigo.
July	Indian red.
August	Sap green.
September	Gamboge.
October	Scarlet lake.
November	New blue.
December	Burnt sienna.

INSTRUCTIONS FOR LEVELING.

STANDARD LEVELING.

Record distance, in feet, for both fore and back sights. Equalize sums of fore and back sights daily.

No sight more than 300 feet in length should be taken, except under unavoidable circumstances.

Fill in fly-leaf blank the first day level book is used, and give date on each page of notes.

For a given H. I., rodman's notes must be at least two lines lower down page than levelman's, and they should not turn over leaf at same time.

Give complete information regarding source from which initial elevation is copied.

Insert sums of fore and back sight, rod readings, and difference between them for each page of notes.

Commence each circuit on a separate page.

A bench mark should be established for each mile run. Standard bench marks (posts or tablets) should not average more than 3 miles apart.

See book of "Instructions" for further details concerning leveling work.

SECONDARY LEVELING.

The plumbing level is dispensed with, and the turning point used only when running over muddy roads or soft ground. The notes are kept in duplicate and in about the same way as for the primary work, except that the lengths of sights are not usually entered and the readings are recorded to hundredths instead of thousandths of a foot. The lengths of sights are not limited and may be as long as can be readily taken.

Benches should be frequently left along the line and should be well placed and well described. Elevations of all points, such as road corners, high and low places, bridges, and water levels should be determined and neatly painted in large white figures, the elevation to the nearest foot only to be used. The outfit for each party consists of 15-inch level and double extension Philadelphia rod, notebook, No. 4 pencils, hatchet, chisel, 50-foot cloth tape, paint can, field glasses, copper nails, and, when necessary, a turning point.

The amount of secondary leveling necessary depends largely on the character of the country. In the rougher sections the valleys should be leveled and along the ridges the lines should be carried until the brow of the hill is reached, when they should be dropped. In gently rolling country it is advisable to follow nearly every road, secondary roads receiving attention as well as others when they are much over a mile apart. In extremely level sections, as in old lake beds, coastal plains, etc., only such lines should be run as will determine contour crossings. By sighting the level to buildings or other objects it can be determined whether there is sufficient rise or fall to warrant carrying the line through.

In marking up elevations for the topographer the number required depends upon the nature of the country; thus, in the rougher regions few are required, while in sections where the ground is gently rolling the elevations should be numerous, and in extremely level sections each contour crossing should be marked. In all cases every road corner passed should be marked and at all good-sized streams both the bridge level and the water level must be painted up.

Every effort should be made to save time. The instrument should be approximately leveled by manipulating the tripod legs, getting ground elevations under the instrument by placing the rod alongside, sighting to the rodman's head, or shoulders, rather than undertaking to set the target by signals, in very long sights, or when the light is poor, and many others that a good levelman will discover. No limit of error is prescribed for this work, the general understanding being that a closure within a fifth of a contour interval is sufficient.

CORRESPONDENCE.

LETTERS.

Brief letters of inquiry are frequently sent to engineers in the field, the answers to which can be given in a few words. It is important to keep down the volume of correspondence and typewriting, and in particular to avoid writing new letters which simply repeat the question and give the answer. Wherever possible, engineers should indorse upon the bottom of the original letter the appropriate reply in a few words and send this back to the Washington office. This can frequently be done with saving of time and energy and reduction of the amount of material to be handled and filed.

When the matter is of such importance that the engineer desires to keep a copy of his statement, this simple method is not advisable, but in the majority of cases the information is not of such a character that a copy need be kept.

TELEGRAMS.

The Washington office frequently receives telegrams which are almost unintelligible and which require a most careful study to determine the probable meaning. Mistakes in interpretation of such telegrams are not rare. To correct the difficulty, all persons sending telegrams should prepare their draft without punctuation or capitalization, and then read this draft carefully to see whether the message as thus written is intelligible or is capable of more than one meaning. All messages are, of course, received without punctuation or capitalization, and frequently the last word of one sentence, when transferred to the beginning of the next, completely alters the sense.

DISMISSALS OF EMPLOYEES BEFORE END OF PROBATIONARY PERIOD.

The following is a copy of a letter from the Secretary of the Interior, dated March 27, 1905, addressed to the Director of the Geological Survey, in regard to the proper course to be pursued in dismissing incompetent persons prior to the expiration of the probationary period of their employment:

Referring to your communication of the 23d instant, subject "Dismissals prior to expiration of probationary period" of employees belonging to field parties in the Reclamation Service, and inclosing with your said communication a copy of a letter addressed to you by the chief engineer, dated the 21st instant, on the same subject, I have to advise you that, after informal conference with the Civil Service Commission, the proper course to pursue in such cases would be to suspend incompetents pending the service of notice on them of charges and final action thereon by the Department. Responsible officers in the field may be given this authority with instructions to report promptly all such cases where suspensions are made for inefficiency.

HOLDING OF OTHER OFFICES FORBIDDEN.

Following are copies of Executive orders dated January 17 and 28, 1873, on the subject of the incumbents of Federal offices holding or accepting offices under State or Territorial governments or under the charter or ordinances of municipal corporations:

Whereas it has been brought to the notice of the President of the United States that many persons holding civil office by appointment from him or otherwise, under the Constitution and laws of the United States, while holding such Federal positions accept offices under the authority of the States and Territories in which they reside, or of municipal corporations, under the charters and ordinances of such corporations, thereby assuming the duties of the State, Territorial, or municipal office at the same time that they are charged with the duties of the civil office held under Federal authority; and

Whereas it is believed that, with few exceptions, the holding of two such offices by the same person is incompatible with a due and faithful discharge of the duties of either office; that it frequently gives rise to great inconvenience and often results in detriment to the public service, and, moreover, is not in harmony with the genius of the Government:

In view of the premises, therefore, the President has deemed it proper thus and hereby to give public notice that from and after the 4th day of March, A. D. 1873 (except as herein specified), persons holding any Federal civil office by appointment under the Constitution and the laws of the United States will be expected, while holding such office, not to accept or hold any office under any State or Territorial government, or under the charter or ordinances of any municipal corporation; and, further, that the acceptance or continued holding of any such State, Territorial, or municipal office, whether elective or by appointment, by any person holding civil office as aforesaid under the Government of the United States other than judicial offices under the Constitution of the United States, will be deemed a vacation of the Federal office held by such person, and will be taken to be, and will be treated as, a resignation by such Federal officer of his commission or appointment in the service of the United States.

The offices of justices of the peace, of notaries public, and of commissioners to take the acknowledgment of deeds, of bail, or to administer oaths shall not be deemed within the purview of this order and are excepted from its operation, and may be held by Federal officers.

The appointment of deputy marshal of the United States may be conferred upon sheriffs or deputy sheriffs. And deputy postmasters, the emoluments of whose office do not exceed $600 per annum, are also excepted from the operations of this order, and may accept and hold appointments under State, Territorial, or municipal authority, provided the same be found not to interfere with the discharge of their duties as postmasters. Heads of Departments and other officers of the Government who have the appointment of subordinate officers are required to take notice of this order, and to see to the enforcement of its provisions and terms within the sphere of their respective Departments or offices, and as relates to the several persons holding appointments under them, respectively.

Inquiries having been made from various quarters as to the application of the Executive order issued on the 17th January, relating to the holding of State or municipal offices by persons holding civil offices under the Federal Government, the President directs the following reply to be made:

It has been asked whether the order prohibits a Federal officer from holding also the office of an alderman or of a common councilman in a city, or of a town councilman of a town or village, or of appointments under city, town, or village governments. By some it has been suggested that there may be distinction made in case the office be with or without salary or compensation. The city or town offices of the description referred to, by whatever names they may be locally known, whether held by election or by appointment, and whether with or without salary or compensation, are of the class which the Executive order intends not to be held by persons holding Federal offices.

It has been asked whether the order prohibits Federal officers from holding positions on boards of education, school committees, public libraries, religious or eleemosynary institutions incorporated or established or sustained by State or municipal authority. Positions and service on such boards or committees, and professorships in colleges, are not regarded as "offices" within the contemplation of the Executive order, but as employments or service in which all good citizens may be engaged without incompatibility, and in many cases without necessary interference with any position which they may hold under the Federal Government. Officers of the Federal Government may, therefore, engage in such service, provided the attention required by such employment does not interfere with the regular and efficient discharge of the duties of their office under the Federal Government. The head of the Department under whom the Federal office is held will, in all cases, be the sole judge whether or not the employment does thus interfere.

The question has also been asked with regard to officers of the State militia. Congress having exercised the power conferred by the Constitution to provide for organizing the militia, which is liable to be called forth to be employed in the service of the United States, and is thus, in some sense, under the control of the General Government, and is, moreover, of the greatest value to the public, the Executive order of 17th January is not considered as prohibiting Federal officers from being officers of the militia in the States and Territories.

It has been asked whether the order prohibits persons holding office under the Federal Government being members of local or municipal fire departments; also, whether it applies to mechanics employed by the day in the armories, arsenals, and navy-yards, etc., of the United States. Unpaid service in local or municipal fire departments is not regarded as an office within the intent of the Executive order, and may be performed by Federal officers, provided it does not interfere with the regular and efficient discharge of the duties of the Federal office, of which the head of the Department under which the office is held will, in each case, be the judge. Employment by the day as mechanics or laborers in the armories, arsenals, navy-yards, etc., does not constitute an office of any kind, and those thus employed are not within the contemplation of the Executive order. Master workmen and others who hold appointments from the Government, or from any Department, whether for a fixed time or at the pleasure of the appointing power, are embraced within the operation of the order.

PRIVATE EMPLOYMENT FORBIDDEN.

Several inquiries have come to the chief engineer regarding the propriety of engineers or assistants of the Reclamation Service doing outside professional work. There are occasionally a few tempting opportunities of this kind where a considerable fee can apparently be earned with small outlay of time. The experience of the past has shown, however, that it is not good administration to permit the engineers to be diverted by outside professional work, and on this point the Secretary of the Interior is very definite. In his report for the year ending June 30, 1904, he says, on page 88:

> The reclamation work must therefore be placed in the hands of men who for years have given the subject their best thought, and these men must be protected from external pressure and guarded from the possibility of selfish consideration. In the organic law of the Geological Survey it is provided that the Director and members shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys for private parties or corporations. This law applies to the Reclamation Service, which has been made a branch of the Geological Survey, and although the law may occasionally work hardship I believe that good administration requires its enforcement.

In the case of several men coming into the Service it was agreed that they should finish up the consulting work on which they had previously been engaged, but it is believed that the interests of the Service require that this work should be brought to a close at the earliest possible date.

FEES FOR OATHS.

Treasury Department Circular No. 57, April 22, 1905, gives the following schedule of fees which notaries public and justices of the peace are authorized by the laws of their respective States and Territories to charge for administering oaths:

When an account or voucher in an account is required by law or regulation to be verified by the oath of an officer or employee of the Government, for the cost of which oath said officer or employee is entitled to be reimbursed, the following list of fees may be allowed, and none other, except in cases where the persons claiming reimbursement shall show that a different fee is prescribed, making specific reference to the statute authorizing the same:

Schedule of fees for oaths.[a]

State.	Notary.	Justice.	State.	Notary.	Justice.
Alabama	$0.50	$0.25	Nebraska	$0.25	$0.25
Arizona	.50	.75	Nevada	.75	.50
Arkansas	.50	.50	New Hampshire	.25	.25
California	.50	.25	New Jersey	.32	.32
Colorado	.25	.25	New Mexico	.50	--------
Connecticut	.10	.10	New York	.12	.10
Delaware	.50	.25	North Carolina	.50	.10
District of Columbia	.50	--------	North Dakota	.35	.35
Florida	.50	.16	Ohio	.40	.40
Georgia	.50	.30	Oklahoma	.25	.35
Idaho	.25	.15	Oregon	1.00	.25
Illinois	.25	.35	Pennsylvania[b]	.25	.25
Indiana	.50	.30	Rhode Island	.50	.50
Iowa	.25	.25	South Carolina	.50	.30
Kansas	.25	.20	South Dakota	.35	.35
Kentucky	.20	.20	Tennessee	.50	.20
Louisiana	.75	.25	Texas	.25	.25
Maine	.20	.25	Utah	.50	.50
Maryland	.62½	.30	Vermont	.25	--------
Massachusetts	.25	.25	Virginia	.50	.50
Minnesota	.25	.15	Washington	.50	.25
Michigan	.25	.25	West Virginia	.25	.20
Mississippi	.50	.25	Wisconsin	.25	.25
Missouri	.50	.20	Wyoming	.50	.25
Montana	.50	.50			

[a] This schedule supersedes that at pages 32 and 33 of the "Instructions, United States Geological Survey, May 1, 1903."

[b] Except notary fees in Allegheny County, $1; city of Philadelphia, $0.37½; counties of Blair, Center, Lycoming, Montour, Snyder, Westmoreland, and Wyoming, $0.37½; York County, $0.31¼.

FOSSIL BEDS AND SPECIMENS.

In constructing irrigation works it is probable that fossiliferous beds will be uncovered, giving exceptionally good opportunities for collecting specimens of value to geologists and paleontologists. Well-preserved imprints of leaves, ferns, or other plant remains, fossil shells, and the bones and teeth of animals are always interesting, and may add much to our knowledge of the geologic history and structure of the region.

When any specimens are discovered in connection with the work a brief statement of the nature of the discovery should be promptly sent to the Director, United States Geological Survey, Washington, D. C. If the specimens are small, such as fossil leaves or shells, or small teeth, a few samples should accompany the report, so that the character and importance of the find may be determined and instructions for additional collecting may be given, or a special collector may be sent to the locality, as the case may require.

STATUS OF RECLAMATION SERVICE.

The following is a copy of a letter from the Secretary of the Interior, dated March 10, 1905, addressed to the Director of the Geological Survey, regarding the status of the Reclamation Service:

Referring to my letter of July 8, 1902, regarding the organization of the Reclamation Service, and in order to remove certain erroneous ideas and misunderstandings that have recently arisen regarding the status of said Service, my said letter of July 8, supra, is to be understood as placing the Reclamation Service under the direction and control of the Director of the Geological Survey, but the Reclamation Service is not to be made part of the Survey. The regulations and instructions of the United States Geological Survey shall govern the Reclamation Service, so far as the same may be applicable.

PERSONNEL OF THE RECLAMATION SERVICE.

The report of the first conference of the engineers of the Reclamation Service (Water-Supply and Irrigation Paper No. 93) contains, on pages 315–351, a list giving, in alphabetical order, the names of the principal men of the regular force of the Reclamation Service and the salient facts concerning their education and experience.

The records of a considerable number of employees were not available at that time, however, and many have since entered the Service, and these are listed below:

ADAMS, C. ROBERT, engineering aid. Address, Boston, Mass. Born, Boston, Mass., November 30, 1884. Education, Boston public schools; Massachusetts Institute of Technology, S. B. Member M. I. T. Civil Engineering Society. 1904, rodman and instrument man, Massachusetts. Appointed in Reclamation Service June 8, 1905.

AMBLER, J. OWEN, engineering aid. Address, Montrose, Colo. Born in Kentucky, May 18, 1883. Education, common schools and Missouri School of Mines. 1903, draftsman for Steam Appliance Company, St. Louis. 1904–5, instrument man on canal location with Reclamation Service in Colorado. March 18, 1905, appointed engineering aid in Reclamation Service.

AVAKIAN, JOHN CASPER, assistant engineer. Address, Los Angeles, Cal. Born in Harpoot, Armenia, March 1, 1875. Came to United States, June, 1888. 1889–1894, classical course in Cook Academy, Montour Falls, N. Y. 1894–95, classical course in Colgate University, Hamilton, N. Y. 1895–1897, lecturer in New England and Middle States and Canada. 1897–98, commercial traveler in New England States. 1898–1902, Rensselaer Polytechnic Institute, Troy, N. Y., C. E. June, 1902, to January, 1903, draftsman for Lehigh Valley Railroad at Buffalo, N. Y. February to March, 1903, locating engineer for Buffalo, Dunkirk and Western Railroad. April to June, 1903, private office in Los Angeles, Cal. July, 1903, to February, 1905, draftsman, United States Reclamation Service, on Yuma project. March 24, 1905, appointed assistant engineer, Reclamation Service.

BAKER, SHELDON K., hydrographic aid. Address, Washington, D. C. Born in Washington, D. C., July 6, 1880. Massachusetts Institute of Technology, degree B. S., course in sanitary engineering. In 1901, with a firm of civil engineers, also draftsman under Isthmian Canal Commission. In 1902, traverseman, United States Geological Survey, in Montana. 1903, employed by Springfield (Mass.) Special Water Commission as assistant engineer and chemist on experimental filtration of public water supply. Also employed on bacteriological and chemical analyses of water. March 23, 1904, appointed hydrographic aid in Reclamation Service.

BALCH, LELAND RELLA, engineering aid. Address, Huntley, Mont. Born, Neillsville, Wis., March 10, 1883. Education, University of Wisconsin, B. S. in C. E. 1902–4, assistant to county surveyor of Clark County, Wis., during vacations. Appointed in Reclamation Service May 22, 1905.

BINGHAM, JOSEPH INKOFF, engineering aid. Address, Browning, Mont. Born, Lockwood, N. Y., December 11, 1877. Education, Starkey Seminary, N. Y., 1898. Graduated in sanitary engineering at University of Wisconsin, 1904. 1901–2, chainman, rodman, and levelman, Lehigh Valley Railroad. 1903, traverseman, United States Geological Survey. 1904–5, location and construction work, Chicago and Northwestern Railroad. Appointed in Reclamation Service May 1, 1905.

BRENNAN, MICHAEL SHELLY, engineering aid. Address, Chicago, Ill. Born in Rhode Island December 25, 1870. Education, Brown University, 1900, C. E. Summer of 1899, street and water departments, Providence, R. I. 1900–1903, inspector of concrete bridges, inspector of pile driving, and assistant engineer, Illinois Central Railroad. 1903–4, transitman and chief of party laying terminal tracks, St. Louis. 1904, inspector of reenforced concrete bridge work, Chicago, Ill. Appointed in Reclamation Service March 7, 1905.

BROTHERS, WALTER A., special disbursing agent. Born September 1, 1879. High school education. Entered Reclamation Service January 13, 1903. May 1, 1905, promoted to special disbursing agent and stationed at Casper, Wyo., on North Platte project.

BRUNDAGE, FRANK HOMER, assistant engineer. Address, Washington, D. C. Born at Oil City, Pa., August 21, 1877. Education, civil engineering, three years at Case School of Applied Science; one year at Cornell University. 1899, draftsman, Webster Camp, Lane Machine Company, Akron, Ohio. 1899–1902, aid, United States Coast and Geodetic Survey. 1902–3, computer, United States Coast and Geodetic Survey. March 5, 1903, transferred to computer, United States Geological Survey. July 1, 1904, promoted to assistant engineer.

BURRAGE, JOHN OTIS, assistant engineer. Address, Fort Laramie, Wyo. Born, Lowell, Mass., February 13, 1877. Education, four years student of civil engineering at Tufts College, class of 1900. Member Technical Society of the Pacific Coast; Junior American Society of Civil Engineers. 1899, in engineering office on Merrimac River, Massachusetts. 1900, engineer and draftsman American Ordnance Company, Bridgeport, Conn. 1901, with Union Iron Works, San Francisco, in drafting room. 1902–1905, draftsman, bureau of engineering, city engineer's office, San Francisco. Appointed in Reclamation Service May, 1905.

CALLISTER, THOMAS C., jr., engineering aid. Address, Fillmore, Utah. Graduate Agricultural College of Utah, B. S. in C. E. In 1902, measuring streams under Agricultural College Experiment Station. 1903, field assistant with Reclamation Service in Utah and Idaho. 1904, installing private telephone system connecting the towns of Millard County, Utah; also field assistant with Reclamation Service in Idaho and Utah. 1904–5, on construction work with San Pedro, Los Angeles and Salt Lake Railroad as office and field assistant. January, 1905, appointed engineering aid in Reclamation Service.

CARBERRY, RAY S., assistant engineer. Address, Mitchell, Nebr. Born, Secoo, Ill., May 3, 1873. Education, University of Illinois, School of Civil Engineering, B. S., 1895. 1895, city engineer on construction of sewer system. 1896, land and drainage surveying. 1896–97, city engineer, Monticello, Ill. 1897–98, drainage and dredge work in central Illinois. 1898–1900, engineer and general manager, Marysville Canal and Improvement Company, Idaho. 1901–2, levelman, instrument man, and assistant engineer Oregon Short Line. 1903, on grade reduction, Wabash Railroad, central Illinois. 1904, Wabash Railroad constructing World's Fair grounds terminals. 1904–5, instrument man Chicago and Northwestern Railroad Company, Chicago. Appointed in Reclamation Service April, 1905.

CARPENTER, WILLIAM T., engineering aid. Address, Pittston, Pa. Graduate of Lehigh University, 1902, degree C. E. One year with Coast and Geodetic Survey, on hydrographic work. July 11, 1903, transferred to Reclamation Service as engineering aid.

CASS, FRANK HENRY, transportation agent. Born in Alexandria, N. H. Educated in rural schools. Engaged in railroad work from 1865 as newsboy, brakeman, telegraph operator, and agent on various railroads. From 1881 to 1904 employed by the Chicago and Eastern Illinois Railroad as freight claim agent, bill of lading clerk, contracting agent, and lumber agent. October 16, 1904, appointed transportation agent in the Reclamation Service.

CAVIS, FRED L., special disbursing agent. Address, Boise, Idaho. Born, Marysville, Ohio, December 23, 1879. Education, public and high schools. January 1, 1904, to May 1, 1905, stenographer and bookkeeper in Boise office, Reclamation Service. May 1, 1905, appointed special disbursing agent.

CLEGHORN, JOHN C., engineering aid. Born December 23, 1880, at Onawa, Iowa. Graduated, 1899, from Onawa High School and, 1903, Iowa State College with degree of B. Min. E. 1902, transitman, Yellowstone Park Improvement. 1903, mining in Colorado. 1904, instrument man, Monona-Harrison County (Iowa) ditch; level rodman with United States Geological Survey in Wyoming; superintendent Keystone Coal Company at Shelburn, Ind. Appointed engineering aid in Reclamation Service March 24, 1905.

COLE, D. W., constructing engineer. Born in Georgia, May 10, 1863. Education in home academy. 1884–85, on railroad surveys in New Mexico and Colorado as axman, chainman, and rodman. 1886–1888, with Burlington System as rodman, instrument man, assistant engineer, and resident engineer on surveys, construction, and maintenance. 1889, engineer of mines and works for Chicago, Wilmington, and Vermilion Coal Company. 1890–91, resident engineer in charge heavy construction and track laying for Louisville and Nashville Railroad. 1891, on railroad location, Toledo to Chicago. 1892–93, engineer for industrial corporations in northern Illinois. 1894–95, resident engineer, surveys and construction water-supply system, Waterbury, Conn. 1896–1900, assistant engineer on construction, surveys, and studies for metropolitan water board of Massachusetts. 1901–2, resident engineer, construction of dams, reservoir, and appurtenances for city of Waterbury, Conn. 1903, principal assistant engineer, Catskill department, commission on additional water supply, New York City. 1903–4, on surveys and studies for northern New Jersey flood commission. June, 1904, appointed constructing engineer in Reclamation Service.

COMSTOCK, HAROLD DEARBORN, engineering aid. Address, Chelsea, Vt. Born in Vermont, June 13, 1882. Graduate of Dartmouth College, degree B. S., and Thayer School of Civil Engineering, degree C. E. In 1903, rodman, transit man, and computer on a topographic survey of West Point, N. Y. August 22, 1904, appointed engineering aid in Reclamation Service.

CONNER, RALPH M., engineering aid. Address, East Wilton, Me. Born in Maine, March 25, 1878. Graduate of Wilton Academy, Wilton, Me., and of University of Maine, degree B. S. in C. E. Measured flow of St. Croix River at Spragues Falls, Me., 1903. 1902, assistant civil engineer, Rumford Falls Power Company. 1903, timekeeper and superintendent for contractor. Tutor in mathematics, University of Maine. June 5, 1904, appointed engineering aid in the Reclamation Service.

COULTER, WALDO SCARLETTE, assistant engineer. Address, Wyncote, Wyo. Born, Westboro, Mass., October 12, 1877. Education, common and high schools. Member Boston Society of Civil Engineers. 1896–97, with metropolitan water board on surveys and construction of Sudbury reservoir. 1897–98, structural draftsman. 1898-99, inspector of construction of filtration beds, Clinton, Mass. 1899-1905, with metropolitan water and sewerage board as rodman and instrument man on construction of highways and hydraulic works, Clinton, Mass. Appointed in Reclamation Service April 21, 1905.

COUPE, ALFRED L., engineering aid. Address, Huntley, Mont. Born at Plymouth, Mass., April 7, 1884. Education, Massachusetts Institute of Technology, 1900-1902. 1902, rodman, instrument man, and inspector, Boston and Albany Railroad. Appointed in Reclamation Service March, 1905.

DOERFLING, RICHARD GEORGE, irrigation engineer. Address, Yuma, Ariz. Born in Germany, March 8, 1866. Graduate of Columbian University, B. S. in civil engineering, 1898. Completed course in mechanical engineering of the Scranton Correspondence Schools in 1895. Associate member American Society of Civil Engineers. 1881-1884, apprenticed to county surveyor in Germany. 1884-1886, surveyor and draftsman on railroad location and construction, Harz Mountains. 1886-1889, surveyor and draftsman, North Sea-Baltic Canal. 1889-90, draftsman, street department, St. Louis, Mo. 1890-1894, topographer on upper Missouri River surveys. 1894-1898, draftsman, engineer department, District of Columbia. 1898-99, structural steel draftsman, yards and docks, Navy-Yard, Washington, D. C. 1899-1902, superintendent of construction, United States engineer department, Pittsburg, Pa., on locks, fixed and movable dams, and operating machinery for same. 1902-3, structural engineer, Pacific Rolling Mills, San Francisco, Cal. 1903-4, in private practice. 1904-5, superintendent of construction, twelfth light-house district. Since January 1, 1905, irrigation engineer, Reclamation Service.

DRANE, BRENT SKINNER, engineering aid. Address, Atlanta, Ga. Born, Edenton, N. C., September 9, 1881. Education, University of North Carolina, 1902, A. B. Summer of 1901, with United States Geological Survey on investigation of damages by floods in North Carolina and Tennessee. 1901-2, laboratory assistant, University of North Carolina. 1902-1904, field assistant, United States Geological Survey, in North Carolina, South Carolina, Tennessee, and Virginia. 1904-5, field assistant, United States Geological Survey, in southeastern United States. Appointed in Reclamation Service May 22, 1905.

DUGANNE, CHARLES GEORGE, special disbursing agent. Address, Fallon, Nev. Born, Savannah, Ga., June 18, 1881. Education, common school. Appointed in Reclamation Service March 1, 1905.

EDSON, GORDON, engineering aid. Address, Caneadea, N. Y. Born in New York, August 1, 1877. Education, Houghton Seminary, Houghton, N. Y., and Syracuse University, degree C. E., 1904. 1903, chairman and field assistant United States Geological Survey. Five years teacher in public schools of New York. April 1, 1904, appointed engineering aid in Reclamation Service.

ENSIGN, ORVILLE H., electrical expert. Address, Los Angeles, Cal. Born in New York State, July, 1863. Grammar and high school education; two years course in mechanic arts, Cornell. 1883, machine shop, Ithaca, N. Y. 1884-1886, Schenectady Locomotive Works. 1887-88, on construction of isolated plants for Edison Electric Company, New York City. 1889-1893, in charge of test and chief inspector of General Electric Company's factory, Schenectady, N. Y. 1893, moved to California; consulting engineer on test of first three-phase transmission plant in America, at Redlands, Cal. 1894-95, electrical and mechanical engineer Los Angeles and Pasadena Electric Railway and Los Angeles and Santa Monica Railway. 1896-1904, electrical and mechanical engineer of the companies now known as Edison Company of Los Angeles, constructing and operating long-distance hydro-electric plants. Member American Institute

Electrical Engineers. November 1, 1904, appointed electrical expert, Reclamation Service.

FISHER, CASSIUS ASA, assistant geologist. Address, Washington, D. C. Born in Nebraska, February 15, 1872. Received a common school education. In 1889 entered preparatory school at Fremont, Nebr. Entered University of Nebraska, 1893, from which he graduated in 1898. 1896–1901, field assistant, United States Geological Survey, during field seasons. Appointed fellow in geology at University of Nebraska, 1898, and during the following year assistant geologist in the Nebraska State Geological Survey. M. A., University of Nebraska, 1900. 1901–2, field assistant, United States Geological Survey. 1902–3, assistant instructor in geology, Yale University. Author of various publications on geologic subjects. 1903 to date, with Reclamation Service, investigating geology and underground waters in New Mexico, Wyoming, and Colorado.

FISHER, ERNEST JAMES, engineering aid. Address, Browning, Mont. Born, Morris, Minn., August 4, 1879. Education, University of Wisconsin, C. E., 1904. 1901, chainman with location party, Wisconsin. 1902, levelman, United States Geological Survey, in Missouri. 1903, traverseman in Arkansas. 1904–5, under engineer maintenance of way, Great Northern Railroad. May 1, 1905, appointed in Reclamation Service.

FOLLANSBEE, ROBERT, assistant engineer. Address, Ashby Glen, Delaplane, Va. Born in Minnesota, June 7, 1879. Graduated from Cornell University in civil engineering in 1902. 1902–3, engineer with a firm of general contractors of Cleveland, Ohio. 1903, recorder with United States Lake Survey, Detroit, Mich. January–April, 1904, draftsman, United States Geological Survey. April 9, 1904, appointed assistant engineer in Reclamation Service.

FREEMAN, WILLIAM B., engineering aid. Address, Ithaca, N. Y. Born in Montana, September 26, 1883. Graduate Bozeman High School and of Montana Agricultural College, degree B. C. E. 1900, on stream measurements, etc., Montana Experiment Station. 1901, continued same work and also did transit surveying. 1902–3, on stream measurement and seepage work; also worked for United States Geological Survey as level rodman and assistant. 1903, traverseman, United States Geological Survey, July–November. April 9, 1904, appointed engineering aid in Reclamation Service, and assigned to stream-measurement work in Montana.

FRICKSTAD, WALTER NETTLETON, assistant engineer. Address, Leetville, Nev. Born in New York August 17, 1879. Full course in civil engineering, University of California; graduated in 1901, degree B. S. 1901–3, with Southern Pacific Railroad Company, on location, construction, and inspection. 1903–4, assistant engineer for C. A. Warren & Co., on construction of divisions 1 and 2 of main canal, Truckee-Carson project, Nevada. August 26, 1904, appointed engineering aid in Reclamation Service, and January 1, 1905, promoted to assistant engineer.

GORTON, WILLARD L., engineering aid. Address, Chamber of Commerce Building, Denver, Colo. Born in Wisconsin June 13, 1881. Graduate of University of Oklahoma, degree A. B. 1902, tapeman and rodman, Missouri, Kansas and Oklahoma Railroad, on construction and relocation. 1903–4, with Burns & McDonnell, hydraulic engineers, Kansas City, Mo., making preliminary surveys for waterworks and in charge of construction of Chickasha, Ind. T., waterworks and sewerage system. May 8, 1904, appointed engineering aid, Reclamation Service. May–October, 1904, on surveys in connection with Milk River project, Montana. November 8, 1904, transferred to Wyoming. November–December, 1904, in charge of topographic party on Interstate canal, North Platte project. January, 1905, on topography and triangulation, La Plata project, Colorado–New Mexico. February–March, in Denver office on work connected with the North Platte project.

HALL, ROLLAND SERVIS, engineering aid. Address, Ann Arbor, Mich. Born in Illinois May 19, 1880. Public and high school education; also B. S. in civil engineering, University of Michigan, 1904. August 26, 1904, appointed engineering aid in Reclamation Service.

HAMMOND, GEORGE A., superintendent of borings. Address, Ossining, N. Y. Born in New York State June 23, 1860. 1880–1893, with New York City water supply, making borings for dams and aqueducts. 1894, with American Diamond Drill Company, Virginia. 1894–95, assistant engineer, Ossining Electric Railroad. 1895–96, with New York City water supply. 1896–97, chief engineer, Ossining Electric Railroad Company. 1897–1899, superintendent of borings, United States Deep Waterways Commission. 1900, on drill work in Mexico and California. 1900, superintendent of borings, Erie Canal. 1901, on drill work in British Columbia. 1901–1903, superintendent of borings, Pilleys Island Pyrites Company, Newfoundland. 1903, on Pennsylvania Railroad tunnel, New York City; also Professor Burr commission on additional water supply, New York. 1903–4, drill expert, United States Geological Survey. March 1, 1904, appointed superintendent of borings, Reclamation Service. Inventor of "Hammond" jetting process for sinking casing.

HATCH, LEWIS M., assistant engineer. Address, Denver, Colo. Born at Tacoma, Wash., November 28, 1880. 1902, Washington State College and School of Science, degree B. S. 1902–3, topographer and transitman, Northern Pacific Railway. 1903–4, assistant engineer, maintenance of way, Northern Pacific Railway. August 15, 1904, appointed engineering aid in Reclamation Service and promoted to assistant engineer February 15, 1905.

HAYT, ROBERT OLCOTT, assistant engineer. Address, Huntley, Mont. Born, Corning, N. Y., October 25, 1877. Education, Corning High School; four years in School of Applied Science, Columbia University. 1900–1903, city engineer. 1903–1905, engineer of gas company. April 25, 1905, appointed in Reclamation Service.

HEILEMAN, WILLIAM H., scientist (land classification). Address, Berkeley, Cal. Born, Des Moines, Iowa, October 16, 1869. Education, Iowa State College, B. S. and M. S. Member American Chemical Society, Society of Chemical Industry, London. 1891–1896, assistant chemist, Iowa Experiment Station. 1896–1901, chemist in charge Washington Experiment Station. 1901–2, soil expert, Bureau of Soils, Department of Agriculture. 1902–1905, scientist in charge of alkali reclamation installations, Bureau of Soils. Appointed in Reclamation Service May 10, 1905.

HENNY, DAVID CHRISTIAAN, consulting engineer. Born in Arnhem, Holland, November 15, 1860. Graduate of Government Polytechnic School, Delft, Holland, as civil engineer, 1881. Engaged in reclamation district work and railroad location in Holland, 1881–1884. In railroad construction in Iowa, 1884–85. In waterworks construction in Eastern States, 1885–1887. In railroad construction, Colorado; bridge work, Missouri; tunnel construction, New York, 1887–88. In waterworks construction, Alabama, South Dakota, and Ohio, 1888–89. In general engineering, Colorado and Utah, 1889–1891. Manager Excelsior Wooden Pipe Company, 1892–1902, engaged in construction of wooden stave pipe and general contracting. 1902–1904, general manager Redwood Manufacturers' Company, San Francisco, Cal. Designed and constructed new plant at Black Diamond, Cal., consisting of wharves, yards, tracks, power house, factories, dry kilns, etc. Organized all company's working forces with offices at Black Diamond, San Francisco, and Oakland. 1891–1904, designed and reported on various waterworks and water-power projects. Consulting engineer West Side and West Los Angeles water companies. Expert for the city of Oakland on waterworks valuation. Member civil-service examination board, engineering department, San Francisco. Two terms president Technical Society Pacific Coast. February 8, 1905, appointed consulting engineer in Reclamation Service.

HORN, FRANK C., constructing engineer. Address, Minidoka, Idaho. Born in Illinois January 8, 1861. Public and high school education. Studied and worked under direction of civil engineer engaged in general practice. 1881, transitman on surveys, and in 1882 assistant engineer on construction, St. Louis and San Francisco Railway Company. 1883, with an engineer in general practice. 1884, transitman and later assistant engineer, Burlington, Cedar Rapids and Northern Railway. 1885–86, principal assistant engineer, Lake, Ill. 1887–1889, chief engineer and superintendent, department of public works, Lake, Ill. 1889–1894, with contracting firms building waterworks, sewerage systems, railroads, buildings, etc. 1894, on track elevation in Chicago for Lake Shore and Michigan Southern Railway and Chicago, Rock Island and Pacific Railway. 1896, in charge of construction of regulating works, Lockport, Ill. 1898–1900, with sanitary district of Chicago, bridge department, on masonry construction. 1900, in charge of construction of water-power plant, Joliet, Ill. 1900–1901, assistant chief engineer on construction of water-power plant, Swan Falls, Idaho. 1901, remodeling and enlarging water-power plant at Kankakee, Ill.; and later in charge of constructing filter beds for Denver Union Water Company, Denver, Colo. 1902–1905, resident engineer in charge of construction of granite masonry dam at Lake Cheesman, Colo. January 17, 1905, appointed constructing engineer in Reclamation Service. Member American Society Civil Engineers.

HOSIG, IRWIN BENJAMIN, hydrographic aid. Address, Sun River, Mont. Born, Hartford, Wis., May 24, 1884. Education, Hartford (Wis.) high school, four years in civil engineering at University of Wisconsin, 1901–1905. Appointed in Reclamation Service May 1, 1905.

HOWE, HENRY A., assistant engineer. Address, Cedar Creek, Montrose County, Colo. Born in Massachusetts, September 2, 1870. Degree S. B. in 1895 from Lawrence Scientific School, Harvard. 1895–1905, with metropolitan water board of Massachusetts, as rodman, instrument man, and assistant engineer. January 12, 1905, appointed assistant engineer in Reclamation Service in charge of Gunnison tunnel alignment and levels, Uncompahgre Valley project, Colorado.

HUBBARD, RAY D., assistant engineer. Address, Klamath Falls, Oreg. Born Brock, Nebr., July 11, 1873. Education, University of Nebraska, 1900, B. S. in C. E. 1900–1902, general civil and mining engineering in South Dakota. 1903, surveyor-general's office, South Dakota. 1903–1904, assistant State engineer of Nebraska. November 12, 1904, appointed assistant engineer in Reclamation Service and assigned to Klamath project.

JOHNSON, LUTHER E., engineering aid. Address, Lawton, Okla. Born in West Virginia, August 10, 1881. Graduate of Missouri University, 1904. 1901–2, rodman and chainman. 1904, drafting and field work during appraisal of town lots, Sulphur, Ind. T. September 10, 1904, appointed engineering aid in Reclamation Service and assigned to duty in Oklahoma.

KEMPTON, GEORGE RUTHERFORD, electrical engineer. Address, Denver, Colo. Born Amenia, N. Y., November 22, 1876. Education, common school, one year Albany high school; two and one-half years Drexel Institute, mechanic arts department; three years Tufts College, graduating in 1900 with degree of B. S. in electrical engineering. 1900–1902, with General Electric Company, Schenectady, N. Y. 1902–1905, electrical engineer, office of Supervising Architect, Treasury Department. June 6, 1905, appointed in Reclamation Service.

King, Clifford M., engineering aid. Born December 17, 1879. Address, Minidoka, Idaho. Graduated from Western Reserve University, degree A. B., 1901; Cornell University, degree C. E., 1904. Assistant engineer for the Deschutes Irrigation and Power Company, Bend, Oreg., 1904. Draftsman for the Oregon Water Power and Railway Company, Portland, Oreg., 1905. Appointed engineering aid March 7, 1905, in Reclamation Service.

Larson, Andrew B., engineering aid. Address, Salt Lake City, Utah. Born, Levan, Utah, November 30, 1872. Education, Agricultural College of Utah, 1894, degree of B. C. E. 1895, chairman on land survey. 1896, rodman for Rio Grande Western Railroad Company; later promoted to levelman on same. Appointed in Reclamation Service May 1, 1905.

La Rue, Eugene C., engineering aid. Address, Riverside, Cal. Born in California, November 11, 1879. Graduate of Riverside Grammar School and High School. Graduate of University of California, C. E. June 1, 1904, appointed engineering aid, Reclamation Service.

Lee, Willis Thomas, assistant geologist. Address, United States Geological Survey, Washington, D. C. Born in Pennsylvania, December 24, 1864. Graduate of Wesleyan University, Middletown, Conn., Ph. B. 1894–95, assistant in chemistry and physics, Rhode Island State College. 1895–1898, professor of geology and biology, Denver University. 1898, degree M. S., Wesleyan University. 1898–1900, fellow in geology, Chicago University. 1900–1902, principal of high school, Trinidad, Colo. 1902–3, Johns Hopkins University. Author of various publications on geological subjects. 1903 to date with Reclamation Service, investigating underground waters in Arizona, eastern California, and New Mexico.

Lewis, Samuel James, assistant engineer. Born in New York August 7, 1879. Education, grammar schools and college, New York City, degree B. S. 1902–3, general engineering and stream measurements. 1903, rodman and station assistant, United States Geological Survey. April 11, 1904, appointed hydrographic aid, and on July 1, 1904, promoted to assistant engineer in Reclamation Service.

Lightfoot, William J., engineer. Address, North Yakima, Wash. Born in Ohio March 8, 1857. Attended Southeastern Normal School. Took preparatory Latin and Greeek for classical course at Marietta College, Marietta, Ohio. June, 1881, degree B. S., Kansas State Agricultural College, after which some months were spent at Kansas State University. Associate member American Society of Civil Engineers. From 1882 to 1892 in railroad location, construction, and maintenance, most of the time with Atchison, Topeka and Santa Fe Railroad Company. 1892–1899, in private practice and as United States deputy mineral surveyor and mining engineer, Cripple Creek, Colo. 1899–1904, United States examiner of surveys and special disbursing agent, Department of the Interior. June 1, 1904, appointed engineer in Reclamation Service and assigned to duty on Uncompahgre Valley project, Colorado.

Lillis, Burton C., assistant engineer. Address, Billings, Mont. Born, Ottawa, Ill., July 27, 1879. Education, Case School of Applied Sciences, 1902, B. S. 1901, on railroad maintenance of way. 1902–3, assistant engineer sewer department, Cleveland, Ohio. 1903–4, aid Coast and Geodetic Survey. Appointed Reclamation Service, June, 1904.

Lind, George Edmund, Jr., special disbursing agent. Address, Roosevelt, Ariz. Born, Baltimore, Md., August 3, 1866. Education, common schools, Baltimore City College, Hampden Sydney College, Virginia, and Atlanta Medical

College, M. D. Surgeon in quarantine service, Savannah, Ga. Employed in vital statistics division of Census Bureau. Since 1895 has been connected with the Geological Survey. Appointed in Reclamation Service December 5, 1904.

LYMAN, HENRY LEVIGN, engineering aid. Address, Washington, D. C. Born in Russia, April 14, 1881. Education, Massachusetts Institute of Technology, 1904, B. S. 1901, rodman, Boston, Mass. 1902, plane-table survey in New Hampshire. 1903, rodman and instrument man on Wachusett Aqueduct, metropolitan water board, Clinton, Mass. 1904–5, structural draftsman, Boston, Mass. 1905, draftsman, American Bridge Company, New York, N. Y. Appointed Reclamation Service, March 7, 1905.

LYTEL, JAMES L., assistant engineer. Born in Pennsylvania June 23, 1872. University of Nebraska, degree B. S. 1889–1892, assistant on dam construction and tramways for logging and milling. 1898–99, sergeant, Third Nebraska Volunteer Infantry. 1900–1902, draftsman and topographer in engineering department of military government of Cuba. 1902–1904, with Mexican Central Railway as topographer, transitman, and locating engineer. 1904–5, with United States Reclamation Service, in charge of drafting and designs, Uncompahgre Valley project. March 7, 1905, appointed assistant engineer in Reclamation Service.

MCGEEHAN, PAUL, assistant engineer. Address, Kansas City, Mo. Born in Ohio June 13, 1872. Education, Kansas City High School, Park College, Parkville, Mo., Colorado School of Mines, and Montana School of Mines. 1894, on city surveys, Kansas City. 1895, rodman on railroad location and construction. 1895–1897, topographer. 1897, topographer and assistant locating engineer in southern Illinois. 1897–98, in charge of construction of northern terminals of the Cotton Belt. Engineer officer, United States Army, 1898. In 1899–1900, engineer on railroad location and construction. 1900–1901, with B. & M. Mining Company, Butte, Mont. 1901–2, engineer on railroad location and construction. 1902–3, locating engineer, Orient Railway. April 27, 1904, appointed assistant engineer, Reclamation Service.

MCGREGOR, ROBERT R., engineer. Address, Reno, Nev. Born in California November 26, 1873. Education, Lomper Union High School and University of California. 1899, rodman and instrument man, Southern Pacific Railroad. 1900, transitman with Eldorado Lumber Company; also engineer in charge of railroad location and construction. 1902–3, assistant engineer, Southern Pacific Company, on railroad reconstruction in Nevada. 1903–4, field assistant, Reclamation Service. March 23, 1904, appointed assistant engineer, and on January 1, 1905, promoted to engineer, Truckee-Carson project, Nevada.

MCKINNEY, JOHN M., examiner. Address, Washington, D. C. Born at New York City September 10, 1860. Graduate Washington High School, 1879, and of National University Law School, degree LL. B., 1883, LL. M., 1884. 1880–1884, United States Census. 1884–1905, General Land Office—last ten years on right-of-way work relating to irrigation, railroads, etc. January 26, 1905, transferred to Reclamation Service as examiner.

MAGUIRE, THOMAS FRANCIS JAMES, electrical engineer. Address, Denver, Colo. Born in Massachusetts August 3, 1875. Graduate of Massachusetts Institute of Technology, 1897, degree B. S. in electrical engineering. 1896, rodman with Boston board of survey. 1897–1899, transitman and calculator. 1899–1901, draftsman and calculator with bridge department, city of Boston. 1901–02, electrical engineer, Supervising Architect's Office, Treasury Department. 1902–1904, expert electrical aid, Navy Department. May 16, 1904, transferred to Reclamation Service as electrical engineer.

MAREAN, HERBERT WHEELER, assistant engineer of soils. Address, Washington, D. C. Born in Washington, D. C., December 26, 1878. Education, Colgate University, degree A. B. 1901–1905, assistant in the Soil Survey, United States Department of Agriculture, engaged in field work. Author of various United States Soil Survey reports. April 24, 1905, transferred to Reclamation Service as assistant engineer of soils.

MARTIN, DANIEL GRANT, engineer. Address, Idaho Falls, Idaho. Born in Ohio June 19, 1865. Education, common school, academy at Chetopa, Kans., and Kansas Normal College, Fort Scott, Kans. 1882–1886, teaching school and attending college. 1888–1890, teaching school. 1890–91, with Idaho Falls Canal and Irrigation Company. 1892, engineer and general superintendent Idaho Canal Company. 1893–1897, county surveyor of Bingham County, Idaho. 1893–1896, general engineering practice, city engineer, Idaho Falls, Idaho. 1896, assistant engineer, Idaho Canal Company, on canal construction; engineer on Independent canal, St. Anthony, Idaho, and Marysville canal, Marysville, Idaho. 1897, with Idaho Canal Company, designing and constructing dams, flumes, headworks, etc. 1897–98, superintendent of construction of Marysville canal, Marysville, Idaho. 1898, employed on Idaho canal and Fort Hall Reservation canal; also employed by Independent Canal Company, St. Anthony, Idaho. 1898–99, with Bingham Irrigation and Power Company. 1900–1901, dam and canal work on Pine Creek, Bear River, and Little Lost River, and made the preliminary surveys and estimates for the Twin Falls Land and Water Company in Cassia and Lincoln counties, Idaho; also canal and reservoir reconnaissance surveys on North Fork of Snake River, Idaho. 1902, survey and estimates on canal from Bear River to Chesterfield, Idaho, and general work; also city engineer, Idaho Falls, Idaho. 1903–4, with Twin Falls Land and Water Company; division engineer in charge of construction of dams across Snake River at Milner, Idaho. April 1, 1904, appointed engineer, Reclamation Service, in charge of work on Minidoka project, Idaho.

MARTIN, WILLIAM F., hydrographic aid. Address, Los Angeles, Cal. Born, Attoyac, Tex., January 7, 1878. Education, graduate of University of Texas. One year's graduate study at Cornell, B. S. and C. E. Member Texas Academy of Science. Appointed in Reclamation Service June 14, 1905.

MEANS, THOMAS HERBERT, engineer of soils. Address, Berkeley, Cal. Born in Virginia November 15, 1875. Graduate of Washington, D. C., High School, 1893, scientific course. B. S. in geology, Columbian University, 1898; M. S. in geology, Columbian University, 1901. 1895–1904, with Department of Agriculture in study of western soils and methods of managing irrigated lands. May 6, 1904, appointed engineer of soils in Reclamation Service.

MENDENHALL, WALTER CURRAN, geologist. Address, Washington, D. C. Born in Ohio, February 20, 1871. Education, high school, Portland, Oreg.; B. S., Ohio Normal University, Ada, Ohio; Harvard University; Heidelberg University. 1894–1901, assistant geologist, United States Geological Survey. February 5, 1901, appointed geologist, United States Geological Survey. Author of Geologic section along New and Kanawha rivers (with M. R. Campbell); Reconnaissance from Resurrection Bay to Tanana River, Alaska, 1898; Tertiary granite in Northern Cascades, Washington (with George Otis Smith), 1900; Reconnaissance in the Norton Bay region, Alaska, 1900; Reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, 1901; Mineral resources of the Mount Wrangell district, Alaska (with F. C. Schrader), 1903; The Wrangell Mountains, Alaska, 1903; Development of underground waters in the Coastal Plain region of southern California (3 reports); Hydrology of the San Bernardino Valley, California; Geology of the central Copper River region, Alaska, in preparation; also various extracts and short articles.

MINER, JAMES HENRY, assistant engineer. Address, Warrensville, Ohio. Born in Massachusetts, November 24, 1877. Education, University School, Cleveland, Ohio, and Cornell University, degree C. E. Junior member of American Society of Civil Engineers. 1900–1902, with Chicago and Northwestern Railway, tapeman, rodman, and transitman on construction of second track and maintenance of way of Iowa division. 1902–3, with Mason City and Fort Dodge Railroad, transitman on erection of Des Moines River viaduct. 1903, with Norfolk and Western Railway, instrument man on preliminary survey for Lynchburg cut-off. September, 1903, assistant engineer, Page Coal and Coke Company. 1903, with Rock Island system, draftsman in chief engineer's office. 1904, assistant engineer with National Transit Company and Prairie Oil and Gas Company. April, 1904, appointed engineering aid, and November 23, 1904, promoted to assistant engineer in Reclamation Service.

MORRILL, WILBUR N., topographer. Address, New Albany, Ind. Education, Purdue University, 1891, B. C. E. 1891, instrument man Chicago drainage canal. 1892–93, engineer, American Hydraulic Dredging Company, Chicago. 1894 to 1897, general construction of steel bridges and waterworks. 1898, topographer, United States Geological Survey. 1905, transferred to Reclamation Service.

MORSE, HAROLD MARSTON, engineering aid. Address, Washington, D. C. Born in Massachusetts, May 29, 1881. Education, Dartmouth College, B. S.; Thayer School of Civil Engineering, C. E. May 1 to September 1, 1903, assistant engineer on waterworks at Needham, Falmouth, and Lexington, Mass. Appointed engineering aid January 1, 1905.

MORSE, HOWARD SCOTT, assistant engineer. Address, Dedham, Mass. Born in Massachusetts, June 21, 1881. Graduate of Dedham High School and of Massachusetts Institute of Technology, S. B., class of 1903. 1901–2, instrument man in hydraulic and sanitary engineering. 1903, transitman, Pennsylvania Railroad. 1903–4, assistant in civil engineering, Massachusetts Institute of Technology. May, 1904, appointed engineering aid, and November 13, 1904, promoted to assistant engineer in Reclamation Service.

MULFORD, JOHN C., topographic draftsman. Address, Washington, D. C. Born at Winetha, Ill., April 27, 1876. Education, common and high schools of Evanston, Ill.; also drawing course with Scranton Correspondence School. 1904 to 1905, topographic draftsman, Coast and Geodetic Survey. June 16, 1905, transferred to the Reclamation Service.

MURPHY, DANIEL WILLIAM, irrigation engineer. Address, Los Angeles, Cal. Born in Ohio January 18, 1865. Student Indiana University, three years; graduated Stanford University, 1892, degree A. B.; 1893, A. M.; 1896, Ph. D. 1892, student in astronomy at Lick Observatory. 1893–94, instructor in physics, Stanford University. 1894–95, engaged in physical investigations in the Physikalische Technische Reichsanstalt, Berlin, Germany. 1896–1900, assistant professor of physics, Stanford University. Since 1900 continuously engaged in general engineering practice. 1901–2, in charge of work for the drainage of alkali lands and construction engineer for the American Beet Sugar Company. 1903, made topographic survey of the property of the Organita Gold Mining Company. 1903–4, chief engineer in charge of construction of the Santa Cruz, Capitola and Watsonville Railway. 1903, made location and estimates on the proposed extension of the Monterey and Pacific Grove Railway. September, 1904, employed as field assistant in the Reclamation Service. January 14, 1905, appointed irrigation engineer.

PARKER, HORATIO NEWTON, assistant hydrographer. Born in Massachusetts, February 3, 1871. Educated in private and public schools of Cambridge, Mass., and at the Massachusetts Institute of Technology. In 1896, appointed assistant biologist, Boston waterworks. After the city waterworks were absorbed by the State of Massachusetts he was appointed biologist and became head of the laboratory. December, 1901, appointed health inspector of Montclair, N. J., which post he left November 9, 1904, when appointed assistant hydrographer, United States Geological Survey.

PATCH, WALTER W., engineer. Address, Belle Fourche, S. Dak. Born in Massachusetts, January 19, 1872. Graduate of Massachusetts Institute of Technology, C. E. Prior to 1894, rodman, Cambridge, Mass.; assistant instructor in surveying at Massachusetts Institute of Technology; principal assistant to city engineer, Rockland, Me.; resident engineer on sewer construction, Camden, Me. 1894, assistant to resident engineer, Boston waterworks. 1895, transitman, Boston waterworks. 1896–1903, assistant engineer, metropolitan waterworks of Massachusetts—one year computing; one year in charge field work and aqueduct gagings for maintenance department; two years principal office assistant in Weston aqueduct department; four years in immediate charge of work on reservoir, dam, and filter-bed construction. 1904, assistant engineer to aqueduct commissioners of New York City. Author of articles printed in Engineering News—"Observations on the use of polar planimeters," April, 1899; "Measurements of the flow of water in the Sudbury and Cochituate aqueducts," June, 1902; "The Marlborough Brook filter beds," April, 1903; "An example of the flattening of cast-iron pipes under earth pressure," December, 1904. February 10, 1905, appointed engineer in Reclamation Service.

PAUL, CARROLL, engineering aid. Address, 2015 Kalorama avenue, Washington, D. C. Born in Tokio, Japan, May 5, 1882. Education, public schools of Washington, D. C.; Dartmouth College, degree B. S.; Thayer School of Civil Engineering, degree C. E. Summer of 1900, rodman, United States Coast and Geodetic Survey. Summer of 1903, engaged as inspector on waterworks construction, Littleton, N. H., and with General Electric Company power and mining department. Summer of 1904, field assistant in Reclamation Service. January 24, 1905, appointed engineering aid in Reclamation Service.

PAUL, CHARLES HOWARD, engineer. Address, Glendive, Mont. Born in Rockport, Mass. Education, high school and Massachusetts Institute of Technology, C. E. course. 1895, rodman, Boston sewer department. 1895–96, with Massachusetts State board of health as rodman, etc. 1896–1900, with metropolitan water board, Boston, as rodman, instrument man, and engineering inspector. 1900–1905, with bureau of filtration, Philadelphia, as draftsman and assistant engineer. March 7, 1905, appointed engineer in the Reclamation Service.

PRATT, R. WINTHROP, assistant engineer. Address, Columbus, Ohio. Born in Massachusetts, December 21, 1876. Graduate of Agassiz Grammar School and English High School, Boston; Massachusetts Institute of Technology, degree S. B. In 1896, rodman, city engineer's department, Boston, Mass. 1898, assistant in engineering department, Massachusetts State board of health. 1898–99, with Boston and Albany Railroad, rodman and instrument man. 1899–1903, assistant engineer in engineering department, Massachusetts State board of health. 1903–4, engineer to the Ohio State board of health and at the same time in charge of stream measurements in Ohio for United States Geological Survey. March 28, 1904, appointed assistant engineer, Reclamation Service.

PRENDERGAST, FREDERIC F., assistant engineer. Address, Great Falls, Mont. Born in Nebraska, July 1, 1878. High school graduate, and attended College of Civil Engineering, University of California. In 1897–1899, chainman and rodman on canal and railroad work in southern California. 1901, transitman on construction of wooden-stave pipe line. 1902–3, transitman on railroad location.

1903, engineer in charge of construction of deep-water wharf and trestle, San Francisco Bay; also in charge of steam-shovel work on railroad construction. 1904, field assistant with United States Reclamation Service on Milk River project, Montana. November 25, 1904, appointed assistant engineer Reclamation Service.

PRINCE, JOHN R., topographic draftsman. Address, Los Angeles, Cal. Education, public schools and Malvern College, England. 1883–1889, draftsman, ordnance survey of Great Britain; also, same year, with Julius Bien & Co., New York. 1890–1901, general engineering assistant and draftsman, with C. C. Vermeule, New York, and draftsman to Geological Survey of New Jersey. 1901, topographic draftsman, with United States Board of Engineers, War Department, New York City. 1902–3, draftsman and chief draftsman, city engineer department, Los Angeles, Cal. 1903–1905, draftsman, United States Geological Survey. January 21, 1905, appointed topographic draftsman in Reclamation Service.

PYLE, FRED D., engineering aid. Address, Mitchell, Nebr. Born in Pennsylvania October 8, 1882. Education, Utah Agricultural College, 1903, B. S. in C. E. 1903, rodman and levelman, United States Geological Survey in Utah. 1904, private engineering and assistant to engineer at Utah Experiment Station. 1904, field assistant, United States Geological Survey, Utah. 1905, private engineering work in western Wyoming. May 1, 1905, appointed engineering aid in Reclamation Service.

REABURN, DE WITT LEE, topographer. Address, Klamath Falls, Oreg. Born West Virginia, 1871. Education, University of Illinois and University of Wisconsin. Associate member American Society of Civil Engineers. 1891–1893, on land, town-subdivision, and railroad surveys in Virginia; also with American Bridge Company, Roanoke, Va., on bridge erection. 1893–1897, with Mississippi River Commission engaged in topographic, hydraulic, and triangulation work. 1897–1905, topographer with United States Geological Survey. April 1, 1905, transferred to Reclamation Service and assigned to the Klamath project.

RHEAD, JOSIAH LEWIS, assistant engineer. Born in Utah, May 8, 1868. Education, Agricultural College of Utah, B. S. in civil engineering. From June to December, 1896, assistant in stream measurements and calculations of canals and rivers of Cache Valley, Utah. From 1896 to 1900 acted as assistant engineer and engineer on Bear River canal, Utah, for Bear River Irrigation and Ogden Water Works Company, Ogden and Corrine, Utah. July–October, 1900, assistant engineer on West Gallatin Irrigation Company's canal, in Gallatin Valley, Montana. 1901–2, superintendent and engineer of the Big ditch in Yellowstone County, Mont. 1902–3, with United States Geological Survey in triangulation and leveling in Montana. May 1, 1903, appointed assistant engineer in the Reclamation Service.

RICHARDSON, GEORGE BURR, assistant geologist. Address, Washington, D. C. Born in New York, August 21, 1872. Graduate of Harvard University, S. B., 1895. Johns Hopkins University, Ph. D., 1901. In 1896, geologic field assistant, United States Geological Survey, Richmond basin, Virginia; 1897, same, in Indian Territory. 1898, surveyor and geologist, Cassiar Central Railway Company, British Columbia. 1899, geologic field assistant, United States Geological Survey, Black Hills, South Dakota. Since 1900, assistant geologist, United States Geological Survey, working in Alaska, Pennsylvania, California, Utah, and Texas.

ROBERTS, JOHN MILTON, assistant engineer. Address, Montrose, Colo. Born, Lincoln, Nebr., October 3, 1873. Education, common school and three years in University of Nebraska. 1888, assistant to engineering architect. 1899–1900, constructed Roberts ditch, near Paonia, Colo. 1901, repaired breaks in canal for Overland Ditch Company. 1903, in charge of field party, United States Geological Survey, at Montrose, Colo. 1904, under W. M. Reed in New Mexico. 1904-5, surveys of reservoir sites in Colorado under A. L. Fellows. 1905, in charge of construction of Montrose, Colo., waterworks.

ROTHI, PAUL, engineering aid. Address, Mitchell, Nebr. Born, Moland, Minn., December 14, 1877. Education, high school and University of Minnesota, C. E. Summers of 1900, 1901, 1902, and 1903, railroad surveys; 1904-5, structural draftsman. Appointed in Reclamation Service May 4, 1905.

RUSSELL, WALTER S., engineer. Address, Fallon, Nev. Born in Wisconsin, October 27, 1863. Education, high school and private study. 1887-1889, rodman, levelman, and transitman, on railroad work. 1890, levelman and transitman, Pamo Water Company, San Diego, Cal. 1891, chief of party for irrigation district, San Diego, Cal., also chief of party for Bear Valley Irrigation Company. 1892, locating engineer for Mount Tecarte Water Company, San Diego County. 1893, office practice, San Diego, Cal. 1894-1898, engineer, Southern California Mountain Water Company. 1899, surveyed and reported on water power for hydraulic mining claims in Utah and Arizona. 1900, office practice, Spokane, Wash. 1901-2, with California Construction Company, superintendent of construction of tunnel for Power Development Company at Bakersfield, Cal. 1902-3, with Atlantic, Gulf and Pacific Company, superintendent of construction of dry dock for the United States at Mare Island, Cal. 1903, engineer for E. B. & A. L. Stone Company, general contractors. March 19, 1904, appointed engineer in Reclamation Service.

SANFORD, GEORGE OTIS, assistant engineer. Address, Westboro, Mass. Born in Brockton, Mass. Education, civil engineering course at Worcester Polytechnic Institute, class of 1895. In summer of 1892 in city engineer's office, sewer department, Brockton, Mass. From August, 1895, to March, 1905, with metropolitan water and sewerage board at Clinton, Mass.; as rodman and instrument man on triangulation, topographic surveying, land surveying, construction of roads, railroads, and reservoirs. Assistant engineer on the construction of the third division of the Weston aqueduct and the south dike of the Wachusett reservoir. March 1, 1905, appointed assistant engineer in the Reclamation Service.

SARGENT, RALPH S., engineering aid. Address, Berkeley, Cal. Born in Michigan, November 25, 1880. University of California, civil engineering course. 1903, rodman and transitman on topography. Summer of 1904, rodman and levelman on a stadia survey on the Kaweah River. Winter of 1904, mine surveying in Amador County, Cal. April 27, 1904, appointed engineering aid in the Reclamation Service, and assigned to duty on the Boise-Payette project, Idaho.

SEIDEMANN, HENRY P., special disbursing agent. Address, Belle Fourche, S. Dak. Born in Texas, April 4, 1883; education, public schools and business college. 1899-1902, office assistant in pay department of the army at San Juan, P. R. 1902-1905, messenger, clerk, and bookkeeper in United States Geological Survey. May 10, 1905, promoted to special disbursing agent in the Reclamation Service.

SHELEY, HORACE W., engineering aid. Address, Salt Lake City, Utah. Born in Missouri, April 29, 1880. Educated in public schools of Texas and Missouri. Attended Westminster College, Missouri, 1894-1897, and University of Utah 1897-1901. 1901, studied and assisted mining engineers and experts in Tintic mining district. 1901-2, with Rio Grande Western Railway. January to June, 1903, student. 1903-4, field draftsman, computer, and topographer in Reclamation Service. December 23, 1904, appointed engineering aid.

SHINBUR, ELVER L., assistant engineer. Address, Wyncote, Wyo. Born, Oakland, Nebr., April 3, 1879. Education, University of Nebraska, B. S. in C. E. 1900, rodman and chainman on railroad in Colorado and Montana. 1901, instrument man and inspector on viaduct construction, Nebraska. 1901–2, with United States military government in Cuba as topographer. 1902–3, assistant engineer in charge of location and construction, Insular Railway Company, Habana. 1903–4, resident engineer on construction of railroad, Mexico. 1904–5, in charge of field parties on irrigation investigations in Colorado and New Mexico. March 7, 1905, appointed in Reclamation Service. Now resident engineer in charge of division 2, interstate canal, North Platte project.

SHIPMAN, CHARLEY E., engineering aid. Address, Great Falls, Mont. Born at West Liberty, Iowa, November 16, 1882. Graduated from West Liberty High School and from Iowa State College, civil engineering department. Paving inspector, Cedar Falls, Iowa, summer of 1903. Draftsman with American Bridge Company, Ambridge, Pa., for six months. March 7, 1905, appointed engineering aid in the Reclamation Service.

SIEBENTHAL, CLAUDE ELLSWORTH, assistant geologist. Address, Bloomington, Ind. Born in Indiana, April 16, 1869. Stanford University, A. B. in 1892 and A. M. in 1893. Fellow in geology, University of Chicago, 1897–1899, 1900–1901. Instructor of physiography, high school, Indianapolis, Ind., 1899–1900. 1889–1893, assistant and assistant geologist, Geological Survey of Arkansas. 1896–1898, assistant geologist, Geological Survey of Indiana. In 1901 appointed assistant geologist, United States Geological Survey. Now on work in western section, division of hydrology.

SIMPSON, PAUL DYER, engineering aid. Address, Chamber of Commerce Buiding, Denver, Colo. Born in Nebraska, March 10, 1876. B. S. in civil engineering, University of Maine. Eight years in general engineering work, including land surveying, highway location and construction, waterworks, sewer, and masonry construction, city, tunnel, and railroad work, and hydrographic and topographic surveying and drafting. With United States Army during Spanish-American war. Tutor in civil engineering, University of Maine. September 29, 1904, appointed engineering aid in Reclamation Service, and assigned to duty in western Nebraska, Wyoming, and Colorado.

SLOAN, JAMES HARVEY, engineering aid. Address, Browning, Mont. Born, Bozeman, Mont., April 10, 1881. Education, Bozeman High School; Montana Agricultural College, 1903, B. C. E. Summer of 1904, field assistant to L. E. Granke on Milk River project. Appointed in Reclamation Service April 28, 1905.

SMITH, CHESTER WASON, constructing engineer. Address, Roosevelt, Ariz. Born in New Hampshire, February 21, 1866. April, 1888, to June, 1892, with Aspinwall & Lincoln, Boston, Mass., in miscellaneous private practice. June, 1892, to August, 1893, assistant to city engineer, Marlboro, Mass., on sewer and waterworks construction. August, 1893, to August, 1895; with Massachusetts State board of health on preliminary surveys and estimates for an additional water supply for the metropolitan district. August, 1895, to December, 1904, assistant engineer and division engineer for metropolitan water board and metropolitan water and sewerage board on construction of works for additional water supply. 1901 to December, 1904, division engineer in charge of construction of Wachusett dam; during 1904 also chief inspector on same. December 16, 1904, appointed construction engineer in Reclamation Service.

SOPER, RALPH C., engineering aid. Address, Washington, D. C. Born, South Royalton, Vt., February 3, 1881. Education, Dartmouth College, 1902, A. B.; Thayer School of Civil Engineering, 1904, C. E. 1903, assistant on railroad survey. 1904–5, with Illinois Steel Company. Appointed in Reclamation Service May 1, 1905.

SPALDING, WALTER J., engineering aid. Address, Salt Lake City, Utah. Graduate of Missouri University, degree of B. S. in C. E. Summer of 1903, levelman and transitman on proposed St. Louis and St. Paul Railroad. 1904, student assistant in surveying, having charge of parties in the field and examining and grading papers. August 24, 1904, appointed engineering aid in Reclamation Service. Junior member American Society Civil Engineers.

STEERE, ANTHONY ENOCH, engineering aid. Address, Minidoka, Idaho. Born, Scranton, Iowa, January 22, 1882. Rhode Island College, B. S., mechanical engineering, 1900. 1901–2, student civil engineering, Rhode Island College. 1902–1904, with metropolitan water and sewerage board, Boston, Mass. Appointed in Reclamation Service, June, 1904.

STILES, ALBERT IRVINE, engineering aid. Address, Washington, D. C. Born in Pennsylvania, October 1, 1883. Education, Washington, D. C., high schools; civil-engineering course at Stanford University. 1900–1902, chainman, computer, and draftsman, General Land Office. 1903–4, aid, Coast and Geodetic Survey, on surveys in Alaska. April 25, 1904, appointed engineering aid, Reclamation Service. Levelman and transitman, Utah Lake project.

STONE, CHARLES HENRY HOWARD, assistant analyst. Born in Massachusetts, September 11, 1876. Educated in Newton public schools. Entered Massachusetts Institute of Technology in 1892; graduated in 1896, chemical course, degree B. S. 1897, in charge of chemical laboratories at Rhode Island State College of Agriculture and Mechanic Arts. 1897–1900, chemist with Massachusetts State board of health. 1900–1905, assistant State gas inspector of Massachusetts. January 16, 1905, appointed assistant analyst in Reclamation Service.

STROEBE, GEORGE G., engineering aid. Address, Mandan, N. Dak. Born Ferrysburg, Mich., October 11, 1877. Education, Chicago University, University of Wisconsin, C. E. Instructor descriptive geometry and drawing, University of Wisconsin, 1904–5. May 2, 1905, appointed in Reclamation Service.

STUBBLEFIELD, GARFIELD, engineering aid. Address Exeter, Mo. Born in Missouri, July 18, 1878. Graduate of University of Arkansas, and attended Cornell University civil-engineering course. Summers of 1900, 1901, and 1902, levelman, topographer, and draftsman. 1902–3, instructor in civil engineering at University of Arkansas. 1903, levelman, United States Geological Survey. September 1, 1904, appointed engineering aid in Reclamation Service.

SWENDSEN, WARREN G., engineering aid. Address, Box S, Salt Lake City, Utah. Born in Utah, July 26, 1880. B. S. in civil engineering, Agricultural College of Utah, 1904. Summer of 1901, employed at Utah experiment station. Summer of 1902, transitman and levelman on survey of Cub River reservoir site and proposed aqueduct, and later in reconnaissance party, United States Geological Survey. Summer of 1903, assistant to resident engineer, Glennsferry Land and Irrigation Company. 1904, with Reclamation Service, gaging streams and on reconnaissance work as transitman and levelman. December 19, 1904, appointed engineering aid.

TABOR, ERNEST F., engineer. Address, U. S. Geol. Survey, Cody, Wyo. Born February 26, 1866. Graduate of grammar school; attended high school and University of California. 1887–1889, computer and assistant, San Diego Flume Company. 1890, preliminary surveys for irrigation works for the Escondido irrigation district, and 1894–95, in charge construction of same. 1891, on resurvey of subdivision of Rancho Rincon del Diablo. 1892–93, assistant engineer, Bear Valley Irrigation Company. 1895–96, location and construction city waterworks of San Jacinto, Cal. 1896, plans and estimates for waterworks for Elsinore, Cal. 1897–98, on river gagings and minor land, irrigation, and mining surveys. 1898–1900, with San Diego Flume Company. 1900, with Southern California Mountain Water Company. 1901–2, on railroad surveys. 1902–3, superintendent for Escondido irrigation district. 1903–4, engineer (superintendent), Sweetwater Water Company. April 25, 1904, appointed assistant engineer, Reclamation Service; October 25, 1904, promoted to engineer.

WEBSTER, NORMAN E., jr., accountant. Address, Washington, D. C. Born, Decatur, Mich., March 26, 1869. Education, Decatur High School and one year at Union College, Schenectady, N. Y. Degrees of LL. B., 1897, and LL. M., 1898, from National University Law School, Washington, D. C. Admitted to the bar of the District of Columbia 1899. Began office work in February, 1885, and continued thereat continuously since, excepting one year at college. Was for six years with Michigan Buggy Company, Kalamazoo, Mich., in all grades up to assistant cashier in charge of collections; was division superintendent in the department of collections, World's Columbian Exposition, Chicago, 1903; and was for eleven years in the office of the Auditor for the Post-Office Department. Stood No. 1 in special examination for bookkeeper, Reclamation Service, August 31, 1904, and appointed October 19, 1904. April 19, 1905, designation changed to accountant.

WELLS, CHARLES EDWIN, constructing engineer. Address, Casper, Wyo. Born in North Adams, Mass., April 27, 1858. Graduate Worcester Polytechnic Institute, B. S., 1880. Summer of 1880, assistant engineer in charge of sewer construction, North Adams, Mass. 1880–1885, assistant engineer Troy and Greenfield Railroad and Hoosac tunnel. 1886, assistant on track laying and ballasting, Chicago, Burlington and Northern Railroad. 1887–88, division engineer, Chicago, Santa Fe and California Railroad. Latter part of 1888, locating engineer, Sault Ste. Marie and Southwestern Railroad. 1889–90, assistant engineer, Chicago and Northwestern Railway. 1891–1893, engineer and superintendent of construction for McArthur Brothers Construction Company, of Chicago. 1894, in charge of improvement of city property, Davenport, Iowa. 1895, superintendent of waterworks, Galesburg, Ill. 1895–1905, with metropolitan water and sewerage board of Massachusetts. August, 1895, to September, 1903, as division engineer on construction of Wachusett aqueduct and reservoir, and after September, 1903, as engineer of the reservoir department. January 4, 1905, appointed constructing engineer in the Reclamation Service.

WHITBY, WILLIS R., engineering aid. Address, Billings, Mont. Born in Wisconsin, August 5, 1878. Educated at Oshkosh Normal School and University of Wisconsin. Graduate of University of Wisconsin, B. S. Member U. of W. S. C. E. In 1903, on railroad construction for Chicago, Burlington and Quincy Railroad. 1904–5, in charge of extra gang work in maintenance-of-way department, Great Northern Railway. April 28, 1905, appointed in Reclamation Service.

WILLIAMS, CHARLES PAGE, engineer. Born in Missouri, February 3, 1866. Graduated from University of Missouri in 1890. 1890–91, instructor in mathematics, Missouri Military Academy. 1891–92, topographer and observer on triangulation on survey of upper Missouri River. 1893, agent for H. W. Sebastian, St. Louis, Mo., contractor for highway bridges, pile driving, dock construction, etc. 1894–95, draftsman, United States engineer office, Sioux City, Iowa. 1895–1897, in street-extension department, Washington, D. C. 1897–1899, in United States engineer office, Portland, Me., engaged on plans for river and harbor improvements and fortifications. 1899–1900, in charge of construction of fortifications, Great Diamond Island, Maine. 1901–2, in charge of construction of fortifications and power house at Fort Williams, Me.. 1902–1904, in charge of construction of fortification, sea wall, installation of steam and electric plants, Fort Michie, N. Y. Member American Society of Civil Engineers. Appointed engineer in the Reclamation Service June 20, 1904.

WILSON, WALTER C., engineering aid. Address, New Haven, Conn. Education, Earlham College, Richmond, Ind., 1904, C. E. 1903, rodman with Pennsylvania Railroad in Indiana. 1904, making drawings for Louisiana Purchase Exposition. March 24, 1905, appointed engineering aid in Reclamation Service.

YOUNG, HENRY AMERMAN, engineer. Address, Huntley, Mont. Born Elizabeth, N. J., November 6, 1876. Education, College of Civil Engineering, Cornell University, degree of C. E. Associate member American Society of Civil Engineers. 1899 to 1900, field work and designing and drafting with New York Central Railroad. 1900 to 1902, assistant engineer, department of street cleaning and parks; superintendent of construction and repair shops, Habana, Cuba. 1902, building roads in New York and designing locks and dams in Alabama. 1902–1905, in charge of construction work, United States engineer department, Fort Washington, Md. May 30, 1905, appointed in Reclamation Service.

LIST OF TECHNICAL PAPERS BY MEMBERS OF RECLAMATION SERVICE.

The following is a partial list of papers relating to irrigation and irrigation engineering heretofore prepared by engineers and other employees of the Reclamation Service and published either in book form or in technical periodicals. Only the most important of those relating to irrigation or irrigation engineering are included, and many minor papers have been omitted.

BABB, CYRUS C., engineer.

Hydrograhpy of the Potomac Basin: Trans. Am. Soc. Civil Eng., vol. 27, 1892, pp. 21–33.

Discussion on Black Eagle Falls Dam, Montana: Trans. Am. Soc. Civil Eng., vol. 27, 1892, p. 67.

Rainfall and River Flow: Trans. Am. Soc. Civil Eng., vol. 28, 1893, pp. 323–337.

Surveys and Examinations of Uinta Indian Reservation: House Doc. No. 671, 57th Cong., 1st sess., 1902.

BENNETT, S. G., engineer (with J. B. Lippincott).

Relation of Rainfall to Run-off in California: Eng. News, vol. 47, No. 23, p. 467.

BIEN, MORRIS, supervising engineer.

Right of Way on Public Lands for Irrigation Power and Railroad Purposes: Circulars General Land Office, 1894–1901.

Grants of Rights of Way over Public Lands: Ann. Repts. General Land Office, 1893–1902.

Right of Way upon the Public Lands: Proc. Third Irr. Cong., Denver, 1894.

Relation of Federal and State Laws to Irrigation: Proc. Eleventh Irr. Cong., Ogden, 1903, and Water-Sup. and Irr. Paper No. 93, U. S. Geol. Survey, 1904.

Draft of a State Irrigation Code, 1904.

Discussion of a Draft of an Irrigation Code: Proc. Twelfth Irr. Cong., El Paso, 1904.

CHANDLER, ALBERT E., engineer.

Water Storage on Cache Creek, California: Water-Sup. and Irr. Paper No 45, U. S. Geol. Survey, 1901.

Duty of Water in Tule River Basin, California: Report of Irr. Investigations for 1901, Office of Experiment Stations, Bull. No. 119, Washington, 1902.

Irrigation Development in Nevada: Proc. Nevada Acad. Sci., vol. 1, No. 1, Reno, Nev., 1904.

CHANDLER, E. F., assistant engineer.

Irrigation in North Dakota: Bull. Univ. North Dakota, October, 1904.

Methods of Stream Measurement: Third Bien. Rept. North Dakota State Geol. Survey.

River Systems of North Dakota: First Bien. Rept. North Dakota State Engineer.

DOERFLING, RICHARD G., irrigation engineer.

Ueber Wasserbau im allgemeinen und Stauanlagen im besonderen: Technologist, vol. 6, No. 3, 1900.

DRANE, BRENT SKINNER, engineering aid.

Collection of Data from Vertical Velocities Observations in Southeastern Rivers: Water-Sup. and Irr. Paper No. 95, U. S. Geol. Survey, 1904., pp. 139–150.

Report on the Destructive Flood of June 6, 1903, near Spartanburg, S. C.: Water-Sup. and Irr. Paper No. 96, U. S. Geol. Survey, 1904, pp. 13–19.

DURYEE, EDWARD, cement expert.

Comparison of Standard Specifications for Testing Portland Cement: Eng. News, 1900.

Cement: Water-Sup. and Irr. Paper No. 33, U. S. Geol. Survey, 1900, pp. 82–90.

Refractory Linings for Portland Cement Kilns: Eng. Record, 1900.

The First Manufacture of Portland Cement by Direct Process in Rotary Kilns: Eng. News.

FELLOWS, A. L., engineer.

Water Resources of the State of Colorado: Water-Sup. and Irr. Paper No. 74, U. S. Geol. Survey, 1902.

Measurement of Water: Irr. Bull. No. 1, Office State Engineer of Colorado.

The Gunnison Tunnel: Forestry and Irr., November, 1902.

FIELD, JOHN E., engineer.

Irrigation from Big Thompson River: Bull. No. 118, U. S. Dept. Agriculture, 1902.

FITCH, CHARLES H., engineer.

Land Classification in Sonora Quadrangle, California: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 5, 1900, pp. 569–571.

Land Classification in Yosemite Quadrangle, California: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 5, 1900, pp. 571–574.

Woodland of Indian Territory: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 5, 1900, pp. 603–662.

HALL, BENJAMIN H., consulting engineer.

Hydraulic Excavation: Eng. Soc. Ann., Univ. Georgia, 1894.

Plans for Irrigation of Rio Grande Valley in New Mexico, Texas, and Mexico: Third Ann. Rept. U. S. Reclamation Service.

HAMLIN, HOMER, engineer.

Water Resources of Salinas Valley, California: Water-Sup. and Irr. Paper No. 89, U. S. Geol. Survey, 1904.

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HANNA, F. W., assistant engineer.

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HARDESTY, W. P., assistant engineer.

The Swan Lake Reservoir and Canal System, Utah: Eng. News, August 29, 1895.

The Bear River Irrigation System, Utah: Eng. News, February 6 and 13, 1896.

The Twin Lakes Reservoir, Colorado: Eng. News, June 30, 1898.

The Montrose Irrigation Canal, Colorado: Eng. News, March 23, 1899.

The Utilization of Utah Lake as a Storage Reservoir: Eng. News, May 21, 1903.

HENNY, D. C., consulting engineer.

Water Pipe Built of Wooden Staves: Trans. Tech. Soc. Pac. Coast, March, 1892.

Effect of Curves in Pressure Pipes upon the Required Support: Trans. Tech. Soc. Pac. Coast, November, 1893.

Discussions of Flow of Water: Trans. Am. Soc. Civil Eng., July, 1898, and November, 1900.

Wooden-Stave Pipes *v.* Riveted-Steel Pipes: Jour. Assoc. Eng. Socs., November, 1898.

Discussion on Stave Pipe, with Records of Original Experiments: Trans. Am. Soc. Civil Eng., June, 1898.

HORTON, ROBERT E., hydrographer.

The Indian River Dam: Eng. News, May 18, 1899 (with George W. Rafter and Wallace Greenalch).

Discussion on Flow of Water over Dams: Trans. Am. Soc. Civil Eng., 1900, vol. 44, pp. 340–345.

Backwater and Flowage: Trans. Michigan Eng. Soc., 1902, pp. 49–57.

Weir Experiments, Coefficients, and Formulas (in preparation as a Water-Sup. and Irr. Paper, U. S. Geol. Survey).

HOYT, JOHN C., engineer.

Methods of Measurement of the Flow of Streams: Eng. News, January 14, 1904.

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LEE, WILLIS T., assistant geologist.

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LIPPINCOTT, JOSEPH B., supervising engineer.

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California Hydrography: Water-Sup. and Irr. Paper No. 81, U. S. Geol. Survey.

Water Supply in San Bernardino Valley, California: Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 4, pp. 540–629.

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MATTHES, GERARD H., engineer.

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MEANS, THOMAS H., engineer of soils.

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Soil Survey in the Pecos Valley, New Mexico: Field Operations Div. Soils, Dept. of Agriculture, 1899.

MEANS, THOMAS H.—Continued.

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Reclamation of Alkali Lands in Egypt: Bull. 21, Bureau Soils, Dept. of Agriculture.

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Crops Grown on Alkali Lands in Egypt: Yearbook, U. S. Dept Agriculture, 1902 (with Thos. H. Kearney).

Use of Alkali Waters in Irrigation: Circular 10, Bureau Soils, Dept. of Agriculture; also Water-Sup. and Irr. Paper No. 93, U. S. Geol. Survey.

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MURPHY, E. C., engineer.

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Method of Computing Daily and Monthly Discharge of Streams of Sandy, Changeable Bed: Eng. News, April 21, 1904.

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Increase of Rainfall in Kansas: Proc. Kans. Acad. Sci., vol. 14.

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Irrigation in the United States: Bull. 23, Eleventh Census United States, 1893.

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Run-off from Various Drainage Basins in United States: Eng. News, vol, 29, 1893, p. 484.

NEWELL, FREDERICK HAYNES—Continued.

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Water Supply for Irrigation: Thirteenth Ann. Rept. U. S. Geol. Survey, 1893.

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Irrigation on the Great Plains: Yearbook Dept. Agriculture, 1896.

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NOBLE, THERON A., engineer.

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Gaging of Cedar River: Trans. Am. Soc. Civil Eng., vol. 41, p. 1.

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Flow of Water in Wood Pipes: Trans. Am. Soc. Civil Eng., vol. 49, pp. 112, 158.

Cooperation of State and Federal Governments in Topographic and Hydrographic Surveys: Pac. Northwest Soc. of Eng., vol. 3, No. 5.

RUSSELL, W. S., engineer.

Construction of Lower Otay Dam: Eng. Record, June, 1897, and Eng. News, March 10, 1898.

SLICHTER, CHARLES S., consulting engineer.

Theoretical Investigations of the Motions of Ground Waters: Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1899, pp. 295–385.

Mechanics of Slow Motions: Sci., vol. 11, 1900, pp. 535–537.

Motions of Underground Waters: Water-Sup. and Irr. Paper No. 67, U. S. Geol. Survey, 1902.

New Method of Determining the Velocity of Underground Water: Eng. News, vol. 48, 1902, p. 151.

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Measurements of the Underflow at the Narrows of the Hondo and San Gabriel River, California: Eng. Record, vol. 48, 1903, pp. 462–465.

Tests of Irrigation Pumping Plants and Wells in the Valley of the Rio Grande: Eng. News, vol. 52, 1904, pp. 280–282.

Measurement of Underflow Streams in Southern California: Jour. Western Soc. Engineers, vol. 4, 1904, pp. 632–653.

Description of Underflow Meter: Water-Sup. and Irr. Paper No. 114, U. S. Geol. Survey, 1905.

SLICHTER, CHARLES S.—Continued.
- Field Measurements of the Motions of Ground Waters: Water-Sup. and Irr. Paper No. 140, 1905.
- Observations on the Ground Waters of the Rio Grande Valley: Water-Sup. and Irr. Paper No. 141, 1905.

SMITH, CHESTER W., constructing engineer.
- Wachusett Dam: Harvard Eng. Jour., January, 1903.

STANNARD, JAY D., assistant engineer.
- Practical Irrigation: Yearbook Dept. Agr., 1900 (with C. T. Johnston).
- Irrigation in the Valley of Weber River, Utah: Bull. 124, Office Experiment Stations, Dept. Agriculture.
- Irrigation Investigations in Humboldt River Valley, Nevada: Bull. 54, Nev. Agr. Exp. Sta.
- Use of Water from Wood River, Idaho: Bull. 133, Office Experiment Stations, Dept. Agriculture.

STEINER, CHARLES R., assistant engineer.
- The Roxbury Dam Failure: Eng. News, June 18, 1903.
- Proposed Steel Dam, Reclamation Service, U. S. Geol. Survey: Eng. News, June 11, 1903.
- Steel Dams for Storage Reservoirs: Eng. News, August 6, 1903, and September 3, 1903.
- Economical Construction of Reinforced Concrete Beams and Floor Slabs: Eng. News, March 9, 1905.

TABOR, E. F., engineer.
- Experiments on Pumping from Artesian Wells at San Jacinto, Cal.: Eng. News, October 15, 1896.

TAYLOR, THOMAS U., resident hydrographer.
- The silting up of Lake McDonald and the leak at the Austin Dam: Eng. News, vol. 43, pp. 135–136.
- Failure of Austin Dam: Eng. News, April, May, and December, 1900.
- Austin Dam: Water-Sup. and Irr. Paper No. 40, U. S. Geol. Survey.
- Irrigation Systems of Texas: Water-Sup. and Irr. Paper No. 71, U. S. Geol. Survey.
- Rice Irrigation of Texas: Rice Industry, Houston, Tex., December, 1904.

WISNER, GEORGE Y., consulting engineer.
- Worthless Government Engineering: Eng. Mag., 1892.
- Hydraulics of Rivers having Alluvial Beds: Technic, 1896.
- Geodetic Field Work: Trans. Am. Soc. C. E., 1883.
- Brazos River Harbor Improvement: Trans. Am. Soc. C. E., 1891.
- Breakwaters, Sea Walls, and Jetties: Eng. Mag., 1893.
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- Regulation of Lake Levels: Proc. Deep Waterway Assn., 1895.
- Regulation of Lake Levels: Rept. to Congress, 1899.
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PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 146.]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

Most of the above publications may be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they may be obtained, free of charge (except classes 2, 7, and 8), on application.

2. A certain number are allotted every member of Congress, from whom they may be obtained, free of charge, on application.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they may be had at prices slightly above cost.

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The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This paper is the nineteenth in Series I and the twelfth in Series J, the complete lists of which follow:

SERIES I—IRRIGATION.

WS 2. Irrigation near Phœnix, Ariz., by A. P. Davis. 1897. 98 pp., 31 pls. and maps. (Out of stock.)

WS 5. Irrigation practice on the Great Plains, by E. B. Cowgill. 1897. 39 pp., 11 pls. (Out of stock.)

WS 9. Irrigation near Greeley, Colo., by David Boyd. 1897. 90 pp., 21 pls. (Out of stock.)

WS 10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker. 1898. 51 pp., 11 pls. (Out of stock.)

WS 13. Irrigation systems in Texas, by W. F. Hutson. 1898. 68 pp., 10 pls. (Out of stock.)

WS 17. Irrigation near Bakersfield, Cal., by C E. Grunsky. 1898 96 pp., 16 pls. (Out of stock.)

WS 18. Irrigation near Fresno, Cal., by C. E. Grunsky. 1898. 94 pp., 14 pls. (Out of stock.)

WS 19. Irrigation near Merced, Cal., by C. E. Grunsky 1899. 59 pp., 11 pls. (Out of stock.)

WS 23 Water-right problems of Bighorn Mountains, by Elwood Mead. 1899. 62 pp., 7 pls. (Out of stock.)

WS 32. Water resources of Porto Rico, by H M Wilson. 1899. 48 pp , 17 pls. and maps. (Out of stock.)

WS 43. Conveyance of water in irrigation canals, flumes and pipes, by Samuel Fortier. 1901. 86 pp., 15 pls. (Out of stock.)

WS 70. Geology and water resources of the Patrick and Goshen Hole quadrangles, Wyoming, by G. I. Adams. 1902. 50 pp., 11 pls.

WS 71. Irrigation systems of Texas, by T. U. Taylor. 1902. 137 pp., 9 pls.
WS 74. Water resources of the State of Colorado, by A. L. Fellows. 1902. 151 pp., 14 pls.
WS 87. Irrigation in India (second edition), by H. M. Wilson. 1903. 238 pp., 27 pls.
WS 93. Proceedings of first conference of engineers of the Reclamation Service, with accompanying papers, compiled by F. H. Newell, chief engineer. 1904. 361 pp.
WS 117. The lignite of North Dakota and its relation to irrigation, by F. A. Wilder. 1904. 59 pp., 8 pls.
WS 143. Experiments on steel-concrete pipes on a working scale, by J. H. Quinton. 1905. 61 pp., 4 pls.
WS 146. Proceedings of second conference of engineers of the Reclamation Service, with accompanying papers, compiled by F. H. Newell, chief engineer. 1905. 267 pp.

The following papers also relate especially to irrigation: Irrigation in India, by H. M. Wilson, in Twelfth Annual, Part II; two papers on irrigation engineering, by H. M. Wilson, in Thirteenth Annual, Part III.

SERIES J—WATER STORAGE.

WS 33. Storage of water on Gila River, Arizona, by J. B. Lippincott. 1900. 98 pp., 33 pls. (Out of stock.)
WS 40. The Austin dam, by Thomas U. Taylor. 1900. 51 pp., 16 pls. (Out of stock.)
WS 45. Water storage on Cache Creek, California, by A. E. Chandler. 1901. 48 pp., 10 pls.
WS 46. Physical characteristics of Kern River, California, by F. H. Olmsted, and Reconnaissance of Yuba River, California, by Marsden Manson. 1901. 57 pp., 8 pls.
WS 58. Storage of water on Kings River, California, by J. B. Lippincott. 1902. 100 pp., 32 pls. (Out of stock.)
WS 68. Water storage in Truckee Basin, California-Nevada, by L. H. Taylor. 1902. 90 pp., 8 pls.
WS 73. Water storage on Salt River, Arizona, by A. P. Davis. 1902. 54 pp., 25 pls.
WS 86. Storage reservoirs on Stony Creek, California, by Burt Cole. 1903. 62 pp., 16 pls.
WS 89. Water resources of Salinas Valley, California, by Homer Hamlin. 1904. 91 pp., 12 pls.
WS 93. Proceedings of first conference of engineers of the Reclamation Service, with accompanying papers, compiled by F. H. Newell, chief engineer. 1904. 361 pp.
WS 116. Water resources of Santa Barbara, Cal., by J. B. Lippincott. 1904. 99 pp., 8 pls.
WS 146. Proceedings of second conference of engineers of the Reclamation Service, with accompanying papers, compiled by F. H. Newell, chief engineer. 1905. 267 pp.

The following paper also should be noted under this heading: Reservoirs for irrigation, by J. D. Schuyler, in Eighteenth Annual, Part IV.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

AUGUST, 1905.

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Reference.

U. S. Dept. of the Interior.

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