

COMPLIMENTS OF THE

BOARD OF WATER SUPPLY

OF THE

CITY OF NEW YORK

MUNICIPAL BUILDING



SCHOHARIE RESERVOIR—General view of construction work on the Gilboa dam, looking easterly. The masonry placed in the dam is shown to the left of the cableway tower in foreground with excavation for the spillway channel in progress beyond. The full length of the stone tramway is shown in this view. In right foreground are the Steen Kill dike and temporary flume. In the background Road 1 and the temporary road can be seen with the crusher plant and quarry on Stevens mountain at extreme right.

SIXTEENTH ANNUAL REPORT

OF THE

Board of Water Supply

OF THE

CITY OF NEW YORK



Accompanied by Report of

THE CHIEF ENGINEER

January 1, 1922

NEW YORK CITY

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BOARD OF WATER SUPPLY CITY OF NEW YORK

Municipal Building,

NEW YORK, January 1, 1922.

HON. JOHN F. HYLAN,

Mayor of The City of New York,

Executive Chamber, City Hall, New York.

SIR:

We submit herewith the report of the Board of Water Supply of the City of New York for the year ending December 31, 1921.

The activities of the Board during the past year included the preparation and award of the contracts for the completion of the steel-pipe siphon installations along the Catskill aqueduct, the advancement of studies and investigations looking toward the development of possible future sources of water-supply and extensions of the delivery system within the City limits, and the vigorous prosecution of construction work upon the Schoharie project.

On July 1, the Board of Estimate and Apportionment authorized an issue of Corporate Stock to the amount of \$15,750,000.00 for the use of the Board of Water Supply, and a considerable portion of these funds will be expended in connection with the construction of two pipes in each of the fourteen steel-pipe siphons of the Catskill aqueduct, at various locations in Ulster, Orange, Putnam and Westchester counties. In the original plans for the aqueduct, the complete installation at these points was deferred until such future time as the Schoharie development would be well under way; accordingly, only one of the three pipes necessary for developing the full capacity of the Catskill aqueduct was installed at that time. The other two pipes will now be constructed at each of the siphons in order that the aqueduct will be capable of delivering the full supply of not less than 500 million gallons daily to the City when water from the Schoharie watershed will have become available in 1924.

The new siphon pipes will consist of riveted steel pipes from 7 feet 4 inches to 11 feet 3 inches in nominal inside diameter, with plates from $\frac{7}{16}$ to $\frac{9}{16}$ inch in thickness; they will be lined with Portland cement mortar, enveloped with concrete and covered

with an embankment of earth or of earth and rock. Their construction is comprised in three contracts which were awarded on November 23, in the total amount of \$6,252,788.00. One of these contracts is for steel pipe aggregating about 12,200 feet in length in the three siphons between the Ashokan reservoir and the Hudson river, and was awarded to Rice and Ganey, Inc., in the estimated amount of \$999,325.00. Frederick Snare Corporation was awarded the contract for approximately 34,000 linear feet of pipe in the seven siphons between the Hudson river and the Kensico reservoir; the estimated amount of this contract is \$2,978,103.00. The third contract, which totals \$2,275,360.00, was awarded to the Thomas Crimmins Contracting Company, and covers the construction of about 20,000 feet of pipes in the four siphons between the Kensico and the Hill View reservoirs. The contractors have been served with notice to begin work and have started preliminary operations on the three contracts.

On June 17, the Board of Estimate and Apportionment adopted the following resolution:

“WHEREAS, The Commissioner of Water Supply, Gas and Electricity under date of May 6, 1921, has advised the Board of Estimate and Apportionment as to the necessity of an additional supply of water to meet future needs of the City, and also as to the more immediate need of an additional tunnel and pipe conduits to convey water to the Boroughs of Brooklyn, Queens and Richmond; and

“WHEREAS, This Board is of the opinion that it is imperative that studies looking to the solution of these problems should be immediately undertaken;

“RESOLVED, That the Board of Estimate and Apportionment hereby requests that the Board of Water Supply shall undertake studies to ascertain the most desirable and best sources for an additional supply of water for the City of New York and the manner in which the supply can best be delivered to the several boroughs of the City, in accordance with Chapter 724 of the Laws of 1905, as amended; and the Commissioner of Water Supply, Gas and Electricity and the Board of Water Supply are requested to co-operate to the full extent in order that the interests of the City may be best served and to report back to this Board from time to time.”

Upon receipt of this request, active investigations of new sources of water supply and studies for a new tunnel and conduits in the City were immediately begun and material progress had been made at the end of the year. In view of conditions, preferential attention was given to the immediate needs of the Borough of Richmond. Our investigations and recommendations will be made the subject of special reports.

The Hugh Nawn Contracting Company continued work on the construction of the Gilboa dam and appurtenant structures, and at the end of the year all essential plant had been installed, two large quarries had been developed, the portions of the highways included in this contract were practically completed, the Schoharie Creek and Steen Kill stream-control systems were substantially finished, excavation was in progress in the foundation of the dam, cut-off and spillway channel, and the placing of masonry for the dam and of embankment for the dike was well under way; the value of the work done to date is \$1,193,449.38, or approximately 17.5 per cent. of the estimated amount of \$6,819,910.00 at which the contract was awarded in 1919.

Excavation of the Shandaken tunnel was carried on by the Shandaken Tunnel Corporation throughout the entire year, and at the present time the tunnel is being driven from six of the eight shafts and approximately 63 per cent. of the entire length of 18.1 miles has been excavated; on December 31, the gross estimates for payment totaled \$5,590,565.00. The contract for this work was awarded November 9, 1917, in the estimated amount of \$12,138,738.00, to The Degnon Contracting Company, which company made an assignment to the present contractor November 10, 1920.

The Coffin Valve Company has completed and delivered 93 per cent. of the materials included in the contract for gate-valves, hydraulic cylinders, bronze castings and appurtenances for the Gilboa dam and the Shandaken tunnel, and at the end of the year \$84,052.55 had been earned by the contractor.

The removal of bodies, head-stones and monuments from the cemeteries on lands acquired for the construction of the Schoharie reservoir was included in the contract which was awarded June 9 to Charles Meads & Co., who completed the work on September 16 at a total cost of \$8,728.20.

The contracts for 7½ miles of marginal highways around the Schoharie reservoir, the Schoharie and Manor Kill steel highway bridges and approaches, the masonry guide walls at the Ashokan spillway and the final planting in the vicinity of the Kensico dam were completed during the year.

Catskill water was delivered into the City of New York at the average rate of 406 millions of gallons per day throughout the past year, furnishing about 60 per cent. of the total supply from all municipal sources. The quantity of Catskill water consumed during 1921 was 148 billion gallons, which makes a total of 700 billion gallons delivered to the City since water from this source first became available for distribution in 1917.

On December 31, the Ashokan reservoir was about half full, the storage at that time being 66 billions of gallons as compared

with 92 billion gallons on the same date last year. The Kensico reservoir is slightly less than nine-tenths full at the present time with a storage of $25\frac{1}{2}$ billions of gallons, there being a net gain of two billion gallons during the past year.

The Board of Water Supply Police continued to patrol the territory in the vicinity of the work on the Schoharie development. The construction of the new siphon pipes during the coming year will necessitate the assignment of additional men at locations accessible to the points where the contractors' operations will be in progress.

The Schoharie commission for the trial of claims submitted a report during the year wherein awards aggregating \$57,112.25 were made for fee and easement parcels upon which claims totaling \$256,103.75 had been made by the former owners. There were filed during the year, 29 claims in the total amount of \$125,475.00 for damages alleged to be due to the operations of the Board of Water Supply in the Schoharie and Esopus watersheds. There were brought to trial before the damage commissions 14 claims aggregating \$1,111,180.00; total awards of \$150,325.00 were made upon eight of these claims; of the remaining six, one for \$5,000.00 was withdrawn and five totaling \$55,000.00 were dismissed. To date, a total of 1,064 claims have been tried, aggregating \$8,673,522.83 in amount claimed, and awards totaling \$1,293,222.80 have been made by the damage commissions, but appeals, exceptions, modifications, etc., reduced the actual awards uncontested to \$566,954.14.

At the end of the year, the expenditures of the Board of Water Supply for all purposes since its organization totaled \$150,168,338.01, apportioned under the following main classifications: Administration, \$2,033,996.56; Police, \$2,666,787.74; Surveys, Maps, Plans, etc., \$5,037,180.42; Acquisition of Property, \$19,385,719.66, and Permanent Construction, \$121,044,653.63.

The Board of Water Supply force on December 31 consisted of 291 employees, which total is thirty greater than the number employed on the corresponding date last year. The force is divided as follows: Administration, 33, including the Commissioners and the offices of the Secretary, Auditor and Bureau of Claims; Police, 59; engineers and assistants, 155, and labor class, 44.

Respectfully submitted,

GEORGE J. GILLESPIE,	} Commissioners of the Board of Water Supply
<i>President,</i>	
L. J. O'REILLY,	
JAMES P. SINNOTT,	

ADMINISTRATION BUREAU

BENJ. F. EINBIGLER, *Secretary*

Benj. F. Einbigler continued as Secretary and Mary M. Logan as Assistant Secretary throughout the entire year. On October 26, Assistant Secretary Ralph T. Stanton resigned, effective the same date.

BOARD OF WATER SUPPLY FORCE, EXCLUSIVE OF ENGINEERING AND
POLICE BUREAUS, 1921

TITLE	JANUARY 1	DECEMBER 31
Secretary.....	1	1
Assistant Secretaries.....	2	1
Auditor.....	1	1
Confidential Secretaries.....	3	3
Chief, Bureau of Claims.....	1	1
Assistant Engineer.....	1	1
Investigators of Claims.....	3	3
Bookkeeper.....	1	1
Clerks.....	10	10
Stenographers and Typewriters.....	6	6
Messenger.....	1	1
Laborer.....	1	1
Totals.....	31	30

The work of this office continued as heretofore under the established systems. The additional activities of the Board in the past year in the studies and investigations to increase the water-supply to Staten Island and to procure an additional supply of water for the City, as well as the authorization of funds and the awarding of contracts for the new siphon pipes of the Catskill aqueduct, are reflected in the routine work of this bureau, as shown in the weekly minutes of the Board of Water Supply.

The purchase of supplies for the use of the various bureaus of the Board was continued upon requisition and open market orders and amounted to \$41,101.89 for the year.

POLICE BUREAU

The work of this bureau continued under the direction of President George J. Gillespie during the past year.

FORCE IN POLICE BUREAU, 1921

TITLE	JANUARY 1	APPOINTED	SEPARATED	DECEMBER 31
Sergeants.....	9	2	1	10
Patrolmen.....	36	7	4	39
Clerk.....	1	.....	.....	1
Caretakers.....	4	.....	.....	4
Hostlers.....	4	.....	.....	4
Cleaner.....	—	1	.....	1
Totals.....	54	10	5	59

No new precincts were opened during the year, but the rapid growth of the construction work in the Schoharie watershed, necessitating the employment of larger numbers of men by the contractors, increased the activities of the force and made it necessary to lengthen posts of patrol at some places and establish new ones at others. The additions to the contractors' forces also resulted in more infractions of the law than heretofore, which were promptly dealt with. All told, there were 23 arrests for felonies and 140 for misdemeanors.

Constant watch has been maintained to prevent the smuggling of drugs and liquor into the camps and marked success has been achieved in this direction, a great deal of evidence pertaining to violations of the Liquor Law having been placed in the hands of the proper authorities, which brought about successful raids, culminating in the imposition of heavy fines on the offenders.

In anticipation of the need of more men for the policing of the areas involved in the approaching construction work on the siphon pipes of the Catskill aqueduct, the Municipal Civil Service Commission has been requested to establish a list of eligibles for the position of patrolman-on-aqueduct; a promotion list of eligibles for sergeant-on-aqueduct is already in existence. A total of 31 horses and 7 motor-cycles was assigned for use by the force at the end of the year.

BUREAU OF CLAIMS

JOHN H. McMANUS, *Chief of Bureau*

As in previous years, there were referred to this bureau for record, classification, investigation and preparation for defense, all claims arising under the Water Supply Act, due to the development of the Catskill Mountain sources. These claims, in general, comprised damage to established business, decrease in value of real estate not taken, loss of employment in established business or upon lands taken, damage by reason of the diversion of the waters of streams, and the taking of easement in and fee of all other real estate.

The following table shows the claims received during the year and on file to date:

CLAIMS FILED WITH BOARD OF WATER SUPPLY TO DECEMBER 31, 1921

CLASS	ON FILE DECEMBER 31, 1920		RECEIVED DURING 1921		TOTAL ON FILE DECEMBER 31, 1921	
	Number	Amount	Number	Amount	Number	Amount
SCHOHARIE SUPPLY						
Business.....	67	\$516,681.77	9	\$51,075.00	76	\$567,756.77
Indirect Real Estate....	19	71,800.00	11	44,900.00	30	116,700.00
Wage.....	3	1,090.00	.....	.....	3	1,090.00
Diversion.....	11	*	2	14,000.00	13	14,000.00
Totals.....	100	589,571.77	22	109,975.00	122	699,546.77
ESOPUS SUPPLY						
Business.....	711	3,528,251.00	.....	.....	711	3,528,251.00
Indirect Real Estate....	347	1,056,400.00	2	2,000.00	349	1,058,400.00
Wage.....	116	33,666.35	.....	.....	116	33,666.35
Diversion.....	177	4,615,380.00	5	13,500.00	182	4,628,880.00
Totals.....	1,351	9,233,697.35	7	15,500.00	1,358	9,249,197.35
Grand totals ...	1,451	\$9,823,269.12	**29	\$125,475.00	**1,480	\$9,948,744.12

* No amounts specified in these claims.

** There are records on file of 1,759 claims. Of these 1,515 are for claims coming under the jurisdiction of the Bureau of Claims, the remainder being otherwise settled by the Board of Water Supply. There are included in the 1,515 claims, but not listed in the above table, the following Schoharie claims filed to date: 29 fee and easement claims totaling \$1,052,140.00, 5 highway claims (no amounts stated) and 1 use and occupation claim for \$5,000.00, making a total of 35 claims aggregating \$1,057,140.00.

The investigation of claims was carried on as in previous years and reports on specific claims were given to the Special Corporation Counsel as these cases were noticed for trial. Assistance was also given in the preparation for argument of motions, and affidavits were made by members of the bureau, who attended all sessions before the Supreme Court and the Appellate Division. General reports were made by the three local investigators of claims on the

lumber and stone industries, the number of new buildings around the Ashokan reservoir, property transfers, the migration of inhabitants from within the Schoharie Reservoir taking and on other matters relating to claims.

A study was made of water powers in the Schoharie region, and information was furnished the Special Counsel as to purchase, time of sale, consideration, hight of fall and drainage area. Creek conditions below the City's reservoirs were studied. Witnesses were interviewed and obtained for the City, and views of property were made with them. Members of the bureau attended all sittings of commissions, accompanied them on all views of properties, testified before the commissions and aided in the examination of witnesses. Data for trial were obtained by investigations in the field, at the various county clerks' offices, at the State offices in Albany, at City and Federal offices in New York City and from Government departments in Washington.

During the year the following commissions held sessions at New York City, Kingston and Albany:

Schoharie—

The Schoharie Commission (General).

The Delaware and Eastern Railway Commission.

Esopus—

The Commission for the re-trial of the Saugerties
Water Power cases.

The Commission for the re-trial of the E. I. du
Pont deNemours Powder Company claim.

New Damage Commission 5.

The Schoharie Commission (General) held five daily sessions prior to its re-organization and reported on ten fee parcels, four permanent tunnel easements, one permanent road easement, twelve business claims and one use and occupation claim. The total amount claimed for fee and easement parcels was \$256,103.75 and total awards for same aggregated \$57,112.25. For business and use and occupation claims a total of \$46,100.00 was claimed, with aggregate awards of \$7,665.00. One of the fee awards, amounting to \$32,500.00, was for a parcel of 130 acres with an adjacent permanent tunnel easement of $1\frac{3}{4}$ acres, this property consisting of a farm with a house and barns, a waterfall with a 27-foot vertical drop and a tract of large timber. Another award of \$8,163.50 was made for the taking of a telephone system within the Schoharie Reservoir basin.

The commission re-organized on April 26, 1921, and since that date has held 45 daily sessions in the taking of testimony on eight cases upon which it will report next year.

The commission has before it three water-power claims,—the Schwarzwaelder claim on the Manor Kill involving a power right to part of the falls, that of the Tri-County Light and Power Company situated at Gilboa Falls, and the claim of the Smedberg Estate at Devasego Falls. Questions as to title have arisen in these cases in which claims aggregating \$1,308,000.00 have been filed. In preparation for the defense of these claims it was necessary to examine into the power plants and power markets in the Schoharie, Mohawk, Hudson, Upper Susquehanna and Upper Delaware valleys.

The Tri-County Light and Power Company objected to the appointment of the Schoharie Commission to try its claim, asserting that the Water Supply Act was unconstitutional, but the objections were overruled by the Special Term of the Supreme Court and its decision was sustained by the Appellate Division. In connection with this case, full copies were made of all the claimant's yearly reports to the Public Service Commission from 1912 to date and extracts were made from the reports filed with the State Tax Commission. Similar information was obtained as to the West Branch Light and Power Company, an associated company. An analysis was made of the complete daily records of the claimant's plant and much chronological, hydrographic, financial and other data were compiled for use in the trial of this claim.

The Towns of Gilboa, Conesville, Roxbury and Prattsville and the County of Schoharie have filed claims on account of the taking by the City of certain highways and the substitution of new ones therefor and the first of these claims has been partly tried. The Corporation Counsel was furnished with data as to the nature and condition of the old and substituted roads and specifications and other information obtained by the bureau regarding State and county highways were used in the cross-examination of witnesses.

The Delaware and Eastern Railway Commission was organized on March 18, 1921, and has held six daily sessions. This commission was appointed to take proof and determine first, whether said company is the owner of a right-of-way through the City's lands, and second, whether it had become defunct through its failure to comply with the provisions of the Railroad Law, requiring it to expend a certain amount on the construction of its

road and put it in operation within a specified period. Should the finding of the commission on these points be favorable to the claimant, it is then to take proof and determine the damages to which the claimant may be entitled.

From certain portions of the order appointing this commission, the City appealed to the Appellate Division of the Supreme Court and raised the questions of title and forfeiture of franchise referred to in said order, and also contended that the Water Supply Act gave the City the exclusive right, in the first instance, to move for the appointment of commissions, and also that its application for leave to deposit one-half the assessed valuation of Parcel 8, Schoharie, should have been granted. The Appellate Division affirmed the order appealed from, and later denied the City's application for a re-argument or leave to go to the Court of Appeals. Thereafter, the claimant applied for a court order restraining the City from retaining possession of Parcel 8, which motion was denied, this decision being later affirmed by the Appellate Division.

Aid was furnished the Corporation Counsel in the preparation of briefs and other papers and for argument before the Court on all matters relating to this case and representatives of the bureau attended all hearings before the court.

The Commission for the Re-trial of the Saugerties Water Power Cases held ten sessions during the year and awarded the Diamond Mills Paper Company the sum of \$90,000.00 and the Martin Cantine Company \$53,000.00 for diversion of the waters of the Esopus creek, these awards being \$227,000.00 less in the aggregate than those previously made in 1918. Digests were made of the testimony given at the previous trials of these cases, levels were run on the Barclay dam, cross-examinations of claimants' witnesses were worked up, testimony was given, and the Special Counsel was assisted in his briefs for the commission.

The Commission for the re-trial of the E. I. duPont deNemours Powder Company Claim.—This commission held twelve daily sessions, concluded the taking of testimony and will submit its report during 1922. For this re-trial the case was digested and additional study was made of the wood flour market through the New York Custom House records and at Napanoch, N. Y., Salisbury, Vt., and Newhall, Me., where wood flour was manufactured.

New Damage Commission 5 re-organized on February 7, 1921, held thirty-eight daily sessions and took testimony on about eighty

claims during the year. This commission tried the use and occupation claims of Stella T. Flood, whose property lies below the Olive Bridge dam at the Tongore Dam site. Testimony was given through the bureau from actual observation of conditions as of 1906 in regard to boring and surveying operations.

In the re-trial of the claim of Nathan and Max Klein, filed for diversion of the waters of the Esopus creek, the claimants seek to recover damages to lands situated a quarter of a mile from the Esopus creek and fronting on a binnekill, the surface of which is eight feet higher than the creek. It was claimed that this binnekill was fed by the Esopus creek and that the diversion of the creek caused a decrease in its depth rendering it unsuitable for the cutting of ice. The bureau, by means of surveys, ground-water measurements, stream-flow data and ice observations extending over a long period of years maintained that this pond was unaffected by such diversion.

General Matters.—In the matter of Frank Vicevich against The City of New York, the Supreme Court decided that certain lands originally owned by the State situated in the region of the Esopus South Siphon chamber were not acquired by the City from the State by the filing of its maps and the taking of the oaths of the commissioners. Some years after the filing of the City's maps, these lands were sold by the State to the plaintiff and steps were taken by him to oust the City. After the decision of the Court, the City entered into negotiations of settlement with the plaintiff and the matter is now before the Board of Estimate and Apportionment.

The Cohoes Power and Light Corporation served a summons and complaint on the Corporation Counsel on October 4, 1921, stating, among other things, that the diversion of Schoharie water to New York City will deprive it of that water for power that steps have not been taken by the City to determine the damage to the plaintiff and that the diversion of Schoharie water will damage the corporation in excess of one million dollars. The plaintiff asked the Supreme Court to restrain the City from proceeding further with the construction of the Schoharie reservoir and the Shandaken tunnel and from diverting any part of the waters of the Schoharie creek. In connection with this case, there were turned over to the Corporation Counsel notes taken on February 5, 1915, at Cohoes when the new power-house was being constructed, and those taken at later dates up to the present time, and data in the office of this bureau obtained from the files of the Public Service Commission.

CLAIMS TRIED BEFORE COMMISSIONS

DISPOSITION AND DATES	NUMBER	AMOUNT CLAIMED		AWARDS
		Before Board of Water Supply	At Trial	
SCHOHARIE SUPPLY				
BUSINESS AND INDIRECT DAMAGE CLAIMS				
Awarded—				
To December 31, 1920.....	25	\$179,000.00	\$190,000.00	*\$47,285.00
During 1921.....	6	21,100.00	21,100.00	7,325.00
Total to December 31, 1921.....	31	200,100.00	211,100.00	†54,610.00
Dismissed—				
To December 31, 1920.....	12	25,900.00	25,900.00	.....
During 1921.....	5	**55,000.00	**55,000.00	.....
Total to December 31, 1921.....	17	80,900.00	80,900.00	.....
Withdrawn—				
To December 31, 1920.....	2	2,500.00	2,500.00	.....
During 1921.....	1	5,000.00	5,000.00	.....
Total to December 31, 1921.....	3	7,500.00	7,500.00	.....
Totals, Schoharie supply.....	51	288,500.00	299,500.00	†54,610.00
ESOPUS SUPPLY				
BUSINESS, INDIRECT DAMAGE AND DIVERSION CLAIMS				
Awarded—				
To December 31, 1920.....	632	6,296,890.00	5,947,125.00	1,095,612.80
During 1921.....	2	1,030,080.00	1,030,080.00	143,000.00
Total to December 31, 1921.....	634	7,326,970.00	6,977,205.00	††1,238,612.80
Dismissed—				
To December 31, 1920.....	347	1,318,117.00	1,323,647.00	.....
During 1921.....	.....	.....	.....	.....
Total to December 31, 1921.....	347	1,318,117.00	1,323,647.00	.....
Withdrawn—				
To December 31, 1920.....	31	71,200.00	71,200.00	.....
During 1921.....	.....	.....	.....	.....
Total to December 31, 1921.....	31	71,200.00	71,200.00	.....
Mistrial.....	1	1,970.83	1,970.83	.....
Totals, Esopus supply.....	1,013	8,718,257.83	8,374,022.83	††1,238,612.80
Grand totals.....	1,064	\$9,006,757.83	\$8,673,522.83	\$1,293,222.80

* Does not include awards in three claims which were included in the fee awards made in the Second Separate Report of New Schoharie Commission 1.

** Includes a combined claim, the major portion of which was dismissed.

† Appeals reduce the actual awards uncontested to \$52,960.00.

†† Appeals, exceptions, modifications, etc., reduce the actual awards uncontested to \$513,994.14.

REPORT OF THE AUDITOR

NEW YORK, January 1, 1922.

BOARD OF WATER SUPPLY,
Municipal Building, New York.

GENTLEMEN:

There is transmitted herewith the annual report covering the financial operations of the Board of Water Supply for the year 1921, and for the period from June 9, 1905, to date, composed of 3 tables and 25 statements which disclose the outlay for construction of the Catskill Water Supply system from Silver Lake reservoir on Staten Island in the south to the Schoharie reservoir in the north.

In the annual report for 1920, attention was directed to the correlative features of the tables and statements contained therein, especially Tables 2 and 3 as supported by the several statements referred to on said tables which depict the functional activities of the Board of Water Supply, classified in detail from the beginning of the work in 1905 to the date of said report.

The importance of presenting the result of construction operations, as revealed in the tables and statements mentioned, may now be fully appreciated by comparing the outlay during the year 1921 with the preceding year, as set forth in Tables 2 and 3 of the present report, from which it will be noted that construction activities have perceptibly increased in the second development of the Catskill system known as the Schoharie supply.

A brief summary of the outlay and resulting operations during 1921, as compared with 1920, on a percentage basis as disclosed in Table 3, follows:

	1920	1921
ADMINISTRATION		
Salaries.....	03.740	01.776
Other expenses.....	00.233	00.140
POLICE		
Salaries.....	02.826	01.709
Other expenses.....	00.640	00.262
ENGINEERING		
SURVEYS, MAPS, PLANS, ETC.		
Salaries.....	00.675	00.631
Other expenses.....	00.028	00.065
CONSTRUCTION		
Salaries.....	13.243	06.563
Other expenses.....	02.229	00.857
Contracts.....	50.618	79.518
ACQUISITION OF LAND	25.768	08.479
Totals	100.00	100.00

An examination of the tables and supporting statements will disclose the increase in construction activities as a whole with the attendant overhead, or covering separate projects in detail as may be desired.

In the present report, attention is directed to real estate acquisition. For construction of the Catskill aqueduct, necessary reservoirs and appurtenant works, 23,779.252 acres of land have been acquired in fee and easement, representing an outlay of \$19,385,719.66.

In order to facilitate taking the large tracts of land required because of the magnitude of the work, acquisition of real estate is divided into several main geographical divisions, and each of said divisions is subdivided into sections as required in Section 5 of Chapter 724 of the Laws of 1905, in order that awards for a particular section of land might reasonably be passed upon by the commissioners of appraisal within the limits of a year from the date of filing their oaths of office.

For further convenience the above-mentioned sections are again divided into individual parcels and listed according to owners from which the land is to be taken over. An examination of the statements mentioned below will reveal the disbursements for acquisition of land as follows:

Statement 4.—Classified disbursements to date, segregating the outlay in the main construction departments and divisions, thus making it possible to ascertain the outlay for real estate as a whole, or for any department or division of the work.

Statement A.—A composite statement which discloses the total outlay to date for land acquired and indirect damages in the development of the Esopus and Schoharie watersheds. The percentages supplied indicate the attendant classified expenses incurred for acquiring the property and likewise for indirect damages.

Statement B.—Disclosing acreage of land acquired for construction purposes in each of the main departments, the amount disbursed for acreage upon which awards have been confirmed by the courts and also the amount paid for expenses in each of said main departments; likewise, the average cost of land per acre and average attendant expense per acre in each of said departments. Percentages also indicate the proportionate expense outlay to awards paid.

Statement C.—Said statement shows the detailed classified outlay to date for acquisition of land as a whole and for each main department, or separately by sections, as may be desired.

By examining Statement 4 and Statements A, B and C the detailed cost of acquiring land over any part of the work may be promptly ascertained.

The following consolidated statement shows the gross outlay to date for construction purposes and for supervision of construction; likewise, the outlay for preliminary surveys, maps, plans, etc., prior to actual construction. The percentages indicate the proportionate disbursements for the several purposes shown and distinctively for:

- (a) The Schoharie supply.
- (b) The Esopus supply.
- (c) Preliminary surveys, maps, plans, etc., other sources.

DISBURSEMENTS FROM JUNE 9, 1905, TO DECEMBER 31, 1921

	AMOUNT	PER CENT. OF GRAND TOTAL	PER CENT. OF TOTAL FOR SCHOHARIE CONSTRUCTION AND SUPERVISION
SCHOHARIE SUPPLY			
CONSTRUCTION			
Contracts.....	\$6,754,151.40	04.498	70.889
Acquisition of land, and damages.....	1,187,253.53	00.791	12.461
Taxes.....	25,887.90	00.017	00.272
Total construction.....	7,967,292.83	05.306	83.622
SUPERVISION OF CONSTRUCTION			
ENGINEERING			
Salaries.....	930,721.26	00.620	09.768
Equipment.....	19,173.62	00.013	00.201
Supplies and expenses.....	97,236.00	00.064	01.021
Total engineering.....	1,047,130.88	00.697	10.990
*ADMINISTRATION			
Salaries.....	232,195.77	00.155	02.437
Equipment.....	387.32	00.000	00.004
Supplies and expenses.....	15,900.53	00.011	00.167
Total administration.....	248,483.62	00.166	02.608
**POLICE			
Salaries.....	220,360.05	00.147	02.313
Equipment.....	8,111.00	00.005	00.085
Supplies and expenses.....	36,344.45	00.024	00.382
Total police.....	264,815.50	00.176	02.780
Total supervision of construction.....	1,560,430.00	01.039	16.378
Total construction and supervision.....	\$9,527,722.83	06.345	100.00

	AMOUNT	PER CENT. OF GRAND TOTAL	PER CENT. OF TOTAL FOR SCHOHARIE SURVEYS, MAPS, PLANS, ETC.
SCHOHARIE SUPPLY			
PRELIMINARY SURVEYS, MAPS, PLANS, ETC.			
ENGINEERING			
Agreements.....	\$114,486.64	00.076	25.020
Salaries.....	252,772.90	00.169	55.240
Equipment.....	10,773.89	00.007	02.355
Supplies and expenses.....	32,613.31	00.022	07.127
Damages to land.....	1,598.64	00.001	00.349
Total engineering.....	412,245.38	00.275	90.091
†ADMINISTRATION			
Salaries.....	42,543.48	00.028	09.297
Equipment.....	98.50	00.000	00.022
Supplies and expenses.....	2,700.83	00.002	00.590
Total administration.....	45,342.81	00.030	09.909
Total surveys, maps, plans, etc., Schoharie supply.....	457,588.19	00.305	100.00
Total disbursements, account Schoharie supply, for construction, supervision and surveys, maps, plans, etc.	\$9,985,311.02	06.650	

	AMOUNT	PER CENT. OF GRAND TOTAL	PER CENT. OF TOTAL FOR ESOPUS CONSTRUCTION AND SUPERVISION
ESOPUS SUPPLY			
CONSTRUCTION			
Contracts.....	\$96,878,234.99	64.513	71.584
Agreements.....	2,842,183.21	01.893	02.100
Work by force account.....	2,561,147.33	01.706	01.893
Acquisition of land, and damages.....	18,199,426.13	12.119	13.448
Taxes.....	781,320.35	00.520	00.577
Total construction.....	121,262,312.01	80.751	89.602
SUPERVISION OF CONSTRUCTION			
ENGINEERING			
Salaries.....	8,671,955.11	05.775	06.408
Equipment.....	220,242.17	00.146	00.163
Supplies and expenses.....	1,261,440.29	00.840	00.932
Total engineering.....	10,153,637.57	06.761	07.503
††ADMINISTRATION			
Salaries.....	1,242,611.83	00.827	00.918
Equipment.....	32,603.29	00.022	00.024
Supplies and expenses.....	241,159.59	00.161	00.178
Total administration.....	1,516,374.71	01.010	01.120
††POLICE			
Salaries.....	2,000,326.02	01.332	01.478
Equipment.....	118,453.04	00.079	00.088
Supplies and expenses.....	283,193.18	00.189	00.209
Total police.....	2,401,972.24	01.600	01.775
Total supervision of construction.....	14,071,984.52	09.371	10.398
Total construction and supervision.....	\$135,334,296.53	90.122	100.00

	AMOUNT	PER CENT. OF GRAND TOTAL	PER CENT. OF TOTAL FOR ESOPUS SURVEYS, MAPS, PLANS, ETC.
ESOPUS SUPPLY			
PRELIMINARY SURVEYS, MAPS, PLANS, ETC.			
ENGINEERING			
Contracts.....	\$299,856.59	00.200	06.766
Agreements.....	568,121.87	00.378	12.818
Salaries.....	2,592,448.02	01.726	58.494
Equipment.....	141,175.30	00.094	03.185
Supplies and expenses.....	600,278.92	00.400	13.544
Damages to land.....	6,340.92	00.004	00.143
Total engineering.....	4,208,221.62	02.802	94.950
ADMINISTRATION			
Salaries.....	174,283.32	00.116	03.932
Equipment.....	7,653.33	00.005	00.173
Supplies and expenses.....	41,858.77	00.028	00.945
Total administration.....	223,795.42	00.149	05.050
Total surveys, maps, plans, etc., Esopus supply.....	4,432,017.04	02.951	100.00
Total disbursements, account Esopus supply, for construction, supervision and surveys, maps, plans, etc.	\$139,766,313.57	93.073	.....

	AMOUNT	PER CENT. OF GRAND TOTAL
PRELIMINARY SURVEYS, MAPS, PLANS, ETC., OTHER SOURCES		
RONDOUT SUPPLY		
Taxes.....	\$91.61	00.000
Agreements.....	8,004.40	00.005
Salaries.....	54,900.47	00.037
Equipment.....	5,279.86	00.004
Supplies and expenses.....	15,366.16	00.010
Damages to land.....	500.00	00.000
Total, Rondout supply.....	84,142.50	00.056
CATSKILL CREEK SUPPLY		
Salaries.....	19,471.46	00.013
Equipment.....	170.77	00.000
Supplies and expenses.....	1,217.33	00.001
Total, Catskill Creek supply.....	20,859.56	00.014
LONG ISLAND SUPPLY		
Agreements.....	19,169.27	00.013
Salaries.....	196,391.16	00.131
Equipment.....	15,159.26	00.010
Supplies and expenses.....	58,079.19	00.038
Damages to land.....	85.00	00.000
Total, Long Island supply.....	288,883.88	00.192
NEW SOURCES OF SUPPLY		
Salaries.....	20,552.54	00.014
Equipment.....	974.84	00.000
Supplies and expenses.....	1,300.10	00.001
Total, New Sources of Supply.....	22,827.48	00.015
Total disbursements, all purposes, to December 31, 1921.....	\$150,168,338.01	100.00

RECAPITULATION

	AMOUNT	PER CENT. OF GRAND TOTAL
DISBURSEMENTS, ACCOUNT SCHOHARIE SUPPLY		
Actual construction.....	\$7,967,292.83	05.306
Supervision of construction.....	1,560,430.00	01.039
Total construction and supervision.....	9,527,722.83	06.345
Preliminary surveys, maps, plans, etc.....	457,588.19	00.305
Total, Schoharie supply.....	9,985,311.02	06.650
DISBURSEMENTS, ACCOUNT ESOPUS SUPPLY		
Actual construction.....	121,262,312.01	80.751
Supervision of construction.....	14,071,984.52	09.371
Total construction and supervision.....	135,334,296.53	90.122
Preliminary surveys, maps, plans, etc.....	4,432,017.04	02.951
Total, Esopus supply.....	139,766,313.57	93.073
PRELIMINARY SURVEYS, MAPS, PLANS, ETC., OTHER SOURCES		
Rondout supply.....	84,142.50	00.056
Catskill Creek supply.....	20,859.56	00.014
Long Island supply.....	288,883.88	00.192
New Sources of Supply.....	22,827.48	00.015
Total disbursements to December 31, 1921.....	\$150,168,338.01	100.00

* Disbursements for 1920 and 1921 and 50 per cent. of disbursements for 1919.

** Disbursements for 1919, 1920 and 1921.

† Fifty per cent. of disbursements for 1919.

†† Disbursements for 1908 to 1918, inclusive.

‡ Disbursements for 1905, 1906 and 1907.

The funds disbursed to date, *i.e.*, as set forth in the foregoing consolidated statement, were realized from the sale of corporate stock. The actual cash requirements for interest and amortization purposes to cover the corporate stock issued from 1905 to 1921, inclusive, aggregate as follows:

YEAR	INTEREST	AMORTIZATION	TOTALS
1906.....	\$900.00	\$1,194.42	\$2,094.42
1907.....	19,650.00	26,150.47	45,800.47
1908.....	133,167.50	56,812.68	189,980.18
1909.....	277,077.50	86,967.29	364,044.79
1910.....	605,222.31	162,154.81	767,377.12
1911.....	1,232,106.45	304,319.71	1,536,426.16
1912.....	2,234,853.58	544,177.92	2,779,031.50
1913.....	2,901,621.61	683,265.64	3,584,887.25
1914.....	3,849,539.56	942,266.23	4,791,805.79
1915.....	4,660,001.84	1,111,328.56	5,771,330.40
1916.....	5,240,173.86	1,225,628.82	6,465,802.68
1917.....	5,497,613.81	1,279,330.76	6,776,944.57
1918.....	5,727,614.15	1,324,643.36	7,052,257.51
1919.....	5,727,614.15	1,324,643.36	7,052,257.51
1920.....	5,727,614.15	1,324,643.36	7,052,257.51
1921.....	5,727,614.15	1,324,643.36	7,052,257.51
1922.....	5,727,614.15	1,324,643.36	7,052,257.51
Totals.....	\$55,289,998.77	\$13,046,814.11	\$68,336,812.88

The assessment rolls for the year 1921 covering real estate remaining under the jurisdiction of the Board of Water Supply were examined in the several townships in which the land is located. The valuations were found to be just and equitable and comparable with assessments levied on holdings of adjacent owners.

In the Town of Roxbury, examination disclosed an increase in the valuation on Schoharie Parcel 4 from \$3,000.00 to \$10,000.00. Objection thereto resulted in the parcel being restored to the original valuation of \$3,000.00. An erroneous assessment on Parcel 218 of \$1,000.00, in the Town of Roxbury, was also stricken from the tax roll.

In the Town of Prattsville, the entire area of Schoharie Parcels 211, 212 and 213 appeared on the assessment rolls, while only 4.77 acres are situated in said town, the balance of 117.98 acres being located in the Town of Roxbury. With the aid of the Corporation Counsel's office this inequality was adjusted so that the land is properly assessed in the towns as located.

Miscellaneous revenue collected during the year and deposited with the City Chamberlain amounted to \$11,767.65.

Respectfully submitted

HENRY C. BUNCKE,

Auditor.

REPORT AND FINANCIAL STATEMENT OF THE BOARD OF WATER SUPPLY

DISBURSEMENTS FOR THE YEAR AND TOTAL DISBURSEMENTS FROM JUNE 9, 1905, TO DATE (CLASSIFIED BY BUREAUS, DEPART- MENTS AND SUBDIVISIONS OF WORK, ETC.) AND ESTIMATED LIABILITIES AT THIS DATE, DECEMBER 31, 1921

TABLE 1.....	Summary of the financial condition at the close of business, December 31, 1921.
TABLE 2.....	Comparative disbursements for personal services, supplies, etc., for the year 1921 and total to date by departments.
TABLE 3.....	Comparative disbursements for personal services, supplies, etc., from 1905 to 1921 and total to date by bureaus.
STATEMENT 1.....	Classified disbursements, Administration bureau.
STATEMENT 1-A.....	Disbursements, Police bureau, for personal services, supplies, etc., by precincts.
STATEMENT 2.....	Disbursements, Engineering bureau, by departments and divisions.
STATEMENT 3.....	Disbursements, Engineering bureau, for personal services, supplies, etc., by departments and divisions, account surveys, maps, plans, etc.
STATEMENT 4.....	Classified disbursements, Engineering bureau, by departments and divisions, account acquisition of property.
STATEMENT 5.....	Classified disbursements, Engineering bureau, for personal services, supplies, etc., by departments and divisions, account permanent construction.
STATEMENT 6.....	Estimated liabilities on account of contracts and agreements in force as of December 31, 1921.
STATEMENT 6-A.....	Completed contracts and agreements.
STATEMENT 7.....	Classified disbursements, Esopus supply, by departments, account surveys, maps, plans, etc.
STATEMENT 8.....	Classified disbursements, Schoharie supply, by divisions, account surveys, maps, plans, etc.
STATEMENT 9.....	Classified disbursements, Other Sources of Supply, account surveys, maps, plans, etc.
STATEMENT 10.....	Classified disbursements, Headquarters department, Esopus supply, by divisions, account permanent construction.
STATEMENT 11.....	Classified disbursements, Reservoir department, Esopus supply, account permanent construction.
STATEMENT 12.....	Classified disbursements, Northern Aqueduct department, Esopus supply, by divisions, account permanent construction.
STATEMENT 13.....	Classified disbursements, Southern Aqueduct department, Esopus supply, by divisions, account permanent construction.
STATEMENT 14.....	Classified disbursements, City Aqueduct department, Esopus supply, by divisions, account permanent construction.
STATEMENT 15.....	Classified disbursements, Schoharie supply, by divisions, account permanent construction.
STATEMENT 15-A.....	Classified disbursements, Headquarters department, Schoharie supply, by divisions, account permanent construction.
STATEMENT 15-B.....	Classified disbursements, Gilboa division, Schoharie supply, by subdivisions, account permanent construction.
STATEMENT 15-C.....	Classified disbursements, Prattsville division, Schoharie supply, by subdivisions, account permanent construction.
STATEMENT 15-D.....	Classified disbursements, Allaben division, Schoharie supply, by subdivisions, account permanent construction.
STATEMENT 16.....	Classified disbursements, Esopus supply, by departments, account work by force account.
STATEMENT A.....	Comparative disbursements for acquisition of land and indirect damages.
STATEMENT B.....	Comparative costs of acquiring land.
STATEMENT C.....	Classified disbursements for acquisition of land and indirect damages by departments and proceedings.

TABLE 1

SUMMARY OF THE FINANCIAL CONDITION AT THE CLOSE OF BUSINESS DECEMBER 31, 1921

RESOURCES			
Amount of Corporate Stock authorized to be issued, pursuant to Section 33 of Chapter 724, Laws of 1905, in accordance with the resolutions adopted by the Board of Estimate and Apportionment from June 16, 1905, to July 1, 1921, as follows:			
DATE OF RESOLUTION	AMOUNT AUTHORIZED		
June 16, 1905.....	\$100,000.00		
November 24, 1905.....	500,000.00		
December 8, 1905.....	1,002,000.00		
November 23, 1906.....	10,000,000.00		
June 14, 1907.....	15,000,000.00		
March 20, 1908.....	11,000,000.00		
June 26, 1908.....	22,600,000.00		
February 26, 1909.....	41,200,000.00		
July 1, 1910.....	25,000,000.00		
March 6, 1913.....	14,715,000.00		
June 26, 1913.....	755,000.00		
January 29, 1915.....	3,000.00		
January 31, 1916.....	22,175,400.00		
July 1, 1921.....	15,750,000.00		
Premium on sale of corporate stock.....		\$179,800.00	
Miscellaneous revenue.....		539,322.97	
		214,584.35	
Total resources.....			\$180,554,307.32
DISBURSEMENTS AND LIABILITIES			
DISBURSEMENTS			
	YEAR 1921	TOTAL TO DATE	
Per Statement 1, Administration bureau.....	\$106,366.86	\$2,033,996.56	
Per Statement 1-A, Police bureau.....	109,384.07	2,666,787.74	
Per Statement 2, Engineering bureau.....	5,334,396.17	145,467,553.71	
Total disbursements.....	\$5,550,147.10	\$150,168,338.01	
LIABILITIES			
Contracts—			
A. Registered after public letting, as per Statement 6.....	\$18,975,373.32		
B. Agreements, as per Statement 6.....	371,904.79		
Open market orders, as per order register.....	10,910.78		
Acquisition of property, as per register.....	76,860.13		
All other miscellaneous, as per register.....	1,288.02		
Total liabilities.....			19,436,337.04
Total disbursements and liabilities.....			169,604,675.05
January 1, 1922, amount available, i. e., excess of resources over disbursements and liabilities.....			\$10,949,632.27

STATEMENT 1

CLASSIFIED DISBURSEMENTS OF ADMINISTRATION BUREAU

	1921	TOTAL TO DATE
SALARIES		
Commissioners.....	\$35,741.93	\$593,220.10
Secretaries to Commissioners.....	6,982.25	96,201.13
Secretary's office.....	21,750.64	319,687.71
Auditor's office.....	25,262.74	311,880.98
Chief Clerk's office.....	5,000.00	216,661.75
Examiner of Real Estate, Taxes and Legislation's office.....	.....	85,610.92
Messengers, cleaners, etc.....	3,190.00	48,006.70
Garage.....	616.70	11,858.47
Stenographic services, State Board hearings.....	.....	8,506.64
EQUIPMENT		
Furniture and fixtures.....	247.57	19,613.44
Transportation equipment.....	.....	21,129.00
CONSUMABLE SUPPLIES AND EXPENSES		
Stationery and printing.....	5,182.10	93,657.86
Traveling expenses.....	463.60	20,498.33
Postage, telegrams, telephone and messenger service.....	699.58	23,708.50
Miscellaneous expenses.....	300.60	29,697.59
Rent of offices.....	.....	92,101.06
Advertising.....	10.50	3,160.51
Contingent fund.....	.....	5,000.00
Automobile hire.....	.....	3,686.45
Repairs and maintenance of automobiles.....	918.65	22,689.98
Advertising State Board hearings.....	.....	7,268.01
All other expenses, State Board hearings.....	.....	151.43
Totals.....	\$106,366.86	\$2,033,996.56

STATEMENT 1-A

DISBURSEMENTS, POLICE BUREAU, BY PRECINCTS

	SALARIES		EQUIPMENT		CONSUMABLE SUPPLIES AND EXPENSES		TOTALS	
	1921	Total to Date	1921	Total to Date	1921	Total to Date	1921	Total to Date
Headquarters.....	\$3,801.22	\$155,794.17	\$4,327.62	\$89,403.14	\$2,226.04	\$52,851.75	\$10,355.48	\$298,049.06
Grand Gorge precinct.....	8,510.00	11,929.28	76.45	239.85	560.08	842.61	9,146.53	13,011.74
Gilboa precinct.....	18,894.66	34,896.65	20.15	161.56	1,180.47	5,431.29	20,095.28	40,489.50
Prattsville precinct.....	25,910.26	67,958.35	110.89	1,076.32	2,872.14	11,685.15	28,893.29	80,719.82
West Kill precinct.....	18,874.28	57,343.58	5.27	54.42	1,312.06	8,161.48	20,191.61	65,559.48
Allaben precinct.....	18,863.39	51,870.54	6.02	204.04	1,832.47	9,197.27	20,701.88	61,271.85
Inspector's office.....		24,950.29		801.91		7,772.56		33,524.76
Instruction squad.....		39,895.51		3,738.32		9,922.98		53,556.81
Olive Bridge—West Shokan precinct.....		125,183.20		5,887.65		19,291.43		150,362.28
Brown Station precinct.....		133,985.14		822.19		19,841.06		154,648.39
Ashokan precinct.....		20,955.97		122.38		4,229.90		25,308.25
Stone Ridge precinct.....		32,942.51		1,162.47		4,866.61		38,971.59
High Falls precinct.....		35,438.17		1,180.19		5,260.48		41,878.84
Mohonk precinct.....		17,811.31		117.02		1,796.37		19,724.70
New Paltz precinct.....		74,980.02		1,800.25		12,319.82		89,100.09
West Hurley precinct.....		78,364.11		803.98		11,477.99		90,646.08
New Hurley precinct.....		26,180.89		949.32		3,354.87		30,485.08
East Coldenham precinct.....		40,492.51		541.71		7,499.73		48,533.95
Gardiner precinct.....		41,170.62		331.13		5,346.36		46,854.11
Cornwall precinct.....		90,644.89		2,246.00		13,114.91		106,005.80
Nelsonville—Cold Spring precinct.....		90,221.04		891.96		8,914.81		100,027.81
Garrison precinct.....		84,873.68		1,233.44		7,739.34		93,846.46
Sprout Brook precinct.....		45,812.29		567.01		5,808.50		52,187.80
Peekskill precinct.....		98,840.06		2,342.28		10,395.11		111,577.45
Yorktown Heights precinct.....		72,742.18		821.28		8,657.32		82,220.78
Kithawan—Millwood precinct.....		60,241.03		826.44		5,897.32		66,964.79
Pleasantville precinct.....		81,327.14		820.08		6,497.04		88,644.26
Valhalla precinct.....		172,942.93		986.95		12,100.65		186,030.53
Kensico precinct.....		121,679.87		4,175.54		22,794.32		148,649.73
Elmsford precinct.....		98,406.47		1,398.61		9,880.51		109,685.59
Yonkers precinct.....		130,805.67		856.60		6,588.09		138,250.36
Totals.....	\$94,853.81	\$2,220,686.07	\$4,546.40	\$126,564.04	\$9,983.86	\$319,537.63	\$109,384.07	\$2,666,787.74

STATEMENT 6

ESTIMATED LIABILITIES ON ACCOUNT OF CONTRACTS AND AGREEMENTS IN FORCE DECEMBER 31, 1921

CONTRACTS

CONTRACT	CONTRACTOR	ESTIMATED COST	AMOUNT PAID ON ACCOUNT	AMOUNT RETAINED	AMOUNT EARNED	ESTIMATED LIABILITY
SCHOHARIE SUPPLY						
200.....	Shandaken Tunnel Corporation, Assignee of The Degnon Contracting Company	\$12,138,738.00	\$5,235,228.31	.....	\$5,235,228.31	\$6,903,509.69
203.....	Hugh Nawn Contracting Company.....	6,819,910.00	1,074,104.44	\$119,344.94	1,193,449.38	5,745,805.56
207.....	Coffin Valve Company	90,480.00	79,849.92	4,202.63	84,052.55	10,630.08
ESOPUS SUPPLY						
AQUEDUCT DEPARTMENT						
209.....	Rice and Ganey, Inc.....	999,325.00	.....	.....	.....	999,325.00
210.....	Frederick Snare Corporation.....	2,978,103.00	.....	.....	.....	2,978,103.00
211.....	Thomas Crimmins Contracting Company.....	2,275,360.00	.....	.....	.....	2,275,360.00
RESERVOIR DEPARTMENT						
3.....	MacArthur Bros. Co. and Winston & Co.....	12,276,259.17	12,275,849.19	409.98	12,276,259.17	*409.98
10.....	Jules Breuchaud.....	1,085,282.10	1,084,826.59	455.51	1,085,282.10	*455.51
60.....	MacArthur Brothers Company.....	806,898.70	805,398.70	1,500.00	806,898.70	*1,500.00
NORTHERN AQUEDUCT DEPARTMENT						
PEEKSKILL DIVISION						
2.....	Benjamin B. Odell, Jr., Sole Receiver of Thomas McNally Company.....	3,979,242.28	3,970,326.49	8,915.79	3,979,242.28	*8,915.79
SOUTHERN AQUEDUCT DEPARTMENT						
55.....	Rinehart & Dennis Co.....	4,370,363.90	4,363,380.25	6,983.65	4,370,363.90	*6,983.65
CROTON DIVISION						
23.....	Glyndon Contracting Co.....	1,111,916.71	1,110,954.23	962.48	1,111,916.71	*962.48
24.....	Bradley Contracting Co.....	862,067.85	859,437.05	2,630.80	862,067.85	*2,630.80

STATEMENT 6 (Concluded)

CONTRACT	CONTRACTOR	ESTIMATED COST	AMOUNT PAID ON ACCOUNT	AMOUNT RETAINED	AMOUNT EARNED	ESTIMATED LIABILITY
ESOPUS SUPPLY (Concluded)						
SOUTHERN AQUEDUCT DEPARTMENT (Concluded)						
KENSICO DIVISION						
9.....	Empire Engineering Company, Inc., Assignee of H. S. Kerbaugh, Inc., Assignee of John C. Rodgers, James M. Rodgers and John J. Hagerty.....	\$8,006,294.39	\$8,005,294.39	\$1,000.00	\$8,006,294.39	*\$1,000.00
HILL VIEW DIVISION						
30.....	Keystone State Construction Company.....	3,213,865.16	3,213,840.58	24.58	3,213,865.16	*24.58
CITY AQUEDUCT DEPARTMENT						
174.....	Charles Meads & Co.....	42,108.40	41,921.64	186.76	42,108.40	*186.76
BRONX DIVISION						
63.....	Mason and Hanger Company.....	3,744,678.18	3,743,305.32	1,372.86	3,744,678.18	*1,372.86
65.....	John J. Hart, Trustee in Bankruptcy of Pittsburg Contracting Company.....	5,386,157.54	5,348,157.54	38,000.00	5,386,157.54	*38,000.00
CONDUIT AND RESERVOIR DIVISION						
89.....	Beaver Engineering and Contracting Co.....	668,601.66	668,404.08	197.58	668,601.66	*197.58
	Totals.....	\$70,855,652.04	\$51,880,278.72	\$186,187.56	\$52,066,466.28	\$18,975,373.32

AGREEMENTS

AGREEMENT	CONTRACTOR	ESTIMATED COST	AMOUNT PAID ON ACCOUNT	ESTIMATED LIABILITY
37.....	Cranford Co.....	\$450,000.00	\$78,754.24	\$371,245.76
X.....	New York Telephone Company.....	2,000.00	1,340.97	659.03
	Totals.....	\$452,000.00	\$80,095.21	\$371,904.79

* The work under these contracts is completed. The estimated liability represents amounts deducted by the Comptroller from final estimates, and is, accordingly, carried as a contingent liability pending the outcome of final settlement. The amount paid on account of these contracts, \$45,491,096.05, should be considered in connection with the total of Statement 6-A.

STATEMENT 6-A

COMPLETED CONTRACTS AND AGREEMENTS

CONTRACT	CONTRACTOR	COMPLETED Cost
CONTRACTS		
ADMINISTRATION BUREAU		
A.....	The J. W. Pratt Company.....	\$1,713.52
D.....	Goldman & Steinberg Printing and Publishing Co.....	1,668.74
W.....	Clarence S. Nathan.....	1,843.88
POLICE BUREAU		
C.....	Fiss, Doerr & Carroll Horse Company.....	8,187.50
O.....	Fiss, Doerr & Carroll Horse Company.....	8,437.50
T.....	Fiss, Doerr & Carroll Horse Company.....	32,500.00
AB.....	Fiss, Doerr & Carroll Horse Company.....	8,937.50
ENGINEERING BUREAU		
HEADQUARTERS DEPARTMENT		
B—Class A.....	Technical Supply Co.....	3,995.34
B—Class B.....	The J. W. Pratt Company.....	1,697.38
B—Class C.....	Continental Playing Card Co.....	1,956.50
B—Class D.....	Joseph N. Early.....	3,617.50
E.....	The J. W. Pratt Company.....	7,982.67
I—Class D.....	E. J. Brooks & Company.....	2,518.50
J—Class A.....	Keuffel & Esser Co.....	2,376.00
N—Class 1.....	Alexander Pearson.....	3,701.46
N—Class 2.....	John Wanamaker, New York.....	1,588.19
Q.....	The Martin B. Brown Company.....	6,897.59
X.....	Brooklyn Daily Eagle.....	9,036.90
Y—Class D.....	Hammacher, Schlemmer & Co.....	1,297.05
Y—Class O.....	Keuffel & Esser Co.....	3,598.74
Z—Class B.....	Tower Manufacturing and Novelty Company.....	3,629.25
AA.....	M. B. Brown Printing & Binding Co.....	15,373.89
AC.....	The J. W. Pratt Company.....	9,386.00
AE.....	M. B. Brown Printing & Binding Co.....	7,274.42
AF.....	The J. W. Pratt Company.....	10,364.13
AG.....	Trow Directory, Printing and Bookbinding Company.....	6,944.89
AI.....	M. B. Brown Printing & Binding Co.....	3,527.47
SCHOHARIE SUPPLY		
202.....	Schunnemunk Construction Company.....	165,193.69
204.....	Lupfer & Remick.....	199,775.04
206.....	Charles Meads & Co.....	8,728.20
RESERVOIR DEPARTMENT		
5.....	Haggerty Contracting Co.....	13,653.22
31.....	Ogden Iron and Steel Manufacturing Company.....	54,900.00
48.....	King, Rice and Ganey Co.....	171,776.25
49.....	The Harrison and Burton Company, Assignee of Harrison and Burton.....	246,363.20
56.....	L. K. Comstock & Company.....	12,770.00
59.....	The C. P. Bower Construction Company.....	306,193.60
72.....	J. F. Cogan Company, Contractors.....	383,472.90
76.....	Transit Construction Company.....	107,475.79
111.....	Ward and Tully, Inc.....	145,138.73
112.....	Vulean Rail and Construction Company.....	2,547.06
124.....	Michael Staub.....	345,230.36
143.....	Zadoc P. Boice.....	29,838.16
151.....	State Highway Construction Co.....	641,667.17
152.....	Winston & Company.....	178,552.70
182.....	State Highway Construction Co.....	8,427.00
185.....	Alsen's American Portland Cement Works.....	23,515.29
186.....	Sprague & Henwood, Inc.....	55,105.00
193.....	Henry E. Fox Construction Co., Inc.....	83,235.80
NORTHERN AQUEDUCT DEPARTMENT		
1.....	The Phoenix Construction Company, Assignee of American Diamond Rock Drill Company.....	125,320.88
4.....	Daniel Carpenter.....	11,095.00
6.....	John J. McLean.....	8,965.00
11.....	H. S. Kerbaugh, Inc., Assignee of H. S. Kerbaugh, Assignee of Stewart-Kerbaugh-Shanley Co.....	2,279,324.04
12.....	The T. A. Gillespie Company.....	6,283,433.69
15.....	Stephen L. Selden, Receiver of the Elmore & Hamil- ton Contracting Company.....	845,634.11

STATEMENT 6-A (Continued)

CONTRACT	CONTRACTOR	COMPLETED COST
CONTRACTS (Continued)		
NORTHERN AQUEDUCT DEPARTMENT (Concluded)		
16.....	King, Rice & Ganey Company, Assignee of King, Rice & Ganey.....	\$578,624.77
17.....	American Pipe & Construction Co.....	655,530.60
18.....	American Pipe & Construction Co.....	756,944.80
20.....	Mason & Hanger Company.....	3,208,584.74
22.....	James G. Shaw and Benjamin Barker, Receivers of Patterson & Company.....	724,642.97
40.....	John J. Wilson.....	11,859.00
45.....	Pittsburg Contracting Company.....	1,521,901.09
47.....	The Degnon Contracting Company.....	4,682,557.88
58.....	D'Olier Centrifugal Pump & Machine Co., Assignee of D'Olier Engineering Company.....	60,664.00
61.....	The Harrison and Boice Company, Assignee of Harrison and Boice.....	166,500.14
62.....	The Snare & Triest Co.....	1,601,467.55
80.....	The Dravo Contracting Company.....	397,704.52
90.....	The T. A. Gillespie Company.....	1,496,363.41
101—District 4.....	Abner M. Harper, Inc.....	48,708.56
109.....	A. L. Guidone and Company.....	80,185.29
117.....	Michael Staub.....	96,034.82
160.....	Oscar Daniels Company.....	313,751.60
165.....	Sullivan Machinery Company.....	12,205.06
180-B.....	Falkill Construction Co., Inc.....	14,528.56
G—Class 1.....	Parrish, Phillips & Company.....	23,379.58
G—Class 2.....	George D. Harris & Company.....	319.49
H—Class M.....	Erie City Iron Works.....	3,374.00
J—Class K.....	Arthur C. Jacobson & Sons.....	10,585.06
J—Class L.....	E. W. Palen's Sons.....	536.81
K—Class F.....	Alden S. Swan & Company.....	1,798.28
P—Class F.....	Alden S. Swan & Company.....	1,970.79
R.....	George D. Harris & Company.....	44,233.53
U—Class M.....	Godfrey, Keeler Co.....	5,380.00
V—Class K.....	Arthur C. Jacobson & Sons.....	5,058.09
SOUTHERN AQUEDUCT DEPARTMENT		
7.....	Shelley Brothers.....	8,360.00
25.....	Chas. W. Blakeslee & Sons.....	1,284,436.15
34.....	Fox-Hennessy Co.....	26,654.52
39.....	Lord Electric Co.....	34,384.00
50.....	Joseph A. Dassler.....	11,868.00
52.....	Pittsburg Contracting Company.....	2,032,379.44
53.....	Stephen L. Selden, Sole Receiver of The Elmore & Hamilton Contracting Company.....	1,513,319.57
54.....	W. W. Crawford, Trustee in Bankruptcy of George W. Jackson, Incorporated.....	1,385,406.31
68.....	The T. A. Gillespie Company, Assignee of David Peoples.....	1,182,513.81
74.....	Joseph A. Dassler.....	8,065.00
77.....	Geo. L. Brown and T. J. Brown.....	53,352.63
79.....	Thomas O'Hern.....	95,783.08
81.....	John F. Hickey.....	18,402.00
100.....	Stobaugh Contracting Company.....	44,677.24
121.....	Joseph Balaban Co.....	78,817.75
123.....	Frederic W. Burnham.....	147,822.29
128.....	William H. Egan.....	93,463.00
135.....	J. E. Butterworth.....	23,153.24
142.....	Charles Cochar.....	11,900.00
148.....	Lord Electric Co.....	15,975.65
159.....	Guarantee Construction Company.....	21,480.00
162.....	H. S. Kerbaugh, Inc.....	24,300.00
169.....	A. L. Guidone & Son, Inc.....	124,152.46
171.....	H. S. Kerbaugh, Inc.....	36,587.52
173.....	William Heyman.....	13,658.02
178.....	William Heyman.....	30,035.05
179.....	Empire Engineering Company, Inc.....	36,046.46
180-C.....	J. E. Butterworth.....	19,829.21
184.....	Henry E. Fox Construction Co.....	38,759.95
190.....	Masterson Construction Corporation.....	30,604.99
191.....	Scott Bros.....	20,700.22
195.....	Frank R. Pierson.....	3,241.75
AH.....	Electro Bleaching Gas Co.....	7,057.64

STATEMENT 6-A (Concluded)

CONTRACT	CONTRACTOR	COMPLETED COST
CONTRACTS (Concluded)		
CITY AQUEDUCT DEPARTMENT		
38.....	The Snare & Triest Co.....	\$92,163.61
66.....	Grant Smith & Co. & Locher.....	4,376,968.63
67.....	Holbrook, Cabot and Rollins Corporation, Geo. B. Fry and Thos. B. Bryson.....	4,905,581.37
70.....	Paul S. Reeves and Co.....	146,374.00
73.....	Sprague & Henwood.....	58,665.96
75.....	F. V. Smith & Son, Inc.....	234,550.60
84.....	American Manganese Bronze Company.....	89,826.53
86.....	Beaver Engineering and Contracting Co.....	286,557.76
87.....	Wm. F. Donovan and Charles Cranford.....	340,893.71
88.....	Beaver Engineering and Contracting Co.....	67,386.63
98.....	The Healey Sewer Machine and Construction Company.....	21,078.01
99.....	Merritt & Chapman Derrick & Wrecking Co.....	879,049.30
103.....	Beaver Engineering and Contracting Co.....	343,813.64
105.....	Henry W. Dunning and Lord B. Hillard, Receivers of The Exeter Machine Works.....	280,668.73
113.....	Sweeney & Gray Company.....	4,933.28
114.....	Coffin Valve Company.....	13,405.00
129.....	John T. Brady and Company.....	64,712.34
132.....	Healey Contracting Company.....	3,769.85
140.....	M. L. Bayard.....	34,823.00
144.....	P. T. Cox Contracting Company, Inc., Assignee of P. T. Cox.....	40,721.12
146.....	Coldwell-Wilcox Company.....	150,423.79
147.....	L. K. Comstock & Company, Incorporated.....	25,236.25
154.....	Frederick N. Lewis.....	13,539.99
166.....	North-Eastern Construction Co.....	27,429.60
170.....	Lupfer & Remick.....	176,465.64
181.....	John T. Brady and Company.....	50,683.08
189.....	Karlsson Bros.....	13,993.24
194.....	Sprague & Henwood, Inc.....	21,612.00
APPURTENANT WORKS		
41.....	Ogden Iron and Steel Manufacturing Company.....	90,670.00
42.....	Coffin Valve Company.....	148,066.00
43.....	Coffin Valve Company.....	71,754.31
44.....	Coldwell-Wilcox Company.....	182,950.27
83.....	Carpenter & Lindsay.....	11,256.49
91.....	Vulcan Rail and Construction Company.....	32,123.29
93.....	New York Telephone Company.....	51,526.31
94.....	J. Edward Ogden Company.....	17,028.87
95.....	Lord Electric Co.....	32,200.00
101—Districts 1, 2, 3, 5 and 6.....	The Degnon Contracting Company.....	189,289.15
104.....	Coffin Valve Company.....	87,082.36
106.....	Charles Meads & Co.....	21,130.13
107.....	The Chapman Valve Manufacturing Co.....	123,260.49
110.....	Builders Iron Foundry.....	9,557.96
118.....	A. L. Guidone and Company.....	108,608.75
120.....	A. L. Guidone & Son, Inc.....	105,689.04
145.....	American Cement Tile Mfg. Co.....	110,127.00
149.....	Concord Construction Co.....	17,245.97
156.....	The North-Eastern Forestry Company and Franklin Forestry Company.....	26,003.23
161.....	Lord Electric Co.....	32,991.24
164.....	L. F. Bannon Plumbing, Heating and Contracting Co.....	5,434.32
168.....	Lord Electric Co.....	77,755.00
172.....	American Manganese Bronze Company.....	12,845.00
176.....	Lupfer & Remick.....	50,613.02
180-A.....	P. C. Osterhoudt & Company.....	51,440.49
188.....	Coffin Valve Co.....	131,738.81
Totals.....		*\$52,473,680.29
AGREEMENTS		
Agreements completed prior to September 30, 1921 (see Statement 6-A, Quarterly Report).....		\$993,658.90

* In addition to this amount, \$45,491,096.05 should be added as per note on Statement 6.

STATEMENT 9

CLASSIFIED DISBURSEMENTS, OTHER SOURCES OF SUPPLY, ACCOUNT SURVEYS, MAPS, PLANS, ETC.

	LONG ISLAND SUPPLY		RONDOT SUPPLY		CATSKILL CREEK SUPPLY		NEW SOURCES OF SUPPLY	
	1921	Total to Date	1921	Total to Date	1921	Total to Date	1921	Total to Date
SALARIES								
Engineering force.....		\$139,818.19	\$2,498.99	\$42,427.19	\$1,752.14	\$19,465.46	\$20,102.54	\$20,102.54
Laborers.....		39,625.97		12,373.28		6.00		
Consulting engineers.....		11,470.00						
Other expert services.....		5,477.00		100.00			450.00	450.00
EQUIPMENT								
Furniture and fixtures.....		564.31						
Engineering instruments and tools.....		123.50		157.96		156.07		
Boring rigs, machinery and tools.....		12,962.46		2,142.34				
Other machinery, tools, equipment and supplies.....		1,508.99		2,979.56		11.70	974.84	974.84
CONSUMABLE SUPPLIES AND EXPENSES								
Engineering supplies.....		8,523.93	1.35	1,236.35		134.31	61.81	61.81
Hardware supplies.....		778.79		97.96		6.66		
Iron pipe, valves and fittings.....		3,416.72		733.81				
Lumber.....		3,997.86		142.22		3.00		
Fuel and light.....		2,456.57		1,440.79				
Stationery and printing.....		2,240.70		139.04		94.06	2.90	2.90
Repairs to machinery and other implements.....		695.63		1,076.96		11.15	162.35	162.35
Repairs and maintenance of buildings.....		46.87						
Team hire.....		9,543.44		6,245.94		158.76		
Automobile hire.....		6,037.40					220.00	220.00
Traveling expenses, including board and lodging..		9,866.57	117.83	3,628.77	33.83	727.62	757.64	757.64
Postage, telegrams, telephone and miscellaneous expenses.....		4,818.20		251.17		25.47	3.92	3.92
Rentals, offices and buildings.....		4,072.50		312.50		25.00		
Advertising.....		1,584.01						
Repairs and maintenance of automobiles.....			5.25	60.65	3.55	31.30	91.48	91.48
TAXES			21.17	91.61				
AGREEMENTS		19,169.27		8,004.40				
DAMAGES TO LAND		85.00		500.00				
Totals		\$288,883.88	\$2,644.59	\$84,142.50	\$1,789.52	\$20,859.56	\$22,827.48	\$22,827.48

STATEMENT 10

CLASSIFIED DISBURSEMENTS, HEADQUARTERS DEPARTMENT, ESOPUS SUPPLY, BY DIVISIONS, ACCOUNT PERMANENT CONSTRUCTION

32

	EXECUTIVE DIVISION		DESIGNING DIVISION		LABORATORY AND INSPECTION DIVISION		TOTALS	
	1921	Total to Date	1921	Total to Date	1921	Total to Date	1921	Total to Date
SALARIES								
Engineering force.....	\$849.22	\$830,888.53	\$741.72	\$1,197,531.91	\$83.76	\$256,963.84	\$1,674.70	\$2,285,384.28
Laborers.....		1,793.52		4,609.93		5,106.14		11,509.59
Consulting engineers.....		100,082.86		3,975.00				104,057.86
Other expert services.....		63,855.80		39,102.00				102,957.80
EQUIPMENT								
Furniture and fixtures.....	*93.02	1,332.91		265.60		419.61	*93.02	2,018.12
Engineering instruments and tools.....		470.13		176.67		168.89		815.69
Other machinery, tools, equipment and supplies..		7,171.32		121.15		3,859.80		11,152.27
Storeroom.....	206.53	19,291.92					206.53	19,291.92
Other City departments.....	11,413.77	96,508.24					11,413.77	96,508.24
CONSUMABLE SUPPLIES AND EXPENSES								
Engineering supplies.....	8.15	11,480.29		30,239.17		30,668.89	8.15	72,388.35
Hardware supplies.....	*2.00	94.65		263.19		585.14	*2.00	942.98
Iron pipe, valves and fittings.....		7.42		843.91		140.76		992.09
Lumber.....		118.10				441.58		559.68
Fuel and light.....		135.72		113.11		3,492.76		3,741.59
Stationery and printing.....	10.50	37,404.02		3,317.07		1,400.70	10.50	42,121.79
Repairs to machinery and other implements.....	1.05	896.48		608.78		1,089.37	1.05	2,594.63
Repairs and maintenance of buildings.....		1,601.17		97.22		1,075.30		2,773.69
Team hire.....		42.25		173.50				215.75
Traveling expenses, including board and lodging..	16.15	11,641.94	21.53	9,848.49		32,219.29	37.68	53,709.72
Postage, telegrams, telephone and miscellaneous expenses.....	72.60	47,564.31		2,661.79		16,188.50	72.60	66,414.60
Rentals, offices and buildings.....		33,725.44		32,442.20		6,943.55		73,111.19
Advertising proposals.....	689.80	4,861.71					689.80	4,861.71
Repairs and maintenance of automobiles.....	6.68	14.35		232.81			6.68	247.16
Totals.....	\$13,179.43	\$1,270,983.08	\$763.25	\$1,326,623.50	\$83.76	\$360,764.12	\$14,026.44	\$2,958,370.70

* Credits caused by adjustment of storeroom.

STATEMENT 15-A

CLASSIFIED DISBURSEMENTS, HEADQUARTERS DEPARTMENT, SCOHARIE SUPPLY, BY DIVISIONS, ACCOUNT PERMANENT CONSTRUCTION

	EXECUTIVE DIVISION		DESIGNING DIVISION		LABORATORY AND INSPECTION DIVISION		TOTALS	
	1921	Total to Date	1921	Total to Date	1921	Total to Date	1921	Total to Date
SALARIES								
Engineering force.....	\$61,756.87	\$169,522.04	\$70,934.31	\$187,030.21	\$7,957.20	\$19,039.49	\$140,648.38	\$375,591.74
Laborers.....				12.80				12.80
Consulting engineers.....	6,000.00	18,512.50					6,000.00	18,512.50
Other expert services.....	900.00	900.00					900.00	900.00
EQUIPMENT								
Furniture and fixtures.....	17.25	25.80					17.25	25.80
Engineering instruments and tools.....			40.00	40.00			40.00	40.00
Other machinery, tools, equipment and supplies.....	25.00	45.25			3.43	3.43	28.43	48.68
CONSUMABLE SUPPLIES AND EXPENSES								
Engineering supplies.....	78.98	121.75	621.54	1,065.74	86.01	482.03	786.53	1,669.52
Hardware supplies.....			.79	.79	2.61	4.36	3.40	5.15
Lumber.....		5.36						5.36
Stationery and printing.....	2,641.87	7,234.47	125.94	237.26	18.35	18.35	2,786.16	7,490.08
Repairs to machinery and other implements.....	34.63	39.84	36.75	37.65	19.50	20.30	90.88	97.79
Traveling expenses, including board and lodging.....	1,228.16	1,643.17	83.48	332.69		158.83	1,311.64	2,134.69
Postage, telegrams, telephone and miscellaneous expenses.....	1,211.78	1,779.70	52.95	60.83	44.92	45.89	1,309.65	1,886.42
Repairs and maintenance of automobiles.....		20.41		20.50				40.91
Totals.....	\$73,894.54	\$199,850.29	\$71,895.76	\$188,838.47	\$8,132.02	\$19,772.68	\$153,922.32	\$408,461.44

STATEMENT 15-C

CLASSIFIED DISBURSEMENTS, PRATTSVILLE DIVISION, SCHOHARIE SUPPLY, ACCOUNT PERMANENT CONSTRUCTION

	EXECUTIVE		CONTRACT 200— SHANDAKEN TUNNEL		OPERATING AND APPURTENANT WORKS		TOTALS	
	1921	Total to Date	1921	Total to Date	1921	Total to Date	1921	Total to Date
SALARIES								
Engineering force.....	\$14,864.53	\$44,056.68	\$34,712.85	\$92,975.36			\$49,577.38	\$137,032.04
Laborers.....	1,859.60	6,789.75	2,895.30	7,551.85			4,754.90	14,341.60
EQUIPMENT								
Furniture and fixtures.....		44.54	22.25	365.37			22.25	409.91
Engineering instruments and tools.....	1.80	37.17	96.90	1,326.65			98.70	1,363.82
Other machinery, tools, equipment and supplies.....		2,616.02	25.00	403.94			25.00	3,019.96
CONSUMABLE SUPPLIES AND EXPENSES								
Engineering supplies.....	58.48	527.88	729.62	2,658.67			788.10	3,186.55
Hardware supplies.....	21.82	70.75	2.99	13.39			24.81	84.14
Iron pipe, valves and fittings.....	.05	9.46					.05	9.46
Lumber.....				3.40				3.40
Fuel and light.....	530.49	1,627.18					530.49	1,627.18
Stationery and printing.....	38.88	302.59	112.75	529.39			151.63	831.98
Repairs to machinery and other implements.....		35.10	23.00	174.71			23.00	209.81
Repairs and maintenance of buildings.....	59.63	597.38	156.38	239.42			216.01	836.80
Team hire.....	85.00	166.20		897.60			85.00	1,063.80
Traveling expenses, including board and lodging.....	76.92	372.56	738.97	1,025.03	\$77.18	\$77.18	893.07	1,474.77
Postage, telegrams, telephone and miscellaneous expenses.....	371.20	1,374.51	231.63	394.90			602.83	1,769.41
Rentals, offices and buildings.....	100.00	290.90	266.67	1,266.67			366.67	1,557.57
Advertising proposals.....				623.43		48.28		671.71
Repairs and maintenance of automobiles.....	1,236.44	5,536.72	24.80	454.31			1,261.24	5,991.03
TAXES	692.22	759.45					692.22	759.45
CONTRACTS			1,254,511.40	2,030,021.60	7,475.12	7,475.12	1,261,986.52	2,037,496.72
Totals.....	\$19,997.06	\$65,214.84	\$1,294,550.51	\$2,140,925.69	\$7,552.30	\$7,600.58	\$1,322,099.87	\$2,213,741.11

STATEMENT 15-D

CLASSIFIED DISBURSEMENTS, ALLABEN DIVISION, SCHOHARIE SUPPLY, ACCOUNT PERMANENT CONSTRUCTION

	EXECUTIVE		CONTRACT 200— SHANDAKEN TUNNEL		TOTALS	
	1921	Total to Date	1921	Total to Date	1921	Total to Date
SALARIES						
Engineering force.....	\$13,802.91	\$42,353.63	\$45,410.02	\$114,839.50	\$59,212.93	\$157,193.13
Laborers.....	816.40	4,082.92	8,314.50	17,277.58	9,130.90	21,360.50
EQUIPMENT						
Furniture and fixtures.....		6.20	22.25	871.59	22.25	877.79
Engineering instruments and tools.....		46.17	150.40	1,217.65	150.40	1,263.82
Boring rigs, machinery and tools.....				300.00		300.00
Other machinery, tools, equipment and supplies.....		1,657.62	25.00	158.89	25.00	1,816.51
CONSUMABLE SUPPLIES AND EXPENSES						
Engineering supplies.....	91.48	496.92	591.12	2,400.60	682.60	2,897.52
Hardware supplies.....	24.55	200.27	12.82	35.50	37.37	235.77
Iron pipe, valves and fittings.....	1.71	60.66			1.71	60.66
Fuel and light.....	18.60	426.16	442.72	965.70	461.32	1,391.86
Stationery and printing.....	35.13	293.99	108.75	525.94	143.88	819.93
Repairs to machinery and other implements.....	1.00	29.05	3.00	154.61	4.00	183.66
Repairs and maintenance of buildings.....		892.67	1,513.27	1,580.19	1,513.27	2,472.86
Team hire.....	25.00	388.40	188.40	1,057.00	213.40	1,445.40
Traveling expenses, including board and lodging.....	183.75	787.84	306.25	1,730.95	490.00	2,518.79
Postage, telegrams, telephone and miscellaneous expenses.....	184.28	697.35	567.14	798.34	751.42	1,495.69
Rentals, offices and buildings.....	5.00	483.00	420.00	892.00	425.00	1,375.00
Advertising proposals.....				673.42		673.42
Repairs and maintenance of automobiles.....	1,406.18	4,677.17	145.04	1,074.03	1,551.22	5,751.20
TAXES	1,468.89	1,778.62			1,468.89	1,778.62
CONTRACTS			2,047,886.38	3,205,206.71	2,047,886.38	3,205,206.71
Totals.....	\$18,064.88	\$59,358.64	\$2,106,107.06	\$3,351,760.20	\$2,124,171.94	\$3,411,118.84

STATEMENT A

TOTAL DISBURSEMENTS FOR ACQUISITION OF PROPERTY PURSUANT TO CONDEMNATION PROCEEDINGS AND PRIVATE PURCHASES; ALSO DISBURSEMENTS FOR INDIRECT DAMAGES, INDICATING THE ATTENDANT EXPENSE INCURRED FOR ACQUISITION BY PERCENTAGES

	SCHOHARIE SUPPLY				ESOPUS SUPPLY					
	ACQUISITION OF PROPERTY		*INDIRECT DAMAGES		ACQUISITION OF PROPERTY			*INDIRECT DAMAGES		
	Amount	Per Cent. of Total	Amount	Per Cent. of Total	Amount	Per Cent. of Total	Per Cent. of Expenses to Awards	Amount	Per Cent. of Total	Per Cent. of Expenses to Awards
AWARDS										
50-per-cent. payments to obtain possession.....	\$73,232.00				\$183,895.31					
Final awards.....	523,719.50				10,192,200.99					
Purchased under contract.....	2,100.00				375,000.86					
Total awards, etc.....	\$599,051.50	56.946	\$60,463.50	44.690	10,751,097.16	63.226		\$516,501.66	43.250	
Interest on awards.....	76,207.45	07.244	2,457.06	01.816	1,661,758.37	09.773	15.457	76,127.54	06.375	14.739
Advertising.....	12,033.90	01.144			445,913.31	02.622	04.148	3,427.89	00.287	00.664
Fees of commissioners of appraisal.....	58,285.00	05.541			1,118,813.72	06.580	10.406	174,130.00	14.581	33.713
Expenses of commissioners.....	7,505.40	00.713			82,973.13	00.488	00.772	9,161.77	00.767	01.774
Stenographers and other clerks.....	10,618.00	01.009			71,051.37	00.418	00.661	16,322.29	01.367	03.160
Special counsel fees.....	63,314.45	06.019			582,899.51	03.428	05.422	127,344.52	10.663	24.655
Special counsel expenses.....	4,730.94	00.450			29,919.93	00.176	00.278	6,712.46	00.562	01.300
Obtaining orders for 50-per-cent. deposits.....					9,125.00	00.053	00.085			
Closing titles.....					4,885.00	00.020	00.045			
Counsel fees on appeal.....					7,648.72	00.045	00.071			
Costs on appeal.....					4,151.25	00.024	00.039	1,725.04	00.144	00.334
Searching titles.....	494.00	00.047			225,161.84	01.324	02.094			
Preparing abstracts.....					128,462.50	00.755	01.195			
Appraisers' fees.....	11,515.50	01.095			498,333.03	02.931	04.635	24,414.37	02.044	04.727
Appraisers' expenses.....	3,054.17	00.290			6,153.91	00.036	00.057	1,685.66	00.141	00.326
Rent of New York office.....					26,294.40	00.155	00.244			
Stenographic services and printing testimony.....	24,096.31	02.291			286,256.90	01.683	02.663	65,021.90	05.445	12.589
Counsel fees of parcel owners.....	29,177.10	02.774	408.18	00.302	411,627.91	02.421	03.829	10,459.36	00.876	02.025
Expenses and disbursements of parcel owners.....	18,689.01	01.776	1,525.35	01.128	275,639.06	01.621	02.564	25,888.63	02.168	05.012
Engineering salaries and expenses.....	133,188.01	12.661	70,438.70	52.064	376,070.12	02.212	03.498	135,306.90	11.330	26.197
Totals.....	\$1,051,960.74	100.00	\$135,292.79	100.00	\$17,004,236.14	100.00	58.163	\$1,194,229.99	100.00	131.215
					Acquisition of property.....			Acquisition of property.....		\$17,004,236.14
					Indirect damages.....	\$1,051,960.74		Indirect damages.....		1,194,229.99
					Total, Schoharie supply.....	\$1,187,253.53		Total, Esopus supply.....		\$18,198,466.13

* The payment for awards for indirect damages in both the Schoharie supply and Esopus supply, \$576,965.16, settled claims aggregating \$5,404,764.77, and the expense of \$752,557.62, or 130.43 per cent. of the amount paid for awards, actually resulted in a saving thus far of \$4,827,799.61, plus the saving in the same ratio on the awards which have not yet been confirmed.

STATEMENT B

SHOWING ACREAGE OF LAND TO BE TAKEN FOR CONSTRUCTION PURPOSES, DISBURSEMENTS FOR ACREAGE UPON WHICH AWARDS HAVE BEEN PAID, EXPENSES INCIDENTAL THERETO, THE PERCENTAGE OF EXPENSES TO AWARDS AND AVERAGE COST AND EXPENSE PER ACRE

	ACREAGE			AMOUNT OF AWARDS PAID	AMOUNT OF EXPENSES PAID	TOTAL AWARDS AND EXPENSES	AVERAGE AWARD PER ACRE	AVERAGE EXPENSES PER ACRE	PER CENT. OF EXPENSES TO AWARDS
	Total to be Taken	Final Awards Paid	Acreage Unpaid						
SCHOHARIE SUPPLY.....	2,452.556	2,305.647	146.909	*\$599,051.50	\$452,909.24	\$1,051,960.74	\$258.13	\$196.44	75.64
ESOPUS SUPPLY									
Ashokan reservoir.....	15,221.305	15,018.108	203.197	3,618,660.18	2,342,006.88	5,960,667.06	240.95	155.95	64.72
Northern aqueduct.....	1,637.351	1,637.351	.....	767,331.92	714,910.86	1,482,242.78	468.65	436.64	93.17
Southern aqueduct.....	956.566	956.566	.....	1,900,465.63	782,341.89	2,682,807.52	1,986.75	817.86	41.17
Kensico reservoir.....	3,181.762	3,179.462	2.300	2,424,705.24	1,439,163.18	3,863,868.42	762.61	452.01	59.36
Hill View reservoir.....	163.380	163.380	.....	1,438,802.00	722,037.20	2,160,839.20	8,806.47	4,419.37	50.18
City aqueduct.....	166.332	**166.332	.....	601,132.19	97,648.59	698,780.78	6,652.63	1,080.66	16.24
Headquarters.....	.....	.....	.....	.....	155,030.38	155,030.38	.....	.....	.....
Totals, Esopus supply.....	21,326.696	21,121.199	205.497	\$10,751,097.16	\$6,253,138.98	\$17,004,236.14	\$510.86	\$297.13	58.16

* This amount includes \$3,908.50 of 50-per-cent. payments necessary to secure possession of property for construction purposes.

** The City was vested with the fee of 75.972 acres of this land when the taking maps were prepared. The amounts for awards and expenses are therefore computed for 90.360 acres.

REPORT OF THE CHIEF ENGINEER

NEW YORK, January 1, 1922.

BOARD OF WATER SUPPLY,
Municipal Building, New York City.

GENTLEMEN:

There is submitted herewith the Annual Report of the Engineering bureau for the year 1921.

The principal work of the past year consisted of the prosecution of construction operations on the development of the Schoharie watershed, the preparation of the contracts for the construction of two siphon pipes at each of the fourteen steel-pipe siphons of the Catskill aqueduct which were awarded on November 23, 1921, and studies and investigations looking toward the development of additional sources of water-supply and the extension of the delivery system within the City limits.

Contract 209, for the construction of six siphon pipes aggregating about 12,200 feet in length in the three siphons between the Ashokan reservoir and the Hudson river, was awarded to Rice and Ganey, Inc., Room 1708 Grand Central Terminal Building, New York City, in the estimated amount of \$999,325.00. Contract 210 was awarded to the Frederick Snare Corporation, 8 West 40th Street, New York City; this contract amounts to \$2,978,103.00 and comprises the construction of approximately 34,000 linear feet of pipe at the seven locations between the Hudson river and the Kensico reservoir. Thomas Crimmins Contracting Company, 126 East 59th street, New York City, was awarded Contract 211, amounting to \$2,275,360.00 and covering the construction of eight siphon pipes with a total length of about 20,000 feet in the four siphons between the Kensico and the Hill View reservoirs. The contractors have been served with notice to begin work, and preliminary operations preparatory to the starting of actual construction have been begun on the three contracts.

The Hugh Nawn Contracting Company continued work on Contract 203, for the construction of the Gilboa dam and appurtenant structures, and at the end of the year all essential plant had been provided, the Stevens Mountain and Riverside quarries were in operation, the portions of the highways included in this contract and the stream-control works were practically completed, excavation in the foundation of the dam, the cut-off and spillway channel was well advanced and progress had been made on placing masonry for the dam and embankment for the dike. The value of the work done on this contract at the end of the year was \$1,193,449.38.

On Contract 200, for the construction of the Shandaken tunnel, the Shandaken Tunnel Corporation continued excavation of the tunnel throughout the year, and on December 31 the tunnel was being driven from six of the eight shafts and 60,649 linear feet out of a total length of 95,539 feet had been excavated; to date, \$5,590,565.00 has been earned on this contract.

Under Contract 207, for furnishing and delivering gate-valves, hydraulic cylinders, bronze castings and appurtenances for the Gilboa dam and the Shandaken tunnel, the Coffin Valve Company completed and delivered about nine-tenths of the materials included in this contract and at the end of the year the contractor's earnings totaled \$84,052.55.

Contract 202, for the construction of $7\frac{1}{2}$ miles of the marginal highways around the Schoharie reservoir, was completed September 14 by the Schunnemunk Construction Company at a total cost of \$165,193.69.

On October 27, Lupfer & Remick completed work on Contract 204, for constructing two steel highway bridges and approaches at the Schoharie reservoir, the final estimate amounting to \$199,775.04.

Contract 206 was for the removal of bodies, headstones and monuments from the cemeteries on lands acquired for the construction of the Schoharie reservoir, and was awarded June 9, 1921, to Charles Meads & Co., 217 West 14th street, New York City, in the estimated amount of \$9,734.50; provision was made in the contract for reinterment of the bodies and replacement of the headstones and monuments in a plot furnished by the contractor and deeded to the City of New York. The contract was completed September 16 at a total cost of \$8,728.20.

Work on Contract 193 was completed December 3 by the Henry E. Fox Construction Co., Inc., the final estimate amounting to \$83,235.80. This contract comprised the construction of masonry guide walls and the doing of miscellaneous work at the Ashokan spillway.

The final estimate of Contract 191, for planting at the Kensico dam, amounted to \$20,700.22 and was forwarded under date of May 9, 1921. The planting called for by this contract was completed during 1920 by Scott Bros., the contractor, but the final estimate was not rendered until the required replacements had been made during the 1921 planting season.

In connection with possible future sources of water supply and extensions of the City delivery system, progress was made on studies and investigations, conducting surveys and tests, compiling data and preparing drawings.

John R. Freeman and William H. Burr continued as consulting engineers throughout the year. On September 14, Dr. Charles P. Berkey was appointed Geologist to conduct investigations in connection with new sources of supply.

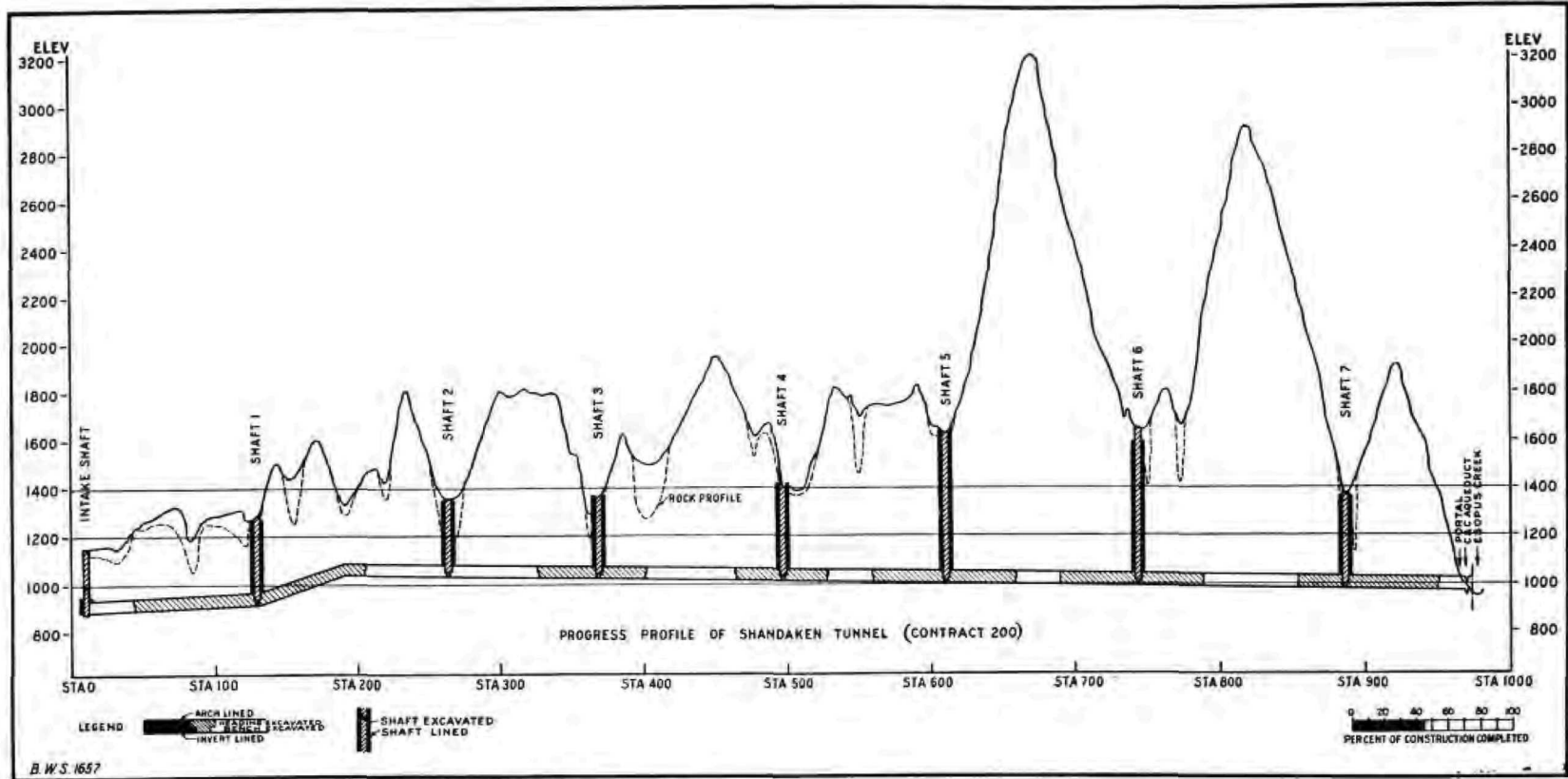
Thaddeus Merriman continued as Deputy Chief Engineer and also in charge of Headquarters department; George G. Honness continued as department engineer of the Reservoir department, in charge in the field of all Schoharie investigations and construction; on December 13, Roy W. Gausmann was appointed division engineer and assigned to the Allaben division of the latter department. Walter E. Spear was appointed department engineer on March 14 and has taken charge of the work on the new sources of supply. On December 13, Charles M. Clark was appointed department engineer of the newly-organized Aqueduct department and will have supervision of the construction of the new siphon pipes of the Catskill aqueduct; the Northern and Southern divisions of the latter department have been placed in charge of Division Engineers Howard P. Barnes and Cornelius J. O'Connor, respectively.

The force in the Engineering bureau was 173 on January 1 and 199 on December 31; of this latter number there were still one in the military service and two on leave without pay. The effective working force on December 31, therefore, was 196, of which 49 were in Headquarters department, 129 in the Reservoir department, 3 in the Aqueduct department, and 15 were engaged on New Sources of Supply.

THE SCHOHARIE DEVELOPMENT

THE SHANDAKEN TUNNEL

Contract 200 comprises the construction of 18.1 miles of tunnel, horseshoe in section and 11 feet 6 inches high by 10 feet 3 inches wide, the sinking of eight shafts aggregating 3,238 linear feet, the erection of shaft-houses and the construction of access roads to each shaft. It includes also the construction of inlet and outlet works and the grading of 6,400 feet of substituted new highway known as Road 6. The intake of the tunnel is situated on the westerly side of the Schoharie creek about $3\frac{1}{2}$ miles north of the Village of Prattsville, from where the tunnel extends in a generally southeasterly direction to the Village of Allaben, the portal being located about $\frac{1}{2}$ mile easterly from the post-office in the latter village. The tunnel is being driven on a uniform grade of 4.4 feet



SHANDAKEN TUNNEL—Progress on construction of the Shandaken tunnel to December 31, 1921. To date, 60,649 linear feet of tunnel out of a total length of 95,539 feet have been excavated.

per mile for the entire length except for the northerly $3\frac{1}{2}$ miles, which is depressed in order that the tunnel may remain in rock. The minimum distance between shafts is 1.3 miles and the maximum 2.7 miles.

The contractor is the Shandaken Tunnel Corporation, 120 Broadway, New York City, Assignee of The Degnon Contracting Company, to whom the work had been awarded on November 9, 1917, in the estimated amount of \$12,138,738.00.

Progress.—At the end of the year a total of \$5,590,565.00 had been earned on the contract, this being equivalent to about 46 per cent. of the estimated contract amount. The yearly progress on the principal items of work is shown in the following table:

ITEM AND UNIT OF MEASUREMENT	1918	1919	1920	1921	TOTAL TO DECEMBER 31, 1921	TOTAL ESTIMATED CONTRACT QUANTITIES
Excavation—Cubic Yards						
Shafts.....	6,319	19,049	1,257	.....	26,625	27,600
Tunnel.....	.....	5,387	68,682	277,749	351,818	569,000
Miscellaneous.....	8,066	33,351	3,192	15,242	59,851	162,000
Pumping from Shafts and Tunnel— Million Foot-Gallons.....	320	7,784	24,091	29,986	62,181	1,500,000
Tunnel Support						
Timber—Thousand Feet, Board Measure.....	.....	.....	295	1,624	1,919	775
Dry Packing—Cubic Yards.....	.....	.....	1,229	8,025	9,254	2,700
Forms for Lining—Linear Feet						
Shafts.....	235	2,706	142	.....	3,083	3,320
Tunnel.....	.....	.....	.....	.....	.....	95,507
Concrete—Cubic Yards						
Shafts.....	620	6,550	431	.....	7,601	9,300
Tunnel.....	.....	.....	.....	.....	.....	186,000
Miscellaneous.....	237	324	23	253	837	9,660
Cement—Barrels						
Shaft Concrete.....	948	8,227	652	.....	9,827	15,000
Tunnel Concrete.....	.....	.....	.....	.....	.....	280,000
Miscellaneous.....	434	683	9	353	1,482	150,000

The contract work for the year consisted almost wholly of driving tunnel, the average for the past five months being over 5,000 linear feet of tunnel driven per month; this work was continuous throughout the year at Shafts 1, 5, 6 and 7, and was in progress from January 7 and April 12 to the end of the year at Shafts 3 and 4, respectively. In those portions of the tunnel which required support, approved types of temporary and permanent timber were placed, the support in general being carried along very closely with the excavation. Intermittent work from May 4 to December 31 resulted in the practical completion of Road 6 and the access road to the intake chamber. Operations were resumed November 21 at the intake on the completion of the

PROGRESS IN THE SHANDAKEN TUNNEL TO DECEMBER 31, 1921—LINEAR FEET

YEAR	INTAKE, SOUTH	SHAFT 1		SHAFT 2		SHAFT 3		SHAFT 4		SHAFT 5		SHAFT 6		SHAFT 7		PORTAL, NORTH	TOTAL
		North	South	North	South	North	South	North	South	North	South	North	South	North	South		
Total for 1919—																	
Excavation.....		165	184	31	31	32	32	31	28	79	75	27	26	184	173		1,098
Timber support.....																	
Dry packing.....																	
Total for 1920—																	
Excavation.....	16	3,089	2,030							1,181	942	1,885	1,047	421	1,430		12,041
Timber support.....										799	704	1,879	1,054	447			4,883
Dry packing.....										285	173	948	950	407			2,763
Total for 1921—																	
Excavation.....		5,128	5,519			4,206	3,343	3,254	3,151	3,783	4,042	3,464	3,582	2,520	5,065		47,363
Timber support.....		2,243				1,710	1,186	120	1,561	3,325	1,510	3,435	3,533	2,482	1,228		22,333
Dry packing.....		473				897	976		1,561	2,813	1,434	3,900	3,637	2,522	908		19,121
Total to December 31, 1921—																	
Excavation.....	16	8,682	7,733	31	31	4,238	3,375	3,285	3,179	5,013	5,059	5,376	4,655	3,131	6,668		60,502
Timber support.....		2,243				1,710	1,186	120	1,561	4,124	2,214	5,314	4,587	2,929	1,228		27,216
Dry packing.....		473				897	976		1,561	3,098	1,607	4,848	4,587	2,929	908		21,884
Total contract length.....	3,625	8,278	8,972	4,416	4,509	5,922	7,105	5,812	4,383	6,815	6,311	7,021	7,267	7,018	7,938		*95,392

* A total of 147 linear feet of tunnel excavation between the "B" lines at the bottoms of the eight shafts was estimated and paid for as shaft excavation and is not included in this table; therefore, the total length of the Shandaken tunnel is 95,539 linear feet.

excavation of the final 20-foot depth of rock. No work was done under the contract items at Shaft 2 or at the tunnel portal.

Tunnel progress during the past year consisted of the driving of 47,363 linear feet of tunnel, the erection of 18,400 linear feet of permanent timber support, placing dry packing over 19,121 linear feet of permanent timber, and the erection of 3,933 linear feet of temporary timber support. The table on page 45 shows the progress attained in these major operations during each year since the award of the contract and to date.

Contractor's Forces.—Labor conditions throughout the year were propitious to tunnel construction work and the supply of all kinds of labor has been ample. The bonus system of payment inaugurated in the early summer had an appreciable influence on general progress. The contractor's force averaged 1,070 men for the year, with a maximum of 1,440 and a minimum of 720.

Camps.—The camps constructed during the previous years continued in general use at the points of activity throughout the year and additional buildings were erected as the need developed. Twelve buildings were destroyed by fire and were re-constructed or are in process of replacement at the present time. An 8-man house at Shaft 2 was remodeled to serve as an isolation hospital and will be used for this purpose while work at that shaft remains inactive. Standard man-proof fences were built around three sides of the upper camp at Shaft 6 and along the westerly border of the Shaft 7 camp to protect the water-supplies at these points.

The camp water-supplies were generally augmented by additional supplies as necessitated by dry periods and in some instances this involved the transportation of water appreciable distances in barrels or tank wagons.

The sanitary conditions have been good throughout the year. Kaustine outfits, operated with either the Kaustine solution or with caustic soda, have given generally satisfactory service at all points on the surface and in the tunnel, and camp and spoil-pile drainage was either conveyed through the chlorinators or led into the chlorinator effluent channel where it mixed with an effluent sufficiently dosed as to thoroughly sterilize the combined flow.

Geological Conditions.—The rock through which the tunnel is being excavated is of sedimentary origin, and is shale or sandstone with widely varying degrees of hardness. The shales, mostly red, with small amounts of blue and green color, drill easily, break well to line and usually stand well for a limited time, but they have a



SHANDAKEN, TUNNEL.—General view at Shaft 4, showing the head-frame, plant and buildings at top of the shaft.

marked tendency to disintegrate when exposed to atmospheric conditions. The red sandstones are of slightly coarser texture, but are often difficult to distinguish from the shales; almost invariably the two are more or less mixed and, when penetrated in the roof of the tunnel, support is usually needed.

The gray and blue sandstones, which are the hardest and coarsest grained of all stones in this vicinity, are consequently more difficult to drill and shoot, but have the advantage of requiring very little scaling and, when not too thinly bedded, generally stand well without support. The phenomenon of "popping rock" frequently occurred in the gray sandstones with a consequent need of roof support.

The inflow of water at the several locations has never been so great as to impede the work or to require other than ordinary methods for its control. The maximum and minimum average inflow per minute for the year occurred at Shafts 1 and 7, and amounted to 74 gallons per minute and 7 gallons per minute, respectively.

Plant.—The contractor's headquarters remained at Allaben, where all plans for the direction of the work on this contract were formulated. Practically all supplies were received by rail at the company's yards just north of the Shandaken railroad station on the Ulster and Delaware railroad and hauled to the shafts by motor trucks of two to four tons capacity. During the summer months the trucks were run sixteen hours daily in an effort toward delivering sufficient supplies to the work to cover the needs of the winter months when the roads would become difficult to travel. Supplies for the intake and Shaft 1 were received at the contractor's yard just south of the Grand Gorge station on the Ulster and Delaware railroad and were transported to those locations by auto truck.

The service on the electric power-line was satisfactory, the whole line being out of service for only 27 hours during the year.

The standard equipment for tunnel driving from shafts and for muck disposal remained the same as in 1920, but a greater number of electric locomotives and more powerful motors for the blowers were intalled as the heading lengths increased. The general use of the mucking machines described in the 1920 report was discontinued and their use limited to full-faced headings. Shaft 4 was equipped during the year with plant similar to that in use at the other shafts.

A crushing plant was erected at Shaft 5 for transforming sandstone selected from the tunnel muck into crushed stone for use in the concrete lining. This plant consists essentially of the following: A Kennedy 32-inch by 18-inch jaw crusher, with a capacity of 25 tons per hour, operated by a Westinghouse 40-horse-power, 3-phase, 60-cycle induction motor; a Kennedy gearless No. 25 gyratory crusher, operated by a Westinghouse alternating-current, 25-horse-power, 3-phase, 60-cycle motor; a rubber conveyer belt, operated by a General Electric 10-horse-power, 3-phase, 60-cycle induction motor, and a bucket elevator and revolving cylindrical screen, operated by a General Electric 25-horse-power, 3-phase, 60-cycle induction motor.

The tipple at the top of the shaft was enlarged to provide a second tipple so that suitable rock from the tunnel can be dumped by one of these tipples into a bin having a capacity sufficient to hold rock excavated from two shifts. From the bin, rock is shoveled into the jaw crusher, thence in turn to the rubber conveyor belt, to the bucket elevator and to the revolving cylindrical screen, the latter of which is divided into two compartments, the first having openings of $\frac{1}{4}$ inch and the second 2 inches. Material passing through the $\frac{1}{4}$ -inch screen falls into the sand storage bin and that passing through the 2-inch screen falls into the stone storage bin. The material which will not pass the latter screen is dumped from the screen into a chute which carries it to the gyratory crusher, back into the bucket elevator, then again to the screen, and finally through the screen into the storage bins. Stone is transported from the bins to a storage pile on the spoil-bank in $1\frac{1}{2}$ -cubic-yard side-dump cars which dump from a trestle to the pile and sand is carried to a contiguous storage-pile in horse-drawn wagons.

Crushing operations were begun on September 6, and at the end of the year 5,300 cubic yards of stone and 1,800 cubic yards of sand had been deposited in the spoil-piles, the plant output averaging 56 cubic yards of stone and 12 cubic yards of sand per shift. A crusher installation similar to that in use at Shaft 5 of the tunnel was in process of erection at Shaft 4 at the end of the year.

The principal items of tunnel-driving plant which have been installed to date at the various shafts of the Shandaken tunnel are given in the following table:

ITEM OF PLANT AND RATING OR CAPACITY	IN-TAKE	SHAFT						POR-TAL	TOTAL
		1	2	3	4	5	6			7
Compressors—									
Chicago (Pneumatic)—750 cubic feet per minute	2	1	2	1	1	2			9
Chicago (Pneumatic)—450 cubic feet per minute		1							1
Sullivan—875 cubic feet per minute				1					1
Laidlaw—750 cubic feet per minute						1			1
Ingersoll-Rand—500 cubic feet per minute		1							1
Air Receivers—150 cubic feet	1	1	1	1	1	1			6
Hoists—									
Flory (Electric)—4-foot 6-inch drum	1	1	1	1	1	1			6
Lambert (Steam)—double drum	1				1	1	1		4
Blowers—									
Connersville—2.77 cubic feet of free air per revolution	1	1	1	1	1	1			6
Motors—									
General Electric, Synchronous (Compressors)—220-horse-power					1				1
Westinghouse, Synchronous (Compressors)—200-horse-power			1						1
General Electric, Synchronous (Compressors)—150-horse-power	1		2	1	1	2			7
Westinghouse, Synchronous (Compressors)—140-horse-power			1						1
Westinghouse, Synchronous (Compressors)—100-horse-power			1			1			2
Westinghouse, Induction (Compressors)—150-horse-power	1								1
General Electric, Induction (Hoists)—112-horse-power	1	1	1	1	1	1			6
General Electric, Induction (Generators)—60-horse-power	1		1	1	1	2			6
General Electric, Induction (Blowers)—50-horse-power	1					1	1		3
Crocker-Wheeler, Induction (Generators)—50-horse-power			1						1
General Electric, Induction (Blowers)—20-horse-power			1	1	1				3
General Electric, Induction (Pumps)—20-horse-power	1		1	1	1	1			5
General Electric, Induction (Pumps)—10-horse-power			1						1
General Electric, Induction (Pumps)—7.5-horse-power	1	1				2			4
Crocker-Wheeler, Induction (Pumps)—7.5-horse-power	2								2
General Electric, Induction (Pumps)—2-horse-power	1					1	2		4
Generators—									
General Electric, Direct Current—125 volts	1		1	1	1	2			6
Westinghouse, Direct Current—125 volts			1						1
Drills—									
Ingersoll-Rand—Water-Leyner	13	12	12	10	9	15			71
Ingersoll-Rand—Jackhammer	10	9	7	5	3	8			42
Drill Sharpeners—									
Leyner	1	1							2
Ingersoll-Rand				1	1	1	1		4
Pumps—									
Gould (Electric)—120 gallons per minute	1		1	1	1	1			5
National (Electric)—75 gallons per minute						1			1
Gould (Electric)—50 gallons per minute	2	1							3
Gould (Electric)—30 gallons per minute		1							1
Gould (Electric)—15 gallons per minute	2								2
Cameron (Air)—125 gallons per minute	2		1	2	1	1			7
Cameron (Air)—100 gallons per minute	1					1			2
Cameron (Air)—50 gallons per minute	2	1	1		2				6
Cameron (Air)—25 gallons per minute		1							1
Cages—									
Lambert	1	2				2			5
Connellsville			2	2	2				6
Mucking Equipment—									
Myers-Whaley Machines—No. 4	1					2	1		4
Armstrong Shovelers							1		1
General Electric Locomotives—draw-bar pull, 1,000 pounds	5	1	5	5	5	5			26
Lakewood Locomotives (Electric)—10-horse-power	2	2							4
Whitcomb Locomotives (Electric)—10-horse-power			2						2
Sandford End-Dump Cars—1½-cubic-yard	35	32	34	36	21	30			188
Western Side-Dump Cars—4-cubic-yard	4	2	2	2	2	3			15

Tunnel Driving.—The type of tunnel driven from the several headings has been subject to frequent changes from Type A to Type C, and *vice versa*, because of changes in the character of the materials encountered. The top-heading method and hand mucking were used for practically the entire period at Shafts 1, 3, 4 and



SHANDAKEN TUNNEL—South tunnel at Shaft 6. The tunnel muck is removed by the mucking machine which loads it into the cars which are in turn hauled to the shaft by the storage-battery locomotive. The platform in background is for use in placing permanent timbering.

5 and Shaft 7-South, and the full-faced method with machine mucking at Shaft 6 and Shaft 7-North. Shifts were in general so organized as to permit of two shots per day in the top-heading tunnels and alternate advances of two shots and one shot per day in the full-faced tunnels. Trimming, above a plane one foot above

the finished concrete invert elevation, was carried along closely behind the main excavation. Water Leyner drills, mounted on vertical columns, were used in headings and jackhammers in the bench.

Transportation of tunnel muck to the shafts was accomplished by means of electric storage-battery locomotives, pulling six or seven end-dump cars, each averaging about one cubic yard of solid rock. The cars were carried singly on the cages to the top of the shaft, where they were pushed by hand to the tippie and dumped into side-dump cars of approximately four cubic yards capacity, which were in turn taken to the dump by means of storage-battery locomotives, the latter of which operated at an average speed of five to six miles per hour. The standard equipment for a 4-shift shaft with hand mucking is four such locomotives and two spare battery boxes inside the tunnel with two locomotives at the top of the shaft, the spare battery boxes thus allowing one set of batteries in each heading to be always charging at stations within the tunnel near the shaft. The motors at the top of the shaft are charged at the tippie between trips to the dump.

Tunnel Support.—A large percentage of the tunnel excavated to date has required roof support, about 45 per cent. of the tunnel being supported by either permanent or temporary timbering; both types are practically of the same design. The temporary types, being placed within concrete limits, will be removed before the lining is placed and are therefore not dry-packed with rock. In case the over-breakage above the temporary support is 18 inches or more, cord-wood packing is required. In both types, the arch ribs, usually spaced 7.5 feet center to center, are formed of three 10-inch by 10-inch timbers supported on each side by three 1¼-inch steel pins 30 inches long, set 24 inches in holes drilled in the rock. Previous to 1921 the lagging was 4 inches by 4 inches, spaced 2 to 4 inches apart, dependent on over-breakage, but as it was found difficult to place dry packing over this, because of the fact that thin slabs of rock or small disintegrated pieces of shale fell between the lagging, 3-inch by 10-inch planks spaced slightly apart to allow free flow of grout, were substituted.

The pin-supported timber has not the advantage of the rigid support of a wall plate, and to keep the ribs in place it was found necessary to use lacing consisting of 2-inch by 10-inch planks 7.5 feet long, spiked to the under side of the arch rib. Where the

roof was of such character that the timber could be kept 40 to 50 feet back of the excavation, seven such pieces of lacing were judged sufficient, but when the support had to be kept very close to the heading, the contractor, in order to avoid shooting down the arch ribs, elected to use a much larger number, often twelve or fourteen to the bent.

The top arch ribs, lagging, lacing, struts and wedges were cut in the shop at the Allaben yard and delivered to the work by motor trucks and the inclined arch legs, which vary in length at each rib, were cut from a templet at the top of the shaft. All permanent timber was dry-packed as the lagging was placed. When the character of the rock permitted, the timber was carried about 100 to 150 feet back of the heading so as not to interfere with drilling and mucking operations.

It was a difficult matter to decide in advance of excavation on the type of timber which would be best suited to the conditions. Generally it has been the rule to place permanent timber wherever the roof was in soft red shale, in thinly bedded sandstone, or when "popping rock" occurred, and where the support was necessary only to protect men from frequent dropping of small thin slabs of material temporary timber was placed.

During the early stages of the work the placing of timber very materially slowed down the progress, but, with experience, the men have acquired skill and proficiency and, when given ground that will stand safely to allow excavation to be kept from 50 to 100 feet in advance of the support, very little delay is caused by its use. The timbering gangs usually consist of four to six men, who have no trouble in placing two to four ribs, or 15 to 30 feet, of lagging and dry packing the same in a shift of eight hours.

Between July 7 and August 27, the contractor placed a thin concrete shell over the rock exposed in the tunnel roof in a portion of the South heading at Shaft 3, with a concrete "atomizer," the theory being that if the rock was protected from air slaking no support would be necessary, and, while the results obtained were fairly satisfactory, the advantages gained did not warrant the continued use of this method, which would also have required a modification of the contract.

Ventilation.—The plenum process of ventilation continued in use from last year. During the year, motors of higher power were installed for operating the blowers in the longer headings with

generally satisfactory results, the greatest difficulties being encountered in the long headings from Shaft 1.

Explosives.—At each shaft the powder magazines were enlarged or others built so that up to 10,000 pounds could be carried in storage and small magazines, sufficient for one day's supply, were also built near each shaft to provide safe storage between loading periods. None of the magazines have any heating facilities as the modern non-freezing powder does not require protection against cold. As is the custom in the east, 60-per-cent. dynamite was used within the tunnel until the summer of 1920, when the contractor, after a considerable amount of experimentation, adopted the use of 60-per-cent. dynamite in cut holes and 40-per-cent. in relief and trim holes. This resulted in some economy, as dynamite prices are fixed on a base price for 40-per cent. powder, each 10-per cent. increase in strength costing about $1\frac{1}{2}$ cents per pound above this base.

Access Roads.—All the access roads were available for use at the end of the year, operations during 1921 being confined to those at the intake and at Shaft 3. The former road was excavated to approximate grade and width and while not completed, is in such shape as to permit haulage over it of the contractor's supplies to the intake. Work on the access road to Shaft 3 consisted largely of placing isolated patches of tunnel muck in fills and cuts.

Intake Channel and Chamber.—At the close of 1920, rock excavation for the intake shaft was completed and the channel excavation had been carried to Elevation 1070, there remaining a 20-foot depth of rock to be removed from the channel and excavation of rock for the foundation of the intake chamber. Work for the year was started at this site on November 21, when rock excavation was resumed in the channel, and the progress attained in the few weeks preceding the end of the year was limited to the removal of a 5-foot lift of rock within the channel limits between Station 0+77 and the east end of the channel at Station 2+20. No work was done within the limits of the chamber, but plant is now available at this site for vigorous prosecution of the work during the coming season.

Studies, Designs and Working Drawings.—The working drawing detailing the galvanized steel floor edgings in the intake chamber was completed, and the drawings of the steel picket fencing at the outlet works were checked and, together with those of the outlet



SHANDAKEN TUNNEL.—Temporary timbering in the north tunnel at Shaft 3. The heading at this point was excavated through mixed red and gray shaly sandstone. The timber was placed three months after the excavation had been done.

chamber and channel masonry which were prepared during the previous year, are ready for tracing at the present time. Computations were made of the weights of the bronze Venturi meter castings for the intake chamber and a wooden form for use in the throat section of this meter, to take the place of the iron casting contemplated at the time the specifications for the contract were prepared, was designed and built by the Board's forces.

HIGHWAYS AROUND THE SCHOHARIE RESERVOIR

Contract 202 was for grading $7\frac{1}{2}$ miles of the marginal highways around the Schoharie reservoir, and the contractor was the Schunnemunk Construction Company of Highland Mills, N. Y. Three miles of the work, known as Road 7, are on the westerly side of the Schoharie creek and form the connecting link between Road 6, which was graded under Contract 200, and the portion of the Grand Gorge - Gilboa road which is not to be disturbed by the Board's operations; $4\frac{1}{2}$ miles of road, designated as Roads 2, 3, 4 and 5, form one continuous highway on the easterly side of the creek and connect the Prattsville-Gilboa road with the new highway bridge over the Manor Kill which was constructed under Contract 204.

Progress.—The work remaining uncompleted at the beginning of the year consisted of minor details on Road 7, the rough grading of 1,400 linear feet and final grading of 16,400 linear feet of Roads 2, 3, 4 and 5 and the surfacing of 1,935 feet of the latter roads with a 10-inch stone course; also the construction of guard-rails, paving of gutters and other minor details. The contract was completed on September 14, on which date the final estimate was forwarded in the total amount of \$165,193.69, or 93.5 per cent. of the estimated amount of \$176,700.00, at which the contract had been awarded on June 13, 1919. The yearly progress on the principal items of the contract is shown in the following table:

ITEM AND UNIT OF MEASUREMENT	1919	1920	1921	TOTAL	
				TOTAL TO SEPTEMBER 14, 1921	ESTIMATED CONTRACT QUANTITIES
Excavation—Cubic Yards.....	35,800	57,309	25,070	118,179	112,500
Masonry, including Paving—Cubic Yards.....	585	1,633	1,401	3,619	6,550
Portland Cement—Barrels.....	690	1,943	109	2,742	6,500
Six-inch Tile Underdrains—Linear Feet.....	.....	1,614	1,382	2,996	3,000
Crushed Stone and Gravel—Cubic Yards.....	.....	2,873	2,175	5,048	800
Guard-rail—Linear Feet.....	.....	3,345	17,869	21,214	22,000

Road 7 continued open for traffic throughout the year, but on the easterly side of the creek traffic was continued over the old roads which were not disturbed by the Board's operations.

Contractor's Forces, Camps and Plant.—The contractor's force, which averaged 64 men for the year, was adequate at all times for the work in hand. The camps established in previous years were continued in use until the completion of the work.

The equipment on hand in the latter part of 1920 was used during the present season. A Thew Type C revolving shovel did all the rough grading, and the required compacting of the sub-base was done by a 10-ton Buffalo steam-roller.

Roads 2, 3, 4 and 5.—The major portion of the contract work for the year was done on the east side roads, Roads 2 to 5, inclusive, by methods similar to those in use during 1920. Excavation was begun on March 31 at Station 191 with the Thew shovel and after digging out at this cut the shovel was used to complete the clay cut at Station 214+50, after which it was again moved back to Station 191 and thence over Roads 2, 3, 4 and 5, finishing the rough grading as it progressed. The shovel was operated as continuously as the weather permitted until it cut through at the south end of Road 5 on July 22. This shovel actually worked 87 days and excavated about 15,000 cubic yards of material, a daily average of 172 cubic yards, which is comparable with a daily average of 213 cubic yards removed by this shovel in 1920. A finishing gang of fifteen to twenty men kept quite closely behind the shovel, trimming the slopes and roadway and excavating gutters.

The 10-inch stone surfacing course between Stations 197 and 239, which was partially completed in the fall of 1920, was finished early in the year, and the same type of surfacing was placed between Stations 53 and 56+40 and between Stations 153 and 165+25, where similar conditions of sub-soil were encountered; 1,382 linear feet of 6-inch tile underdrains were placed immediately after the shovel excavation at all places where high ground-water was encountered, and 2,700 linear feet of berm ditches were dug to deflect water from the cut slopes. One culvert was built at Station 114+50 and a dry-rubble masonry retaining-wall of Board of Water Supply standard section was constructed between Stations 17+05 and 18+50.

The placing of 14,500 linear feet of guard-rail, dry paving 4,500 linear feet of gutters, and paving and grouting 40 culvert

inlets and outlets were carried on simultaneously with the major operations on other stretches of the roads.

Road 7 was opened to traffic in the fall of 1920 and work for the past year consisted of placing the rails for 6,700 linear feet of guard-rails from May 3 to May 14, laying 1,924 linear feet of dry paving in gutters between May 10 and June 3, and digging 1,800 linear feet of berm ditches, widening embankments and cleaning up from July 22 to July 25.

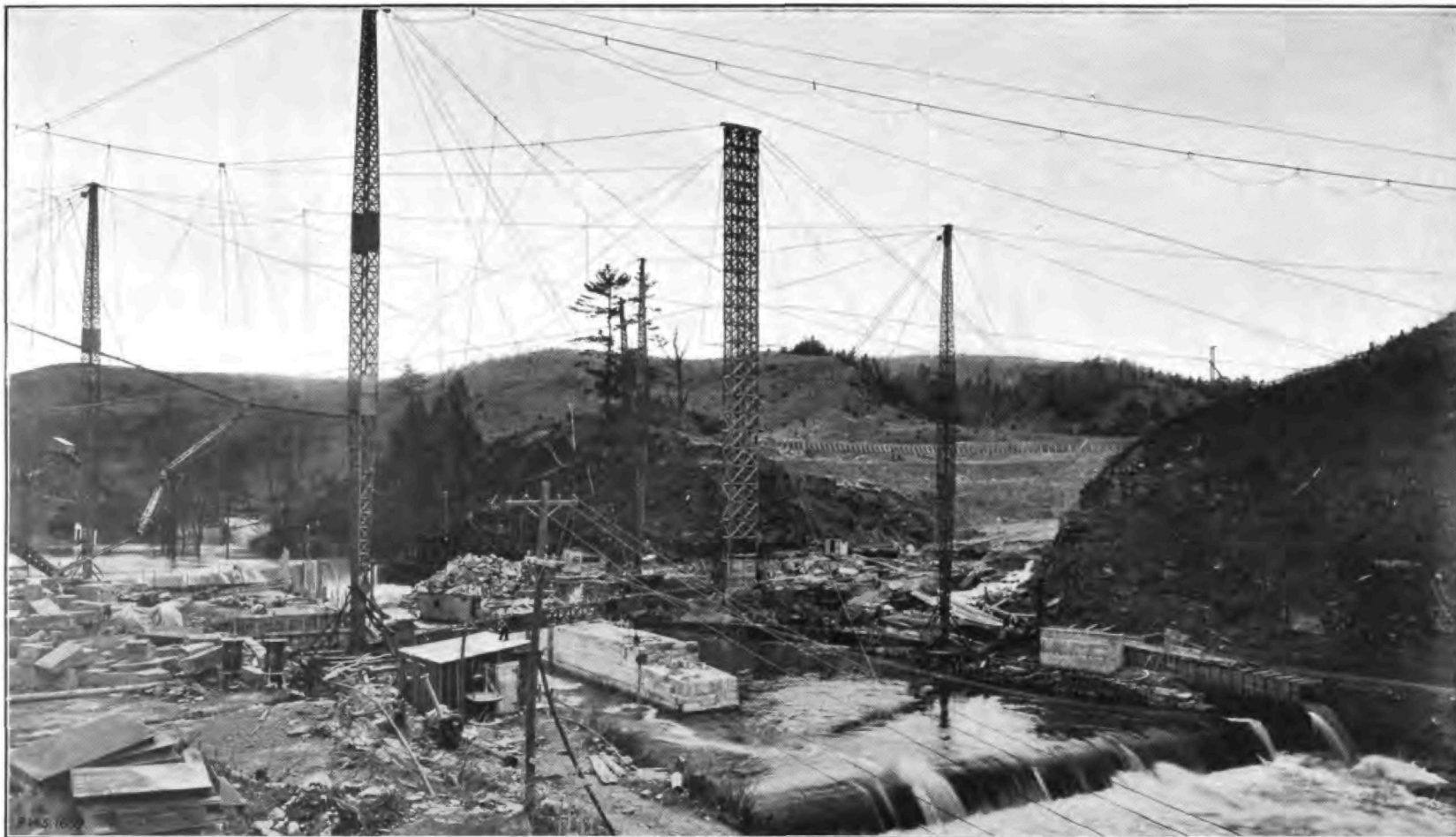
THE GILBOA DAM

Contract 203 is for the construction of the Gilboa dam, which comprises an overfall masonry section about 1,324 feet in length with a maximum height of 160 feet and an earth dike section about 700 feet long with concrete core-wall. The work also includes the construction of a spillway channel and appurtenant structures, stream-control works for both the Schoharie creek and the Steen Kill, about three miles of substituted new highways, and the construction of a temporary highway bridge over the Schoharie creek at Gilboa. About 10,300 feet of the highways, known as Roads 1 and 9, lie on the easterly side of the Schoharie creek and form the connecting link between the new highway bridges over the Manor Kill and the Schoharie creek at Gilboa, which were built under *Contract 204*. Road 8, with a length of 5,900 feet, lies on the westerly side of the Schoharie creek and will connect the high-level Grand Gorge - Blenheim road with the low-level Gilboa - Blenheim road.

The contractor is the Hugh Nawn Contracting Company, 82 Savin street, Roxbury, Mass., to which company the contract was awarded on June 20, 1919, in the estimated amount of \$6,819,-910.00.

Progress.—Excavation of the earth cover overlying ledge-rock within the main structure limits and excavation of rock for the main dam, spillway and cut-off areas were continuous throughout the year. Placing of concrete and cyclopean masonry and face and edge stones was started in the early fall and, with work concentrated on the river sections, operations were advanced sufficiently to permit the breaching of the coffer-dams and starting of the dis-assembling of the two 9-foot steel diversion pipes.

Work on the earth dike has been confined to placing embankment and the stone-paved face protection on that portion of the dike which is to serve as a diverting dam for the Steen Kill. The



SCHOHARIE RESERVOIR—Gilboa dam site, showing flood conditions in the Schoharie creek. The masonry placed in the dam is prominent in center of picture. Note the cableways and the concrete chuting system.

Schoharie Creek stream-control works were in process of demolition on December 31, and the Steen Kill control was modified during the year by a pipe extension to the concrete culvert. Roads 1 and 9 have been surfaced with bituminous macadam and completed in full detail, and on Road 8, which has been surfaced with a 16-inch stone course, some work remained on erection of the guard-rails at the end of the year.

The progress on the contract, as measured by the monthly estimates, amounted to 17.5 per cent. on December 31, the total gross estimates aggregating \$1,193,449.38. The yearly progress on the principal items of work is shown in the following table:

ITEM AND UNIT OF MEASUREMENT	1919	1920	1921	TOTAL TO DECEMBER 31, 1921	TOTAL ESTIMATED CONTRACT QUANTITIES
Main Structures, including Stream Controls—					
Stream Controls—Lump Sums.....		0.73	0.45	1.18	2
Excavation—Cubic Yards.....	1,115	20,766	152,144	174,025	399,000
Masonry, including Paving—Cubic Yards.....	485	3,109	27,310	30,904	449,375
Portland Cement—Barrels.....	763	3,588	28,870	33,221	477,000
Embankment—Cubic Yards.....		1,400	68,120	69,520	617,000
Highways					
Excavation—Cubic Yards.....	14,330	63,763	20,903	98,996	89,500
Masonry, including Paving—Cubic Yards.....	415	2,393	916	3,724	7,150
Portland Cement—Barrels.....	585	1,215	884	2,684	3,000
Crushed Stone—Cubic Yards.....	205	4,167	4,826	9,198	3,000
Bituminous Surfacing—Linear Feet.....			8,870	8,870	11,000
Guard-Rails—Linear Feet.....		2,480	8,200	10,680	15,000

Contractor's Forces.—The labor situation was greatly improved this year, sufficient men, both skilled and unskilled, being available at all times. The efficiency of the employees was also above that of former years. The minimum number of men employed was 170, the maximum 500, and the average 380.

Camps.—The main camp erected during 1919 and 1920 remained in use during the year. The sanitary condition of the camp has been excellent, the Kaustine closets giving satisfactory results and garbage has been collected regularly and disposed of by burning and burying in large pits at a distance from the camp. The emergency hospital was enlarged by an addition which furnished one room for two beds and a larger room for four beds.

Geological Conditions.—The general level of the foundation for the dam in the old creek bed is about 6 feet below the original surface of the rock and displayed some of the characteristics that

have been noted in certain portions of the Shandaken tunnel, in that the rock seems to be under stress; this was first observed in connection with the use of channelers in the cut-off trench. When the channeler cut had been made and the machine had passed on and later returned it was found that the channeler bit could not be inserted in the old slot and that apparently the rock was off-set. Off-sets in the rock were also noticed at other points when the rock in the cut-off trench was removed, the maximum overhang observed being $\frac{1}{8}$ inch. This same peculiar behavior of the rock was noted when tightening up the bottom by barring and wedging as ordinarily in sandstone rocks when a wedge is driven in a seam a flat slab can be removed, but in this rock, which is exceedingly brittle, it breaks with a concave breakage and frequently loose pieces are bound in, something as a marble might be when embedded in clay and the clay had subsequently shrunk. Vertical seams are frequent, extending in all directions, being in general continuous only for short distances, and the blocks between these seams overly or underly adjoining blocks, binding the whole mass together; also, in barring and wedging, small chips sometimes break off with a report, flying to a considerable distance.

Another interesting condition noted in the foundation is an artesian flow from each of the seven diamond-drill holes which had been drilled in the cut-off trench between Stations 13+50 and 14+40. This flow totaled at least 100 gallons per minute and was intercepted at different depths below the floor of the cut-off trench which is at about Elevation 949, one flow starting practically at that level while in another hole the flow was not encountered until a depth of 37 feet had been reached. It was also observed that when the artesian flow began from a hole the leaks from the side-walls in the vicinity ceased and at the end of the year practically no leakage occurred in the side-walls where formerly it had been considerable.

Fossils.—While quarrying face stones for the dam from the Riverside quarry, and later in making the rock excavation for the spillway channel, fossil tree stumps were discovered. These belong to the Devonian age, and were found in the quarry at about Elevation 957 and in the spillway channel at Elevation 1,020. With their bases resting on a layer of shale, they were found in a stratum of hard bluestone, the size of the stumps varying from about 12 inches to over 3 feet in diameter. Previous to the discovery of the fossils at the Riverside quarry, similar ones, though smaller and not as perfect specimens, had been found near the

old highway bridge over the Manor Kill on the road to Prattsville at about Elevation 1120. These various fossils have been presented to several public museums, the largest collection being at the New York State Museum at Albany.

Plant.—The contractor's plant was largely augmented during the past year, principally through installation and co-ordination of elements delivered at the site during 1920. A brief description of the plant in use for placing masonry at the main dam, and its operation, is as follows:

Sand from the Patchin sand-pit is delivered to the sand washer by a narrow-gage railroad and is dumped into a hopper with a grizzly, which feeds onto an inclined belt conveyor, and is then elevated to the upper end of a revolving screen having $\frac{1}{4}$ -inch openings. The sand is then washed through the screen by water delivered at a rate of from 500 to 600 gallons per minute into wooden flumes which convey it to automatic hoppers dumping into the tramway buckets. Material too fine for use is washed from the top of the hoppers, while the material which is too coarse is automatically wasted at the end of the screen. The washed sand is conveyed from the washer to the main concrete mixing plant by a tramway 585 feet long supported at the terminals and by one intermediate tower and carrying two $1\frac{1}{2}$ -yard buckets, operated at a speed of 500 feet per minute; here it is automatically dumped into a 290-cubic-yard bin directly over the mixer.

Some stone from the excavation for the main dam is crushed by the No. 5 crusher on Church hill, but as the Stevens Mountain quarry will be the main source of supply, its operation is described here.

The main crusher plant at the quarry consists of a Traylor "Bulldog" crusher with 42-inch by 48-inch opening, set on a concrete base near the end of a 300-foot trestle which carries the railroad track from the quarry. From this jaw crusher the stone passes into a No. 16 Traylor gyratory crusher delivering onto a belt conveyor 220 feet long which transports the stone to the screen; after passing through the screen, the stone is collected in bins from which it is discharged through a chute upon a boom belt conveyor 90 feet long which in turn discharges it to the storage-pile. The tailings are passed through a No. 5 Traylor gyratory crusher and thence by the bucket conveyor to the screen again, the screenings being conveyed by a belt to a separate storage pile. The entire plant is electrically operated and has a capacity of 150 cubic yards per hour.



SCHOHARIE RESERVOIR—Group of tree fossils found in the Riverside quarry while quarrying face stones for the Gilboa dam.

The storage pile is located over a wooden tunnel 8 feet square and 180 feet long in which are operated two 2-yard cars which are drawn through the tunnel and up an incline by a hoist engine to bins which subsequently discharge the stone to the tramway. This tramway is 3,670 feet long and is operated at a speed of 500 feet per minute with thirty-two 1-yard buckets spaced 250 feet apart. The cable is supported at the terminals and by ten intermediate towers of an average height of 22 feet, the lower terminal being located near the No. 5 Austin crusher on Church hill, from which point the stone is delivered to a belt conveyor which carries it to storage bins over the mixer.

Cement is stored in a storehouse of 18,000 bags capacity located on Conro's flats, and is delivered to the mixer at a rate of 6 bags every 48 seconds by a 3,300-foot tramway which is supported at the terminals and by eight intermediate towers of an average height of 18 feet. Storage for 2,000 bags is provided at the mixer.

Water is supplied to the mixer by a 4-inch gravity line from the Manor Kill. The main mixing plant consists of an electrically-driven 2-cubic-yard mixer which is fed directly from overhead stone and sand bins. The mixer dumps into elevator buckets operated by electric hoist drums which raise the concrete to the top of the 135-foot distributing tower where the buckets automatically dump into the hopper feeding directly into the steel chutes which are suspended from a cable of 430-foot span swung between the elevator-tower and a 168-foot booster tower located near the west retaining-wall of the spillway channel. The chutes are placed on a 1 on $2\frac{3}{4}$ slope and deliver directly to the dam.

Plums for the cyclopean masonry are received from the main excavation for the dam or from the Riverside quarry by truck delivery and are handled by the main cableway of 1,900-foot span and 10 tons capacity and by the four steel derricks now in place.

The main items of plant installed at the principal points of activity under the contract are given in the following table:

ITEM OF PLANT AND RATING OR CAPACITY	LOCATION						TOTAL
	Main Structures	Highways	Quarries	Sand Pits	Compressor Plant	General	
Power Line (Electric)—33,000 volts	—	—	—	—	—	1	1
Transformers—333 kilovolt-amperes	—	—	—	—	3	—	3
Transformers—200 kilovolt-amperes	—	—	—	—	—	2	2
Transformers—150 kilovolt-amperes	—	—	—	—	—	3	3
Transformers—37 kilovolt-amperes	—	—	3	—	—	—	3
Transformers—10 kilovolt-amperes	—	—	—	—	—	2	2

ITEM OF PLANT AND RATING OR CAPACITY	LOCATION						TOTAL
	Main Structures	Highways	Quarries	Sand Pits	Compressor Plant	General	
Motors—							
Cableway—300-horse-power.....						2	2
Washer and Compressor—200-horse-power..			2		2		4
Crusher—150-horse-power.....			1				1
Crusher and Washer—100-horse-power.....			2				2
Hoist and Mixer—82-horse-power.....	2					2	4
Compressor—75-horse-power.....					1		1
Derrick, Hoist and Crusher—60-horse-power	1		1			1	3
Sand Tramway—55-horse-power.....				1			1
Lambert Derrick—52-horse-power.....	4						4
Crusher and Mixer—50-horse-power.....			2			1	3
Pump and Tramways—40-horse-power.....	1		1			1	3
Conveyor—30-horse-power.....				1			1
Conveyor—Bag Cleaner—22-horse-power.....	1					1	2
Conveyor—20-horse-power.....			1			2	3
Channelers—15-horse-power.....	2						2
Crusher and Well Drill—10-horse-power.....			2				2
Crusher—5-horse-power.....			1				1
Generators—Direct-Current.....					3		3
Pipe-Lines—							
10-inch Hydraulic—2,500 linear feet.....			1				1
4-inch Air—10,000 linear feet.....						1	1
Cableway—1,900-foot span.....						1	1
Tramways—							
Stone—thirty-two 1-cubic-yard buckets —3,670-foot span.....			1				1
Cement—fourteen 1/3-cubic-yard buckets —3,300-foot span.....						1	1
Sand—two 1½-cubic-yard buckets—585- foot span.....						1	1
Conveyors—							
Stone—24-inch belt—90 feet, 100 feet, 190 feet and 210 feet.....			2			2	4
Stone—12-inch belt—220 feet.....			1				1
Sand—24-inch belt—150 feet.....						1	1
Embankment—24-inch belt—600 feet.....	1						1
Concrete Towers—135 feet and 150 feet.....	2						2
Lakewood Cage Engines.....	4						4
Lakewood Elevator Buckets—1½-cubic-yard	6						6
Lakewood Hoppers—2-cubic-yard.....	4						4
Lakewood Chutes—14-inch—600 linear feet..	1						1
Hoist Engines—							
Lambert (Electric)—52-horse-power.....	4						4
Electric.....	1						1
Lidgerwood.....	11		2			4	17
Mundy.....			1				1
Boilers—							
Vertical—100-horse-power.....			1				1
Vertical—90-horse-power.....			1			1	2
Vertical—50-horse-power.....			1				1
Vertical—30-horse-power.....	2					4	6
Vertical—15-horse-power.....						2	2
Horizontal—30-horse-power.....						1	1
Horizontal—25-horse-power.....	1						1
Derricks—							
Steel Guy—100-foot boom.....	4						4
Guy—90-foot boom.....			1				1
Guy—55-foot boom.....			1				1
Traveling—75-foot boom.....	1						1
Traveling—65-foot boom.....	1						1
Traveling—45-foot boom.....	1						1
Stiff-Leg—45-foot boom.....	1						1
Hand Grab.....	1					1	2
Compressors—							
Ingersoll-Rand—1,300 cubic feet per minute					2		2
Ingersoll-Rand—400 cubic feet per minute...					2		2
Portable.....	2						2
Air Receivers—							
500-cubic-foot.....					2		2
200-cubic-foot.....					2		2
Pumps—							
Warner (Steam)—6-inch.....	1						1
Worthington (Steam)—6-inch.....	1						1
Worthington (Steam)—4-inch.....					4		4

ITEM OF PLANT AND RATING OR CAPACITY	LOCATION					TOTAL
	Main Structures	Highways	Quarries	Sand Pits	Compressor Plant		General
Pumps—						
Centrifugal (Electric)—10-inch.....	.....	.....	3	.....	.....	3
Centrifugal (Electric)—6-inch.....	1	.....	.....	.....	.....	1
Centrifugal (Electric)—4-inch.....	1	.....	.....	.....	.....	1
Duplex—6-inch.....	.....	.....	.....	.....	3	3
Duplex—3-inch.....	.....	.....	1	.....	.....	1
Diaphragm—3-inch.....	.....	.....	.....	.....	3	3
Gasoline—2-inch.....	.....	.....	.....	.....	4	4
Hand—3-inch.....	.....	.....	.....	.....	4	4
Crushers—						
Traylor "Bull Dog"—42-inch by 48-inch.....	.....	.....	1	.....	.....	1
Traylor Gyratory—No. 16.....	.....	.....	1	.....	.....	1
Traylor Gyratory—No. 5.....	.....	.....	1	.....	.....	1
Austin Gyratory—No. 5.....	1	.....	.....	.....	.....	1
Climax Jaw—9-inch by 15-inch.....	.....	.....	1	.....	.....	1
Concrete Mixers—						
Cylindrical (Electric)—2-cubic-yard.....	1	.....	.....	.....	.....	1
Cylindrical (Electric)—1-cubic-yard.....	1	.....	.....	.....	.....	1
Cylindrical (Gasoline)—6-cubic-foot.....	2	.....	.....	.....	.....	2
Cubical (Steam)— $\frac{3}{4}$ -cubic-yard.....	1	.....	.....	.....	.....	1
Cubical (Steam)—6-cubic-foot.....	1	.....	.....	.....	.....	1
Steam Shovels—						
Atlantic—Type 45.....	1	.....	1	.....	.....	2
Thew—Type A-1.....	1	1	1	.....	.....	3
Thew—Type O.....	.....	.....	.....	.....	1	1
Ship Scrapers.....						
.....	.....	.....	.....	.....	8	8
Rollers—						
Monarch (Steam)—20-ton.....	.....	.....	.....	.....	1	1
Monarch (Steam)—10-ton.....	.....	1	.....	.....	.....	1
Austin (Steam)—12-ton.....	.....	.....	.....	.....	1	1
Buffalo (Steam)—10-ton.....	.....	1	.....	.....	.....	1
Horse—2-ton.....	1	.....	.....	.....	.....	1
Channelers—						
Ingersoll-Rand—7-inch.....	2	.....	.....	.....	.....	2
Sullivan—V. Y. 18.....	1	.....	.....	.....	.....	1
Drills—						
Tripod.....	.....	.....	.....	.....	9	9
Jackhammer.....	.....	.....	.....	.....	14	14
Oldham (Plug).....	.....	.....	.....	.....	9	9
Oldham (Surface Cutting).....	.....	.....	.....	.....	1	1
Giant (Air).....	.....	.....	.....	.....	3	3
Cyclone Well (Electric).....	.....	.....	1	.....	.....	1
Traction Equipment—						
Linn Tractors—5-ton.....	.....	.....	.....	.....	2	2
Linn Trailers—5-ton.....	.....	.....	.....	.....	2	2
Auto Trucks—2½ tons.....	.....	.....	.....	.....	1	1
Dinkeys—18-ton.....	2	.....	.....	.....	.....	2
Dinkeys—15-ton.....	.....	.....	1	.....	.....	1
Horses.....	.....	.....	.....	.....	56	56
Dump Cars—4-cubic-yard.....	35	.....	.....	.....	.....	35
Dump Cars—1½-cubic-yard.....	12	.....	.....	.....	.....	12
Watson Dump Wagons—2-up.....	27	.....	.....	.....	.....	27
Double-End Dump Wagons.....	5	.....	.....	.....	.....	5
Single-End Dump Wagons.....	12	.....	.....	.....	.....	12
Narrow-Gage Track—17,600 linear feet and 1,150 linear feet.....	1	.....	1	.....	.....	2
Buckets—						
Clam-Shell.....	.....	.....	.....	.....	1	1
Orange-Peel.....	.....	.....	.....	.....	1	1
Steel Skips—						
3-cubic-yard.....	20	.....	.....	.....	.....	20
1-cubic-yard.....	6	.....	.....	.....	.....	6
Power Hammers—Sheet Pile.....						
.....	.....	.....	.....	.....	6	6
Sand Washer—Link Belt Company.....						
.....	1	.....	.....	.....	.....	1
Cement Bag Cleaner.....						
.....	.....	.....	.....	.....	1	1

The Riverside Quarry.—Work at this quarry was resumed after the winter shut-down on April 16, when a force started stripping the earth cover to enlarge the working area, following which



SCHOHARIE RESERVOIR.—The Riverside quarry, where stone is obtained for the construction of the Gilboa dam. The stones shown have been quarried and are ready to be dressed.

quarrying operations were begun on May 21 and cutting of face and edge stones on June 10. An air planer was installed during the year for use in dressing the joint faces of the edge stones. Stone from this quarry is particularly adapted for use in the masonry required for facing the dam and walls as it is a gray sandstone of good quality, divided into blocks up to 5 or 6 feet in thickness by horizontal and vertical seams; thus, with free faces to work to, a stone is easily quarried to approximate size by drilling and plug-and-feathering. Because of cold weather, work was suspended for the year on December 22, at which time a total of 1,440 cubic yards of face stones and 59 cubic yards of edge stones had been dressed to dimension.

Deliveries from this quarry are now made by truck, but will eventually be made to the dam by a narrow-gage railroad which was in process of construction at the end of the year.

The Stevens Mountain Quarry.—The cover overlying the rock was stripped from this quarry hydraulically by water from the Manor Kill delivered by one 10-inch single-stage and two 10-inch double-stage centrifugal pumps through a 10-inch spiral riveted pipe-line which delivered 1,900 gallons of water per minute at a nozzle pressure of 90 pounds per square inch. With this equipment, 4,200 cubic yards of material were removed between June 1 and early August, which permitted the starting of quarrying operations during the late summer, and crusher muck was first delivered on October 3. A gasoline well drill capable of drilling 42 feet of 6-inch holes in eight hours was installed in the quarry. Delivery to the crusher is made by a steam shovel and dinkey line and from the crusher to Church hill by way of a tramway 3,670 feet in length.

Sand Pits.—Sand was secured from the Cherry Knoll pit until September 6, when this supply was exhausted, and the River Flat pit was then used as a main pit until October 17 when, with the opening of the Patchin pit, the former was used as an auxiliary supply until December 17. The Patchin pit, which is to be the main source of supply, is located near the intake chamber of the Shandaken tunnel about $2\frac{3}{4}$ miles from the Gilboa dam. The sand is excavated by a Thew shovel, loaded on a 6-car dinkey train and delivered to the sand washing plant near the main dam. This pit has not been fully developed but, as is the case with all pits in this locality, shows materials varying from coarse gravel to fine sand with streaks of clay.



SCHOHARIE RESERVOIR—Excavation for the Gilboa dam, looking easterly along the cut-off trench. The bottom of the cut-off is at Elevation 949. |

Excavation for the Dam and Spillway Channel.—Earth excavation within the limits of the main structures east of the creek gorge was continuous throughout the year. One Thew shovel served by a 2-car dinkey train was operated on a single shift from the first of the year until April 18, on which date a second Thew shovel was started on a single-shift basis and the train was increased to four cars. Double shifts with both shovels were begun on July 25 and continued until early October, when work was suspended pending the installation of a suitable track for delivering materials to the blanket fill. On December 31, shovel excavation was practically completed from the gorge east to Station 10, with but slight progress beyond that point and a small amount of excavation was done by hand on the west side of the creek near Station 16.

Rock excavation was at first confined largely to the river sections and was then extended eastward up the face of the gorge to Station 11+65 and westward to Station 16+70. The portion of the excavation between Stations 12+20 and 15+60 was made to the full width of the dam, and between Stations 11+65 and 12+20 work was limited to widths of from 40 feet to 100 feet. Excavation was carried to approximate channel grade from the easterly face of the gorge to Station 12+30 between the excavation for the dam and 250 feet right.

Work at the river section was started by excavating a sump down-stream from the dam, then driving a trench 10 feet in width from the southerly face of this sump normally across the entire width of the foundation by shallow drilling and light charges of powder, and the excavation was then extended from the faces of this trench in both directions on the main area. Two tripod and two jackhammer drills were used for drilling the rock, which was removed in two or three courses the depths of which depended upon the location of the seams. A total average depth of 6 feet was removed for the full width of the dam.

Channelers were installed for making the face cuts of the cut-off, this work being started on March 2 with a special Ingersoll-Rand electric air swing-back track machine, but, because of unsatisfactory progress, this machine was soon superseded by two smaller channelers of the same type. After considerable experimentation, it was found that these machines equipped with Z-bits, each made up of three pieces of 2-inch by 1-inch "Black Diamond" steel, gave excellent results; a third channeler, a Sullivan

air machine, was placed in operation on August 14 after an unsuccessful experiment had been made with a quarry-bar outfit.

Double shifts operated the machines during June and July, and three shifts during August, but only desultory work was done during the latter part of the year on account of the constricted



SCHOHARIE RESERVOIR—Excavation for the Gilboa dam, looking easterly, showing the cut-off trench below the 9-foot stream-control pipes which temporarily carried the flow of the Schoharie creek. Beyond the pipes work is in progress on placing concrete masonry in the dam.

space. The cut-off trench is being excavated to a 20-foot top width, with its southerly edge coincident with the dam line; an 18-inch inset is made for the channel cuts which vary in depth from 4 to 6½ feet. The total depth of the trench averages 20 feet for the portion now completed between Stations 13 and 16+10. The rock within the cut-off limits is drilled and shot after the face cuts have been made.

The east face of the gorge was composed of decomposed shale which became more compact as the excavation was carried into the hill. In the early stages of the work this material was drilled and shot down into the gorge, from which position it was loaded into wagons by a steam shovel for removal to the spoil-bank, but as the work progressed, a stiff-leg derrick was installed for handling the muck and the shovel was moved from this point, the removal of muck being subsequently made by the derrick, cableway and 4-yard cars to the crusher or to the blanket fill, depending upon the character of the rock. The work at the spillway channel has been carried on by the usual methods, the removal of muck being done by means of a derrick and wagons.

The materials removed during the past year in the several aforementioned operations totaled 140,200 cubic yards.

Main Dam, Masonry Portion.—Placing of masonry in the main dam was practically continuous from August 4 to December 17, during which period a total of 24,000 cubic yards was set between Stations 13+86 and 16+07. This portion of the dam consists of three sections, as formed by the contraction-joints and includes both the stream-diversion conduit section and the steel-pipe diversion section. A complete section was constructed to Elevation 1018 in the easterly portion from Station 13+86 to Station 14+62; a complete section was built to Elevation 1004 and to the conduit lines in the central portion from Station 14+62 to Station 15+38, and a wall section 35 feet in thickness was set at the up-stream face of the westerly portion from Station 15+38 to Station 16+07, this wall being built to Elevation 981 under the pipes and to about Elevation 991 elsewhere. The concrete mix used was 1 : 2.52 : 5.04 of either Nazareth or Whitehall cement, local sand and crushed stone, practically all of the concrete being mixed in the main mixer plant and delivered by chutes to its place in the work. Plums, to the extent of from 10 to 12 per cent. of the total masonry volume, were secured from the main excavation, delivered by cableway and derrick and embedded in the concrete. Facing stones were, in general, carried up ahead of the concrete, and so served as forms. Bulkhead forms were of rough lumber and contraction-joint forms of dressed lumber.

In order to control the water in the cut-off trench, a line of diamond-drill holes $2\frac{1}{8}$ inches in diameter spaced $12\frac{1}{2}$ feet center to center, was drilled on a line five feet to the right of the dam line; these holes were drilled at an angle of $22\frac{1}{2}$ degrees with the

vertical, with varying depths between 40 and 50 feet at the center of the gorge and decreasing in depth toward the west. Artesian flow was encountered in the various holes between Elevations 912 and 942 and amounted to 100 gallons per minute.

After completing the drilling, each hole was cleaned with a stream of water escaping at 125 pounds pressure from small holes in a pipe which was lowered and raised from the top to the bottom of the hole. At the end of the year, eighteen diamond-drill holes had been completed, extending from Station 13+91 to Station 16+08. In order to grout the foundation, 2-inch pipes were sealed into these holes and extended as the masonry was brought up. Leakage through seams was collected in wells and conducted to a longitudinal 4-inch pipe which extended along the floor of the cut-off and carried the accumulated flow from the drill holes and wells; seams in the rock face were calked and pipes set so that they could be grouted at a future date.

Further grouting was also necessary throughout the bottom of the section between Stations 13+86 and 14+62, where thirty-two grout pipes were set, and later, when a sufficient volume of masonry had been placed, were grouted, apparently with good results; each batch contained 23 gallons of water to one bag of cement, being later changed to 12.5 gallons per bag to finish the hole. A total of 213 cubic feet of grout was used.

Facing stones were in general carried ahead of the cyclopean masonry and were bedded in 1:2½ mortar with the face joints raked out to a minimum depth of 2 inches. Tread stones were set and grouted with 1:1 mortar before work on the risers was begun. Edge stones were anchored back into the cyclopean masonry by 1½-inch rods spaced not over 5 feet apart, with steel pins engaging the eyes on the ends of the rods anchoring the adjacent stone. To date, 140 cubic yards of face stones and 46 cubic yards of edge stones have been placed in the work.

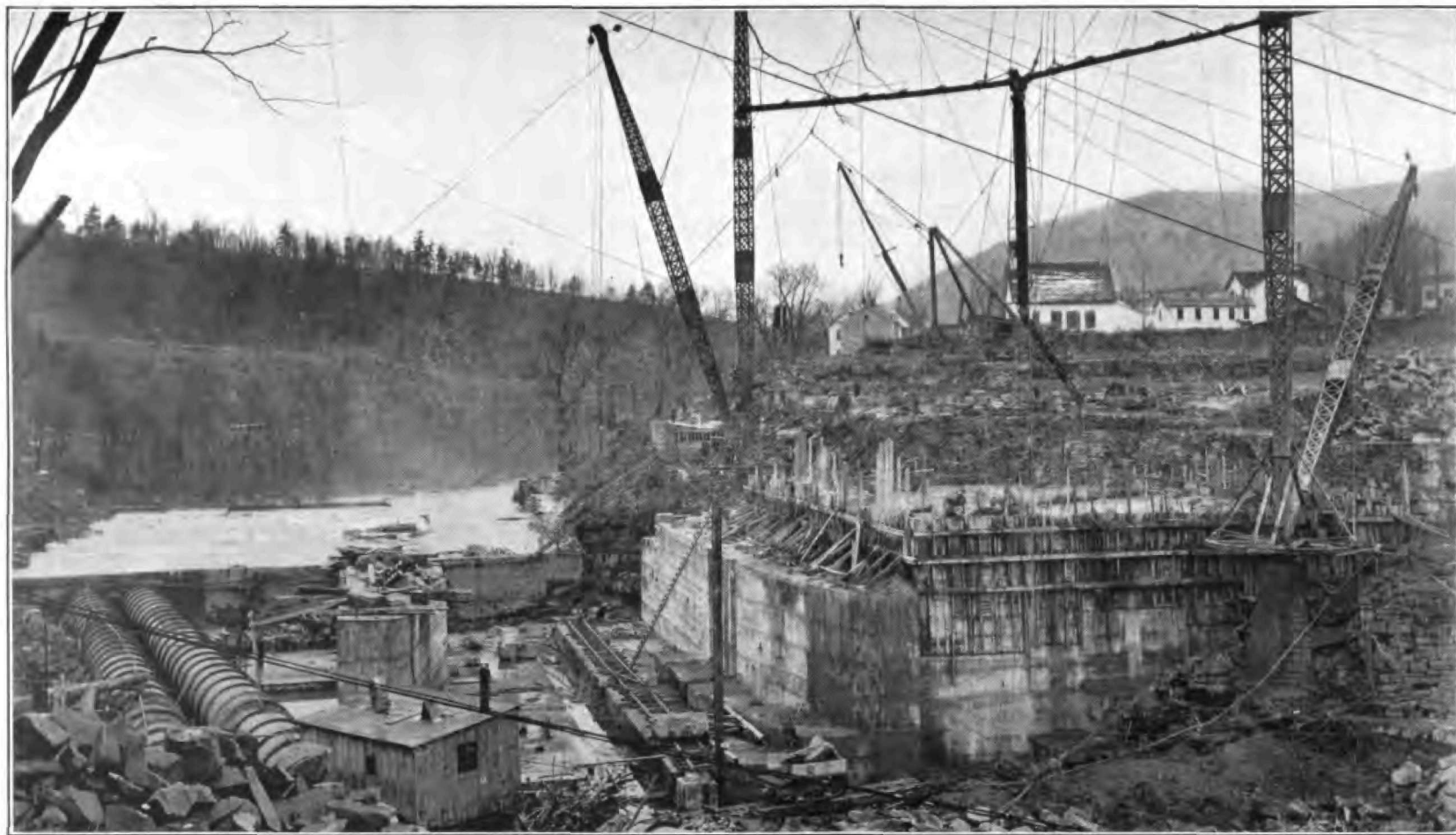
Main Dam, Earth Dike.—The work on the earth dike was concentrated on that portion which is to act as a diverting dam for the Steen Kill. Preliminary work, which was started early in April, consisted of cleaning up debris in the vicinity of the Steen Kill conduit and the stripping of a working area within the limits of that portion of the dike to be built under this first operation. Material for the embankment was obtained from a borrow-pit lying up the hill to the west of the dike. An Atlantic steam shovel was used to load the dirt into narrow-gage dump-cars, which were hauled by a dinkey to the receiving hopper of the

600-foot belt conveyor from which the material discharged into an elevated hopper and thence into bottom-dump wagons. This material was spread by a horse-drawn road machine and by hand and was then compacted to 4-inch layers by a steam roller. The material consists largely of a lumpy red or yellow clay which compacts under the roller to a tight and impervious embankment.

In the latter part of August, when the load thus placed on the steep side hill had become considerable, a slip in the underlying ground near the easterly end of the bank was observed, as evidenced by the appearance of appreciable cracks in the side hill above the dike and investigation showed that the slip occurred along blue clay strata appearing from Elevation 1035 to Elevation 1038. These cracks were sealed at the surface by pouring in sand and cement grout and work was discontinued over the affected area and continued elsewhere with a smaller section. To prevent further slipping it was decided to fill in the valley between the portion of the dike which had been placed and the far side of the original Steen Kill channel to an elevation above that of the clay strata. This work was progressed at all possible speed with three shifts whenever practical until November 28, when a fall flood of unusual magnitude ruptured the Steen Kill conduit and so flooded the working area as to necessitate the discontinuance of this work. The up-stream face of the dike, as built, was protected by stone facing consisting of a 3-foot rip-rap course below Elevation 1050, thus including the 1050 berm, with a standard 2-foot slope paving above that elevation. Stone for the slope paving was delivered from the excavation for the dam by the cableway to the west end of the dike where it was handled by a stiff-leg derrick. The stone, as a rule, was laid on edge, with some stones of large area placed on their beds. A total of 1,250 cubic yards of this paving was placed during the year.

Schoharie Creek Stream Control.—Under normal conditions, the area within the coffer-dams was kept dry by a 6-inch duplex pump working part time at the down-stream sump, but on six different occasions, and for a total of 104½ hours, flood flows overtopped the coffer-dams and flooded the working area at which times unwatering was accomplished by means of a 6-inch electric centrifugal pump.

Operations were started early in December on cleaning up the area between the main dam and the upper coffer-dam, and this work was followed by the building of concrete diverting walls for the conduit of the dam at both its upper and down-stream ends.



SCHOHARIE RESERVOIR—Gilboa dam site, looking down-stream from the upper coffer-dam. The concrete invert and portions of both side-walls of the stream-control conduit through the dam are shown in central foreground. The main portion of the dam built to date is to right of the conduit. The flow of the Schoharie creek is carried through the two 9-foot steel pipes at left. Excavation for the spillway channel is in progress in right background.

On December 20 and 21, respectively, the lower and upper cofferdams were breached and the water was diverted through the conduit; the ends of the 9-foot diversion pipes were then plugged by sand-bag and timber dams and the disassembling of the pipes, preparatory to their removal, was begun on December 28.

Steen Kill Stream Control.—The open-channel portion of the Steen Kill control works up-stream from the dike was excavated by a drag scraper operated by a hoist engine and then paved with 18 inches of grouted paving, this work being completed in the latter part of June. The invert was first excavated to full width and to grade, the spoil from this operation and the necessary excavation of the original surface for the side slopes being removed by the scraper. Four cut-off walls were concreted with a $1:2\frac{1}{3}:4\frac{2}{3}$ mix by a one-bag gasoline-driven mixer discharging into chutes which conveyed the concrete into place. Placing of stone paving was begun as soon as the excavation had advanced sufficiently, delivery of stone being made by wagons from the excavation for the main dam. About 40 linear feet of invert were laid and then the side slope was started. A 1:3 grout, kept well up with the paving, was mixed in a one-bag batch mixer dumping into a mortar box from which it was dipped by pails and poured into place, very little or no separation resulting from this method. The final application of grout was of a heavier consistence than that used for the lower portion of the paving.

The Steen Kill culvert was extended down-stream by a 250-foot double line of 24-inch cast-iron pipe encased in a concrete shell and as this extension resulted in a contraction of the waterway, a timber flume 228 feet long and 12 feet wide was constructed between the upper end of the culvert and the paved channel described above to by-pass portions of the flood flows. This supplementary construction was necessitated by the change in plan made to meet conditions developed by the embankment operations in this locality.

Roads 1 and 9.—The rough grading on these roads was practically completed during 1920, so that the work of the past season consisted largely of the placing of the bituminous macadam surfacing 14 feet in width. The cut slopes and high spots of the subgrade were excavated by a Thew shovel which was followed by grading gangs for the final trimming and shaping. Single lines of 6-inch tile underdrain were laid and a 12-inch sub-drainage course was placed and thoroughly rolled at all places where wet or damp conditions were encountered. Bituminous surfacing was con-



SCHOHARIE RESERVOIR--Looking easterly along Road 1. In left background can be seen the Stevens Mountain quarry and crusher plant, and leading therefrom is the tramway for conveying crushed stone to the site of the Gilboa dam.

fined to the main-line road from the present State road to the Schoharie bridge, with short stretches at the Broome Center "Y's" surfaced with water-bound macadam. Surfacing operations were begun in May and completed on October 18. The surfacing consisted of a 5-inch bottom course and 3½-inch top course including the seal coat. The hot asphalt was applied from a roller-drawn distributor, the amount of asphalt applied being regulated by the speed of the roller. The entire road, 8,795 feet in length, was surfaced from four set-ups of the heating tank, the maximum day's run for placing surface, *i.e.*, beginning with the top course and completing the road, being 250 linear feet, with an average of 150 linear feet; 4.16 gallons of asphalt per linear foot of road were used. That portion of Road 9 which lies west of the Schoharie creek and connects Road 8 with the Schoharie bridge was surfaced with 4 inches of water-bound macadam laid on a 10-inch foundation of large stones.

One standard concrete culvert was constructed at Station 270+81 on Road 1, and one 18-inch pipe culvert at the junction of Roads 1 and 9, the pipe for the latter culvert having been salvaged from the Clay Hill road. A total of 4,657 linear feet of paving was placed in gutters on slopes greater than 3½ per cent., 4,353 linear feet of guard-rail were constructed and inlets and outlets of twenty-two culverts were paved and then grouted.

Road 8.—Retention of moisture by the subgrade in portions of this road resulted in the churning up of the underlying clay and the consequent subsidence of the stone surfacing placed last year together with considerable amounts of crushed stone used as a remedial measure this spring. To correct these conditions, a surfacing section consisting of a base course of large stones 12 inches thick covered with a 4-inch layer of dust-filled crushed stone was adopted. This surfacing was started on July 18 and work was prosecuted continuously until its practical completion on December 10 at which time a small amount of work remained to be done on raising the guard-rails.

The existing surface was first scarified, shaped and rolled and stone from the Spillway Channel excavation was then hauled by trucks and laid on edge upon the prepared foundation; projecting points were broken off by a sledge and small stones sufficient to fill the spaces were spread over the top and all thoroughly rolled, great stress being laid on the rolling throughout the work. On this foundation, four inches of water-bound macadam were placed. A total of 5,538 linear feet of the road was thus sur-

faced, 5,208 feet of which had a thickness of 16 inches and 330 feet a thickness of 4 inches only. While working on the first part of the road, it was possible to detour traffic but beyond Station 12 one-half of the road had to be built at a time as traffic was carried through the work.

The Temporary Road.—This road, for temporarily diverting traffic from the easterly end of Road 1, was surfaced and crowned with gravel from nearby cuts and traffic was diverted over it on April 1. Gutters along the road were excavated but not paved and the necessary wooden culverts and guard-rails were built.

The Temporary Bridge.—This bridge was closed on October 31, when traffic was diverted over the new Schoharie bridge built under Contract 204 and removal of the temporary bridge from the creek was well under way at the end of the year.

Studies, Designs and Working Drawings.—The final cross-section of the Gilboa dam was determined upon early in the year, and soon thereafter the working drawings, which had been deferred pending approval of the section, were completed. Of these drawings, there were one of the cross-section and the contraction-joints of the dam, one locating the spillway wall and one detailing the lower steps of the spillway. A working drawing was completed of the transition section of the dam, one of the gate-chamber and another of the steel bridges over the 30-inch valves and other metal-work in the lower gate-chamber. A study of the details of the steel doors for the gate-chamber passageway and another of the passageway itself were ready for checking at the end of the year.

Pressure Tests at the Gilboa Dam Site.—The pressure tests of the foundation of the Gilboa dam, which were started during 1920, were completed on March 22. The purpose of these tests was to locate rock seams, to form an idea of their connection with one another, and to find their approximate carrying capacity when subjected to a pressure equal to that which would result from a height of ten feet of water over the crest of the dam. The tests showed that in general there is considerable leakage in the upper portion of the holes and near the surface, through both horizontal and vertical seams, the number of seams decreasing with the depth. No well-defined horizontal leakage planes extending over the entire area were observable, though responses were obtained in some cases between holes four hundred feet

apart. Seams are found both in the shale and the sandstone, although the more clearly defined seams are in the sandstone. From a study of these results tentative depths for the cut-off trench were determined and the location and depths of projected grout holes fixed.

Exploration of the Pre-Glacial Gorge at the Gilboa Dam Site.—Because the pre-glacial gorge of the Schoharie creek is located on the westerly side of the present stream, it was deemed advisable to develop this gorge in the vicinity of the Gilboa dam; accordingly, a line was selected which crossed the intersection of the old and new gorges and seven borings, with an aggregate length of 709.8 feet and 104.4 feet in earth and rock, respectively, and with a maximum penetration of 197.5 feet, were made by the Board's forces. The holes showed that the pre-glacial gorge for the portion explored is about 400 feet up-stream from and roughly parallel to the Gilboa dam. The floor is of gray sandstone at about Elevation 850 and the over-burden is in general impervious and consists of fine red sand and clay, with beds of red and blue clay and occasional pockets of gravel.

SCHOHARIE AND MANOR KILL HIGHWAY BRIDGES

Contract 204.—This contract covered the construction of a two-span steel highway bridge 222 feet long, with approaches, over the Schoharie creek at Gilboa, and a single-span steel highway bridge 150 feet in length, with approaches, over the Manor Kill stream. Both bridges have roadways 17 feet 6 inches in width, are paved with asphalt blocks and form a part of the permanent highway system around the Schoharie reservoir.

This contract was completed October 27, 1921, at a total cost of \$199,775.04 by Lupfer & Remick, 594 Ellicott Square, Buffalo, N. Y., to which concern the work had been awarded on April 30, 1920.

Progress.—The work remaining to be done on January 1, 1921, comprised the concreting of one abutment and the pier of the Schoharie bridge, and of both abutments of the Manor Kill bridge with the exception of one footing course, the erection and painting of all steelwork, the grading and surfacing of the approaches, and the concreting and paving of the bridge floors. The progress by years on the principal items of work is shown in the table on page 82.



SCHOHARIE RESERVOIR—Looking southwesterly from Road 9, showing the new Schoharie steel highway bridge and the temporary bridge across the Schoharie creek in right foreground with the Riverside quarry in left background. Road 8 can be seen on the far side of the stream.

PROGRESS ON PRINCIPAL ITEMS OF WORK—SCHOHARIE AND MANOR
KILL BRIDGES—CONTRACT 204

LOCATION	EXCAVATION —CUBIC YARDS	MASONRY, INCLUDING PAVING— CUBIC YARDS	PORTLAND CEMENT— BARRELS	STRUCTURAL STEEL— POUNDS
Schoharie Bridge				
Total for 1920.....	1,951	684	977	.....
Total for 1921.....	1,708	1,204	1,673	461,973
Total to October 27, 1921.....	3,659	1,888	2,650	461,973
Manor Kill Bridge				
Total for 1920.....	382	164	241	.....
Total for 1921.....	2,260	601	869	325,593
Total to October 27, 1921.....	2,642	765	1,110	325,593
Entire Contract				
Total for 1920.....	2,333	848	1,218	.....
Total for 1921.....	3,968	1,805	2,542	787,566
Total to October 27, 1921.....	6,301	2,653	3,760	787,566
Total Estimated Contract Quantities..	7,100	2,700	3,500	735,000

Contractors' Forces.—The contractors' force was composed largely of native labor and averaged 29 men for the working season. No camp was maintained, the employees living at their homes or boarding in the vicinity of the work.

Plant.—All the plant used during 1920 was available for use this year. The one-bag batch mixer located at the Manor Kill site was replaced by a more modern mixer of the same size before the concreting operations were begun.

The plant used in erecting steel at both bridges consisted of a four-wheel traveler about 27 feet in length built by the contractors at the site, this traveler having a track gage of about 10 feet and running on 60-pound rails placed on 3-inch planks laid on the bridge stringers. An "A"-frame derrick was guyed in place at the outboard end, the hoisting engine and boiler furnishing the counterweight at the other end of the traveler. The traveler was laid off the center of the bridge, so that room was left for a 24-inch-gage track at one side on which a small four-wheel truck pushed by hand was used to bring steel from the storage yard at the end of the bridge, the steel being loaded on the truck by a guy derrick located in the storage yard.

Bridge Pier and Abutments.—Work was resumed at the Schoharie Bridge site on January 11 on the excavation for the river pier with wooden sheet pile protection; a shift was made to steel piling and although this necessitated an appreciable delay



SCHOHARIE RESERVOIR—The Manor Kill bridge looking westerly. Details of the bridge seat on the west abutment can be seen in this view. The floor consists of an 8-inch concrete slab carrying the 2-inch asphalt-block pavement.

pending receipt of the sheeting, successful results were obtained. The bottom of the trench was in red clay having a small admixture of gravel, forming an excellent foundation. The first course of the footing concrete was placed by a tremie, following which the coffer-dam was pumped dry and concreting of the pier was carried to completion on June 10. Excavation for the west abutment was done between April 13 and May 9, the foundation being of very hard and compact clay except for a small rock area in the southwesterly corner of the south wing-wall. The concreting was begun immediately after the excavation was completed and was carried to the bridge seat on May 31. The back-wall, as in the other abutments, was not concreted until after the erection of the steel superstructure. The concrete mix and methods of placement for the pier and west abutment were similar to those used during 1920 in constructing the east abutment.

Concreting operations on the abutments of the Manor Kill bridge were resumed for the season on March 31, and were completed to the elevation of the bridge seats on April 19.

Bridge Superstructures.—Delivery of steel for the bridges was made between April 5 and May 21, special care being taken in transporting the 72-foot girders to prevent distortion and undue interference with public travel.

The Manor Kill bridge was erected first, after a thorough inspection and partial rebuilding of the falsework had been made, the erection operations at this bridge being completed on May 22, after a 7-day working period. The riveting required 27 days and was closely followed by the casting of the concrete floor and envelope system, following which the asphalt block paving in the roadway area was placed on September 26 and 27. Painting was done intermittently between August 1 and October 24.

Erection of steel was begun at the Schoharie Bridge site on June 27 and continued until July 13 when it was followed in turn by the riveting, the concreting of the floors and envelope, placing of the asphalt block paving and painting, all of which were completed on September 29.

The methods of steel erection were similar for both bridges. The traveler was started from the side of the stream where the material was stored, erecting the floor system complete to the opposite abutment, then moving back toward the starting point, erecting the truss as it progressed, so that on arrival at the storage-yard end of the bridge the structure was completely erected and ready for jacking up and riveting. The requirement of the

specifications that one erection bolt should be placed for not more than three rivet holes in members of the bridge was rigidly enforced. In jacking-up prior to riveting, the correct camber was set, and after swinging the trusses no settlement was shown by accurate levels. The steel gang consisted of one foreman and six steel men and when two gangs were employed on riveting, this number was increased to eight, allowing four men to a riveting gang.

Air-pressure for riveting at the Manor Kill site was furnished by a portable compressor with a gasoline motor, and at the Schoharie site, air was obtained from the air-line used for the construction of the Gilboa dam under Contract 203.

Bridge Approaches.—The approaches to the Manor Kill bridge were stone surfaced with a section similar to that used on the contiguous highways built under Contract 202. The Schoharie Bridge approaches were surfaced by the force and equipment employed on Contract 203 as a continuation of the work under that contract by agreement between the Hugh Nawn Contracting Company and the contractors on Contract 204. Gutters on slopes greater than $3\frac{1}{2}$ per cent. were paved with standard dry paving and 596 feet of wooden guard-rails were erected at the Manor Kill site and 393 feet at the Schoharie bridge.

Studies, Designs and Working Drawings.—A working drawing detailing the concrete floors of the Schoharie and Manor Kill bridges and the concrete covering for the beams and stringers was prepared and careful estimates of the weights of the trusses were made from the final dimensions.

REMOVAL OF BODIES, ETC., FROM LANDS ACQUIRED FOR THE SCHOHARIE RESERVOIR

Contract 206.—This contract was for the removal of those bodies, headstones and monuments from the lands acquired for the construction of the Schoharie reservoir which had not been removed by the parties of interest under the resolutions of the Board of Water Supply, and for the subsequent reinterment of the bodies and replacement of the headstones and monuments in a plot furnished under the contract.

The contract was awarded on June 9, 1921, to Charles Meads & Co., 217 West 14th street, New York City, in the estimated amount of \$9,734.50. Work was begun on June 29 and was completed on September 16, the final estimate amounting to

\$8,728.20. A summary of the removals made under this contract is given in the table on page 105.

Bodies were removed from four cemeteries located on Parcels 165, 179, 208 and 217, Section 3, of the reservoir taking, and all reinterments were made in the New Gilboa cemetery in a plot purchased by the contractor and subsequently deeded to the City; by the provisions of the deed, this plot is to have perpetual care. All bodies were removed and reinterred between July 16 and August 25 and the headstones and monuments were removed and replaced between August 26 and September 14.

In making removals, the graves were opened as directed, the bodies removed and placed in individually numbered yellow-pine boxes 12 inches by 18 inches by 36 inches, temporarily stored in a tent erected within the cemetery and subsequently transported to the new cemetery in a closed auto-truck. In those cases where no bodies were found in the originally excavated area, the excavation was enlarged to an extent which insured that there was actually no grave at that location.

In the new cemetery, the reinterments were made in individual plots, each being marked by a bluestone marker inscribed with an identifying number $1\frac{1}{2}$ inches in height. These markers were placed just west of the reinterment except when the new graves were marked by stones removed from the old cemeteries and re-erected at these new locations, in which cases the markers were placed at the foot of the grave, *i.e.*, to the east. All monuments were placed on a rubble concrete masonry foundation of suitable depth. After the reinterments and the setting of stones were completed, the entire area acquired was graded to a uniform surface and seeded.

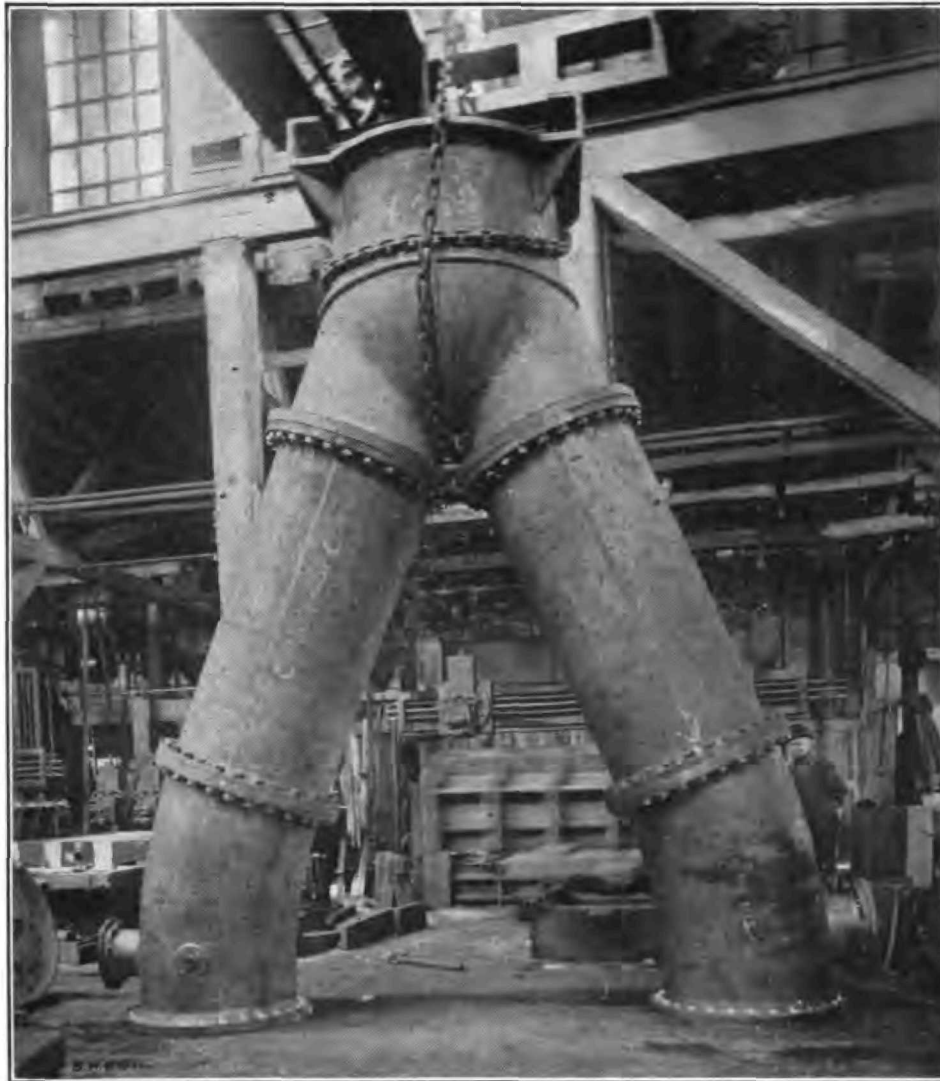
GATE-VALVES, ETC., FOR THE GILBOA DAM AND THE SHANDAKEN TUNNEL

Contract 207 is for furnishing and delivering 30-inch bronze gate-valves with hydraulic cylinders, 12-inch and 8-inch bronze gate-valves, and 30-inch, 12-inch and 8-inch bronze pipes for the gate-chamber of the Gilboa dam; also a 14-foot up-stream ring and an 8-foot 8-inch throat ring for the Venturi meter in the intake shaft of the Shandaken tunnel.

This contract was awarded on April 27, 1920, to the Coffin Valve Company of Neponset, Mass., in the estimated amount of

\$90,480.00, and at the end of the past year approximately 93 per cent. of the work included in the contract had been completed and a total of \$84,052.55 had been certified for payment.

The 30-inch hydraulically-operated bronze gate-valves furnished under this contract are examples of good foundry and



SCHOHARIE RESERVOIR—Gilboa dam; 30-inch bronze blow-off pipes and connection for the gate-chamber of the dam.

machine work and the piston packing used in the hydraulic cylinders is of special interest. This packing, first developed and used in the pistons of the riser-valves in the City tunnel of the Catskill aqueduct, consists of a bronze ring of cupped shape and the method of fitting is similar to that employed in hydraulic leather packing.

The successful application of these rings consists in machining them from a bronze the composition of which gives a dense, homogeneous casting with high elastic limit. After machining the cylinders and rings roughly to shape, the surfaces are brought to a smooth finish by grinding and buffing. No difficulty was experienced in making a good fit between the rings and cylinders and giving a proper shape to the rings. The rings were tested in the cylinders in three positions, one at the top of stroke, one at the bottom of stroke and one midway between, and the leakage for twelve tests was 5 ounces per minute at 100 pounds per square inch pressure.

SLUICE-GATES, ETC., FOR THE SHANDAKEN TUNNEL

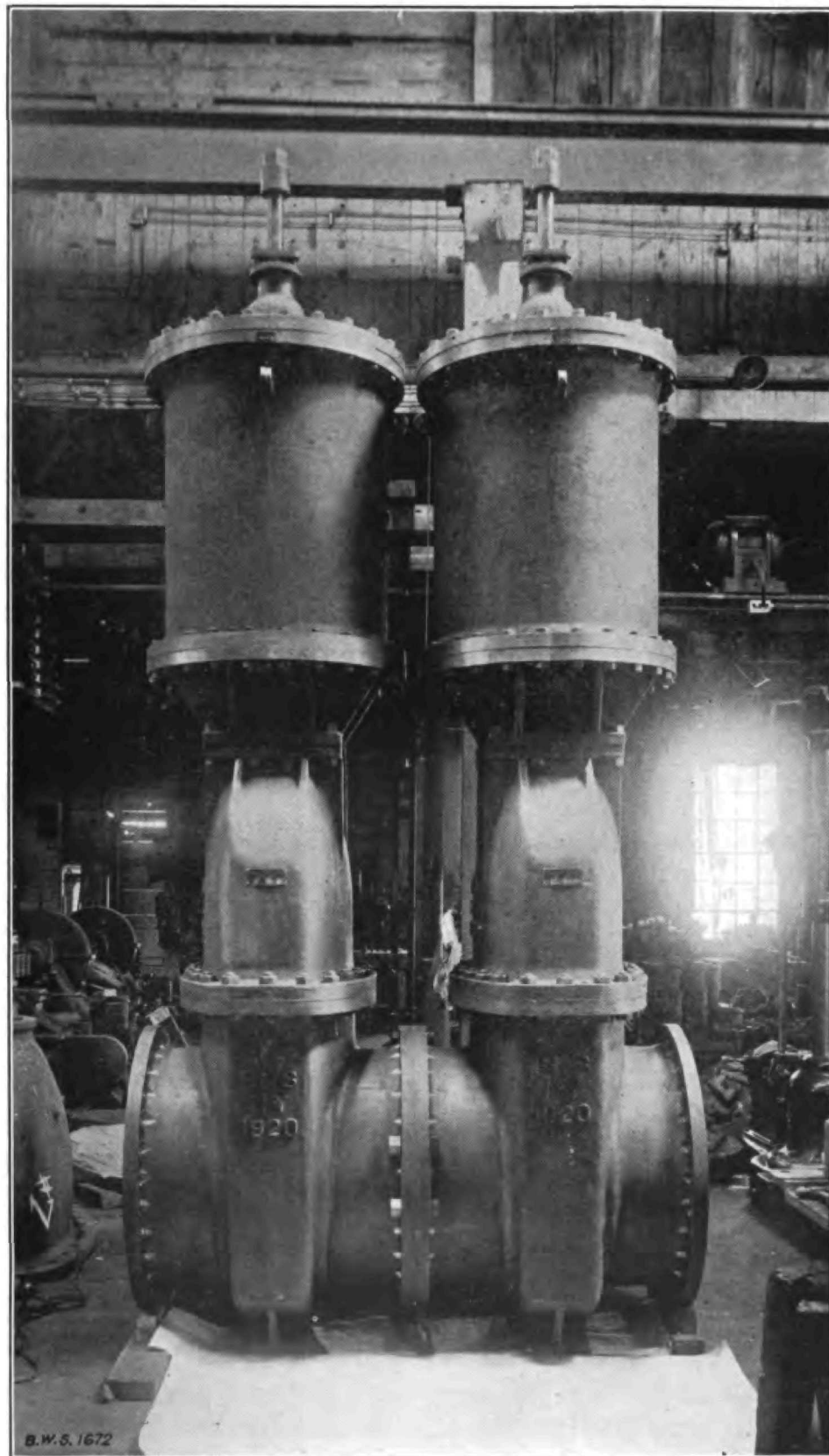
Contract 208 will provide for furnishing and delivering 3-foot by 7-foot sluice-gates with hydraulic cylinders, 10-inch and 6-inch circular sluice-gates, 12-inch and 6-inch cast-iron gate-valves and other apparatus for the intake shaft of the Shandaken tunnel, and at the end of the year progress had been made on studies and designs and on preparation of the contract form, specifications and contract drawings.

THE ESOPUS DEVELOPMENT

PLANTING AT THE KENSICO DAM

Contract 191 was for planting at the Kensico dam with Norway maples, pin oaks, hemlocks and nursery stock and with evergreens transplanted from the City's lands. The contract was awarded on February 17, 1920, to Scott Bros., of Elmsford, N. Y., in the estimated amount of \$20,714.50 and the final estimate in the total amount of \$20,700.22 was forwarded under date of May 9, 1921.

Under this contract, about 15,000 trees and shrubs, the larger portion of which were transplanted from the lands around the Kensico reservoir, were planted during the season of 1920 on the slopes on either side of the meadow below the dam. The work of the planting season of 1921 consisted of replacing losses in the planting to the extent required by the contract and, accordingly, the contractor replaced during the spring of the past year the trees that had failed to live. In this work, particular attention was given to the matter of distributing the replacements so as to fit in with and round out most effectively the groupings and distributions of the already established growths.



SCHOHARIE RESERVOIR—Two 30-inch bronze gate-valves with hydraulic cylinders for the gate-chamber of the Gilboa dam.

CONSTRUCTING GUIDE-WALLS, ETC., AT THE ASHOKAN
SPILLWAY

Contract 193 consisted of the building of a stone-faced guide-wall in the Ashokan Spillway channel at the Spillway bridge, the replacement of the cut-off at the down-stream end of the paved channel by a new and deeper cut-off carried through the overlying shale to sound bluestone, the elimination of the re-entrant angle of the north end wall as originally built and repairs to the surface of the weir and retaining-walls.

The contract was awarded on April 30, 1920, in the estimated amount of \$85,575.00, to the Henry E. Fox Construction Co., Inc., 81 East 125th street, New York City, which concern completed the work on December 3, 1921, at a total cost of \$83,235.80. The work for the past year consisted of the completion of the north end wall to the revised alinement, the completion of the guide-wall and cut-off and the necessary repairs required by the contract. The progress on the principal items of the work is shown in the following table:

LOCATION	EXCAVATION— CUBIC YARDS	MASONRY— CUBIC YARDS	CEMENT— BARRELS
Guide Wall			
Total for 1920.....		450	335
Total for 1921.....		72	47
Total to December 3, 1921.....		522	382
Cut-off			
Total for 1920.....	1,052		
Total for 1921.....	975	1,732	2,608
Total to December 3, 1921.....	2,027	1,732	2,608
North End Wall			
Total for 1920.....	730	189	335
Total for 1921.....	119	439	785
Total to December 3, 1921.....	849	628	1,120
Entire Contract			
Total for 1920.....	1,782	639	670
Total for 1921.....	1,094	2,243	3,440
Total to December 3, 1921.....	2,876	2,882	4,110
Total Estimated Contract Quantities.....	2,800	3,225	5,000

In addition to the quantities in the foregoing table a total of 1,832 cubic feet of excavation was done and 1,426 cubic feet of masonry were placed in connection with trimming and replacing disintegrated concrete.

The average number of contractor's men employed was 21, with a minimum of 8 and a maximum of 32. As in the previous year, no camp was maintained, and the force, largely composed of native labor, lived at their homes in the vicinity of the work.

Concreting of the new north end wall was completed during January and February by methods similar to those employed during the preceding year.

Work in the cut-off trench was resumed in April and carried on intermittently until August, at which time the entire trench had been excavated to sound rock, the methods used and the character of the rock encountered being practically the same as those of the previous year.

Concreting of the cut-off wall was started at the north end on January 11 and completed on August 29. The bed of sound bluestone upon which the wall was founded dipped about four degrees south along the line of the trench. Beginning at its northerly end, where the trench was of minimum depth, the method of concreting was as follows: as sound rock was uncovered and thoroughly cleaned, an end form was built and sufficient concrete placed to level up a stretch 30 to 50 feet in length, thus entirely filling the bottom portion of the trench to a height varying from 3 to 14 feet, and on this foundation, side forms and an end bulkhead were erected and a wall averaging 5 feet in thickness was brought up to the top of the old cut-off wall. After the forms were removed, the space between this wall and the sides of the excavation was refilled with rock to within 3 feet of the top, and above this an apron of concrete was constructed with a top slope of 1 on 2 from the edge of the wall to the original rock surface.

The 5-foot wall was anchored to the existing one by means of a row of $\frac{3}{4}$ -inch steel rods, each 6 feet long and placed 3 feet apart, grouted into holes 3 feet deep in the old concrete. In order to relieve possible pressure, the 6-inch by 6-inch drains in the original cut-off wall were continued through the new wall and additional ones were set at points where water flowed from the rock below the old wall.

The concrete was mixed in a 22-cubic-foot portable mixer operated by a direct-connected steam engine, moving along the old channel paying close enough to the trench to permit chuting directly into place. In the main wall a mix of 1:2:4 proportions was used with as many one-man stones as could be properly placed. The apron was of a 1:3:5 mix. Atlas cement was used. Stone for the concrete was from the run of the crusher, none of it exceeding four inches in diameter and being passed over a screen to exclude material $\frac{1}{4}$ inch and less. The fine aggregate was sand from a local pit and water was obtained

from the Ashokan reservoir. Stone for the crusher was obtained from the pile of bluestone below the channel.

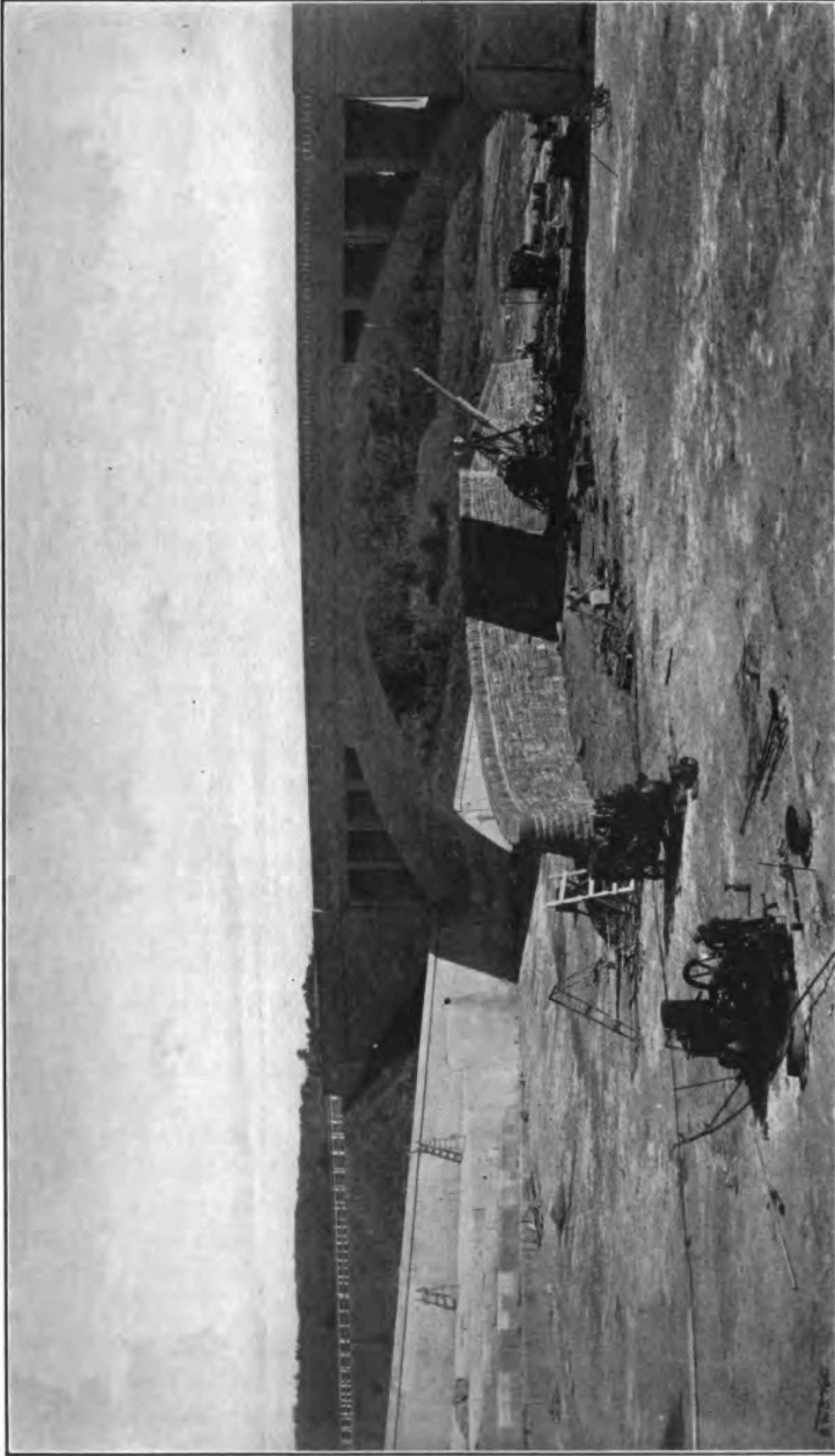
Such portions of the old north end wall as could be properly excavated by drilling and blasting had been removed during 1920 and the necessary hand trimming of this concrete was done during the past summer at which time concrete was placed to extend the spillway apron and steps to the new wall, carrying out the grades and patterns of the original work. For laying this concrete, the mixer was moved to the spillway steps from time to time when work was not in progress at the cut-off wall and deposited the concrete into buckets which were handled by small traveling derricks or pushed in cars to the forms. The concrete was a 1:2:4 mix, with stone, sand and water from the same sources as those for the cut-off wall.

The guide-wall was completed in October, when all of the coping had been placed.

SIPHON PIPES OF THE CATSKILL AQUEDUCT

Contracts 209, 210 and 211.—When the plans for the construction of the Catskill aqueduct were originally prepared it was realized that a number of years would elapse before the entire supply from the Catskill Mountain development would be available. At each of the fourteen valleys for which steel-pipe siphons were designed, it was therefore decided to construct but one of the necessary three pipes and defer the complete installation at these points until the development of the Schoharie watershed was well advanced. The single pipes now in place have been in continuous service for more than five years and have carried a maximum flow of about 400 million gallons daily.

With the construction of the Gilboa dam and the Shandaken tunnel well under way, Contracts 209, 210 and 211, for the construction of the remaining two lines of pipe at each of these fourteen locations, were awarded on November 23, 1921, in the total estimated amount of \$6,252,788.00. Contract 209 is for the construction of steel pipes aggregating about 12,200 feet in length in the three siphons between the Ashokan reservoir and the Hudson river, and was awarded to Rice and Ganey, Inc., Room 1708 Grand Central Terminal Building, New York City, in the estimated amount of \$999,325.00; these siphons are Esopus and Tongore in the Town of Olive, Ulster county, and Washington Square in the Town of New Windsor, Orange county.



ASHOKAN RESERVOIR—The Ashokan spillway and Spillway bridge, showing the new guide wall and north parapet wall.

Frederick Snare Corporation, of 8 West 40th street, New York City, was awarded Contract 210, for approximately 34,000 linear feet of pipe in the seven siphons between the Hudson river and the Kensico reservoir, the estimated amount of this contract being \$2,978,103.00. The seven locations where the work under this contract is to be carried on are as follows: Foundry Brook, Indian Brook and Sprout Brook siphons in the Town of Phillipstown, Putnam county; Peekskill siphon in the Town of Cortlandt, Hunters Brook and Turkey Mountain siphons in the Town of Yorktown and Harlem Railroad siphon in the Town of Mount Pleasant, Westchester county.

Contract 211, which totals \$2,275,360.00, was awarded to the Thomas Crimmins Contracting Company, 126 East 59th street, New York City, and covers the construction of about 20,000 feet of pipes in the four siphons between the Kensico and the Hill View reservoirs. These latter siphons are located in Westchester county, as follows: Kensico in the Town of Mount Pleasant, Elmsford in the Town of Greenburg, Fort Hill in the Town of Greenburg and the City of Yonkers, and Bryn Mawr in the City of Yonkers.

The contractors were served with notice to begin work in November and December and immediately started preliminary operations. The stipulated time for completion is 42 months from the date of service of notice to begin work.

There are three diameters of steel pipe in the line now in place, viz., 9 feet 6 inches, 9 feet 9 inches and 11 feet 3 inches, but from information obtained by studies and tests on the existing single line of pipes, the new pipe-lines have been designed with diameters varying from 7 feet 4 inches to 11 feet 3 inches; the pipes will be made of plates from $\frac{7}{16}$ inch to $\frac{9}{16}$ inch in thickness, varying with the hydrostatic head, and they will be laid in an open trench. After being riveted up, the pipe will be subjected to its normal hydrostatic pressure by being filled with water. It will then be calked to secure watertightness and, with the water still inside, will be jacketed with concrete. Following this operation the water will be drawn off and the pipe lined with 2 inches of mortar. The completed pipe will finally be covered with an embankment of earth or of earth and rock.

The total weight of the steel pipes to be installed under the three contracts is about 42,000,000 pounds. The total number of cubic yards of concrete is about 125,000; the rock and earth excavation totals 600,000 cubic yards and there will be almost

DATA ON SIPHON PIPES OF THE CATSKILL AQUEDUCT—CONTRACTS 209, 210 AND 211

SIPHON	NOMINAL INSIDE DIAMETER OF EACH STEEL PIPE	THICKNESS OF PIPE PLATES AND TYPE OF JOINT	*APPROXIMATE LENGTH IN FEET OF PIPES TO BE INSTALLED	LOCATION IN THE AQUEDUCT DEPARTMENT	
				Division	Section
CONTRACT 209					
ESOPUS.....	8 feet 4 inches.....	$\frac{1}{4}$ -inch lap-joints.....	4,215	Northern	1
TONGORE.....	8 feet 4 inches.....	$\frac{1}{8}$ -inch lap-joints.....	1,390	Northern	1
WASHINGTON SQUARE.....	8 feet 10 inches.....	$\frac{1}{8}$ -inch longitudinal butt-joints.....			
		$\frac{1}{8}$ -inch lap-joints.....	240	Northern	2
CONTRACT 210					
FOUNDRY BROOK.....	8 feet 6 inches.....	$\frac{1}{4}$ -inch lap-joints.....	6,980	Northern	3
INDIAN BROOK.....	7 feet 4 inches.....	$\frac{1}{2}$ -inch lap-joints.....	570		
SPROUT BROOK.....	8 feet 6 inches.....	$\frac{1}{4}$ -inch lap-joints.....	3,530	Northern	4
		$\frac{1}{2}$ -inch lap-joints.....	910		
		$\frac{1}{4}$ -inch lap-joints.....	6,360	Northern	4
		$\frac{1}{2}$ -inch lap-joints.....	785		
PEEKSKILL.....	8 feet 6 inches.....	$\frac{1}{2}$ -inch longitudinal butt-joints.....	4,950		
		$\frac{1}{8}$ -inch longitudinal butt-joints.....	1,235	Southern	1
HUNTERS BROOK.....	8 feet 4 inches.....	$\frac{1}{4}$ -inch lap-joints.....	2,975		
TURKEY MOUNTAIN.....	8 feet 4 inches.....	$\frac{1}{4}$ -inch lap-joints.....	3,010	Southern	2
HARLEM RAILROAD.....	7 feet 10 inches.....	$\frac{1}{4}$ -inch lap-joints.....	1,380		
CONTRACT 211					
KENSICO.....	11 feet 3 inches.....	$\frac{1}{4}$ -inch lap-joints.....	3,240	Southern	2
ELMSFORD.....	11 feet 3 inches.....	$\frac{1}{4}$ -inch lap-joints.....	2,980		
FORT HILL.....	11 feet 3 inches.....	$\frac{1}{4}$ -inch lap-joints.....	2,530	Southern	3
		$\frac{1}{4}$ -inch lap-joints.....	5,090		
BRYN MAWR.....	11 feet 3 inches.....	$\frac{1}{2}$ -inch lap-joints.....	470		
		$\frac{1}{2}$ -inch longitudinal butt-joints.....	4,555	Southern	3
		$\frac{1}{8}$ -inch longitudinal butt-joints.....	1,085		

* Length as given here is the total for the two lines of pipe to be constructed at each siphon.

2,000,000 square feet of mortar lining inside the pipes. The approximate quantities of work to be done under the individual items of these contracts will be found in the canvasses of bids of Contracts 209, 210 and 211, forming Tables 6, 7 and 8, respectively.

Late in 1920 the pipe diameters were decided upon and the economic cross-sections of two of the several sizes of pipe in loose earth were determined, but with these exceptions, the entire work of preparing the designs, locating the pipes, making the contract plans, specifications and estimates and publishing, advertising and awarding the contracts was done during the past year.

The proper location of the pipes in the vertical plane was an important matter requiring close study. Mass diagrams of the distribution of excavation and of required materials for refills and cover embankments gave valuable information in convenient form for correlating the important factors of quantities of materials to be borrowed, spoiled and hauled. The chosen location for each pipe was that which minimized all of these factors to the greatest practicable extent consistent with attention to the other controlling conditions of the problems. Outstanding controlling conditions were good hydraulic alinements, proper drainage of surface-waters from embankments and adjacent lands and advisable æsthetic treatments in embanking and grading.

A total of 75 contract drawings was prepared, on which were shown a plan of each siphon with the existing surface indicated by 2-foot contours and profiles of both pipes of each siphon, together with details of the pipe sections, accessory structures, etc.

The fabrication of the pipes will be governed by a series of working drawings, or geometry sheets, which were in course of preparation at the end of the year. These will indicate the station and elevation of the center line at each change of direction, with the cut angle on either side of each joint, the slope and the slope length between the angle points. In the determination of these elements of location, the value of simplicity in the fabrication of the pipes was kept constantly in mind. As few deflections as practicable were sought with as few varieties of cut angles and as large a percentage of one cut angle of 2 degrees 30 minutes as possible, without departing from the ideal requirements of other conditions enough to offset the advantage gained by uniformity in this respect. No deflections greater than 5 degrees are permitted, no single cuts greater than 2 degrees 30 minutes and angles are made multiples of 0 degrees 5 minutes with few excep-

tions. Short-length closing pieces are restricted to one at each end of each pipe. On December 31, seventeen of the 39 pipe-geometry sheets had been completed.

GATE-VALVES, ETC., FOR THE STEEL PIPES OF THE CATSKILL AQUEDUCT

Contract 212 will comprise the furnishing and delivering of 24-inch bronze gate-valves with hydraulic cylinders, 16-inch, 12-inch and 6-inch bronze gate-valves, 16-inch cast-iron gate-valves, steel-pipe castings, piezometer pipes and fittings, and other appurtenances to be installed under Contracts 209, 210 and 211 in conjunction with the construction of the siphon pipes of the Catskill aqueduct. At the end of the year, preparation of the contract form and specifications was practically completed and work on the contract drawings had been started.

NEW SOURCES OF SUPPLY AND EXTENSIONS OF CITY DELIVERY SYSTEM

New Sources of Supply.—Preliminary work was done in March, April and May of the past year on the revision of the original report on the Long Island sources and the completion of an unfinished report on the geology of Long Island. In connection with this work, an index map was made to indicate the location of thirty geological sections across Long Island, and twelve sheets showing in elevation the wells near these sections were brought up to date and towns and localities were indicated thereon. Drawings and sketches were made for use as studies and in geological reports on dams and reservoir sites, these totaling thirty-five in all. Following this preliminary work, active investigations of new sources of water-supply and studies for a new tunnel and conduits in the City were begun in June, following the request by the Board of Estimate and Apportionment, as expressed in their resolution of June 17, 1921, which is printed on page 2.

After an office study of all available sources of supply within 150 to 200 miles of New York City, a preliminary reconnaissance was made during the months of September, October and November of those which gave promise of being worthy of further investigation. In this reconnaissance, many of the prospective reservoir and dam sites were also visited and particular attention was given to the geological features of the more important ones. The preliminary inspection covered all possible sources on the

larger streams tributary to the Hudson river as far north as Albany, and those on the Ten Mile river and on the Delaware river and its tributaries within the State of New York.

On November 4, 1921, a survey party of six men, comprising two assistant engineers, two rodmen and two axemen, took the field and have thus far made topographical surveys of eight dam sites—three on the Catskill creek near Oak Hill and Preston Hollow, one on the Schoharie creek at Burtonsville, one on the East branch of the Delaware river at Margaretville and three on the Basher Kill at Phillipsport, West Brookville and Godeffroy.

Some preliminary inspections have been made of possible aqueduct lines and attention was given to the geological features of all lines on which studies and estimates are to be made.

Extensions of Delivery System within the City.—In order to determine the need of an additional water-supply and the amount of water to be provided for each section of New York City, a comprehensive study is being made of the population and consumption of the City as a preliminary to fixing the positions of the delivery points. The locations for the necessary delivery conduits and tunnels are being investigated and all available information in regard to the bed rock underlying the City along the prospective routes is being collected.

In order to determine the actual delivery capacity of the present City tunnel and conduits of the Catskill aqueduct, observations were made on September 13 and 14, for a period of 24 hours, on the flows and pressures in these conduits from the Hill View reservoir to Richmond and Queens boroughs.

The Commissioner of Water Supply having requested immediate attention to the needs of Richmond borough, a study looking to the delivery of an additional supply of Catskill water to that borough was undertaken.

GENERAL WORK—CATSKILL MOUNTAIN AND NEW WATER-SUPPLY SOURCES

Delivery of Catskill Water to New York City.—Catskill water was delivered to New York City at the rate of 406 million gallons per day throughout 1921, the total consumption of water in Greater New York from these sources amounting to 148 billions of gallons for the year. The quantities of Catskill water delivered to the City from January 1, 1917 to December 31, 1921 are shown in the table on page 99.

DELIVERY OF CATSKILL WATER TO NEW YORK CITY

MONTH	1917		1918		1919		1920		1921	
	Million Gallons	Million Gallons Daily	Million Gallons	Million Gallons Daily	Million Gallons	Million Gallons Daily	Million Gallons	Million Gallons Daily	Million Gallons	Million Gallons Daily
January.....	2,294	74.0	13,968	450.6	12,482	402.6	13,550	437.1	12,378	396.0
February.....	6,020	215.0	12,768	456.0	11,213	400.5	13,048	449.9	10,845	387.3
March.....	5,642	182.0	13,206	426.0	11,822	381.4	13,345	430.4	11,509	371.3
April.....	8,700	290.0	12,129	404.3	11,094	369.8	12,142	404.7	10,969	365.6
May.....	9,021	291.0	12,874	415.3	11,109	358.4	12,514	403.7	12,757	411.5
June.....	10,770	359.0	12,629	421.0	10,559	352.0	12,779	426.0	13,254	441.8
July.....	13,113	423.0	13,011	419.7	10,620	342.6	12,581	405.8	13,195	425.6
August.....	11,780	380.0	13,074	421.7	10,393	335.3	12,417	400.5	13,418	432.8
September.....	11,070	369.0	12,446	414.9	11,190	373.0	12,437	414.6	13,175	439.2
October.....	11,625	375.0	12,875	415.3	11,589	373.8	12,863	414.9	13,020	420.0
November.....	11,010	367.0	12,100	403.3	11,077	369.2	12,651	421.7	11,577	385.9
December.....	12,183	393.0	12,050	388.7	11,904	384.0	12,626	407.3	12,115	390.8
The Year.....	113,228	310.2	153,130	419.5	135,052	370.0	152,953	417.9	148,112	405.8

Unwatering of the City Tunnel.—The computations of the volume of water to be pumped to unwater the City tunnel of the Catskill aqueduct above and below the section-valve at Shaft 13 and below the similar valve at Shaft 18 were completed, and three drawings showing these amounts by curves were prepared during the year.

Hydrographic Work.—Meteorological observations and measurements of stream flow in the Catskill Mountain watersheds were carried on as in previous years. The principal hydrographic data relative to the four Catskill Mountain watersheds for the year 1921 are given in the following table:

	ESOPUS	RONDOUT	SCHOHARIE	CATSKILL CREEK
Area in square miles above gaging station.....	192	100	236	97
Average number of rainfall stations.....	5	4	5	*5
Rainfall, in inches.....	†17.94	48.15	‡44.43	37.43
Run-off, in inches.....	28.71	26.50	23.11	17.80
Run-off, in billion gallons.....	95.8	46.0	94.7	30.0
Per cent. of rainfall appearing as run-off.....	59.9	55.0	52.0	47.6
Equivalent yield per day per square mile, in million gallons.....	1.4	1.3	1.1	0.8
Mean daily flow, cubic feet per second.....	406	195	402	127
Maximum discharge, date.....	Mar. 9	Mar. 9	Mar. 9	Nov. 28
Maximum discharge, cubic feet per second....	7,470	3,704	7,690	5,020
Minimum discharge, date.....	Sep. 20	Sep. 11	Sep. 17	Sep. 20 and Oct. 8
Minimum discharge, cubic feet per second....	39	32	30	2

* Includes Manor Kill and Windham.

† Average rainfall for entire watershed (257 square miles)=48.17 inches for eleven of the twelve stations (excluding Kingston).

‡ Average rainfall for entire watershed (314 square miles)=42.31 inches for nine of the ten stations (excluding Esperance).

Rainfall Observations.—The average precipitation on the Schoharie watershed for the 15-year period from 1907 to 1921, inclusive, was 41.19 inches. The following is the monthly average for this period: January, 2.78; February, 2.92; March, 2.91; April, 3.71; May, 3.58; June, 3.70; July, 4.04; August, 3.84; September, 3.99; October, 3.43; November, 3.39, and December, 2.90. An analysis of these figures shows a remarkable similarity in the amount of precipitation for the months of April to September, inclusive, during which time the average monthly rainfall was 3.81 inches; April, May and June averaged 0.15 inch less and July, August and September 0.15 inch more than this mean average. The average for October and November was 3.41 inches, with a variation of +0.02 inch and -0.02 inch, respectively. The similarity for the months of January, Febru-

ary, March and December is no less remarkable, the average for those months being 2.88 inches, with a maximum variation of only -0.10 inch. The average monthly precipitation for the Schoharie watershed, as determined from the above figures, was 3.43 inches.

A comparison of the 1921 precipitation for the Schoharie watershed with the foregoing figures shows a deficiency for the months of January, March, May, June, August, September, October and December, ranging from -0.20 inch in August to -1.08 inches in January; the remaining four months, February, April, July and November, give an excess from +0.07 inch in February to +3.26 inches in November. The whole month of November was exceedingly wet, the precipitation aggregating 6.40 inches at Prattsville and for the period from November 26 to November 29 the rainfall was 3.13 inches.

Prior to 1918 the records of rainfall on the Schoharie watershed were misleading. The average rainfall for the 10 years previous to 1916 was only 39.48 inches and it was suggested at that time that a somewhat different distribution of the gages would give other results. The percentage of run-off has apparently been too great when compared with the results of other watersheds of similar characteristics. A record of 55.04 inches at Elka Park for 1921 as compared with an average for the entire watershed (excluding Elka Park) of about 40 inches for the year, and of 41.19 inches for the 15-year period from 1907 to 1921, would seem to indicate very strongly that still higher records would be obtained for the watershed if gages were placed in the more elevated locations.

During several periods in the month of December the tops of the Catskill Mountain watersheds and the higher altitudes surrounding them were covered with ice several inches in thickness. The casual rainfall will not appear as precipitation at the regular stations but would amount to considerable if measurement were possible. The Peakamoose record was continued throughout the entire year, as the winter of 1920-1921 was extremely mild and the gage-keeper remained on the mountain during that season.

Stream-Flow Observations.—Stream gagings of daily flow were continued at Lackawack on the Rondout creek, Cold Brook on the Esopus, Prattsville and Esperance on the Schoharie and Oak Hill on the Catskill creek.

For five days of the period from March 3 to 9, the flow in the Schoharie creek was well above the normal. This was not due, as might be supposed, to the actual precipitation at that time but on account of high temperatures, a maximum of 66 degrees Fahrenheit being reached on March 9; the accumulated snow and ice in the mountains melted at that time and raised the creek to its maximum flow for the year, the gage height being 10.40, with a discharge of 7,690 cubic feet per second.

On March 24-25, and again on April 24-25, very heavy showers occurred in the mountains, several rainfall stations recording from 2 to 2½ inches of rain in twenty-four hours, with a subsequent rise of more than 3 feet in the creek at Prattsville.

Meter measurements were made on all the principal streams, also a few on the Manor Kill and the Bear Kill, tributaries of the Schoharie creek, and on the Esopus creek at Allaben for purposes of studying the effects of flood flows along the creek bed.

The importance of actual meter measurements during the frozen period of the streams was again emphasized during the winter months. At times the streams were filled with anchor ice which seriously obstructed the regular flow, causing the gage heights to indicate very much greater flows than actually existed. A very interesting case in hand was shown at Oak Hill where the ice completely arched over the entire stream, forming at a higher stage and remaining in this position when the water dropped to a lower elevation, the water thus flowing freely with an icy covering but not touching the ice.

During the summer of 1921, a timber crib dam was built across the Rondout creek about a mile above the regular gaging station for boating and bathing purposes in connection with a large summer boarding-house. This dam serves to hold back considerable water and the effect is quite noticeable at times during periods of low water, although eventually all the water finds its way back to the stream.

The small dam and storage reservoir of the Catskill Light and Power Company situated at Tannersville was abandoned during the year with the result that the records at the Prattsville gaging station will more nearly represent the natural flow of the Schoharie creek, especially during low-water periods.

The run-off of the Catskill streams for the period from June to October, inclusive, was considerably lower than the average. The Esopus creek at Cold Brook, with a drainage area of 192 square miles, yielded 0.52 cubic foot per second per square mile per day and the Schoharie at Prattsville, with a drainage area

of 236 square miles, gave 0.40 cubic foot per second per square mile per day. The average minimum daily yield for a like period, as recorded by the Board's forces, occurred in 1909, when these streams gave a run-off of 0.28 cubic foot per second and 0.15 cubic foot per second, per square mile per day, respectively

Temperature and Turbidity Records.—Temperature records were continued at Grand Gorge and Prattsville and records of turbidity were obtained at Cold Brook on the Esopus and at Prattsville on the Schoharie creek.

Tests and Analyses.—Samples of materials entering into construction were examined in the Board's laboratory and physical tests of asphaltic material were made by the Laboratory of the Department of Public Works by courtesy of the President of the Borough of Manhattan.

Five brands of cement were used during 1921, and there were tested 77,093 barrels of which 6,500 barrels were rejected because of low strength, 41,105 barrels were shipped and 29,488 barrels of accepted cement were in storage at the mills on December 31.

CEMENT SHIPPED DURING 1921

Contract 193.....	3,234 barrels
Contract 200.....	883 barrels
Contract 203.....	34,968 barrels
Contract 204.....	2,020 barrels
Total.....	41,105 barrels

PHYSICAL TESTS—1921

Tensile tests of cements.....	459
Compressive tests of cements.....	34
Physical tests of sand and stone.....	16
Tensile tests of metals.....	51
Transverse tests of metals.....	4
Modulus of elasticity.....	6
Total	570

CHEMICAL EXAMINATIONS—1921

Cements.....	36
Paint materials and asphalts.....	43
Metals and alloys.....	14
Rocks and miscellaneous.....	19
Total	112

Cemeteries.—Ten bodies were removed from the Old Gilboa cemetery during the year by applicants who had conformed to the requirements of the resolution adopted by the Board of Water Supply on March 2, 1920. All bodies, headstones and monuments not removed by parties of interest under this and a previous resolution of the Board were removed under Contract 206 as hereinbefore described. One unidentified body, disinterred by the contractor's operations under Contract 203, was removed and reinterred by the Board of Water Supply forces. A total of 1,286 bodies were thus removed—896 by applicants, 389 under Contract 206 and one by the Board's employees.

Record maps showing complete cemetery removal, reinterment and replacement data were prepared and copies were filed in the Engineering bureau and the Bureau of Claims of the Board of Water Supply and with the Gilboa Cemetery Association and the County Clerk of Schoharie county. The table on page 105 contains a digest of the important details of these record maps.

Sanitation.—As in the preceding year, this work consisted mainly of the inspection of the contractors' camps, water-supplies and sewage-disposal works, and the supervision of the operation of the chlorinators for treating shaft and tunnel pumpage at the shafts of the Shandaken tunnel.

A conference was held in the summer between the commissioners and engineers of the Department of Water Supply, Gas and Electricity and of the Board of Water Supply in relation to sanitary matters on the Schoharie watershed above the Gilboa dam and, as the result of this conference, weekly samples for bacterial tests and monthly samples for chemical analysis were taken from the Schoharie creek and its tributaries at eight stations above the Gilboa dam.

Litigation and Taxation.—The claim of the Village of Pleasantville against the City for alleged damage to the water-supply of that village by the construction of the Catskill aqueduct required considerable attention during the past year. Maps and tabulations were prepared, testimony was given at hearings before the commissioners of appraisal, examination was made of the claimant's exhibits on the strength and flotation of the aqueduct through the Pleasantville watershed, careful analyses were made of certain typical sections of the cut-and-cover aqueduct by the claimant's methods to test their application, and data were collected on the White Plains pumping-station, wells and watershed.

DATA ON REMOVAL OF BODIES, HEADSTONES AND MONUMENTS FROM THE CEMETERIES ON LANDS ACQUIRED FOR THE
CONSTRUCTION OF THE SCHOHARIE RESERVOIR

PARCEL	REMOVALS										
	SHOWN ON CEMETERY MAPS			BY APPLICANTS			BY BOARD OF WATER SUPPLY UNDER CONTRACT 206			BY BOARD OF WATER SUPPLY FORCES	NO BODY FOUND
	Bodies	Headstones	Monuments	Bodies	Headstones	Monuments	Bodies	Headstones	Monuments	Bodies	
2.....	25	9	.....	19	9	.....	.....	.....	.....	1	5
165.....	635	285	15	222	175	11	354	110	4	.....	59
179.....	697	371	145	645	369	141	32	2	4	.....	20
182.....	7	2	.....	7	2	.....	.....	.....	.....	.....	.....
193.....	3	.....	.....	3	.....	.....	.....	.....	.....	.....	.....
208.....	1	.....	.....	.....	.....	.....	1	.....	.....	.....	.....
217.....	2	2	.....	.....	.....	.....	2	2	.....	.....	.....
Totals.....	1,370	669	160	896	555	152	389	114	8	1	84

Aid was given the Corporation Counsel and maps and tabulations were prepared in connection with the retrial of the case of the Fairlawn Cemetery Society against the City for damages to its land alleged to be due to the raising of the ground-water thereon by the grading incidental to the construction of the Kensico steel-pipe siphon.

Maps and descriptions of property were made for use in the Vicevich claims relative to property in the vicinity of Esopus South Siphon chamber. Drawings and tabulations were prepared in connection with the taxation of the Hudson Drainage Chamber property, and assistance was also given the consulting engineer retained by the Corporation Counsel in making an estimate of the cost of Kensico dam for purposes of taxation.

Organization.—For the supervision of construction work on the siphon pipes of the Catskill aqueduct, a new department was organized on December 13, 1921, to be known as the Aqueduct department, and Charles M. Clark, who had been division engineer of the Allaben division of the Reservoir department, was placed in charge of the new organization as department engineer. The department will have two divisions,—the Northern and Southern, with Division Engineers Howard P. Barnes and Cornelius J. O'Connor in charge, respectively. The dividing line between the divisions is at Hunters brook. The Northern division will be charged with the construction work at the three siphons of Contract 209 and the four most northerly ones of Contract 210; the Southern division will supervise the work at the three southerly siphons of Contract 210 and the four siphons of Contract 211.

The Aqueduct department office will be located in the Village of Peekskill, and the old Board of Water Supply division office on Peekskill Hollow road adjoining the Peekskill siphon will serve as the Northern Division office, while the former White Plains Division office of the Board at Elmsford will serve in the same capacity for the Southern division.

To take charge of the work in connection with the new sources of supply and the extensions of the delivery system within the City limits, Walter E. Spear was reinstated as department engineer on March 14, 1921, and shortly thereafter a small force was organized and is now engaged upon these investigations.

On December 13, Roy W. Gausmann was appointed division engineer to fill the vacancy in the Allaben division of the Reser-

voir department resulting from the appointment of Division Engineer Charles M. Clark as department engineer, as hereinbefore noted.

The maximum number of employees in the Engineering bureau of the Board of Water Supply was 200 on December 16 and the minimum number during the year was on February 1, when the force was 172. A schedule of employees in the bureau on January 1 and December 31 forms Table 1.

FORCE IN THE ENGINEERING BUREAU

	1920	1921
January 1.....	188	173
December 31.....	174	199
Maximum.....	188 (Jan. 1)	200 (Dec. 16)
Minimum.....	173 (Dec. 1)	172 (Feb. 1)
Additions.....	46	49
Separations.....	60	23

CLASSIFICATION OF APPOINTMENTS AND SEPARATIONS DURING 1921

CLASS	MADE	RESCINDED	REPORTED	SEPARATED
Exempt.....	4	---	4	---
Competitive.....	27	4	23	12
Labor.....	6	1	5	6
Temporary and Miscellaneous.....	20	3	17	5
Totals.....	57	8	49	23

Equipment Transferred.—No transfers of equipment were made to other City departments through the Sinking Fund Commission during the year; the total value of equipment transferred to date amounts to \$33,522.20.

Contracts.—The amounts of contracts awarded and the value of work done, based on the estimates forwarded by the Engineering bureau, are shown in the following tables:

SCHEDULE OF CONTRACTS—1921

	NUMBER	AMOUNT
Contracts in force January 1, 1921.....	7	\$19,518,977.50
Contracts entered into during 1921.....	4	*6,262,522.50
Contracts completed during 1921.....	5	477,632.95
Contracts in force December 31, 1921.....	6	25,301,916.00

* Does not include additional amount certified to be expended on contract awarded during 1920.

AMOUNTS OF CONTRACTS AWARDED AND VALUE OF WORK DONE—
1906 TO 1921, INCLUSIVE

YEAR	*AMOUNTS OF CONTRACTS AWARDED	NUMBER OF CONTRACTS OPERATIVE DURING YEAR	VALUE OF WORK DONE UNDER OPERATIVE CONTRACTS
1906.....	\$79,775.00	1	\$22,983.75
1907.....	16,912,086.35	5	228,132.60
1908.....	9,746,103.67	12	1,877,789.58
1909.....	38,233,463.40	39	7,713,422.82
1910.....	6,031,795.11	43	15,600,268.21
1911.....	22,250,129.41	54	19,104,290.26
1912.....	1,359,344.55	62	19,459,969.70
1913.....	2,471,850.16	58	15,053,256.33
1914.....	2,668,106.43	51	11,026,494.57
1915.....	727,194.36	47	4,309,893.00
1916.....	675,767.22	30	1,816,067.92
1917.....	12,906,303.72	43	815,007.40
1918.....	37,476.52	26	602,053.51
1919.....	7,034,427.05	15	1,300,993.37
1920.....	383,629.50	8	1,375,704.63
1921.....	6,282,522.50	11	4,545,769.44
Totals.....	\$127,799,974.95	---	\$104,852,097.09

* Includes additional amounts certified to be expended on contracts awarded during previous years.

Respectfully submitted,

J. WALDO SMITH,
Chief Engineer.

TABLE 1

EMPLOYEES IN ENGINEERING BUREAU IN 1921 BY DEPARTMENTS

CLASS	HEADQUARTERS DEPARTMENT		RESERVOIR DEPARTMENT		AQUEDUCT DEPARTMENT		NEW SOURCES OF SUPPLY		TOTAL			
									NUMBER		PER CENT.	
	Jan. 1	Dec. 31	Jan. 1	Dec. 31	Jan. 1	Dec. 31	Jan. 1	Dec. 31	Jan. 1	Dec. 31	Jan. 1	Dec. 31
Engineers—Assistant Engineers and higher rank.....	23	22	30	30	....	3	....	10	53	65	30.7	32.7
Engineering Assistants—Draftsmen, inspectors, transit- men, rodmen, axemen, etc.....	12	10	33	41	....	....	....	6	45	57	26.0	28.6
Clerks—Clerks, stenographers and miscellaneous.....	17	17	14	16	....	....	....	....	31	33	17.9	16.6
Labor class.....	2	2	28	28	....	....	....	....	30	30	17.3	15.1
Gage keepers.....	....	....	14	14	....	....	....	....	14	14	8.1	7.0
Totals.....	*54	†51	‡119	129	....	3	....	‡16	173	199	100.0	100.0

Maximum 200, December 16; Minimum 172, February 1.

* Includes Chief Engineer and Deputy Chief Engineer, 2 Consulting Engineers, 2 Assistant Engineers, 1 Private Secretary and 1 Stenographer on staff of the Chief Engineer; also 1 Rodman absent on military service and 1 Architect absent on leave without pay.

† Includes Chief Engineer and Deputy Chief Engineer, 2 Consulting Engineers, 1 Geologist, 2 Assistant Engineers, 1 Private Secretary and 1 Stenographer on staff of the Chief Engineer; also 1 Rodman absent on military service and 1 Assistant Engineer absent on leave without pay.

‡ Includes 1 Assistant Engineer absent on leave without pay.

TABLE 3
STREAM FLOW—CATSKILL MOUNTAIN WATERSHEDS

MEAN MONTHLY DISCHARGE IN CUBIC FEET PER SECOND

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	THE YEAR
*ESOPUS CREEK AT OLIVE BRIDGE DAM—DRAINAGE AREA 239 SQUARE MILES													
1906...										†363	426	359	
1907...	743	202	633	543	594	416	90	30	423	847	1,439	1,116	590
1908...	642	803	1,140	961	1,567	242	136	56	36	176	191	203	513
1909...	811	1,539	820	1,279	838	388	78	106	57	56	42	158	514
1910...	1,077	606	1,704	1,958	460	407	92	65	101	48	146	92	563
1911...	579	349	548	1,000	336	504	130	88	159	909	578	527	476
1912...	327	460	1,494	1,737	819	188	77	232	155	352	576	705	594
1913...	1,155	277	1,485	768	462	231	41	44	95	701	1,401	498	596
ESOPUS CREEK AT COLD BROOK—DRAINAGE AREA 192 SQUARE MILES													
1914...	195	389	843	2,008	643	112	91	77	45	32	106	199	395
1915...	1,283	1,031	284	561	242	97	478	747	237	177	327	610	506
1916...	823	908	505	1,194	496	560	449	171	86	130	280	406	501
1917...	472	144	906	1,061	536	729	224	151	113	468	354	170	444
1918...	83	574	1,184	1,093	367	235	88	32	132	135	187	462	381
1919...	351	177	933	862	899	198	398	242	396	114	599	459	469
1920...	138	106	1,561	1,624	461	367	288	204	149	298	500	1,134	569
1921...	338	209	1,344	982	488	129	135	109	55	66	369	628	404
*ESOPUS CREEK AT MT. MARION—** DRAINAGE AREA 368 SQUARE MILES													
1907...				††836	953	652	162	50	859	1,352	2,177	1,681	
1908...	1,240	1,323	2,157	1,406	2,392	401	242	99	43	223	243	239	834
1909...	1,247	2,824	1,527	1,757	1,278	661	138	168	99	100	83	316	850
1910...	1,608	678	3,029	3,356	791	761	147	105	133	76	204	146	920
1911...	784	544	952	1,504	406	818	192	152	268	1,506	936	824	740
1912...	496	719	2,360	2,383	1,181	305	94	258	191	522	916	1,022	871
1913...	1,833	511	2,787	1,378	803	373	101	98	††68	837	1,978	898	972
1914...	191	1,324	1,401	3,367	996	74	48	23	15	81	103	76	642
1915...	683	1,169	441	183	92	49	671	729	683	1,365	365	472	575
1916...	522	518	495	629	224	826	583	247	45	79	186	§467	402
1917...	1,032	314	1,099	1,289	800	675	175	86	63	163	163	101	497
*RONDOUT CREEK AT HONK FALLS—DRAINAGE AREA 102 SQUARE MILES													
1906...		†184	310	601	202	198	128	73	37	85	93	102	
1907...	251	252	359	172	172	119	23	19	149	279	479	380	221
1908...	260	322	516	468	459	84	39	30	14	31	38	72	194
1909...	383	680	335	372	347	140	47	26	27	27	28	58	206
1910...	354	258	725	623									
*RONDOUT CREEK AT LACKAWACK—DRAINAGE AREA 100 SQUARE MILES													
1910...					246	142	39	38	70	34	91	154	
1911...	251	210	304	484	128	204	51	39	79	387	276	273	224
1912...	273	333	616	555	288	97	40	108	76	126	190	282	249
1913...	522	208	691	394	209	105	42	65	76	266	517	224	277
1914...	166	196	532	831	316	87	75	51	27	35	54	140	209
1915...	569	557	160	198	123	50	293	349	108	82	135	307	244
1916...	411	384	301	631	228	344	350	112	78	88	138	222	274
1917...	228	103	471	442	198	245	214	142	105	164	189	124	219
1918...	64	283	568	413	158	86	49	22	103	123	143	316	194
1919...	245	135	413	338	329	104	112	159	176	91	358	267	227
1920...	84	42	715	583	191	157	148	139	114	153	223	425	248
1921...	162	124	596	416	197	66	68	54	76	62	270	248	195

TABLE 3 (Concluded)

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	THE YEAR
*SCHOHARIE CREEK AT PRATTSVILLE—DRAINAGE AREA 236 SQUARE MILES													
§§1903	550	982	1,547	617	98	770	149	639	261	1,306	372	662	663
§§1904	733	850	1,054	1,064	553	415	89	118	66	466	302	521	519
§§1905	766	278	1,343	693	84	52	26	69	321	285	138	534	382
§§1906	485	343	706	1,254	577	350	88	82	30	179	383	347	402
§§1907	485	160	648	605	510	352	114	22	255	778	1,333	1,238	542
1908...	429	763	992	720	957	145	75	33	17	129	100	194	380
1909...	628	1,220	771	1,045	674	291	51	37	27	30	28	91	408
1910...	796	802	1,312	1,394	376	499	80	49	56	53	311	337	505
1911...	649	204	578	1,063	286	481	41	34	142	614	365	604	422
1912...	270	517	1,410	1,573	592	137	42	94	84	315	376	594	500
1913...	1,057	241	1,402	675	347	150	33	34	88	507	1,200	439	514
1914...	319	488	1,120	2,351	814	52	57	60	24	24	129	200	470
1915...	1,311	1,201	296	735	276	60	609	896	267	216	298	879	587
1916...	1,192	897	623	1,454	461	314	354	186	144	181	306	378	541
1917...	431	223	805	936	648	649	128	83	63	564	412	113	421
1918...	50	819	1,060	1,148	441	172	65	18	162	181	185	362	389
1919...	376	177	770	1,040	870	171	632	181	630	111	557	400	493
1920...	66	61	1,761	1,243	359	301	213	237	248	553	471	1,170	557
1921...	274	196	1,312	808	479	95	172	80	52	76	552	702	400
CATSKILL CREEK AT OAK HILL—DRAINAGE AREA 97 SQUARE MILES													
1910...	.....	.....	.....	.....	S1	156	11	6	7	8	42	35	.....
1911...	97	83	121	224	52	206	5	2	5	57	75	105	86
1912...	46	90	378	456	153	38	6	8	12	59	123	157	127
1913...	360	124	469	191	83	27	3	2	2	38	293	16	134
1914...	70	114	574	937	321	9	14	7	3	2	5	8	172
1915...	228	271	89	202	58	6	184	199	53	51	65	138	129
1916...	318	173	206	461	119	42	40	9	10	11	30	49	122
1917...	57	62	274	227	200	138	12	32	19	161	90	24	108
1918...	12	271	284	262	89	37	12	2	19	38	22	59	92
1919...	61	29	187	266	203	59	52	36	190	23	139	74	110
1920...	12	7	526	368	66	119	29	113	115	115	151	372	166
1921...	70	60	458	214	169	7	97	8	4	7	261	163	126

*On January 1, 1913, a re-determination of drainage areas was made, based on the United States Geological Survey quadrangles, some of which were not available when the original areas were determined; the following is a comparison with values published prior to that date:

CREEK AND STATION	AREAS USED TO DECEMBER 31, 1912, SQUARE MILES	AREAS USED, 1913 AND AFTER, SQUARE MILES
Esopus creek at Olive Bridge dam.....	239	239
Esopus creek at Mt. Marion.....	378	**368
Rondout creek at Honk Falls.....	105	102
Rondout creek at Lackawack.....	104	100
Schoharie creek at Prattsville.....	240	236

**The drainage area of the Esopus creek at Mt. Marion does not include the Sawkill diversion for the Kingston water-supply (33 square miles), nor the Plattekill diversion for the Saugerties water-supply (17 square miles); the total drainage area above Mt. Marion is therefore 418 square miles. This gaging station was discontinued April 6, 1918, and the figures for the early part of 1918 are not recorded here.

† 13 days' record.

†† 27 days' record.

‡ 16 days' record.

‡‡ The conduit of the Olive Bridge dam was closed September 9, 1913; from this date on the flow was influenced by storage and waste.

§ The water-level in the East basin of the Ashokan reservoir reached the Waste Weir crest, Elevation 587, on December 12, 1916; several days prior to this water was wasted over the crest, due to wave action.

§§ Figures for period from January 1, 1903 to April 30, 1907 are from United States Geological Survey records.

TABLE 5

CANVASS OF BIDS OPENED JUNE 7, 1921, FOR **Contract 206**, FOR THE REMOVAL OF BODIES, HEADSTONES AND MONUMENTS FROM THE LANDS ACQUIRED FOR THE CONSTRUCTION OF THE SCHOHARIE RESERVOIR

ITEM	DESCRIPTION	UNIT	QUANTITY	*A	B	C	D	E	AVERAGE
1	Opening and refilling graves.....	Grave.....	449	\$7.50	\$12.50	\$12.00	\$8.00	\$10.00	\$10.00
2	Furnishing boxes, placing remains in said boxes, transporting and reintering the same, including furnishing space for reinterment.....	Remain.....	449	8.00	6.00	12.00	20.00	26.00	14.40
3	Removing, transporting and placing headstones.....	Headstone.	127	4.00	3.00	1.50	6.00	5.00	3.90
4	Removing, transporting and placing monuments of $\frac{1}{4}$ cubic yard and greater in volume.....	Monument	9	40.00	5.00	1.50	30.00	12.00	17.70
5	Furnishing, cutting and setting bluestone markers.....	Marker.....	449	3.00	2.00	1.50	3.00	5.00	2.90
6	Furnishing foundations for headstones and monuments.....	Cubic foot..	800	.70	.75	.45	.50	.45	.57
Amounts of bids.....				\$9,734.50	\$10,230.50	\$12,013.50	\$15,351.00	\$19,512.00	.....

Time for completion: 7 months. Bond required: \$2,000.00. *Awarded contract. *A—Charles Meads & Co., 217 West 14th Street, New York City. B—Decker and Lasher, Brown Station, N. Y. C—Thomas H. Thyer, 108 West 43rd Street, New York City. D—S. S. Jones Contracting Corporation, Grand Central Terminal, New York City. E—E. W. Brown, Castleton-on-Hudson, N. Y.

CANVASS OF BIDS OPENED NOVEMBER 10, 1921, FOR Contra

ITEM	DESCRIPTION	UNIT	QUANTITY	*A
1	Removal of soil.....	Cubic yard.....	10,000	\$1.00
2	Earth excavation.....	Cubic yard.....	80,000	1.30
3	Rock excavation.....	Cubic yard.....	2,900	4.00
4	Stream and highway crossings.....	Lump sum.....		6,000.00
5	Refilling and embanking.....	Cubic yard.....	75,000	.65
6	Surface dressing.....	Cubic yard.....	9,000	1.10
7	8-foot 4-inch steel pipe, $\frac{1}{8}$ -inch plate, lap-joints.....	Linear foot.....	5,365	25.00
8	8-foot 4-inch steel pipe, $\frac{1}{8}$ -inch plate, longitudinal butt-joints.....	Linear foot.....	240	35.00
9	8-foot 10-inch steel pipe, $\frac{1}{8}$ -inch plate, lap-joints.....	Linear foot.....	6,550	27.00
10	Steel castings.....	Pound.....	32,000	.10
11	Steel for reinforcing concrete.....	Pound.....	50,000	.06
12	Cast-iron pipe and special pipe castings.....	Ton.....	5	150.00
13	Miscellaneous bronze, brass, copper and lead.....	Pound.....	1,500	1.50
14	Miscellaneous cast iron, wrought iron and steel.....	Pound.....	85,000	.10
15	Galvanizing.....	Pound.....	20,000	.10
16	Caring for and setting metal-work furnished by The City.....	Pound.....	10,000	.05
17	Cutting concrete.....	Cubic foot.....	500	2.00
18	Portland cement.....	Barrel.....	34,000	3.50
19	Concrete masonry around steel pipes.....	Cubic yard.....	14,400	11.75
20	Concrete masonry for blow-off chambers, culverts, waterways, retaining-walls and other appurtenant structures.....	Cubic yard.....	2,500	12.00
21	Reinforced concrete.....	Cubic yard.....	500	15.00
22	Mortar lining of steel pipes.....	Square foot.....	325,000	.20
23	Dry rubble masonry and paving.....	Cubic yard.....	1,000	5.00
24	Rubble masonry and paving in mortar or grouted.....	Cubic yard.....	100	6.00
25	Crushed stone and gravel.....	Cubic yard.....	1,000	4.00
26	Tile pipe, 6 inches and less in diameter.....	Linear foot.....	1,000	.50
27	Tile pipe, 8 inches to 12 inches in diameter.....	Linear foot.....	500	1.00
28	Tile pipe, larger than 12 inches and not exceeding 24 inches in diameter.....	Linear foot.....	100	4.00
29	Timber and lumber.....	Thousand feet, board measure.....	150	60.00
30	Stop-planks.....	Lump sum.....		6,000.00
31	Stone guard walls.....	Linear foot.....	100	3.00
32	Wooden fences and guard-rails.....	Linear foot.....	200	1.00
33	Wire fences.....	Pound.....	10,000	.10
34	Removal and installation of 5-foot by 13-foot sluice-gates.....	Lump sum.....		5,000.00
35	Seeding and grassing.....	Acre.....	25	100.00
36	Engineers' offices.....	Square foot.....	2,500	4.00
37	Medical and surgical practitioners.....	Practitioner-month.....	60	300.00
38	Sanitary services.....	Month.....	40	200.00
39	Chlorinated lime.....	Pound.....	8,000	.10
40	Liquid chlorine.....	Pound.....	10,000	.10
41	Automatic control chlorine dosing machines.....	Machine.....	2	1,000.00
42	Cleaning up.....	Lump sum.....		3,000.00
Amounts of bids.....				\$999,325.00

Time for completion: 42 months. Bond required: \$250,000.00. *Awarded contract. *A—Rice and Ganey, I and Lowe and Law Brothers, Herkimer, N. Y. E—Frederick Snare Corporation, 8 West 40th Street, New York, Baltimore, Md. I—Scott Brothers, 120 North Washington Street, Rome, N. Y. J—T. A. Gillespie Company, 112 North Broad Street, Philadelphia, Pa. N—Michael Staub, Mamaroneck, N. Y. O—George Colon

Act 209, FOR THE CONSTRUCTION

B	C	
\$0.73	\$0.90	
.87	.90	
4.80	3.00	
4,800.00	8,000.00	25,
.70	.90	
.73	1.50	
37.30	46.80	
42.80	55.11	
43.40	46.80	
.15	.20	
.08	.05	
240.00	120.00	
1.20	1.00	
.15	.12	
.08	.12	
.03	.03	
1.00	1.50	
3.35	2.60	
6.42	7.00	
8.22	10.00	
12.00	15.00	
.18	.10	
4.80	5.00	
6.00	10.00	
3.60	3.00	
1.20	.40	
2.40	.60	
6.00	2.00	
70.00	70.00	
1,200.00	2,000.00	9
1.20	2.00	
1.20	1.00	
.12	.12	
2,400.00	2,000.00	1,4
60.00	100.00	2
4.80	5.00	
360.00	150.00	3
240.00	200.00	7
.12	.05	
.12	.12	
3,000.00	2,000.00	3,0
5,000.00	5,000.00	12,0
,053,214.50	\$1,096,998.40	\$1,157,9

Room 1708, Grand Central Terminal
 City. F—Peter F. Connolly Co., K
 7 Dey Street, New York City. K—
 Company, 81 East 125th Street, New