A CENTURY OF PROGRESS IN WATER WORKS

1833 CHICAGO 1933

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PREPARED BY BUREAU OF ENGINEERING

DEPARTMENT OF PUBLIC WORKS CITY OF CHICAGO

EDWARD J. KELLY
MAYOR

OFFICE OF THE MAYOR
CITY OF CHICAGO

June 10, 1933.

To Friends of The Chicago Water Works:

As you convene in Chicago during the period of our Century of Progress Exposition, we cordially invite you to visit the plants and structures which serve our water works system.

Chicago is rightfully proud of its municipally owned water works and the progress it has made within the span of a century. It not only pumps more water than any other city system, but it supplies this commodity to our citizens and neighboring towns at the lowest rate of any large city in America.

This booklet has been prepared as a reference document for your technical library and we hope it will be of value to you as well as a remembrance of your visit to our water works.

Yours very sincerely,

Edward J. Kelly

Mayor.

EDWARD J. KELLY
Mayor

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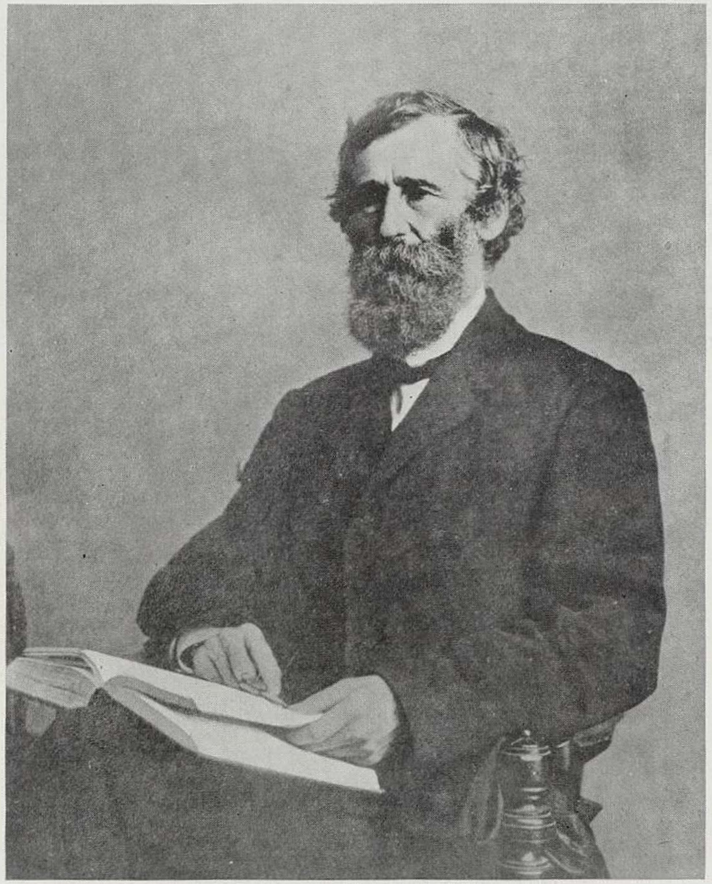

ELLIS SYLVESTER CHESBROUGH

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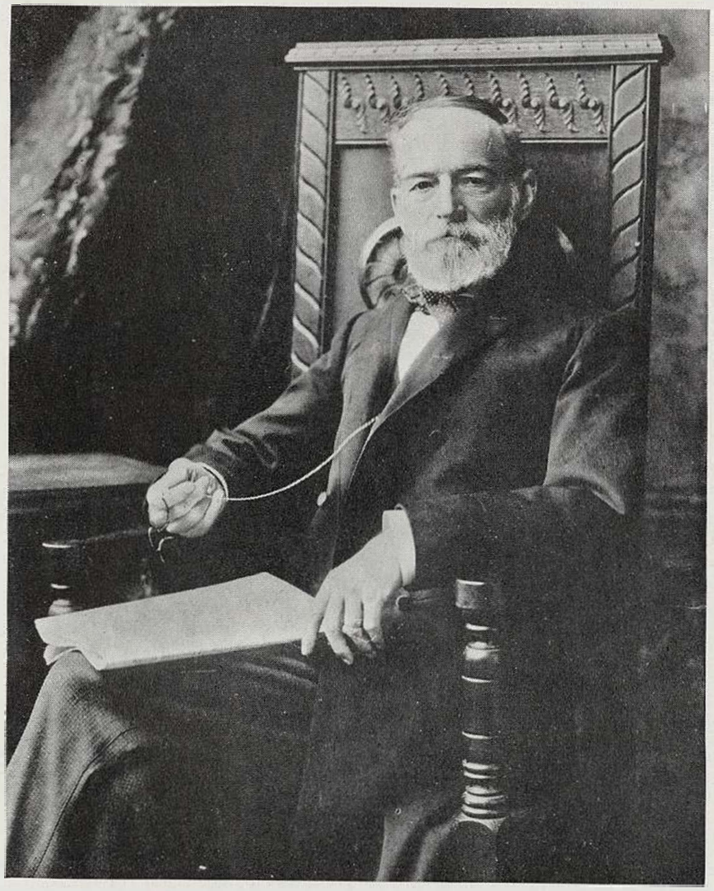
ELLIS S. CHESBROUGH, internationally known as the builder of Chicago's first water tunnel, was born in Baltimore County, Maryland, on July 6, 1813. His early engineering training was associated largely with railroad work under former army engineers. In 1846 he was invited to accept the position of chief engineer of the Western Division of the Boston Water Works in charge of the Brookline reservoir project. After a reorganization of the department in 1850, Mr. Chesbrough became sole commissioner. In 1851 he was made chief engineer of the commission and city engineer of Boston as well. It was in this capacity that he had charge of the Chochituate project of this board.

At the invitation of Wm. B. Ogden, President of the Chicago Sewerage Commission, Mr. Chesbrough on October 1, 1855, accepted the position of chief engineer of that commission. He had while in Boston, obtained a national reputation for a report on sewerage practice in England. During the winter of 1856-7 Mr. Chesbrough went to Europe for the Commission, to study the sewerage systems in the large cities. While serving the sewerage commission in planning a comprehensive sewer system for Chicago, Mr. Chesbrough's advice was also sought and freely given to the Water Board on matters pertaining to improving the city water supply. When in 1861, the Water and Sewerage Commissions were abolished and a Board of Public Works created, he became the chief engineer of this board.

It was in this capacity and, after a very careful study of possible means of improving the quality of Chicago's water supply, that he recommended the construction of a tunnel under the lake to an intake two miles from shore. In the face of great opposition the plan was adopted and work on the 5 ft. diameter brick tunnel was commenced under contract on March 17, 1864, and completed three years later. This tunnel project attracted wide interest all over the world. Detailed plans were sent, on request, to the Universal Exhibit in Paris in April, 1867. As a part of the lake tunnel project Mr. Chesbrough planned the enlarged water works system which served the city prior to the Great Fire of 1871, consisting of the new tunnel, the Chicago Avenue pumping station and the Old Water Tower. The year after the fire, work was commenced on a new lake tunnel and intake with a land extension to a new pumping station on the West side. This tunnel, also brick lined, was 7 feet in diameter and about six miles in total length.

In January, 1879, Mr. Chesbrough was appointed to the newly created office of Commissioner of Public Works, which he held for a period of four months, resigning to enter consulting engineering practice. While chief engineer of the Board of Public Works, he directed not only the water works developments of the city, but its sewerage system, bridges and river tunnels. As a consulting engineer he reported on water works and sewerage projects for many of the large cities of the United States. In 1882 he was appointed permanent consulting engineer for New York on the Croton Water Supply project and spent several months in France and Spain studying high masonry dams.

Mr. Chesbrough was president of the Civil Engineers Club of the Northwest—later the Western Society of Engineers—in 1869, and of the American Society of Civil Engineers in 1877. His death on August 18,1886, took from Chicago one of the most able, courageous and public spirited men the city has ever known.



DE WITT CLINTON CREGIER

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DE WITT CLINTON CREGIER, the son of John L. and Ann E. (Le Fort) Cregier, was born June 1, 1829, in New York City. He was educated in the public schools of New York. On August 2, 1853, he married Mary S. Foggin and the young couple left immediately for Chicago where Cregier had been employed to superintend the erection of the new 8.0 M. G. D. pumping engine for Chicago's first municipally owned water works. Thus began what was to be thirty-five and one-half years of service to the City of Chicago, culminating in his election in 1889 as Mayor of the city.

Mr. Cregier served as chief engineer of Chicago's North side pumping station—now known as the Chicago Avenue station—until 1880, when he was appointed city engineer. In this capacity he had much to do with the selection of the early pumping equipment for Chicago, both at the North and Central Stations. Steam driven reciprocating pumps were developed from small low pressure engines similar to "Old Sally" at the North Works to the five giant triple expansion engines erected at the 14th Street and Harrison Street pumping stations while he served as Chief executive of this city. It was while Mr. Cregier was Mayor that he caused to be written a very valuable history of early Chicago and of the water works system, both being published in the Annual Report of the Department of Public Works for 1890.

On February 4, 1882, he was promoted, through appointment by Mayor Carter H. Harrison, Sr., to the position of Commissioner of Public Works. This position he resigned on January 31, 1886, to become Superintendent of the West Chicago Street Railway Co.

In 1889 Mr. Cregier was elected Mayor of Chicago by a large majority on the Democratic ticket. It was during his term of two years as Mayor that plans were inaugurated and completed to secure for Chicago the World's Fair of 1893, known as the Columbian Exposition. This project received the fullest support of Mr. Cregier and he served as a director of the exposition. While Mr. Cregier was Mayor the city through annexation of suburbs increased in area from thirty-seven to one hundred and seventy square miles, and in population from 853,000 to 1,107,000.

Mr. Cregier's services to the Chicago Water Works were manifold. Perhaps his greatest contribution was the design of the 36 M. G. D. pumping engine installed at the North side pumping station in 1872. He was also the designer of numerous other mechanical appliances for water works use, including a double valve fire hydrant, many of which are still being used in Chicago.

The great Chicago Fire of 1871 found Mr. Cregier a leader in public service. Largely through his untiring efforts, the pumps at the North pumping station which were put out of commission on the afternoon of the second day of the conflagration, were back in service in eight days. Mr. Cregier was in charge of the Masonic Relief Fund after the fire.

After retiring as Mayor of Chicago in 1891, he returned to private engineering practice. In 1883 he served as president of the Western Society of Engineers. He died in Chicago November 9, 1898.

JOHN ERNST ERICSON

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JOHN ERICSON who gave 43 years of distinguished service to the City of Chicago was born in Stockholm, Sweden, on October 21, 1857. He received a degree in Civil Engineering upon graduating from the Royal Polytechnic Institute in his native city in 1880. Prior to entering the employ of the City of Chicago in 1884, he worked a year on bridge construction in Sweden and as rodman for the Pennsylvania Railroad in this country, being promoted to a resident engineer in 1882. He was engaged in survey work on the Illinois-Michigan canal in 1883.

Mr. Ericson first served Chicago as an engineering draftsman in 1884-1886. In the latter year he accepted a position as assistant engineer with the City of Seattle, working on the design of a water works system. Returning to Chicago, he entered the employ of the Chicago Sanitary District in 1890. Mr. Ericson re-entered the city service in 1892 as an assistant engineer on tunnel construction work. A year later he became first assistant city engineer and on July 6, 1897, he was appointed city engineer. This position he held continuously except for four years, 1919-1923, until his death. During these four years he was employed as a consulting engineer by the Department of Public Works.

The forty-three years Mr. Ericson served the City of Chicago saw the welding together of many satellite water works in the Chicago metropolitan area into the world's largest water works system. He pioneered many important water works and miscellaneous engineering projects built by the city. He built up one of the best equipped engineering departments in any large American city.

Mr. Ericson modernized Chicago's water works in every respect. He built the first tunnels in rock, introduced the modern centrifugal pumping equipment, directed construction work by city labor instead of by contract, struggled hard for a universal metering program and urged filtration of the water for over two decades. It was under Mr. Ericson that five of the present twelve pumping stations, and three of the five major tunnel systems were built. Chicago's experimental filtration plant and the new Chicago Avenue tunnel, now well advanced in construction, were projects started by Mr. Ericson in his late years as city engineer.

In 1898, Mr. Ericson designed a special type of bascule bridge for the city, which avoided the payment of heavy royalties. He served on the Harbor and Subway Commission from 1911 to 1914. In 1912 Mr. Ericson was awarded the Chanute Medal by the Western Society of Engineers for an outstanding paper on the flow of water in large tunnels. The King of Sweden decorated Mr. Ericson with the Royal Order of Vassa in 1913.

His untimely death on April 16, 1927, prevented his delivering what was expected to be his finest engineering paper, "A Program for Improving Water Service in Chicago," scheduled for delivery before the American Water Works Association on June 7th of that year.

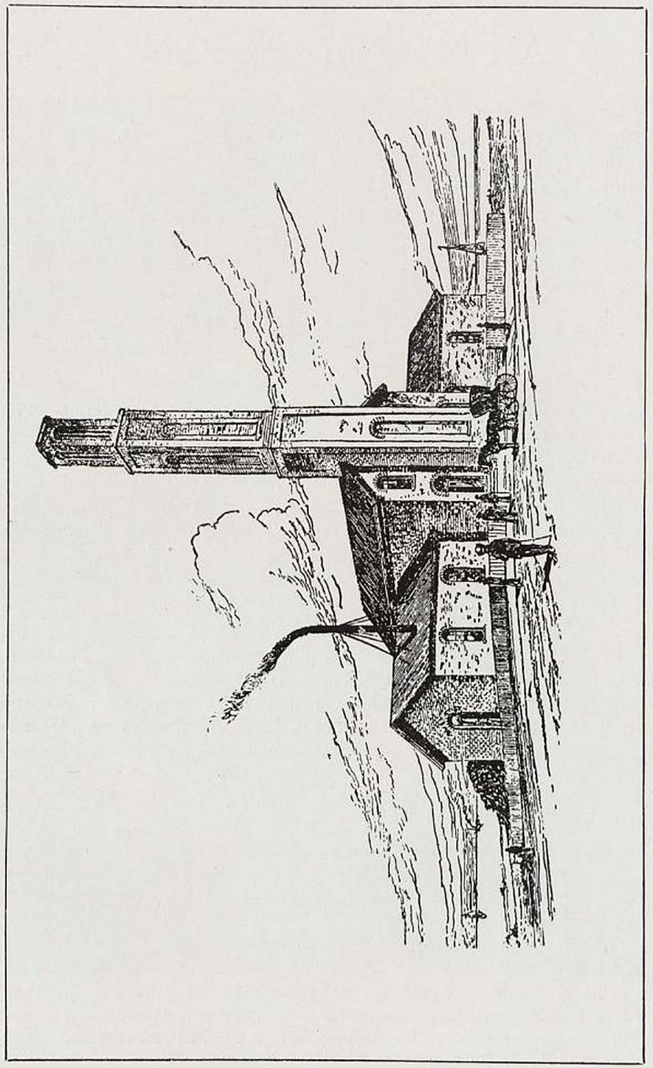


Figure 1—Original Municipal Water Works—In service 1854

A CENTURY OF PROGRESS

IN WATER WORKS

1833—CHICAGO—1933

FORT DEARBORN, built in 1803, and the rude homes of a few settlers was the beginning of Chicago. The river was the principal source of water. As the settlement grew to a village the river became increasingly polluted and the citizens resorted either to wells or the lake for their water. Water was sold by peddlers at rates varying from ten to twenty-five cents per barrel. A well dug by the order of the village trustees in 1834 at what is now the intersection of Cass and Austin streets, was apparently the first official attempt toward a public water supply for the village of Chicago.

The need for a public water supply for the fast growing young city soon became acute and in 1836 the State Legislature granted a 70 year charter for incorporating the Chicago Hydraulic Co., a private enterprise, to supply water to the city. Because of financial difficulties the company did not start its water works construction until 1840. Two years later and at a cost of $24,000, Chicago's first water works was completed and ready for operation. The city then had a population of 4,500.

The intake pipe for the plant extended by means of a pier about 150 feet into the lake off Lake street and terminated in a suction well for a 25 H.P. steam pumping engine. The pumping station was located at the corner of Lake Street and Michigan Avenue, the water being elevated to a wooden reservoir from which it flowed by gravity through wooden mains. The surplus power from this steam engine was also used for operation of a flour mill. The old wooden mains, about two miles of which were laid, were made from 10 ft. cedar logs, bored, with internal diameters ranging from two to six inches and joined together by a special wooden fitting. (See Fig. 18.)

This water works served only a portion of the city south and east of the river and was not equipped to meet the needs of the city with its rapid growth. Much difficulty was experienced with fish entering the intake, with turbid waters following lake storms and with ice in the winter.

By 1851 the population of the city had increased to 35,000 people. Through the efforts of public spirited citizens, the legislature on February 15 of that year granted the city a charter to build and operate its own water works system. The Water Commission created, employed Wm. J. McAlpine of New York City to make an investigation and to design the first municipally owned system. He

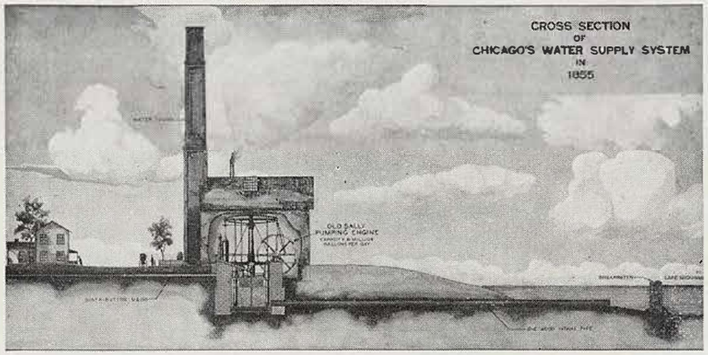


Figure 2—Cross-section Chicago's first municipally owned water works system

recommended a new location for the water works on the lake front at Chicago Avenue. He designed a system based on an estimated population in fifteen years of 100,000 people.

The new intake was of timber 3 ft. x 4 ft. extending into the lake about 600 ft. from shore and terminating in a brick suction well. The intake was protected by a semi-circular breakwater of timber and stone, with an opening to the southeast. (See Fig. 2.) The pumping station of brick in Italian architecture was located at the corner of Pine Street (now Michigan Avenue) and Chicago Avenue. (See Fig. 1.) It housed an 8 M.G.D. single acting pumping engine and had a tower enclosing both the smoke stack and a stand pipe. The new distribution system consisted of about 8¾ miles of cast iron pipe and one iron reservoir. (See Fig. 16.) This new system was first put into operation in February, 1854. The pump operated for the first four months but nine hours a day and not at all on Sundays, except in case of fire.

But this new water system carefully and courageously planned was not satisfactory to serve Chicago with its record breaking growth and development. A second pumping engine of 12 M.G.D. capacity was installed and put in operation in July, 1857. The disposal of sewage, distillery, packing plant and tannery wastes by discharge into the river and lake resulted in gross pollution of the lake. The increasing prevalence of typhoid fever, diarrhea and other water-borne diseases in the city became alarming.

It was clearly evident that an intake further out in the lake, beyond the zone of shore pollution, was necessary. It was also certain that a much larger intake works, pumping station and distribu-

tion system must be provided. With the creation of a Board of Public Works on May 6, 1861, the responsibility for planning this new water system rested on the Chief Engineer, Ellis S. Chesbrough. He had previously investigated the water supply problems of the city and after considering various alternate projects had recommended a tunnel under the lake to an intake about two miles off shore at Chicago Avenue, with a new and larger pumping station and water tower. The adoption in 1863 of the Chesbrough plan for a new water works system marked the beginning of the Chicago Water Works of today.

THE OLD WATER TOWER

The old water tower (see Fig. 4) erected under this plan in 1867 symbolizes both the old water works which passed into history and the new one then being pioneered for posterity. It has now served its usefulness as a water works accessory. Alone it stood undamaged through the heat and destruction of the Great Chicago Fire of 1871. It is a cherished land mark dear to Chicagoans and one which probably will stand for centuries to come.

It is most fitting that on June 12, 1933, three memorial plaques in bronze were placed on the walls of this tower, dedicated in memory and in recognition of the distinguished services of the three Chicago city engineers whose years of devotion to the city water works system totaled over a century—namely, Ellis S. Chesbrough, DeWitt C. Cregier and John Ernst Ericson.

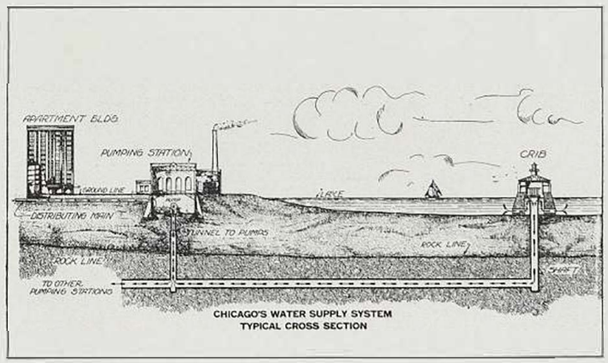


Figure 3—Longitudinal section through modern crib, tunnel and pumping station

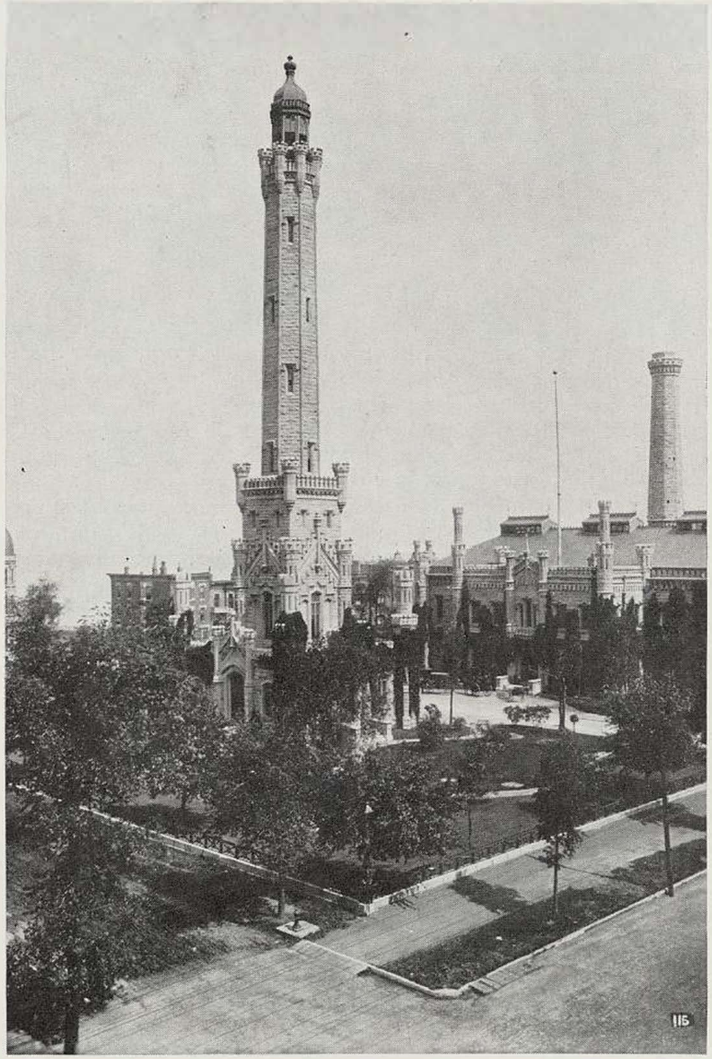


Figure 4—Old Water Tower and Chicago Avenue pumping station
Photographed in 1888

Figure 5—Final Inspection of First Water Tunnel—(From Harper's Weekly, April 20, 1867)

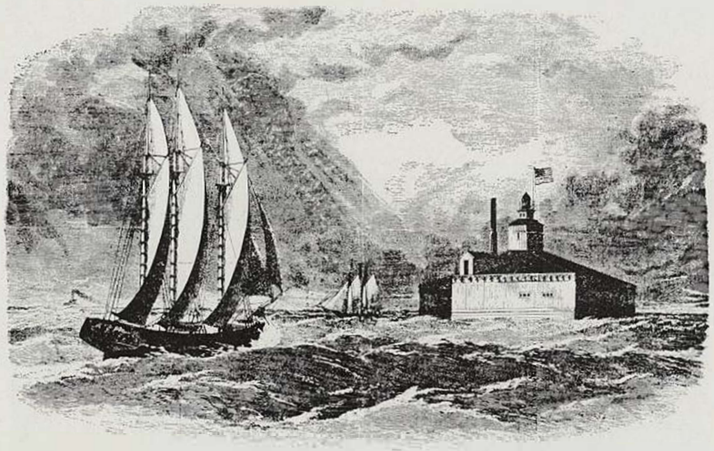


Figure 6—Original Two-Mile Crib Intake (From Harper's Weekly, July, 1865)

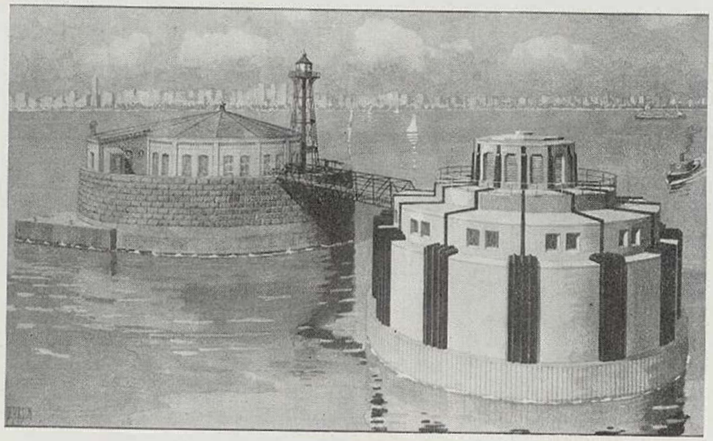


Figure 7—Carter H. Harrison Crib and new Wm. E. Dever Crib—under construction

TUNNELS

CHICAGO'S first water tunnel was a daring engineering project. It brought international fame to the designer, Ellis S. Chesbrough, and to the City water works. The tunnel was designed to deliver 50 M.G.D.: to be dug through clay at a depth of about 60 feet below lake lavel a distance of 10,567 feet out under the lake, and lined to a finished diameter of 5 ft. with two shells of brick with one-half inch cement joints.

In the face of much doubt and criticism the Council passed the necessary ordinances for the project. The Board of Water Commissioners in October, 1863, awarded the contract to Messrs. J. J. Dull and James McGowan, contractors, Pittsburgh, Pa., the second of seven bidders, at a price of $315,139.00. The total cost of the finished project was $457,845.00, of which $380,784.00 was paid the contractors, including extras allowed. When the original estimates were made common labor was being paid $1.25 per day, which was then considered a high wage. But later as the Civil War progressed and the values of gold and currency became disturbed, much higher wages were paid. The finished tunnel cost $18.45 per lineal ft.

With fitting ceremonies the work was commenced on the land shaft on March 17, 1864. The work on the tunnel progressed day and night with an average progress of about 12 ft. per day. Gas pockets, quicksand and boulders were encountered, but no serious mishaps occurred.

The crib—pentagonal in shape (see Fig. 6) and of timber construction was built and successfully launched on July 24, 1865. Because of a lake storm a few days later its position was disturbed some, but the crib was successfully placed and the intake shaft built. Tunneling from the lake shaft followed and at 3:40 P. M. on November 30, 1866, the two working headings under the lake met, being but seven inches out of alignment. The last masonry stone was laid by Mayor Rice with special ceremonies on December 6, 1866. The great Chicago tunnel had been successfully completed!

On March 8, 1867, the tunnel was filled with water and a few days later pumped out for final inspection. (See Fig. 5.) It was officially dedicated on March 25, 1867, on which day water was first pumped from the new lake tunnel. A corner stone was laid in the new water tower which still stands at the intersection of Chicago and Michigan Avenues. The new North Pumping station (now the Chicago Avenue Pumping Station) was completed in 1869.

The Great Chicago Fire of October 8th and 9th, 1871, so damaged the machinery of this new station as to put it out of service for

eight days. While the new tunnel had temporarily solved Chicago's water quality problem, this great conflagration brought serious emphasis on the need for a better balanced water system for fire protection in the city. A break in a water main crossing the river, coupled with an increasing demand for additional water service on the west side, resulted in a decision being made shortly after the Great Fire to build a new tunnel and pumping station to serve the west side.

The second tunnel, also through clay, was begun on July 12th, 1872, and completed on July 7, 1874. It started at a land shaft near the original tunnel shaft and terminated on the lake end in a shaft within the original Two-mile Crib. The land section crossed the city diagonally under private property to a suction well under the new West Side pumping station located at Ashland Avenue and 22nd Street. The new tunnel was 31,490 feet in total length, 7 ft. in diameter and lined with brick with several land shafts for construction purposes.

Because of interference with deep foundations and pilings for large buildings the land section of this tunnel was abandoned in 1909, when the Blue Island Avenue tunnel was put into service. This tunnel, 8 ft. in diameter, and under the city streets, was built under private contract in 1907-9 and was Chicago's first long concrete lined tunnel. In 1932 it was dewatered for the first time in 23 years and found to be in good physical condition.

A second 7-ft. diameter brick tunnel from the Two-mile Crib to the Chicago Avenue Pumping Station, which is also cross connected to the Northwest Land Tunnel, was built in 1895 and is still in service, making a total of three tunnels from this crib. Its intake is between the old crib and the protecting breakwater.

Chicago's third tunnel was the Four-mile Tunnel off 12th Street, still in service. Work on this project started in November, 1887, and water was admitted to the tunnel in December, 1892. It was originally intended to build this tunnel with an internal diameter of 8 ft. through clay with brick lining to serve two new stations, the Fourteenth Street and Central Pumping Stations—the latter now known as the Harrison Street station. Because of serious construction difficulties due to soft, swelling clay and quicksand, the contractor, A. Onderdonk, was granted permission, after constructing 278 ft. of 8-ft. tunnel, to continue with two 6-ft. diameter drifts. At a point 8,870 ft. west of the crib the two tunnels were united again into one 8-ft. tunnel, which was deflected 350 ft. north to clear an abandoned intermediate crib.

The intake shaft for this tunnel is protected by a crib consisting of two concentric steel shells set on a wooden grillage and in 39 ft. of water. The crib was sunk in October, 1889.

Figure 8—Rear View Mucking Machine Chicago Avenue Tunnel

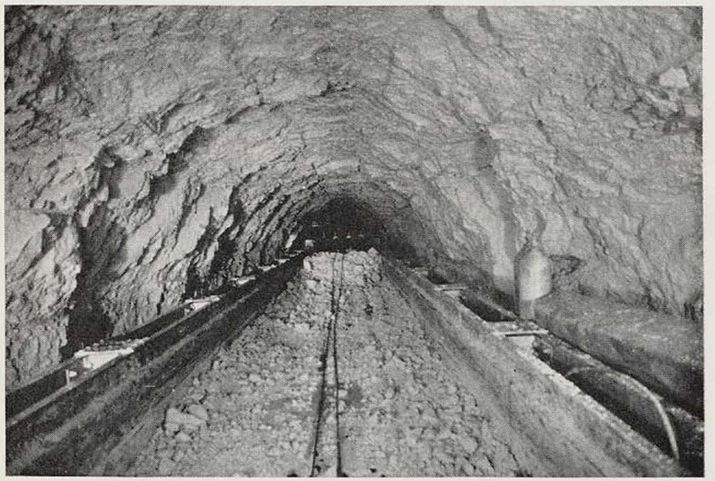


Figure 9—Drag line loading mucking machine Chicago Avenue Tunnel

The land connection to the Fourteenth Street Pumping Station starts from the Park Row shaft in Grant Park and is 8 ft. in diameter for a distance of 225 ft. Because of bad soil conditions it also divides into two 6-ft. diameter sections to a point 200 ft. north of the station, where it returns to the original 8-ft. section. A 7-ft. branch tunnel connecting with the cross town tunnel was finished in January, 1889, to supply the new Central Pumping Station.

Because this tunnel was partially under private property the portion west of Grant Park was abandoned in 1907 when the 7-ft. Polk Street tunnel was constructed. It cross connects the Four-mile and Blue Island Avenue tunnel systems, serving the Harrison Street pumping station.

About three-quarters of a mile northeast of the Two-mile Crib is the Carter Harrison intake. It supplies the northeast lake and northwest land tunnels supplying the central and central west areas of the city, serving the Central Park, Springfield Avenue and part of the Chicago Avenue pumping stations. This crib and tunnel project became necessary because of demands for water service occasioned by extensive annexations in 1889. The crib is built of two concentric steel shells on a wooden grillage and has a masonry and brick superstructure. The diameter of the shells are 112 and 62 ft., respectively.

Authority for the tunnel system was given by the City Council in March, 1896, and the contract for the lake section, 10 ft. in diameter and 14,033 ft. long, through clay and brick lined, was awarded in July of that year. The work was completed in January, 1899. The land section is 10 ft. in diameter from the shore shaft at Oak Street to the junction shaft at Green Street. At this point the tunnel divides into two 8-ft. diameter auxiliary tunnels northwest 22,184 ft. and southwest 19,856 ft. to the Springfield Avenue and Central Park Pumping Stations. These tunnels are through both clay and rock and were completed early in 1900. Because these tunnels are under private property they are scheduled eventually for abandonment, although in good physical condition, when the new Chicago Avenue tunnel is completed.

The annexations of the cities of Hyde Park and Lake View in 1889 gave the city two new lake intakes, both of which have since been abandoned and required that new tunnel systems be constructed to serve the south and north sections of the City.

The Village of Hyde Park, when annexed, was supplied with water from a 6-ft. tunnel with a submerged intake 5,036 ft. from shore, but the quality of the water was not satisfactory. In order to improve this condition and to furnish an additional quantity of water for the Worlds Fair of 1893, the City decided to construct a new

intake two miles from shore with a 7-ft. tunnel connecting with the 6-ft. tunnel. It was found that this project could not be completed in time for the Fair and considerable changes had to be made in the construction program to provide water service for this section of the city. The completed project consisted of a 7-ft. tunnel from the new intake to a point 4,876 ft. from the crib with 5-ft. and 7-ft. diameter branch tunnels to the pumping station. The 5-ft. section was abandoned in 1926, so that the 68th Street crib intake now serves but one 7-ft. diameter brick tunnel to the 68th Street Pumping Station. The old 6-ft. Hyde Park tunnel with submerged intake has also been abandoned.

The 68th Street crib is of timber construction on the order of the Two-mile crib with masonry and brick superstructure. Immediately adjacent to this crib is the Ed. F. Dunne Crib, put into service in December, 1911, to supply the Southwest Lake and Land Tunnel system.

This tunnel was started in April, 1906, and completed in 1911. Its lake section is 14 ft. in diameter from the intake shaft to the Yates Avenue land shaft, through rock, and is lined with concrete. It was the first tunnel Chicago constructed through rock, its depth varying from 92 to 148 ft. below Chicago datum.

The land section now extends west under 73rd Street to Western Avenue and has four branches: an 8-ft. drift to the 68th Street pumping station, 1915-1916; a 9-ft. section south in State Street to the Roseland station, 1909-1911; a 5-ft. tunnel north in Cottage Grove Avenue to the Washington Park pumping station of the South Park Commission (1915-1916) and a western branch 12 ft. in diameter in 73rd Street and Western Avenue to the Western Avenue pumping station built 1919-26.

The Dunne Crib is of steel construction on a wooden grillage and consists of two concentric shells 110 and 60 ft. in diameter filled with concrete. The superstructure is of masonry and brick. This intake supplies the south and southwest sections of the city and has a capacity of about 500 M.G.D.

The city inherited from the Village of Lake View, through annexation, a contract for the construction of a new 6-ft. diameter brick lined tunnel, through clay, to an intake about one mile from shore north of Montrose Avenue where the Village already owned a pumping station and shore intakes. Acting on a petition from the citizens, the city further contracted to extend this tunnel to 10,000 ft. into the lake with a new crib structure.

The new outer crib and tunnel was not finished until July, 1896. In the interum period much trouble was experienced in constructing this tunnel and in serving the pumping station from the temporary and shore intakes.

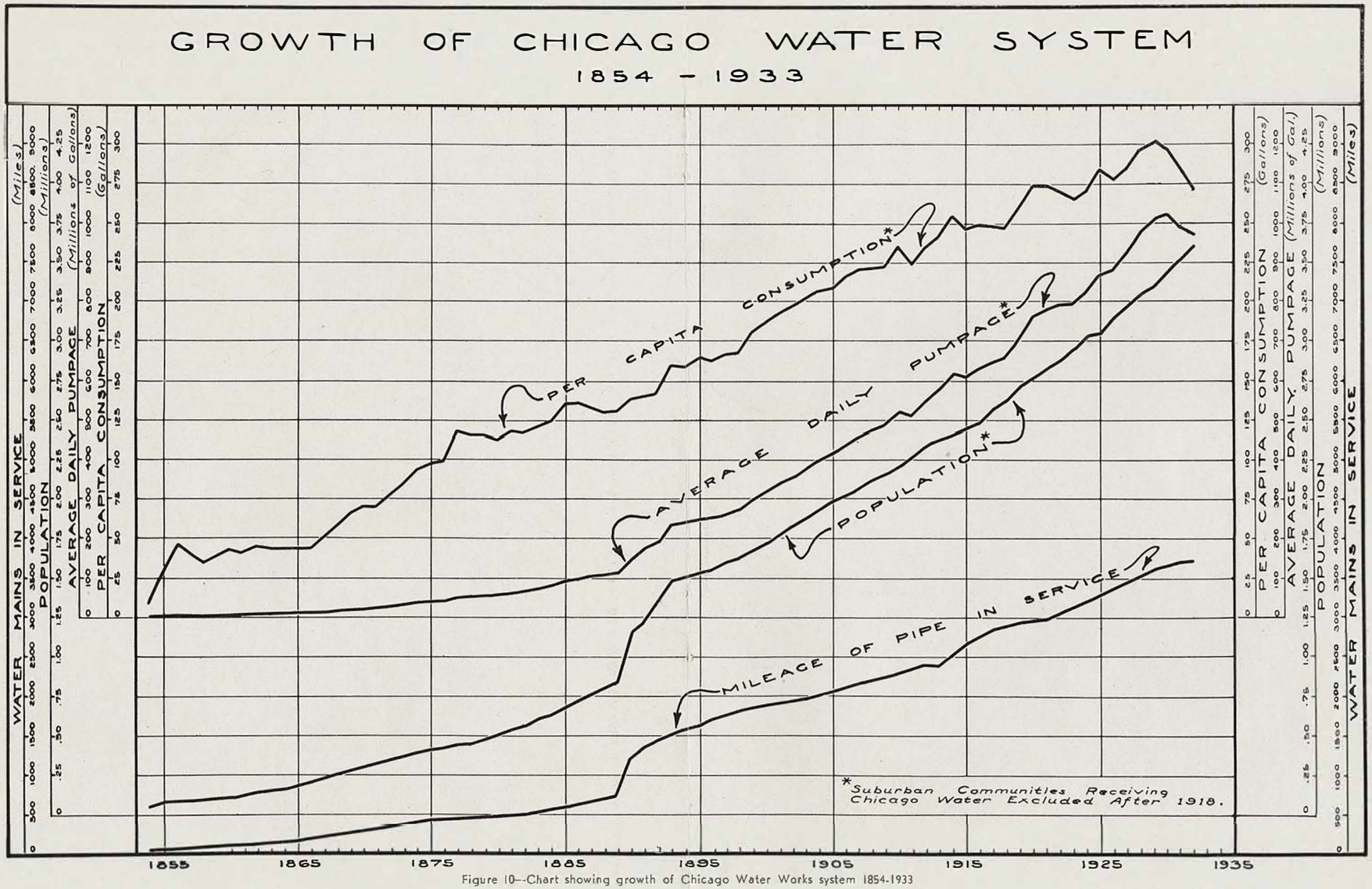


Figure 10--Chart showing growth of Chicago Water Works system 1854-1933

Because of the rapid growth of the city in the north and northwest sections it was decided, in 1912, to locate a new intake about three miles off shore at Wilson Avenue with a tunnel west to a pumping station in Mayfair, and to connect the 6-ft. Lake View tunnel to this new tunnel through a stub to the Lake View crib.

This new and gigantic tunnel project inaugurated several major changes in construction practice. The crib was the first to be built with a solid timber base. It was of all metal construction with flotation chambers built between the steel shells, the latter being 90 and 50 ft. in diameter and having cutting edges to effect a seal at the lake bottom. No gates were provided. It was floated into position and sunk in July, 1915.

The west lake and land sections were constructed by city day labor account and the entire tunnel was completed for official inspection in March, 1918. The total length of the new Wilson Avenue tunnel from the crib to the new Mayfair Pumping Station is 43,268 ft. and the cost, including the crib, was about $3,900,000.00.

A branch tunnel in Clarendon Avenue from the Wilson Avenue tunnel to the Lake View Pumping station was built 1,381 ft. long and 8 ft. in diameter by city day labor in 1913. When the spur tunnel from the Wilson Avenue Tunnel to the Lake View Tunnel was built in 1918 it made the Lake View crib unnecessary and in 1922 the intake shaft was domed over and two years later this crib was demolished.

Increasing demands for additional water service in the central and west portions of the city with the necessity for abandoning tunnels under private property, were factors which led to a decision reached in 1922 to build Chicago's latest and largest tunnel system. This is known as the Chicago Avenue tunnel which is still under construction. (See Figs. 8 and 9.) When finished this project will cost about $13,500,000. Its lake intake is within a crib immediately adjacent to the Carter Harrison Crib 13,830 ft. off shore at Chicago Avenue. (See Fig. 7.) This crib is all steel and is very much like the Wilson Avenue crib, its shells being 90 and 40 feet in diameter. The tunnel when finished will extend westward 7.81 miles from the lake intake. There will be a north branch 10 ft. in diameter to the Springfield Avenue Pumping station, 1.41 miles long, and another, 13-ft. branch 1.86 miles long, southward to the Central Park station. Two 10-ft. stubs will connect to the Chicago Avenue Pumping Station. Under Lake Shore Drive a second northerly branch 10 ft. in diameter and .30 mile long connects to the shore shaft of the northeast lake tunnel. The tunnel is through solid limestone about 200 ft. below lake level and is lined with concrete. (See Fig. 11.)

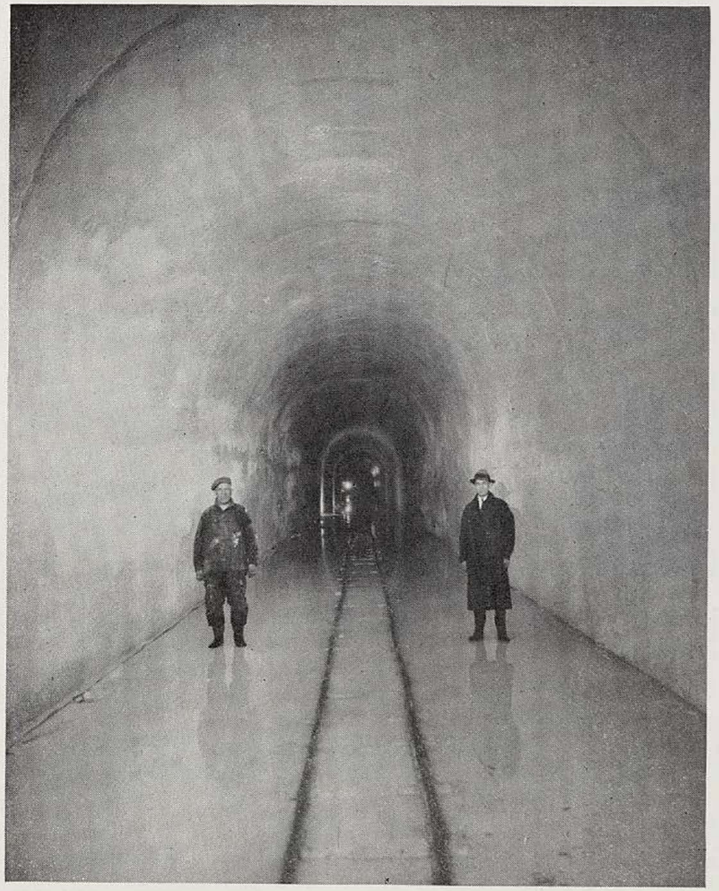


Figure 11—Sixteen-foot completed section—Chicago Avenue Tunnel

PUMPING STATIONS

CHICAGO in 1933 has twelve water pumping stations with a total rated capacity of 1954.5 M.G.D. In 1840 the single pump at the Chicago Hydraulic Co. plant had a rated capacity of 25 barrels per minute or approximately 1.8 M.G.D. In these ninety-two years Chicago has probably had more experience with pumping engines than any city in the world. Its water works have seen the reciprocating type of pump and steam engines develop through their various stages of design and efficiency only to be superseded by the newer centrifugal pumps.

Only one station, Lake View, is now equipped entirely with triple expansion pumping engines. Seven are operated with centrifugal pumps only and the other four have both types of pumping equipment. Of the present twelve pumping stations four are dependent on electrical power and eight are steam operated. The proposed new Central Pumping station will use electric power supplanting two steam and one electric stations.

Chicago's pumping stations deliver water from the suction wells connected to the tunnel system directly into the mains. Each has its own service area, pumping against the others to maintain as near a uniform pressure in the system as possible. Pumps are operated to maintain service on a predetermined pressure schedule, based on consumption and pressure requirements in the respective pumping station districts.

The first municipally owned pumping station was at the site of the present Chicago Avenue pumping station. Its original pumping engine, affectionately nick-named "Old Sally," was installed under the direction of DeWitt C. Cregier in 1853. It was a vertical condensing steam engine with a single acting pump of 8.0 M.G.D. capacity. It served the city faithfully for over 50 years, and outlived Mr. Cregier by six years.

This station was wrecked and the present Chicago Avenue station with the old water tower erected in its place in 1867-69. By successive stages the pumping equipment in this station has been increased in capacity by additional and enlarged units, until today

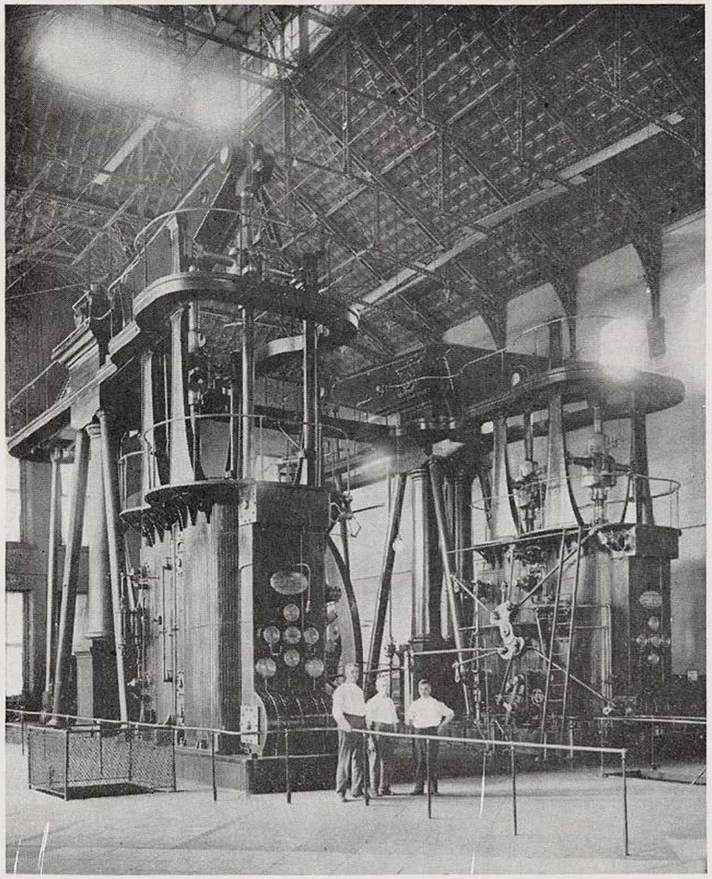


Figure 12—Old Quintard Pumps, 22nd street pumping station—Installed 1884

it has a maximum pumping capacity of 210 M.G.D., 160 M.G. of which are motor driven centrifugal pumps.

The second water pumping station was built at 22nd street and Ashland avenue and was formerly known as the West Side station. It was put in operation in 1876 with two Corliss engines and single acting pumps of 15 M.G.D. capacity each. In 1884 two more pumping engines of the same type were installed. They are still standing —but idle. (See Fig 12.) Their place has been taken by four 32 M.G.D. electrically driven centrifugal units. This station was formerly supplied by the old crosstown tunnel, but now receives water from the Blue Island Avenue tunnel. It will be one of the three stations replaced by the new Central Pumping station when it goes into operation in 1934.

The Harrison and Fourteenth street pumping stations were part of the Four Mile tunnel project to supply additional water for the central and northern portions of Chicago in the late '80s. The former was put into service in 1889, being temporarily supplied from the old cross town tunnel. It was then equipped with two 17.5 M.G.D. capacity Allis Chalmers triple expansion engines which are still operating. The latter was equipped in 1892 with three Allis Chalmers triple expansion engines similar to those at the Harrison Street Station. In 1898 a large 30 M.G.D. Lake Erie pumping engine was installed. All four of these engines are still in operation. Both of these stations will pass into history with the 22nd St. station, when the new Central Pumping station is built on the site of the Harrison St. station. With them will pass all but one — the Chicago Avenue station — of the water pumping stations of old Chicago.

The 68th Street and Lake View pumping stations were obtained by the city through annexations of the cities of Hyde Park and Lake View in 1889. Both have been considerably enlarged and improved in equipment in recent years. The 68th Street station supplied the World's Fair of 1893 with water. It is now served by the 68th Street and Edward F. Dunne cribs. At the present time it has four motor driven centrifugal pumps of 40 M.G.D. capacity each for normal operation, and two double acting horizontal compound pumping engines in reserve.

The Lake View station is supplied through the Wilson Avenue lake tunnel by two branch tunnels. One is the old Lake View tunnel, and the other a branch tunnel from the Wilson Avenue shore shaft in Clarendon Avenue. It is now equipped with four triple expansion engines of 25 M.G.D. each.

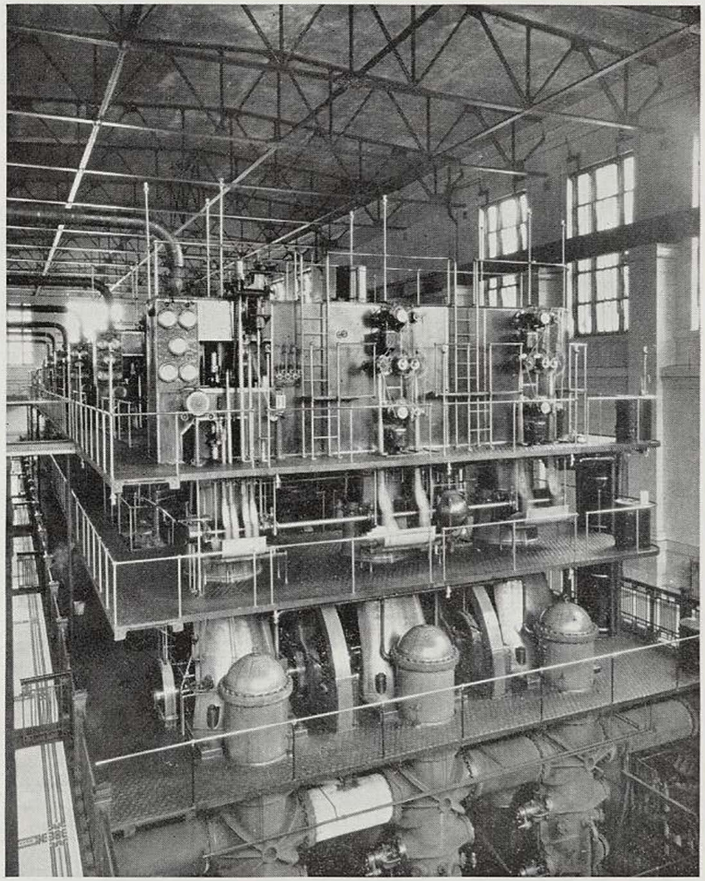


Figure 13—Triple Expansion Pumps—Mayfair pumping station

Figure 14—75 M.G.D. Turbine driven Centrifugal pumps—Western Avenue Station

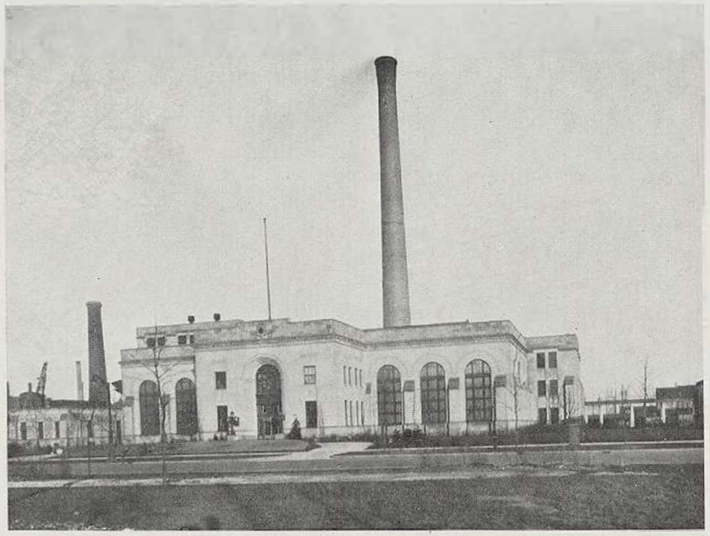


Figure 15—Western Avenue pumping station—Rated capacity 300 M. G. D.

On the West Side the Central Park and Springfield Avenue pumping stations were built as a part of the northwest land and northeast lake tunnel project, supplied from the Carter Harrison crib. Originally in 1900 and 1901 both were equipped with three Worthington vertical triple expansion engines of 20 M.G.D. capacity each. In 1922-26 these engines were removed and each station was equipped with three steam driven DeLaval centrifugal pumps of 60 M.G.D capacity.

The Roseland pumping station was built when the southwest land tunnel was put into operation in 1911. It serves the extreme south and southwest sections of Chicago. The pumping units are four vertical triple expansion single acting engines of 25 M.G.D. capacity each, and two 5 M.G.D. turbine driven centrifugal Worthington pumps for high pressure service, installed in 1914.

At the extreme northwest section of the city is the Mayfair pumping station, put into service with the Wilson Avenue tunnel system in 1918. It has four 25 M.G.D. Allis Chalmers vertical triple expansion engines and two high pressure pumping engines of the same type of 17.5 M.G.D. capacity each. (See Fig. 13.) In 1932 its capacity was supplemented by two turbine driven De Laval centrifugal pumps of 60 M.G.D. capacity each.

Chicago's largest pumping station is the Western Avenue station (See Fig. 15) put in service in August, 1927, when the Western Avenue extension of the Southwest land tunnel was completed. It is equipped with four steam turbine driven DeLaval centrifugal pumps of 75 M.G.D. capacity each. (See Fig. 14.) This station is also the largest municipally owned water pumping station in the world. It serves the central south and southwest sections of the city, including the Stock Yards and the Central Manufacturing District.

The twelfth and newest pumping station is the Thos. Jefferson station built in less than a year and put in service in 1928. It serves the central north side and is supplied from the Wilson Avenue tunnel system. Its pumping equipment consists of four motor driven Fairbanks-Morse centrifugal units of 40 M.G.D. capacity each.

Chicago's latest pumping station project for which a loan of over $2,327,000 was obtained from the Reconstruction Finance Corporation in 1932 is the new Central Pumping station, to be built on the site of the Harrison St. station. It will serve the Loop and south central portions of the city. Its equipment will consist of six 50 M.G.D. motor driven centrifugal pumps. It is expected to be ready for service in 1934.

THE DISTRIBUTION SYSTEM

FROM two miles of bored cedar log mains from 2 to 6 inches in diameter in 1840 to 3,712 miles of cast iron mains ranging from 4 inches to 54 inches in diameter (See Fig. 20) on January 1, 1933, is the story of the growth of Chicago's water distribution system during the span of the last 92 years. Such phenomenal advancement parallels the growth of Chicago itself, for in the former year the city's population was only 4,500 while in 1932 its water system served an estimated total population of over 3,980,000, of which over 3,600,000 were Chicagoans. (See Fig. 10.)

The first iron pipe in the distribution system was laid in Clark street in 1852 and it was 4 inches in diameter. A 24-inch main laid in La Salle street in 1854 and removed in 1932 was found to be in excellent condition. (See Fig. 19.)

The original municipally owned water works with its single pumping station and three 500,000 gallon wrought iron reservoirs on

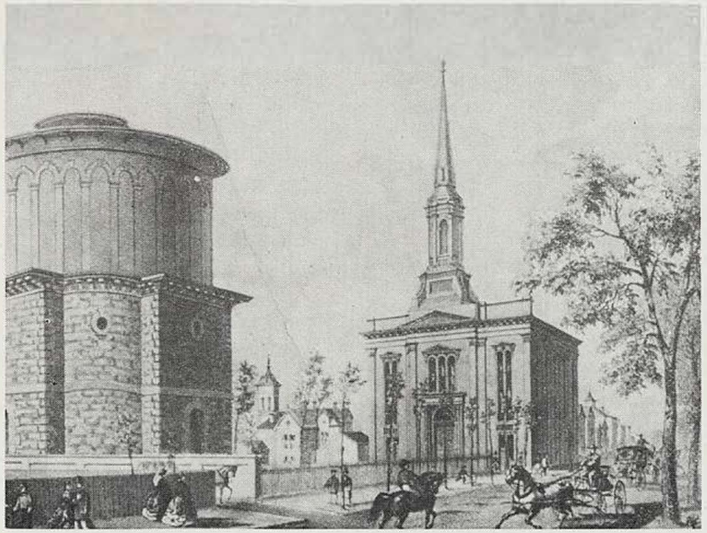


Figure 16—Old Reservoir at Monroe and Morgan Streets—1858

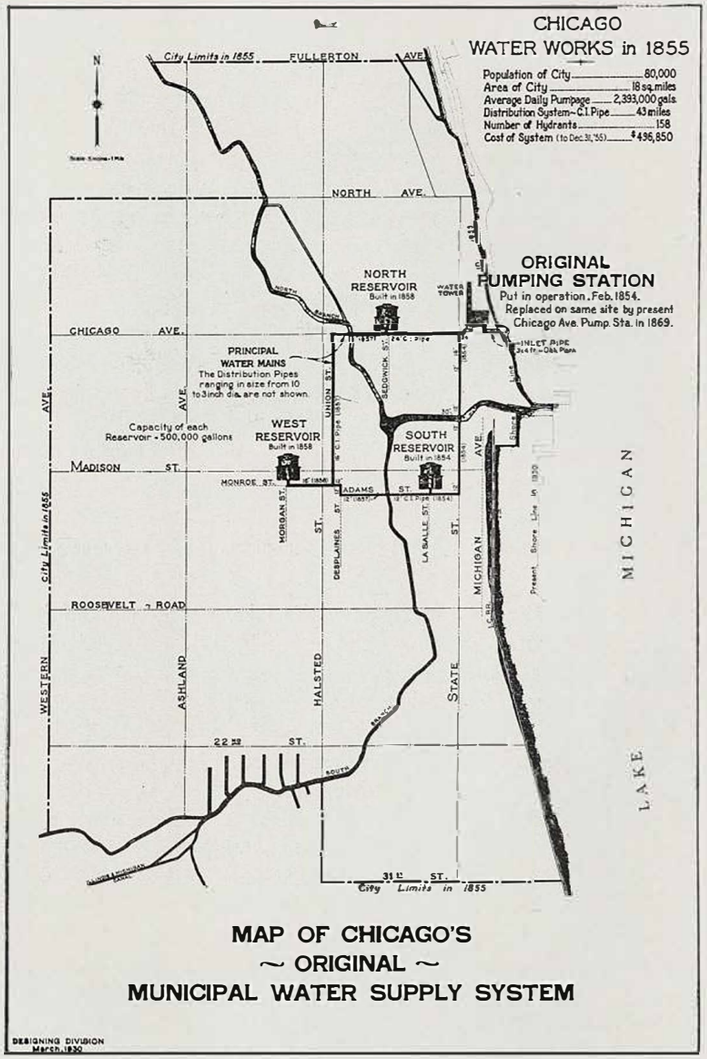


Figure 17—First Circuit Distribution System Chicago Water Works 1858

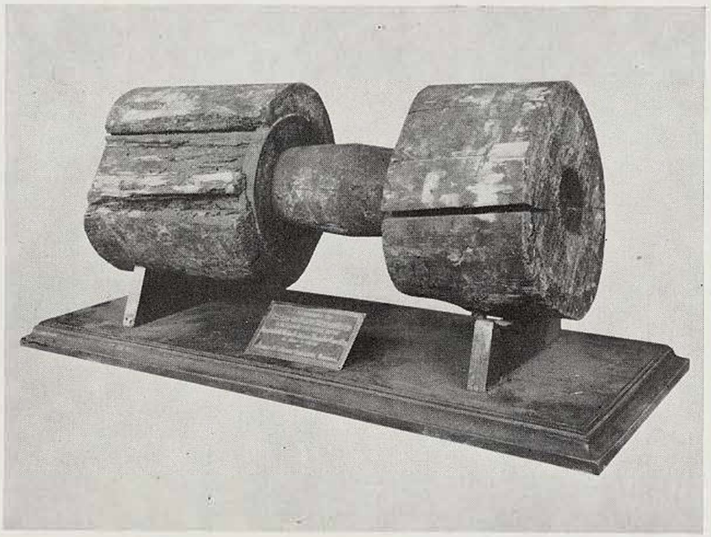


Figure 18—Wooden pipe used in Chicago's distribution system. Laid in 1840

masonry foundation 80 feet above the lake, was connected by a cast iron distribution system, as shown in (Fig. 17). Weak links in the system were the river crossings and serious damage was caused to pipe by anchors from boats in the river. Breaks from this cause led City Engineer Chesbrough to urge tunnels for river crossings prior to the Chicago fire. Today all river crossings, 28 in number, are made in special brick or concrete lined tunnels.

The Great Fire caused serious damage to the distribution system, as well as to the pumping station. It is estimated that over 15,000 lead service connections were melted during this conflagration. This, coupled with the loss of records, was a serious loss to the city and made location of underground leaks most difficult. The year before the Great Fire there were about 275 miles of mains in the streets with over 400 fire hydrants.

Through extensive annexations the city in 1889 added several large satellite water systems to its public properties. From then on it became necessary to develop, as rapidly as possible, a unified

water system for the entire city. Some idea of this problem may be gleaned from the fact that in one day — July 15th, 1889 — the city area increased from 37 sq. miles to 170 sq. miles, through annexations of the City of Lake View and the towns of Hyde Park, Lake and Jefferson.

The Division of Water Pipe Extension was organized for the purpose of developing a unified distribution system. It has done so as effectively as possible with the rapid development of the city, the construction of more and larger tunnels and additional pumping stations. Constant studies are being made of the water service in each pumping station district, and for future requirements, two and three decades in advance of present construction schedules.

A system of pressure control in the distribution system was inaugurated in 1915. Special attention is given to maintaining pressures conforming at least to the minimum standards of the National Board of Fire Underwriters. Fire flow tests are made regularly. Pitometer surveys to check leaks and to determine flow data are made con-

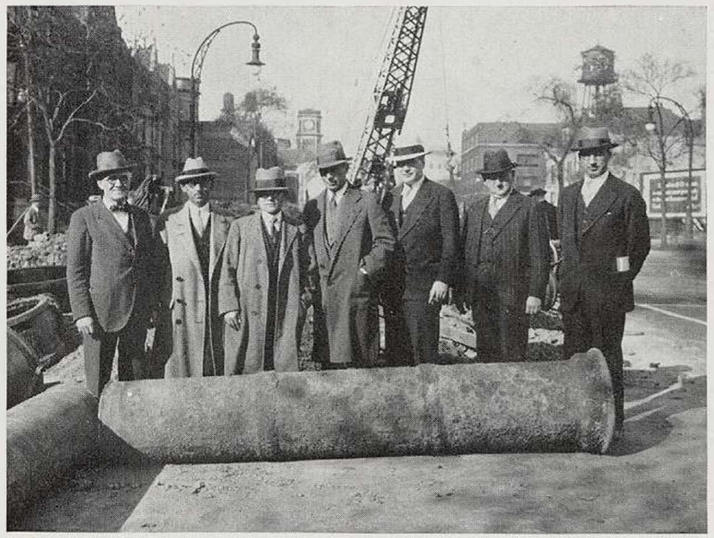


Figure 19—Section of 24-inch cast iron main laid in 1854 and removed in 1932

Figure 20—Laying large water main

tinuously. In recent years substantial reduction in underground leakage has been made by special leakage survey parties, followed by rehabilitation crews.

The use of meters in Chicago was started in 1860, when twelve were installed. At the time of the fire in 1871, 656 meters were in service, about one-half of which were injured by the fire. In 1900 there were 6,396 in use and on January 1, 1933, this had increased to 109,194. Chicago's policy has been to meter the large consumers first and at the present time practically all consumers whose annual bills exceed $25.00 are metered. There are approximately 310,000 domestic accounts which are unmetered.

Chicago used reservoirs in connection with its first municipally owned water works, one being installed in 1853 and two more in 1858. (See Fig. 16.) Because of rapid increase in consumption these reservoirs were of little value after the Chicago fire and were abandoned. The one at La Salle and Adams streets, where the Rookery Building now stands, served temporarily as a public library after the fire. The use of inland reservoirs to provide water service to meet peak demands is now being made the subject of special study by the Bureau of Engineering.

The suburban cities and villages supplied with water from the Chicago system number 34. Many have their own storage reservoirs which are filled at night. The total suburban population served by the Chicago system in 1932 was 381,416.

WATER AND PUBLIC HEALTH

CHICAGO'S brilliant accomplishments in sanitation are intimately associated with its water supply history. In the years prior to the World's Fair of 1893, Chicago was internationally advertised as a "typhoid fever city." Today it has one of the lowest typhoid fever rates of any of the large cities of the world. Extraordinary measures to dispose of its sewage and a strict supervision over the safety of its water supply are the major items responsible for this record.

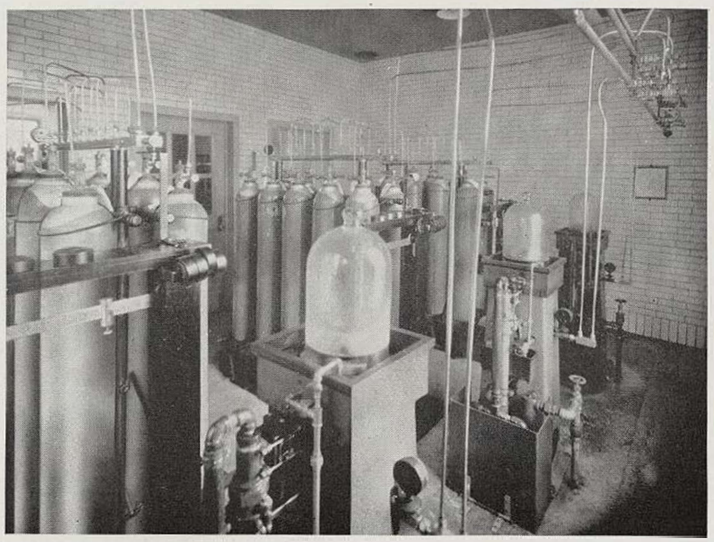


Figure 21—Chlorine booth—Mayfair pumping station

Cholera was epidemic among the soldiers stationed in Chicago during the Black Hawk War in 1832 and among the villagers. Both cholera and typhoid fever were very prevalent in this city in 1849, '50 and '52, attributed to pollution of the public water supply by sewage and of private wells due to general unsanitary conditions.

When the new municipally owned water works was put into operation in 1854, with its extended shore intake, the quality of the water improved. But it was not long before the pollution of the lake front by sewers and the outflow from the Chicago river caused gross pollution at this new intake. Typhoid fever and water borne dysentery increased very rapidly in the years just prior to the Civil War. Conditions were so serious, that in spite of this national emergency, Chicago decided to risk all in a new tunnel two miles out under the lake to obtain a clean water supply. The completion of this project brought marked relief, but as the city grew the disposal of sewage and industrial wastes into the lake and the river became so offensive that after nearly every heavy rain storm the gross pollution from the river drifted outward in the lake, frequently toward the new intake. Even the Four Mile intake was affected.

In 1872, the typhoid fever death rate increased to 142.6 per 100,000 population. In 1891, it reached its peak rate of 173.8. It was this outbreak which seriously affected publicity for the World's Fair. In fact, a special pipe line over 100 miles long was laid from a spring near Waukesha, Wisconsin, to the Fair Grounds to supply spring water to visitors at one cent per glass. The city water on the grounds was filtered in special Pasteur-Chamberlain filters and in some places heated or Pasteurized as a public health precaution.

In 1900, with the opening of the Drainage Canal by the Sanitary District of Chicago, the great change for a clean lake began. Then followed the installation of intercepting sewers on the South Side in 1906, and on the North Side in 1908. The North Shore Channel opened in 1910 and the Calumet Sag Channel, finished in 1922, with effective dredging of the river in 1928, are later projects which have restored Chicago's lake front almost to its original beauty and cleanlineess and removed serious pollution from the lake water along the city's lake front.

Chlorination of Chicago's water supply began on March 12, 1912, at the Dunne Crib intake on the South Side, using hypochlorite of

Figure 22—Experimental Filtration Plant

lime. It was then extended to the Hyde Park Crib, the water being treated only when off shore winds were blowing. Treatment was discontinued in winter because of freezing of the chlorine solution. Chlorination was then extended to the Lake View crib. In 1915, liquid chlorine was used in place of hypochlorite solution at the Lake View and Hyde Park Cribs.

The process in all instances was crude, but effective and made marked reductions from year to year in the water borne dysentery and typhoid fever rates. Liquid chlorine plants were installed at all pumping stations in 1915 and 1916.

Following a localized typhoid fever outbreak on the South Side in November and December, 1923, the city began in 1924 the installation of the present rigid system for chlorination control. Modern equipment and accessories — all in duplicate — were installed at each pumping station. (See Fig. 21.) Special chlorine attendants were employed to give full attention to operation of chlorine equipment and to make the necessary control tests for efficient operation. A regular system for analyzing the water and studying potential pollution hazards was perfected.

Today Chicago's chlorination control system is a standard which has been copied by many other large cities. The city is now planning for a special plant at the Dunne Crib to apply ammonia and chlorine to the water for increased bactericidal efficiency and to eliminate objectionable tastes which occasionally develop in the water due to pollution by industrial wastes from the Calumet region of Indiana. The results of this new control system are shown in the typhoid fever records. (See Fig. 23.) For the year 1932 there were only 102 cases and 14 deaths from typhoid fever in Chicago — a death rate of .40 per 100,000 population, as compared with 173.8 in 1891.

In 1926, on the recommendation of City Engineer John Ericson, Chicago started construction of a most complete Water Filtration Experimental Plant on the South Side. (See Fig. 22.) In the interim years, exhaustive research studies have been conducted on chemical treatment and filtration methods for purifying Lake Michigan water economically. From this plant have come some of the most outstanding contributions to the art of water purification in the last decade.

Based on research at this station, Chicago is now designing its first filtration plant along most efficient and economic lines. It is expected that the first filtration plant will be constructed to serve the South Side, being located along the lake front near the south end of Jackson Park.

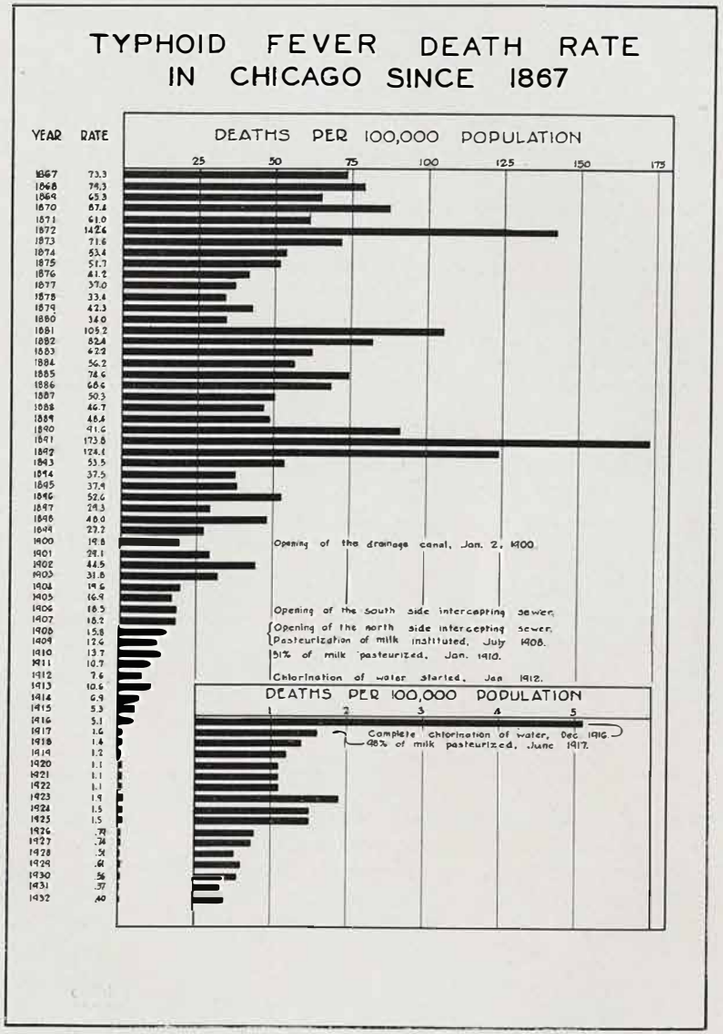


Figure 23—Typhoid Fever in Chicago 1867-1932

STATISTICS CHICAGO WATER WORKS

HISTORICAL

Chicago, incorporated as village	August 10, 1833
Chicago, incorporated as city	March 4, 1837
State charter to Chicago Hydraulic Co. for first public water supply	January 18, 1836
First public water service began	1842
City obtains permission from legislature to build water system	February 15, 1851
City supplied by own water works	February, 1854
First cast iron pipe in distribution system laid in Clark Street	1852
Work on first water tunnel under lake began	March 17, 1864
Water from first crib intake and tunnel delivered to city	March 25, 1867
New North pumping station (present Chicago Ave. Station) first pump put in service	July 20, 1867
Great Chicago fire destroys North Pumping Station and leaves City without water for eight days	October 8-9, 1871

GROWTH OF CHICAGO WATER WORKS 1854-1933

PUMPAGE

Year	Population using City water *	Average daily pumpage gallons	Average daily per capita consumption gallons	Rated Capacity of pumps million gallons
1854	65,000	591,000	9.1	8
1860	109,000	4,704,000	43.1	20
1870	307,000	21,766,000	70.9	35
1880	503,000	57,384,000	114.1	96
1890	1,107,000	152,372,000	137.6	229
1900	1,727,566	322,683,000	186.8	331
1910	2,214,286	518,579,000	234.2	635
1920	2,767,533	760,100,000	274.0	1,147
1930	3,439,512	1,019,875,000	297.0	1,831
1932	3,600,154	972,226,000	270.0	1,954

*From 1920, the population, average daily pumpage, and per capita consumption data given applies to Chicago only and does not include water pumped to outside communities.

DISTRIBUTION SYSTEM

Year	Miles of pipe	Number of Fire Hydrants	Number of Gate Valves	Number of Meters
1854	30	123		
1860	91	415		
1870	272	1,552	1,076	656
1880	455	3,361	3,105	2,113
1890	1,205	11,836	8,595	3,924
1900	18,872	19,108	14,862	6,396
1910	2,272	23,980	19,710	15,032
1920	2,941	31,759	27,232	29,921
1930	3,642	38,812	34,494	85,845
Dec. 31, 1932	3,712	39,519	35,420	109,194

STATISTICS CHICAGO WATER WORKS

WATER CONSUMPTION—1932

Population of Chicago	3,600,154
Population of outside communities supplied through Chicago Water Works System	381,416
Total population supplied	3,981,570
Pumpage City of Chicago, gallons	355,834,849,856
Water delivered through meters to communities outside of Chicago,—gallons	13,638,150,144
Total net pumpage of water system—gallons	369,473,000,000
Water passed through meters within city limits of Chicago—gallons	105,623,494,356
Percentage of water consumption metered—City	29.68
Average daily consumption in Chicago—gallons	972,226,000
Average daily per capita consumption, Chicago,—gallons	270

FINANCIAL—1932

Cost of Water Works System to date, Dec. 31, 1931	$130,303,548.64
Appraised value of Water Works System to date, Dec. 31, 1931	111,534,762.48
Revenue from unmetered water (assessed rates), Dec. 31, 1932	3,603,972.01
Revenue from metered water, Dec. 31, 1932	8,139,245.49
Percentage of Revenue from metered water	69.3
Metered water rate per 1000 cubic feet	$.60 less 15%
Net metered water rate per 1000 gallons	$.068

DISTRIBUTION SYSTEM—DECEMBER 31, 1932

Assessed services	310,029
Metered services in use	109,174
Metered services (meters temporarily removed)	2,776
Total services	421,979
Percentages of services metered	26.6
Kind of pipe used for services and sizes	Lead ¾ in. to 2 in. Cast Iron 3 in. to 16 in.
Miles of cast iron used in distribution system, miles	3712.2
Size of cast iron pipe—inches	4 to 54
Fire Hydrants	39,519
Gate Valves	35,420
Pressure Range in Mains—lbs. per square inches	25 to 65

INTAKE CRIBS

	Wilson Avenue	Carter H. Harrison	Two Mile	Four Mile	68th St.	Edw. F. Dunne	William E. Dever
Begun	1915	1897	1864	1889	1892	1907	1927
Put in service	1918	1900	1867	1892	1894	1911	—
Distance from Shore, ft.	11,000	13,830	9,340	16,600	10,525	10,525	13,800
Elevation of lake bed, ft. below City datum	—33.5	—33.8	—29.0	—38.0	—32.0	—32.0	—34.0
Number of Intake Ports	7	6	4 3 gates outside shaft	4	4	8	8
Elevation of Top of Ports, feet below City datum	—22.5	—22.6	N. Port—14.0 N. W. Port—14.0 W. Port—1.5 E. Port—2.0 3 gates—4.0 abt.	—29.0	—16.0	—18.5	No. 1 Port —24.5 No. 5 Port —27.5
Total effective area of Ports—sq. feet	463.9	178.7	124.0	100.0	77.0	392.0	530.2
Capacity of Crib at port velocity one foot per second million gallons per day	300	115	80	65	50	253	342

STATISTICS CHICAGO WATER WORKS

TUNNELS

Name of Tunnel in Service	Year Put in Service	Length Miles	Diameter Ft.	Lining	Supply Crib	Pumping Stations Served
Wilson Ave. and connections	1918	8.62	13, 12, 8	Concrete	Wilson Ave.	Mayfair, Jefferson, Lake View
Lake View	1896	2.03	6	Brick		Lake View
North East Lake	1898	2.66	10	Brick	C. H. Harrison	Springfield
North West Land	1900	9.60	10, 8	Brick	C. H. Harrison	Cent. Park
Chicago Ave. 5 Ft.	1867	2.01	5	Brick	Two Mile	Chicago Ave.
Chicago Ave. 7 Ft.	1875	2.05	7	Brick	Two Mile	22nd Street
Chicago Ave. 7 Ft.	1895	2.01	7	Brick	Two Mile	Chicago Ave.
Chicago Ave. Misc.		.29	7, 6, 5	Brick	Two Mile	Chicago Ave.
Blue Island Ave.	1908	5.60	8	Concrete	Two Mile	22nd Street
Four Mile Lake	1892	6.64	8, 6	Brick	Four Mile	14th Street
14th St. connec.	1889	.50	8, 6	Brick	Four Mile	Harrison St.
New Polk Street	1907	1.71	7, 6	Concrete	Four Mile	
Blue Island-Polk St. cross connection	1932	.24	7	Concrete	Two Mile, Four Mile	
68th Street	1898	2.40	7	Brick	68th St.	68th St.
South West Lake & Land and connec.	1911	10.72	14, 12, 9, 8	Concrete	Dunne	68th Street
Western Ave.	1927	6.06	12, 10	Concrete	Dunne	Roseland, Western Ave.

Miles of Tunnels in service	63.04
Miles of Tunnels abandoned	8.56
Miles of Tunnel under construction	11.43
Miles of Brick lined tunnel in service	30.19
Miles of concrete lined tunnel in service	32.85
Number of tunnel shafts in service	77
Number of tunnel shafts under construction	5

PUMPING STATIONS

Station	In Service	Capacity—M.G.D. Original	Capacity—M.G.D. 1933	No. Pumps	Type Engine	Type Pump	Capacity Each M.G.D.
Chicago Ave.	1854	8	210	4	Motor	Centrifugal	40
				2	Triple Exp.	Single Act.	25
22nd Street	1876	30	128	4	Motor	Centrifugal	32
Lake View	†1889	19.5	100	4	Triple Exp.	Single Act.	25
68th Street	†1889	41	174	2	Motor	Centrifugal	30
				2	Motor	Centrifugal	40
				1	Compound	Double Act.	14
				1	Compound	Double Act.	20
Harrison Street	1890	36	60	2	Triple Exp.	Single Act.	17.5
				1	Turbine	Centrifugal	25
14th Street	1891	54	107.5	3	Triple Exp.	Single Act.	17.5
				1	Triple Exp.	Single Act.	30
				1	Turbine	Centrifugal	25
Central Park	1900	60	*180	3	Turbine	Centrifugal	60
Springfield	1901	60	*180	3	Turbine	Centrifugal	60
Roseland	1911	50	100	4	Triple Exp.	Single Act.	25
				2	Turbine	Centrifugal	10
Mayfair	1918	110	*255	4	Triple Exp.	Single Act.	25
				2	Triple Exp.	Single Act.	17.5
				2	Turbine	Centrifugal	60
Western Ave.	1927	300	*300	4	Turbine	Centrifugal	75
Jefferson	1928	160	*160	4	Motor	Centrifugal	40

*Capacity of station limited by tunnel capacity.
†Annexed to Chicago.

STATISTICS CHICAGO WATER WORKS

QUALITY OF WATER SUPPLY

Average B. coli per 100 c. c. (confirmed) chlorinated water at pumping stations (1932)	0.105
Average Bacteria per c. c. 37° C. 24 hrs. chlorinated water at pumping stations (1932)	1.8

Turbidity—parts per million:

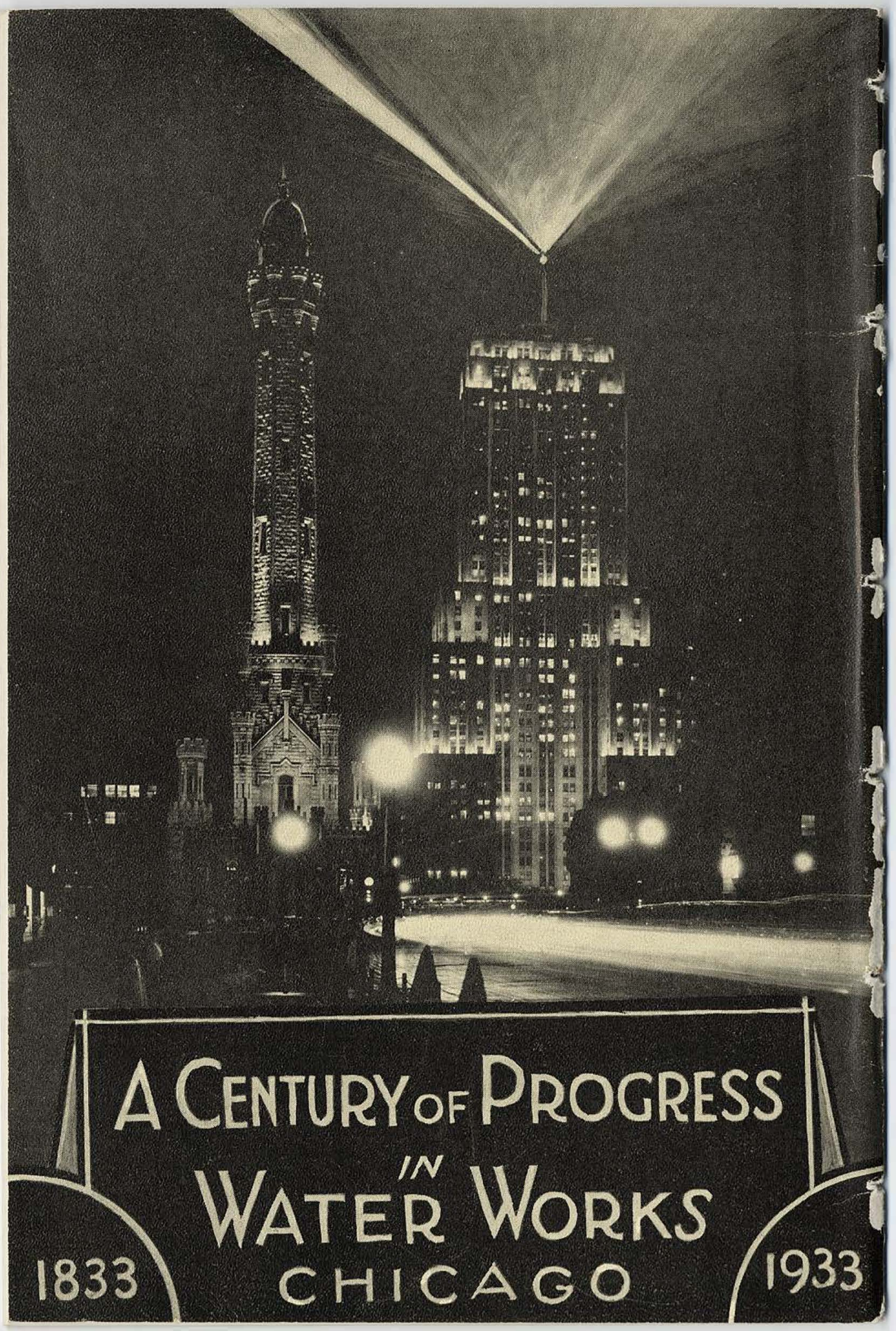
Year	Average	Highest Monthly Average	Highest Daily Average
1932	8.7	17.1	42.0
1931	9.9	42.4	118.7
1930	16.9	79.7	151.9
1929	16.4	63.8	192.1
1928	9.0	31.7	53.7
1927	11.5	20.4	43.4
1926	15.6	41.3	139.0
1925	8.6	13.8	27.1
1924	9.7	28.6	60.0

Average Hardness (calculated as calciumcarbonate) p. p. m.	130
Average Hydrogen Ion Concentration	8.0
Average temperature of water at Two Mile Crib degrees F. (1932)	48.3
Maximum Temperature—degrees F. (1932)	72.0
Minimum temperature—degrees F. (1932)	32.0

CHLORINATION—1932

Average chlorine dosage applied at stations—lbs. per M. G.	4.41
Maximum chlorine dosage—lbs. per M. G.	10.0
Minimum chlorine dosage—lbs. per M. G.	3.0
Total pounds of chlorine used	1,627,544
Approximate cost of chlorination (chlorine, supervision and laboratory)	$240,000.00
Approximate cost of chlorination per million gallons treated	$ .65
Approximate cost of chlorination per capita	$ .067


RINGLEY
83


A CENTURY OF PROGRESS
IN
WATER WORKS
CHICAGO
1833
1933