[The following article appeared in the New York Times, November 30, 1902. It has been largely quoted from and reprinted. Certain omitted portions, which the Times had not space for, appearing later in magazines and other newspapers. At the request of a number of citizens the full text is here given in correct sequence.]

Concerning
The Water Supply of New York.

BY BENJAMIN S. CHURCH.

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"An editorial in your columns of October 11 on the city's water supply so impressed me that I am prompted to supplement it by recounting a few personal experiences illustrating the soundness of your views. For over a quarter of a century I was engineer in charge of the direct handling of the supply of water and its general distribution. During that period the city passed through a memorable series of years of water stringency and danger to life and property which should be a warning to be heeded at the present time, and in order to give better realization of the intimate relationship of the past to the present and future requirements of this community, what there is to say had best be put in the form of a narrative of events as they occurred.

First, let me accentuate the evil effects of procrastination, which in our democratic community seems always to paralyze official action in preparing for an increase of water supply in time to prevent emergencies. This is due mainly to apathy and misconception on the part of the public, reflected in the press, which has heretofore developed into active opposition to every measure of the kind involving expenditure of the public money.

When first connected with the water supply as engineer in charge in 1859, the city was using less than half the computed carrying power of the old Croton Aqueduct. Its size was 7½ x 8 feet. A wise precautionary law required that once a year

the forty miles of masonry aqueduct should be emptied for inspection and interior repairs made over its entire length, by the engineer in charge. The date of each crack and its repair was marked in chalk on the masonry above the flow line. In 1859 this line was less than half way up the side of the walls, which chronicled its changing conditions. Within a few years with acceleration far beyond expectation, the depth of flow increased, indicating the city's demands. The chalk records were soon obliterated and had to be transferred to note book entries. Here was an impressive demonstration of the steadily increasing consumption of the city which mere tabulated annual report records failed to force upon the minds of the city authorities, although they had had the situation fully explained, and were constantly warning the citizens against careless waste and leaking plumbing.

The Central Park Reservoir contained storage for maintaining the supply while the aqueduct was shut off for inspection and yearly repairs, as well as for the purpose of equalizing uneven daily and hourly demands.

It took 35 hours to empty the aqueduct and seventeen hours for water to reach the city when again let in at Croton Dam, requiring over two days to empty and refill. To this must be added the time needed for executing the interior repairs, making an aggregation of about four or five days, during which the city drew its supply entirely from the Central Park Reservoirs.

Before the city consumption became so great, these reservoirs would bridge over the interim of time enabling repairs to be made when needed. But for many years prior to the building of the New Aqueduct, leakages were constantly occurring from the cracking of the old conduit, where it crossed the hundred depressed points on embankments. These required the water to be shut off for interior repairs, which, if not attended to, threatened to wash away the embankment and a piece of the aqueduct with it. If this were allowed to occur, the city would be totally deprived of water, as rebuilding embankments and reconstructing the masonry of such a rupture would have taken weeks, and the storage reservoirs contained only a few days supply.

About this time the fire protection of Washington Heights became a pressing necessity, as no water mains from the Croton had yet been laid, and the locality was rapidly building up. I therefore caused fire hydrants to be dropped down into the aqueduct itself, which ran under 152d street and Tenth avenue. In making a test

of these hydrants it was found that the local fire engine did not possess suction power enough to raise the water up from the Aqueduct, a lift of only eight feet. Application was made to the Fire Commissioner to send up some of the best engines (this was prior to the introduction of the steam fire engines), and it was discovered that not a hand engine in the city was in condition to draw water by suction. All were dependent on the Croton pressure to feed the pumps, and if that pressure were withdrawn by any accident the Fire Department would have been wholly powerless.

When the year 1869 arrived the people were using the full legitimate carrying power of its one aqueduct in which water flowed at a depth of six feet eight inches. For several years prior to 1869 the consumption had been so great that every time the aqueduct was shut off for repairs there was serious risk that the city reservoirs would be exhausted before the water, when let in, at Croton Dam, could reach the city. As a consequence, such repairs were only made in cases of extreme necessity.

At this juncture, I chanced, when passing by the laundry, at my country house, to see a maid throw a platefull of bran into one of the square wooden washtubs, and found that her object was to stop a leak. I had just received notice of a serious leak on an embankment of the aqueduct near Tarrytown, that necessitated shutting off the water for repairs. Taking the hint from the maid's treatment of a tub, I ordered a load of bran carried to an opening in the conduit some distance above the leaking embankment. The bran was mixed in a mortar box, reduced to a paste, and then dumped into the aqueduct, a man being stationed to watch the effect.

The result was a gratifying surprise. When the bran reached the point, the flow from the leak steadily diminished and finally stopped altogether. For the years that followed, this dosing the aqueduct in the same manner, was the only resource for maintaining the city's regular supply, and the water was shut off only when danger of actual breaks in the masonry menaced, and there was no other alternative. It is amazing to think of a city of nearly one million of people solely dependent on one aqueduct when in such a condition, and held to a degree of regular delivery by so crude and expedient. Yet all efforts to check waste or secure legislation for an additional supply were unheeded. In fact, every official announcement of the actual conditions was regarded as sensational, and denounced as a "put up job" for squandering the city's money. But in extenuation of such unreasoning obduracy, it must be under-

stood that as yet as yet the people had not been inconvenienced because the Supply had been, so far, maintained through unremitting vigilance and an anxious watchfulness known and appreciated only by those whose labors stood between the city and disaster. Another menace added to the gravity of the conditions at the time. The conduit had cracked longitudinally, varying in length from one to two hundred feet, and in some of the worst banks it was found that the roof arch was spreading and in danger of falling in. Should this occur at Tarrytown, where the situation was most critical, a falling in of such description would result in daming back the water, which would react and carry away many weak embankments above, thus causing an appalling disaster.

In the spring of 1870 the old Croton Aqueduct Department came to an end. It was the most efficient executive board that ever existed in New York. William M. Tweed, familiarly remembered as "Boss Tweed," was all powerful at that time. He had carried through the legislative enactment and obtained control of city expenditures by creating a Board of Public Works and making himself commissioner. As Engineer-in-Charge of the water maintenance, I was called upon, with other city employees, to receive the ultimatum of the political rule of the cabal he represented. Alone in his office, he interviewed one after another of the awaiting officials, who, obedient to the summons, appeared before him for dismissal or reappointment. When my turn came, I confronted him with considerable interest and curiosity. He was executive, evidently astute, and went straight to the point. After giving my name and position, he asked, "How many men have you under you?" On my reply, he said, "Well, Mr. Church, several people have spoken to me about your work. I will tell you what I propose to do. - I am going to discharge all your men and appoint others. What have you to say about it?" I answered, "I do not suppose I have any voice in the matter." He said, "That is not it. Tell me what the practical objections are?" I replied "That the Croton Aqueduct was overstrained and in so dangerous a condition that it was being patrolled twice a day. That the entire force under me consisted of trained men, and that if they were replaced by inexperienced ones we would have a disaster that would totally deprive the city of water." After a brief pause, he exclaimed: "That is just what I wanted to know. Now, I will tell you what I will do. Here is your reappointment. You can keep every man and have your own way in your department, and if anyone meddles with you, let me know, and I will stop it. But you must *keep the water going*, for if

anything happens to the water supply, it would spoil all my plans." Tweed was clever enough to realize this, and much to my surprise, he kept his word. My department had never been placed under contract, owing to the critical nature of its maintenance. All was carried on by day's work, which, together with its supplies and materials, were under my personal control. He brooked no interference with the routine I had previously followed, and I paid no attention to the blustering ring politicians who frequently

threatened when I refused to do their bidding or find places for their men. Evidently Tweed took no one into his counsel in the matter, for after a while they became imbued with the idea that I had a "political pull" with the Boss, who I never saw again. Subsequently after the Ring was upset by the splendid exhibit of its rascality brought out by the New York *Times*, the searchlight that penetrated every corner of the city government failed to detect aught amiss in this one instance. This self interest had acted as a fortunate curb on rapacity that would have made it impassable for any honest engineer to have remained in charge of the water supply.

Again and again efforts to secure relief failed, and several years passed, adding to the number of leaks and spreading roof arches

The Commissioner of Public Works was at this time defeated in securing appropriations to make these points safe, which could be accomplished from the outside without interfering with interior flowage. Dismayed by the conditions and in a state of desperation I resolved to make a personal appeal to John B. Jarvis, the original constructor and former Chief Engineer, who at an advanced age was still living. I therefore wrote, explaining the situation and urging him to add his voice, and that if he desired to save his great work he must come to New York at once.

Mr. Jarvis promptly responded, and the Commissioner, Allan Campbell, requested that I bring my notes and diagrams to his office to show the condition of the aqueduct to Mr. Jarvis, who would be there. The venerable engineer was dismayed at the situation, and excitedly exclaimed: "Why has this been permitted?" The Commissioner rejoined that his most earnest demands upon the Aldermen for appropriations for adequate repairs had been of no avail. Mr. Jarvis, who was pacing the room in his excitement, exclaimed: "Mr. Commissioner, in your position I could neither eat nor sleep! When do the Aldermen meet, for I will make them vote all the funds needed without a moment's delay." This he accom-

plished that very afternoon, and the following week I began the outside reinforcements of the most dangerous points of the conduit.

Thanks to the timely intervention of Mr. Jarvis, the city was rescued from inevitable and dire disaster. Although these special outside repairs greatly modified the dangers, it did not eradicate them. Only by constantly dosing the aqueduct with bran and sawdust could constant water supply be maintained.

Before the winter of 1878 the aqueduct, where it had settled, was running full to the very top, producing a strain it was never designed to bear and increasing its leakage and the danger of rupture. During the fall the city began to draw from the city reservoirs faster than the Aqueduct, now strained to its maximum limit, could deliver into them. This developed still another serious situation, for if the reservoirs became depleted or exhausted, they could not be replenished. In case of conflagration or a break in the aqueduct there would be no city storage to meet such emergencies. The public constantly forewarned that this contingency was rapidly approaching, manifested little interest, and even the Commissioner seemed taken by surprise, although I strongly urged lowering the reservoir gates and restricting the amount furnished the city. I was summoned to his house, where the following conversation took place: In a tone of apprehension, he said: "What is to be done? I am informed by the Corporation Attorney and other advisers that I have no legal right to restrict the citizens' use of water by lowering the reservoir pipe gates as you have advised, and how else can we maintain the city reservoir margin of safety for emergencies that are constantly occurring? I want your views on the situation and sent for you to come here to my house, where we can consider the matter freely without interruption." My reply was, "Mr. Commissioner, were you the captain of a ship whose voyage had been so prolonged that provisions had run short, you would not hesitate to restrict rations below what the law required, until you could reach the nearest port. The city is now in like position. Consider what will happen if no effort is made to control consumption. The city can only consume from the city reservoirs what is being delivered into them, until that storage is exhausted, after which the consumption will of necessity be reduced to the carrying power of the aqueduct, and it will be accompanied with entire loss of city storage. Therefore, conditions will force that restriction whether or no. But as this storage must be maintained, the case is one that knows no law, and forcible restriction of consumption must be

made without further delay, in protection of life and property. The reservoirs are daily being drawn down and must be refilled." The Commissioner's consent having been obtained, that course was pursued and respite gained for the city.

Up to this time the gates of the six 36-inch and 48-inch mains from the reservoirs had remained fully open. Now they were gradually lowered to restrict increasing demands from month to month, until finally the city was drawing the full flowage power of the aqueduct through these gates when they each were opened but about three and half to four inches.

Of course the pressure in the street pipes diminished proportionately and at elevated points in the city, the water could not rise above the second floor, while in the City Hall neighborhood and lower parts of the city it did not rise but seven feet above the sidewalk.

The patience of the citizens in submitting to these conditions was only equalled by the indifference they had previously displayed to warnings that such would be the result if preventable waste was allowed to go on. All that time two-thirds of the city's daily supply was being wasted, and but one-third actually utilized. The house tanks and pumps put in at private expense to supply upper stories during that period would have paid for meter appliances that would have put this great waste into use and have maintained adequate pressure throughout the city with hygienic conditions and comfort. It may not be amiss in this connection to give some details of what occurred. In 1878-9 or thereabouts, I had succeeded in interesting the Commissioner of Public Works in the matter of waste, hoping that he might arouse the community to a realization of these necessities. After investigating the methods of various cities in this country and Europe, and finding the most successful one in vogue, the Deacon system, used in Liverpool and elsewhere, was inapplicable to New York, I devised a simple appliance for detecting undue flow of water into private houses where it had been proved by investigation the greatest waste took place. A stop cock of special design was inserted near the curbstone in the water pipe entering the house. By applying a pressure gauge key between midnight and three o'clock in the morning the running water could be detected and located, and the occupant made to rectify the leaking plumbing. Strenuous objections had been urged against house meters, and they had been prohibited by law, but here occurred an opportunity to convert reckless abuse of water privileges into legitimate use

that might secure a margin of safety for bridging over the intermediate time before a fresh supply could be obtained. I offered the device gratis to the city, free of all personal remuneration. The Commissioner of Public Works ordered the test experiments made on a block of houses in 49th street, between Fifth and Madison avenues. The number of people occupying these houses was ascertained, and the first three nights' inspection between one and three o'clock a. m. revealed that the water was running at the rate of 140 gallons per capita, and the cause proved to be imperfect ball cocks in the closets, also leaking faucets. These were all rectified and another night test showed a reduction of 100 gallons per capita. Moreover the improved pressure in each dwelling resulted in winning over the occupants and their urging the application of the system throughout the entire city. This saving was accomplished within a week.

It would have cost about $300,000 to have such use made of this device as would have nearly doubled the supply that originally cost over thirty millions. The loss of pressure would have been reestablished, and the city relieved. An effort was made by the Commissioner to secure an appropriation for this purpose, but the bill was defeated in the Legislature because of the outcry against it, when it was made public. The dearth of water, however, had its effect ere long in demonstrating to the people and the authorities the need of additional supply, which eventuated in another turn of the wheel in the city water affairs in 1882.

As far back as 1868-9 I had developed a project for trebling the supply of the Croton River by utilizing the flood waters that annually escaped into the Hudson. The plan was shown to several prominent citizens who were my personal friends. Among them were John Jay, Gouverneur Morris, Sr., William B. Ogden, and Theodore Roosevelt, father of the President. I was desirous of obtaining their co-operation in bringing forward these plans for an increased water supply. Although they approved the designs, their opinion was unanimous in deciding that the outlay involved was prohibitive at the time, and that it would be difficult to carry it through. They advised me not to propose it until the demands of the city were forced upon the public. * * *

In 1882, the date referred to, when I held the position of consulting and resident engineer in the Department of Public Works, E. S. Chesborough, Chief Engineer Isaac Newton and myself were called upon by Commissioner of Public Works H. O. Thompson

to prepare plans for increased water supply. My project for utilizing the flood waters of the Croton River by means of an ample storage made available by a high dam near its mouth, to be supplemented by other smaller storage dams higher up the watershed, was then brought forward. After this general plan had been approved by the Commissioner, it was examined by eminent engineers, among whom were E. S. Chesborough, James B. Francis, whose experimental work in hydraulics had won him world-wide reputation; John B. Jarvis, who constructed the old Croton aqueduct; Gen. George S. Greene, former Chief Engineer, who constructed the large reservoirs in Central Park; Julius W. Adams, Chief Engineer of the Brooklyn Works, and Robert K. Martin, who built the Baltimore Water-Works. These men indorsed the plans for the tunneled aqueduct and large storage reservoir to be formed by the dam at Quaker Bridge, which was the pivot on which the entire design rested. The Mayor's commission likewise approved, and the matter was brought before the Legislature. The bill passed both houses, but owing to the unintelligent opposition of certain citizens, Gov. Cornell was influenced to give it his veto. The next year it passed both branches of the Legislature again. Then followed an incident illustrating the misguided zeal of self-appointed guardians of the City Treasury.

It was confidently believed that Gov. Cleveland would make the bill a law by his signature. But on the last day allowed by law for approving bills passed that session he notified the Commissioner that, owing to opposition and the appeals of citizens, he did not feel justified in signing the act for increasing the water supply of New York. The Commissioner sent for ex-Mayor Cooper, Mr. Andrew H. Green, and Judge Spencer, who were in conclave when I happened in on department business and heard of the Governor's attitude. Mr. Green turned to the Commissioner and said: "Here is Mr. Church, who has personally wrestled with the difficulties of the city's water supply. Let us send him to make a final appeal to the Governor to-night." The Mayor and others furnished me with a number of letters, in order to pass the guards stationed at the Capitol at Albany on that day, and I started on the 7.30 train. The letters passed me through the outer guards, and I reached the door of the Executive Chamber with but two remaining. The attendant took me to Col. Lamont, the Governor's private secretary. He said with emphasis: "No one can see the Governor to-night." I handed him my last letter with the request that he give it to the Governor,

to whom it was addressed. "I will take it to him," was the reply, "but he will not see you or any one on the last night for signing bills." Nevertheless, the Governor followed him out, and said to me: "You are just the one I wanted to see," and he led me into his private room. I said, "Gov. Cleveland, I know how important time is to you to-night. I was sent to you, without an hour's warning, but to economize time I have jotted down on the train some of the important points, which I will read with your permission." When I had finished he took my memorandum and began to consider each statement. I was put under a hot fire of cross-examination, wherein he evinced an astonishing grasp of what must have been an unfamiliar subject to him. The interview lasted but a few minutes, and when ended the Governor said: "Go back to those who sent you and tell them that I will not be responsible for keeping a million people out of water, and will therefore sign the enabling act for an additional supply." The next morning the papers contained Gov. Cleveland's reasons for its approval, in which he embodied the memorandum I had given him, thereby justly fixing the responsibility where it belonged—on the professional advocates of the bill. It is to Mr. Cleveland's courage and independent action that the city is indebted for avoiding further postponement of a measure that had already been dangerously delayed.

There was one clause in the enabling act which, although intended as a safeguard, proved exceedingly detrimental to the city's interest. It required that all plans should be submitted to public hearings before being adopted by the Commission. It amounted practically to holding town meetings on technical engineering matters, with the anomalous spectacle in an intelligent community of supposing that an aggregation of ignorance could produce wisdom and the result was what might have been expected. Representative citizens and taxpayers took no interest in the hearings, outside of a few who had personal interests to urge which were at variance with the city's imperative demands. The mass of attendants were those who came to air their vagaries and be quoted in the press. The Commissioners were business men, and however intelligent and desirous of acting wisely, the discussions at the public hearings confused and unsettled them. They failed to discriminate, as Gov. Cleveland had done, between the value of an opinion of professional men of high standing on a complicated scientific problem, and the ignorant assertions of plausible talkers. The consequence of such opportunity being afforded for prejudice and unreason to make

themselves felt proved distinctly a misfortune and a monetary loss to the city. The incompetent opposition made possible by the "public hearings" clause delayed the adoption of the plans for the construction of the Quaker Bridge dam, and the true order of building was thereby reversed. The new aqueduct was of course begun first. The small reservoirs in the upper watershed, which had been designed to supplement the storage secured by the great lake according to future requirements, were also built. Had the main dam been under way, interest on the money expended on the small reservoirs could have been saved for many years, as they would not have been needed. Owing also to the demoralization directly attributable to the public hearings, the purchase of lands for the Jerome Park Reservoir was postponed until their increased value largely added to its cost and delayed its construction. Another misfortune for the city occasioned by the delays resulting from that one mischievous clause was the change in the site of the great dam from near the mouth of the Croton River to a point a mile and half above. For a year previous to the final passage of the enabling act investigations had been made with the diamond drill in the Croton Valley of all available sites. Some $30,000 was spent in gaining a knowledge of the best rock foundation on which such weighty superstructures as a solid masonry dam 277 feet high should rest. The borings and the records were laid before the conclave of engineers whose names, already given, stood foremost in the country for expert knowledge and experience. They decided on the location at Quaker Bridge as being altogether preferable to any other. The site of the present Cornell dam was discarded as the least desirable of any available spot examined, because of the treacherous limestone found in the borings. Besides, the location of the Quaker Bridge dam being near the mouth of the river, gave a mile and a half additional storage. It possessed the natural advantages of being the narrowest part of the valley, with precipitous rock banks rising above the height of the proposed dam. This gneiss rock extended across to the opposite shore and down vertically 100 feet under the river bed. It was the natural and ideal site for so high a dam, designed to be of solid masonry welded to a solid rock foundation. The plans were nevertheless altered, and the Cornell dam, higher and longer by several hundred feet, and built partly of earth instead of on rock, was decided upon. Wise precaution in strengthening this dam have called for an additional appropriation of some $500,000 from the city, a matter upon which the press has recently com-

mented. The mile and a half of additional storage is forever lost to the city, an aqueduct commission still sits, and the great dam is still uncompleted after a lapse of sixteen years.

This brief summary shows how important it is that the law should be so framed that the plans of a great public work, on which the highest expert intelligence has set its seal, should not be tampered with or altered after the work has been begun. No large undertaking which involves special scientific preparation should be entered into without being pronounced upon by a consensus of the highest professional authority, and such authority should be final. No opening should be left to political interferences and professional jealousies, to which the municipalities of this country offer so free a field.

Another matter in relation to the new aqueduct construction became such a handicap that it finally led to serious consequences. I refer to the demands of the civil service law, which, however advisable in its aims, miscarried most unfortunately in regard to aqueduct masonry inspection. Special rules should have been made to fit the needs of the new aqueduct, because of its exceptional character, magnitude, and necessity for speedy execution. Anticipating this the Commissioners sought relief from its restrictions by carrying a test case to the highest court, which ruled that the commission must conform to civil service regulations. It was not that such regulations could not be adjusted to such work, but they were unprepared for it. The work was begun and pushed ahead night and day over a length of thirty miles, divided into eight divisions, all under ground, amid the smoke of explosives, dripping water, the rock debris being sent to the surface, while the masonry lining followed upon the excavation. Average men under such trying conditions require extra watching to prevent reckless, irresponsible work. There was immediate and crying need for competent inspectors to be stationed at short intervals, to insure carrying out the terms of the contract, but it was absolutely impossible to obtain from the civil service the right men for such work, nor did we succeed in providing enough men to cover it. Frequently one inspector was obliged to do the work of three in overlooking several gangs of workmen separated by a distance of from 400 to 600 feet. In the darkness or imperfect light, amid always trying conditions, it was a natural consequence that men slighted their work. The local Civil Service Board was overloaded with other departments of the city to be provided for, and the city appropriations did not per-

mit of a special force to effectually provide for the needs of the new aqueduct, which differed widely from the other routine department requirements. Daily examinations, together with the labor of rating, could scarcely have kept pace with the immediate demands of the tunnel work. But the other departments had to be taken in turn, and thus the supply of competent inspectors was crippled from the start. The law worked disastrously in this respect, making eligible for such positions only those who passed the examinations. Incompetent men passed with high ratings because the list of written questions were carried off by the applicants, and although they were frequently changed, very shortly the fund of questions bearing on masonry were exhausted, and the subject matter of examination could be easily prepared for and recited like a lesson with a moderate amount of coaching. In this way a small grocer's clerk, or a person accustomed to the use of the pen, could learn their lesson, and feel secure of high rating. The best inspectors came from an illiterate class of skilled mechanics, who stood small chance against such school-craft competitors. For this reason the most competent inspectors either failed or received a low rating. To add to the embarrassment of the work in this department, it frequently became necessary to discharge for incompetency many who had a high rating from the Civil Service Board. Before their places could be filled the aqueduct work was constantly depleted of even the continuously scant supply. This insufficiency of inspecting force was a constant source of anxiety to both engineers and Commissioners. The hands of the staff of division engineers immediately in charge were literally tied in this manifest inability to have the contractor's men watched.

Anticipating what was sure to follow, I decided to apply a method I had used for years in the old aqueduct for the discovering of any deterioration of the masonry. This was done by soundings with a hammer which in seasoned masonry of long standing had proved an efficient means of detection. When applied to the newly finished masonry, even when only a few days old, it worked successfully. The scale of sounds differed somewhat, but were soon understood, and the system was established of discovering all defective work, which compelled the contractors to make it good at their own cost.

This was the situation weeks before the Fassett Committee was appointed.

In considering the present status of the water question it is nec-

essary to revert to the conditions that attained during critical periods before the additional supply existed—viz.: For a few years prior to the construction of the great reservoirs in Central Park, the then existing city reservoirs stored so small a quantity of water in relation to daily demands, that whenever water was stopped at the Croton Dam to repair breaks in the aqueduct, the city was in imminent danger of being entirely deprived before the aqueduct was again in operation. On several occasions these reservoirs were within a few hours of being exhausted by the time renewed aqueduct flowage reached and began to replenish them. Again, a few years after, the large Central Park Reservoir was in service, the same conditions recurred, the former experience having been unheeded owing to the apathy of both legislators and the citizens towards efforts of those in office to avoid such dangers by enactments required either to check preventable waste or to provide an increased supply. Hence it is desirable to consider how matters stand to-day, as to whether city storage is sufficient to enable the new aqueduct supply to be shut off long enough should anything occur to make repairs imperative. The city is now consuming over three times more water than it was twenty years ago. The amount of storage in Central Park was inadequate then for shutting off the conduit for necessary repairs, and the storage within city limits is no greater now, with three times the consumption. This is due to delay caused by the public hearings in beginning work not yet completed on the Jerome Park City Reservoir. This new reservoir at the city end of the new aqueduct, and the Quaker Bridge Dam thirty miles away, providing an adequate storage lake, were designed as before stated to be built simultaneously.

Before the work on the Cornell Dam can be completed the new aqueduct will be using the fullest quantity it is capable of carrying. That it has water to convey now is because the cycle of wet years has kept it supplied through sheer good luck of ample rainfall. Should a dry period arrive, such as prevailed in 1881-2, the city would again be in straits. The new aqueduct is now carrying 280,000,000 gallons per day, to which is to be added 15,000,000 gallons from the Bronx, making the total city consumption 295,000,000 gallons per day, or over 200 gallons per capita, 50 per cent. of which is preventable waste. The old aqueduct can be put in service should the new one have to be shut off, and it, together with the Bronx, would furnish daily 95,000,000 gallons, but even with this flowing into the city reservoirs the city storage would give a ratio

one-third less than the city had thirty years ago. It is therefore evident that there really is not time for inspection and repairs in the new aqueduct at this juncture without producing water stringency. Although it is in tunnel, and practically free from the dangers of rupture that pertained to the embankment construction of the old aqueduct, yet it has other dangers peculiar to masonry lined tunnel construction.

The old aqueduct had about two miles of rock and two of earth tunnel and over thirty miles of it had been constructed in open and refilled through cut. It had been in service about eighteen years before I took charge. For ten years after that I found it necessary from annual interior inspections, to make additional vents through the brick lining to let outside water enter where it was gathering pressure enough to crack the brick work and would ultimately force in the masonry if not relieved by such vents and in one case this did occur. Yet the old aqueduct was not more than thirty feet under the surface at any point, and did not average over five. Because of this experience on the first conduit, in the construction of the new one vents, or "weeper drains," were placed in the masonry lining to permit outside tunnel water to enter at all points, thus relieving external pressure where it was encountered. This was all the more necessary because the new aqueduct averaged 150 feet below the surface, which would produce a dangerous inward water pressure on the lining masonry, unless thus given a chance to enter through inward vents. Broken stone filling between the masonry roof arch and the tunnel roof was used that enabled water to follow and reach the nearest inward vent along the top of the aqueduct. But this blind drain connecting the inward vents was not always continuous, especially in earth tunnels. Again, in making good the defective work I instituted the forcing in of liquid cement to solidify the unfilled spaces behind the masonry. This at some points unavoidably choked the weeper vents. Hence, when the new conduit was put in service it needed interior inspection and watchfulness in placing additional vents at such points where outer water might be found oozing in through the brick work. It was twenty years after the old aqueduct was first used before all such places manifested and were provided with inlets when inspections were annually made. When it is realized that the lack of storage within the city has not permitted a single interior inspection of the new aqueduct since the day it was put in service, there is reason for apprehension as to its present condition.

The masonry work is undoubtedly equal to, if not better than, that existing in any similar work. But it must be understood that there are points along the new aqueduct which are in unsound, water-filled, micaceous rock, similar to that encountered in the subway tunnel which slipped and destroyed foundations of dwellings in Park Avenue. These places have needed inspection and care to prevent excessive water pressure from gathering and adding its load on masonry already bearing heavy rock pressure.

As regards additional requirements, it is necessary to find how long the present water supply will suffice, in view of the growing demands of the city, in order safely to judge of the time left for providing the future supply. The increasing value of city lots, the use of elevators, and the new forms of iron structure will add story upon story to buildings, causing the city to grow vertically as well as horizontally, and thereby augmenting the demands for water. Besides the down town office buildings, high apartment houses up town are rapidly superseding former residences. The development of the city over more distant areas will have but little effect in checking its vertical growth, and this should be considered in reallion to the further increase of the water supply. The new aqueduct is now giving its maximum delivery, which, together with the small Bronx supply, amounts to 295,000,000 gallons per diem. The only margin the city possesses is the 80,000,000 gallons daily from the old equeduct when it is again put into service. In other words, the emergency is right on the city, and the old-time story is repeating itself. The only efficacious method of meeting this problem is the utilization of waste, and along with legislation for a new supply, money should be appropriated for the work and appliances of converting preventable waste into legitimate use. This utilization of water now constantly wasted can be so developed that it will keep pace with increase of population, doubling the existing supply in effect, and giving time to develop in detail and construction appurtenances for a new supply; it will also give that supply greater longevity when secured.

There is no question in social economics, involving hygienic and other life interests, that is so persistently misunderstood, ignored, and unreasonably resisted by the public at large as this matter of preventing the waste of water in great cities, or one that implicates in like degree, life, health and property. The absurdity of the popular assertion that water should be as free as air is manifest. The more or less complicated systems of modern hydraulics that intro-

duce running water into every habitation exist because of the expenditure of millions of dollars, while air exists for the taking. The running supply of water is kept up by the continual outlay of capital. The people are taxed for this, but the unreasoning conviction remains. They resent even the suggestion of the curtailment of lavish abuse instead of use of a luxury, the cost of which they must ultimately pay.

It costs even to obtain water from a brook or well by the side of a cottage. It costs to store by the pailful as well as to impound for the city's use. Like other articles of necessity, it has a positive market value, varying with supply and demand, and this the mercantile mind might be supposed readily to grasp. Water, weighing 62½ pounds to the cubic foot, transported thirty miles, and supplied with pressure energy enough to force it to every story, has cost the city about $100,000,000 for dams, reservoirs, aqueducts, and pipes, with all their appurtenances. The city's water costs more than gas per cubic foot, but gas is not recklessly wasted, because it has to be paid for by the cubic foot. As water is furnished by the city, and paid for by water tax, the people are indifferent as to the quantity they draw. Had it to be paid for by actual measurement, like gas, they would curtail speedily all but what was legitimately used. This would amount to doubling the water supply.

One frequently hears a plea for the free use of water because it flushes the sewers and plumbing, and that therefore it is better to increase supply than to put any restriction on consumption. This sounds plausible, but such waste has a contrary effect on house plumbing by keeping discharge pipes constantly moist, which prevents oxidation by air ventilation. As to street sewers, this general waste, distributed and dissipated through all the city sewers, has no effect in flushing them, whereas a minute fraction of it, when forced through in volume occasionally, would accomplish practical results on one sewer at a time that could not be obtained from the dribblings constantly running into the sewers all over the city.

Again, it is claimed that unrestricted use of water induces greater cleanliness, promoting hygienic results. This also is an error. To maintain a sufficient supply, not only must the water, weighing 62½ pounds per cubic foot, be delivered to each house, but also it must be at a pressure that will lift it to upper floors. Therefore adequate volume together with adequate pressure is required for both consumers and fire protection. By a familiar law of hydraulics velocity is increased by excess of waste through a city

pipe. You lose in pressure to a higher degree than the quantities drawn represent. Theoretically, what is gained in velocity is lost in pressure, but, including pipe friction, pipe pressure is lost to an increased degree. Therefore, when waste represents one-half or two-thirds of the supply, it produces a loss of over approximately one-half or two-thirds of the pressure. This loss of pressure deprives upper floors of water, which interferes with cleanliness, and by depriving plumbing on upper floors of water produces unsanitary results. This detrimental condition reacts harmfully on the daily consumer, and it is the people upon whom the monetary loss falls, besides the inconvenience.

An object lesson was furnished by the conditions that continued for over fifteen years prior to obtaining the new aqueduct supply, during which, if waste could have been stopped, upper floors would not have been deprived of water, nor would there have been thousands of victims from bad air. Losses by fire were greatly in excess of ordinary rates, directly attributable to the loss of the pressure that might have been maintained had the waste been prevented. Many will remember the anxiety felt in the dry goods district because of this loss of pressure, which so handicapped the Fire Department.

During my connection for so many years with the water supply, I made repeated efforts to further the checking of preventable waste, and always were they frustrated by the unreasoning, ill-judged opposition of the people, re-echoed through the press. I began finally to believe that their prejudices were possibly a "Tweed ring" inheritance. It seemed honestly to be believed that all attempts in this direction were for the purpose of robbing the city, and these prejudices seem still to exist. It is vitally important for the people to realize the truth of relationships in this matter which so nearly concerns their daily lives. After spending half a lifetime devoted to active work in the city's service connected with the water supply, which period involved fighting prejudice and ignorance single-handed, and often against odds, it was with great satisfaction that I read your article on waste, and determined to make another effort, even at a late day, to bring about a better knowledge of what really bore on the good of the community. It only needs a little time and common sense to examine statistics, reports, and records. The questions, I have touched upon in necessarily a desultory fashion are within reach and can be verified. They are facts, not opinions, and as such I trust that they may help to strengthen your position

and induce you to continue to throw the influence of your powerful journal on the side of utilizing waste and securing more water for future needs without delay. .It is with a sense of discouragement, overborne only by the hope that you may be able to arouse interest that I have undertaken to say even this much. People are habitually indifferent to such statements, but must face the truth sooner or later. Warnings heretofore on the subject seem to have produced scarcely a passing impression, but perhaps these hints of serious conditions may cause officials to give attention to the matter."

The public at large in other cities are beginning to apprehend that it is as important to provide means of controlling a city water supply as to obtain the supply itself. Otherwise extravagant misuse will inevitably appropriate in the present what is provided for the future. Hydraulic engineers are convinced that all consumers of city supplies should pay for water by meter measurement. The restraint is necessary upon water takers, and paying for leakage alone causes them to keep their fixtures in order. Universal application of meters for both large and small consumers has become a necessary part of the equipments of a judiciously managed city water service. In New York and other older cities it may be advisable to initiate the general application of meters by some simple means of detecting waste and locating where it exists in its more aggravated form. It has been demonstrated that by such means a very rapid reduction of excessive consumption can be effected. But for permanent results, the meter has become indispensable.

In 1842, when Croton water was first introduced, fifteen gallons per capita was considered a liberal provision for all purposes. Modern uses and needs have, however, increased legitimate requirements to from sixty to seventy gallons per capita. Sources of supply are being exhausted, damaged or appropriated for other purposes than town supplies, and the entire civilized world is becoming embarrassed in obtaining more water for its cities. Hence true economy in its use is everywhere being demanded, and its sale must now be regulated by positive measurement through meters."

B. S. CHURCH.

New York, November 10, 1902.

Commenting on the above, the *Times* of the 4th inst., says, editorially, under the heading, "Water Waste in New York":

"In his valuable and interesting letter on the water supply of

New York in *The Times* of Sunday, Mr. B. S. Church, whose name is identified with the history of the Croton system and whose reputation in the field of hydraulic engineering is international, puts the case very clearly, as follows:

The new aqueduct is now giving its maximum delivery, which, together with the small Bronx supply, amounts to 295,000,000 per diem. The only margin the city possesses is the 80,000,000 gallons daily from the old aqueduct when it is again put into service. In other words, the emergency is right on the city, and the old-time story is repeating itself. The only efficacious method of meeting this problem is the utilization of waste, and along with legislation for a new supply, money should be appropriated for the work and appliances of converting preventable waste into legitimate use. This utilization of water now constantly wasted can be so developed that it will keep pace with increase of population, doubling the existing supply in effect, and giving time to develop in detail and construction appurtenances for a new supply; it will also give that supply greater longevity when secured.

The present water draught of New York is equivalent to about 120 gallons per head of population per day. Of the population of New York it is safe to assume as a statistical proposition that at least one-third do not use an average of two gallons per day. The immense tenement population is not well provided with toilet accommodations, and very little water goes a great way when it has to be brought in buckets from a tap common to all tenants. This would account for a use of 2,388,620 gallons per day. If for another third of the population we allow 20 gallons, we are within the probabilities, and have accounted for 23,886,240 gallons per day more. If the remaining third is accredited with the capacity to use an average of 30 gallons, we have accounted for 35,829,360 gallons more. This would give for the entire 3,582,930 population of New York a daily use of 62,104,220 gallons. In this there is no provision for waste, and the estimate of use is liberal. A number of householders for whom this inquiry had interest put their plumbing in order and metered their dwellings. In bath, toilet, laundry, and kitchen their households used water without economy, and to all appearance wastefully, but in no instance during a test of three months in the season of maximum bathing was the consumption for all purposes found to average as much as 25 gallons per head of family. These tests were made under conditions much more favorable to the liberal, and even reckless, use of water than are found in

the average New York dwelling. In view of these facts, an allowance for legitimate use of, say, 65,000,000 gallons per day for the private and domestic uses of all New York should fully cover them. If we double this total to cover public use, commercial use, fire extinguishment, shipping, etc., we have a total somewhat less than one-half of what is now charged to consumption in Manhattan and the Bronx.

This is a subject concerning which the average citizen cherishes illusions and shuts his eyes to the truth. At the last annual meeting of the British Association of Water-Works Engineers, the President, Mr. Frederick Griffiths, of Leicester, showed that the consumption of that city by good management had been gradually reduced to 20 gallons per head for all purposes, 'without curtailing in any way the legitimate use of water to any inhabitant.' Sheffield, a great manufacturing city, finds 21 gallons per head sufficient for all uses, municipal, industrial, commercial, and domestic. Hull has reduced its consumption from 48 to 28 gallons per head, and is still reducing it without inconvenience to the people. Dublin requires 38 gallons, having reduced it some 43 per cent. since 1893. London manages very well with a consumption only about one-third of ours per capita.

To save one-half the present daily draught of water in New York, not only without inconvenience to the consumer but with positive and immediate advantage to the householder in increased pressure and more ample supply for emergency purposes, is perfectly possible. The present administration of the Department of Water, Gas and Electricity will fail in its most important public duty if it does not impress this elementary fact so clearly upon the public attention that the obstacles to water reform in New York will be brushed aside by the force of public opinion. To spend millions to increase the supply that the present waste may continue unchecked would be a criminal misuse of the public money."

The *Water and Gas Record* of December, on its editorial page, says:

"There seems to be an awakening on the part of a number of prominent and influential interests in this city with regard to the threatened shortage in the water supply incident to the continually increasing waste now and for many years prevailing in all the boroughs. The *New York Times* has been conspiciuous for some time past in its efforts to expose and correct the evil. The Mer-

chants' Association has gone to great trouble and expense in its attempts to enforce a remedy and now the City Club, an organization composed of many of the best known members of the Bar and of others prominent in the professional and mercantile life of the metropolis has by its address, which will be found printed in another portion of this issue, and by the very emphatic utterances of some of its most representative individual members, which will also be found reproduced in this number of the REVIEW, set forcibly before the public an urgent demand for reform of a most necessary character in the future administration of the water department.

The very able and comprehensive letter of Mr. Benjamin S. Church, former Chief Engineer of the Croton Aqueduct, which we also republish, is a valuable and instructive contribution to the existing discussion."

It is curious to note, however, that not only in the *Times'* editorial review of Mr. Church's communication but also in the address of the City Club there is no direct statement made as to what methods are to be adopted or what means used in a remedial way. True enough "scientific methods" are recommended, but excepting among water-works engineers and officials this term has a very vague meaning. Mr. Church and Mr. Deming, however, understand very well what is the only and the true method and they do not hesitate to say so. These are Mr. Church's views:

"There is no question in social economics, involving hygienic and other life interests, that is so persistently misunderstood, ignored, and unreasonably resisted by the public at large as this matter of preventing the waste of water in great cities, or one that implicates in like degree, life, health and property. The absurdity of the popular assertion that water should be as free as air is manifest. The more or less complicated systems of modern hydraulics that introduce running water into every habitation exist because of the expenditure of millions of dollars, while air exists for the taking. The running supply of water is kept up by the continual outlay of capital. The people are taxed for this, but the unreasoning conviction remains. They resent even the suggestion of the curtailment of lavish abuse instead of use of a luxury, the cost of which they must ultimately pay.

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