Employees of the Water Department live both at Spruce Hill Lake and at Chain Lake dams whose duty it is to look after the dams and gate houses. The screens in summer when the water is low require changing frequently they become choked with leaves or other impurities suspended in the water. During the fall of 1905 when the water was at its lowest two men were on duty day and night continually changing the screens, otherwise the supply could not have been kept up to the City through them.

CANAL.

As has already been stated, the water was conducted from Long Lake to Chain Lakes by a canal which was originally constructed in 1848 by an open cut, and was intended to be low enough to draw the water of Long Lake down seven feet below the waste weir level, but during construction owing to difficulties met with by the Contractor the grade line was raised 1 foot 3 inches, thus, only allowing 5 feet 9 inches of Long Lake water to be drawn off. The conduit was 2 feet x 2½ feet, and was entirely too small to pass the water in sufficient volume to give full effect to the storage of Long Lake. The present conduit, rebuilt in 1836, is 1300 feet long, 3½ feet wide and 4½ feet high, built of 4 inch x 4 inch hemlock deals with four manholes throughout its length. Its upper end is at an elevation of 196.20 with a fall to Chain Lakes of six inches.

ICE.

The experience with the formation of anchor ice has been similar to that of other places. With a sheet of open water at a temperature of 32 degrees F., and the temperature of the air varying from 5 degrees to 20 degrees above zero, and a high wind blowing, the ice forms in small detached needles or crystals. Thin portions of it accumulate in spongy masses and float along at or below the surface, their specific gravity differing but little from that of water. They adhere readily to all solid bodies with which they come in contact and grow rapidly when once they have secured a centre of crystallization. It will not form in bright sunshine—on the contrary, it rises to the surface in spongy masses, and when the surface freezes over it lets go its grip. The lee side of a reservoir gets most of its anchor ice, and whenever we have been troubled with it the wind has always been from a northwesterly direction. Between 1883 and 1893 no trouble was had from the ice, and it is thought that this was due to the fact that a screen of stout pickets driven into the bottom capped on top with a boom rising and falling with the level of the water was placed in front of the pipe houses. In 1892 this was removed, and on the 11th December of that year ice closed the sluice gate at the south pipe house cutting off the supply to the 24 inch main and continued until four o'clock in the morning, when the wind subsided, and the ice stopped running. In 1898 the filter wall already referred to was built in front of the south pipe house, but ice formed inside the wall, and there was danger that the gate house would freeze up solid, so the screens were removed until the danger was passed. This is the last time there has been any trouble from it.

RIPARIAN RIGHTS.

When the Water Company decided to bring the water from Chain Lakes there were several mills situated on the stream flowing from the lakes and enjoying the privilege of the water from them. Some difficulty having arisen in securing the rights to the water, it was seriously contemplated by the Company to bring the water direct from Long Lake. However, an agreement was eventually made in 1849 with the owner of the privileges that for a consideration of £500 the Water Company could build dams and take the water from Chain Lakes provided that they would not interfere with the natural flow through the lakes as heretofore enjoyed by the mill owners. The first difference arose in 1863 when the Commissioners of water supply received a letter from the attorneys of the mill owners stating that the mills had closed down for want of water, and that in previous years the Water Company had let down a supply in dry weather. The Commissioners on this occasion gave orders to their superintendent to let down enough water to fill Chocolate Lake, on the understanding that this was not to be taken as a precedent or to act as any acknowledgement of the rights of the mill owners to the supply, and on April 13th. 1863, they presented a lengthy report dealing with these claims. From that time to this there has been constant friction with the mill owners as to the amount of water which should be let down to them under the agreement. This has culminated in an action being brought by them for a declaration of their rights and an injunction restraining the City from interfering with their supply. As this is now before the courts the question may not be discussed fully, and is mentioned only to serve as an example of the necessity for looking to the demand for a largely increased supply always following the introduction of water to a town in a short time, and of the advisibility of either securing all the rights to a watershed, or at least having a definite agreement as to the actual quantity to be allowed the owners, and the method by which said quantity should be measured.

MAINS.

The water was originally brought from the Chain Lakes to the City by a 12 inch main to St. Andrew's Cross, laid in 1848, and was assumed by Mr. Jarvis to be capable of delivering at this point 800,000 gallons daily. It was cast iron, and was ordered in Scotland through the Messrs. Kidston & Son, of Glasgow, and cost £7/5 per ton delivered, the freight being 15/ per ton. 2550 feet of these pipes were to be 5/8 inch thick, to be tested to withstand a pressure of 160 lbs. to the square inch, and 13,650 feet to be ½ inch thick tested to 145 lbs. All pipes to be 9 feet long. 550 of these pipes were ordered with spigots cast on them to fit a ¾ inch iron service pipe so that the water would not have to be turned off in making connections. The pipes were uncoated and were laid with lead joints.

In January 1856 the Water Company ordered from Kidston & Sons 284 lengths of 15 inch pipe, 8 feet long, ¾ inch thick, to be laid in the valley of the Arm, and 1341 lengths 5/8 inch thick. The pipes to be tested to 165 and 135 lbs respectively. These pipes were laid during this year alongside the 12 inch. The estimated delivery of this pipe was over 1,000,000 gallons per day at St. Andrew's Cross. Messrs. Kidston wrote to the directors recommending the use of a coating (Smith's Patent Varnish) which was then just coming into use, and the Directors wrote saying that if this coating had the approval of authorities in Great Britain to put it on the pipes; but subsequently, fearing it would reduce the capacity of the pipes, passed the following resolution, a copy of which they sent their agents:—

"*Resolved,*—That the Directors having ordered a 15 inch pipe which was larger than was contemplated for the very purpose of preventing the pipes filling up, do not consider that the glazing mentioned will be necessary; but if the glazing is considered a benefit that all the small pipes ordered be glazed."

Fortunately, before this letter was received the order had been placed and the pipes came out coated. These pipes were laid with wood joints. The cost was £5 14s. 10d. per ton exclusive of freight.

In 1862 the Commissioners of Water Supply took up the original 12 inch main and substituted therefor a 24 inch main. These pipes were ordered from Glasgow. The quantity required for the Arm Valley to be 1 inch thick tested to 200 lbs., and the remainder to be ¾ inches tested to 150 lbs. All pipes to be 9 feet long and coated with Smith's Patent Coating. They were laid with wooden joints and cost £4 4s. 3d. per ton exclusive of freight or duty, or £6 18s. exclusive of truckage. The total cost of laying this main was $54,994.39, or an average cost of $4.00 per lineal foot.

The estimated capacity was $5\frac{1}{4}$ million gallons when new. There is a 12 inch exit pipe at the Dutch Village Road. On the introduction of the High Service in 1868 the 15 inch main laid in 1856 was used as a part of the supply main and was extended to within $1\frac{1}{4}$ miles of Spruce Hill Lakes, this latter distance being laid with 20 inch pipe. These are 5/8 inch thick and the 15 inch are $\frac{3}{4}$ inch. They are 9 feet long and coated with Smith's Patent Varnish and are laid with wooden joints. That portion of the old 15 inch lying in the valley of the Arm was uncovered and lead joints substituted for the wood. On the 14th January 1869 the Commission had a report from their Superintendent complaining that the 15 inch pipes laid the previous year were giving considerable trouble from the fact of the unequal casting, a number of pipes breaking under a pressure of 68 lbs. On examination these pipes were found to be only 3/8 inch thick on one side and full 7/8 inch on the other and during the winter the pressure was regulated so as not to exceed 45 lbs, at Chain Lakes pipe house. The pipes split along the thin side. The estimated capacity of this main when discharging at an elevation of 250 feet was 2,485,000 gals. There are exits in this main at the end of the 20 inch, at Beaver Dam Brook, at Head of Chain Lakes and at the Dutch Village Road.

In 1893 a new low service main 27 inches in diameter was laid from the Chain Lakes. This main follows the route of and is laid alongside the other two supply mains to the brow of the hill on the western side of the Dutch Village Road, thence striking across the valley in a straight line to Bayers Road near North Kline Street, thence along Bayers Road and in prolongation thereof to Kempt Road, and then to Young Street at the corner of Gottingen Street, connecting there with a 24 inch main running to Cogswell Street where the latter joins the 12 inch and 15 inch running from the 24 inch at St. Andrew's Cross. The specification for this pipe calls for three thicknesses—$\frac{3}{4}$ 7/8 1 1/32,—the first to test to 250 lbs. and the latter to 300 lbs. per sq. inch, and while this test is being applied the pipes to be struck a series of sharp blows at various points through their length with a 3 lb. hammer attached to a handle 16 inches long. The pipes are 12 feet long with turned and bored joints and coated inside and out with coal pitch varnish. The contract price delivered in Halifax free of all charges was $32.05 per 2000 lbs., for plain pipe and $56.10 for special castings. The contract for excavating the trench was let for $1.85 per cubic yard for rock and 28 cts., for earth excavation. Measurement limited to a trench 4 feet wide. The cost of the 27 inch main laid was $5.71 per lin. foot inclusive of all charges. The cost of the 24 inch laid in Gottingen Street was $5.52 inclusive of all charges. This main slopes from the lake and from Gottingen Street to the Dutch Village Road where a 12 inch exit pipe is placed.

COATING.

The coating on the high service main and on the 24 inch was ordered as "Smith's Patent Varnish." This is probably the coating process of Dr. Angus Smith which was first introduced into the States in 1858. The weight of experience seems to show that in uncoated pipes the first ten or twelve years of their life results in more or less rapid corrosion. After they have become thoroughly tuberculated very slight changes take place. If this is removed by scraping or cleaning it begins to form again and the life of uncoated pipe becomes much reduced.

The interior of coated pipes becomes tuberculated in the same way, due to a large extent to defects in the coating, but very much less quickly, and when removed by scraping the iron is uninjured. The writer was present recently when a piece of pipe was cut out of the 15 inch main, and when the deposit was rubbed off the coating was as sound and good as when first put on. The outside of the pipe was also in good condition. This pipe had been cleaned a year previously, and the tubercules had not begun to form, but there was a slight deposit over the face of the pipe. There are a few points to be observed in coating cast iron water pipes :—

That the ovens in which the pipes are heated before being dipped in the cold tar bath shall be so arranged that all portions of the pipes shall be heated to an even temperature.

The pipes should be heated to a temperature of 300° F before being dipped.

The varnish to be heated to a temperature of not more than 300° F. and kept at this while the castings are in the bath.

The pipes should not be submerged for less that five minutes and when taken from the bath should be evenly coated.

JOINTS.

There are three kinds of joints in use in the water system—lead, wood and turned and bored. These latter joints have been in use since 1890, but they do not seem to find favor with Engineers in America and are very little used in Canada or the United States; although in the Metropolitan Water Works of Mass. for the crossing of the Charles River one of the three kinds of joints used was described as follows :—Three turned grooves were made in the bell instead of the single one so as to hold the lead more securely and the spigot was smoothly turned with a straight taper to a standard pattern so as to be interchangeable. After inserting one of these tapering spigots in the bell of the pipe and running the joint with lead the spigot could be withdrawn and when again inserted would make a tight joint. This is practically one pattern of a turned and bored joint. In our pattern a lip or rim is cast on the spigot end of the pipe varing in length from $2\frac{1}{4}$ inches in a 27 inch to $1\frac{3}{4}$ inch long on a 6 inch pipe, tapering about 1/24 of an inch in their length. A finished lip or rim is cast in the hub, the pipes are then centred in a lathe and the rim on the spigot end is turned and the rim on the hub end is bored by the same movement of the lathe. Care is taken that the pattern is made to give a full size casting so that when planed down the ends fit accurately. The total depth of the hub varies in the different sizes from 4 to 5 inches.

In laying, the pipe is lowered into the trench with the joint smeared with oxide paint and placed in position on its blocking, entering the faucet of the last laid pipe. The next pipe is then lowered and held in its slings while the men in the trench swing it backwards and forwards and thus ram the last laid pipe tightly home in its place. A block of hard wood between the pipes prevents any damage to them. Pipes under 12 inches are held in slings by four men on the bank; larger pipes are lowered with a derrick. Should there be any slight weepage the joint soon rusts tight. In the fifteen years' experience with this form of joint there have only been two leaks through them, one in the 27 inch main near Young St., and one in the 6 inch main in Young Avenue. In the latter case the pipe was laid in the sewer trench. As the back filling of the latter settled the blocking of the pipe was disturbed and the pipe settled and drew one joint. In the case of the 27 inch a leak developed during the winter following the laying of the pipe, and on digging down to the main a joint was discovered to have drawn out about $\frac{3}{4}$ of an inch. This was caulked with cold lead and gave no trouble until the following winter, when it again showed signs of leaking, and on investigation the joint was found to have drawn another $\frac{1}{2}$ inch. The blocking of the pipes on each side had apparently not settled out of place, being laid on the top of the ledge rock. It was thought that this drawing apart of the joint might have been due to the contraction of the pipes. Assuming the difference of temperature to have been 30 degrees, which is a fair estimate between the temperature of the pipes when laid and when the leak developed, the contraction to open the joint $\frac{3}{4}$ inch would have to take place through 324 feet of pipe. If this took place on each side of the defective joint there would be a strain on the joint of over 16 tons, the pipes weighing a ton and a quarter to the 12 foot length, if the leakage was from this cause, it should close up again in the summer when the temperature of the pipe rose. Unfortunately, the ½ inch which it is said the pipes separated in the second winter was not measured accurately, but was estimated by the foreman and may have been overstated; but assuming it to be correct, the writer cannot advance any theory for the increase in the opening from this cause as there would not be any more difference in the temperature than the amount given above. It is possible that the joint may not have been driven home, and as at this point there was only about four lbs. pressure when testing, the oxide paint used may have prevented the leak shewing when the pipe was tested on being laid, and a settlement may have occurred in one or two lengths of pipe distant from the leak dragging the pipe apart at the weakest point.

It will be seen from the description of the method of laying that the process of lowering and blocking is exactly the same as for plain pipe except the ramming home which takes but very little more time than the extra care required in centering the pipe for a lead joint and then the joint is complete, whereas with the plain pipe the process of jointing has not yet been begun and necessitates considerable labor and material being employed to finish the work. To get the best results with lead or wood joints also requires a higher class of labor. The pipes can be sprung around curves, but in this case should be caulked with lead.

Previous to the introduction of the T & B., pipes wooden joints were used extensively for pipes of 6 inch and over. They have the merit of cheapness as compared with the lead joint and are durable, but possess the defect of being liable to be blown out with a sudden increase of pressure and most of our trouble with discovered leaks has been from this cause. The faucets of the 24 inch and 15 inch for this kind of joint were made tapering 1/8 inch inwards. The joint is made as follows:—After the pipe is inserted in the socket it is raised up by means of a tool called a raising iron and soft pine wedges or staves thoroughly seasoned and cut to the radius of the pipe are inserted on the lower side for about 1/3 of the circumference of the pipe. The pipe is then lowered and raising irons are driven in the top and on each side of the joint at intervals of about 3 to 5 inches. The wedges are then driven in with a sledge hammer beginning from those already laid and working up both sides the raising irons being withdrawn as the work proceeds. When all the wedges are in, keys are driven where necessary between them to tighten the joint.

The wood joints in the 15 inch main where under the water of the Chain Lakes were strengthened by adding an angle strap of wrot iron bolted closely to the pipe in front of the wedges. The difference in cost of Turned and Bored and plain pipes has varied from 55cts. to $1.00 per ton, the former being the difference in the tenders for the 27 inch and 24 inch pipes laid in 1893. The net saving over lead joints in laying the 27 inch main amounted to $3,147. Taking the cost of Turned and Bored pipes at 75 cts. per ton more than plain pipes, the following table gives the detailed cost of laying mains with turned and bored joints.

Cost of Laying and Jointing 9′ Lengths of C. I. Pipe with Wood, Lead and Turned & Bored Joints.

		Wood.					Lead.								Turned and Bored.			
Size in inches.	Weight of 9′ length.	No. of pipes six men will lay and test in 10 hours costing $10.20.	Cost of labor per length.	No of staves @ 1¾ No. of wedges @ ¼.	Cost of staves and wedges.	Cost of one length laid, jointed & tested.	No. that 6 men will lay & test in 10 hrs., cost $10.20.	Cost of labor per length.	Lbs. lead @ 3½c.	Cost of lead.	Lbs. Gasket @6¼c.	Cost Gasket.	Cost one length laid, jointed & tested.	No. that 6 men will lay & test in 10 hrs., cost $10.20.	Cost of labor for each length.	Extra cost of pipe per length @ 75c. per ton.	Cost one length laid, jointed & tested.
24	2077	10	$1 02	22	$0 44	$1 46	10	$1 02	50	$1 75	½	$0 04	$2 81	15	$0 68	$0 75	$1 43
20	1263	12	85	19	38	1 23	12	85	40	1 40	½	04	2 29	18	56	47	1 03
15	1128	15	68	16	32	1 10	15	68	30	1 05	⅓	02	1 75	23	44	42	86
12	680	20	51	13	26	77	20	51	24	84	⅓	02	1 37	32	32	25	57
9	500	25	41	12	24	65	25	41	17	60	¼	02	1 03	40	25	19	44
6	280	30	34	9	18	52	30	34	12	42	⅛	01	77	50	20	11	31
4	156	....	......	......	......	......	40	26	8	28	1-10	01	55	60	17	05	22
3	130	....	......	......	......	......	50	21	6	21	1-10	01	43	......	......	......	......

INCRUSTATION OF PIPES AND CLEANING.

In 1875 the old 3 inch water pipes laid by the Water Company having become almost choked up with rust and sediment, they were cleaned out during the succeeding year by a scraper attached to iron rods and propelled by hand. The scraper had four arms or knives attached to a center and sprang outwards by a thick rubber disc. This method was not practically applicable to pipes of a larger diameter than 12 inches. The cost was 14 2/10 cents per lineal foot. In 1880 about a mile of 12 inch pipe was cleaned by a self-acting mechanical scraper imported from Scotland and known as the Kennedy scraper. In 1887 Mr. Keating, the City Engineer at that time constructed new scraping machines which differed from the others in having additional springs for the cutters and pistons. These scrapers consist of an iron rod to which are attached two pistons and two sets of cutting tools one in front of the other. The cutters are each made up of four strips of steel 2½ inches broad sloping backwards from the rod and at their outward termination sharpened like the barbs of an arrow, thus they can yield when necessary and the cutting diameter can be altered by moving the steel strips. The pistons are of iron, lead and leather to which are added rubber springs. All the main supply pipes were cleaned in that year at an average cost of 2 8/10 cents per lin. foot. The immediate results were that the average pressure on twenty-five hydrants on the wharves increased from 34.2 lbs. in February 1881 to 52.4 lbs. in February 1882. These were on the low service. On the high service there were a pressure of 19 lbs. on hydrants where in the previous year there had been no water at all. The pipes have been cleaned periodically since that date and usually twice a year.

In cleaning the mains the water is turned off at the gate house and the exits opened and pipes emptied. A section of pipe jointed with collars bolted together is removed and the scraper inserted by hand into the main. The piece taken out is then replaced and secured. The water is turned on and by its power forces the scraper along. As it passes the exits they are turned of by men stationed there and the scraper continues its course to the end of the main proposed to be cleaned where a length of pipe has been removed. A sufficient quantity of water escapes through the valves ahead of the scraper to wash the incrustation removed and keep it from sticking. The water is allowed to run for some time until the sediment disappears when it is shut off and the length of pipe inserted again and the water turned on to the distribution pipes. The average cost of cleaning the 24 inch low service main for the past twenty years has been $15.07 for each cleaning of 13,400 feet and of cleaning the high service main $18.80 for each cleaning of 36,340 feet. Between 1882 and 1904, both inclusive, there has been cleaned 223 miles of mains at a total cost of $732.07 or at an average rate of $3.28 per mile.

DISTRIBUTION MAINS.

The pipes in the distribution system are of cast iron, all those laid since 1855 being coated, and those 6 inch and over laid before 1890 having mostly wood joints. They range in size from 3 inches to 24 inches in diameter, the mains to the hydrants being with few exceptions taken from a six inch pipe or larger. Some of the old 3 inch mains lately removed and replaced with larger pipes when cut were found to be so choked that there was barely room to insert a lead pencil through the opening. These were old, uncoated pipes and the metal had deteriorated badly. The mains are generally laid on the north and east sides of the streets with valves set in line with the street lines. Iron pipes with sleeves were first used for stopcock boxes about 1862. Before that wood had been used. The valves used for letting the high service into the low for purposes of fire protection are kept clear from ice and snow during the winter.

In 1905 there were 69.68 miles of mains and distribution pipes and 804 valves.

HYDRANTS.

There were 424 hydrants in use at the end of 1904. A large number of these are of an old style set in a brick well or chamber below the sidewalk inside the curb. The chamber is covered with a cast iron plate provided with a hatch by which access is gained to the bottom of the hydrant where it joins the branch from the mains. This arrangement while admitting of the easy removal of the hydrant, is objectionable on account of the difficulty and expense in keeping the valves free from ice, and the large iron plate becoming smooth and dangerous to pedestrians. These hydrants are gradually being replaced with a hydrant of a special patern. The main valves and guide rod which also forms the waste valve are similar to the Matthews hydrant. A brass and leather attachment to the valve rod forms the waste valve. There is a waste hole bored in the center of the flange in the stand pipe against which this valve works. The hole was formerly at the bottom of the hydrant, but owing to the difficulty of reaching it it has in the later patterns been placed in the side. The main screw on the valve rod is protected from the action of frost and water by a partition and stuffing box. The frost jacket is securely bolted to the iron seat and when once set need never be removed. It forms an air chamber which prevents the frost from reaching the valve. A third nozzle is added to take the suction hose of the fire engines. The hydrants are examined and opened twice a day by employees of the Water Department all through the winter.

SERVICE PIPES.

When the City took over the works in 1861 only about one quarter of the number of families on the line of pipes were supplied with water directly by service pipes to their houses, the remainder obtaining their supply from the free domestic hydrants paid for by the City. These service pipes were in all cases ¾ inch cast iron pipes connected to the distribution mains by spigots cast on the latter. When on the assumption of control of the works by the City a general assessment was levied to provide the funds necessary to maintain them all citizens on the line of pipes applied for service pipes to their properties. There had been considerable doubt in the minds of the Directors of the Water Compauy as to the material to be used for service pipes and in 1846 they asked Mr. Jarvis for a report as to the merits of tin-lined lead pipes for this purpose. He replied that three-quarters of the service pipes used in New York at that time were common lead pipes and adds that there was considerable discussion then going on as to the injurious effects of lead pipe on water. He had no doubt that they injured a pure water, but that the length is so short that no material influence is produced. However, the Water Company, as before stated laid all service pipes of cast iron. The Commissioners of Water Supply decided to use lead pipes and during their first year in office they laid over 6½ miles of lead service pipes to supply water to 1058 takers. A large number of these were renewals as the old ¾ inch iron pipes were found to be badly choked and corroded. Since that time all services have been lead pipes. While Halifax water is a very soft water, and as such, from general observation elsewhere, should be injuriously affected by lead pipes, such has not been the case, the experience being that after a short time a film or layer of sedimentary deposit forms over the surface of the pipe which prevents the water coming in direct contact with it. No cases of lead poisoning from using the water have been reported here since the introduction of lead pipes for services in 1861. Under the regulations of the Water Department each building is entitled to one ½ inch service pipe laid at the Department's expense from the main to the street line. In the event of a larger pipe being required the difference in cost is paid for by the person desiring the same. In the winter of 1882-3 a very large number of underground leaks were discovered and were found to result from the service pipes being severed at the connection with the main. The Gas Company had the same trouble during this winter and the City Engineer at the time suggested that the only cause of this could be from shock of earthquake felt on the peninsula on the 31st December 1882. Subsequent to the explosion of the Acadia Powder Company's works at Waverley (about 12 miles from Halifax) on the 1st January 1905, the Gas Company had the same trouble with a number of their service pipes especially on Coburg Road and in that vicinity, but the water pipes escaped injury.

At one time in the history of the works eels were a constant source of annoyance in choking service pipes, but latterly it is quite rare to have any bother from this cause. An exception to this was in 1896, when owing to the danger of ice blocking the screens at the pipe house they were removed, and the following spring there were several complaints of service pipes being choked by eels.

The total number of service pipes laid up to the first of January 1904, was 6,939.

CONSUMPTION AND WASTE.

(See note at end of paper.)

In January of this year (1906) three Venturi meters were received from the makers to measure the quantity of water flowing through the mains to the City. One of them, that on the 15 inch, was installed, and it was hoped that results would have been obtained before the reading of this paper, but owing to delay in sending the registering apparatus no records have as yet been obtained. The Venturi meter is different in principle, design and operation from the water meters generally used for measuring water, and it consists of two truncated cones of cast iron joined at the smallest diameter by a short throat lined with brass having a diameter varying in different meters from one-quarter to one-half of the diameter of the large ends of the cones, the three parts making what is known as the meter tube. At the up-stream end and at the throat small holes are drilled into the tube, from which pipes are carried to the register. The operation of the meter is due to the fact that when water is flowing through the tube the pressure at the throat is less than at the up-stream end, and that the difference in pressure is dependent upon the quantity of water flowing through the tube. The differing pressures at the up-stream end and throat of the meter tube are transmitted through small pipes to the register, which can be located at any convenient point within 300 to 400 feet of the tube. In the register the differences of pressure affect the column of mercury which carries a float. The position of the float is thus made dependent upon the quantity of water passing through the meter; and by suitable mechanism the quantity is recorded by a counter, and the rate of flow at intervals of ten minutes is recorded upon a chart, so that the fluctuations in the flow throughout each day can be observed. Although the pressure at the throat of the meter is often several pounds less than at the inlet or up-stream end, the lost pressure is almost all regained by the time the water reaches the outlet end of the tube, so that the net loss of pressure caused by the meter is seldom more than one pound under ordinary conditions of use. The meters in Halifax are set on a by-pass so as not to interfere with the operation of the scraper in cleaning the mains.

As there has been no direct means of measuring the water used it has had to be estimated by finding out the loss of pressure by friction in the pipes by gauges placed on the hydrants at different points and to estimate the co-efficient to use in the Chezy formula. In a report on the water system of St. John the engineers found by experiment that the co-efficient to use there was 65. For new pipe this should be about 120, so that the discharge from their 24 inch main laid in 1873 would be a little more than one-half that of a new pipe. The 24 inch and 15 inch in Halifax have been cleaned regularly twice a year for some time, although the usual fall cleaning was omitted last year on account of the lowness of the water in the lakes; but from an inspection of the condition of the pipes where cut this year the above co-efficient of 65 is considered much too low for the mains of the Halifax water works system, and 80 would be nearer the mark, although this is considered a minimum. However, assuming 80 to be applicable, the amount of water flowing into the City on the 8th of January 1906 was 3,288,600 gallons through the 24 inch main, 4,294,000 gallons through the 27 inch main and 1,600,000 gallons through the 15 inch main, or a total of 7,582,600 gallons for the low service and 1,600,000 for the high, or 9,182,600 gallons for the whole city. The day was mild and there had been but little frost for some days previously. There are 19,000 consumers on the low service and 16,400 on the high. This would mean an average consumption for all the water takers of 260 gallons per cap. per. day, or 399 gallons per cap on the low service and 98 gallons per cap. on the high.

Our population as given by the last four census is as follows:—

1871	29,582	1881	36,100
1891	38,437	1901	40,332

The figures for per capita consumption were given for the actual number of consumers. The better and usual practice is to give the per capita consumption for the total population as there may be some industries using large quantities of water, the employees of which may not be using water for domestic purposes. The figures given above would show a consumption for the entire population (assuming it to be 41,000) of 224 gals per cap. per day. From exhaustive investigations undertaken by the Metropolitan Water Board of Massachusetts the conclusion arrived at was that a liberal supply for domestic purposes is 25 gallons per day, for manufacturing, mechanical and trade use 23.5 gallons. and for public use 7 gallons, making a total of 55.5 gallons per cap. per day. Taking these figures as being applicable to Halifax, the consumption should be 2,275,000 gallons per day, which means that 6,907,680 gallons per day are being wasted. The average daily consumption through 144 meters on dwelling houses of various values in the City amounts to 105 gallons for each service pipe. Allowing five persons to a family, this would give 21 gallons per capita per day which agrees practically with the amount stated above as being a fair and liberal allowance for domestic use. Another proof that the figures of the daily consumption are under estimated is the fact that during the past year on the low service supply over 1000 million gallons of storage was used up during 155 days which would equal 6,500,000 gallons per day.

If 60 gallons per capita per day be assumed as a fair allowance, it follows that at least 170 gallons per capita per day brought into the City is wasted either through leaks in the mains or water pipes and fittings in private premises. There is no doubt considerable leakage from the mains, particularly on the low service where so many of them are laid with wood joints, and as a number of them are laid through or near old drains and sewers the leaks do not show at the surface but the water runs off through the drains. In Milton, a small town in Massachusetts, where all the services are metered and where the total quantity of water supplied is measured, and there are 35 miles of pipe laid, the leakage from the mains amounts to about 3600 gallons per day per mile of pipe. In Fall River it amounts to 10,000 gallons per day per mile of pipe, although in their case they have *only* 96% of their services metered and the consumption for the other 4% is estimated; and in seven cities having over 86% of the services metered the amount unaccounted for varies from 3,500 to 23,000 gallons per mile per day (these amounts are in U. S. gallons). Waste from pipes and fittings on the premises of water takers is due either to defective plumbing or to negligent or wilful waste in allowing the water to run from the taps. In a house with modern plumbing the chief cause of waste is from a leaky ball cock in the tank supplying fixtures. In one instance a meter was put on a pipe supplying a closet where the valve in the flushing cistern was worn and did not fit its seat properly. The waste was but a trickling stream, but the consumption was 1,073 gallons a day, while after the valve was repaired it was reduced to 43 gallons. In other houses closets supplied with hopper cocks are the chief cause of waste. There are at present about 450 of these in use in the City. In 1891 a test was made on nine of these closets, and applying the results then obtained there would be a waste from this sourse alone of three-quarters of a million gallons per day. During the cold weather an enormous amount of water in the aggregate is allowed to run to prevent pipes freezing. As up to the present there has been no means of accurately measuring the water supplied to the City, this amount cannot be stated in gallons; but the pressure at night at the various permanent gauges throughout the City drops from five to ten pounds below that of the day time. The modern method of controlling waste is to supply each taker through a meter, so that each consumer pays only for the water used. There were on May 1st, 1905, 6,939 service pipes, of which 5 per cent. were metered. In October 1905 when owing to the small rainfall there was danger of the supply becoming exhausted a house to house inspection by the police was ordered, and wherever any leaky fixtures were found the water was turned off and only turned on again when repairs had been made and on payment of a fine. The immediate result of this was a gain of eleven pounds pressure all over the City, notwithstanding there was a loss of about 3¼ pounds owing to the lowness of the lakes. This in conjunction with the fact of the pressure lowering at night would seem to prove conclusively that the waste from the mains bears a very small proportion to that from negligent and wilful waste.

The following table of the data of the consumption of water of eleven cities about the size of Halifax gathered from late reports is here inserted to enable a comparison to be made, and also to shew the effect meters have on the consumption of water. It will be noticed that the average consumption of those cities having over 50 per cent. of their services metered is 41 U. S. gallons, and those under 50 per cent. 91 gallons, or 50 and 197 Imperial gallons per capita respectively:

Town.	Population supplied.	Number of services.	Percentage of services metered.	Miles of pipe.	Consumption. Daily.	Night rate.
Brocton	37,800	......	90	......	36	......
Woonsocket	34,474	......	86.7	......	28	......
Newton	35,400		86	......	54	..
Malden	36,900	6,700	63.4	82.	47	25
Haverhill	37,200	......	10.	....	95	......
Waltham	24,550		6		99	
Quincey	26,800	4,850	3.1	83.7	89	57
Salem	36,250		3		79	
Everett	28,000	4,670	1	42.	81	55
Chelsea	35,000	6,251	2.	38.7	94	65
Halifax	35,400	6,939	5	69.6	260	......

FINANCIAL.

The rates are levied from four sources—meter, fire protection, domestic and special.

The meter rates vary from 15 cents to 7 cents per 1,000 gallons by a sliding scale, depending on the quantity used per day. A meter rental is charged on all meters except those on domestic supply. The consumer pays only for the actual quantity used, and there is no minimum rate for this class of consumer. The fire protection rates are levied on the assessed value of all lands and premises and are paid by all classes of consumers.

The domestic rates are levied on the assessed value of properties and also on the number of fixtures, the minimum rate for fire and domestic purposes being $4.00 where no meter is on the premises.

Water is supplied to the military and naval properties and the Intercolonial Railway under special agreements, in the former cases at so much per fixture and in the latter by actual measurement of water consumed, with a lump sum added for fire protection. No mains are extended in the distribution system unless a bond is executed guaranteeing the interest of 5 per cent. on the actual outlay required. This business-like method of making extensions has been the means of assuring the revenue keeping pace with the expenditure. The following statement shews the amount of the funded debt and annual cost of maintenance in five year periods since the City took over the works ;—

1860	Funded Debt, £	71,900	—The works costing £56,000 paid for this year.
1865	" $	640,000	—N. S. Currency.
1870	"	669,653.33	—Dominion Currency.
1875	"	740,973.33	
1880	"	740,973.33	—Maintenance $55,496.46
1885	"	740,973.33	" 58,605.76
1890	"	633,906.48	" 66,534.96
1895	"	990,266.67	" 65,894.91
1900	"	1,061,000.00	" 69,252.38
1905	"	1,056,600.00	" *83,511.77

*Includes cost of renewing old 3 inch mains with 4 inch mains.

NOTE.—*The Venturi meters having* been set and put in operation during the period between the reading of this paper and its publication the exact consumption has been obtained and this note is added giving the revision of the figures in accordance with the information thus gained. For the 24 hours ending at 1 p. m. on the 6th December, 1906, the following quantity of water passed through the meters :—

Through the 14″ meter 2,291,500 gallons
" 24″ " 4,492,500 "
" 26″ " 4,586,000 "

making a total of 11,370,000 imperial gallons flowing into the City This would give a consumption of 140 gallons per day per consumer on the high and 477 gallons per consumer per day on the low service, or an average of 321 gallons per day per consumer, or taking the whole population of the City, an average consumption of 277 gallons per capita per day. The figures *given in the* body of the paper were conservatively estimated, and while startling enough, were considerably below the actual results, which are unequalled by any other city of which the writer has any knowledge.

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CITY HALL, HALIFAX.