STATISTICS,

TABLES AND WATER RATES

—OF—

CITIES AND TOWNS,

TOGETHER WITH FACTS ABOUT WATER METERS.

COMPILED BY THE

NATIONAL METER COMPANY,

MANUFACTURERS OF THE

CROWN,

EMPIRE AND GEM WATER METERS,

CROWN GAS PUMPS AND GAS ENGINES,

252 Broadway, New York.

NEW YORK:
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1887.

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NATIONAL METER COMPANY.

ORGANIZED JANUARY 5TH, 1870.

President,

JOHN C. KELLEY.

Vice-President,

JOHN GRAHAM.

Treasurer,

JOHN I. HOLLY.

Secretary,

EUGENE PITOU.

TRUSTEES,

JOHN C. KELLEY. DAVID H. GILDERSLEEVE.

JOHN I. HOLLY, EUGENE PITOU,

JOHN GRAHAM.

INTRODUCTORY.

HAVING frequently received inquiries from many of our correspondents for lists of water rates charged in various cities and towns, and for other information in reference to water supply and the use of meters, we have prepared lists and statements of the same, made up from the most reliable data we have been able to procure, and we submit them in the following pages, hoping they will prove interesting and useful to all who are concerned in the great question of Water Supply. We have also introduced evidence establishing beyond question the utility and equity of the Meter System, whether it be applied to large or small cities and towns, managed by either municipalities or private companies, as it reduces the *pro rata* expenses of the Department, effects a large saving of water, and adds largely to the revenue, without increasing the rate or sum required from the water taker or consumer, because it effects a saving in fuel, labor, wear and tear of machinery, and incidental expenses.

NATIONAL METER COMPANY,

JOHN C. KELLEY, PRESIDENT,

252 Broadway, New York.

April, 1887.

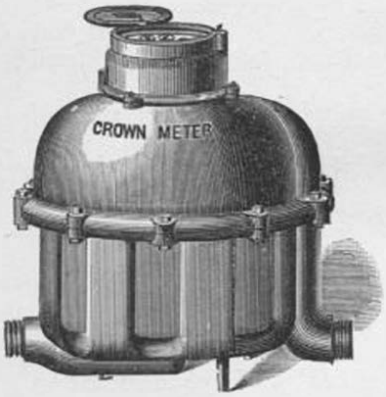
WATER METERS

MANUFACTURED BY THE

NATIONAL METER COMPANY,

252 BROADWAY, NEW YORK.

CROWN.



EMPIRE.

This Meter specially adapted for hot water.

GEM.

APRIL, 1867,

OVER 45,000 METERS MADE AND SOLD TO DATE.

CROWN WATER METER.

The success of the CROWN WATER METER is without a parallel. Put upon the market but little more than five years ago, it is already used and adopted by no less than 400 CITIES AND TOWNS in the United States, the Dominion of Canada, and abroad. No other Water Meter ever made has, in the same length of time, been so widely introduced, shown such favorable results and secured such universal approval.

The Crown Meter is claimed and conceded to be pre-eminently THE BEST WATER METER NOW KNOWN OR IN USE. Its extensive introduction and large popularity are confidently submitted as the best possible guarantee of its commanding superiority in point of efficiency. It is ACCURATE, DURABLE, SIMPLE, COMPACT and INEXPENSIVE—combining, in an eminent degree, all the essentials of the ideal Water Meter—and in its construction no labor or expense has been spared to meet all the requirements of the service.

The Crown Meter is constructed on the positive displacement principle, and has ONLY ONE WORKING PART—a hard rubber rolling piston—rendering it almost, if not entirely, exempt from liability to derangement. It measures equally well on all sized openings, whether the pressure be small or great, and its piston, being perfectly balanced, is almost frictionless in its operation.

Constructed of composition (gun-metal) and hard rubber, the Crown Meter is NOT LIABLE TO CORROSION — as other meters are. An ingenious stuffing-box insures at all times a perfectly dry and legible dial. Special care is bestowed upon the registering mechanism of the Meter; all the gearing of the intermediate is made of a combination of metals unequaled for durability and wear, and inclosed in a case of gun-metal, while every part of the Meter throughout is fashioned and adjusted in the most careful and substantial manner by the most skilled workmen.

Years of exhaustive service in every section of the country have demonstrated the thorough efficiency and absolute superiority of the Crown Meter.

A critical test and comparison of the Crown Meter with other patterns is cordially invited, and to that end Water Departments will be cheerfully furnished, upon application, a one-inch or smaller size, if preferred, to be thoroughly tested for two months, when it may be either paid for or returned free of expense, if not found satisfactory.

For further particulars, address

JOHN C. KELLEY, PRES'T,

NATIONAL METER COMPANY,

252 Broadway, New York.

SIZES, CAPACITIES AND DIMENSIONS OF CROWN METERS.

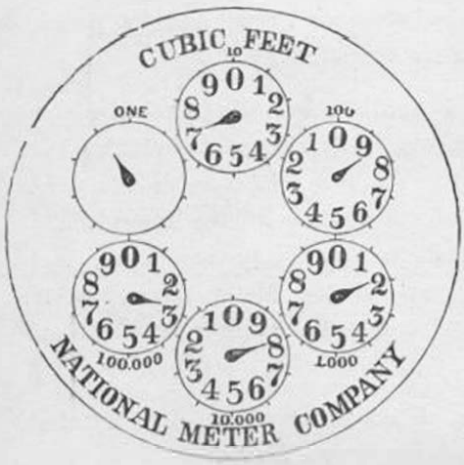
Size.	Greatest proper Quantity, per minute.	Dimensions and Weight. Length.	Height over all.	Width.	Weight, complete.	Weight, boxed.
⅜ inch.	1 cubic foot or 7½ gals.	6 inches.	5⅝ inches.	5 inches.	7½ lbs.	9 lbs.
½ "	2 " " 15 "	7¼ "	7½ "	6½ "	15 "	19 "
¾ "	4 " " 30 "	9 "	9½ "	8½ "	28½ "	35 "
1 "	8 " " 60 "	10⅜ "	10½ "	9½ "	40 "	51 "
1½ "	12 " " 90 "	12⅜ "	12 "	11 "	55 "	70 "
2 "	20 " " 150 "	15½ "	14½ "	12½ "	94½ "	117½ "
3 "	36 " " 270 "	24 "	16 "	15⅝ "	209 "	227 "
4 "	72 " " 540 "	29 "	21½ "	20½ "	427 "	457 "
6 "	120 " " 900 "	36½ "	28½ "	28½ "	940 "	975 "

Connections are made only for the ⅜ inch, ½-inch, ¾-inch and 1-inch sizes, as quoted above. The ⅜-inch, ½-inch, ¾-inch and 1-inch Crown Meters are made with male thread, and the 1½ and 2-inch are made with female thread, all cut to fit standard thread. The larger sizes are made with flanges.

FISH TRAPS are made for the 1½-in., 2-in., 3-in., 4-in. and 6 to 10-in. sizes, and their use is strongly recommended, since they protect the meters from any foreign substance which might destroy the working parts.

N. B.—FOR ECONOMY IN TRANSPORTATION, ⅜-INCH, ½-INCH, ¾-INCH AND 1-INCH METERS ARE PACKED FIVE IN A BOX, WHEN ORDERS WILL ADMIT. SUCH PACKAGES WEIGH RESPECTIVELY 45 LBS., 98 LBS., 172 LBS., 242 LBS.

CROWN METER INDEX.



This engraving shows the Counter of the CROWN METER. It registers cubic feet—one cubic foot being $7\frac{48}{100}$ U. S. gallons and is read in the same way as the counters of gas meters.

The following example and directions may be of service to those unacquainted with the method:

If a pointer be between two figures, the smallest one must always be taken. When the pointer is so near a figure that it seems to indicate that figure exactly, look at the dial next below it in number, and if the pointer there has passed 0, then the count should be read for that figure. Let it be supposed that the pointers stand as in the above engraving, they then read 28,187 cubic feet. The figures are omitted from the dial marked "ONE," because they represent but tenths of one cubic foot, and hence are unimportant. From dial marked "10," we get 7; from the next, marked "100," we get 8; from the next, marked "1,000," we get the figure 1; from the next, marked "10,000," the figure 8; from the next, marked "100,000," the figure 2.

INSTRUCTIONS FOR SETTING THE METER.

In setting a meter in position let it be plumb, and properly secured to remain so. It should be well protected from frost.

If used in connection with a Steam boiler, or under any other conditions where it is exposed to a back pressure of steam or hot water it must be protected by a check valve, placed between the outlet of the meter and the vessel it supplies.

It is absolutely necessary to blow out the supply pipe before setting a new meter, so that if there be any accumulation of sand, gravel, etc., in it, the same may be expelled, and thus prevented from entering the meter. Avoid using red lead in making joints. It is liable to work into the meter and cause much annoyance by clogging the piston.

CROWN METER ILLUSTRATIONS.

Fig. 1.

Fig. 1 is a perspective view of the Meter, showing the index on the top. It is shown here as when placed in position. The proper threads at the inlet and outlet make it easy of attachment to the supply and discharge pipes.

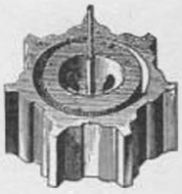


Fig. 2.

Fig. 2 is a view of the hard rubber piston (the only working part of the Meter), with spindle for moving the leather communicating with the intermediate gear, as shown in Fig. 3.

Fig. 3 gives a view of the interior, with the cover (or top of the Meter) thrown back.

The vertical shaft projecting through the orifice in the cover (or cylinder head) of the Meter, is the spindle of the rolling piston (Fig. 2), and imparts motion to the arm, or lever, of the intermediate gear, which is enclosed in the elliptical-shaped case attached to the inside of the cover. This cover (presenting but a comparatively small surface to the water) is the *only* part of the Meter not made of composition.

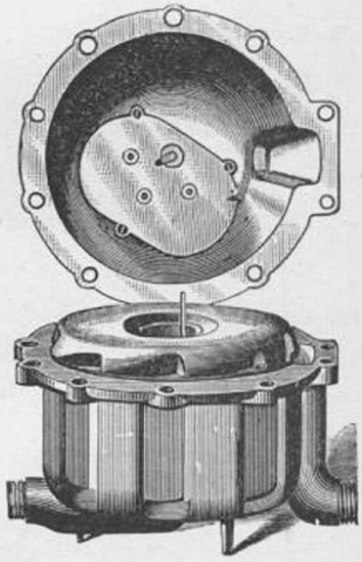


Fig. 3

We would suggest that the "Crown Meter Index" and directions for reading dials (see opposite page), with METER RATES, be printed on back of water bills, and we will be pleased to forward any Department an electrotype of the dial who may desire it.

REFERENCE TO PARTS OF METER.

1. Perspective view of Meter complete.
2. Gives a view of the interior with cover thrown back
3. Cover of meter.
4. Body or cylinder.
5. Head of body or cylinder.
6. Piston, with driving shaft.
7. Counter complete, with dial and hands, and driving gear.
8. Counter, without dial.
9. Cap, with number plate thrown back, which contains the counter.
10. Intermediate train of gears for reducing the speed before connecting with counter.
11. A.—Gear on intermediate shaft for connecting with counter as shown in fig. 10.

    B.—Intermediate packing nut of stuffing-box.

    C.—Jam nut for securing intermediate to cover.
12. Dial or face.
13. Wheel and pinion marked number 2 in counter, fig. 8.

    In ordering parts for counter, order by numbers and letter as shown in view fig. 8.
14. First pinion in counter.
15. Piston shaft complete.
16. Shaft with pinion and driving-arm marked number 1 in intermediate case, fig. 10.

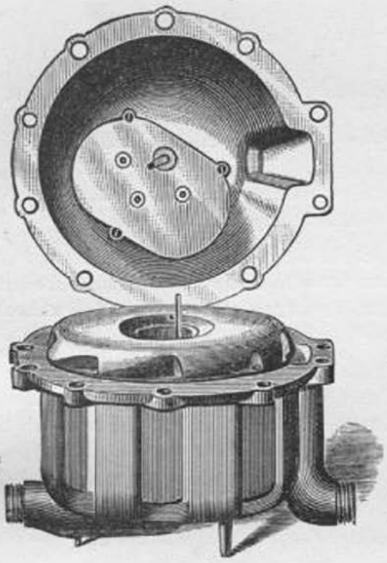
    In ordering parts for Intermediate, order by numbers and letter as shown in view fig. 10.
17. Number plate as shown thrown back on Cap in No. 9.

    The cuts shown on opposite page represent the parts of a ¾-in. Crown Meter.

    The numbers apply to any size meter.

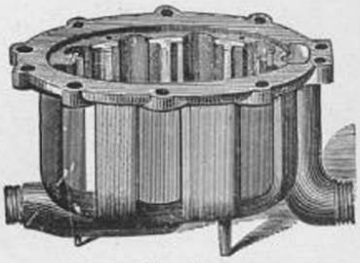
In ordering parts of a Meter, however, it will be necessary to state the Size of the Meter and its Number.

No. 1.



No. 2.

No. 3.



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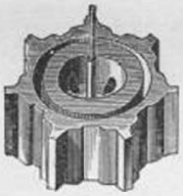

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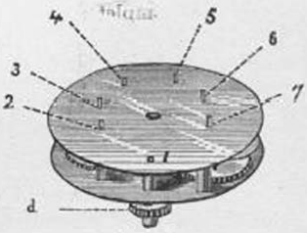
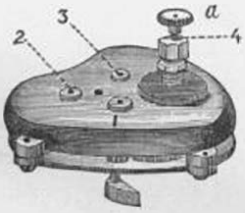
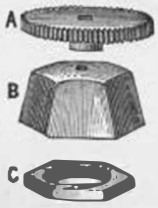


No. 8.

No. 9.



No. 10.



No. 11.

No. 12.

No. 13.

No. 14.

No. 15.

No. 16

No. 17.

DIRECTIONS FOR SETTING WATER METERS.

As used by some of the Largest Departments.

Particular care must be taken to set the meter in a clean and dry location, where the Agent of the Water Department can reach to read it at any time.

In houses where the occupant is obliged to leave the meter locked up while away to his or her work, then the key to the cellar or apartment where the meter is so locked up must be left with some one on or near the premises and the Water Registrar must be notified where it may be found, or a duplicate key must be left at his office.

There must be a stop and waste cock between the meter and the city service pipe, so arranged that the water will drain from the meter and water pipes in the house; this stop must be closed nights when the weather is cold, and all faucets in the sink must be opened to admit air and allow the pipes to empty. These faucets should remain open until such time as the water is turned on again.

Water takers who use meters should be careful to observe if there is any waste of water, and if any leak is found on the pipe or faucets, it should be repaired immediately, as any waste, however small it may appear when running, will look large when found in the bill, and the Water Department has no alternative but to charge for the full amount, whether consumed or wasted.

It would be well for every one to learn to read his meter, and know how much water he is using.

A SIMPLE WAY OF TESTING A METER.

We would recommend that a tank or other vessel holding say 80 gallons, be procured and placed on a suitable scale, then allow sufficient water to pass through the meter to make one revolution of the lowest circle on dial, which on ½ inch is one cubic foot, and on sizes from ¾ to 2 inches both inclusive, 10 cubic feet, and the larger sizes 100 cubic feet; the difference between the reading of meter and actual weight will give the variation of meter.

TABLE

Showing the quantity of water registered by the different size Crown Meters in one revolution of all the circles.

	Cubic Feet.	Number of Gallons calculated at 7.48 gallons per foot.
½ inch.	1 foot to 100,000	748,000
¾ "	10 feet to 1,000,000	7,480,000
1 "	10 " 1,000,000	7,480,000
1½ "	10 " 1,000,000	7,480,000
2 "	10 " 1,000,000	7,480,000
3 "	100 " 10,000,000	74,800,000
4 "	100 " 100,000,000	748,000,000
6 "	100 " 100,000,000	748,000,000

THE GEM METER.

In view of the demand in many instances for an efficient Water Meter of low price, we would call attention to the Gem Meter which we are now making in sizes from 2 inches to 10 inches inclusive. Fifteen years' actual service in different sections of the country is a practical demonstration of the efficiency of the Gem Meter.

It is ACCURATE, DURABLE, SIMPLE and COMPACT.

FIG. 1.

FIG. 3.

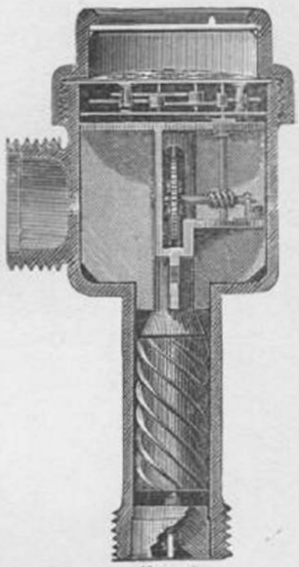


FIG. 2.

Figure 1 is a perspective view of the Meter, showing the index box on the top. It is shown here as when placed in position—the water to enter at the bottom and pass up and out at the side. The proper threads at the inlet and outlet make it easy of attachment to the supply and discharge pipes.

Figure 2 is a sectional view, showing the interior machinery. In the lower part of the cylinder will be seen a propeller made of hardened rubber, with wings so nicely adjusted as to just clear the inner walls of the cylinder, and the material being of about the specific gravity of water, will move as the water moves. Opposite the outlet will be seen the main wheel of the index-box. Each revolution of the propeller causes the wheel to turn, which, being connected with other wheels suitably adjusted for the purpose, will accurately register the number of cubic feet passed through.

Figure 3 shows a sectional view of the wing-piece containing the main wheels for moving the index-hands, and will be readily understood.

GEM METERS.

Size.	Weight of Meter.	Quantity of Water discharged under 60 lbs. pressure
2 inch.	15 lbs.	32 cubic feet or 240 gallons a minute.
3 "	40 "	72 " " 540 " "
4 "	80 "	128 " " 960 " "
6 "	125 "	288 " " 2,160 " "
10 "	400 "	800 " " 6,000 " "

No charge for boxing and shipping.

Connections for Setting furnished without additional charge.

THE "CROWN METER"

AS A

POSITIVE, DISPLACING PISTON, MEASURING DEVICE.

A Demonstration of the Displacing Action of the "Crown" Piston Meter.

BY LEWIS H. NASH, M. E.

The motion of the "Crown" Meter Piston is only a modified form of a rocking piston movement, and it can best be studied by beginning with the simple elementary motion, and then reasoning to the series of rocking motions which go to make up one complete revolution of the "Crown" piston.

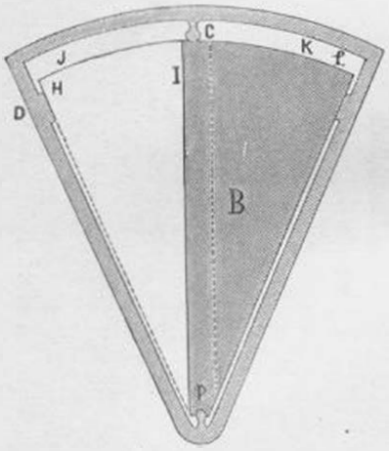


Fig. 1.

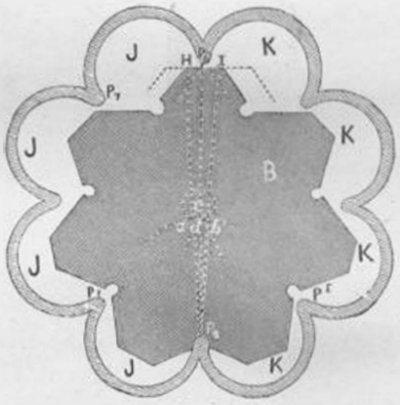


Fig. 2.

Let Fig. 1 represent the section of a swinging piston device, and for convenience we will call the depth one inch. Let *B* be the piston, free to move around a stud *P* as a center, and let the surface *I f* be a portion of a cylinder of which P is the center; let *C* be a projection of the case, making contact with the faces (*f I*). It will now be seen that if the piston rotates from *I* to D, it must of necessity displace a body of water from space *J*, shown by the line (H I P), while, on the other side, space *K* must receive a body of water equal to (*f* C P).

This, therefore, is, without doubt, a displacement meter, and it only remains to be shown that the motion of the "Crown" piston is only a series of such rocking movements.

Now, referring to Fig. 2 we have a body made up of a series of such segmental pistons, capable of rotating about a series of points, P_1, P_2, P_3, &c.

Let (*d*) be the center of the piston (*B*), and *c* the center of the enclosing cylinder.

Then in a complete revolution of *B* around the Points P_1, P_2, &c., of the cylinder, back to its original position, the center *d* of piston B will travel approximately in a circular path around *c* (but really in a series of arcs *a b*.)

The line (P_2 P_6) shows a radial line of piston B. (P_2 II) shows the position this radial line will take when the piston has rocked on to Point (P_1), and (P_2 I) represents the position assumed by the radial line when the piston has rocked on to Point P_3.

The piston now rocks around P_3, making the same movement with regard to P_7 that it made with regard to P_2 and P_6, and so on through a series of rocking motions.

In the movement we are considering, from P_1 to P_3, the spaces J, J, J, &c., have free communication with each other, and hence, for this movement, act as one single space; the same being true of spaces K, K, K, &c.

Hence, in the rocking movement from P_1 to P_3, the radial line will describe the surface (P_2 II I), and the volume discharged will be equal to the area of (P_2 H I) multiplied by the height of the piston, which we have taken at unity for simplicity.

There being n such points, in a complete revolution of the piston we have for the discharge in one revolution of B—

$$V = n\left(\frac{(HI) \times (P_2 H)}{2}\right) \quad (1.)$$

From the similar triangles ($a\ b\ P_2$) and ($H\ I\ P_2$), we have :

$$HI : a\ b : : P_2 H : P_2 a ;$$

and—

$$HI = \frac{(ab) \times (P_2 H)}{(P_2 a)} \quad (2.)$$

but—

$$(ab) = 2 \text{ sin. } \tfrac{1}{2}(acb) \times (ch). \quad (3.)$$

Substituting the value of equation (3) in equation (2), we have :

$$III = \frac{2 (\text{sin. } \tfrac{1}{2} acb) \times (P_2 H) \times (ch)}{P_2 a). \quad (4.)}$$

Substituting the value of III in equation (1), we have :

$$V = n\left(\frac{\text{sin. } \tfrac{1}{2}(acb) \times (P_2 H)^2 \times (ch)}{(P_2 a)}\right) \quad (5.)$$

But in this case $n = 8$, and $a\ c\ b = \frac{1}{8}$ of the circumference of a circle, and

$$\text{Sin. } \tfrac{1}{2}(a\ c\ b) = \text{sin. } (22\tfrac{1}{2})^\circ = .38268.$$

Hence for this case,

$$V = 3.06144\left(\frac{(P_2 H)^2 \times (ch)}{(P_2 a.)}\right) \quad (6.)$$

This figure (Fig. 2) represents the exact motion of the first "Crown" Meter ever made by the National Meter Company, and which they now have in their possession.

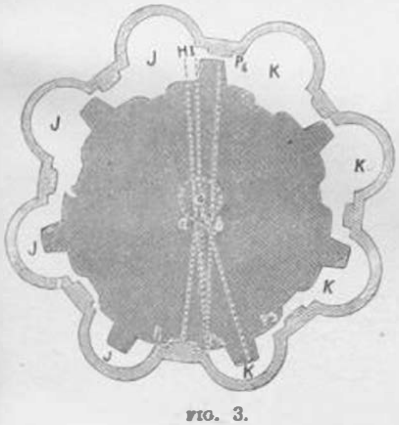


FIG. 3.

Fig. 3 represents the "Crown" piston as now made by the company. It differs from Fig. 2 in that it has 16 bearing points instead of 8.

The radial line ($P_2\ P_6$) does not pass through the center of the piston, but an equal line, P_2 H, passing through the center a will have the same movement, and the space passed over by it will be the same as that passed over by $P_2\ P_6$.

We find that in rocking from P_1 to P_3, the space by P_2 H will be the space H I P_2 as before, but in this case $n = 16$, and $acb = \frac{1}{16}$ of a circumference, hence :

$$\text{sin. } \tfrac{1}{2}(a\ c\ b) = \text{sin. } (11\tfrac{1}{4})^\circ = .19509.$$

Substituting these values in equation (5,)

$$V = 3.12144\left(\frac{(P_2 \times H^2 (cb)}{(P_2 a),}\right)$$

and this multiplied by the height of the piston h.

(7.) $$V = 3.12144 \left(\frac{(P_{\frac{1}{2}} H^2) \times (c\ b)}{(P_{\frac{1}{2}} a),} \right) h.$$

which is the general formula for all Meters like that shown in Fig. 3.

It will be seen that the more bearing points we have, the nearer does the value of our numeral co-efficient approach to the value of $\Pi = 3.1416$, and when the center of the piston travels in a circle, our co-efficient would be Π, and the formula would become

$$V = \frac{\Pi\ (c\ d) \times (P_{\frac{1}{2}} H)^2}{(P_{\frac{1}{2}} a)} h = \text{or,}$$

$$V = \frac{2\ \Pi\ (c\ d) \times (P_{\frac{1}{2}} H)^2}{2\ (P_{\frac{1}{2}} a);} h,$$

but 2 ($P_{\frac{1}{2}}$ a) is the diameter of the rolling circle of the piston, and 2 Π (c d) is the circumference of the circle passed over by the center of the piston, or in other words, the distance traveled by the center of the piston; hence, the general formula for any "Crown" Meter of any number of bearing points would be

(8.) $$V = \frac{(\text{Radial line})^2 \times (\text{Distance traveled by center of piston})}{(\text{Diam. of rolling circle of piston.})} + h.$$

APPLICATION.

To test the formula, Meters in stock were taken off the shelves and accurately measured, and the calculated delivery compared with the record of the test, with the following results:

The dimensions of a half-inch "Crown" Meter are as follows:

$P_{\frac{1}{2}}$ H = 3.82 $\quad ac$ = .245
$P_{\frac{1}{2}}$ a = 1.78 $\quad h$ = 1.49

Substituting in formula (7.)

V = 9.34 cubic inches.

by actual test:

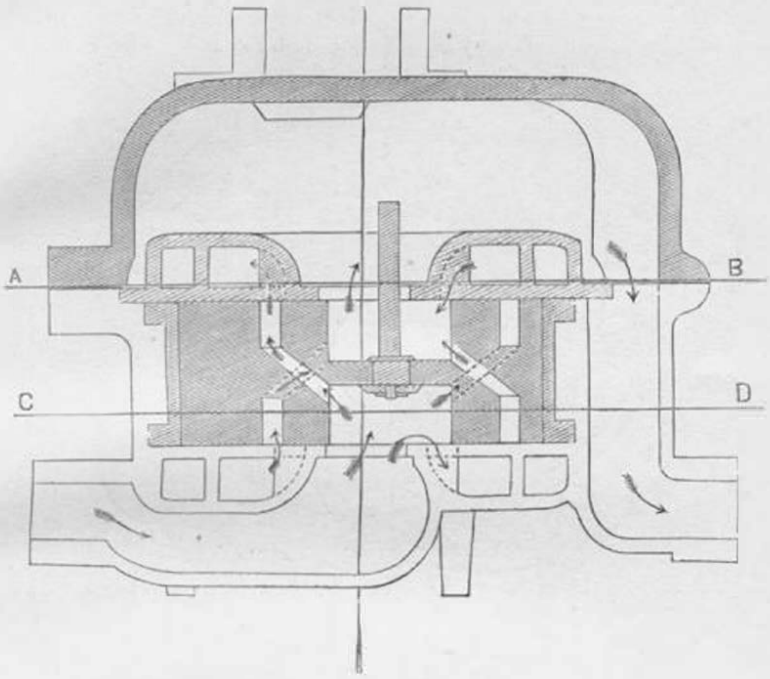
V = 9.40.

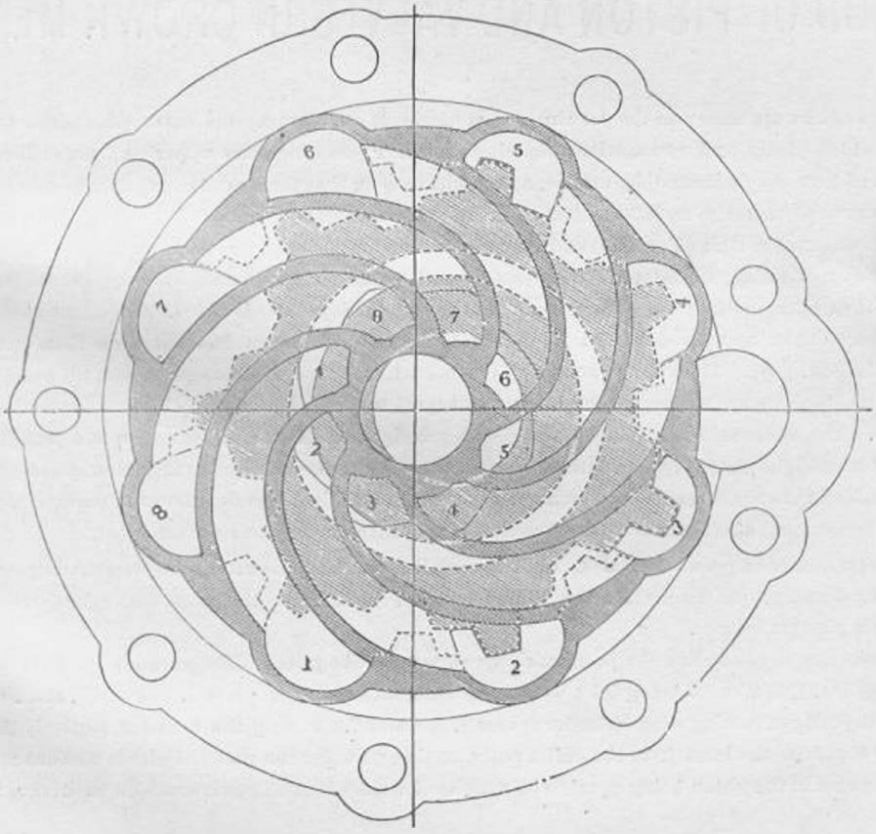
THE 3-4 CROWN METER.

$P_{\frac{1}{2}}$ H = 4.72 $\quad a\ c = \frac{3}{32}$
$P_{\frac{1}{2}}$ a = $2\frac{3}{32}$ $\quad h$ = 2.

Calculated delivery	17.628
By actual test	17.64

Which is as close as calculations for a Plunger Meter will agree.


A
B
C
D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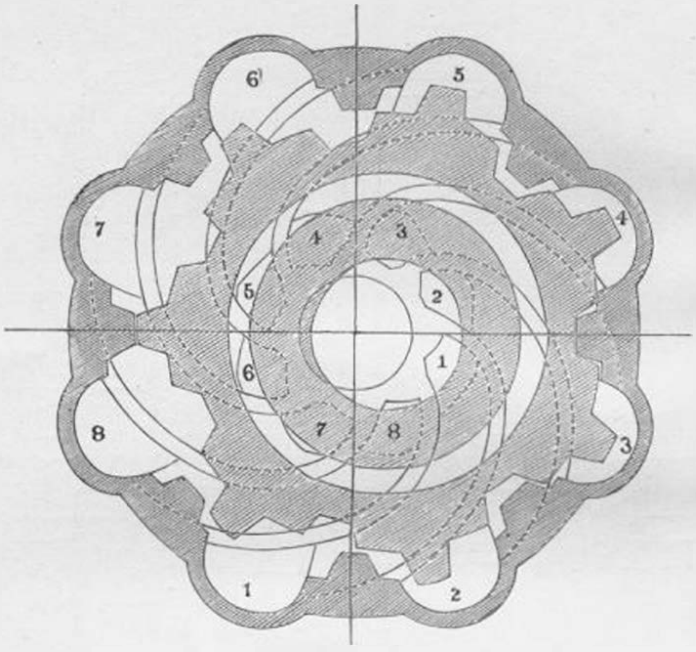

DESCRIPTION OF DRAWINGS ILLUSTRATING

ACTION OF PISTON AND VALVES IN CROWN METER.

Three sections are shown in the drawings—a vertical section, showing the water passages in the meter, the case and the piston, and two sections, showing the water passages in the upper and lower heads. The directions of flow are indicated by arrows, and it will be seen that there are two separate pairs of valves in action all the time—namely, an inlet and an outlet valve acting through passages in the upper head (a section of which is shown at A B), and an inlet and an outlet valve acting through passages in the lower head. Thus there are always three or four inlet and three or four outlet passages open through the upper head, and three or four inlet and three or four outlet passages open through the lower head—shown in sections at C D. The combined area of the inlet ports, open at the same time, in the ½-in. Crown Meter is more than equal to the capacity of a ¾-in. pipe. The valve is simply a D valve such as is in use in plunger meters; is round in form from a necessity of its motion, and slides around from port to port, opening and closing one after another in succession. The meter acts upon the positive piston principle, and is similar in action to a plunger meter, having seven or eight pistons in which three are receiving and three are discharging water at the same time. The Crown Meter, however, has no such complication of parts as the latter device would require. One piston answers for seven and also forms a valve for each. Hence there is only one working part.

The ports and passages are numerous but not complicated. They are arranged symmetrically—each passage leading directly from its port to the cylinder space, the same as the ports and cylinder spaces are connected in plunger meters.

The two cross sections show the position of the valves and the piston. The ports and cylinder spaces are numbered—Nos. 1, 2, 3 and 8 being inlet ports connecting with cylinder spaces 1, 2, 3 and 8, and Nos. 4, 5, 6 and 7 outlet ports connecting with cylinder spaces 4, 5, 6 and 7. Fitting the cylinder perfectly the piston completely separates the inlet from the outlet ports, so that no water can pass the piston without moving it. The driving area of the piston being equal to its cross section there is great power available in driving it ahead.

TESTS OF ACCURACY AND DURABILITY.

DEPARTMENT OF PUBLIC WORKS, CHIEF-ENGINEER'S OFFICE, CITY HALL,
NEW YORK, February 27, 1879.

G. W. BIRDSALL, Esq., First Assistant Engineer in Charge of Bureau.

DEAR SIR: In accordance with your instructions, I yesterday tested the ¾-in. Rotary Piston "Crown" Meter (No. 2915), presented by Mr. J. C. Kelley, President of the National Meter Company, and append the following statement:

DURATION OF TEST.		INDEX.	FEET REGISTERED.	FEET RUN.	PRESSURE.		DISCHARGE.
HOURS.	MINUTES.				MAIN.	BACK.	
.....	.....	25	.....	.....	.....	.....	.....
1	5	127	102	100	25	5	Full.
.....	32	178	51	50	25	5	"
.....	32	228	50.5	50	25	5	"
1	36	381	152.5	150	25	5	"
.....	33	391	10	10	25	25	1-8
.....	*20	392	7¾ gallons in 20 minutes	.....	.....	.....	1-16
.....	* 7	.....	1 " 7 "	.....	.....	.....	1-32
.....	*14	.....	1 " 14 "	.....	.....	.....	1-50
.....	*29	.....	1 " 29 "	.....	.....	.....	1-100

Respectfully, JOHN E. McKAY, ASSISTANT ENGINEER.

DEPARTMENT OF PUBLIC WORKS, CHIEF-ENGINEER'S OFFICE, CITY HALL,
NEW YORK, April 24, 1879.

G. W. BIRDSALL, Esq., First Assistant Engineer in Charge of Bureau.

DEAR SIR: In accordance with your directions, on March 14th I had the National Meter Company's ¾-in. Rotary Piston "Crown" Meter (No. 2915) connected with the water-main at the pipe yard, for the purpose of testing the meter in regard to durability. When the meter was started running on March 14th, the index stood at 760 cubit feet, and it was allowed to run continuously until the 23d of April, when the water was shut off it. The index then stood at 101,782, having run 100,972 cubic feet. The meter was then connected with the tank for the purpose of testing it with regard to accuracy of measurement. Annexed is a statement of the different tests that were made:

DURATION OF TEST		INDEX.	FEET REGISTERED.	FEET RUN.	PRESSURE.		DISCHARGE.
HOURS.	MINUTES.				MAIN.	BACK.	
.....	.....	101,744	.....	.....	.....	.....	.....
.....	59	101,846	102	100	27	5	Full.
.....	32	101,896.5	50.5	50	27	5	"
.....	29	101,947	50.5	50	28	5	"
1	43	101,977.6	30.6	30	28	28	1-8
		The pressure on the following was 29 lbs.:					
.....	*20	7.8 gallons in 20 minutes	.....	.....	.....	.....	1-16
.....	* 6	1 " 6 "	.....	.....	.....	.....	1-32
.....	*13	1 " 13 "	.....	.....	.....	.....	1-50
.....	*26	1 " 26 "	.....	.....	.....	.....	1-100

[*Tests made to ascertain how small a stream the meter would register.]

After the above tests were made, the meter was disconnected and taken apart, and upon examination of the different parts carefully, no signs of wear could be discovered, but they appeared in as good condition as when first started.

Respectfully, JOHN E. McKAY, ASSISTANT ENGINEER.

January 1, 1887, *New York has in service* 7,731 *Meters.*

FACTS ABOUT THE CROWN METER.

Test of ¾-inch "Crown" Meter, No. 2,962, for Accuracy, at Providence (R. I.) Water Works, July 17, 1879.

Cubic Feet Run.	Pounds Run.	Size of Outlet.	Percentage, More or Less	Cubic Feet Run.	Gallons Run.
10	635	½ inch	+ 1.9		
10	631	¼ "	+ 1.3		
5	315.5	⅛ "	+ 1.3		
10	631	1/16 "	+ 1.3		
5	326.5	1/32 "	+ 4.6		
*10	633.5	⅛ "	+ 1.7		
* Opened and shut 100 times while running last 10 feet. Set at Hope Station, outlet ¼ inch.					
July 24, 1879, reading			000,165 ft.		
Oct. 16, 1879, "			114,293 "	114,128	855,960
DISCONNECTED TO TEST FOR ACCURACY.					
10	641.5	½ inch	+ 2.9		
10	635	¼ "	+ 1.9		
5	317	⅛ "	+ 1.8		
2	126	1/16 "	+ 1.3		
2	133	1/32 "	+ 6.4		
*10	634.5	⅛ "	+ 1.9		
* Opened and shut 100 times while running last 10 feet. Reset at Hope Station.					
October 30, 1879, reading			114,384 ft.		
June 23, 1880, "			233,081 "	118,697	890,227.5
				232.825	1,746,187.5
DISCONNECTED TO TEST FOR ACCURACY.					
10	644	½ inch	+ 3.3		
10	637	¼ "	+ 2.2		
5	319	⅛ "	+ 2.4		
2	127.5	1/16 "	+ 2.3		
2	137.5	1/32 "	+ 9.4		
*10	641	⅛ "	+ 2.9		
* Opened and shut 100 times while running last 10 feet.					
At the completion of the durability test, the meter was found to register about 70 per cent on a 1/16 inch outlet.					

BOARD OF WATER COMMISSIONERS, CITY HALL,
PROVIDENCE, R. I., October 27, 1880.

Mr. JOHN C. KELLEY, *President National Meter Company.*

DEAR SIR: Please send us twenty-five ¾-inch, five 1-inch, and one 1-inch "Crown" Water Meters as soon as possible.

Very respectfully,

CLINTON D. SELLEW, Secretary.

Jan'y 1, 1887, Providence has in service 3,226 "Crown" Meters.

TESTS IN
BOSTON, MASS., CHARLESTOWN DISTRICT.

Test of ½ inch "Crown" Meter, No. 3,273, for Accuracy, at Mystic Water Works, March 1, 1880.

Water Pressure.	Time. Hrs.	Mins.	Secs.	Size of Outlet.	Water Delivered.	Water Registered.	Back Pressure.
45 lbs.	00	09	35	1 Inch.	20 Feet.	20 $\frac{15}{100}$ Feet.	
46 "	00	11	55	$\frac{3}{4}$ "	20 "	20 $\frac{15}{100}$ "	
46½ "	00	15	20	$\frac{1}{2}$ "	20 "	20 $\frac{15}{100}$ "	
47 "	00	32	25	$\frac{3}{8}$ "	20 "	20 $\frac{15}{100}$ "	
48 "	01	37	30	$\frac{1}{4}$ "	20 "	20 $\frac{10}{100}$ "	
47 "	07	34	30	$\frac{1}{8}$ "	20 "	19 $\frac{75}{100}$ "	

Test of same Meter, same Runs, with Open Nozzle.

Water Pressure.	Time. Hrs.	Mins.	Secs.	Size of Outlet.	Water Delivered.	Water Registered.	Open Nozzle.
45 lbs.	00	09	30	1 Inch.	20 Feet.	20 $\frac{15}{100}$ Feet.	
45 "	00	11	40	$\frac{3}{4}$ "	20 "	20 $\frac{15}{100}$ "	
45 "	00	15	00	$\frac{1}{2}$ "	20 "	20 $\frac{15}{100}$ "	
46 "	00	31	18	$\frac{3}{8}$ "	20 "	20 $\frac{15}{100}$ "	
46 "	01	36	30	$\frac{1}{4}$ "	20 "	20 $\frac{15}{100}$ "	
46 "	07	38	30	$\frac{1}{8}$ "	20 "	19 $\frac{75}{100}$ "	

Run of 1,861 feet in 8 hours, 45 minutes; water delivered on test 20 feet, registered 20 $\frac{15}{100}$ feet.
Run of 1,135 feet in 7 hours, 28 minutes; water delivered on test 20 feet, registered 20 $\frac{15}{100}$ feet.

CHARLES H. BIGELOW,

ATTEST.

Superintendent Mystic Water Works.

Boston, January, 1887, has in service 1,585 "Crown" Meters.

TEST OF THE QUANTITY OF WATER RUN THROUGH 1/2-IN. CROWN METER, NO. 44,669, ON MARCH 14, 1887.

Size of Openings.	No. of Pounds.	No. of Cubic Feet.	No. of Cubic Feet per Minute.	Time.	Pressure.
Full.	876	14	2.8	5 minutes.	40 Lbs.
1 Inch.	711	11.4	2.3	5 "	40 "
$\frac{3}{4}$ "	564	9	1.8	5 "	40 "
$\frac{1}{2}$ "	287	4.6	$\cdot\frac{92}{100}$	5 "	41 "
$\frac{3}{8}$ "	174½	2.$\frac{86}{100}$	$\cdot\frac{69}{100}$	5 "	42½ "
$\frac{1}{4}$ "	77	1.$\frac{23}{100}$	$\cdot\frac{46}{100}$	5 "	43½ "
$\frac{1}{8}$ "	30	$\cdot\frac{92}{100}$	$\cdot\frac{18}{100}$	5 "	44 "
$\frac{1}{16}$ "	5	$\cdot\frac{15}{100}$		5 "	44 "
$\frac{1}{32}$ "	2½	$\cdot\frac{8}{100}$		5 "	45 "
$\frac{1}{50}$ "					

This test was made at our manufactory through a 2-inch pipe reduced to ½-inch, and the water weighed. The first test, or full stream, was with the 1-inch pipe full open; the ¾-inch, and other following tests, were made by placing a ½-inch, and other size reducers, on the end of the outlet pipes.

OFFICIAL RECORD OF CROWN METER, 9722,

Set at Works of Roxbury Gas Light Co., Boston, Mass.,

Taken from the Books in the Water Department, Boston, Mass.

		Cubic Feet.
October 23,	1882	0 Set
" 26,		3,432
November 25,		55,421
December 19,		86,550
January 22,	1883	142,619
February 28,		203,217
March 16,		229,153
April 21,		287,644
May 21,		337,081
June 21,		381,260
July 20,		381,420
August 22,		381,420
September 21,		381,420
October 17,		388,417
November 26,		400,337
December 27,		412,176
January 26,	1884	423,473
March 1,		435,168
" 26,		443,888
April 30		458,944
May 29,		472,095
June 28,		485,299
July 31,		501,680
September 1,		517,667
" 29,		530,876
November 3,		544,612
December 1,		569,660
" 29,		595,502
February 17,	1885	636,837
March 18,		660,695
April 17,		684,828
May 15,		708,386
June 16,		738,305
July 20,		778,452
August 28,		831,522
September 18,		857,012
October 16,		891,978
November 19,		929,513
December 16,		963,801
January 15,	1886	1,001,660
February 15,		1,039,811
March 12,		1,070,318
April 7,		1,103,066
May 18,		1,154,712
June 5,		1,176,918
July 6,		1,214,916
August 19,		1,240,954
September 6,		1,251,141
October 5,		1,267,089
November 5,		1,299,231
December 4,		1,329,245
January 7,	1887	1,364,307
February 5,		1,393,288
March 4,		1,420,641

This meter has averaged 204,900 gallons per month.

BOSTON, MASS., March 19, 1887.

HORACE T. ROCKWELL, Esq., Chairman Boston Water Board.

DEAR SIR: Will you have the kindness to inform us whether the accompanying memorandum of readings of ¾-in. Crown Meter, No. 9722, as shown by the books of the Water Department—the same aggregating 1,420,641 cubic feet—is correct? By so doing you will oblige

Yours truly,

CHAS. H. BALDWIN, Representative of Nat. Meter Co., New York.

OFFICE BOSTON WATER BOARD,
BOSTON, March 19, 1887.

MR. C. H. BALDWIN.

DEAR SIR: In reply to your note of this date, I have to reply that the record of the Department shows the result named.

Yours truly,

H. T. ROCKWELL, Chairman.

OFFICE ROXBURY GAS LIGHT COMPANY, 39 DUDLEY STREET,
BOSTON, MASS., March 11, 1887.

This is to certify that ¾-inch CROWN METER, No. 9722, set at the works of this Company in October, 1882, by the Water Department of this City, has given us no trouble from any cause, and has never cost us one cent for repairs. It has never been removed from its original position until the present week, when it was taken out for testing at the request of Mr. Charles H. Baldwin, representative of the NATIONAL METER COMPANY of NEW YORK.

It has registered during its service 1,420,641 cubic feet, or 10,654,807 gallons.

T. J. PISHON, Supt.

The above Crown Meter, No. 9722, was tested by weight in March, 1887, on streams up to and including ¼ inch, with a variation of less than 8%. This meter can be placed in as good condition as at first at a cost not to exceed $3.00

DURABILITY.

THE NUMBER OF CROWN METERS THAT HAVE REGISTERED 100,000 CUBIC FEET, AND OVER, AT THE COCHITUATE AND MYSTIC DEPARTMENTS OF THE BOSTON, MASS., WATER WORKS, MARCH, 1887.

Size of Meters.	100,000 to 200,000 Cubic Feet.	200,000 to 300,000 Cubic Feet.	300,000 to 400,000 Cubic Feet.	400,000 to 500,000 Cubic Feet.	500,000 to 600,000 Cubic Feet.	600,000 to 700,000 Cubic Feet.	700,000 to 800,000 Cubic Feet.	800,000 to 900,000 Cubic Feet.	900,000 to 1,000,000 Cubic Feet.	1,000,000 to 1,500,000 Cubic Feet.	1,500,000 to 2,000,000 Cubic Feet.	2,000,000 to 2,500,000 Cubic Feet.	* One ½ inch Crown Meter, No. 9722, registered from October, 1882, until March, 1887, 1,420,641 cubic feet, or 10,654,807 gallons.
½ or ⅝-inch.	263	101	40	16	7	1	4	2					
¾ "	35	15	9	1	3		1						
1 "	28	18	14	11	1	9	5	5	2	3	2	1	1—One inch Meter 3,515,053 cubic feet.
	100,000 to 500,000 Cubic Feet.	500,000 to 1,000,000 Cubic Feet.	1,000,000 to 1,500,000 Cubic Feet.	1,500,000 to 2,000,000 Cubic Feet.	1,000,000 to 2,000,000 Cubic Feet.	2,000,000 to 2,500,000 Cubic Feet.	2,000,000 to 3,000,000 Cubic Feet.	2,500,000 to 3,000,000 Cubic Feet.	3,000,000 to 3,500,000 Cubic Feet.	3,000,000 to 4,000,000 Cubic Feet.	5,000,000 to 6,000,000 Cubic Feet.	6,000,000 to 7,000,000 Cubic Feet.	7,000,000 to 8,000,000 Cubic Feet.
1½ "	14	2	3	1				3		1			
2 "	13	4	2	1				1	1	1			
3 "		9		8	3		3		1	1		1	1
4 "		2	4	4		2			1	1		1	
6 "											1	2	

701 Crown Meters that have registered over 100,000 to 8,000,000 cubic feet from January, 1881, to March, 1887—6 years.

* The ½-inch Crown Meter, No. 9722, which has registered 10,654,807 gallons in 52 months, is on exhibition at the Office of the National Meter Company, the Company presenting the Gas Company a new meter for it.

TESTIMONIALS.

DEPARTMENT OF PUBLIC WORKS,
CHIEF-ENGINEER'S OFFICE,
NEW YORK, August 12, 1886.

NATIONAL METER COMPANY.

GENTLEMEN: Having for the past six years used the Crown Meter and thoroughly tested same before recommending its use by the City of New York, I hereby testify, that it has always given satisfaction, and has been the means of educating the consumers in the economical use of water. 7,500 now in use in the City of New York. Respectfully yours,

G. W. BIRDSALL, Chief-Engineer, Croton Aqt.

January, 1887, New York has in service 7,728 "Crown" Meters.

DEPARTMENT OF PUBLIC WORKS,
CITY ENGINEER'S OFFICE, CITY HALL,
PROVIDENCE, R. I., April 13, 1883.

JOHN C. KELLEY, Esq., *President National Meter Company, New York.*

DEAR SIR: In reply to yours of the 7th inst. I would say, I tried to write something for the "Crown" Meter in my annual report, but concluded that the figures showing its continued use and the small number of repairs were more of a recommendation than could be properly expressed in writing.

Yours truly,

SAMUEL M. GRAY, City Engineer.

We have sold and delivered to the City of Providence 1,183 "Crown" Meters.

CITY ENGINEER'S OFFICE, CITY HALL,
PROVIDENCE, R. I., March 17, 1887.

JOHN C. KELLEY, Esq., *President National Meter Company, New York.*

DEAR SIR: In reply to your favor I have to say, that I consider your meter, the CROWN, the BEST IN THE MARKET. Our long-continued use of it confirms my good opinion of the meter.

Yours respectfully,

SAMUEL M. GRAY, City Engineer.

March 1, 1887, Providence has in service 3,381 "Crown" Meters.

PHILADELPHIA WATER DEPARTMENT,
PHILADELPHIA, August 25, 1886.

MR. JOHN C. KELLEY, *President National Meter Company.*

SIR: Yours of the 19th requesting endorsement of Crown Meter, etc., is received.

Philadelphia has 260 Crown meters in use. They have given general satisfaction for accuracy, and will run well under light or heavy pressure.

Under a light pressure consumers complain that they obstruct the flow, but this objection applies to all meters, that have been used by this department. Respectfully,

JOHN L. OGDEN, Chief-Eng.

LOWELL WATER WORKS, SUPERINTENDENT'S OFFICE, CITY HALL,
LOWELL, MASS., March 16, 1887.

JOHN C. KELLEY, Esq., *President National Meter Company.*

DEAR SIR: Yours of the 12th inst. is at hand, and in answer I have to say that we have 196 Crown Meters in use here January 1, 1887, of the following sizes: 67 ¾-inch, 94 ¾-inch, 32 1-inch, 2 2-inch, and 1 4 inch. Our first Crown Meter was set, March 27, 1882, and has run up to March 3, 1887, 148,500 cubic feet of water without any perceptible wear, and the only repairs which have ever been needed to any Crown Meter (except several cases of freezing) was a new piston to the 4-inch meter, which broke on account of not having a fish trap connected with it, and I think we have no Crown Meter running to-day, but what is registering as accurate as when it was first set.

As regards the cost of setting meters, it depends largely on the place and position, but I think there is no meter that can be set any cheaper than the Crown. Yours truly,

H. G. HOLDEN, Supt.

January 1, 1887, Lowell has in service 196 "Crown" Meters.

JOHN C. KELLEY, *President National Meter Company, New York.*

PAWTUCKET WATER WORKS,
PAWTUCKET, R. I., June 10, 1881.

DEAR SIR: Our experience with the "Crown" Meter has been perfectly satisfactory.

We believe it to be one of the best meters in use. We find it to cost less for repairs in case of frost than any we are acquainted with, and I am fully convinced that the only true way to sell water is by meter. My experience is that when I became connected with our Water Works, April 2, 1879, we were pumping 700,000 gallons of water per day, and were receiving a revenue of $15,000 per year, with 884 services and 317 meters. Now we have 2,200 services, and over 1,200 meters—yet we are not pumping 1,000,000 gallons daily and are in receipt of from $40,000 to $45,000 revenue. This proves to my mind that the use of meters prevents the excessive waste of water and increases the revenue to the extent that would warrant the furnishing of meters to the consumers at the expense of the town or city, for family purposes, as we do here.

Very respectfully yours,
EDWIN DARLING, Superintendent.

Pawtucket has in service 798 "Crown" Meters.

PAWTUCKET WATER WORKS, COMMISSIONER'S OFFICE,
PAWTUCKET, R. I., August 9, 1886.

NATIONAL METER COMPANY.

GENTLEMEN: The Crown Meters used in connection with the Pawtucket Water Works are giving the best satisfaction of any kind we have tried on the Works.

They were first introduced in 1879, with other style of meters.

We have now about 1,700 in use, and are adding no other kind.

The cost of keeping in repair is in favor of the Crown every time, and we are buying no others.

Yours with respect,
EDWIN DARLING, Supt.

January, 1887, Pawtucket has in service 1,716 "Crown" Meters.

OFFICE OF THE WATUPPA WATER BOARD,
FALL RIVER, MASS., February 20, 1883.

JOHN C. KELLEY, Esq., *President, 51 Chambers Street, New York.*

DEAR SIR: Yours of yesterday, asking how I like the "Crown" Meter, is at hand, and it gives me pleasure to say that I like it so well that I have adopted it for general use, and am taking out all our other meters as fast as possible, and replacing them with the "Crown." Send me 25 ¾-inch "Crown," with couplings, the first of next month, to commence the season with.

Very truly yours,
A. R. MARTINE, Eng. and Supt.

Fall River has in service 408 'Crown' Meters.

OFFICE OF WATUPPA WATER BOARD,
FALL RIVER, MASS., August 9, 1886.

JOHN C. KELLEY, Esq., *President National Meter Company, New York.*

DEAR SIR: Yours of the 6th inst., asking how we like the Crown Meter, is at hand. It gives me pleasure to say we like it better than any other meter we have had anything to do with. We have in use five other kinds, which we had before we commenced using the Crown Meter six years ago. Of the twenty-six hundred and seventy-five (2,675) meters that we have in use to-day, thirteen hundred and sixty-seven (1,367) are of the Crown pattern.

This is the only meter that we now allow to be put in.

The cost of its maintenance is very small, and it is the most accurate meter on large and small streams that we have in use. We have replaced ninety-two (92) meters of other kinds with Crown Meters since the first of the year, and expect to replace a good many more before the year is ended.

Very respectfully,
PATRICK KIERAN, Supt. Fall River Water Works.

January, 1887, Fall River has in service 1,824 "Crown" Meters.

EXECUTIVE BOARD OF THE CITY OF ROCHESTER,
ROCHESTER, N. Y., May 18, 1880.

JOHN C. KELLEY, Esq., *President National Meter Company.*

DEAR SIR: We now have in use in this city in connection with our Water Works quite a number of your "Crown" Meters, and they are fast becoming a favorite with us. They register with great accuracy both large and small streams, and in an experience of many months none of them has required repairs. So far as our experience extends, I think the "Crown" Meter has no superior. Please send us six ¾-inch and three ¾-inch "Crown" Meters at your earliest convenience.

Yours,
J. NELSON TUBBS, Chief-Engineer.

EXECUTIVE BOARD OF THE CITY OF ROCHESTER,
ROCHESTER, N. Y., Oct. 10, 1881.

JOHN C. KELLEY, Esq., *President National Meter Company.*

DEAR SIR: In February, 1879, this Department ordered one of your "Crown" Meters for trial. This meter was put in actual service and its operations pleased the Department so well that we have continued to order and set them ever since.

Our orders for the various sizes now amount to 222. They have given very excellent satisfaction. We find them accurate in their registration, and very durable, requiring few repairs. The amount paid for repairs on all the "Crown" Meters so far used by us has been $21.60, and most of these repairs became necessary by reason of being set in exposed situations where they were frozen up. We think very highly of the "Crown" Meter, and expect to continue to be large purchasers of these meters.

Respectfully yours,
J. NELSON TUBBS, Chief-Engineer Water Works.

Rochester has in service 587 "Crown" Meters.

EXECUTIVE BOARD, HIGHWAY, FIRE AND WATER COMMISSIONERS' OFFICE, CITY HALL,
ROCHESTER, NEW YORK, December 2, 1886.

NATIONAL METER COMPANY.

GENTLEMEN: The Water Department of this City commenced using your Crown Meters in 1879. They have now in use between 800 and 900. They have given us excellent satisfaction. They have proved more durable under the conditions in which they are used here than any others which we have tested, and have cost much less for repairs. In accuracy of registration they have also proved entirely satisfactory.

Respectfully yours,
J. NELSON TUBBS, Chief Engineer Water Works.

January, 1887, Rochester has in service 842 "Crown" Meters.

OFFICE OF CORNING WATER WORKS,
CORNING, N. Y., May 22, 1880.

NATIONAL METER COMPANY.

GENTLEMEN: You may forward to us one 1-inch and one ¾-inch "Crown" Meters.

We have just completed a series of experiments with the ¾-inch "Crown" Meter, No. 3,300, sent us March 22, 1880, and find the same to register accurately on streams running through orifices $\frac{1}{2}$, $\frac{5}{8}$, $\frac{7}{8}$ and $\frac{1}{10}$ inches in diameter, the discs used bearing the stamp of the Brown & Sharpe Manufacturing Co. of Providence, R. I.

Other tests were also made, and all found entirely satisfactory.

H. C. HEERMANS, Supt.

CORNING WATER WORKS,
HEERMANS & LAWRENCE, Proprietors,
CORNING, N. Y., February 16, 1887.

NATIONAL METER COMPANY.

GENTS: We still like the "Crown" Meter the best of any meter we have tried. We have used the Crown, Empire, Gem, Worthington, Union, Rotary, Ball & Fitz, Thomson. We have 31 meters in use, of which 26 are Crowns.

Yours, etc.,
HEERMANS & LAWRENCE.

Order for 1,000 Meters:

CITY OF NEWTON, WATER DEPARTMENT,
WEST NEWTON, MASS., August 9, 1886.

THE NATIONAL METER COMPANY, 252 *Broadway, New York City.*

GENTLEMEN: I am instructed by our Water Board to send you an order for *one thousand* half-inch composition Crown Water Meters and connections therefor. We wish the meters to be shipped to us as follows: 125 in August; 125 in September; 125 in October; 125 in November; 125 in December, and the balance of the order, 375, in January, 1887.

Very truly,
ALBERT S. GLOVER, Clerk Newton Water Board.

KANSAS CITY, Mo., February 21, 1883.

NATIONAL METER COMPANY.

GENTLEMEN: Yours of the 14th inst. at hand, inquiring how we like the "Crown" Meters. In reply would say, that we began using them nearly a year ago, and from that time have set a large number of the various sizes, every one of which has worked perfectly. Previous to this, we tried almost every kind of meter that came to our notice, but none of them worked to our satisfaction, many breaking under our extreme pressure, and others sticking and requiring considerable repairs. Have had no trouble whatever with the "Crown," and no repairs, and believe it is all that you claim for it. We are buying no others.

Yours respectfully,
NATIONAL WATER WORKS Co.,
by FRED WING, Cashier.

OFFICE OF THE NATIONAL WATER WORKS COMPANY,
KANSAS CITY, Mo., August 16, 1886.

JOHN C. KELLEY, Esq., *President National Meter Company, New York.*

DEAR SIR: In reply to your favor of the 7th inst, I beg to say, that we have been using meters of various kinds for some years and are increasing the number rapidly, and as a matter of course have felt interested in investigating the merits of the various meters used.

So far as our investigation has been made we incline to the Crown, as the simplest, cheapest, and the least likely to give us annoyance. We have not kept up closely enough with the comparative cost of repairs, but in a general way our meter man is satisfied that the Crown suits our purpose best, all things considered and we expect to continue their use in preference to any other now known to us.

NATIONAL WATER WORKS COMPANY,
B. F. JONES, Supt.

January, 1887, Kansas City, has in service 518 "Crown" Meters.

THE ST. JOSEPH WATER COMPANY, 105 North Third St.,
ST. JOSEPH, Mo., August 23, 1886.

NATIONAL METER COMPANY, *No. 252 Broadway, N. Y.*

GENTLEMEN: Herewith find exchange in payment of enclosed voucher, which you will please receipt and return to me.

Referring to your favor of the 7th inst. in which you ask me to submit to you, in writing, my opinion of the merits of the Crown Water Meter, said opinion being based upon actual experience. I have to say in March, 1883, I tried my first Crown Meter, and so well was I pleased that I replaced the Worthington Meters that I had in use with the Crown. Since making the change I have used Crown meters exclusively. The Worthington I found expensive, both because it did not register all the water consumed but also because of the repairs I found necessary to be made. I have also tried the "Undine Union" and "Worthington Improved" meters, but find they are not so satisfactory as the Crown.

The water here is under a heavy pressure and contains fine sand, so while the Crown Meter is better adapted for our service, yet one of the above meters might give equal satisfaction, where the conditions are different.

The value of water meters arises, not so much from the increase of revenue as that they prevent waste. And since the expenditure of fuel and the wear and tear of machinery are directly proportionate to the pumpage, and have no relation to the legitimate consumption or wastage of water after delivery, so is the meter to that extent an advantage.

That there will be repairs after a few years to prevent water passing through the meter without being registered, and especially in water that has a sediment of sand, cannot be denied. But notwithstanding all that, experience has convinced me that the use of the meter is necessary in cases where the opportunity exists of wasting considerable water. Very truly yours,

LEWIS C. BURNES, Sec'y.

January, 1887, St. Joseph has in service 104 "Crown" Meters.

HACKENSACK WATER COMPANY, REORGANIZED,
CHAS. B. BRUSH, Chief-Eng. and Superintendent,
No. 15 NEWARK ST., HOBOKEN, N. J., August 17, 1886.

NATIONAL METER COMPANY, 252 *Broadway, New York City.*

GENTLEMEN: In reply to your request as to the opinion that this Company holds of the Crown Meter, I would say that we commenced introducing them on our work in October, 1882, and now have 1,217 in operation. We are well satisfied with them, and are continually attaching new meters to our service-pipes.

Respectfully submitted,

CHAS. B. BRUSH, Chief-Eng

January, 1887, Hackensack Water Co. has in service 1,329 "Crown" Meters.

WATER COMMISSIONER'S OFFICE,
DEPARTMENT PUBLIC WORKS AND SEWERS,
POUGHKEEPSIE, N. Y., October 29, 1886.

MR. JOHN C. KELLEY, *President National Meter Company, New York, N. Y.*

DEAR SIR: In response to your request, for the result of my experience with the Crown Meter, I will say that in the Fall of 1882, a duplex piston meter, on a domestic service in this city, occasioned much annoyance by stopping on the center, permitting no water to pass, and endangering the boiler. It was removed and replaced by another with no better result.

A half-inch Crown Meter having been sent here for trial, I had it placed on this service, as an experiment, on the 28th of November of that year, and it is still there, having never been obstructed from any cause, or failed to register, or require any attention or repair whatever.

The success of this meter led to the purchase of others—like success attending their use—until during the two years last past no others have been purchased for this department, save a few of your Empire Meters. We now have about two hundred and thirty Crown Meters in use, of sizes from ¾ to 3 inch, every one of which has thus far given excellent satisfaction, as regard both accuracy of registration and freedom from derangement.

I have no hesitation in saying, that for the water-service of this city, I now regard the Crown Meter as the best known to me. Yours very truly,

CHAS E FOWLER, C. E., Supt. Water Works and Sewers.

January, 1887, Poughkeepsie has in service 233 "Crown" Meters.

DES MOINES, August 30, 1886.

J. C. KELLEY, ESQ., *President National Meter Company, 252 Broadway, New York.*

DEAR SIR: It is with great pleasure we say that we have used the Crown Water Meter since 1883, and that they have given us great satisfaction and performed better duty with no loss of registration from fault of theirs, and a minimum cost for repairs.

They are unquestionably the best meter for our service that we have ever used.

I wish you to send us say 50 one-half inch Crowns. We shall need some of them at once, so please do not forget us. Yours truly,

DES MOINES WATER WORKS COMPANY
by A. N. DENMAN, Sec'ty

January, 1887, Des Moines has in service 484 "Crown" Meters.

BOARD OF WATER COMMISSIONERS,
TROY, N. Y., October 21, 1886.

JOHN C. KELLEY, ESQ., *President National Meter Company.*

DEAR SIR: Your favor of the 27th September has remained without answer in consequence of my absence (nearly a month) from the office. Our use of meters in this Department is so very limited that little attention has been paid to comparative tests. We can say, however, that our experience with Crown Meters, though small, has been entirely satisfactory, and the expense of maintenance merely nominal. We doubt there is any better meter in the market, whether for accuracy, durability or *compactness*, the latter alone being frequently an important consideration. Very truly yours,

JOHN C. OGDEN, Clerk.

TOLEDO WATER WORKS, OFFICE, MASONIC TEMPLE BUILDING,
TOLEDO, OHIO, August 11, 1886.

NATIONAL METER COMPANY, *New York City.*

GENTLEMEN: The Toledo Water Works has in use at the present time 219 Crown Meters, in sizes ranging from ¾ inch to 4 inches.

Our experience with Water Meters has lead us to prefer the Crown to any other, on account of its ability to accurately measure, under different heads, streams of water, both large and small, and both continual and intermittent.

The lasting quality of this meter has proved with us first class, and we find the cost of necessary repairs to be extremely low.

When attacked by frost (by far the greatest enemy of all water meters), the cost of repairs is less than with any other, which is partly owing to the fact that extra parts can be obtained to replace those destroyed, and the necessary work done here by our men, whereas a frozen piston meter must necessarily be sent to the home factory, unless a complete shop is at hand, fitted out with expensive machinery, and manned by experienced machinists.

Another advantage of the Crown, is the small space occupied by it when in use, and the large amount of water it can pass and register in a given time, with consequent higher pressure when compared with a piston meter.

We consider the Crown the only rotative meter which has demonstrated its reliability by sufficient continuous service to make its adoption safe and not in a measure experimental. For the past two years we have purchased substantially no other make. Yours truly,

DANIEL SEGUR, Sec.

January, 1887, Toledo has in service 254 "Crown" Meters.

BOARD OF PUBLIC WORKS,
GRAND RAPIDS, MICH., April 3, 1883.

JOHN C. KELLEY, Esq., *President.*

SIR: In reply to yours of March 30th, inquiring in regard to the "Crown" Meter, I would say we have now about 50 of these meters running, the first of which were set over two years ago.

The performance of the "Crown" is very satisfactory, the cost of repairs so far is about nothing, and no difficulty has been had from their getting stuck, a trouble which we have with some other patterns.

Yours truly,

A. C. SEKELL,

Superintendent Water Works.

SYRACUSE WATER COMPANY,
SYRACUSE, N. Y., October 11, 1886

NATIONAL WATER METER COMPANY, *New York City.*

GENTLEMEN: In reply to yours of the 9th inst, we have in use between three and four hundred of your Crown Meters, and prefer them to any meter that we have ever tested, having less trouble from stoppages and less repairs. Yours, etc.,

EDWARD H. BROWN, Supt.

January 1st, 1887, Syracuse has in Service 348 "Crown" and 24 "Gem" Meters.

THE ELMIRA WATER WORKS COMPANY,
ELMIRA, N. Y., October 29, 1886.

NATIONAL METER COMPANY.

DEAR SIRS: Now have one hundred forty-three (143) Crown Meters in use, out of a total of two hundred thirty-seven (237) of all kinds. The Crowns have given excellent results, and have been very satisfactory. Cost for repairs has been very light. Most repairs have been on account freezing or hot water getting into meter through failure of check-valve.

Have just tested a 1½ inch Crown, which has been in use, constantly, since July 14, 1881, and has passed 1,110,238 cubic feet, and now registers a little less than eight gallons per cubic foot, with a ½ inch stream, which convinces me that the *life* of the meter will be long. Yours truly,

G. M. DIVEN, Sec'y.

OFFICE OF THE BOARD OF WATER COMMISSIONERS,
TAUNTON, MASS., February 8, 1883.

MR. JOHN C. KELLEY, *President National Meter Company, 51 Chambers Street, New York.*

DEAR SIR: I return to you to-day the circular postal card containing answers to your questions relating to the supply and consumption of water.

With your permission I will add some figures which I have arranged, which may have some interest for you.

The whole number of gallons pumped into the city during the year 1882 was 212,460,584; of this there passed through domestic meters 16,644,737 gallons, and through the quarterly or large meters 64,645,581, making the amount of metered water 81,190,318, and the amount of water supplied at faucet rates 131,270,266.

For the water passed through the domestic meters we received $5,152.00—at 25 cents per 1,000 with minimum charge of $10.00—and for the water passed through the quarterly or large meters we received $6,987.17 at prices varying from 20 to 12½ cents per 1,000 gallons. Our three largest consumers, however, use over 20,000 gallons per day and get it for 12½ cents. The total receipts from water rates, exclusive of hydrant service, were $25,064.32 (see page 4 report), and for metered water as above, $12,139.17, making the receipts for water supplied at faucet rates $13,825.15. From these figures we see, if I have made no mistake, that we get 14 cents per 1,000 for our metered water and 10 cents per 1,000 for the balance. If we could get 4 cents more per 1,000 for the water we have pumped during the past year which was not metered we should make enough to more than pay for the entire cost of running our pumping engines for one year.

Yours respectfully,

WILLIAM R. BILLINGS, Clerk and Supt.

TAUNTON WATER WORKS,
TAUNTON, MASS., March 3, 1887.

NATIONAL METER COMPANY, *John C. Kelley, President.*

DEAR SIR: Replying to yours of yesterday, I take pleasure in saying that nearly one half of our 680 meters are CROWN, and that as matters stand to-day, I have no hesitation in placing the CROWN FIRST ON THE LIST.

Yours very truly,

WM. R. BILLINGS, Supt.

March 1, 1887, Taunton has in service 295 "Crown" Meters.

OFFICE OF THE BOARD OF WATER COMMISSIONERS,
MANOR HALL, YONKERS, N. Y., February 26, 1887.

MR. JOHN C. KELLEY, *President National Meter Company.*

DEAR SIR: In reply to your inquiry I have to say that after ten years experience with meters of various patterns we prefer the Crown, and buy but few of any other style.

We have now in use 1,330 meters of seven different kinds, of which 870 are Crowns, of all sizes, from ½ inch to 4 inches.

We began using the Crown Meter in December, 1880, and they are working very satisfactory, giving us less trouble than any meter that we have used.

Yours truly,

JOS. A. LOCKWOOD, Asst. Eng. and Supt.

March 1, 1887, Yonkers has in service 870 "Crown" Meters.

OFFICE OF THE WATER DEPARTMENT,
ERIE, PENN., October 18, 1886.

NATIONAL METER COMPANY, *New York.*

GENTLEMEN: In reply to yours of the 14th, I am pleased to say, that we have had in use in this department a number of your Crown Meters, and up to this time they have given perfect satisfaction. The repairs required have been merely nominal. I can safely recommend them to parties requiring a reliable and perfect meter.

Yours truly,

B. F. SLOAN, Sec. and Treas.

CITY ENGINEER'S OFFICE,
HALIFAX, N. S., November 17, 1886.

JOHN C. KELLEY, Esq., *President National Meter Company.*

DEAR SIR: The 1-inch, ¾-inch and ½-inch Crown Water Meters received from you on trial have recently been tested, with the most satisfactory results under varying pressures, and with large and small streams of water passing through them. I have therefore accepted them, certified your bill and handed it in for payment.

Yours truly,

E. H. KEATING, City Engineer.

CITY HALL, MONTREAL, August 21, 1880.

JOHN C. KELLEY, Esq., *President National Meter Company.*

DEAR SIR: Yours of the 17th and 19th inst. are at hand. With regard to the first, asking about the durability of your "Crown" Meters, I cannot say more than that since we began using them (since July, 1879), I have not been able to detect yet any deterioration in any of them. We have now twenty of these meters at work, and one (a one-inch meter) has already registered above 222,100 cubic feet. I am so far satisfied, that until I am aware of a better meter in the market, I will give yours the preference in my future purchases. At this moment our Water Department wants one 2-inch and six ¾ inch water meters, and I beg you to send me the same ("Crown" Meters) at once. I have received invoice inclosed in yours of the 19th inst. for two 3-inch "Gem" Meters ordered in July last.

I remain, yours truly,

LOUIS LESAGE, Supt.

WATER WORKS, ENGINEER'S DEPARTMENT,
MONTREAL, Feb. 26, 1887.

JOHN C. KELLEY, Esq., *President National Meter Company.*

DEAR SIR: At your request I send you a statement from our Meter Inspector, in reference to National Meter Company's meters in use by the Montreal Water Works, said statement requires no explanation or comment from me.

Yours very truly,

LOUIS LESAGE, Superintendent Montreal Water Works.

MONTREAL, February 23d, 1887.

The following is a statement of CROWN and GEM Water Meters, in use in the City of Montreal, to date:

Number of Meters in use.	Size.	Kind.
6	4 inch.	Crown.
4	3 "	"
9	2 "	"
9	1½ "	"
23	1 "	"
39	¾ "	"
50	½ "	"
140		
6	6 "	Gem.
16	4 "	"
42	3 "	"
32	2 "	"
13	1½ "	"
5	¾ "	"
4	½ "	"
118		

The Crown Meters are principally used in places where small streams of water are used, and they register correctly the smallest streams. With the exception of the damage from frost, these meters *do not require much repairs.*

The Gem Meters are used principally for outside Municipalities, Elevators and Brewers, or in places where a large quantity of water is required at a time.

S. LAFOND, Meter Inspector.

THE EMPIRE WATER METER.

The remarkable growth in popularity of the system of supplying water by meter measurement, as indicated in the extraordinary demand for water meters from all sections of the country, has been attended with a demand in many quarters for a water meter that should be "positive" in principle and efficient in operation, and that can measure HOT WATER.

An earnest determination to meet this demand prompted the initiation of a series of experiments that has finally culminated in the perfection of the Empire Water Meter.

This meter is made of composition throughout, including the piston, and is the embodiment of simplicity in its construction, in that it has *only one working part*—an oscillating piston. In the formation of the piston extreme lightness of weight, freedom of movement and large area of wearing surface combine with the large bearing surface supporting it, to render wear insignificant. The volume of water discharged by the piston in one revolution is vastly greater than in any other form of "positive" meter, being nearly equal to the volume of the meter chamber, and hence the capacity of the meter is very large.

The supply and discharge passages of the smaller meters are several times greater in area than that of the respective supply pipes, and the piston moves freely in its chamber without offering any perceptible resistance to the flow of water. This has been demonstrated by actual test, since the meter, has delivered the same amount of water with the piston in place as with the piston removed.

Thus it is obvious that the wear upon the moving piston must be inappreciable and that the meter, in use, will deliver as much water as will pass through the pipe connections at the pressure usually carried in large cities, with no more loss of head than is caused by a similar length of pipe. In the Empire Meter it has been sought to combine *accuracy, durability, simplicity, compactness and economy.*

To this end the very best materials and the most skilled labor obtainable have been exacted in its mechanical construction.

The thorough efficiency of the Empire Meter has been satisfactorily established by a series of tests as to accuracy and durability extending through several years.

This meter is specially adapted for hot water, or, if required, to be placed near steam boilers.

Water Departments desiring to test the Empire Meter will be cheerfully furnished upon application a one-inch meter, or smaller size if preferred, to be thoroughly tested for two months, when it can be either paid for or returned to us at our expense, if not found satisfactory.

SIZES, CAPACITIES AND DIMENSIONS OF EMPIRE METERS.

Size.	Greatest proper Quantity per minute.	DIMENSIONS AND WEIGHT. Length.	Height over all.	Width.	Weight, complete.	Weight, boxed.
½ inch	2 cubic feet or 15 gals.	5½ inches.	5 9/16 inches.	4⅝ inches.	6½ lbs.	10 lbs.
¾ "	4 " " " 30 "	6¼ "	6¼ "	5⅝ "	10 "	15 "
1 "	8 " " " 60 "	7⅛ "	8 "	7½ "	18½ "	27 "
1½ "						
2 "	20 " " " 150 "	9 "	9¾ "	10½ "	40½ "	52 "
4 "	72 " " " 540 "	14½ "	14 "	16 "	135 "	170 "

Connections are made only for the ½-inch, ¾-inch and 1-inch sizes, as quoted above. The ½-inch, ¾-inch and 1-inch Empire Meters are made with male thread, and the 2-inch is made with female thread, all cut to fit standard thread. The large sizes are made with flanges.

We manufacture fish traps, and would recommend their use on sizes above 1½-inch, as they protect the meters from any foreign substance which might destroy the working parts.

N. B.—FOR ECONOMY IN TRANSPORTATION, WE PACK ½-INCH, ¾-INCH, AND 1-INCH METERS, FIVE IN A CASE, WHEN ORDERS WILL ADMIT. SUCH PACKAGES WEIGH RESPECTIVELY 48 LBS., 70 LBS., 130 LBS.

EMPIRE METER ILLUSTRATIONS.

Fig. 1.

Figure 1 is a perspective view of the meter showing the index on the top. It is shown bore as when placed in position. The proper threads at the inlet and outlet make it easy of attachment to the supply and discharge pipes.

Fig. 2.

Figure 2 is a view of the brass piston (the only working part of the meter), with short spindle that engages and turns the arm on the under side of the cylinder-head, shown in Figure 4, giving motion to the intermediate gear.

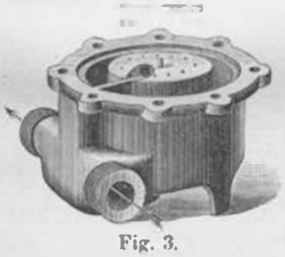

Fig. 3.

Figure 3 is a view of the composition body with the cover and cylinder-head removed and the piston in place.

Figure 4 is a view of the meter with the cover thrown back, disclosing the mechanism of the intermediate gearing.

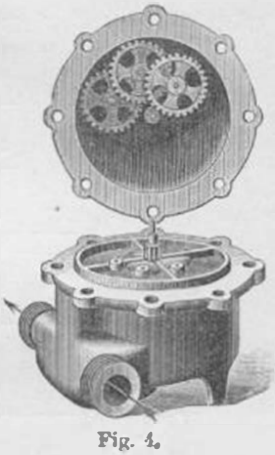

Fig. 4.

TESTIMONIALS OF THE EMPIRE METER.

OFFICE OF SUPERINTENDENT OF WATER WORKS,
WHITEHALL, N. Y., October 8, 1886.

NATIONAL METER COMPANY, *New York.*

Yours of the 7th at hand, and in reply would say, the 2 inch Empire was set November 28th, 1885. On April 13th, 1886, it had registered 1,042,000 cubic feet; on August 23d, 1886, it read 2,008,280 cubic feet, and as you read it yesterday 2,398,200 cubic feet.

This meter is passing water constantly. I have been to examine it every week since it was placed and never have found it at rest.

I can recommend this meter as doing the work assigned it with as much efficiency and correctness as any meter in the market. With kind regards,

C. M. HOTCHKISS, Supt.

The above meter had registered, January 2d, 1887, 3,286,720 cubic feet, or 24,650,400 gallons in one year and fifty-three days. And for the last fifty-three days, average 62,189 gallons.

OFFICE OF WATER DEPARTMENT,
ERIE, PA., March 25, 1887.

NATIONAL METER COMPANY, *New York.*

A 2-in. Empire Meter, set at Lake Shore R. R. Depot, Erie, Pa., on August 31, 1885, had registered on December 31, 1886 (16 months), 1,620,652 cubic feet, or 12,154,890 gallons.

R. T. SLOAN, Sec'y-Treas.

COST OF REPAIRS ON 20,086 CROWN METERS IN USE IN NINE CITIES,

FROM SEPTEMBER, 1879, TO JANUARY, 1887.

	Meters Furnished.	Meters furnished Yearly. 1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	Value of Meters.	Cost of repairs for all causes.	Cost of repairs to frozen Meters	Cost of repairs exclusive of frozen Meters.	Amount paid Yearly for repairs from all causes. 1870.	1871.	1882.	1883.	1884.	1885.	1886.	Percentage on value of Meters of cost of repairs from all causes.	Percentage on value of Meters of cost of repairs exclusive of frozen Meters.
New York	7,728			81	1009	2052	2453	1534	599	$182,075.00	$3,935.16	$1,750.25	$2,184.91			$49.40	$72.30	$548.64	$1,359.37	$1,905.45	2.11%	1 20/100%
Providence	3,331		109	456	443	460	730	617	516	62,097.50	1,044.15	641.04	403.11			147.40	117.60	95.65	471.95	211.55	1.69	65/100 of 1%
Boston	1,655		1	72	988	174	25	89	300	42,360.25	1,838.91	884.73	954.18			51.55	290.65	274.15	602.51	620.05	4.23	2 20/100%
Pawtucket	1,108		158	149	83	164	138	194	222	18,653.25	489.15	310.50	178.65		$30.90	28.40	57.65	12.15	138.00	227.05	2.62	96/100 of 1%
Central Falls	608	127	127	75	51	51	74	50	53	8,435.50	252.90	117.20	135.70	$35.05	2.55	24.40	31.40	9.50	15.10	134.90	2.99	1 81/100%
Fall River	1,473	31	15	77	248	262	274	286	280	22,972.50	952.71	827.66	125.05		18.50	13.90	160.80	201.26	264.20	294.05	4.10	55/100 of 1%
Hoboken	1,429				9	314	344	372	390	25,331.00	826.25	732.80	93.45				35.20	152.40	391.50	247.15	3.26	36/100 of 1%
Atlanta	967		6	14	12	7	213	518	197	13,037.00	298.05	94.30	143.75			3.85	14.80	29.05	16.00	174.35	1.83	1 18/100%
Rochester	870	2	81	147	285	120	93	57	85	17,090.50	1,350.47	762.40	588.07	6.00	19.35	62.70	234.40	385.97	399.15	242.90	7.90	3 44/100%
Yonkers	917		7	51	126	134	165	167	267	14,629.00	462.62	292.10	170.52			7.40	43.80	62.45	148.87	200.10	3.16	1 77/100%
Total	20,086									$407,681.50	11,390.37	6,412.98	4,977.39								*2.79	†1 22/100%

* † Percentages on total value of Meters.

NOTE—The Cost of Repairs for Yonkers is not complete by perhaps 25%, as this Department has no separate record of the simpler repairs made on the spot. The percentage of cost for repairs is NOT PER ANNUM, but extends from the setting of the first meter, to January 1st, 1887.

Extracts from Reports of Chief-Engineers and Superintendents of Water Works on the Advantages of using Water Meters to Check Waste and Increase Receipts, taken from their Annual Reports, 1885 and 1886.

[*Chief-Engineer William Ludlow, of Philadelphia, Pa., in his Annual Report for the year 1885, says:*]

WATER CHARGES.

In my previous reports I have presented data tending to show the advantage of the method of direct measurement of water supplied to large consumers and the economical results both to water-takers and to the City to be anticipated from the use of meters for the purpose of assessment of water charges. In my last Annual Report it is stated as follows:

"The table of Meter Charges is a most interesting exhibit. Early in 1883 a preliminary investigation of the Registrar's books showed marked inequalities in charges and in some cases most singular disparities between those charges and the amount of water consumed. Later, it became manifest also, from both observation and computation, that a large proportion of the total daily pumpage was wasted, thereby entailing a heavy additional and unnecessary expense upon the City—since the expenditure of fuel and the wear and tear of machinery are directly proportionate to the pumpage and have no relation to the use or misuse of the water after delivery. Furthermore, this waste, by diminishing in effect the capacity of the basins and distributing mains, occasions an artificial scarcity which impairs the effectiveness of the Fire Department, hampers manufacturers, and interferes seriously with domestic comfort; and these disadvantages must, perforce, continue until either the means of distribution shall be greatly increased or the waste prevented.

"No arrangement having been concluded for the instrumental determination of domestic waste, the vigilance of the Department Inspectors, aided by casual information from citizens, had to be depended upon to correct the thousands of leaky and flowing hydrants, water-closets and basins — quite ineffectively, it must be admitted, in the absence of any plumbing regulations and supervision.

"For the large consumer the obvious means to systematize and equalize water charges as well as restrict the waste, was to measure the water drawn and charge for it.

"For this purpose, under the provisions of the joint resolution of Councils of May 18, 1870, authorizing the Chief-Engineer to apply meters when necessary to ascertain the amount of water consumed, the establishments named on the meter schedule were supplied with meters, and the records kept. The result in many cases was quite unexpected both to the Department and to the consumers, and a large body of fresh and valuable information was rapidly obtained. The general system of rating premises for water rents, under which the Water Department, since its organization in 1854, has proceeded, is to make an inspection of the premises and base the charges upon the number and character of the water appliances in service, the charge for each appliance being regulated by a schedule in force in the old City previous to consolidation and re-enacted by ordinance thereafter. The charges against the several appliances named in the schedule were presumably proportioned originally in accordance with the average amount of water which it was supposed could be drawn from them; but as plumbing arrangements developed, and in especial as manufacturing methods were altered, and new devices, labor-saving and other, came into use, it was found necessary from time to time to amend the schedule. This was done by the joint action of the Chief-Engineer and the Water Committee, without re-submitting the matter to councils; but notwithstanding the changes, the schedule has failed to keep pace with industrial modifications, and continues to bear indications of its early origin. The record of the meters clearly brought out these points, and has served as a valuable aid in the readjustment of the details of charges, which is now under consideration by the Water Committee.

"It was mainly upon this evidence that the Department recommended, and the Committee approved, a decrease in the charge for steam power from $3 to $2 per horse-power, which is now the lowest charge in the United States. The old charge was probably a lower one, when it was adopted, than is the smaller charge now, since the introduction of condensing and compound engines, with other improvements in mechanical engineering, has effected a marked economy in both fuel and water, the latter being used over and over again. As will be seen by reference to the Registrar's detailed Statement of Appliances, the number of steam engines and boilers in service in the City exceeds three thousand, with an aggregate

horse-power in excess of sixty-five thousand. The reduction of $1 in the horse-power charge correspondingly relieves the steam-using industries and diminishes the revenues of the Department. The change was made early this year, in time to go into effect in making out the bills for 1885. The meter further developed the fact that in some establishments appliances were in use not named in the schedule nor known to the Department, and therefore not charged for, which, nevertheless, consumed large quantities of water. It also showed that in many cases the amount of water wasted was largely in excess of that usefully employed, as was evidenced by the rapid decrease of consumption so soon as the meter readings were made, and the managers saw that a proper and large economy could be effected by requiring their employés to stop unnecessary flow. The reduction in some instances was fifty per cent., and even as high as seventy per cent. This result was, of course, anticipated ; since it is quite clear that, as a rule, little if any care will be taken to restrict the flow of water which is not charged for, nor even noted, and that even were strict instructions given, employés will not take the trouble to obey them so long as their dereliction could escape observation. A pipe would be used, for example, to fill a tub, and a workman would throw the hose upon the floor and let the water run until he again had occasion to use it. In other cases a pipe in constant flow during the day would also be allowed to run after shutting down the mill. Leaking pipes were not repaired, nor were urinals and basins shut off. All these sources of waste the meter readily controls to the advantage of every interest.

"The establishments given in the Meter Statement are not all of those to which meters were provisionally or experimentally applied, but are selected as exhibiting the characteristic results afforded by direct measurement. In some the charges remain about the same by meter as by regular schedule rates ; in others the meters, after correction of the waste, largely reduced the cost to the consumer ; while in still others the increase by meters was so great as to show clearly the inadequacy and inequality of the schedule charges as based upon assessment of appliances. In these cases, as was natural, the meter was strenuously objected to ; and, in fact, it was made evident that in regard to certain industries which are compelled to use immense quantities of water for cleaning and similar purposes the City could well afford to reduce the charge per thousand gallons below even the moderate rate of eight cents.

"It would seem equitable, in considering these matters, that consumers using over a certain quantity should be allowed a reduced charge—either by a sliding scale, as has been adopted in many other cities, or by the minimum draught per day, or per annum, above which the reduced rate would go into effect.

"It is in these two directions, of restricting waste and equalizing charges, that the meter exhibits its useful qualities ; and under favorable circumstances its application to all large consumers would be attended with excellent results. This is now done in many cities where the business of furnishing water has been carefully and intelligently regulated, and in several instances meters are universally applied even to private houses.

"The free use of water for bathing purposes is so desirable that it should be in every way encouraged and nothing done that would tend to restrict it.

"Whether any extension of the use of meters shall be hereafter made or not, the information furnished by them has been most valuable in clearly indicating where revision of the schedule charges is needed and how readily waste can be prevented."

I shall not seek to enlarge upon the views above expressed beyond the statement of a few facts in the same connection.

The primary objects sought to be attained by the direct measurement of the quantity of water supplied are, first, the proper and equitable regulation of the Department business ; second, the equalization of charges to consumers ; and third, the restriction of waste. It will not be contended, I presume, that the securing of these results is other than desirable. Useless waste cannot be defended; it benefits no one, injures those who are thereby deprived of a needful supply, and adds an item of superfluous cost to the maintenance of the Department. At a moderate estimate one-third of the water now pumped and distributed is wasted, passing into the sewers without having served any useful purpose whatever, and in most cases having done harm on its way. The pumping expenses for fuel for the year 1885 were in round numbers $90,000, and the waste of water therefore represented an unnecessary expenditure in this item alone of not less than $30,000, to which must be added that large but incomputable amount due to short supply occasioned by the non-utilization of that same waste, which dwellings, stores and factories, needed but had to go without, to the serious detriment of individuals and interests. Were Philadelphia situated as is Baltimore, with a gravity supply by conduit from a stream having a much larger flow than for the present can be utilized, the economical argument would be weakened; but even then it is manifest that in time the conduit would no longer suffice, and meanwhile the unnecessary draft upon the mains, due to waste, diminishes the available pressure in the City. To restrict waste, therefore, is to augment the supply, to reduce expense, and to improve sanitary conditions; and there is no way in which waste can be so effectually checked as by ascertaining and charging for it. The equalization of charges to consumers is certainly equitable and just. Of two establishments with the same appliances and equal requirements, why should one get from the City three times the quantity of water supplied to the other, when both pay the same water-rent? Or, conversely, if both take the same quantity of water, why should one pay three times as much for it as the

other? It is quite impossible to answer these questions in any manner consistent with the present method of dealing with the subject. The regular schedule of charges takes account of appliances only, and not of the water drawn and used or wasted. It is out of the question that equalization can be effected while this is the case, and the City is only encouraging wasteful and extravagant methods in certain cases at the expense of the community. It may be said that if the arrangement be good as regards large consumers it would also include small consumers and dwellings. This is not necessarily so. In the first place, the charges to dwellings are much higher in proportion than to manufacturers, and the annual water rent would cover considerable waste at the present meter price. Furthermore, the City has a right to consider her own interest; and if in a given case the cost of suppressing waste exceeded that of the waste itself, it might be worth while to let it go or try another method. From the administrative point of view, the regulation of the Department business is a matter of importance, and especially is this the case since the Department is dealing pecuniarily in sums large and small through various agents with a very large number of people, and the temptation to dishonestly economize payments and to influence the Department agents improperly should be as completely removed as possible. In other words, the basis of Department accounts and bills rendered should be so simple and satisfactory as to be open to ready and clear determination and closed to dispute or dishonest avoidance. With the existing manufacturer's schedule this is not the case, nor are its incongruities and inequalities susceptible of correction, unless it can be determined by measurement how much water each appliance should be charged for; but this involves the use of the meter, without which the correction cannot be made. The main argument advanced against the use of meters is that the manufacturing interests, upon which, to so large a degree, the prosperity of the City depends, must be protected against excessive charges, and that the effect of the meter would be to increase the charges now made.

The obvious answer to this is, that the meter is a mere instrument to measure the volume of water passing through it, and has nothing to do with regulating the price charged for that water.

If the price is too large, nothing is simpler than to reduce it, but in the adjustment of matters of this sort it is essential that it be done "in the open" *and in the general interest, not that of individuals however influential.* My efforts have been directed to the elimination from the Department business of this intolerable "personal equation," and the adoption of impartial and systematic regulations, but with the complicated machinery of the City government, as at present constituted, the task has hitherto proved impracticable. Examination of the comparative statement of schedule and meter charges, printed in the report for 1884, will indicate the gross inequalities of the so-called "regular" rates. Two typical illustrations will suffice. A sugar refinery was found to be charged $150 per annum, while the actual value of water used, if charged at the meter rate of eight cents per thousand gallons, would be $1,500. There are many cases of this sort in which the basis of charge is quite indeterminable. Of two large establishments, one a dye house and the other a brewery, using the same quantity of water, viz., about 430,000 gallons per day, one pays $4,872 water rent, the other $10,922. Now, since the service performed by the City to these two customers is precisely the same in one case as in the other, it is manifest that if one is paying a just rate the other is getting his water supply at less than half rates, or if the latter's bills are equitable the former is being grossly overcharged. The fact probably is that the equitable rate, both to the City and the two consumers, lies intermediate between the two charges.

My own views upon the general question are, that so far at least as the manufacturing interests are concerned, the City charges for water should exceed the actual cost of service, as determined by the average maintenance expenses of the Department, by such amounts only as would suffice to meet the cost of renewals and additions to plant required to keep pace with the increase of growth and demand; in other words, to maintain the service.

It was shown in the Report of 1883, at page 70, that considering the entire period since consolidation, and comparing the total quantity of water supplied with the gross expenditures, exclusive of interest on loans or plant, the cost of the service was at the rate of *nearly 4 and 75-100 cents per thousand gallons delivered.* If now this amount be increased by 25-100 of a cent to provide for needed enlargements, an equitable charge to large manufacturing industries would be at the rate, say, of *five cents per thousand gallons.* The effect of this charge in the case of the dye-house and brewery already referred to would be to reduce the $10,922 water rent, and increase the $4,872 rent to $6,825 for each, an amount with which certainly neither one nor the other could justly find fault.

In opposition to the allegation that the use of meters would increase the burden to consumers, it can be conclusively shown that while certain partialities to individuals would be eliminated, in the greater number of cases the water charges would be reduced, even at the present price of eight cents per thousand gallons, but that the advantage of repressing useless waste and regulating the Department business would so nearly offset the loss of revenue that the application of the direct system of measurement would be found both to justify further reductions in the rate per thousand gallons, and to inure to the joint benefit of the City and the manufacturer.

Supt. Darling, of Pawtucket, R. I., states:

"While the question of the general use of meters has been held with difference of opinion in the past, we have advocated meter measurement *first, last* and *all the time.* It is convincing proof that we were not in error when we see the opponents from year to year falling into line and stating that something must be done to stop the wilful waste of water, or large expenditures for pumping machinery and supply were inevitable, and acknowledge the remedy is in a general use of meters."

Pawtucket has in use, Jan. 1, 1886, 2,400 meters, from ½-inch to 4 inch. 1,457 Crown.

January, 1887, 2596 meters. Crown, 1616.

Water Register Robertson, of the Fall River, Mass., Water Works, states:

"Two reasons apply here to explain such a decrease in the amount of the water pumped for the ordinary consumption of the City. One is the saving of waste water over the stand-pipe, which has been brought down to a minimum, and which can be carefully calculated by means of the six-inch meter attached to the overflow from the stand-pipe. The other reason is the evidences of economy in the use of water from the large proportion of meters on the service-pipes of the City.

"It is unnecessary to dwell here upon the benefits of this method of assessing consumers of water. It is sufficient to say that since the free adoption of meters by water takers, the price of a large amount of waste water has been saved to the city, and the consumers themselves have learned economy, as has been alluded to under the head of 'Water Pumped'; especially has this been evident during the year just past."

Fall River has in use, Jan. 1, 1886, 2,669 meters, from ½-inch to 6-inch. No. of Crown and Gem, 1,603.

From Annual Report of Fall River, Mass., Water Works for year 1886, Water Registrar Robertson states:

"The increase of water revenue for the year over that of 1885 (apart from the City's appropriation) is nearly $7,300. Referring to the statement of receipts, it will be seen that the sum received from water takers, paying schedule rates, is $11,737, which amount is only 22 cents in excess of that derived the year before from water takers who pay annually 'by the faucet, etc.' It is clear, then, that the increase of revenue is from the meters, from which a proportion of over 80 per cent. to the entire amount collected from both classes of consumers is obtained. Of the whole number of service-pipes in the city, 69 per cent. are metered."

Supt. Kieran, of the same Water Works, also says, in the same report: "The meter system gains in favor each year, a proof that this method of determining water rates is the only satisfactory one, and that it must eventually become universal. As a prevention of waste there is no better means."

There are now in use, Jan. 1, 1887, 2,725 meters, an increase over 1885 of 156. 1,824 Crown and Gem meters.

Supt. Billings, of the Taunton, Mass., Works, in his report for 1885, says:

"Sixty-one meters have been set during the year, so that 23 per cent. of the taps in use are metered. Through the metered taps passes 32 per cent of the total consumption, but they furnish 41 per cent. of the total revenue from the sale of water. In other words, we get as an average price 16.5 cents per 1,000 gallons for metered water, and 11.6 cents per 1,000 gallons for water sold at faucet rates. In the light of these facts, we shall feel justified during the coming year in using every reasonable and proper means to increase the number of meters, and as one step in that direction, we shall, on and after January 1, 1886, make no charges for maintaining and repairing them, except in cases of neglect or carelessness on the part of the users."

Taunton has in use Nov. 30, 1885, 597 meters, ⅝-inch to 4-inch. Crown, Gem and Empire, 258.

The Water Commissioners, of Taunton, Mass., in their report for 1886, state:

"Eighty-three meters have been set during the year, making a total of 680. so that 25 per cent. of the taps in use are metered. We continue to believe in a judicious application of meters, and in their value as preventives of waste."

Number of meters, January, 1887, 680. Crown, 295.

J. Nelson Tubbs, Esq., Chief-Engineer of the Rochester, N. Y., Water Works, says in his report of 1884:

"The most successful method of checking waste is proved by our experience to be the application of meters to all public places. * * * *

"The meter system has done much to reduce the waste of water here, but we shall not reap similar benefits to those which have been derived from its use in other cities, until our rates for large consumers of water are largely increased. I am of the opinion that there should be a practically uniform rate for metered water, of not less than ten cents per one thousand gallons, and that this rate would more nearly approximate the arbitrary schedule of rates required to be paid for ordinary domestic uses, than any other lesser rate."

Rochester has in use April, 1884, 807 meters, 86 added last year.

CHIEF-ENGINEER TUNIS also adds in his report for 1885: "The system of placing meters on the services of private consumers should be inaugurated, with the view of an eventual and comparatively speedy metering of every Hemlock water service in use. The meter rates for water should be uniform, without reference to the amount of water used by the several consumers.

"When the municipality furnishes water to any citizen for a commercial or manufacturing use, out of which the citizen is to make money, there is, to say the least, no reason why it should be furnished at any time below the full cost of procuring it, neither can there be any excuse for furnishing it to him at all a moment beyond the period and when there is an abundant surplus over what is required by the purely *public* uses, above enumerated. The argument that water should be supplied at cheap rates for commercial purposes to attract manufacturing enterprises to the city, at first statement seems to have some strength in it, but the statement would be of equal force as an argument why the City should go into the business of furnishing steam-power to all manufacturing at cheap rates, to attract that kind of business to the City. And the City could, with the same propriety, remit its taxes, in whole or in part, on property used for commercial purposes, in order to attract it to the City.

"I recommend that the number of meters be largely increased during the coming year and that private residences be metered whenever there is a well-grounded suspicion that water is wasted during the Summer or Winter months. If each department was compelled to pay for its water at meter rates, it would tend to cause those in charge to exercise care that none should be wasted."

Rochester has in use April, 1885, 827 meters.

CHIEF-ENGINEER TUNIS of Rochester, N. Y., in his annual report for 1886, says: "While it is desirable, for sanitary reasons, that our citizens should be encouraged to use all the water which their necessities or comfort demands, yet it is the manifest duty of the officials in charge of the Water Works to confine the consumption of water to needful use, and to rigidly enforce such rules as will prevent needless waste. Some of our older cities, which originally constructed a system of water works at great cost, are now struggling with the problem of an additional and costly supply, the present necessity for which arises not from a deficiency for legitimate use, but from a long-continued and confirmed habit among all classes of citizens of needlessly wasting the water. While the waste of this City has not assumed such enormous proportions as in some of our sister cities, yet it is evident that 30 per cent of our use may be classified as waste. Any citizen engaged in a private manufacturing enterprise would regard a discovery that 30 per cent. of his manufactured product was being wasted or destroyed as a most startling and alarming fact, and his ingenuity would be taxed to the fullest extent to devise a full and efficient remedy, and when found it would be applied with the utmost rigor and with remorseless energy. It is difficult to see why the general rule should not apply in the management of cities water works business, and as it seems to be a generally admitted fact that the general application of meters is the best and surest remedy, I can see no reason why it should not be settled as the policy of the Executive Board to *apply meters at once and continuously in large numbers.* I therefore repeat the recommendations made by me in previous years, that the City, at its own cost, should apply meters to all services supplying water from the Hemlock Lake system as rapidly as possible. I would recommend, however, as preliminary to applying a meter on any premises, that a careful inspection of the said premises and the plumbing therein be made by a competent person, to determine whether the plumbing is properly located and so arranged that neither the pipes themselves nor a meter which may be placed upon the service would be subjected to injury by freezing, that if found subject to these contingencies, the owner should be required to properly rearrange, place and protect the plumbing, and also to become responsible for the security of the meter when it shall have been applied by the City."

Number of meters in use April, 1886, 978. Crown, 842.

Mr. John G. Ogden, of the Troy, N. Y., Water Works, in his report ending March, 1885, says:

"The legitimate uses of water for manufacturing and other purposes have largely multiplied during the last few years, while during the same period we have also had to meet the demands of a growing population and an enlarged area of distribution. But worst of all, and that which has created in the Department a feeling of the gravest apprehension, is the waste, the absolute and unnecessary waste, of water. Waste implies an outgo of money without any equivalent return for it. The full significance of this idea is not, it is safe to say, very generally realized by our citizens, to whom, in fact, this wasted property belongs, and who, nevertheless, appear content daily and hourly to see their substance thus wasted and frittered away. It does not occur to them that every cup of water, small and insignificant as the quantity may be, has, nevertheless, its own certain and ascertainable value in money—money expended in coal, labor and machinery, to place that cup of water where, at their option, they can use it or waste it; and money, too, which they themselves have actually paid out of their own pockets to this Department in order that they might have that privilege. For what else have our citizens been paying, year after year, their annual water tax? For what else did they last year pay into the hands of this Department the large sum of $65,-

529.60? Surely it was for the sole purpose that this gracious element might be supplied to them in the greatest abundance; in quantity fully adequate to meet not only the legitimate requirements of necessary or rational use, but also the largest demands of luxury and refinement. Such is the supposed object of the annual water tax; but practically it has come to include both the means and the vicious privilege of wasting one's own property.

"That there should be some waste not due to ignorance and want of a just and proper comprehension of the subject is, of course, unavoidable, but whatever the cause or nature of the waste, it has now assumed proportions that are too great and too serious to pass longer unnoticed. It is the intention of the Board the coming year to institute measures more thorough than have hitherto been employed for the suppression of this needless and very expensive waste."

JOHN G. OGDEN, Clerk of the Water Commissioners of Troy, N. Y., in his report for 1885, says: "In our last report the question of waste was referred to at some length, as a matter of individual and personal concern to our citizens.

"An appeal was also made to them on that ground to use personal exertions in suppressing waste.

"We are to-day using water at the rate of 100 gallons per diem for every man, woman and child within the limits of the low service district. This is twice more than is necessary for purposes of utility, comfort or health; but what is worse, it is very near the capacity of our present pumping facilities to supply. It means practically that this Department is put to the expense of pumping over six million gallons daily, when three million should be amply sufficient for all our wants.

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"In short, in whatever light the question is considered, there seems to be nothing so clear, nothing so obvious, nothing that would completely cover the whole ground, as to enlarge the supply by checking the waste, and the more so when it is considered that *checking waste is only another name for reducing expense.*"

Chief-Engineer Bearmann, of the Troy, N. Y., Water Works, in his report ending March, 1885, says:

"This alarming increase in the consumption of water can be attributable to but one cause, and that is waste, wilful and unnecessary waste. Its importance in regard to increased annual cost of the pumping service, and to the increased pumping capacity of the machinery, cannot be over-estimated, and the same question that has presented itself to every large city in the country, viz., How can the waste be reduced?

"There are three principal methods of controlling or preventing this waste. House to house inspection, the application of water meters to all service pipes, and the use of waste detectors. With regard to the application of water meters, wherever they can be introduced at the time of the construction of the works, the best results are obtained."

CHIEF-ENGINEER BEARMANN, of Troy, N. Y., in an elaborate article on "Waste of Water," in his report of 1885 (page 106), and worthy of attention by every one connected with Water Works, says, among other statements: "The cost of the water to the City of Troy will be represented by the interest on the investment, that is, the interest on the entire construction to date; plus the cost of furnishing the year's supply and the expense of the maintenance of the works. While the introduction of meters to any great extent is attended with considerable expense, it would be a matter of economy to make their introduction general. Thus 5,000 meters would cost in place $150,000, the interest on which, at 4 per cent., is $6,000, which amount would represent the cost of decreasing the consumption one-half, and increasing the revenue twice. There is something more than a money value to water. No money can determine its value in its relation to a city's prosperity. If one million gallons are daily wasted, the cost of that waste can be determined; but if it can be saved to the City by a certain cost, the value of the saving will be found only in the benefit conferred by that million of gallons; *the value of water lies in the benefit conferred.*"

Number of meters, Nov. 1886, 35.

Supt. Colter, of the Toledo, Ohio, Water Works, in his report ending December 31, 1885, says:

"Ninety-three additional meters have been set during the year, making the total number in service at the present time 279. A number are of large capacity, and are set in manufacturing establishments and in business blocks, where large quantities of water are daily consumed. The most effective argument yet suggested for the prevention of waste is where water rents are collected by actual measurement. I would therefore recommend that the setting of meters be continued."

SECRETARY DANIEL SEGUS, of the Toledo Works, also says in his report, 1885: "I desire to call your attention to a subject that is destined to cause much trouble in the near future, as it has already done to a limited extent this year, namely, the private ownership of meters. A meter becomes unreliable from one cause or another, and its use must, with justice to the Works, be discontinued and another substituted for it. The consumer using said meter, having purchased and paid for same, refuses, as a matter of course, to pay for another, and the result is that the service is forced either to furnish a new meter or allow the old one to continue in use, which is, as a rule, a very expensive alternative. A great deal of trouble of this kind has arisen from the use of the ——— meter, which has been a favorite with consumers from the time its most prominent characteristics became generally known, namely, its unreliability. To keep a set of ——— in running order, under normal circumstances, would require a large force of men. Its wings become locked upon

the introduction of the least possible quantity of any foreign substance, and when in this condtion it requires three or four smart blows from a hammer to start the machine again in motion, under a water pressure of 50 pounds to the inch, although the locking does not prevent the consumer from receiving all the water required for ordinary use. The remedy, to my mind, consists in the works hereafter furnishing and owning all meters and fixing upon a judicious minimum rate per year, sufficiently large to cover the wear of the meter in the case of the small consumers. In case of the large ones, the increased rents and prevention of rates would generally make the practice profitable. In some cases, where the meters referred to have been changed and taken out and Crowns substituted, the increased water rent during a period of six months more than equalled the cost of the meter."

Number of meters in service, 279. Crown and Empire, 192. 93 meters set in the year; of these 87 were Crown.

January, 1887, meters in service, 304. Crown and Empire, 254.

Sec'y Geo. Rudge, of Youngstown, Ohio, Water Works, in his report March 31, 1885, says:

"The more general use of meters has proved beneficial, and is money well invested. By measure is the only correct manner of selling water. We find most persons where meters are attached well satisfied; it certainly makes them more careful as to waste of water and leaks, and those are among the greatest difficulties Water Works, as a rule, have to contend with. If waste of water is permitted, like most other evils, it grows, and it is only a question of time until it would be necessary to enlarge our pumping capacity, taxing the citizens for what is really of no benefit, besides it detracts from the efficiency of fire protection."

Eighty meters in service January, 1886.

Manchester, N. H., Water Works furnishes and sets one water meter free near the cellar wall.

Number of meters November, 1886, 675.

Number of Crown meters, March, 1887, 251.

Supt. Henion of the Minneapolis, Minn., Water Works, in his report, March 1, 1885, says:

"There have been 72 meters set during the year, and they have given good satisfaction, and I recommend that a large number be set the coming season, at the cost of the Department, where waste is suspected, exacting an annual rental therefor to be paid in advance, sufficient to pay interest upon the cost and wear and tear, the rates to be governed by the scale of prices established for metered water. In a few instances, parties have complained of increased charges to which they have been subjected on account of meters, but it will not be seriously argued, that if the quantity of water indicated be actually used, they should not pay for it. It seems but right that the use and distribution of water, with all its blessings, should be subjected to the ordinary principles of equity and economy; no person will then be charged for more than he consumes, nor will any be allowed to use water at the expense of their neighbors."

Number of meters November, 1886, 140.

City Eng'r Van Buren, of Brooklyn, N.Y., states, in his report of 1885, regarding the increase of daily consumption of over four million gallons over 1884: "This yearly increase is extraordinary and cannot be accounted for by the increase in population alone, but means a greater waste of water. It is difficult to check reckless waste of water without metering private houses. If people are made to pay for wasted water they would be more careful in its use and reduce their consumption."

Number of meters, January 1, 1886, 2,316. Gem and Crown, 1,368.

Supt. Parker, of Burlington, Vt., Water Works, in his report for 1885, says:

"The use of meters is each year increasing among the best managed water departments in this country, and opinion is gaining ground that the fairest and most equitable way, of selling water is obtained by use."

Number of meters, November, 1886, 239.

Number of meters, January, 1887, 262. Crown and Empire, 138.

Secretary Elwood, of Joliet, Ill., Water Works, says in his report for 1885:

"Believing that water should be paid for by the quantity used, and the amount determined by measurement, the suggestion and recommendation is urged to place meters at all services, at least where bills are $6.00 and over per annum. The meter system in use by many eastern cities, and rapidly gaining in favor, is unquestionably superior to any plan in operation. The use of meters seems an easy and practical solution of a difficulty. By advising the consumer from month to month, at the outset, of the condition of his meter, and cautioning against waste, the demand will shortly confine itself to the actual wants."

Supt. Hancock of the Springfield, Mass., Works, in his report for 1885, says:

"The daily consumption of water has been about three millions of gallons, a quantity sufficient to give every inhabitant of the city seventy-nine gallons, or

every consumer one hundred and four gallons. At least one-third of this amount is wasted.

"If an individual should throw away one-third of his income, when the whole was only sufficient for his actual needs, we should look upon the act as almost criminal. The city needs all the water the present main can furnish for its domestic, manufacturing and fire purposes. Now, to throw away one-third of the amount delivered looks to me, as in the case of the individual, to be equally wrong. If the city was all metered the waste would be reduced to a minimum, but unless something is done to reduce this enormous waste we must not be surprised to find our fire protection very much impaired, and a loud call made for a new main from Ludlow."

Number of meters, November, 1886, 285.

Supt. Coggeshall of the New Bedford, Mass., Water Works, says in his report for 1885:

"The total consumption shows an increase over the figures of last year of 20 per cent. With the exception of December and May, there is shown an increase over the corresponding month of last season, of from nine million gallons in May to thirty-seven million in August. A general application of meters would undoubtedly check this growing trouble, and result in a considerable reduction of the daily consumption."

Number of meters in use, November, 1886, 67.

Number of meters in use, January, 1887, 82. Crown, 43.

The Trustees of the Water Works of Sandusky City, Ohio, in their report for 1885, say:

"The reduction of the waste of water with what few meters we have been able to furnish has been very considerable, as our record of the number of gallons pumped during the past year shows. That we have succeeded in reducing the waste and increasing the revenue are facts which should call for the approbation of every citizen desirous of promoting the interest of the City and the success of the Water Works. It seems that hardly any one could be found to object to the measurement of an article that he was engaged in purchasing. If a price is agreed upon, it should be for a given quantity, and neither buyer nor seller, one would suppose, could honestly object.

"We are aware that it is claimed that the meters are not correct. No sufficient proof of that fact has been made to our knowledge, but we are inclined to believe that the meter is disliked because it is the *truthful, sleepless and unprejudiced witness of the quantity of water used or wasted.* The meters we have used have all been tested by the makers, and the popularity and extensively growing use of the *Crown* meters throughout the United States and Canada furnish sufficient evidence of their reliability. We are of the opinion that no better or fairer method can be adopted for large consumers than the application of the meter, and whether the public approve or reject it, we shall retire from the positions we now occupy with the conscientious conviction that we have taken a step in the right direction, which, if persisted in, will be found most equitable for water takers and most beneficial to the Water Works. The success of the Water Works is a public gain; the reckless running of the engines without adequate remuneration is a public loss for private gain."

Supt. Judson, of the same Works, says, after showing the increase in receipts: "That the meters (which cost about $1,000) have more than paid for themselves in increased rent, or, in other words, have cost the Board nothing, and are ready for service another year, and will be for many years, if properly cared for. In fact, not only have the meters been the means of increasing the revenue, but they have done a great deal to check the waste of water in nearly every case where they have been put in. Consumers have accomplished the same results as formerly with fifty per cent. of the water formerly used."

Number of meters, September, 1886, 50. 44 Crown and Empire.

Supt. Dunbar of the Bay City, Mich., Water Works, in his report of 1885, says:

"The receipts for the first half of the year shows an increase of more than twenty-three million gallons over the first half of 1884, while the last half of the year shows a decrease of about eighteen million gallons from the last half of 1884. This is due principally to the cutting off the waste of water on services metered during the year."

Number of meters, November, 1886, 174. Crown and Empire, 127.

Supt. Bolling of the Richmond, Va., Water Works, in his report for 1885, says:

"There are now in use in the City thirty-one meters of different make, the majority are the *Crown* meters, and are giving general satisfaction. Great improvement has been made in the water meter, and in many cities they are rapidly being introduced as the only reliable means of making correct charges. I would recommend the purchase of quite a number, at least to place them on supplying manufacturers, motors, elevators, etc. They will also render much assistance in detecting waste, and will many times repay their cost."

Number of meters in use, November, 1886, 40. Crown, 23.

Supt. Miller of the Savannah, Geo., Water Works, in his report for 1885, says:

"The adoption of meters as recommended years ago, is becoming more necessary every recurring

year to large and indefinite consumers. Quite a disparity of rates are charged for uncertain quantities, which if measured to consumers at so much per thousand gallons, would be much more satisfactory."

No meters in service.

Supt. L. H. Knapp of Buffalo, N. Y., Water Works, says in his report of 1885:

"The amount received for metered water, including the three cent and six cent rate, was a little over $52,000. If the remainder of the water was sold at ten cents per 1,000 gallons, which would be one of the lowest rates for domestic consumers, the revenue of the Department would be $930,000, or more than double what was received, showing how important it is to meter large consumers, and preventing unnecessary waste."

Number of meters in service, November, 1886, 94.
Number of meters in service, January, 1887, 100.
Crown, 41.

Chief-Engineer Benzenberg of Milwaukee, Wis., Water Works, in his report for 1885, says:

"Water waste—nothing new could be said upon the subject. The useless waste of water is still going on. The hope for legislation last Winter failed to materialize, and resistance to the metering of water has arisen. It appears that a larger waste will be necessary to secure a proper support in the checking of the same. Meters, however, are continually being placed where deemed best and necessary."

720 meters in use November 1, 1886.

Supt. W. G. Richards of Atlanta, Ga., Water Works, in his report for 1885, says:

"The introduction of water meters, which, up to January 1, 1886, number 1,392, has certainly saved money to all classes of our citizens, as without them the rate of taxation must have been increased to raise money to pay for another main pipe, another set of pumping machinery, an additional reservoir, the necessary dam and suction pipe, etc., all of which would have cost between one hundred and thirty and one hundred and fifty thousand dollars. Facts show conclusively that the plan adopted was the very best method of securing just what we now have and all that has ever been promised by your body, namely, a good water supply for fire protection and sanitary purposes. Even the insurance agents are well pleased, which I take as good evidence of the efficiency of the water works. Another evidence of the effect of the meters is shown by the monthly reports of the Engineer. For the month of November, 1884, the pumpage was 132,679,900 gallons, and the coal consumed was 575,000 pounds, an average pumpage per day of 4,422,993 gallons, and a consumption of 19,133 pounds of coal. For the month of November, 1885, the pumpage was 48,130,000 gallons, and the coal consumed was 256,000 pounds, showing a saving in pumpage since the general introduction of meters of 2,818,993 gallons per day, and of coal 10,573 pounds per day. For more than two months past the small or original set of pumps have been furnishing the water for domestic uses and fires. I think it hardly necessary to produce any further argument in favor of the meter system."

Supt. W. G. Richards also adds in his report for the year 1886: "I cannot close this report without again mentioning the very gratifying results that have been obtained through the universal use of meters. The waste has been stopped, the pumpage has been reduced to about one-third what it was prior to their introduction, the consumption of coal is also about one-third of what it was, we are enabled to give the firemen all the pressure wanted or required, we have been enabled to get the pumping machinery in splendid condition, we are carrying a uniform domestic pressure that is giving satisfaction at the highest altitudes in the City and affording all the pressure required for the hydraulic elevators, the rate of insurance has been reduced, and the insurance underwriters are pleased with the uniform efficiency of the Works. There are no complaints or grumbling, except the regular monthly growls from those who have to pay for neglect or carelessness in the shape of a big water bill. Whatever merit the Water Works has is due to the meter system and the Board of Water Commissioners, aided by his honor the Mayor, who displayed the nerve to require their universal introduction, and thereby saved the Water Works from becoming a wreck."

Number of meters in service, 1885, 1,392.
Number of meters in service November, 1886, 1,778.
Number of Crown in service, March, 1887, 967.

Supt. Chas. E. Fowler of Poughkeepsie, N. Y., in his report for 1885, says:

"The long continued extreme cold of last Winter caused a flow to prevent freezing, and an impression that the sanitary condition was improved thereby, maintained the flow through the Summer months. The most diligent efforts of the inspector failed to stop it, as the fixtures were in good order, and as soon as he left the premises the flow would be resumed. The only remedy seems to be in the rapid increase of meters. The worst cases have been noted and meters have been put on; others were noted for future application. Eighty-eight meters (eighty-seven were Crown and Empire) have been added during the year."

Number of meters in service, January 1887, 433.
Crown and Empire, 243.

John Caulfield, Sec'y of Board of Water Commissioners of St. Paul, Minn., in his report ending December, 1886, says:

"There are now in use 200 meters, an increase of 34. The revenue derived from this source was $30,603, an increase of $1,120 over former year. It is the intention of this Department to place meters on all livery stables, restaurants, laundries, manufacturing establishments where steam is used, and on all other places where large quantities of water is used or waste suspected."

Number of meters in service, December, 1886, 200.

Edward W. Cate, Esq., Pres. of Water Board, City of Newton, Mass., in the report for the year ending December 31, 1885, says:

"The established policy of the Department in encouraging the use of meters meets with the continual approval of the Board, not only because, in the opinion of the Board, the sale of water by measure is the most equitable and satisfactory method of its disposal, but also for the reason that meters are invaluable in the proper administration of the most important branch of Water Works management, the suppression of water waste. The Board have been for some time considering the question of recommending a more general use of meters even than now exists; and, while believing that possibly at the present time there may not be a necessity for requiring all services supplying bath-rooms to be metered, they feel that in the near future such a plan or an approximation to it, will be deemed expedient."

Number of meters, January, 1887, 1,998. Crown 1,415.

Secretary Sloan of Erie, Pa., Water Works, in his report for 1885, says:

"Fifty-two meters are in use, being nine more than last year. Except in one or two instances, every meter that has been set has shown a greater consumption of water than has been suspected. No consumer can justly complain when a meter is applied to his premises, as every failure in the operation of the same must, from the nature of their construction, be in his favor."

Number of meters in use January, 1886, 53.
Number of meters in use January, 1887, 63.

Supt. R. N. Ellis, of Jacksonville, Fla., in his report dated July, 1886, says:

No new Meters have been bought this year, owing to the other large outlays we have had to make, but we need them badly, and another hundred should be procured as soon as possible. We now have in use 240 meters. The cost of meter service for repairs, cleaning, testing and reading for the year was $170.99, a very small amount, when compared with the revenue derived from the use of the meters.

Number of meters in use July, 1886, 240. All Crown meters.

Extracts from Thirty-one Water Departments.

STATEMENT OF

CHARLES B. BRUSH, Chief-Engineer and Superintendent of the Hackensack Water Company, Hoboken, N. J.,

ON THE USE OF WATER METERS.

HACKENSACK WATER COMPANY, REORGANIZED,
No. 15 NEWARK ST., HOBOKEN, N. J., February 23, 1887.

NATIONAL METER COMPANY, 252 *Broadway, New York.*

GENTLEMEN: In reply to your request of the 18th inst., I would inform you that the population of the district supplied by this Company, which includes Hoboken and Northern New Jersey, in the Hackensack Valley and easterly to the Hudson River, contained, according to the census of 1885, a population of 68,588 people. During the year 1886 the operating expenses of the Company amounted to $43,012.65, and the gross receipts amounted to $125,674.83, the receipts over expenses amounting to $82,662.18. The daily consumption in gallons is 3,659,067. 1,888 meters are used, of which 1,329 were made by your Company.

Yours respectfully,

CHAS. B. BRUSH, Chief-Engineer and Superintendent.

HACKENSACK WATER COMPANY REORGANIZED,
No. 15 NEWARK ST., HOBOKEN, N. J., February 21, 1887.

NATIONAL METER COMPANY, 252 *Broadway, New York City.*

GENTLEMEN: The following data is furnished in reply to your request of the 18th inst. There are at present 4,643 consumers from the mains of this Company. 1883 of these consumers are metered. 1,329 of these meters were made by your Company, and the balance (559) were made by H. R. Worthington. In order to ascertain the effect of attaching meters on premises which had been supplied for many years with water on the ordinary House Rate Plan (without meters), 439 houses were selected in Hoboken, and after a great deal of public opposition, meters were attached to each of them. These premises were principally large tenements, apartment houses, saloons, and some private residences. The following table, showing the effect each quarter for the last fifteen months of metering these 439 houses, demonstrates most conclusively the original position taken by this Company, that the attachment of meters was decidedly to the interest of the great majority of the consumers, as well as to the Water Company.

Consumers.	House Rates.	Meter Rates.	Difference.
Nov. 1, 1885 to Feb. 1, 1886:			
83⅓% reduced	$2,978.39	$2,047.92	$930.47
17⅓% increased	687.41	1,042.73	355.32
	$3,665.80	$3,090.65	Loss, $575.15
Feb. 1 to May 1, 1886:			
63% reduced	$2,382.13	$1,433.28	$948.85
37% increased	1,424.87	2,610.50	1,185.53
	$3,807.00	$4,043.78	Gain, $236.68
May 1 to Aug. 1, 1886:			
59% reduced	$2,254.88	$1,453.26	$801.62
41% increased	1,566.95	2,775.17	1,208.22
	$3,821.83	$4,228.43	Gain, $406.60
Aug. 1 to Nov. 1, 1886:			
57% reduced	$2,188.45	$1,447.16	$741.29
43% increased	1,633.38	2,813.29	1,179.91
	$3,821.83	$4,260.45	Gain, $438.62
Nov. 1, 1886, to Feb. 1, 1887:			
72% reduced	$2,751.72	$1,941.04	$810.68
28% increased	1,070.11	1,948.81	878.70
	$3,821.83	$3,889.85	Gain, $68.02

In order to ascertain the effect of the meter system in a NEW DISTRICT, 191 average dwellings were selected on Union Hill, which contained about eight occupants to each house. These houses were metered. If house

STATEMENT OF CHARLES B. BRUSH—CONTINUED.

rates in each case had been charged, the daily draft per capita would have been about 75 gallons, and the following result would have been obtained :

Houses, 191.	Annual Revenue, $2,597.62.	Daily Draft, 115,000 galls.

The following have been the actual results :

First six months, Winter,	$1,081.32	12,860	"
Second " " Summer,	1,617.26	18,948	"
Third " " Winter,	1,510.44	18,000	"
Fourth " " Summer,	1,869.94	24,000	"
Fifth " " Winter,	1,385.17	16,550	"
Sixth " " Summer,	1,959.24	23,000	"

At House Rates each house would have averaged $13.66 per annum.

At Meter Rates the actual return was :

At rate of 1st six months, Winter,	$5.66 per Annum	
" " " 2d " " Summer,	8.46 " "	
	~~Whole year, $14.12~~	
" " " 3d " " Winter,	$7.90 " "	
" " " 4th " " Summer,	9.74 " "	
	~~Whole year, $17.64~~	
" " " 5th " " Winter,	$7.58 " "	
" " " 6th " " Summer,	10.25 " "	
	~~Whole year, $17.83~~	

Our experience indicates that two-thirds of all consumers on the House Rate Plan pay for one-third more water than they use, and the remaining one-third of the consumers are careless, wasteful, and consume more water than double the number of their more careful neighbors save ; hence, any form of House Rate Tax is a manifest injustice to the great majority of consumers.

When the revenue of the meter system equals the revenue from House Rates, the consumption with meters is reduced about two-thirds below the consumption which exists when House Rates are charged.

This Company furnishes all meters and keeps them in repair (except in case of misuse or frost) without cost to consumers. This is done because it is believed to be just to the consumers and economical to the Company. No NEW CONSUMER is accepted without A METER ATTACHED to his service pipe. Only one meter is furnished by the Company to each tap.

Respectfully submitted,

CHAS. B. BRUSH, Chief-Engineer and Superintendent.

Hackensack Water Company reports

	Consumers.	Average daily consumption.	Per capita.	No. of meters.
1883.	2,846	3,850,905 gallons.	136 gallons,	76
1886.	4,653	3,659,067 " 191,838, less—	54 "	1,888

HOW DO YOU GOVERN WATER BILLS WHEN USING METERS?

This question is often asked, and we offer this solution:

Make a minimum charge to EVERY CONSUMER, PAYABLE IN ADVANCE.

Charge ALL CONSUMERS the same rate per 1,000 gallons up to minimum amount, all over that quantity, charge as per your meter schedule.

To illustrate:

Minimum annual charge, say, $10.00 @ 25c. per 1,000 galls, give 40,000 gallons per year.
" " " " 12.00 " " " " " 48,000 " "
" " " " 15.00 " " " " " 60,000 " "

25 cents per 1,000 gallons should be the minimum price for that amount of water.

Examine and read meters quarterly, on LARGE CONSUMERS MONTHLY.

Many Departments charge yearly rental of 10 to 15% on cost of meters, payable in advance.

We strongly recommend that EVERY DEPARTMENT own and control all Meters in service, and that it HOLD CONSUMERS RESPONSIBLE FOR DAMAGE OR NEGLIGENCE.

COST OF SETTING WATER METERS.

The Meter Inspector (J. C. Whitney) of the Water Works at Newton, Mass., states: "The average cost of setting 700 ¾-inch CROWN METERS—during last six months—was 88 cents each, the 1-inch about double, $1.75.

PROVIDENCE, R. I., Water Works charge for setting a ¾-inch or 1-inch, $3.75.

We cite the above regarding the setting of meters, and would say, in our judgment, the cost ordinarily would be, from $2.00 to $3.00 for the smallest size.

STATISTICS OF WATER WORKS USING WATER METERS IN COMPARISON WITH THOSE WHICH DO NOT. IN EXPENSES, RECEIPTS, AND DAILY CONSUMPTION, FROM ANNUAL REPORTS OF 1885 AND 1886.

TABLE No. 1.	Population.	Date of Pop.	Report for Year.	Expenses in Dollars.	Receipts in Dollars.	Receipts over Expenses in Dollars.	Daily Consumption in Gallons.	Difference in Daily Consumption in Gallons.	Number of Meters	Meters Mnfd. by North Meter Co.	Gal. per Capita.
New York ..... N. Y.	1,206,299	1880	1885	997,040	2,299,365	1,302,325	109,000,000		'86 14,582 '85 14,230	7,731 7,129	90
Philadelphia ..... Penn.	947,000	Est. 1885	"	534,960	1,826,164	1,291,204	68,945,260		'85 305 '86 3,891	277 1,585	72 5/16
Boston ..... Mass.	451,898	1886	1886	470,946	1,455,673	984,727	34,027,700		'85 4,662	1,304	77
Buffalo ..... N. Y.	225,000	Est. 1885	1885	92,448	Receipts, - 353 069 Frontage Tax, 91,355 444,424	351,992	28,606 557	Less. 5,421,143	'86 100 '85 94	41	127
Detroit ..... Mich.	180,000	1880	"	62,375	313,205	250,830	27,317,341		'85 36		152
St. Louis ..... Mo	350,518	Est. 1885	"	298,892	800,325	501,433	26,900,000	417,341	'86 2,143	364	77
Washington ..... D. C.	159,176	1880	"	108,925	145,585	36,860	26,500,000		'85 3 '86 1,175		166
Cleveland ..... Ohio.	210,000	Est. 1886	"	74,049	321,992	247,943	17,950,694	8,549,306	'85 1,098 '86 720		85
Milwaukee ..... Wis.	158,509	Est. 1885	"	94,609	240,027	145,418	16,062.475		'85 572 '86 7,135	59 3,226	102
Providence ..... R. I.	120,000	Est. 1885	"	129,972	313,561	183,569	4,730,556	11,331,919	'85 6,648 '86 38	2,678 23	39
Richmond ..... Va.	72,000	Est. 1885	"	68,478	98,632	30,154	9,906,122		'85 31 '86 963	842	138
Rochester ..... N. Y.	110,000	Est. 1885	"	59,346	179,445	120,099	6,343,292	3,562,830	'85 827		57
Allegheney City ..... Penn.	78,682	1880	"	41,481	191,955	150,471	13,000,000		'8 1 '8 1,503		164
Lowell ..... Mass.	64,051	Est. 1885	"	47,156	153,748	106,592	3,561,000	9,439,000	'8 1,421 '8 304	161 254	56
Toledo ..... Ohio.	50,137	1880	"	24,998	50,170	25,172	3,740,148		'8 279	192	75
Worcester ..... Mass.	68,383	Est. 1885	"	55,133	110,265	55,132	3,450,000	290,148	'85 6,005		51
Savannah ..... Geo.	44,831	1884	"	24,517	45,831	21,214	4,739,612		00		105
Springfield ..... Mass.	37,577	Est. 1885	"	28,904	111,882	82,987	2,000,000	2,739,612	'86 308 '85 285	136	79

STATISTICS OF WATER WORKS USING WATER METERS IN COMPARISON WITH THOSE WHICH DO NOT, IN EXPENSES, RECEIPTS, AND DAILY CONSUMPTION, FROM ANNUAL REPORTS OF 1885 AND 1886. CONTINUED.

TABLE No. 2.	Population.	Date of Rep.	Report for Year.	Expenses in Dollars.	Receipts in Dollars.	Receipts over Expenses in Dollars.	Daily Consumption in Gallons.	Difference in Daily Consumption in Gallons.	Number of Meters.		Meters Manf'd. by Nat'l Meter Co.	Gal. per Capita.
Minneapolis. Minn.	160,000	Est. 1886	1885	41,864	84,115	42,251	7,093,254		'86	140		
Columbus. Ohio.	51,647	1880	"	25,832	85,066	59,234	5,086,957	2,006,297	'85	72		47
Nashville. Tenn.	55,000	Est. 1886	"	46,847	71,363	24,516	6,000,000		'85	449		99
Fall River. Mass.	59,026	1886	"	35,783	127,475	91,692	1,488,137	4,511,863	'85	8		109
St. Paul. Minn.	125,000	Est. 1886	"	46,916	152,860	105,944	7,708,846		'86	2,725	1,824	
Hartford. Conn.	42,015	1880	"	30,587	143,815	113,228	5,500,000	2,208,846	'85	2,569	1,603	24
Harrisburg. Pa.	30,762	1880	"	24,967	68,173	43,206	5,143,015		'86	200	92	
Manchester. N. H.	42,000	Est. 1886	"	15,169	80,404	65,235	1,452,644	3,690,371	'85	165	36	63
Erie. Pa.	27,737	1880	"	17,386	53,550	36,164	2,879,574		'85	280		131
Lawrence. Mass.	39,151	1880	"	16,472	78,114	61,642	2,296,265	583,309	'85	1		171
Wilmington. Del.	55,000	Est. 1886	"	41,927	98,489	56,562	4,431,339		'86	675	251	
Lynn. Mass.	37,000	Est. 1886	"	19,328	110,539	91,211	1,920,619	2,310,820	'85	486		344
Dayton. Ohio.	50,000	1886	"	17,394	25,297	7,903	1,643,937		'86	63	14	
Atlanta. Geo.	50,000	Est. 1886	1886	17,936	33,182	15,246	1,575,416	68,521	'85	52		104
Lancaster. Pa.	25,769	1880	1885	12,490	48,500	36,010	4,017,155		'86	702	422	
Salem. Mass.	28,000	Est. 1886	"	21,612	47,796	26,184	2,491,930	1,525,225	'85	680	272	58
Fort Wayne. Ind.	26,880	1880	"	10,662	21,181	10,519	1,307,790		'85	5		81
Kalamazoo. Mich.	18,000	Est. 1886	"	8,611	9,557	946	1,262,161	45,629	'86	225	15	
									'85	184		52
									'86	100	51	33
									'86	1,778	967	
									'85	1,492		31
										00		161
									'85	138	12	89
									'85	103	98	49
									'85	9		70

STATISTICS OF WATER WORKS USING WATER METERS IN COMPARISON WITH THOSE WHICH DO NOT, IN EXPENSES, RECEIPTS, AND DAILY CONSUMPTION, FROM ANNUAL REPORTS OF 1885 AND 1886. CONTINUED.

TABLE No. 3.	Population.	Date of Pop.	Report for Year.	Expenses in Dollars.	Receipts in Dollars	Receipts over Expenses in Dollars.	Daily Consumption in Gallons	Difference in Daily Consumption in Gallons	Number of Meters		Meters Mnfd. by Nat'l Meter Co.	Gal. per Capita.
Bay City, Mich.	32,000	Est. 1886	1885	13,628	20,212	6,584	2,293,068		'86	174	127	72
									'85	154	107	
Taunton, Mass.	23,674	1885	"	14,938	42,249	27,311	675,870	1,617,198	'86	680	295	28
									'85	597	258	
East Saginaw, Mich.	30,329	1885	"	14,145	24,616	10,471	2,136,764		'86	91	68	71
									'86	1,998	1,415	
Newton, Mass.	16,995	1880	"	12,873	53,846	40,973	614,969	1,521,795	'85	998	413	36
Sandusky, Ohio.	23,000	Est. 1886	"	14,067	17,565	3,498	1,517,284		'86	48	44	66
								More.	'85	24	23	
Pawtucket, R. I.	25,000	"	"	16,912	79,013	62,101	2,256,281	738,997	'86	2,596	1,666	81
									'85	2,400	1,462	
Augusta, Ga.	35,000	"	"	8,816	28,030	19,214	2,177,595		'85	00		84
								Less.	'86	1,315	940	
Yonkers, N. Y.	22,000	"	"	19,293	49,636	30,346	1,407,000	770,595	'85	1,084	728	64
Zanesville, Ohio	22,000	"	"	18,049	29,184	11,135	2,185,406		'85	3		99
New Brunswick, N. J.	20,000	"	"	11,364	43,949	32,585	1,059,101	1,126,305	'85	86	80	53
Rome, N. Y.	13,000	"	"	7,280	12,967	5,687	1,733,711		'85	00		133
									'86	262	138	
Burlington, Vt.	13,500	"	"	14,238	29,281	15,043	572,674	1,161,037	'85	239		44
Staunton, Va.	6,664	1880	"	2,037	10,999	8,962	740,584		'85	3		123
									'86	525	26	
Woonsocket, R. I.	16,059	1880	"	6,933	16,726	9,793	147,634	592,950	'85	364		9
50 CITIES.												

In arranging these tables, we have grouped two cities together, and you will notice the cities having the most meters, have the largest net receipts, and less daily consumption.

COMPARISONS.

The last Annual Report for 1885, of Providence, R. I., stated, the gross amount received for Water was $313,561. Average daily consumption was 4,730,556 gallons. Meters, 6,648. Had the following Cities received the same proportion for their daily consumption, it would be

	Amount now received in Dollars.	Average Daily Consumption in Gallons.	Number of Times More than Providence.	What the Gross Amount would Come to in Dollars.	Number of Meters in Use.
New York, N. Y.	$2,299,365	169,000,000	23 3/100	7,221,209	14,582 Dec. 31, '86.
Philadelphia, Pa.	1,826,164	68,945,360	14 43/100	4,430,616	277
Chicago, Ill.	1,339,038	91,647,642	19 37/100	6,073,676	3,100
Brooklyn, N. Y.	1,257,769	43,414,270	9 18/100	2,878,489	2,396
Boston, Mass.	1,548,322	32,344,550	6 84/100	2,144,756	4,662
Buffalo, N. Y.	444,424	28,006,557	6 47/100	2,028,749	94
Detroit, Mich.	313,205	27,317,341	5 83/100	1,828,059	36
St. Louis, Mo.	800,325	26,900,000	5 68/100	1,781,025	2 143
Washington, D. C.	145,586	26,500,000	5 49/100	1,693,220	3
Milwaukee, Wis.	210,027	16,052,475	3 40/100	1,066,107	572
Allegheny City, Pa.	191,955	13,000,000	2 75/100	862,292	1
Louisville, Ky.	226,670	9,920,340	2 09/100	655,882	427
Richmond, Va.	98,632	9,906,122	2 09/100	655,882	72
Troy, N. Y.	82,034	8,000,000	1 69/100	529,918	35
Minneapolis, Minn.	84,115	7,093,254	1 50/100	536,189	72
Nashville, Tenn.	71,363	6,000,000	1 27/100	398 222	00
Rochester, N. Y.	179,445	6,343,292	1 34/100	420,171	906
Harrisburg, Pa.	68,173	5,143,015	1 08/100	338.645	1
Wilmington, Del.	98,489	4,431,339	94/100 of 1%	294.748	6
Lancaster, Pa.	48,500	4,017,165	85/100 of 1%	266,527	00
Toledo, O.	50,170	3,740,128	79/100 of 1%	232,035	279
Erie, Pa.	53,550	2,579,874	54/100 of 1%	169,322	52
Salem, Mass.	47,796	2,491,930	52/100 of 1%	163,051	138
Bay City, Mich.	20,212	2,293,066	48/100 of 1%	150,509	154
Zanesville, O.	29,184	2,185,406	46/100 of 1%	144,238	3
Lawrence, Mass.	78,114	2,296,265	48/100 of 1%	150,509	680
Augusta, Ga.	28,030	2,177,595	46/100 of 1%	144,238	00
Lynn, Mass.	110,539	1,920,519	41/100 of 1%	128,560	225
Rome, N. Y.	12,967	1,733,711	37/100 of 1%	116,017	00
Lewiston, Me.	30,580	1,718,445	37/100 of 1%	116,017	73
Fall River, Mass	127,475	1 488,137	30/100 of 1%	94,068	2,569
Manchester, N. H.	80,404	1,452,644	30/100 of 1%	94,068	486
Sandusky, O.	17,665	1,517,284	31/100 of 1%	97,283	24
Pittsfield, Mass.	20,557	1,465,786	30/100 of 1%	94,068	6
Dayton, O.	25,295	1,643,937	34/100 of 1%	106,610	100
Pawtucket, R. I.	79,013	2,256,281	46/100 of 1%	150,509	2,400
26 Cities	$12,174,851	578,054,622		$38,275,493	Prov. 6,648 Meters Total, 43,222 "

If at the same ratio as Providence, it would be $38,275,493. Difference, $26,100,642.

Amount now received for daily consumption of 578,054,622 galls., $12,174,851.

Total number of Meters, including Providence, 43,222.

QUERY.—Why do not all Water Works receive the same pro rata amount for their water as PROVIDENCE, R. I. and FALL RIVER, MASS.?

ANSWER.—Because PROVIDENCE, R. I. has 57 per cent., and FALL RIVER, MASS., 67 per cent. of their taps metered.

A GOOD INVESTMENT FOR WATER WORKS.

$10,000 invested in "Crown" Meters a year, at 6 per cent.		$600.00
Repairs on same (from all causes), 2 per cent.		200.00
" " " less frozen meters, 1 per cent.	$100.00	

In estimating the Cost of Repairs at 2 per cent. per annum we have exceeded the amount at least four times, as it will not amount to ½ of 1 per cent. per annum. (See "Table of Cost of Repairs," page 34.)

The saving in a *year* of	3,200,000	gallons, or	8,767	gallons a *day*,	at 25	cts.	1,000	gallons,	$800.00
" "	4,000,000	" "	11,233	" "	" 20	"	"		800.00
" "	5,332,000	" "	14,608	" "	" 15	"	"		800.00
" "	8,000,000	" "	22,466	" "	" 10	"	"		800.00
" "	16,000,000	" "	44,932	" "	" 5	"	"		800.00

$20,000 invested in "Crown" Meters a year, at 6 per cent.		$1,200.00
Repairs on same (from all causes), 2 per cent.		400.00
" " " less frozen meters, 1 per cent.	$200.00	

The saving in a *year* of	6,400,000	gallons, or	17,534	gallons a *day*,	at 25	cts.	1,000	gallons,	$1,600.00
" "	8,000,000	" "	22,466	" "	" 20	"	"		1,600.00
" "	10,664,000	" "	29,216	" "	" 15	"	"		1,600.00
" "	16,000,000	" "	44,932	" "	" 10	"	"		1,600.00
" "	32,000,000	" "	95,864	" "	" 5	"	"		1,600.00

$50,000 invested in "Crown" Meters a year, at 6 per cent.		$3,000.00
Repairs on same (from all causes), 2 per cent.		1,000 00
" " " less frozen meters, 1 per cent.	$500.00	

The saving in a *year* of	16,000,000	gallons, or	43,835	gallons a *day*,	at 25	cts.	1,000	gallons,	$4,000.00
" "	20,000,000	" "	56,165	" "	" 20	"	"		4,000.00
" "	26,660,000	" "	73,040	" "	" 15	"	"		4,000.00
" "	40,000,000	" "	112,330	" "	" 10	"	"		4,000.00
" "	80,000,000	" "	224,660	" "	" 5	"	"		4,000.00

TABLE ILLUSTRATING WHAT 10 PER CENT. OF DAILY CONSUMPTION AMOUNTS TO, IF SAVED.

It is estimated that the wastage of most Water Works amounts to **at least 30 per cent. of the daily consumption.** **A saving of 10 per cent. of the daily consumption** would show:

	Daily Consumption in gallons.	10% of Daily Consumption.	Amount of 1,000 Gallons a Day.	Amount of 1,000 Gallons Per Day For a Year.	Which is the Interest on at 6 per cent.	Which is the Interest on at 4 per cent.
New York,	109,000,000	10,900,000	@5 cts. $545.00	$198,925	$3,315,416	$4,973,125
			10 1,090.00	397,850	6,620,832	9,946,250
Philadelphia, Pa.,	68,945,260	6,894,526	5 344.70	125,815	2,083,524	3,095,375
			10 689.40	247,630	4,167,048	6,190,750
Brooklyn, N. Y.,	43,414,270	4,341,427	5 217.05	82,223	1,370,384	2,055,575
			10 434.10	164,446	2,740,678	4,111,150
Boston, Mass.,	32,344,550	3,234,455	5 161.70	59,020	983,668	1,475,500
			10 323.40	118,040	1,967,332	2,951,000
Buffalo, N. Y.,	28,606,557	2,860,655	5 143.00	52,195	869,916	1,304,875
			10 286.00	104,290	1,739,832	2,607,250
Milwaukee, Wis.,	16,062,475	1,606,247	5 80.30	29,309	488,482	732,725
			10 160.60	58,618	976,964	1,465,450
Detroit, Mich.,	27,317,341	2,731,734	5 136.55	49,840	830,666	1,237,000
			10 273.10	99,681	1,661,332	2,492,025
St. Louis, Mo.,	26,900,000	2,690,000	5 134.50	49,092	785,472	1,227,300
			10 269.00	98,185	1,570,944	2,454,625
Washington, D. C.,	26,500,000	2,650,000	5 132.50	48,362	789,912	1,209,050
			10 265.00	96,725	1,579,824	2,418 125
Cleveland, Ohio.,	17,950,694	1,795,069	5 89.75	32,758	545,966	818,950
			10 179.50	65,516	1,091,932	1,637,900
Richmond, Va.,	9,906,122	990,612	5 49.50	18,067	301,116	451.675
			10 99.00	36,135	602,232	903,875
Rochester, N. Y.	6,343,292	634,329	5 31.70	11,570	192,834	289,250
			10 63.50	23,140	385,166	578,500
Allegheny City, Pa.	13,000,000	1,300,000	5 65.00	23,725	395,416	593 125
			10 130.00	47,450	790,832	1,186,250
Lowell, Mass.,	3,561,000	356,100	5 17.80	6,497	108,284	162,425
			10 35.60	12,994	216,568	324,850
Toledo, Ohio.,	3,740,148	374,014	5 18.70	7,825	130,425	195,630
			10 37.50	15,651	260,850	391,275
Savannah, Ga.,	4,739,612	473,961	5 23.69	9 826	163,781	245,671
			10 47.38	19,653	327,562	491,325

From Reports of 83 Water Works on their daily waste, the average was 33 $\frac{71}{100}$ per cent. of their daily consumption. Six reported wastage very large.

According to Chief-Engineer Wm. Ludlow, 57 per cent. of the water supply is used, while 43 per cent. is wasted.

TABLE SHOWING THE WATER RATES PER 1,000 GALLONS IN THE FOLLOWING PLACES WHERE METERS ARE USED:

	Cents.
MAINE.	
Bangor	30
Portland	20 to 40
" Minimum annual charge, $10.	
NEW HAMPSHIRE.	
Manchester	20
" Minimum annual charge $15.	
Nashua	15 to 30
VERMONT.	
St. Alban's	10 to 30
Burlington	12 to 50
MASSACHUSETTS.	
Amesbury	30 to 50
Boston	20
Clinton	15 to 50
Cambridge	10 to 20
Fall River	30
" Minimum annual charge, $10.	
Haverhill	15 to 20
Hingham	25
Lawrence	20 to 25
" Minimum annual charge, $10.	
Lowell	15
" Minimum annual charge, $12.	
Lynn	17½ to 20
" Minimum annual charge, $12.	
New Bedford	2½ to 15
Northampton	10 to 20
North Adams	10 to 15
Quincy	12½ to 30
Peabody	20
Pittsfield	10
Salem	13⅓ to 20
Springfield	10 to 20
" Minimum annual charge, $8 & $10.	
Taunton	12½ to 25
" Minimum annual charge, $10.	
Waltham	25 to 30
Westboro	50
Worcester	15 to 25
CONNECTICUT.	
Bridgeport	20 to 30
Hartford	7½ to 30
Meriden	10 to 25
New Britain	10
New Haven	10 to 35
New London	20 to 30
Norwich	15 to 30
Stonington	10 to 20

	Cents.
RHODE ISLAND.	
Providence	15 to 30
" Minimum annual charge, $10.	
Pawtucket	6 to 30
Woonsocket	30
Waterbury	10 to 30
NEW YORK.	
Albany	5 to 40
Amsterdam	6 to 30
Binghamton	6 to 25
Brooklyn	10½
Buffalo	3
Catskill	12 to 25
Cortland and Homer	20 to 50
Corning	10 to 30
Elmira	9 to 45
Flushing	20 to 60
Johnstown	25
Kingston	30
Mt. Morris	10 to 30
New York	13⅓
Owego	80
Oneonta	20 to 50
Oneida	20 to 50
Rochester	5 to 13
Saratoga	15
Syracuse	6 to 25
" Minimum annual chrage, $10.	
Troy	10 to 20
Utica	15 to 30
" Minimum annual charge, $10.	
Waverly	20
Waterford	5 to 20
Whitehall	6 to 20
Yonkers	16 to 40
" Manufacturers special rates: Minimum annual charge, not less than $1.00 per quarter. No connections without meters since December 3d, 1885.	
NEW JERSEY.	
Bridgeton	20
Hackensack	13 to 23
" all new consumers must have a meter.	
Jersey City	21 to 27
Morristown	33
Newark	15
" Minimum annual charge, $15.	
New Brunswick	12½ to 50
Trenton	15 to 20

Pennsylvania.

	Cents.
Allegheny City	15
Bloomsburg	10 to 35
Conshohocken	15
Easton	16⅔ to 40
Erie	6 to 10
Franklin	60
Hazelton	10 to 15
Lebanon	5 to 15
Meadville	8 to 30
McKeesport	4½ to 30
Philadelphia	8
Pittsburg	5 to 20
Reading	10¾ to 21½

Ohio.

Cleveland	6⅔ to 13⅓
Cinicinnati	9
Columbus	7 to 20
" Minimum annual charge, $6.	
Dayton	8 to 40
Norwalk	10
Sandusky	6 to 20
" Minimum annual charge, $5.	
Springfield	10 to 40
Toledo	8 to 20
Wooster	15

Indiana.

Indianapolis	12 to 40
Terre Haute	11
South Bend	

Illinois.

Bloomington	10 to 15
Chicago	8 to 10
Joliet	15 to 30
Jacksonville	13 to 40
" Minimum annual charge, $5.	
Quincy	15 to 50

Michigan.

Bay City	5 to 10
Detroit	10
East Saginaw	6 to 12
Flint	6 to 30
Grand Rapids	9½ to 30
Kalamazoo	10
Port Huron	5 to 20

Wisconsin.

Kenosha	10 to 15
Milwaukee	4½ to 20
Madison	20 to 50

Iowa.

	Cents.
Council Bluff	15 to 35
Cedar Rapids	15 to 40
Dubuque	30 to 60
Davenport	10 to 40
Des Moines	15 to 20
Ottumwa	10 to 30
Muscatine	35 to 60
Sioux City	13 to 40

Minnesota.

Minneapolis	10 to 20
" Minimum annual charge, $10.	
Winona	8
St. Paul	15 to 40

Missouri.

Hannibal	20 to 50
Kansas City	10 to 35
Springfield	25
St Louis	12½ to 30

Kansas.

Abilene	30 to 50
Atchison	20

Colorado.

Denver City	30
Gunnison to large consumers	10

Nebraska.

Lincoln	10 to 20

California.

Los Angeles	30
Oakland	30 to 55
San Francisco	23½ to 46
Vallego	40 to $1

Delaware.

Wilmington	10

Maryland.

Baltimore	8
Hagerstown	8 to 60

Virginia.

Norfolk	20 to 40
Richmond	15

North Carolina.

Charlotte	30 to 50
Wilmington	10 to 20

South Carolina.

Charleston	25 to 60

Georgia.

Atlanta	17
" new consumers must have a meter.	

	Cents.
ALABAMA.	
Birmingham	6 to 40
Montgomery	25
LOUISIANA.	
New Orleans	15 to 30
TEXAS.	
Fort Worth	20 to 45
San Antonio	25 to 50
KENTUCKY.	
Maysville	15 to 30
Newport	10
" Minimum annual charge, $15.	
Owensboro	10 to 25
KENTUCKY—*Continued.*	
Lexington	17½ to 25
Louisville	6 to 35
TENNESSEE.	
Chattanooga	6 to 33
Knoxville	10 to 30
Nashville	7 to 15
CANADA.	
Brantford	12 to 20
Hamilton	12½
Halifax	30
London	20 to 33⅓
St. Catharine	14

Average Minimum Price for 1,000 Gallons, in 163 places, - - 9.4 cents.
" Maximum " " " " " - - - 28 "
Extremes, 2 1/2 cents to 100 cents.

THE FOLLOWING TABLE WILL SHOW HOW CITY WATER MAY BE WASTED.

Gallons and hundredths of gallons of water that will be discharged per minute through various sized orifices at the heads stated.

Head in Feet.	Pressure per Square Inch.	DIAMETERS OF ORIFICES IN INCHES AND FRACTIONS OF AN INCH.													
		1-64	1-32	1-16	⅛	¼	⅜	½	⅝	¾	1	1¼	1½	1¾	2
20	8.66	0.02	0.07	0.30	1.20	5.10	11.70	20.66	32.20	46.20	82.30	128.40	184.80	252.00	328.80
40	17.32	0.02	0.11	0.45	1.80	7.40	16.30	29.60	45.50	65.50	116.50	182.40	261.60	256.40	465.60
60	25.99	0.03	0.14	0.55	2.20	8.90	20.00	35.60	57.70	80.30	142.80	223 20	320.40	436.80	571.20
80	34.65	0.04	0.16	0.65	2.60	10.30	23.20	41.20	64.30	92.60	164.40	258 00	370.80	505.20	658.80
100	43.31	0.04	0.18	0.75	2.90	11.50	25.90	46.10	72.00	103.70	183.60	288.00	415.20	565.20	738.00
120	51.98	0.05	0.19	0.78	3.10	12.60	28.30	50.40	78.80	113.50	201 60	315 60	453.60	624.40	807.60
140	60.64	0.05	0.21	0.85	3.40	13.60	30.60	54.50	85.20	122.40	217.20	340.80	490.80	668 40	872.40
150	64.97	0.05	0.22	0.88	3.50	14.10	31.70	56.40	88.20	127.20	225.60	352.80	507.60	691.20	902 40
175	75.80	0.06	0.24	0.95	3.80	15.20	34.20	61.00	95.30	136.80	243.60	380 40	548.40	748.80	975 60
200	86.83	0.06	0.26	1.02	4.10	16.30	36.60	65.20	101.80	146.40	260.40	406.80	588.00	798.00	1042.80
235	101.08	0.07	0.28	1.12	4.50	17.90	41.30	71 50	137.70	185.80	285.20	445.90	642.20	871.30	1140.80

' The wire of which pins are made is 1-32d of an inch in diameter—No. 21, wire gauge. The finest cambric needle is made of wire 1-64th of an inch in diameter—No. 27, wire gauge. A stream the size of a pin, running one year with a head of 235 feet, will flow 147,168 gallons, equaling 4,600 barrels, at a loss—counting at the rate of 10 cents per 1,000 gallons—of $14.71. A stream the size of a cambric needle, running at the same pressure, and for the same time, will waste 36,792 gallons, a loss of $3.68.

(From The Sanitary Engineer and Construction Record, of Jan. 29th, 1887.)

MEASURING WATER.

WHY at the close of the nineteenth century water should have been sold by guess-work and every other necessary domestic article by measure, is one of the problems that students of political economy will puzzle themselves over a hundred years hence, if not sooner. It is so evidently wasteful and so manifestly uneconomical that it is a marvel that the business men of the country submit to the imposition. Mr. Benzenberg, the City Engineer of Milwaukee, Wis., has grouped together some interesting and instructive facts in this connection, his object being to show the taxpayers of his city that they are being swindled in the matter of their water-supply. Not that the Water Commissioners of Milwaukee are deliberately or intentionally allowing the people to be robbed. So far as we know they are honorable and worthy men, but nevertheless they allow the public money to be spent in pumping up annually into their reservoir about 5,000 millions of gallons more than the consumers of water use for any legitimate purpose or than they need. If those who made away with this extra quantity of water paid the bills, it would not be so bad; but they do not pay their share. The careless and wasteful user of water pays no more than the careful one, although there is three or four times as much coal and labor paid for by the city to furnish him with water as to supply his frugal neighbor. It can, we think, be easily shown that the annual saving in operating expenses consequent upon the application of meters to every service-pipe in Milwaukee would be more than double the interest on the cost of the meters. Besides this, every consumer would pay only for what he used and not be taxed for his neighbor's wastefulness.

(From Sanitary Engineer.)

THE SUPPRESSION OF WATER WASTE.

The following data, for which we are indebted to Mr. Samuel M. Gray, City Engineer, was prepared in response to certain inquiries made by us, and will be found of special interest. It certainly makes a good showing for the meter system:

CITY ENGINEER'S OFFICE, WATER DEPARTMENT, PROVIDENCE, R. I., MARCH 7TH, 1883.

Data relating to Meters, Daily Consumption of Water, etc., for the past six years. *Providence Water Works.*

Year.	Estimated Population to Middle of the Year.	Number of Meters in use Dec. 31st	Net Amount charged to Meter Dept. for Setting and Repairing Meters, Etc. *	Number of Services Opened to Dec. 31st †	Total Water Receipts for the year, in dollars.	Average Daily Consumption of Water during the Year	Gallons per Capita.	Per Cent. of Meters to Services Opened.	Estimated per cent. of Length of Received & Platted Streets and the Received Streets, to the Length of Distribution Pipe Laid.		Remarks
									Received and Platted.	Received	
1877	101,000	3,203	$476.40	7,789	200,039.39	2,492,032	24.7	41.1	49	93	
1878	102,286	3,648	602.34	8,566	218,883.33	2,701,404	26.4	42.6	50	95	Water rates reduced.
1879	103,572	4,036	805.37	9,139	229,551.78	3,110,279	30.	44.2	49	96	
1880	104,857	4,452	324.35	9,757	247,705.06	3,547,264	33.8	45.6	49	97	
1881	109,671	4,784	111 99	10,305	260,530.87	3,716,937	33.9	46.4	51	98	Water rates reduced.
1882	114.377	5,279	57.39	10,919	269,318.77	3,665,427	32.	48.3	51	100	
			$3,277.84								

NOTE.—From the Sixteenth Quarterly Report of Providence, R. I., dated December 31, 1886.

Population Estimate.	Number of Meters.	No. of Services opened to date.	Water Receipts for the Year.	Average Con. in gals.	Gallons per capita.	Per cent. of Taps Metered.
120,000.	7,135	12,552	$323,084.67	4,604,844.	39	57

Number of Crown Meters, 3,226.

* Yearly balance from the books of the Water Board: for individual years it is only approximate, as the amounts are not entered until the bills are paid, which is more or less in the following year. The total sum of the six years is very nearly correct, but from this amount also should be deducted some charges which were paid early in 1883. The employés of the Meter Department are at times called upon to do other work than that actually pertaining to meters, but they do not read the meters.

† The actual number of services in use December 31st, 1882, was 10,357, and the difference between 10,357 and 10,919 should be the number closed, disconnected, etc., since the first service was opened in 1871; therefore, the actual per cent. of services now open, metered to December 31st, 1883, is 51, instead of 48.3 per cent. as above.

All of the above figures include data for $7\frac{9}{10}$ miles of pipe supplied with water lying outside of the city limits, with the exception of population and percentage of streets in which pipe is laid, which include only the city proper.

THE BENEFITS OF THE METER SYSTEM

AS SHOWN BY PRACTICAL RESULTS.

Paper read by John C. Kelley, President National Meter Co., of New York, at the Annual Meeting of American Water Works Association, held at Columbus, Ohio, March 14, 1882.

It would, perhaps, be more in keeping with the fitness of things if some one less interested than the writer in the article concerning which most of this paper has reference to, would present its claims for the attention and consideration of the members of this convention. Without doubt, if some one of our able engineers would take the stand I propose to take, and discourse in learned and technical phrases upon the benefits of the meter system, his opinion, at least among that professional class whose words carry with them so much authoritative weight, would have a deeper and more lasting effect. It is characteristic, however, of professional men of all classes that, in many particulars, they lack enthusiasm. They grow so into the habit of weighing and measuring things by set rules, and of estimating possible results by some carefully contrived mathematical analysis, that it may be said they are rarely, if ever, drawn into a warm advocacy of any system or theory, but they have a fashion of according to everything within their professional sphere a measure of faint praise, just enough to make its applicability a doubtful question to the less learned world outside their circle. True enough, the advocates and indorsers of the meter system find some of their strongest favorable authorities among the engineering corps of this and other countries, but, as a rule, those who have the direction and superintendency of vast and important systems of water supply in many of our cities are rather indifferent when the claims of the meter, as a remedy for suppressing waste, are advanced. They will tell you when you relate the experience of some city where the application of meters has accomplished wonders, that it may be very true, but it would never work with their population; or, that the same conditions do not prevail with them as may exist in the example cited. One thing they very carefully avoid, and that is, any extended argument upon the subject; they are firm believers in giving the people all the water they want, and firmly, though erroneously, convinced that such a thing is impossible where meters are generally applied. It may be that these gentlemen are members of the old school, and so wedded to their idols that nothing can break off the attachment. Like that much abused royal family of France, they never forget and never learn anything. It seems, though, that one plan of solving the great question of water supply never lacks supporters, and that is the plan having for its object the acquisition of new water sources and an increase of the supply. To give our engineering talent full credit, we need not hesitate to say that they are exceedingly liberal, and whenever an opportunity occurs, do not fail to record their belief emphatically in favor of an unlimited supply of water, particularly if a proposition looking to that end necessitates the accompaniment of a liberal appropriation.

But as this method of providing for the wants of the public is apt with much repetition to grow monotonous, and as it has almost invariably resulted in failing to be of any lasting benefit, we are compelled to look for other means of relief which a practical experience of several years under the most exacting tests of every kind proves to be the only appliance which will remedy all waste, increase to the fullest extent the supply, reform the injustice and abuses which tax-payers have suffered by tariff rates for years, equitably distribute and faithfully collect the water revenue, and put out of the range of probabilities everywhere the expenditure of immense sums of money to increase sources of supply which, under proper management, are entirely competent to render the service for which they were constructed.

To satisfactorily set before you the truth of this assertion, it is only necessary for me to give you as briefly as possible the experience of those who have the control of water works in cities where the meter system has proven a complete success, and whose ability and reputation entitle their opinions to full respect and confidence. It may be said that in this respect experiences are liable to differ, and what may be good and effectual in one locality would fail in another; but the authorities at hand are so varied, and represent so many different phases of the subject, that this argument, if advanced, will not hold good. I shall endeavor to show you what the authorities think, what their experience has been regarding the use of the meter in cities which depend for their supply upon a pumping system, upon a gravitation supply, upon a combination of pumping and gravitation, where the supply is comparatively meagre, where it is sufficient for all present demands, and where also it is ample enough to last for all time, taking into consideration the increase of consumption which a growing population will need from year to year.

In the City of Brooklyn, where I reside, and with whose interests I am somewhat identified, the question of water supply is a constantly recurring one. When the thermometer goes up to 90 or down to zero, the same old water famine comes along with touching regularity. In anticipation of the one due in a few months, and to provide against an enormous daily consumption, much larger than it should be under

proper restrictions, a plan is being discussed to expend a quarter of a million dollars to find new water sources somewhere by digging wells or buying lakes, which will give the city a daily increase of only five or six million gallons; while at the same time a contract is about to be awarded for constructing a new pumping engine, the cost of which will be over $100,000. Of course, the average citizen who takes an interest in such matters is of the opinion that when this money is spent all fears of any further trouble about the supplying of water may be banished from the public mind. But the history of other and older cities who have in this respect gone over the same road that we are traveling, proves that our work and vast expenditure of money is but a temporary expedient, a short-lived makeshift, and when the bills are all paid and the account closed in the books of our City Comptroller, when all the additional water procured is flowing through our conduit, we shall have in a very short time the same trouble over again.

The City of New York, or rather those in charge of its water works, think that an expenditure of several millions is necessary to remedy the defects and dangers of a present insufficient supply. It is due to the Water Department of New York, however, to state that those at its head are fully alive to the importance and advantages of the meter system, and a continuance on their part of the determination now shown to meter every building that the law permits them to, will show before long results so favorable that it will surprise even those who have been the warmest advocates of the measure.

The constructors and superintendents of water works and many engineers do not appreciate the fact which statistics so fully bear out, that the waste of water is greatest where the supply is most abundant, and that by forcing upon the people at large the knowledge that there is, so to speak, no end of water available for use, is only still further educating them in habits of extravagance. Take the City of Milwaukee, for example. The water consumed there is pumped from Lake Michigan into the reservoir supplying the city. Here, certainly, there is no necessity of looking for new sources of supply if Milwaukee should grow to be the most populous city on earth. When the pumping machinery was erected it was supposed that complete provision had been made to insure a supply for very many years, yet the machinery is now inadequate, owing to the immense consumption. According to a late report made by the very capable Water Registrar of that city, Mr. G. B. Seaman, there is consumed an average of 124 gallons for each person daily, for each service 1,551 gallons, and the total consumption 10,600,000 gallons a day.

The experience of Chicago, Detroit and other lake cities who have the same facilities for procuring an inexhaustible supply will show similar results. As an argument against the theory that a sufficient supply is the only thing necessary in solving the water problem, these results and the evidence they furnish would seem to be unanswerable. Now, as a counter argument in support of the position I have taken, let us look at the results obtained in Providence, where the meter system has been generally adopted. I will quote the exact words of the authority mentioned above:

"Providence, R. I., has one of the best, if not the best, managed Water Departments in this or any other country to-day. The City of Providence, with a population about equal to Milwaukee, and with 855 more service connections, uses but 2,500,000 gallons per day. It uses 25 gallons per day for each inhabitant; it consumes daily for each service 337 gallons; it derives a revenue of over $200,000 for 2,500,000 gallons; while Milwaukee gets $121,555 for 10,603,857 gallons; Providence derives $219 per million gallons, Milwaukee $31. The reason for this vast and important difference in results is simply this: Providence had in use when this statement was made up 3,203 meters, Milwaukee was content with 101."

He concludes by calling attention to the great waste of water, states that they have attempted a remedy in hundreds of cases, notwithstanding which the evil seems to be constantly increasing. Mr. Seaman is evidently of the opinion that such an application of the meter system in Milwaukee as prevails in Providence would rectify all the evils which the former city, in the management of its Water Department, seems to be laboring under.

It may not be out of place right here to give the opinion of a prominent official connected with the Water Department of Providence as to the experience of that city in establishing so successful an administration of the Water Works. This gentleman thinks that the meter system is an admirable one, and the best way of supplying water. The expense of maintaining the meter branch of the work is a merely nominal one. He would recommend the introduction of the meter system in all cities, because the water supply is more or less limited everywhere, and the use of meters is the only way to check the waste and keep the supply within proper bounds. He thinks the use of meters makes the water cheaper to consumers, lessening extravagance, while not affecting the quantity needed for necessary purposes. He considers the meter system as tending to make a great saving of fuel, wear and tear, etc., of pumping machinery." These are the opinions of Edmund B. Weston, Esq., engineer in charge of the Water Works, and, coming from such an authority, they will admit of no question.

It is probable that Providence has nearly 5,000 meters in use to-day, and it is a matter of record that private consumers are changing from paying regular rates and having meters put in. A comparative table shows that this class of consumers pay much less by meters than they did under the old plan.

This evidence comes from a city where the meter system is not now regarded as an experiment, but where it has proven in every particular, a grand success. If Providence, instead of adopting the plan it has, would do as some cities are fond of doing, increase its supply by building new reservoirs and conduits, would such grand results have been ob-

tained? Upon the principle of giving the people all the water they want, there would have been no difficulty in getting an abundant reserve to draw from. The resource is unlimited, for during a long continued drought, a few years ago, there was passing by the inlet to the pumping station about 115,000,000 gallons every twenty-four hours. In all respects Providence seems to have adopted the best methods in conducting its Water Department. The fixing of the minimum annual charge of $10 when meters are set secures a sufficient revenue for all purposes, and puts out of doubt the possibilty of any excessive economy in the use of water working unfavorably toward the City. In leaving Providence I do not hesitate to hold it up, so far as its Water Department is concerned, as a model City, having, in the words of our Milwaukee friend, already quoted, "one of the best, if not the best, managed Water Departments in this or any other country to-day."

The City of Pawtucket, R. I., is an example of the success of the meter system on a smaller scale. Pawtucket, has a population of about 30,000, and an average daily consumption of about 1,250,000 gallons. It has about 1,400 meters in use. Like Providence, its source of supply may be said to be unlimited. The storage capacity of its reservoir is about 72,000,000 gallons, and it has a river to draw from. The Secretary of the Board of Water Commissioners, who has the experience of nearly a lifetime in his official position, thinks the meter system the only proper way to sell water, especially where there is more than one faucet used; thinks it a benefit to the City, as it is a protection against the waste of water, and consequently a great help in increasing the revenue. Pawtucket has adopted the same plan as Providence in compelling the payment of a fixed minimum rate; being compulsory, it secures a revenue sufficient to properly conduct the Department. Figures which the books of the Water Department of Pawtucket exhibit would seem to controvert one great objection made to the meter system by those unfavorably inclined toward it, that is, that its application makes water more expensive to the poorer classes of the inhabitants of large cities. The records of Pawtucket prove this a fallacy, and I presume if the books of other departments where meters are largely used are consulted the same results will be found.

A meter in a tenement occupied by twelve families, and in which there is a store and one office, showed that the entire cost of water during one year was $58.25. Omitting the store and office, this would leave an average water rate of only $4.86 for each family. A meter in a tenement occupied by fourteen families cost for one year $58.64; average water tax, $4.19. A meter in a tenement occupied by seven families, total cost for the year $22.26; average tax, $3.18. A meter in a tenement occupied by nine families, total cost $28.64; average tax, $3.19; and so it runs all through the list about in that proportion, being from fifteen to forty per cent. less than faucet rates. These figures would seem to be an effectual reply to the argument that the meter system works unfavorably toward the poorer class of society. Pawtucket is entitled to a place as having one of the model Water Departments. It believes, like Providence, that it has solved the water-problem, and will have no trouble in that regard for the future. Like Providence, it is keeping pace with the spirit of the age in the march of improvement, and is not blind to the facts which increased intelligence and advanced science make so patent to all.

I cannot do better, in concluding this reference to Pawtucket, than by quoting the following extract from the report of Mr. Edwin Darling, its Superintendent of Water Works, of February 1, 1882: "During the past year there have been added to the works 363 meters, making the total number on the works 1,422, showing that we have more than one-half of the services metered. The results showed conclusively that it is the most wise and judicious plan of furnishing water, not only to the town, but to the consumer, thereby reducing the waste of water. And here let me say that the waste of water is a very important factor in the Water Supply Problem of large cities and towns. New York, Brooklyn and Boston have, during the past season, experienced great anxiety on this particular point, and I believe these places have now adopted the plan of using meters to a large extent. To illustrate: The City of Newark has 10,000 services with but few meters; the City of Providence has about the same number of services and about 5,000 meters. The City of Newark uses 10,000,000 gallons of water per day, while the City of Providence uses 4,000,000 per day. The City of Newark receives for water $190,000; the City of Providence receives for water $260,000. Providence thereby receiving $177 per million gallons, while Newark receives only $52 per million gallons. Pawtucket receives $128 per million gallons; but it must be remembered that the much greater price charged by Providence for metered water should be considered when comparing the receipts per million gallons with the receipts per million gallons in Pawtucket.

"Still another feature in favor of meters must be allowed, I think, viz., that by the restrictions produced on the waste of water by the use of meters, the demand for sewerage is lessened, thereby saving a large outlay which would be demanded of the town. If the waste of water in Pawtucket was in proportion to the waste in Newark, we should be pumping 4,000,000 gallons daily; but under the present system the average for the year has been but 1,068,877 gallons per day.

"In conclusion I would say, that I believe the plan adopted by the Water Commissioners, when they proposed to provide meters for their own consumers, was wise and judicious, and that other cities and towns can well afford to adopt the same plan where excessive waste is apparent."

The experience of Fall River and Worcester has been almost similar, and the opinions of those I have given above are nearly repeated by the Water Works Superintendents of these two cities. In Worcester the judgment of the non-professional taxpayer is on record, and it is decidedly in favor of the meter system.

Charles B. Pratt, Esq., President of the National Fire Insurance Co., and ex-Mayor of the City speaks as follows: "I could not say anything but what would be favorable to the use of meters. I know that I save fully fifty per cent. by the system. I paid $32 a year at my residence under the regular rate plan, and it costs me now $15. I am heartily in favor of the use of meters, and I believe that both the City and the consumer are benefited by it. The reckless waste of water is checked, and, on the whole, the benefit to the City, to the taxpayer and to the consumer is mutual."

Several of the leading merchants, and the proprietor of the principal hotel hold similar views. Mr. George Tower, of the Lincoln House, thus expresses himself: "My opinion is that the furnishing of water by meter is the fairest and most satisfactory way. Under the old system of paying by tariff, my bills were double what they are now; in fact, the expense became so onerous that I requested the Water Board to put in a meter, because I was satisfied that I was being charged for a great deal more water than I was using. When the meter was attached, the difference was apparent at once. Now I think my bills are about $90 a year; formerly they ran over $200. I do not restrict the use of water in any way. My help and guests have all they require; in fact, I do not force any economy in that respect. Of course, my fixtures are all arranged so as to prevent any waste; but I have never given any orders, nor do I exercise any supervision whatever over the consumption of water. Nothing would induce me to go back to the old system."

If time permitted, and your patience was not already exhausted, I might continue for a much longer time in support of the position I have taken; but the facts I have given and the evidence furnished must be quite as familiar to all of you as it is to me. It should be a matter of regret that Water Works Officials everywhere do not assume as positive, emphatic and unmistakable an opinion upon this important question as have those whose views I have cited.

It may be that in most of our large cities, where the problem of Water Supply is torturing the minds of engineers and superintendents, that, after many more millions of the people's money has been wasted, there will be a complete awakening to what is the real remedy.

Perhaps a new generation, seeing the errors and shortcomings of this, will look back with wonder at it, not however, without due praise for those who, appreciating the situation so far in advance of their fellows, were prompt and efficient in their treatment of it, and due condemnation for those who, groping blindly in the dark, were willfully negligent of the opportunities which a complete experience had proven so successful. Let those of us who believe in progress and enlightenment, who recognize the potent influences of science in every department where improvement is the watchword, be guided in the administration of our duties by such light as the times give us.

From those who have the management of Water Works I should bespeak an honest, candid, fair consideration of the points I have submitted. They are brief and imperfect, but, to my unprofessional mind, conclusive enough, when fortified by the evidence obtainable everywhere, that the adoption of the meter system in all cities and towns must ultimately come as the sole and simple solution of the all important question of Water Supply.

(From Engineering News, November 29th, 1879.)

WATER METERS.

By Lewis H. Nash, M. E.

In a previous article the writer directed attention to the mechanical difficulties which have to be encountered in the construction of a water meter, offered a few hints as to the best mode of overcoming them, and briefly stated a general principle by which the value of a device may be tested.

In the present article, he would draw attention to the application of these principles to well-known devices which operate upon the displacement principle.

First, let us consider what may be called the INHERENT DEFECT OF A DEVICE. In studying any device it will be seen that, in order for it to succeed at all, certain contingencies, arising from the nature of the design itself, must be carefully guarded against.

Though entirely free from the defects existing in other designs, some devices may still possess their own peculiar defects. For instance, a piston meter must have some valve device. This is inherent in the design, because, without it, the latter cannot work.

The valve performs only a secondary part in the office of measurement; it requires great care in making, and is liable to get out of order; hence it should be considered a defect.

The reciprocation of the pistons is another defective feature of this design, and special contrivances are necessary to overcome the difficulties arising from this condition.

On the other hand, piston meters are free from defects to which many rotaries are subject. It does not follow, however, that because a device is

defective it will be impossible to make the machine measure correctly.

Assume that two persons, having identically the same conceptions, start to practically work them out. The first, possessed of a thorough knowledge of mechanical principles, may, by careful workmanship and attention to details, so design and construct his machine as to make it, in a measure, successful, even though the device itself be defective. The other, from lack of such knowledge, may fail to produce anything of value. This has been the history of some of the rotary meters which to-day are meeting with a degree of success.

The essential principle has been tried by many persons, who have constructed machines to embody the idea; but, owing to imperfection of design or workmanship, they have failed to give any satisfaction, until some person with the required knowledge and experience has, by a peculiar combination of the parts, by careful adjustment and excellent workmanship succeeded in producing a working machine.

No amount of skill can perfect a faulty design beyond a certain point, for the essential defects of the device cannot be eliminated.

The most that can be expected is to so modify them as to reduce, as far as possible, their injurious effects; and after a time the design will have been so far perfected that no improvement can be made without a radical change in the design itself. Hence it is important that great judgment be used by a manufacturer in selecting a device upon which he is to spend his time and money.

Engineers and managers in charge of Water Works now demand such perfection in a meter that a design, to be successful, must be almost, if not absolutely, free from disturbing elements; while, at the same time, they require its price to be placed at such a low figure as to place many good designs beyond the reach of competition.

It needs almost a surgical operation to remove from the mind of an inventor an idea once conceived. It is the child of his brain, and becomes his pet. He conceives a love for it. Whatever be its faults, he hopes to overcome them. Others may see that the design is not capable of accomplishing the result desired; but he himself is blind, and cannot break away from his original conception. True it is that such tenacity of purpose will, if intelligent, develop the design to its greatest perfection, but if the same energy be directed upon the improvement of a faulty design, it becomes only a monument of folly.

The principle of reciprocating pistons is among the oldest of designs, and, in the opinion of the writer, it has been developed to about the highest state of perfection of which it is capable.

It is the one which would strike the mind as being most likely to make a measuring machine, and in perfecting it the greatest amount of time and money have been expended. Modifications of the principle may be found with one, two, three or four pistons or plungers.

The number of modifications of the valve-gearing is legion. Its pistons or plungers have been placed vertically, horizontally, parallel, at right angles to each other, and in many other relations. Various means have been adopted to control the length of stroke and movement of the piston—by abutting devices, by crank movements, and by sudden changes of the valve. Its pistons or plungers have been made of wood, of metal, and of various other substances. They have been made hollow so as to float in the water. The valves have been actuated by rocking arms carrying a weight, or by a spring; by the action of the fluid itself, and in various other ways. One piston has been made to control the valve of another. Attempts have been made to pack the piston, or plunger, with hemp, leather, rubber, or other materials. Many other things have been tried, of which the public have never heard; and it seems as if the ingenuity of man had been taxed to the utmost to perfect this principle. Yet it has only one good feature—namely, the total area of the piston is effective in driving, and there is no side pressure upon the piston. But it is solely to this feature that the piston-meter owes its value as a measuring device; for, whatever the clumsiness of design in the auxiliary parts, there is very sure to be power enough to drive them.

Let us follow the action through one cycle. We have a vision of a cylinder, bored perfectly true, with a piston fitting accurately into it. The piston starts from one end of the cylinder, the water flowing in from behind and driving it ahead. This is very beautiful so far, for the delivery amounts to exactly the area of the piston multiplied by the distance it traverses. But this cannot go on forever; our cylinder must have an end, and so must the stroke of the piston. At some point the piston must stop, and, if we are to register the number of its strokes, it must stop always in the same place. Here arises the first difficulty, and it is met with a series of devices to accomplish the desired result. Since the piston must come to a dead-stop, it must be brought to rest without injury to the device. An abutting piece is, at best, only an apology for a serious defect; and let it be made of whatsoever material we may, it will not do to let the piston strike it heavily. Consequently, we cannot have a high speed of piston. If we attempt to cushion with the liquid itself, we endanger the accuracy of the meter, by causing variation in the length of stroke. If we introduce a crank to control the motion, we have introduced another part to wear out.

In the opinion of the writer, the only proper way to control the movement of the piston, is by the flow of the liquid itself, which is the method adopted in single piston meters. Again, our piston having reached the end of its stroke, the flow of the liquid must be changed in direction; and for that instant the flow, if it to be continuous, must find another passage.

First. A valve is necessary to change the flow of the liquid; and this introduces another serious difficulty. It is impossible in this paper to discuss the various valve devices; their number and variety speak louder than language of the attempts in this direction, and show that inventors have long struggled with this problem.

Second. There are two ways by which a continuous flow is secured; first, by increasing the number of the pistons, and, second, by almost instantly reversing the valve. So long as the meter is not forced, both methods will be found practicable.

Piston meters usually possess ample power to drive them, and will work without close fitting, unless the design of the meter is very clumsy. If it be desired to increase the sensitiveness of the meter, the result may better be accomplished by reducing the resistance to the motion of the parts than by a resort to tight fitting. Since there are meters in the market which do depend upon the making of a tight fit, it is proper to make a few remarks upon the subject.

The question is asked: "We make a tight fit in our motors and pumps; why can we not do it in a meter, and by the same means?"

To which it is answered: First, tight-fitting is a primary requisite in a pump or positive motor, and must be secured at all hazards. Second, a motor is always under a kind of supervision, and it is somebody's business to keep it in order. This is not the case with a meter. The more water the meter will pass without registering, the better the consumer likes it; he will never give notice of the meter being out of order so long as he gets his water. Third, it is unnecessary, as a meter will work without being thus constructed. Fourth. A slight leak will not seriously injure a motor while it may entirely destroy the accuracy of the meter upon small streams. Hence it is apparent that if we make any attempt to fit tightly, we must carry the fitting throughout the whole machine—from piston to valve—and leave no passage anywhere for the fluid to pass. Thus, in addition to the other liabilities to derangement which are unavoidable, we have added another unnecessary one—the danger that, by some means, the perfect joint will be at some point impaired.

The diaphragm meter is designed upon the supposition that it is necessary to prevent all possible leakage. But even if a perfectly flexible and durable substance could be obtained for the diaphragm, it still possesses the defect of valve and gearing, besides a number of defects peculiar to itself.

The writer has no desire to disparage what has been accomplished in perfecting the reciprocating piston principle. Such meters have been in use in all the water departments throughout the country, and every engineer knows exactly what they have been doing. But the standard of the best meters is far higher than it was a few years ago; and it is doubtful if piston meters can be made to do much better in the future than they are doing at present. However, the field is widely open for another class of meters.

In view of the difficulties of reciprocating motions, inventors have struggled with that of a continuous motion, as, for instance, that of rotation. For illustration, let us again start with our cylinder and piston. As before, let the piston begin its stroke, the water flowing in behind and driving it ahead. Now, instead of the cylinder being straight, let it be bent into the form of an annulus, or ring. Then if the motion of the piston be continuous, it will finally arrive at the point from which it started, and be ready to begin another revolution.

But we overlook the fact that the water must flow into a part of the cylinder that must be separated from the part whence the water issues. Hence, there must be at least two divisions of the cylinder—the piston forming one wall of separation, and an abutment forming the other wall. When the piston has passed around to an abutment, there must be some arrangement by which it may be allowed to pass the spot. Thus, our simple conception of the piston becomes much complicated by auxiliary parts. We have introduced this conception not for any value of its own, but to illustrate a large class of rotary meters, and to show what is the office of the "abutment" spoken of so frequently in patents relating to such meters.

Our example of such a class was illustrated and described in a previous article. A drum rotates within a cylinder upon a spindle; projecting points or arms upon the side of the drum act as pistons, causing it to rotate. An abutment is formed either by a projection within the cylinder, or by placing the center of the drum eccentric to the center of the cylinder and so making one side of the case to act as an abutment. This class of meters has never met with any success; their defects are too serious for even the most exquisite workmanship to overcome.

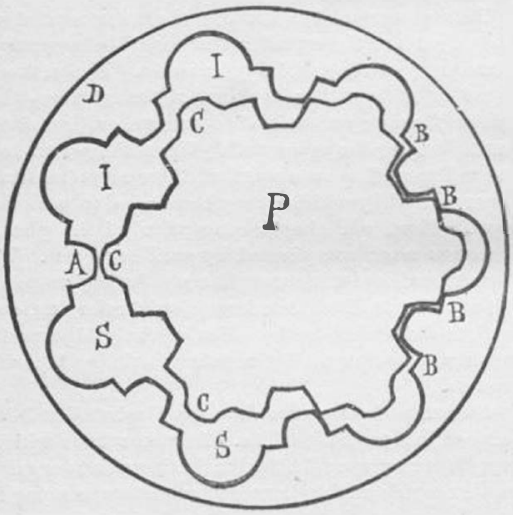
There is another class of meters, in which two or more revolving pistons are employed; and the use of an abutment is obviated by a combined action of the pistons. Such devices have been successfully used; as blowers, pumps, and even fire-engines have been constructed upon this principle. As an example, let us take one in which two spur gears run together. The teeth of the gears, meshing together, form a joint between, while the case fitting upon the teeth prevents the flow of water around the outside. In this device the effective driving area is only equal to the radial section of one tooth, and therefore such a device would be very faulty as a meter. A better form is that in which two revolving pistons are used.

The two pistons are carefully hung upon bearings in such a way that they do not touch the case. They are connected with each other by gearing, so as to make the same number of revolutions. As they revolve, one piston overlaps the other, and the effective driving area of the pistons is only equal to the amount of surface thus relieved from pressure. In one of the best forms this area amounts to one radial action of the piston, or half its total section; while the total area of the pistons is

about three times this amount. One side of a piston is thus always advancing against the pressure of the liquid.

It is essential in this device that the pistons revolve upon a spindle of sufficient rigidity to keep them away from the case; for if they were to touch it the accuracy of the meter would be destroyed.

The National Meter Company, of New York, is now manufacturing a meter called the "Crown," which has



none of the defects of rotary meters, while at the same time it possesses the valuable feature of reciprocating piston meters, viz., the total area of piston is effective in driving. The above illustration presents a view of the piston in its cylinder. There is no spindle or bearing of any kind to keep in order; the piston simply rolls around the inside of the cylinder. It is made of hard rubber and just floats in the water, being of about the same specific gravity. The piston of the half inch meter weighs but five ounces; hence, the slightest motion of the liquid will move it. If in a piston meter we had a free piston, without attachments, moving in a cylinder, it could not be more free to move than is the piston of this meter to move within its cylinder. The only work to be done is to drive a train of gearing connecting with the registering apparatus; and, since the total area of the piston is effective in driving, the power is ample. Let *S S* be the space in which the water is entering, *I I* the space from which it can escape. Then the line of pressure acts from *A* to *B*, causing the piston to roll over *B* until it strikes another bearing point, and continues its rotation from point to point. The piston is its own valve and the pressure of the liquid is so exactly balanced that there are no rubbing surfaces. Actual experiment has proved this to be the fact; for when meters that have been in constant use are examined, it is found that the case is completely tarnished, as if there had been no moving piston passing over it. In this design there are a number of things which must be kept up to a certain standard of perfection, the failure of any one of which would destroy the accuracy of the machine, but it is ready to do its work at all times. It will pass anything ordinary found in water furnished to cities. The company believes that it has the meter which will stand the greatest amount of abuse of any in the market, and, at the same time, such abuse will not materially alter the registration of the meter. An experimental meter has been fitted up very loosely to see what the effect would be upon the registration, and it was found that the piston will run and measure correctly even when it is cut very much smaller than the cylinder, and that no amount of hacking will prevent its movement which does not actually destroy it. These meters, as ordinarily fitted up at the factory, will register upon a stream $\frac{1}{200}$ of an inch in diameter.

CHECKING WASTE.

To the Editor of "The Sanitary Engineer:"

Shortly after the publication of the conclusive article on "New York Water Supply," which appeared in your issue of the 5th inst., the writer began a communication in response to your wish to have those of your readers who have had experience in dealing with the question submit such views in relation to the best method of insuring a permanent and sufficient supply of water in New York City, as seemed to them most feasible. Unlooked-for causes prevented its earlier completion. Of course no single ordinary newspaper article, confined within reasonable limits, can adequately cover all the points referred to in your article of the 5th inst., hence it will be necessary to allude to only some of them, and that briefly. In order to put myself properly on record at the start it is, perhaps, better to acknowledge that your first method, "the placing of a meter in every house, assuming no control over plumbing, but relying on the consumer's desire to economize in water tax to secure a stoppage of waste, to cause the reconstruction of defective plumbing and the removal of wasteful fix-

tures," is the plan, and the only one in the writer's opinion, that can satisfactorily solve the problem of water supply in New York City, as well as in other large centers of population. This opinion is founded not only upon a personal study and close observation of the question in all its details and by a somewhat lengthy and instructive experience of it, but is fortified by the almost unanimous verdict of all the best engineering talent, not only in this country, but in Europe. There are cities whose public spirited officials have tried all known remedies in their attempts at a solution of this seriously important question, and who have in the end adopted and continue to maintain the meter system with such successful results that their only regret is that the advantages of it were not earlier known, so that it might have saved the authorities much anxiety and the public treasury an abundance of the taxpayers' money. Having taken the position specified, I shall endeavor to answer the several questions based upon your proposition in their order:

1. As to the danger that a metered service would tend to prevent any considerable number of people from bathing, etc., the allowance of any ample quantity of water *per capita* for all legitimate uses, for which a certain specified rate would be charged whether that quantity is used or not, but whatever quantity would be used in addition thereto to be paid for by measurement, would obviate any trouble that might arise, from a sanitary point of view, consequent upon a too stringent economy in its use. As to the action of the usual flushing facilities for closets and urinals, it is a question whether they are in any degree of great value. If it were possible to educate the community to understand that the ordinary dribbling of a closet faucet is practically of no value in cleansing drains or waste pipes, but that the occasional sudden discharge of a pailful or two of water will do the work most effectually, a great point will be gained in preventing a considerable percentage of waste. With a metered service and properly arranged fixtures, this serious item of water waste would necessarily be considerably reduced.

2. Your third query assumes a state of affairs that does not, to any extent, exist. I think it is the rule for the owners of houses in New York City to pay the water tax, as they are held responsible for it by the Water Department. That being the case, it would certainly be to their interest, in the event of a measured service being applied, to keep their fittings in order and protected from frost, and necessarily would make the supervision of plumbing in buildings largely superfluous.

3. No measures are necessary to ascertain what waste is taking place under ground until we have first put an end to the waste that we know is taking place above ground. That done, we can afford, I think, to let the underground waste go. It is an insignificant portion of the great evil which we can permit to continue—at least until the much greater one is effectually abated. It is generally acknowledged by water works superintendents and engineers that the waste caused by leaky and imperfect fittings is the main cause of the immense consumption of water in all large communities. Mr. William F. Davis, Water Registrar of the City of Boston, whose long official experience and complete knowledge of the water supply question entitles him to be ranked as a high authority, says that according to figures recently made by him the percentage of waste in that city equals forty per cent., and one of the principal reasons for this waste he states to be the immense number of leaky fixtures; of this he gives a very striking illustration.

About three years ago application was made for a meter to be put on at the Simmons Building, one of the best built and supposed to be the best plumbed building in Boston. After the meter had been attached it was found that at night, without a single occupant in the building except, perhaps, the janitor and his family, the consumption of water was 13,000 gallons against 9,000 in the daytime, when the building was occupied by the tenants. An examination was made to determine the cause of this enormous waste, and it was found that of the thirty-six tanks with ball cock fixtures to operate the flow of water, sixteen were out of order, and the increased pressure in the mains at night as compared with the daytime explained the reason. The tanks filled, but the fixtures being out of order, the ball did not rise and close the faucet, so that there was a steady flow running off into the waste pipes from these tanks during at least twelve of the twenty-four hours. An extended and searching examination of the waste caused by leaky closet fixtures in the city of Boston was made by the same official, and the figures are somewhat appalling. They are too long for reproduction here. Enough to say that it was proven there was a waste from this cause alone of nearly 4,500,000 gallons in every twenty-four hours. With a metered service, who doubts but that all this great defect would have been remedied and removed so that it would never recur.

4. The probable expense of placing meters in the houses of New York can probably be arrived at as follows: The number of taps in the City, according to the official figures, is 85,000, of which about 7,000 are now metered, leaving a balance of 78,000 not metered. Of this 78,000 it would not be advisable to meter one-fourth, or they would not be metered, probably, if full power and discretion were given to the Water Department, so that there would remain to meter, say 58,500 taps. It would cost for meter, setting, etc., not more than an average of $30.00 for each tap, or $1,755,000, and they could be furnished and set, it is believed, in two years—certainly in three.

5. If the City should purchase the meters and issue bonds to pay for the same, they would unquestionably be sold at par, paying from three to four per cent. interest—say three and a half per cent., or $612,425 per annum. The cost of repairs for ten years would not exceed an average of one dollar each, —in view of the vast improvement made in recent years in the construction of meters,—or five per cent.

on the cost of the meters, which on 65,500 meters would amount to $65,500, estimating the average cost of each meter at $20.

New York City consumes a daily average of 95,000,000 gallons of water, 10,000,000 gallons of which are used for public and fire extinguishing purposes. The present annual revenue amounts to $1,640,000, more than one-fifth of which is received for water sold by meter measurement. Assuming that the 85,000,000 gallons consumed by private parties was delivered through meters at a cost of thirteen and one-third cents per thousand gallons, it would give us a yearly revenue of $4,136,563.25, or an excess over the present amount of $2,496,563.25.

But the application of meters would reduce the consumption of water to say two-thirds the quantity now used, or about, in round numbers, 60,000,000 gallons; this quantity, at the same rate per thousand gallons, would bring in a yearly revenue of $2,919,927.00, or an excess over the present amount of $1,279,927.00.

6. The clerical staff of the Department would not have to be increased; in fact, it is a question if, in the event of a general application of the meter system, it could not be reduced.

There would be less work to perform, the bills calling for but one item.

7. For the City of New York it would not require more than twenty inspectors to take the readings of the meters quarterly, provided they would do half as much as those who are employed by the gas companies.

When the City of Providence had 4,500 meters in use there was employed by the Department then only two men who were regularly engaged at that work, one of whom, in addition, acted as collector and examiner of fittings, both of whom would be required if there were no meters in use. During certain seasons of the year a clerk or two from the office is detailed for the work, but it is a merely temporary employment, lasting for a few weeks only. The City of Worcester, with about 4,000 meters in use, had four meter inspectors, but they were not employed especially for that purpose. These men read the meters and examined them once a month. This takes about two weeks; the balance of the time they are employed at other work. It seems that if employed all the time as meter inspectors the services of two would be sufficient.

In view of these facts, it is within reason to suppose that twenty men would be enough of a force of meter inspectors for the 65,500 meters placed in New York.

8. The Providence plan, by which a charge is made for every tap and fixture unless the house owner elects to accept and pay for a meter, it being understood that a specified tax shall be paid whether water is used or not, but only the excess of this specified amount to be charged for by measurement, is an admirable one and cannot very well, in my opinion, be improved upon. If the meter system is to be applied in New York that would be as good a plan to adopt as any. To my mind, the house owner should be made to purchase the meter, and it should be considered as much a part of the water fittings of a house as a hydrant or any other fixture. Under a law compelling its purchase, the whole question would be greatly simplified, and public officials would be relieved from the charge of originating and fostering a huge job for the purchase of meters with public funds, with which they would assuredly be charged by that irrepressible class of indignant tax-payers who can never be made to understand or believe that public officials are ever induced to advocate salutary measures for the good of the commonwealth without having concealed somewhere a scheme to fleece the public treasury.

In conclusion, let me say that it is a matter of easy demonstration to show that the general application of meters in New York would greatly increase the water revenue and correspondingly decrease the consumption of water, by putting an end to waste. There is no reason why the experience of Providence and other cities should not be repeated in New York. The same conditions exist and the same remedies are available. Human nature is pretty much the same everywhere. The inhabitants of Providence are similar in habits and customs to those of New York, and what has proved good and beneficial there would have a like effect in the metropolis. It appears somewhat incongruous, however, that we should go to the small New England cities for proper instructions upon this great question of water supply, but so it is nevertheless.

Boston has gone through all the varied experiences of New York, and has settled down at last to a firmer belief in the efficiency of the meter system. Our transpontine neighbor, the City of Churches, is entering upon a grand scheme to expend half a million dollars to increase the water supply without any real necessity for doing so. One-half the sum invested in meters would settle the question there for an indefinite time. When she gets her additional five or ten million gallons the annual water famine will come along as usual with touching regularity. And so it will be until her authorities fall into line with the advanced thought of the day upon the question and advocate the application of the meter system. And so it must come in New York sooner or later. When it does, those who have prophesied the result will have abundant satisfaction in knowing that they did not predict in vain.

C. E.

SOME PERTINENT QUESTIONS ABOUT WATER WASTE.

1. What is meant by "water waste?"

The consumption of more water than is required for absolute need—for the demands of health and fire protection. The basis upon which this should be determined is a reasonable limit of allowance for consumption *per capita*. The quantity used over and above such allowance can be fairly called wastage. Statistics of cities show that one barrel of water each twenty-four hours for each inhabitant is a generous allowance; whatever is consumed over such allowance is either used by manufacturers, or is an absolute loss.

2. What are Water Works called on to do?

They are to distribute one of the necessary articles of life. But because it is necessary, should it therefore be free—free to use and to waste at pleasure? No more so than that other necessities should be furnished with like generosity. Water Works should deliver the water without cost at the building, and then charge by a *measuring rate* for what is used the same as a charge is made for other valuable commodities; such charge should be ample enough to put the investment for supplying the water on a safe basis. This plan is the only one that deals fairly with both the consumer and the one furnishing the supply—the one pays only for what he receives, the other receives pay for all he delivers.

3. Is the prevention of waste by means of Water Meters any advantage to Water Works, taking into account the investment, cost of repairs and life of the meter?

From a careful examination of the repairs from the books of nine cities, up to January 1, 1887, on 20,086 Crown Meters, some of which were set seven years before, amounting in value to over four hundred thousand dollars ($400,000) was $2\frac{72}{100}$ per cent. *for the entire time for all causes*; deducting the cost of repairs for frozen meters, it was $1\frac{24}{100}$ per cent.

As meters pay for themselves in increased receipts in most cases, they can be justly classed among the assets of the Department, paid for by the *unexpected profits*, or from the receipts of the waste that was formerly lost to the works.

SUMMARY.

$10,000, cost of water meters at 6 per cent. interest,		$600.00	
Repairs of same from all causes—2 per cent.		200.00	
			$800.00
" " less frozen meters, 1 per cent.	$100.00		

In estimating the Cost of Repairs at 2 per cent. per annum, we have exceeded the amount at least four times, as it will not amount to one-half of one per cent. per annum. (See Table on page 34.)

The saving in a year of	3,200,000 gallons,	or	8,767 gallons a day,	at	25c.	per	1,000 gallons,	800.00
" "	4,000,000 "	"	11,233 "	"	20c.	"	"	800.00
" "	5,300,000 "	"	14,608 "	"	15c.	"	"	800.00
" "	8,000,000 "	"	22,466 "	"	10c.	"	"	800.00
" "	16,000,000 "	"	44,932 "	"	5c.	"	"	800.00

As the *daily* wastage of a large proportion of Water Works is at least 30 per cent. of the amount delivered, you can readily see how soon this amount will be saved.

PRODUCERS' COMPLAINTS.

Water Supply	limited
Cost of Works	increasing
Interest on Investments	increasing
Receipts	questionable and uncertain
Extensions	needed without limit
Depreciation of Works	constant
Abuse by Consumers	no limit

REMEDY.
DELIVER WATER BY MEASUREMENT.

CONSUMERS' COMPLAINTS.

Charges	estimated to cover wastage of one's neighbor
Bills	excessive, compared with quantity actually used
Demands	Water to be delivered in any quantity, without regard to the condition of the water supply.

REMEDY.
PAY FOR WATER BY MEASUREMENT.

HOW WATER IS WASTED.

That water is wasted everywhere, when the public can have free access to it, is clearly proved by the Annual Reports of the Water Departments of the various cities of the United States. It seems incredible that whole communities should recklessly and dishonestly persist in such criminal waste of water as is found to prevail everywhere. The evil has grown to such magnitude that it becomes a serious question whether the guardians of one of Nature's greatest blessings—pure and wholesome water—should longer continue to permit so demoralizing and dishonest a custom, as it really has grown to be.

Frequently the very method of carrying the water into the house occasions waste. The plumber, as a matter of convenience and economy, is permitted to place the hot and cold water pipes side by side, so that in warm weather the consumer deems it necessary to empty the pipe, wasting gallons for a single cup of cool water.

A more flagrant practice in wasting water is found in the custom of permitting the faucets to run during cold weather to prevent freezing. The practice is as unjust as it is unnecessary. When it is remembered that most houses are rated for a consumption of 25,000 gallons of water per annum, and that an ordinary faucet will discharge 10,000 gallons daily, it will be readily seen that if it be let running five nights, more water will in that time pass through it than is charged for a year's use; yet there are people who esteem themselves honest who permit this practice by their families.

THE REMEDY FOR WATER WASTE.

It is altogether impossible to determine how much of all the water supplied to cities is wasted; yet when we see the great disparity in the number of gallons used per person in different localities, and the great increase of quantity supplied to each person in the same city from year to year, we are forced to the conviction that the supply of water needs to be doubled every five years, after having made full allowance for an increase of population and of manufacturing industries. Individuals and families certainly *need no more water* this year than they did five years ago, an the increase of the domestic consumption of water must be wholly attributable to an ever-increasing and lavish waste.

Engineers in charge of Water Works find it very difficult to satisfy a consumer who desires to have a large amount of water. The consumer wishes to have it at the lowest rate, and he will be equally dissatisfied whether charged $25, $50, $100, or $1,000 per year! He does not *know* how much he uses, and he is very confident that the engineer who has assessed him has been guilty of injustice, and by means of that injustice the Water Board robs him day by day. How simple the remedy! When a consumer wants water, Water Boards should authorize their Engineers and other employees to say that they would furnish it at a given price per gallon, and that he would only be required to pay *for as much as he consumed, and no more.* Both parties would be better satisfied, because they would cease to *guess*, and would have positive knowledge! They would comply with the usual laws of supply and demand—"*so much for so much.*" The equity of the whole transaction could not be otherwise than satisfactory to all parties interested.

METERS PRESERVE HEALTH.

Pure water is an indispensible element of life and happiness to all residents of cities. It supplies an absolute want in their eating, drinking and cleanliness, while it gives them the means of protecting themselves from noxious odors, disease and conflagrations by fire. Health Officers so far appreciate and acknowledge its value, and, while they admit the prevalence of *lead poison* in cities, seem to be at a loss as to the actual cause of it. It is here suggested that it may be mainly occasioned by alternately exposing the lead water pipe, in dwelling houses, to the action of water and atmospheric air. When the reservoir is full, the pipes in the upper stories of houses are also full; but soon after consumption and waste have commenced, the pipes in the upper stories are emptied of water, air taking its place. *Atmospheric air coming in contact with the wet lead pipe, oxidation at once commences, and continues until the water is pressed back, when infinitesimal particles of lead are washed off and carried into the supplies of the family.* There can be no doubt but in that manner most of the prevalent lead poisoning has been brought about. If cities were metered reservoirs *would always be full*, and much of this danger averted.

Where there is a public supply to cities built on a clay soil, the water, while conferring many blessings, may and often does promote rheumatic and pulmonary diseases, unless there be a well-regulated system of sewerage. How, without sewers, can the people dispose of their waste water? It must be permitted to run into the yards or the streets, in time saturating the ground to the depth of several feet. It will readily be seen that soil, so saturated, will in the Spring be subjected to alternate freezing and thawing, begetting a state of atmosphere exceedingly uncomfortable to invalids suffering from the diseases named. In Summer, under the rays of a hot July or August

sun, the heat will be excessive. The sun's rays will draw the water to the surface by capillary attraction, and impart moisture to the atmosphere, rendering the heat more intense than if it were dry. The lesson here taught is, that meters are indispensable to prevent waste where there are no sewers.

WATER SHOULD BE FREE.

Water, one of the essentials of life, should be free to all—yes, as free as when quietly resting in a lake, running in a river, or babbling in a mountain brook. That it is free in either place will not be denied, and yet, when we come to utilize it for domestic purposes, it will cost either money, time, or labor, and will have a fixed value per gallon. It cannot be obtained from *any* source without an investment that has a moneyed value, be it either time or labor. If we go to the lake, river or brook, where it flows as free as the air we breathe, we cannot procure it and carry it home without labor, and we find that it *does cost* something. Under *no circumstances* can we obtain it without it having a fixed value represented by money.

When, then, we speak of *free water*, it must be understood to mean water delivered in dwellings, workshops and elsewhere at the *absolute cost* of introduction. Every good citizen will feel it a *duty* to pay his proportion of the cost for the convenience and the labor of taking care of the works, interest of money invested, etc. Theoretically, every consumer of water does assent to this; but practically he ignores it entirely. Water Boards throughout the world are made to feel, day by day, and year by year, that many consumers who are supplied with water at an assessed valuation, have no conscience in this matter. It is not unfrequent for consumers to use *many times the amount of water allotted to them*, seeming to be utterly oblivious of the fact that they are doing a great moral wrong to their fellow-citizens, who are made to pay for *their* individual waste.

Municipal authorities themselves have often been to blame for much of the waste of water complained of. Having first determined that they would furnish water to the citizens, they have been accustomed to boast of their unlimited supply; of their ability to furnish all that will be possibly called for during the coming quarter of a century, etc. These promises of more than an abundance begat an extravagance in the use of water, and like every other extravagance, it has become difficult to reform. It seems but right that the use and distribution of water, with all its blessings, should be subjected to the ordinary principles of equity and economy. No person will then be charged for more than he consumes, nor will any be allowed to use water at the expense of their neighbors.

The history of the Croton Board, as well as that of Water Boards of all cities having a public supply of water, shows that this *lavish waste* is on the increase—that all known methods of preventing it have most signally failed, unless delivered by actual measurement, and charged at a fixed rate per gallon for the number of gallons used.

There are on New York Island at least 85,000 dwellings. Now, let us suppose that a pump in the street be allotted to each block of houses, for *all* purposes, does any one believe that there would be a *per capita* consumption of 25 gallons of water per day? Let us go a little farther, and suppose a pump placed in every kitchen, for the sole use of the family, where water might be obtained for the mere expenditure of labor in pumping. Would not servants "strike" against pumping fifty gallons for each inmate of the house?

TWENTY REASONS

Why the Crown Meter should be used.

1. It will prevent the waste of water.
2. It will make consumers self-interested guardians of the Water Works.
3. It will save trouble to Water Departments, and insure justice to all.
4. It will render Water Works more efficient.
5. It will save the main conduit from danger.
6. It will render the extension of Water Works unnecessary.
7. It will cheapen the price of water to all consumers who do not recklessly waste it.
8. It will regulate the price of water to meet its cost.
9. It will facilitate the changing of rates.
10. It will increase the revenue by the great saving of fuel, without increasing the rates charged.
11. It will increase the force or head of water in the pipes.
12. It will insure sufficient water in the reservoir for use at fires, etc.
13. It will insure enough water for public fountains.
14. It is simple in its construction, having only one working part.
15. It is accurate and efficient.
16. It is durable, as attested by many departments.
17. It has greater capacity than any other piston meter ever made.
18. It will cost less than any other meter to keep it in repair.
19. It is very compact, being made of the best known material, under our own supervision.
20. It is (we claim) the cheapest and best meter in the market.

On January 1st, 1887, there were in use in NINE CITIES over 20,000 CROWN METERS.

Extracts from a Paper read by Peter Milne, Jr. (late Water Purveyor of Brooklyn, N. Y.), before the Meeting of the American Water Works Association, held at Boston, Mass., April, 1885,

—ON—

"WATER WASTE IN ITS DIFFERENT PHASES."

The introduction and inauguration of a meter system should be gradual. The expense attending their purchase and setting should be borne by the City and the City be responsible for their durability and reliability. In the restrictive qualities evolved by the use of water meters three prominent phases are apparent as the basis for the assumption that an advantage is obtained compared with *ad libitum* methods. 1st. The determination of the figure of waste. 2d. The cessation of waste. 3d. The saving effected. The last advantage is the more important in character and in its effect upon the system of distribution. Whatever of quantity saved in a system of water distribution hitherto wasted is logically an increase of water supply. Whatever proportion of waste is checked in a given time the figures of that proportion must be credited to the item of water supply. It matters not what the expense may be in effecting the saving by abridging waste permanently, when it can be proved that it costs more to provide water to be wasted than it costs to save it or prevent its waste. No public or private Water Works will meter service pipes expecting to derive an increased revenue from that source direct, but the increased revenue will be determined eventually by the fact of reduced expenditures in the saving effected in pumping power and expenses connected therewith. Costs of additional water plants or priviliges, cost of water mains required to maintain head or pressure which becomes impared as the works are extended and increased from year to year to provide for legitimate use and waste. As an illustration of this phase will better serve my purpose, I figure a city's population to be 100,000, and the daily consumpton to be 6,000,000 gallons, or 60 gallons *per capita*. If one-third, or 20 gallons, of that quantity is the estimated daily waste, and it is not an excessive estimate, then power required to elevate that quantity of water and to distribute it as demanded, is wasted. If it can be saved in five years, will not the saving effected suffice to supply a city of 150,000 population, at a *per capita* consumption of 40 gallons and with the original plan of distribution intact and source of supply the same without increased expenditures on the original plant? If, on the other hand, no effort has been made to restrict waste in five years, and at the end of that period the consumption was in the same ratio *per capita* with a population of 150,000 it would be 9,000,000 daily consumption and requiring 50 per cent. more power to provide it.

The remaining features of this question to be considered and which will excite if not interest your attention, are the comparative expenses contingent and inevitable in the adoption of a meter system and a continuance of the *ad libitum* method.

There is something more than a money value to water, no money can determine its value in its relation to a city's prosperity. If one million gallons are daily wasted, the cost of that waste can be determined, but if it can be saved to the city by a certain cost the value of the saving will be found only in the benefit conferred by that million of gallons, the value of water lies in the benefit conferred. If a meter system will save water that otherwise will be wasted, it is a positive advantage, in that the results will exercise an influence in the direction of leading the water takers to use water carefully, liberally and not wastefully. The logic growing out this process of reasoning is that the experience of many Water Works are: that in all calculations for increasing the plant, the factor of waste must be considered. If this is so, why not seek to reduce the factor of waste, and through the methods suggested by experience in the government and administration of Water Works. A City works with a population of 104,857 in year 1880 had in use 10,921 taps and 5,721 meters, daily consumption 4,143,798 gallons, a fraction less than 40 gallons *per capita*.

I do not know anything about cost of plant, cost of administration, etc., I do know, however, that the source of a city's supply is a river, and if it were for any reason that a meter system was adopted it could not be from any fear of water famine.

It may have grown out of the fact that the cost to provide the city with water, reckoning the factor of waste, was greater than the outlay, made necessary to prevent waste. I fully appreciate the difficulties and prejudices that are met with, and to be overcome if the question of waste is to be combatted and controlled. It is not to be expected that any question of public interest can be agitated without misconception and misrepresentation. The broadest views and soundest judgment must be enlisted and a process of learning be instituted, leading up to a proper consideration of all the features connected with the question, in order that it may be thoroughly understood, appreciated and approved.

It takes time to accomplish needed reforms in a Water Works Administration, and reforms to be substantial must be of slow and steady growth.

Practical results must be proved to be the outcome of any new feature of reform in order to be introduced in an administration, if commendation and approval are expected.

Experimental features should be managed economically and effectively.

A preliminary step in the shape of testing consumption at the expense of the City, in my judgment, is the best mode of aiming at a satisfactory solution of the question.

The writer herewith submits the result growing out of the application of test meters, 80 in number. The water was supplied to 80 premises, comprising dwellings, restaurants, boarding-houses, drug stores, offices, stables and a variety of small manufacturing establishments. The estimated rates were for the whole number $1,029.03. The rate determined by the meter increased the revenue $2,894.96.

In no instance did the registration of the meter fall below the estimated amount, as heretofore rated. The percentages of increase were from 30 *to* 200 *per cent.* The following determinations are reached by application of test meters:

First. The evidence revealed by test meter registration shows a quantity of water consumed largely in excess of what the city had estimated for, in its determination of legitimate use and waste of water.

Second. That its judgment of an estimated rate to be paid for water consumed, though favorable to the consumer, was a means of depriving the City Treasury of its lawful revenue.

Third. Whatever the consumption of water may be due to, whether from legitimate use, or careless waste, or faulty construction of interior plumbing work, the City's bounty will not suffer, and the amount of water consumed will be based upon an accurate measurement, and not upon an estimated amount.

Mr. Peter Milne, Jr., Ex-Water Purveyor,

—ON—

"BROOKLYN'S WATER SUPPLY."

An interesting Paper read before the OXFORD CLUB, *Brooklyn, N. Y., February* 23, 1887.

Mr. Van Buren in his annual reports, from the year of his entry into offices as Chief-Engineer of the Department of City Works to the present, refers in prominent and emphatic terms to the question of waste. For eight years I was officially associated with him as chief officer of the Bureau of extension and distribution. We agreed upon the question of waste and that heroic treatment was required to effectually check it. I believe now, as I did then, that a limitation of the bounty of the city should be established, a liberal one, a fair and just one. I stood alone officially upon the question of adopting a meter system to be gradually introduced, not to increase revenue, but to check waste, to virtually supplement the water supply. Mr. Van Buren honestly felt that our people would prefer to go on from year to year extending our water works supply to meet the increased demand, rather than submit to a gradual adoption of a meter system. I have respect for public opinion even when I know it to be wrong. I believe also in the effort to set it right. I belive in discussing the question that vitally affects the prosperity of the City. I candidly believe the judgment of the people of Brooklyn, after due deliberation, would sustain any practical and wise measure to check waste. It would seem to be the penalty of Water Works history as with individual life, that a certain amount of experience must be passed through before any positive benefit can accrue to those that stand in most need of it. You may form some idea of the cost of waste to the City when in the year 1880 it cost $35,000. I venture to assert that to-day it costs the sum of $50.000 per annum. The question of waste is not so much the question of water as it is of pumping and distributing. In cities bordering upon rivers and lakes from which they obtain a water supply, the consumption of water without any restriction has increased the cost of pumping to such an extent that in some of them the engineers in charge of their works have no further hesitation in recommending the adoption of meters to effectually check waste. New York City, Boston, Buffalo and Chicago are moving in this direction. It is simply history repeating itself. It is the experience of many European cities. The scheme of the proposed water extension is the result of years of study. It should be commenced and prosecuted with vigor to its completion. The present inexcusable delay is dangerous and it menaces the life of the city. It is stated that our population at the close of the year 1886 was close to 700,000. The consumption of water per capita about sixty-five gallons. In the ratio of her increase during the past ten years our city at the close of the Nineteenth Century will have reached a population of 1,000,000 and the daily consumption will reach the figure of 70,000,000 gallons. The proposed extension, together with its accessories, will cost three millions of dollars. If Brooklyn, during the coming thirteen years, will commence a gradual introduction of the meter system, covering the entire period by a proportional expenditure of equal amounts each year to be inserted in the budget or be a part of construction account, at the end of that period will be expended a sum

not to exceed $1,000,000. The year 1900 will, instead of bringing to public notice the question of further proposed extension, demonstrate the fact that forty gallons per capita is the figure of consumption, and that the water system of Brooklyn upon that basis of per capita consumption is sufficient for an increase of 500,000 to her population of 1,000,000. Waste of water is the result of thoughtlessness and a want of proper attention concerning the question of local distribution in premises, as to fitness of apparatus used and their permanency or durability. If premises are metered and a liberal amount in gallons allowed in consideration of tax or rent paid, the owner or party obligated to pay for all water used in excess of the amount allowed will pay heed to the nature and character of the water consuming apparatus, or he will be made to pay for his neglect. Good plumbing will be required and only allowed. It is bad plumbing that wastes water. The rules and regulations of the Department of City Works do not and cannot permanently and effectually check waste. A meter system will. Its office is that of an *inspector and detector of leaks*, and it will silently perform its duty without intruding upon the domesticity of the household, and effectively, because individual responsibility is determined. The theory that a restricted water supply will have the effect of limiting the use of water for sanitation is perfect nonsense. In fact, where water is used for "flushing" purposes, it must be done by mechanical appliances made for the purpose, to be effectual. If water is permitted to run to waste for "flushing" purposes, it is done in ignorance and owing to the fact that the appliances used are defective in construction. The most prominent phase of water waste is manifest during the Winter months, when the temperature falls below the freezing point. In many buildings the faucets are "set running" water, and so continue during the Winter months day and night. Plumbing should be constructed so as to be not liable to the action of frost. Rules and regulations and inspection of houses are failures in this respect. A water meter will regulate the question. The householder becomes interested at once. The plan of local distribution and character of apparatus will be critically investigated, not to abridge legitimate use, but to avoid waste. It would seem in view of the more than unusual expense attending the cost of pumping and maintenance which of necessity is a part of our system, and will inevitably increase as our population increases, that some organized effort should be made to permanently check waste, thereby supplementing our present system and the proposed plan of extension and which will assuredly and eventually, establish a diminished per capita consumption.

Extract from a Paper on "SELF CLOSING WORK, Etc.," read at a Meeting of the American Water Works Association, held in Denver, Colorado, 1886, by B. F. Jones, Esq., Sup't National Water Works Company, Kansas City, Mo.

We know there is waste, and we can find it, but when found, "what will you do with it?" Actual measurement is preferable, as being more exact, automatic, effective and equitable. The Water Meter, as defined by Ludlow, of Philadelphia, is merely a sleepless and tireless machine not susceptible to bribery or violence without discovery, requiring little attention and recording actual consumption, regardless of the disposition made of the water which passes through it.

The two systems of waste prevention, namely 1st, Inspection and enforcement of penalites, and 2d, Measuring and charging for the quantity taken, may be compared by supposing a given establishment to be furnished with gas at an annual rental, dependent upon the carefulness of its occupants, and an occasional visit by an inspector. The suggestion is simply absurd, and yet that is precisely what we all do in every single case where we rate premises with poor plumbing work or with careless occupants.

According to Ludlow, from whom I love to quote, 57 per cent. of the water supply is used while 43 per cent. is wasted.

In Kansas City we have over 500 meters in use, and some 5,000 places not metered. Notwithstanding the expense attending the cost of meters and maintenance I am of opinion that these have paid for themselves many times over, not only in increased revenues, but in saving waste which is simply saving coal and wear and tear upon machinery.

We are placing meters about as rapidly as we conveniently can, but giving precedence to premises with promiscuous occupancy, or when waste is likely to occur. On other well regulated smaller premises ordinarily not likely to waste, the rates are more satisfactory than the result from meters would be, and yet one of these could, and sometimes do, waste more water than is used by some of the first mentioned class with careful tenants. And yet again, if a meter should be placed upon the smaller premises, nine times out of ten the waste is reduced, and bills come in at less than former rates; so much so as not to justify the continuence of the meter. It is therfore ordered out, and in a little while as like as not, the waste goes on as before. So after all, as before stated, the universal use of meters is the only perfect remedy, at the same time the universal use of meters is not practical for the reasons already given; and so after all we drift back to the original proposition. How can we prevent waste without the universal use of meters?

TABLE

Showing the number of gallons of water, at fixed rates, which a consumer is entitled to per day, for one year, for each dollar paid per 1,000 gallons.

Rate paid Per annum.	5 cents per 1000 gallons.	10 cents per 1000 gallons.	15 cents per 1000 gallons.	20 cents per 1000 gallons.	25 cents per 1000 gallons.	30 cents per 1000 gallons.	40 cents per 1000 gallons.	50 cents per 1000 gallons.
$1	54.8	27.4	18.2	13.7	10.9	9.1	6.8	5.5
2	109.6	54.8	36.5	27.4	21.9	18.2	13.7	10.9
3	164.4	82.2	54.7	41.1	32.8	27.4	20.5	16.4
4	219.2	109.6	73.0	54.8	43.8	36.5	27.4	21.9
5	274.0	137.0	91.3	68.5	54.8	45.6	34.2	27.4
6	328.8	164.4	109.6	82.2	65.7	54.8	41.1	32.8
7	383.6	191.8	127.8	95.9	76.7	63.9	47.9	38.3
8	438.4	219.2	146.1	109.6	87.6	73.0	54.8	43.8
9	493.1	246.6	164.4	123.3	98.6	82.2	61.6	49.3
10	547.9	273.9	182.6	137.0	109.6	91.3	68.4	54.8
20	1096	548	365	274	219	182	137	109.6
30	1644	822	548	411	329	274	205	164.4
40	2192	1096	730	548	438	365	274	219.2
50	2740	1370	913	685	548	456	342	274.0
60	3288	1644	1096	822	657	548	411	328.7
70	3836	1918	1278	959	767	639	479	383.5
80	4383	2191	1461	1095	876	730	549	438.3
90	4931	2465	1643	1232	986	821	616	493.1
100	5479	2738	1826	1369	1095	913	684	547.9
200	10.959	5479	3653	2739	2191	1826	1369	1095.8
300	16.438	8219	5479	4109	3287	2739	2054	1643.8
400	21.918	10.959	7306	5479	4383	3653	2739	2191.7
500	27.397	13.698	9132	6849	5479	4566	3424	2739.7
600	32.876	16.438	10.958	8219	6775	5479	4109	3287.6
700	38.356	19.178	12.785	9.589	7671	6392	4794	3835.6
800	43.835	21.917	14.611	10.958	8767	7305	5479	4383.5
900	49.315	24.657	16.438	12.328	9868	8219	6164	4931.5
1000	54.794	27.397	18.264	13.698	10.959	9182	6849	5479.4

NOTICE OF
KANSAS CITY WATER CO. REGARDING METERING ELEVATORS.

OFFICE OF NATIONAL WATER WORKS COMPANY,
KANSAS CITY, MO., September 13, 1886.

TO PLUMBERS AND ELEVATOR MANUFACTURERS:

From the date of this notice all Hydraulic Elevators connected with the Water Supply in this City must be furnished with Rotary Meters to register the quantity of water used. The Indicators heretofore in use have become so objectionable and inaccurate in their measurement, that it has been decided to abandon their use in the future and supply Elevators through Meters entirely.

Meters will be furnished at cost by the Water Company, and set at the expense of the owner or occupant of the premises. Notice is also given that as soon as Indicators on Elevators now in use are reported out of order, their use will be discontinued, and Meters required set upon the supply at the expense of the owner or occupant of the premises.

The system of supplying Hydraulic Elevators through Meters has been adopted in a number of other cities, and the constantly increasing annoyance and expense occasioned this Company by Indicators reported out of order have shown it to be necessary here.

It might be well for Plumbers and Elevator Manufacturers to mention this fact to parties about to have elevators attached to the water supply, as much unnecessary friction may thus be avoided.

Respectfully,

NATIONAL WATER WORKS COMPANY,

B. F. JONES, Supt.

CITY ENGINEER'S OFFICE, WATER DEPARTMENT, PROVIDENCE, R. I.

TABLE FOR TESTING METERS,

SHOWING THE PERCENTAGE REGISTERED BY METER OF THE ACTUAL AMOUNT WEIGHED.

10 CUBIC FEET OF WATER AT 70° FAH.

PER CENT. MORE THAN ACTUAL WEIGHT.				LIMIT OF ACCEPTANCE.				PER CENT. LESS THAN ACTUAL WEIGHT.			
Pounds.	Per Cent.	Pounds.	Per Cent.	Pounds.	Per Cent.	Pounds.	Per Cent.	Pounds.	Per Cent.	Pounds.	Per Cent.
566	10.0	588	5.9	610½	2 0	623	0.0	636	2.1	664	6.2
½	9.9	½	5.8	611	1.9	½	.1	½	2.2	½	6.3
567	9.8	589	5.7	½	1.8	624	.2	637	2.2	665	6.4
½	9.7	½	5.6	612	1.8	½	.3	½	2.3	½	6.4
568	9.6	590	5.5	½	1.7	625	.4	638	2.4	666	6.5
½	9.5	½	5.5	613	1.6	½	.4	½	2.5	½	6.6
569	9.4	591	5.4	½	1.5	626	.5	639	2.5	667	6.6
½	9.3	½	5.3	614	1.4	½	.6	½	2 6	½	6.7
570	9.2	592	5.2	½	1.3	627	.7	640	2.7	668	6.8
½	9.2	½	5.1	615	1.3	½	.8	½	2.8	½	6.8
571	9.1	593	5.0	½	1.2	628	.8	641	2.9	669	6.9
½	9.0	½	4.9	616	1.1	½	.9	½	2.9	½	7.0
572	8.9	594	4.8	½	1.0	629	1.0	642	3.0	670	7.1
½	8.8	½	4.7	617	.9	½	1.1	½	3.1	½	7.1
573	8.7	595	4.7	½	.8	630	1.2	643	3.2	671	7.2
½	8.6	½	4.6	618	.8	½	1.2	½	3.2	½	7.3
574	8.5	596	4.5	½	.7	631	1.3	644	3.3	672	7.3
½	8.4	½	4.4	619	.6	½	1.4	½	3.4	½	7.4
575	8.3	597	4.3	½	.5	632	1.5	645	3.5	673	7.5
½	8.2	½	4.2	620	.4	½	1.5	½	3.5	½	7.5
576	8.1	598	4.1	½	.4	633	1.6	646	3.6	674	7.6
½	8.0	½	4.0	621	.3	½	1.7	½	3.7	½	7.7
577	7.9	599	4.0	½	.2	634	1.8	647	3.8	675	7.7
½	7.8	½	3.9	622	.1	½	1.9	½	3.8	½	7.8
578	7.7	600	3.8	½	0.0	635	1.9	648	3.9	676	7.9
½	7.6	½	3.7	.....	.....	½	2.0	½	4.0	½	7.9
579	7.6	601	3.6					649	4.0	677	8.0
½	7.5	½	3.5					½	4.1	½	0.1
580	7.4	602	3.4					650	4.2	678	8 2
½	7.3	½	3.4					½	4.3	½	8.2
581	7.2	603	3.3					651	4.3	679	8.3
½	7.1	½	3.2					½	4.4	½	8.4
582	7.0	604	3.1					652	4.5	680	8.4
½	6.9	½	3.0					½	4.6	½	8.5

Weight of 10 Cubic Feet of Water at 70° Fah. = 622.72 Lbs.

583	6.8	605	2.9
½	6.7	½	2.8
584	6.6	606	2.8
½	6.5	½	2.7
585	6.4	607	2.6
½	6.4	½	2.5
586	6.3	608	2.4
½	6.2	½	2.3
587	6.1	609	2.3
½	6.0	½	2.2
		610	2.1

Per Cent. Less than the Actual Weight indicates that the Meter Registers in favor of the Consumer.

Constants to be applied to the Weight of Water at various Temperatures in order to use this Table.

CONSTANT	FOR	80°.....1.00132
"	"	70°.....1.00000
"	"	60°..... .99905
"	"	50°..... .99846
"	"	40°..... .99824

Multiply the Weight of the Water in the Tank by the Constant corresponding to its Temperature, and the Product will be the Weight that should be used in ascertaining the Per Cent.

653	4.6	681	8.6
½	4.7	½	8.6
654	4.8	682	8.7
½	4.9	½	8.8
655	4.9	683	8.8
½	5.0	½	8.9
656	5.1	684	9.0
½	5.1	½	9.0
657	5.2	685	9.1
½	5.3	½	9.2
658	5.4	686	9.2
½	5.4	½	9.3
659	5.5	687	9.4
½	5.6	½	9.4
660	5.6	688	9.5
½	5.7	½	9.6
661	5.8	689	9.6
½	5.9	½	9.7
662	5.9	690	9.8
½	6.0	½	9.8
663	6.1	691	9.9
½	6.1	½	9.9
		692	10.0

To use this Table in connection with any number of Cubic Feet, divide 10 by the number, and with the quotient multiply the Weight of Water in the Tank, and the product will be the Weight that should be used in ascertaining the Per Cent.

2 CUBIC FEET OF WATER AT 70° FAH.

PER CENT. MORE THAN ACTUAL WEIGHT.

Pounds.	Per Cent.	Pounds.	Per Cent.
113	10.2	118	5.5
½	9.7	½	5.1
114	9.2	119	4.7
½	8.8	½	4.2
115	8.3	120	3.8
½	7.8	½	3.4
116	7.4	121	2.9
½	6.9	½	2.5
117	6.4	122	2.1
½	6.0		

LIMIT OF ACCEPTANCE.

PER CENT. MORE THAN ACTUAL WEIGHT.		PER CENT. LESS THAN ACTUAL WEIGHT.	
Pounds.	Per Cent.	Pounds.	Per Cent.
122½	1.7	125	.4
123	1.3	½	.8
½	.8	126	1.2
124	.4	½	1.5
½	0	127	1.9

Weight of 2 Cubic Feet of Water at 70° Fah. = 124.544 Lbs.

PER CENT. LESS THAN ACTUAL WEIGHT.

Pounds.	Per Cent.	Pounds.	Per Cent.
127½	2.3	133	6.4
128	2.7	½	6.7
½	3.1	134	7.1
129	3.5	½	7.4
½	3.8	135	7.7
130	4.2	½	8.1
½	4.6	136	8.4
131	4.9	½	8.8
½	5.3	137	9.1
132	5.6	½	9.4
½	6.	138	9.8

Per Cent. Less than the Actual Weight indicates that the Meter Registers in favor of the Consumer.

TABLE SHOWING FRICTIONAL HEAD AND DISCHARGE OF UNCOATED CAST IRON PIPES.

UPPER FIGURES SHOW FRICTIONAL HEAD PER 1,000 FEET.—147.2.
LOWER FIGURES SHOW DISCHARGE IN CUBIC FEET PER SECOND.—.0064.

Velocity, Feet Per Second.	DIAMETER OF PIPE IN INCHES.																		
	0.625	0.75	1.0	1.25	1.5	2.	3.	4.	6.	8.	10.	12.	16.	20.	24.	30.	36.	40.	48.
3.0	147.2 .0061	115.4 .0092	78.7 .0164	58.3 .0256	45.8 .0368	31.0 .0655	18.14 .1473	12.35 .2618	7.20 .5890	4.91 1.047	3.64 1.636	2.85 2.356	1.95 4.189	1.45 6.545	1.13 9.425	.842 14.73	.66 21.21	.574 26.18	.45 37.70
3.5	200.4 .0075	157.1 .0107	107.1 .0191	79.3 .0295	62.4 .0429	42.2 .0764	24.7 .1718	16.8 .3054	9.80 .6372	6.68 1.221	4.96 1.909	3.90 2.749	2.65 4.887	1.97 7.635	1.54 10.996	1.15 17.18	.90 24.74	.78 30.54	.612 43.98
4.0	261.7 .0085	205.2 .0123	139.8 .0218	103.6 .0341	81.4 .0491	55.1 .0873	32.3 .1964	22.0 .3490	12.8 .7854	8.72 1.396	6.48 2.182	5.08 3.142	3.46 5.585	2.57 8.726	2.02 12.57	1.50 19.64	1.17 28.28	1.02 34.90	.80 50.26
4.5	331.2 .0096	259.7 .0138	177. .0245	131. .0383	103.1 .0552	69.8 .0982	40.8 .2209	27.8 .3926	16.2 .8836	11.04 1.570	8.2 2.454	6.43 3.534	4.38 6.283	3.25 9.817	2.55 14.14	1.90 22.09	1.49 31.81	1.29 39.26	1.00 56.55
5.0	409. .0106	320.7 .0153	218.5 .0273	161.9 .0426	127.3 .0613	86.2 .1091	50.4 .2454	34.3 .4363	20.0 .9817	13.63 1.745	10.1 2.727	7.94 3.927	5.41 6.981	4.02 10.91	3.15 15.71	2.34 24.54	1.83 35.34	1.59 43.63	1.25 62.83
5.5	494.8 .0117	388. .0169	264.5 .03	201. .0469	154. .0675	104.3 .1200	61.0 .2700	41.5 .4799	24.2 1.080	16.5 1.919	12.25 3.00	9.60 4.820	6.54 7.680	4.86 12.00	3.81 17.28	2.83 27.00	2.22 38.88	1.93 48.00	1.50 69.11
6.0	588.9 .0128	461.8 .0184	314.7 .0327	233. .0511	183. .0736	124.1 .1309	72.6 .2945	49.4 .5235	28.8 1.178	19.6 2.094	14.55 3.272	11.45 4.712	7.80 8.378	5.80 13.09	4.54 18.85	3.37 29.45	2.64 42.41	2.29 52.35	1.80 75.40
6.5	691.1 .0138	542. .0199	369. .0354	274. .0554	215. .0797	145.6 .1418	85.2 .3191	58.0 .5671	33.8 1.276	23.05 2.268	17.1 3.545	13.4 5.105	9.15 9.076	6.80 14.18	5.32 20.42	3.95 31.91	3.10 45.95	2.70 56.71	2.1 81.68
7.0	801.5 .0149	628.5 .0215	428. .0378	317. .0596	249. .0859	169.0 .1527	98.8 .3486	67.3 .6108	39.2 1.374	26.7 2.443	19.85 3.818	15.56 5.498	10.60 9.774	7.85 15.27	6.17 21.99	4.58 34.36	3.60 49.48	3.10 61.08	2.45 87.96
7.5	920.1 .0160	721.6 .0230	492. .0405	364. .0639	286. .0920	194. .1636	113.4 .3682	77.3 .6544	45. 1.473	30.7 2.617	22.75 4.09	17.86 5.890	12.15 10.47	9.05 16.36	7.10 23.56	5.25 36.82	4.10 53.02	3.60 65.44	2.8 94.25
8.0	1047. .0170	821.9 .0245	559. .0436	415. .0682	326. .0982	221. .1746	129. .3927	87.9 .6980	51.2 1.571	34.9 2.792	25.9 4.363	20.3 6.283	13.85 11.17	10.3 17.45	8.05 25.13	6.0 39.27	4.70 56.55	4.10 69.80	3.2 100.5
8.5	1182. .0181	927. .0261	631. .0464	468. .0724	368. .1043	251. .1855	146. .4173	99.2 .7416	57.8 1.669	39.4 2.966	29.25 4.636	22.95 6.676	15.65 11.87	11.6 18.54	9.10 26.70	6.75 41.73	5.30 60.09	4.60 74.16	3.6 106.8
9.0	1322. .0192	1037. .0276	707. .0491	525. .0767	411. .1104	281. .1964	163. .4418	110. .7853	64.8 1.767	43.6 3.141	32.45 4.909	25.70 7.069	17.35 12.57	13.00 19.63	10.2 28.27	7.57 44.18	5.91 63.62	5.14 78.53	4.05 113.1
10.	1633. .0213	1280. .0307	872. .0545	648. .0852	508. .1227	347. .2182	202. .4909	137. .8725	80. 1.963	54.5 3.49	40.5 5.454	31.75 7.854	21.65 13.96	16.05 21.82	12.6 31.42	9.35 49.09	7.35 70.69	6.35 87.26	5. 125.7
11.	1975. .0234	1549. .0337	1056. .060	784. .0937	617. .1350	420. .240	244. .540	166. .9597	96.8 2.159	66. 3.839	49. 5.999	38.4 8.639	26.20 15.36	19.45 24.00	15.25 34.56	11.30 54.00	8.90 77.76	7.70 95.99	6.05 138.2
12.	2351. .0256	1843. .0368	1256. .0654	933. .1022	731. .1472	499. .2618	290. .5891	198. 1.047	115.2 2.356	78.5 4.188	58.3 6.545	45.7 9.425	31.15 16.76	23.15 26.18	18.15 37.70	13.45 58.91	10.55 84.83	9.20 104.7	7.2 150.8
13.	2759. .0277	2163. .0399	1474. .0709	1095. .1108	858. .1595	586. .2836	341. .6382	232. 1.134	135.2 2.552	92.1 4.537	68.4 7.09	53.65 10.21	36.55 18.15	27.15 28.36	21.3 40.84	15.8 63.82	12.4 91.9	10.8 113.4	8.45 16.34
14.	3200. .0298	2509. .0429	1710. .0763	1230. .1193	996. .1718	678. .3055	395. .6873	.269 1.222	156.8 2.748	106.8 4.886	79.35 7.635	62.25 10.995	42.40 19.55	31.50 30.54	24.7 43.98	18.35 68.73	14.4 98.97	12.5 122.2	9.80 175.9
15.	3673. .0320	2660. .0460	1963. .0818	1457. .1278	1143. .1840	781. .3273	454. .7363	309. 1.309	181. 2.945	122.6 5.235	91.1 8.181	71.4 11.781	48.6 20.95	36.10 32.72	28.3 47.12	21.05 73.63	16.5 106.0	14.3 130.9	11.25 188.5

TABLE OF QUANTITY OF WATER DELIVERED BY SERVICE PIPES OF VARIOUS SIZES, UNDER VARIOUS PRESSURES.

Proportion of Head of Water (H) to length of Pipe (L). Results in gallons per minute.

Diameter of Pipe. Inches.	H=10 L	H=9 L	H=8 L	H=7 L	H=6 L	H=5 L	H=4 L	H=3 L	H=2 L	H=1⅞ L	H=1¾ L	H=1½ L	H=L	H=¾ L	H=½ L	H=⅜ L	H=¼ L	H=⅛ L	H=1/16 L	H=1/32 L	H=1/64 L	H=1/128 L
½	19.8	18.7	17.7	16.5	15.3	14.0	12.5	10.8	8.8	8.3	7.7	7.0	6.3	5.4	4.4	3.6	3.1	2.8	2.6	2.4	2.2	2.1	2.0
⅝	34.5	32.7	30.1	28.9	20.5	24.4	21.8	18.9	15.4	14.4	13.4	12.2	10.9	9.5	7.7	6.3	5.5	4.8	4.4	4.1	3.9	3.6	3.5
¾	54.4	51.7	48.7	45.6	42.2	38.5	34.4	29.8	24.3	22.8	21.1	19.3	17.2	14.9	12.2	9.9	8.6	7.7	7.0	6.5	6.1	5.7	5.4
1	111.8	106	100	93.5	86.6	79	70.7	61.2	50	46.8	43.2	39.5	35.3	30.1	25	20.4	17.7	15.8	14.4	13.4	12.5	11.8	11.2
1¼	195.2	185.2	174.6	163.3	151.2	138	123.4	106.9	87.3	81.6	75.6	69	61.7	53.5	43.7	35.6	30.9	27.6	25.2	23.3	21.8	20.6	19.5
1½	308	292.1	275.4	257.6	238.5	217.7	194.8	168.7	137.7	128.8	119.3	108.9	97.4	84.3	68.7	56.2	48.7	43.9	39.8	36.8	34.4	32.5	30.8
2	632.2	599.7	566.4	538.9	488.1	447	399.8	346.3	282.7	264.4	248.8	223.5	199.9	173.1	141.4	115.4	100	89.4	81.6	75.6	70.7	66.6	63.2
2½	1104	1048	987.8	924	855.4	780.9	698.5	604.9	493.9	482	427.7	390.4	349.2	302.4	246.9	201.6	174.6	156.2	142.6	132.0	123.6	116.4	110.4
3	1745	1631	1560	1460	1351	1234	1103	955.5	780.2	728.8	674.8	615.9	555.5	477.1	390.1	317.6	275.8	246.7	225.2	208.5	195.1	183.9	174.5
4	3581	3397	3203	2996	2774	2532	2265	1962	1602	1496	1385	1264	1133	979.3	800.8	653.8	566.2	506.5	463.2	428.0	399.9	377.5	358.1
5	6247	5928	5588	5227	4839	4417	3951	3406	2791	2613	2420	2209	1976	1711	1394	1114.1	987.7	883.5	806.5	746.7	698.5	658.5	624.7
6	9855	9349	8814	8245	7633	6968	6233	5391	4407	4122	3817	3481	3116	2693	2204	1799	1558	1138.4	1272	1178	1102	1103.9	985.5

To illustrate this table, assume a ⅝-inch pipe 100 feet long, with a pressure of 44 lbs. at the inlet; 44 lbs. = 100 feet head, then the head H = the length L, or H = L; the column of the table shows a discharge of 10.9 gallons per minute. If the pipe was 300 feet long then the head H would be ⅓ of L and the discharge would be 6.3 gallons. If the pipe was 20 feet long, H would be 5 times the length of L, and the discharge 24.4 gallons.

To determine the feet of head, multiply the pounds pressure by 2.31, and divide the product by the length of the pipe.

ILLUSTRATION.—85 feet of 1 in. pipe at 65 lbs. pressure. 65 lbs. × 2.31 = 150 feet head—then the head 150 = very nearly 1¾ times the length, or, H = 1¾ L, the table then shows 46.8 gallons per minute.

Table of Pressnre in Lbs. per Sqnare Inch for Different Heads of Water.

Head. Feet.	0	1	2	3	4	5	6	7	8	9	Head. Feet.
0		.4335	.8670	1.3005	1.7340	2.1675	2.6010	3.0345	3.4681	3.9016	0
10	4.3351	4.7686	5.2021	5.6356	6.0691	6.5026	6.9361	7.3696	7.8031	8.2366	10
20	8.6701	9.1036	9.5372	9.9707	10.4042	10.8377	11.2712	11.7047	12.1382	12.5717	20
30	13.0052	13.4387	13.8722	14.3057	14.7392	15.1727	15.6063	16.0398	16.4733	16.9068	30
40	17.3403	17.7738	18.2073	18.6408	19.0743	19.5078	19.9413	20.3748	20.8083	21.2418	40
50	21.6754	22.1089	22.5424	22.9759	23.4094	23.8429	24.2764	24.7099	25.1434	25.5769	50
60	26.0104	26.4439	26.8774	27.3109	27.7444	28.1780	28.6114	29.0450	29.4780	29.9120	60
70	30.3455	30.7790	31.2125	31.6460	32.0795	32.5130	32.9465	33.3800	33.8135	34.2471	70
80	34.6806	35.1141	35.5476	35.9811	36.4146	36.8481	37.2816	37.7151	38.1486	38.5821	80
90	39.0156	39.4491	39.8826	40.3162	40.7497	41.1832	41.6167	42.0502	42.4837	42.9172	90
Head. Feet.	0	1	2	3	4	5	6	7	8	9	Head. Feet.

For other heads than those given, alter the decimal point as necessary: for example, pressure per square inch due to 77 feet = 33.38 lbs., per square inch for 7.7= 3.338 lbs., for 770 = 333.8.

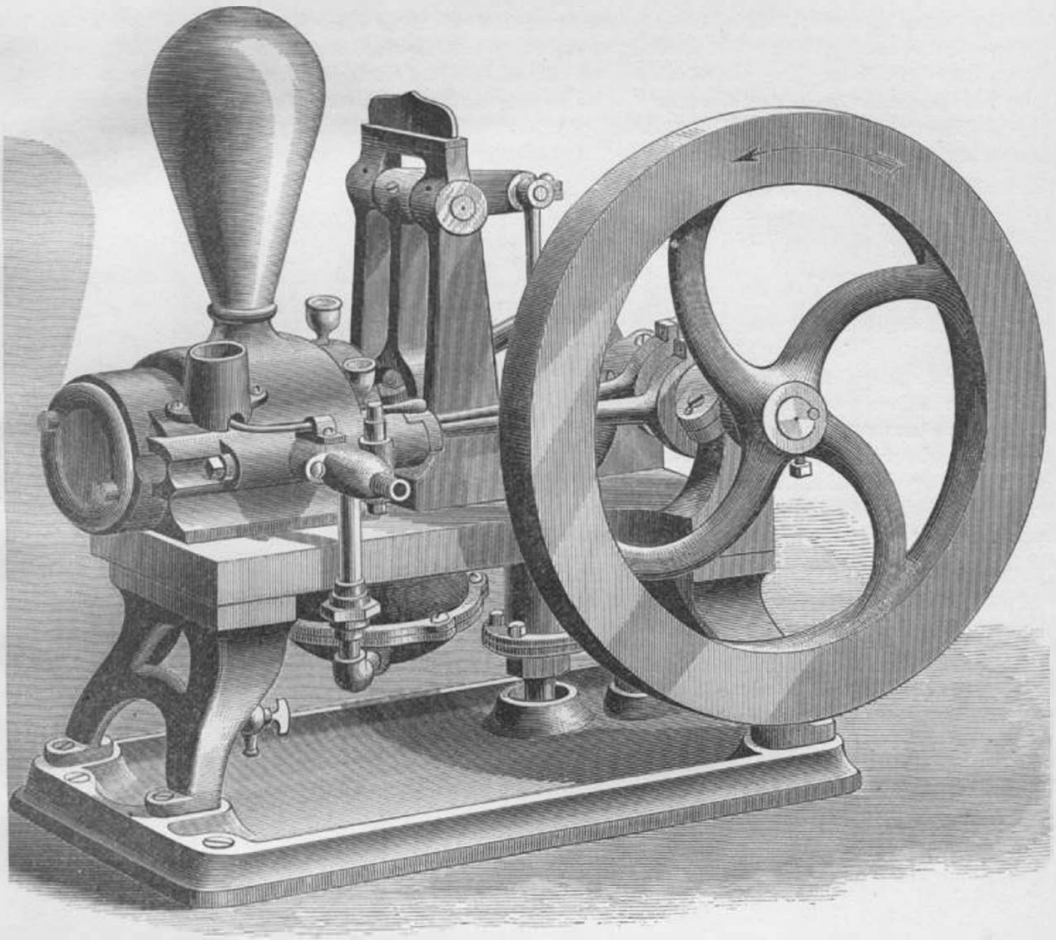
Table of Heads, in Feet, for Different Pressures in Lbs. per Sq. Inch of Water.

Press-ure.	0	1	2	3	4	5	6	7	8	9	Press-ure.
0		2.307	4.614	6.921	9.228	11.535	13.842	16.149	18.456	20.763	0
10	23.070	25.377	27.684	29.991	32.298	34.605	36.912	39.219	41.526	43.833	10
20	46.140	48.447	50.754	53.061	55.368	57.675	59.982	62.289	64.596	66.903	20
30	69.210	71.517	73.824	76 131	78 438	80.745	83.052	85.359	87.666	89.973	30
40	92.280	94.587	96 894	99.201	101.508	103.815	106.122	108.429	110.736	113.043	40
50	115.350	117.657	119.964	122.271	124.578	126.885	129.192	131.499	133.806	136.113	50
60	138.420	140.727	143.034	145.341	147.648	149.955	152.262	154.569	156.876	159.183	60
70	161.490	163.797	166.104	168.411	170.718	173.025	175 332	177.639	179.946	182.253	70
80	184.560	186.867	189.174	207.630	193.788	196.095	198.402	200.709	203.016	205.223	80
90	207.630	209.937	212.244	214.551	216.858	219.165	221.472	223.779	226.086	228.393	90
Press-ure.	0	1	2	3	4	5	6	7	8	9	Press-ure.

For other pressures than those given, alter the decimal point as necessary: for example, head, due to pressure of 75 lbs. = 173.025 feet, for 7.5 lbs. = 17.3025. for 750 lbs. = 1730.25

"CROWN" GAS PUMP.

(PATENTED FEBRUARY 6, 1883.)



The Crown Gas Pump is specially adapted for pumping water from wells or cisterns, or for forcing water into tanks on the upper floors of buildings from city supply.

Always ready to operate, it can be started instantly with a match.

The amount of gas consumed is very small, being 8 cubic feet when pumping 200 gallons of water 50 feet high per hour, or less water to a proportionately greater height.

The pump is small, compact and ornamental, and occupies a floor space of only 12x24 inches, and stands 22½ inches high.

It is made of the best materials, and by the most careful and skillful workmen. All the crank and bearing pins and the lighter valve are of hardened steel, being ground to a fit. The pump and valve are of composition, and every part of the whole is accurately made and carefully finished.

The diameter of the power cylinder is	3 inches	Capacity	200 gallons per hour.
" stroke	4 "	Height	22½ inches.
" diameter of pump	1½ "	Floor space required	12x24 "
" stroke of pump	2 "	Weight	140 lbs.
" strokes per minute	200	Price	

LAWS OF NEW YORK.

1873, Chap. 335, Sect. 73 on Page 503.

The Commissioner of Public Works is hereby authorized in his discretion to cause Water Meters, the pattern of which and price of which shall be approved by the Mayor, Comptroller and Chief-Engineer of the Croton Aqueduct, to be placed in all stores, workshops, hotels, manufactories, public edifices, at wharves, ferry houses, stables, and in all the places in which water is furnished for business purposes (consumption) by the Department of Public Works, except private dwellings, so that all water so furnished therein or thereat may be measured and known by said Department.

DEPARTMENT OF PUBLIC WORKS.

NEW YORK,_____188____

Form of notice sent to parties who are required to *place Meters* on their premises:

Under the provisions of Sec. 73, Chap. 335, Laws of 1873 (City Charter), authorizing the Commissioner of Public Works to cause water meters to be placed "in all stores, workshops, hotels, manufactories, public edifices, at wharves, ferry-houses, stables," and in all places where water is furnished for business consumption, "except private dwellings," you are hereby required within thirty days from the receipt or service of this notice to place a ..... or a **Crown Water Meter** (which are the meters approved in accordance with said Sec. 73 of the Charter), on the pipe supplying your premises ..... with water, and thereafter to pay for water consumed according to measurement.

In case of refusal or neglect to place the meter as herein required, it will be placed by the Department of Public Works, and the expense charged to you; and refusal or neglect to pay the water rates according to measurement will be followed by immediate stoppage of the supply.

Your attention is respectfully requested to the accompanying rules and regulations.

Very respectfully,

COMMISSIONER OF PUBLIC WORKS.

RULES AND REGULATIONS OF NEW YORK CITY.

All meters before being placed, must be sent, with a memorandum of the owner's or purchaser's name, residence and places of business, to the Department Pipe Yard, 24th Street and East River, to be tested. They will be returned within forty-eight hours, upon the written order of the owner, giving the names of the plumber who is to receive and set the meter.

Consumers are required to keep their meters in repair and protect them from frost and injury of any kind, at their own expense.

All meters are to be placed under the supervision and to the satisfaction of the Commissioner of Public Works, or such person as he may designate, so that they can be easily examined and read.

Between each meter and the Croton main, a stop cock must be placed on the service pipe, within one foot of the meter, and no water from Croton mains shall be introduced or used on premises to be supplied by meter, except that which passes through the meter.

No meter shall be set within two feet of any sink, privy, cesspool, manure heap or pit.

Licensed plumbers of this city, and employees of the Department of Public Works, are the only persons authorized to make connections with water mains, and to set or remove meters.

No meter shall be removed or repaired, except upon a permit from the Department of Public Works; and whenever a meter is removed for any cause, the Commissioner of Public Works will require another to be put in its place.

RULES AND REGULATIONS OF NEW YORK CITY.—CONTINUED.

In case of violation of any of the preceding requirements and regulations, or if free access to the meters for examination or repair shall at any time be denied to the Engineer or such person or persons as the Commissioners of Public Works may employ for that purpose, or if upon examination it shall be found that the meter has been tampered with, the water supply shall be stopped, unless the party shall promptly pay such additional charge as the Commissioner of Public Works may impose; nor will the supply be resumed except upon payment of the expense of shuttingoff and turning on and upon satisfactory understanding that no future cause of complaint shall arise.

It is provided by Section 73, Chapter 335, Laws of 1873, that "all expenses of meters, their connections and setting, water rates and other lawful charges for the supply of Croton Water, shall be a lien upon the premises where such water is supplied as now provided by law."

A proper reduction will be made for water rates already paid for the fiscal year ending April 30, 1880, when bills for water furnished through meters are made out.

Bills for all expenses or charges in connection with meters, and for water furnished through them, and permits required therefor, and all information in reference thereto, can be obtained at the office of the Chief-Engineer, Room 11½ City Hall.

All payments for use of water, for meters, setting, &c., must be made at the office of the Water Register, and no other person is authorized to receive money atany other place.

COMMISSIONER OF PUBLIC WORKS.

TABLE,

Prepared by J. NELSON TUBBS, ESQ., Chief-Engineer, Rochester (N. Y.) Water Works, showing the capacity of Water Service Pipes, one hundred feet in length, in gallons per minute, with diameters and heads as indicated.

Diameter of Pipe in inches.	10 ft. Head. Gallons per Minute.	20 ft. Head. Gallons per Minute.	30 ft. Head. Gallons per Minute.	40 ft. Head. Gallons per Minute.	50 ft. Head. Gallons per Minute.	60 ft. Head. Gallons per Minute.	70 ft. Head. Gallons per Minute.	80 ft. Head. Gallons per Minute.	90 ft. Head. Gallons per Minute.	100 ft. Head. Gallons per Minute.
3-8	0.92	1.30	1.59	1.84	2.06	2.26	2.44	2.61	2.76	2.91
1-2	1.89	2.68	3.27	3.78	4.23	4.63	5.00	5.34	5.67	5.98
5-8	3.30	4.68	5.72	6.61	7.39	8.09	8.74	9.34	9.91	10.44
3-4	5.21	7.37	9.03	10.42	11.65	12.77	13.79	14.74	15.64	16.48
7-8	7.66	10.84	13.27	15.32	17.13	18.77	20.27	21.67	22.97	24.23
1	10.70	15.13	18.53	21.40	23.92	26.20	28.30	30.26	32.10	33.83
11-8	14.36	20.31	24.87	28.72	32.11	35.18	38.00	40.62	43.08	45.31
11-4	18.68	26.43	32.29	37.37	41.70	45.77	49.44	52.85	56.06	59.09
13-8	23.72	33.54	41.08	47.33	53.03	58.09	62.75	67.08	71.15	75.00
11-2	29.48	41.65	51.06	58.96	65.92	72.22	78.00	83.38	88.44	93.23

Experiments at Rush Reservoir with one inch hose two hundred and twenty feet long, under twenty-two feet head, with three-eights of an inch nozzle, gave 7-5 gallons per minute, or four hundred and fifty gallons per hour. The table gives for one inch pipe with head one-tenth of its length, with free discharge 10.7 gallons per minute, or six hundred and fifty-two gallons per hour.

If the capacity is required for any other length, diameter and head than those given in the table, multiply the number in the table by 10, and divide by the square root of the required length and the result will give the number of gallons per minute.

ON the last page of the book which we present to our patrons and friends, trusting it may aid them in their work of conducting Water Works, and prevent the great wastage of water now going on, it may be also interesting to give a few facts connected with the NATIONAL METER COMPANY, of New York.

This Company was organized January 5, 1870—seventeen years ago—with the same Officers and Directors as are holding office to-day, they have met monthly for business, through the many years of the Company's history, and under the management of the President, Mr. John C. Kelley, we are able to state that we have MADE AND SOLD OVER 45,000 WATER METERS, a number largely IN EXCESS of any other MANUFACTORY OF WATER METERS IN THE WORLD, and leave you to judge if in choosing the motto, "Nothing succeeds like success," we cannot add another, "Labor has sure reward."

When visiting New York we will be pleased to have you call at our Salesroom and Office.

Yours truly,

NATIONAL METER COMPANY,

252 BROADWAY, NEW YORK.