NOTES AND EXPERIMENTS ON WATER METERS.

Read by MR. H. J. I. Bilton.

It is perhaps safe to say that in no subject confronting the hydraulic engineer has more difficulty been experienced than in the accurate measurement of flowing water under varying pressures, and at varying rates of discharge. It is not the intention of the writer, however, to add to the already large list of water measuring instruments by submitting any original designs, but rather to shortly review the subject of water meters in general, to state their pros and cons as given by various investigators, and finally to give particulars of such tests as he has himself made, and of such experience as he has gained in dealing with the type commonly used here—the Siemens Turbine Inferential Meter.

In reviewing the subject, it is hardly necessary to remark that, of the many types of meter in existence, comparatively few are well known here. In shortly describing some of them, the writer, in the absence of personal experience, will therefore quote somewhat fully from the excellent paper on water meters, read by Mr. Wm. Schonheyder, before the Institute of Mechanical Engineers, and republished in "Engineering" of February 2nd, 1900, from which a number of the illustrations accompanying this paper have been reproduced.

Mr. Schonheyder writes as follows:—"Although purely elementary knowledge, it is necessary at the outset to state that meters are divided into the following classes:—

1. Low pressure meters.
2. Volume or capacity meters, without device for rendering them tight.
3. Those of the Venturi class, which have a special function.
5. Positive meters, or meters which provide a space to be filled and emptied of water, and which have some contrivance for rendering them tight at varying pressures and under diverse conditions of service.
6. Inferential meters.

Before treating of each of these classes it may be observed generally that they all have a useful purpose, which they are capable of answering with more or less advantage, according to their individual merits. The mistake most commonly made, in the author's opinion, is that they are indiscriminately used and frequently selected
on account of first cost, without due consideration of the duty they have to perform. . . . The next question presenting itself is, Of what importance is the measurement of waste in dribbles?"

Here Mr. Schonheyder gives a table showing the amount of water passing per hour through holes of various sizes under a head of 100 feet. He shows that the discharge through a hole 1/32nd in. in diameter is 6 gallons per hour, or 144 gallons for 24 hours, which is sufficient to supply 10 persons at the rate of about 15 gallons per head per day. He says:—"Even as little as 10 gallons per head per day of the London water supply admittedly represents waste, This quantity, based on a population of five millions, is 50 million gallons per day, sufficient to supply 25 gallons per head per day to an increased population of two millions, or, in other words, is more than sufficient for the needs of the City of Berlin. Here is a great problem, and, as the author believes, the solution of it lies in the sale of water either by meter only, or by meter with a fixed charge for a minimum supply, in order to ensure health and cleanliness."

Referring to the different kinds of meters above classified, Mr. Schonheyder's descriptions and criticisms may shortly be summarised as follows:

1. Low Pressure Meters.—"These are more specially applicable to measuring small flows, such as dribbling supplies to flushing cisterns. The oldest, and probably the best known, is the Parkinson" (described in a paper read before the Inst. M. Engineers in 1882, p. 41). These meters are commonly used to measure the exhaust water in hydraulic power supplies. The Bascule is another. "Like the Parkinson, it has only one moving part, which is in the form of a double bucket mounted on pivots, and so arranged that, when one of the buckets is taking its supply from the main, the other is being emptied, and vice versa. A meter of this kind was described by the late Sir Wm. Siemens in the Pro. Inst. Mech. Engineers for 1854, and was called a 'bucket' meter. (Sheet 1, Fig. 2.) The great objection to these meters is that the whole of the pressure from the main is lost in passing through them."

2. Volume or Capacity Meters.—"These meters are almost exclusively made in the United States of America, and their use is chiefly confined to that country. In construction they are, broadly speaking, all the same, as they consist of a casing of either gunmetal or vulcanite, in which works a vulcanite block, serving both as piston and valve. They very seldom possess any provision for taking up wear, and the parts are therefore difficult and expensive to repair. Hence (though they profess to measure the volume passing through them), as they are not tight, even when new, they cannot measure small flows, and their leaky condition is necessarily augmented by wear. Their merits appear to be simplicity, small size, lightness and cheapness, and for large flows they are said to be very accurate. The 'Hersey' (sheet 1, Fig. 4), the 'Crown' (Fig. 5), the 'Bee' or 'Thomson' (Fig. 6), the 'Gem,' the 'Empire,' the 'Trident,' the 'Nash,' the 'Kent Uniform' (Fig. 3), and some others belong to this
class, but only in the Kent Uniform has an attempt been made to compensate for wear. It appears from recent comments in the American press that the unreliability of these meters to record accurately small flows is being more and more recognised. When the water is not very clear, is rather hard, or for some time stagnant, the meter will set fast, while still allowing a large quantity to pass—of course unregistered. Judging from their general construction, and from reports of their workings, as well as from the author's own experiments, he fails to detect any advantage to be obtained from the use of these meters over those of the 'Inferential' type. Indeed, he has come to the conclusion that they do not equal in accuracy a well made and maintained Siemens' meter."

With regard to this type, the writer has recently had some experience of a 2-inch Kent "Uniform" meter (Fig. 3). This meter (which costs nearly three times as much as a Siemens' Inferential meter of the same size), was placed on a 4-inch main, delivering water to a tank under a head varying from 1 foot 6 inches to 5 feet. After running for some months at a rate of discharge, assumed (as a result of preliminary tests) to be about 10 to 20 per cent. slow, it stopped altogether for a week, without preventing the passage of the water. After being taken to pieces, examined and refixed, it again commenced to work, but gaugings showed that it registered about 33 per cent. slow under the smallest head, and it was finally taken out as being unsuited to the conditions and requirements.

An article in the Pro. Am. Soc. C.E., Vol. XXV. (Hill on Tests of Meters), describes in very full detail the results of a large number of tests of American meters. There is, however, very little information as to their performance after a number of years' use. The writer is of opinion that tests of different meters, when new, afford only a very approximate and imperfect indication of their comparative values as water-measuring instruments. To complete the experiments, he thinks tests should be made after a considerable period of use, without disturbing the meters by removing them from their places.

3. The Venturi. —"The possibility of constructing the Venturi meter," Mr. Schonheyder remarks, "is due to the practical absence of loss of head in the main, which is contracted and again expanded by means of properly formed cones. The difference between the pressures where the water is passing through the main pipe before arriving at the meter, and where it is passing through the neck of the tube, forms an index for gauging the flow. It is cheap, considering the larger volume of water it deals with, and for ordinary rates of flow in water mains it is said to be very accurate, and it is certainly most convenient and useful." This meter has been perfected by Mr. Clemens Herschel, of America, and is fully described in the American engineering publications.

4. Waste Detection Meters.—These meters are used for detecting and locating general waste, especially in large mains. The "Deacon" apparatus (Fig. 1) is said to be in very extended use for the purpose.
The water enters the upper end of the conoidal tube, and passes downwards and around the balanced disc A, which rises or falls according to the discharge. Its motion is communicated to a pencil which marks on a diagram, placed on the revolving cylinder B, the various rates of discharge at all hours of the day or night. These meters are placed one to each block or city section, and it is claimed that considerable reduction in waste consumption is effected by their use. The methods of application are fully described in the "Encyclopædia Britannica."

5. Positive Meters.—"As the name implies, these meters aim at the accurate or 'positive' measurement of all water passing through them under varying conditions of head and volume."

Amongst meters of this class may be mentioned the "Frost" or "Manchester" (sheet II., Fig. 8), the "Worthington" (American), the "Frager" (French), the "Schriever" (French), (sheet III, Fig. 13), the Kent "Absolute," the "Goodwin," the "Schmid," the "Bernay," and the "Kennedy." To all of these objections can be raised, and attempts to introduce them on a large scale appear to have failed. In some, the pistons and valves are said to become leaky with wear, and are apt to set fast with small impurities. Frequent lubrication is required. In some, the pistons have very imperfect packing, in others none at all. Repairs are expensive and troublesome. On account of the slow velocity of the water through them, the ports and passages get choked with sediment. The slightest variation in the stroke of the piston, due to wear, will impair their efficiency. The "Kennedy" and "Frost" meters appear to rank among the best. A 6 inch Kennedy exists on the Melbourne and Metropolitan Board of Works' main supplying Mordialloc, and two 2 inch meters of this class are in use at the City Council's electric light works, measuring the boiler feed water, for which purpose they appear to be fairly well adapted. One is also in use at the sugar works. A number of the "Frost" meters are in use at Broken Hill, it is said with satisfactory results, but at Cape Town the peculiar quality of the water is said to render them unreliable. Considerable thumping at the end of each stroke is said to sometimes cause a breakdown.

The Kennedy meter has a single vertical, double-acting cylinder (A, sheet II., Fig. 7), its piston being packed with a rolling indiarubber ring (B). The valve is reversed by a tumbling weight (W), the fall of which is arrested by suitable springs or indiarubber buffers. The stroke is variable, but by an ingenious system of adding up the lengths by means of a counter, this is not an objection. It is claimed that these meters will discharge large quantities of water under small heads, but the rolling indiarubber ring sometimes becomes displaced and damaged by sudden increases or stoppages in the consumption, and the reversing mechanism occasionally causes trouble. According to the manufacturer's instructions, these meters require to be cleaned, oiled and examined every month. They are, with the exception of the "Frost," perhaps the only single cylinder positive meters in use, the others having two or more pistons, worked
on the duplex principle, or by independent valves. They are particularly large and cumbersome, and their cost is sufficient to prevent their use except under special circumstances.

The Kent “Standard” meter (Sheet III., Figs. 11 and 12), described in “Engineering” of February 6th, 1903, is one of the latest positive meters, and is claimed to be accurate down to a drip of a few pints per hour. Another is the “Imperial,” the invention of Mr. Schonheyder (sheet II., Figs. 9 and 10). This meter is fully described in his paper, and seems to have given very satisfactory results when properly maintained and periodically cleaned. It is of the three-cylinder type, and of comparatively simple construction. It is claimed to have a definite stroke. Mr. Schonheyder states in the discussion on his paper that rust deposit, lime crystals in suspension, and similar evils are inevitable in all water services, and that in course of time these impurities must unfavourably affect the working of any meters. In his meter, the “Imperial,” the operation of cleaning both dirt box and meter is facilitated, and the meter can be kept practically up to the standard of a new one by periodical attention. Where the difficulties of sand, grit, or lime are pronounced, he recommends vulcanite cylinders in lieu of gunmetal.

In a table of tests, a ¾-inch Imperial meter, after seven months’ use, is shown as running only ¾ per cent. fast at 1100 gallons per hour, and 2 per cent. fast at 12. In another case a ¼-inch meter, which had been in use two years and five months, and had registered 267,000 gallons, was found correct at 20 and 450 gallons per hour, and at 5 gallons per hour showed a leakage of about half a gallon an hour. “The cups might have required renewal after their 2½ years’ service, otherwise nothing was wrong with it.”

Mr. Schonheyder states that his ¾-inch meter has ¾-inch cylinders, with a piston stroke of 1¼ inch. “At 100 revolutions per minute the meter delivers about 1350 gallons per hour, but in practice it is very seldom run at this speed.”

The point about this meter which most strikes the writer is its large bulk, compared with the size of its inlet and outlet. Unless there is some mechanical objection, such as undue wear under high piston speed, he questions whether the meter is not larger than is necessary for its nominal size. Investigations show that a ¾-inch meter, discharging 1350 gallons per hour, means a velocity of 20 feet per second through ¼-inch pipes. The frictional resistance of every 10 feet of such pipes computes to 20 feet head, or nearly 9 lbs. per square inch pressure. Such conditions are most unusual in practice. The writer finds that even 500 gallons per hour is an exceptionally high rate of discharge for ¾-inch house service taps. It is sometimes, owing to incrustation, as low as 50. The maximum rates of discharge which the writer considers meters in ordinary use are subjected to, and above which it is not wise they should be continually subjected to, are shown by the horizontal curves on diagram No. 2. In so many cases has he found that meters in use only absorbed a few feet head, that diagram 3 was prepared (as presently described) on which the discharges under low heads can be read more correctly.
6. Inferential Meters.—It is with this type of meter (generally used here), and with its various modifications and adaptations, that the writer proposes specially to deal. The water is not actually measured by them, but the quantity passed is "inferred" from the number of revolutions made by the turbine, which, with the exception of the registering mechanism, is the only moving part. The best known of this type is that introduced by Sir Wm. Siemens in 1850, and is constructed upon the principle of the Barker’s mill, long used as a motive power for working mills and for other purposes. There are two distinct kinds—namely, the “Fan” and the “Turbine.” The former is said to be preferred on the Continent, the latter in Great Britain. The fan meter is sometimes preferred to the turbine, where the available head is small, a distinction which to the writer seems unwarranted, for reasons presently given. Turbine meters are said to retain any bias or percentage of error under repeated tests, whereas fan meters, not being so well balanced, are more erratic. Other makes, in addition to the Siemens, are the “Tyler Inferential” (fan), the “Meinecke” (fan), the “Siemens-Halske” (fan), the “Dreyer, Rosenkranz and Droop” (vulcanite fan), and the “Smith Rotary” (spiral turbine). The writer, however, proposes to confine himself to the Siemens turbine type, which, though still the same in principle, has undergone many slight modifications since first introduced, chiefly in the direction of facilitating construction and repairs.

A section of one of the latest types as made here is shown on sheet IV. The casing consists of gunmetal in the smaller sizes and cast iron in the larger. The turbine wheel (W) is made of 24 gauge stamped phosphor bronze, which best resists the corrosive action of water. To it are attached the regulating vanes (V), which prevent the turbine from running too quickly at the higher speeds. By means of these vanes the registration of the meter is adjusted. As illustrating the effect of these vanes, it may be mentioned that a test showed that the absence of one of them caused a ¾-inch meter to run 18 per cent. fast at 100 gallons per hour. The turbine is supported on the bullet-nosed steel pivot (P), on which bears a level-faced small steel block let into the turbine spindle (shown in black). The pivot and block are both tempered glass hard. The turbine is a close fit round the conductor tube (N), and is guided by the bearing (B). The two chambers (F and G) are partly filled with oil, which will remain there for years. The pressure of the water from below forces the oil upwards, and prevents its escape. When stored, the meter should be placed dial downwards, or the oil will find its way out. In the upper chamber is the small dial spindle (D), with a conical bearing, the pressure on which prevents the escape of the oil into the dial chamber (C). The water enters the meter in the direction of the arrows, passes through the screen (K), down the conductor tube (N), into the turbine, and is discharged through the waterways (R) in a diagonal direction, the reaction turning the turbine wheel, which, by means of the worm and worm wheel, actuates the clockwork of the dial.
An example of the dial of a small meter is given in Fig. 15, sheet V. On account of the mistakes made in reading these circular dials by inexperienced persons, rectangular dials, registering on the gas meter principle, as shown in Fig. 16, are sometimes made. Many of these are in use in Sydney. An objection to them is, that, owing to certain mechanical difficulties of construction and the smallness of the dials, it is impossible to accurately gauge the flow when testing by the use of a reasonable amount of water.

Another modification has been tried in the form of a movable cover (C, Fig. 17), to which is attached the whole of the meter mechanism, the object being to remove and replace it by spare parts without disturbing the meter casing. The objection to this is that no inferential meter can have its inner parts removed, and others substituted, without a considerable liability of inaccuracy resulting, a legal as well as a practical objection.

These meters are comparatively small, light and cheap, and, if properly maintained, are fairly accurate when passing water at a speed above their minimum rated capacity. The chief objection to them is that they will not register accurately small rates of consumption (a matter of special importance where large meters are concerned), and will often fail to register dribbling discharges of 3 gallons or more per hour. Each size of meter has an approximate minimum correct rate of discharge when new, below which it will cease to register accurately, and at which it will commence to fall off or run slow, to the benefit of the consumer. The minimum rates of correct discharge claimed for various sized meters, when new, are marked on the curves on diagram No. 2. With great accuracy of construction, these minimum rates may be reduced, but the figures must in any case only be taken as approximations. They vary with each meter, even when new, and still more so after years of continuous use. They are, however, useful indications of the size of meter required to suit any given conditions.

The following table shows the number of revolutions made by the turbines of various sized meters per gallon of water registered on the dial. These figures have been adopted by the writer as a means of comparing the work done by various meters in tests presently described:

<table>
<thead>
<tr>
<th>Size of Meter</th>
<th>Revolutions of Turbine per Gallon Registered</th>
<th>Size of Meter</th>
<th>Revolutions of Turbine per Gallon Registered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td>326</td>
<td>—</td>
<td>3&quot;</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>133</td>
<td>—</td>
<td>4&quot;</td>
</tr>
<tr>
<td>1&quot;</td>
<td>42</td>
<td>—</td>
<td>5&quot;</td>
</tr>
<tr>
<td>1 1/4&quot;</td>
<td>31</td>
<td>—</td>
<td>6&quot;</td>
</tr>
<tr>
<td>1 1/2&quot;</td>
<td>29</td>
<td>—</td>
<td>7&quot;</td>
</tr>
<tr>
<td>2&quot;</td>
<td>13</td>
<td>2.94</td>
<td>8&quot;</td>
</tr>
</tbody>
</table>
NOTES ON WATER METERS.  

TESTS AT LOW RATES OF DISCHARGE.

A number of tests having been made at various times by or under the direction of the writer, the results will be given in their proper places, to illustrate the various points raised in the paper. The following tables, for instance, show tests at low rates of discharge on four meters selected at random from stock. Additional tests were made at rates of discharge higher than those given for the 1-inch, 3-inch, and 4-inch meters, but as these discharges were in all cases correctly registered, there is no necessity to give them.

It should here be explained that by the expression “running, or registering slow,” the writer means that the meter registers \( x \) per cent. less water than is passed through it, and by “running fast,” \( x \) per cent. more:

**TABLE II.**

1-INCH SIEMENS INFERENTIAL TURBINE METER—REPAIRED AND TESTED.

<table>
<thead>
<tr>
<th>Size of Measure</th>
<th>Time taken to fill Measure</th>
<th>Equivalent Discharge.</th>
<th>Meter Registration.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10 45</td>
<td>56</td>
<td>10</td>
<td>Correct</td>
</tr>
<tr>
<td>10</td>
<td>14 0</td>
<td>43</td>
<td>9</td>
<td>10% slow</td>
</tr>
<tr>
<td>10</td>
<td>16 20</td>
<td>37</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>24 30</td>
<td>24½</td>
<td>7</td>
<td>30% slow</td>
</tr>
<tr>
<td>10</td>
<td>24 0</td>
<td>25</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>16 30</td>
<td>18</td>
<td>nil</td>
<td>stopped</td>
</tr>
</tbody>
</table>

From the above table it will be observed that this particular 1-inch meter registered correctly down to 56 gallons per hour (at which rate the head absorbed is only a few inches). It ran 10 per cent. slow at 43, and had stopped working at 18:

**TABLE III.**

3-INCH METER REPAIRED AND TESTED, DISCHARGING THROUGH A 4-INCH BEND.

<table>
<thead>
<tr>
<th>Size of Measure</th>
<th>Time taken to fill Measure</th>
<th>Equivalent Discharge.</th>
<th>Meter Registration.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>5 30</td>
<td>218</td>
<td>20</td>
<td>Correct</td>
</tr>
<tr>
<td>50</td>
<td>14 0</td>
<td>214</td>
<td>49</td>
<td>2% slow</td>
</tr>
<tr>
<td>20</td>
<td>7 35</td>
<td>158</td>
<td>17</td>
<td>15% ,</td>
</tr>
<tr>
<td>20</td>
<td>9 30</td>
<td>126</td>
<td>16</td>
<td>20% ,</td>
</tr>
<tr>
<td>20</td>
<td>10 30</td>
<td>114</td>
<td>12</td>
<td>40% ,</td>
</tr>
<tr>
<td>20</td>
<td>20 0</td>
<td>60</td>
<td>nil</td>
<td>stopped</td>
</tr>
</tbody>
</table>
The above 3-inch meter, when discharging through a length of pipe with a tap at the end, instead of direct into the atmosphere through the 4-inch bend, ran 15 per cent. slow at 144 gallons per hour, and 40 per cent. slow at 112. There appears to be no material difference in the registration of a large meter, whether discharging direct into the atmosphere or under back pressure through a length of pipes, as is usually the case in practice. Theoretically, there must be a slight difference due to pressure on the conical bearing of the small dial spindle (D, sheet IV.)) but in practice this is insignificant in well-made meters, where the bearing is of the proper shape and workmanship:

### TABLE IV.

#### 4-INCH METER.

<table>
<thead>
<tr>
<th>Size of Measure</th>
<th>Time taken to fill Measure</th>
<th>Equivalent Discharge</th>
<th>Meter Registration</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>1 54</td>
<td>6316</td>
<td>200</td>
<td>Correct</td>
</tr>
<tr>
<td>200</td>
<td>2 32</td>
<td>4390</td>
<td>196</td>
<td>2% slow</td>
</tr>
<tr>
<td>200</td>
<td>18 20</td>
<td>654</td>
<td>192</td>
<td>4%</td>
</tr>
<tr>
<td>200</td>
<td>29 30</td>
<td>407</td>
<td>178</td>
<td>11%</td>
</tr>
<tr>
<td>200</td>
<td>39 20</td>
<td>305</td>
<td>162</td>
<td>19%</td>
</tr>
<tr>
<td>200</td>
<td>44 15</td>
<td>271</td>
<td>160</td>
<td>20%</td>
</tr>
<tr>
<td>50</td>
<td>17 0</td>
<td>176</td>
<td>nil</td>
<td>stopped</td>
</tr>
</tbody>
</table>

### TABLE V.

#### 6-INCH METER.

<table>
<thead>
<tr>
<th>Size of Measure</th>
<th>Time taken to fill Measure</th>
<th>Equivalent Discharge</th>
<th>Meter Registration</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>1 4</td>
<td>11,250</td>
<td>192</td>
<td>4% slow</td>
</tr>
<tr>
<td>200</td>
<td>1 11</td>
<td>10,141</td>
<td>192</td>
<td>4%</td>
</tr>
<tr>
<td>200</td>
<td>1 19</td>
<td>9,114</td>
<td>194</td>
<td>3%</td>
</tr>
<tr>
<td>200</td>
<td>20 0</td>
<td>600</td>
<td>192</td>
<td>4%</td>
</tr>
<tr>
<td>200</td>
<td>31 55</td>
<td>376</td>
<td>186</td>
<td>7%</td>
</tr>
<tr>
<td>200</td>
<td>66 0</td>
<td>182</td>
<td>172</td>
<td>14%</td>
</tr>
<tr>
<td>200</td>
<td>76 0</td>
<td>158</td>
<td>160</td>
<td>20%</td>
</tr>
</tbody>
</table>
NOTES ON WATER METERS.

The above 6-inch meter appears to have been running 4 per cent. slow at the higher rates. It should have registered correctly down to 750 gallons per hour.

Dribbling Discharges.—The foregoing tables of tests are given merely to illustrate the approximate percentages of error under low rates of discharge, which may be expected from inferential meters of various sizes. The necessity for measuring slow or dribbling discharges depends upon circumstances. Water used in hydraulic power supplies, perhaps requires the greatest accuracy of measurement, but the discharge is usually at a regular and not a dribbling rate.

In England, where the consumption is only from 20 to 40 gallons per head per day, mostly through flushing cisterns, a large proportion of it being pumped, the correct registration of dribbling or slow discharges is desirable, and positive meters, involving considerable expense in first cost and maintenance, are often insisted on. In Berlin and Vienna, where the inhabitants live principally in flats, 60 or 70 per tenement, all supplied through one meter, inferential fan meters are said to be satisfactory, as there is seldom a low rate of discharge. In some of the large cities of America, where the consumption reaches the enormous amount of 200 gallons per head per day, the proportion of small discharges is not great, and volume or capacity meters are claimed by some authorities to be sufficiently accurate for practical requirements.

In Melbourne, the average rate of consumption is about 60 gallons per head per day, and owing to the liberal allowance of water on the municipal valuation, the necessity for measuring dribbling discharges is not great. In country townships, however, where there is no minimum water rate and all water consumed is paid for by meter measurement, a fair degree of accuracy is required, especially when a varied rate of consumption has to be measured by a large meter. It may also be assumed that in cities such as Coolgardie or Broken Hill, where water is a valuable commodity, correct registration is more necessary than usual.

It is therefore a matter of opinion, depending on circumstances, what percentage of error under low rates of discharge may be accepted as reasonable, and what expenditure in first cost and maintenance is warranted.

TESTS AT HIGH RATES OF DISCHARGE.

A number of disputes as to the correct working of the meters in several country towns led to investigation of the causes, particulars of which are given further on. As a result, it first became evident to the writer that the size of meter should be more accurately proportioned than is often the case, to the work it is called on to do. This led to the working out of tables showing the quantity of water discharged by various sized meters under various heads. The following are some experiments on 1-inch, 3-inch and 4-inch meters after being overhauled. In the last column are shown the discharges as read from diagrams 2 and 3, computed as presently explained:—
### TABLE VI.
1-INCH METER.

<table>
<thead>
<tr>
<th>Head in Feet</th>
<th>Size of Measure</th>
<th>Time taken to fill Measure</th>
<th>Equivalent Discharge</th>
<th>Computed Discharge as read from the Diagrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100 Galls.</td>
<td>2 Min. Sec.</td>
<td>2093 Galls. per Hour</td>
<td>2110</td>
</tr>
<tr>
<td>90</td>
<td>100 Galls.</td>
<td>2 Min. Sec.</td>
<td>2023 Galls. per Hour</td>
<td>2000</td>
</tr>
<tr>
<td>80</td>
<td>100 Galls.</td>
<td>3 Min. Sec.</td>
<td>1935 Galls. per Hour</td>
<td>1900</td>
</tr>
<tr>
<td>70</td>
<td>100 Galls.</td>
<td>3 Min. Sec.</td>
<td>1714 Galls. per Hour</td>
<td>1790</td>
</tr>
<tr>
<td>60</td>
<td>100 Galls.</td>
<td>3 Min. Sec.</td>
<td>1622 Galls. per Hour</td>
<td>1650</td>
</tr>
<tr>
<td>50</td>
<td>100 Galls.</td>
<td>4 Min. Sec.</td>
<td>1494 Galls. per Hour</td>
<td>1500</td>
</tr>
<tr>
<td>45</td>
<td>100 Galls.</td>
<td>4 Min. Sec.</td>
<td>1385 Galls. per Hour</td>
<td>1430</td>
</tr>
<tr>
<td>40</td>
<td>100 Galls.</td>
<td>4 Min. Sec.</td>
<td>1328 Galls. per Hour</td>
<td>1350</td>
</tr>
<tr>
<td>35</td>
<td>100 Galls.</td>
<td>4 Min. Sec.</td>
<td>1208 Galls. per Hour</td>
<td>1250</td>
</tr>
<tr>
<td>30</td>
<td>100 Galls.</td>
<td>4 Min. Sec.</td>
<td>1147 Galls. per Hour</td>
<td>1150</td>
</tr>
<tr>
<td>25</td>
<td>100 Galls.</td>
<td>3 Min. Sec.</td>
<td>994 Galls. per Hour</td>
<td>1050</td>
</tr>
<tr>
<td>20</td>
<td>100 Galls.</td>
<td>3 Min. Sec.</td>
<td>904 Galls. per Hour</td>
<td>950</td>
</tr>
<tr>
<td>15</td>
<td>100 Galls.</td>
<td>3 Min. Sec.</td>
<td>822 Galls. per Hour</td>
<td>800</td>
</tr>
<tr>
<td>10</td>
<td>100 Galls.</td>
<td>4 Min. Sec.</td>
<td>672 Galls. per Hour</td>
<td>650</td>
</tr>
<tr>
<td>5</td>
<td>100 Galls.</td>
<td>6 Min. Sec.</td>
<td>474 Galls. per Hour</td>
<td>450</td>
</tr>
</tbody>
</table>

### TABLE VII.
3-INCH METER.

<table>
<thead>
<tr>
<th>Head in Feet</th>
<th>Galls. per Hour Discharged</th>
<th>Computed Discharge as read from the Diagrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>46</td>
<td>7406</td>
<td>7300</td>
</tr>
<tr>
<td>40</td>
<td>6954</td>
<td>6950</td>
</tr>
<tr>
<td>35</td>
<td>6358</td>
<td>6300</td>
</tr>
<tr>
<td>30</td>
<td>6104</td>
<td>6000</td>
</tr>
<tr>
<td>25</td>
<td>5364</td>
<td>5400</td>
</tr>
<tr>
<td>20</td>
<td>4886</td>
<td>4900</td>
</tr>
<tr>
<td>15</td>
<td>4271</td>
<td>4100</td>
</tr>
<tr>
<td>10</td>
<td>3600</td>
<td>3200*</td>
</tr>
</tbody>
</table>

* This discrepancy is due to a slight inaccuracy in the plotting or tracing of the diagram where the lines converge. The accurately computed discharge is 3522.
NOTES ON WATER METERS.

TABLE VIII.
4 INCH METER.

<table>
<thead>
<tr>
<th>Head in Feet</th>
<th>Galls. per Hour Discharged</th>
<th>Computed Discharge as read from the Diagrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>10588</td>
<td>10000</td>
</tr>
<tr>
<td>27</td>
<td>9351</td>
<td>9500</td>
</tr>
<tr>
<td>22</td>
<td>8571</td>
<td>8400</td>
</tr>
<tr>
<td>17</td>
<td>7423</td>
<td>7300</td>
</tr>
<tr>
<td>12</td>
<td>6316</td>
<td>6000</td>
</tr>
<tr>
<td>7</td>
<td>4390</td>
<td>4870*</td>
</tr>
</tbody>
</table>

* Although at this rate of discharge the meter ran 2% slow, the test appears unreliable.

The results of the above experiments are indicated by circles on diagram No. 2.

The head in most of the experiments given in this paper was obtained by reading the pressures on a specially-made gauge having a large dial registering only up to 30 lbs. per square inch. The pressures were capable of being read to the nearest ½ lb. This gauge was tested and calibrated by means of a mercury column, and was periodically tested during the experiments. For greater pressures than 30 lb. a 100 lb. gauge was used. The gauges were placed either on the dirt box or on the branch pipe immediately behind the meter.

HEAD ABSORBED BY REVOLVING MECHANISM.

With the object of finding the resistance of the turbine in revolving and driving the registering mechanism, the writer next made some tests, first with the turbine revolving freely, and then fixed by means of a fine wire. The results were as under:

TABLE IX.

1-INCH METER.

<table>
<thead>
<tr>
<th>Head in Feet</th>
<th>Discharge in Galls. per Hour</th>
<th>3-INCH METER.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Turbine Free.</td>
<td>Turbine Fixed.</td>
</tr>
<tr>
<td>70</td>
<td>1714</td>
<td>35</td>
</tr>
<tr>
<td>45</td>
<td>1385</td>
<td>1428</td>
</tr>
<tr>
<td>35</td>
<td>1208</td>
<td>1241</td>
</tr>
<tr>
<td>25</td>
<td>994</td>
<td>900</td>
</tr>
<tr>
<td>15</td>
<td>822</td>
<td>809</td>
</tr>
<tr>
<td>5</td>
<td>474</td>
<td>493</td>
</tr>
</tbody>
</table>

The above experiments on the 3-inch meter give results contrary to the writer's expectations, showing slightly lower discharges with the turbine fixed. Those particular tests were, however, of short duration, and any error in timing would have been magnified in converting to gallons per hour.
The writer finds that in no case, even of large meters, does the head absorbed by the whole meter, when discharging at its minimum rate of correct registration, exceed a few inches. He therefore concludes that the resistance of the turbine in revolving and driving the mechanism is so small as to be practically negligible, and that the discharge of a well-made and maintained inferential turbine meter under any given head, is due almost entirely to the resistance of the turbine waterways to the passage of the water, and is capable of being calculated with a fair degree of accuracy.

**Turbine Waterways.**—The next proceeding was to measure the minimum area of waterway in the turbines of various sized meters. These are given in the following table:

<table>
<thead>
<tr>
<th>Nominal Size of Meter</th>
<th>3/4in.</th>
<th>½in.</th>
<th>1/3in.</th>
<th>1/2in.</th>
<th>1 in</th>
<th>1½in.</th>
<th>1¾in.</th>
<th>2 in</th>
<th>2½in.</th>
<th>3 in</th>
<th>4 in</th>
<th>5 in</th>
<th>6 in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum area of Turbine Waterways in sq. ins.</td>
<td>0.25</td>
<td>0.5</td>
<td>1.0</td>
<td>2.5</td>
<td>3.7</td>
<td>5</td>
<td>6.8</td>
<td>10</td>
<td>13.3</td>
<td>23</td>
<td>3.5</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

**COEFFICIENTS OF DISCHARGE.**

In determining the coefficients of discharge \((C)\) in the fundamental formula \(V = \sqrt{2gh \times C} \) or \(V = (2gh)^{1/2} \times C\), the writer, in the case of large meters, had to depend on the published discharges, which are only given for two or three pressures, too high for the usual conditions met with in practice. But for the 1-inch, 3-inch, 4-inch and 6-inch meters on which he experimented, he has taken his own tests as giving a wider, or at least a lower, range of head. Table XI, on the following page, for instance, shows the mean coefficient for 1-inch meters so obtained.

Treating his own and the published experimental data (which, so far as they can be compared, practically agree) in a similar manner, the writer finds that the coefficients of discharge vary with the size of the meter, from 0.70 for ½-inch meters, down to 0.60 for 6-inch and larger meters, and the curves on diagrams 2 and 3 have been calculated and plotted accordingly.

**FULLWAY METERS.**

In referring to Fullway meters, it should be explained that by the term "Fullway" the writer means such meters as have a minimum area of turbine waterway equal to the area of the pipe corresponding to their nominal size. For instance, a 3-inch "Fullway" meter has an area of waterway equal to that of a 3-inch pipe. These meters are made with their vanes shaped as shown on sheet IV. It is necessary to draw attention to this distinction, because some meters termed "fullway" consist of an ordinary turbine of larger size placed within
NOTES ON WATER METERS.

the casing of a smaller meter. The computations for such meters should, of course, be made as for ordinary meters, and not as for fullway meters within the writer's definition. The shape of a small size ordinary turbine is also shown on sheet IV.

**TABLE XI.**

(Minimum Area of Turbine Waterways in a 1-Inch Meter = .25 Sq. Inch = 0.0174 Sq. Feet).

<table>
<thead>
<tr>
<th>Head in Feet</th>
<th>Discharge through Meter</th>
<th>Velocity: Feet per Sec.</th>
<th>Coefficient of Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>2093</td>
<td>.093</td>
<td>53</td>
</tr>
<tr>
<td>90</td>
<td>2023</td>
<td>.090</td>
<td>52</td>
</tr>
<tr>
<td>80</td>
<td>1935</td>
<td>.086</td>
<td>49</td>
</tr>
<tr>
<td>70</td>
<td>1714</td>
<td>.076</td>
<td>44</td>
</tr>
<tr>
<td>60</td>
<td>1622</td>
<td>.072</td>
<td>41</td>
</tr>
<tr>
<td>50</td>
<td>1494</td>
<td>.067</td>
<td>38</td>
</tr>
<tr>
<td>45</td>
<td>1385</td>
<td>.061</td>
<td>35</td>
</tr>
<tr>
<td>40</td>
<td>1328</td>
<td>.059</td>
<td>34</td>
</tr>
<tr>
<td>35</td>
<td>1208</td>
<td>.054</td>
<td>31</td>
</tr>
<tr>
<td>30</td>
<td>1147</td>
<td>.051</td>
<td>29</td>
</tr>
<tr>
<td>25</td>
<td>994</td>
<td>.044</td>
<td>26</td>
</tr>
<tr>
<td>20</td>
<td>904</td>
<td>.040</td>
<td>23</td>
</tr>
<tr>
<td>15</td>
<td>822</td>
<td>.037</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>672</td>
<td>.030</td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>474</td>
<td>.021</td>
<td>12</td>
</tr>
</tbody>
</table>

Mean co-efficient of discharge: ... ... ... .66

The writer has had to depend entirely on the manufacturer's published discharges under a few pressures in computing the coefficients and curves for fullway meters. From these he concludes that the coefficients of discharge for meters of this type are about one-half those for ordinary meters. They compute as follows:—For 2-inch fullway meter (the smallest made), C equals .29; for 3-inch, .30; for 4-inch, .32; and for 6-inch and over, .33. The curves on Diagram 2 have been calculated and plotted accordingly. The reverse curves on this diagram are due to the graduated scales to which it has been drawn.

Attention may here be directed to the fact as shown on diagram 2, that under any given head the discharge of a 3-inch fullway meter is approximately the same as that of a 5-inch ordinary meter; and as the cost of each is the same, it might on first consideration be concluded that the only advantages a fullway meter possesses are
its smaller weight and bulk. There are occasional instances where this is an important consideration, otherwise the 5-inch ordinary meter exemplified, has the advantages of a minimum correct rate of registration of 550 gallons per hour, as against 900 for the fullway. The writer is therefore somewhat in doubt as to the advantages of fullway meters for general use, except as regards their greater durability owing to the lower rate of rotation of their turbines. In exceptional cases, however, where the rate of consumption is seldom or never below its minimum rated capacity, a fullway meter certainly has decided advantages. The writer was recently present at the tests of a 10-inch meter of this type, designed to discharge at the rate of 120,000 gallons per hour to two water cranes, without absorbing more than 16 feet head out of 40 available. This meter was found to register correctly within one per cent. down to 3500 gallons per hour. A meter of this size may reasonably be expected to run correctly for about 10 years without attention.

The following case exemplifies practically the advantage of this type of meter:—A 6-inch fullway meter registering the water consumed at the North Melbourne locomotive depot, was placed in position in October, 1890. It ran without any attention whatever till taken out, in October, 1897, in order to repair a broken dial face. During this period of seven years it had registered no less than 896,600,000 gallons (one-sixth of the available capacity of the Yan Yean reservoir), and its turbine must have revolved no less than 170 million times. On testing, prior to overhaul, the writer is credibly informed it was found to register correctly within 4 per cent.; only about 1.16th inch of wear showing on the steel bearing block of the turbine. The indications were, that in doing this immense amount of work this meter would have lasted out two or three 6-inch meters of the "ordinary" turbine type. The discharge when in use varied approximately from 2000 gallons per hour (equal to the discharge of a minimum jet of water used in washing out a boiler), up to about 60,000 gallons per hour (the discharge through two water cranes). At the former rate, the velocity of the water through the turbine computes to about 5½ inches per second, and the head absorbed by the meter to a fraction of an inch. At the latter rate, the velocity computes to 14 feet per second, and the head absorbed to about 3½ feet.

How many pieces of mechanism, the writer asks, would run for seven years without any attention whatever, and have done such an amount of work so satisfactorily as this? And how many "volume" or "positive" meters would have come anywhere near it, either as regards first cost, wear and tear, cost of attention and lubrication, or even correct registration? Surely this example of the work a meter may be called on to perform suggests the futility of comparing various types of meters merely by gauging their accuracy when new.

BYEPASS COMBINATIONS.

The principal objection urged against inferential meters, as already remarked, is that they will not register correctly small rates of
NOTES ON WATER METERS.

The following example within the writer's experience will serve to illustrate this disadvantage. A 7-inch meter, registering an occasional large flow to a water crane, was also called on to register the water passed through three \( \frac{3}{4} \)-inch service pipes. It was found by the use of a test meter that only 70 per cent. of the full amount of 1200 gallons per hour discharged by the three pipes was registered; only 7 per cent. of 666 gallons per hour passed by two of the pipes, and nothing at all of the 170 gallons per hour passed by one pipe only.

In drawing attention to this defect, Mr. Schonheyder states that attempts have often been made to obtain the same accuracy at all speeds by combining a large and a small meter, but that he has no personal knowledge of the efficiency of this plan. Mr. Henry Gill, in his paper on Meters, Vol. CVII., Pro. Inst. C.E., also mentions a weighted byepass valve, but does not describe it. In this paper, particularly dealing with inferential meters, the writer cannot omit a reference to a type of byepass valve manufactured by Messrs. Davis, Shephard and Co., here and in Sydney, of which a short description may not be out of place.

The combination is shown on sheet V., Fig. 18. A represents the dirt box; B, the byepass valve; C, the large meter; and D, the small or byepass meter. The sizes of the meters and valve must be carefully selected to suit requirements. All small rates of consumption are passed through and registered by the small meter only. When the rate of consumption approaches the capacity of the smaller, or byepass meter, and is well above the minimum rate of correct registration of the large meter, the byepass valve automatically opens, and the large meter comes into action. When the consumption drops again to the critical rate, the byepass valve automatically closes, and the water is passed by the small meter only, as before.

Fig. 19 is a section of the byepass valve. The water passes through it in the direction of the arrows. So long as the consumption is below the critical rate, all the water passes into the pipe, E, and is registered by the byepass meter. When the consumption exceeds the capacity of the byepass meter and the minimum correct rate of the large meter, the pressure on the consumer's side of the valve, F, drops, and the valve opens automatically, allowing the large meter to come into use. When the rate of discharge again drops, and the water pressure on each side of the valve approaches equilibrium, the pressure on the larger effective area of the valve, on the consumer's side, causes the valve to close automatically. The larger effective area on the consumer's side is due to the smaller effective area of the back of the valve, caused by the small piston, G, opening to the atmosphere through the pipe, H. A reduction in pressure of about 2 lb. per square inch on the consumer's side is sufficient to cause the valve to commence to open, but the combination has this slight disadvantage, that it under-registers the consumption at such rates of discharge as occur between the valve just lifting off its seat and properly opening. The following table, for instance, shows the results of some tests on a combination consisting of a 4-inch discharge.
fullway meter with a 4-inch byepass valve and a 1½-inch byepass meter:

<table>
<thead>
<tr>
<th>Rate of Discharge (Galls. per Hour)</th>
<th>Amount registered by 1½&quot; Meter</th>
<th>Amount registered by 4&quot; Meter</th>
<th>Total Amount Registered</th>
<th>Amount Gauged in Tank</th>
<th>Percentage Unregistered</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>nil</td>
</tr>
<tr>
<td>600</td>
<td>39</td>
<td>7</td>
<td>46</td>
<td>50</td>
<td>8</td>
</tr>
<tr>
<td>700</td>
<td>40</td>
<td>2</td>
<td>42</td>
<td>50</td>
<td>16</td>
</tr>
<tr>
<td>700</td>
<td>45</td>
<td>1</td>
<td>46</td>
<td>50</td>
<td>8</td>
</tr>
<tr>
<td>800</td>
<td>47</td>
<td>0</td>
<td>47</td>
<td>50</td>
<td>6</td>
</tr>
<tr>
<td>900</td>
<td>80</td>
<td>10</td>
<td>90</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>900</td>
<td>77</td>
<td>13</td>
<td>90</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>1000</td>
<td>73</td>
<td>22</td>
<td>95</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>1200</td>
<td>60</td>
<td>37</td>
<td>97</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>1300</td>
<td>60</td>
<td>30</td>
<td>90</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>1800</td>
<td>68</td>
<td>82</td>
<td>150</td>
<td>150</td>
<td>nil</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>690</strong></td>
<td><strong>204</strong></td>
<td><strong>894</strong></td>
<td><strong>950</strong></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>

From the above figures it will be observed that at a rate of 500 gallons per hour, the whole discharge was registered correctly by the small 1½-inch meter. The higher discharges up to 1300 gallons per hour were not fully registered by an average of 6 per cent., the proportion of water passed by the large 4-inch meter being below its minimum rate of correct registration. At 1800 gallons per hour the discharge was again correctly registered by the two meters working together. The discharge of this combination may be taken as correctly registered from a rate of 50 gallons per hour (the minimum rate of correct registration of the 1½-inch meter), up to, say, 40,000 gallons per hour (the approximate capacity of the 4-inch meter), with the above exceptions. By the adoption of a 3-inch meter in place of the 4-inch, these errors would, of course, be considerably reduced, so that the possibilities depend on the combination in which, however, the sizes of the meters must necessarily be proportioned according to the requirements and available head.

Where the water pressure is good, the writer is of opinion that these combinations should give very satisfactory results if properly maintained, but where only a low head is available, as from an elevated tank, his experience is that a considerable reduction in pressure will result to consumers, when the consumption approaches the critical rate at which the byepass valve opens, owing to the resistance of the small meter. He further finds that the small meter generally passes a large proportion of the consumption, and in doing so
is worked much more severely than is usual, and consequently re-
quires more frequent repairs. The following is a case within his
experience:—A 7-inch ordinary meter, with a 4-inch byepass valve
and a 1-inch byepass meter registering a railway station consumption,
ran for 3½ years before requiring an overhaul. During this period
the 7-inch meter registered 6 million gallons, and the 1-inch meter
3,343,000. Now the writer estimates that a 1-inch meter measuring
an average domestic supply, would not pass more than about 500,000
gallons in the same time, and submits the following table of com-
parisons:—

<table>
<thead>
<tr>
<th>Amount Registered by 7-inch Meter.</th>
<th>No. of Revolutions of Turbine.</th>
<th>Amount Registered by 1-inch Meter.</th>
<th>No. of Revolutions of Turbine.</th>
<th>Estimated Consumption by 1-inch House Meter.</th>
<th>No. of Revolutions of Turbine.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galls.</td>
<td>6,000,000</td>
<td>Galls.</td>
<td>3,343,000</td>
<td>Galls.</td>
<td>2,000,000</td>
</tr>
<tr>
<td></td>
<td>5,000,000</td>
<td></td>
<td>140,000,000</td>
<td>500,000</td>
<td>2,000,000</td>
</tr>
</tbody>
</table>

From the above table it will be observed that the turbine of the
1-inch byepass meter revolved 28 times as often as that of the 7-inch
meter, and 70 times as often as is estimated for an average 1-inch
house service meter in the same time. Consequently its percentage
of error increases at a faster rate, and more frequent repairs are
necessary.

The cost of these combinations begins to approach that of the
cheaper positive meters, but insufficient experience precludes the
writer from further comparing them. Suffice it to say that a large
number of them are now in use, especially in Sydney, where the water
supply authorities appear to have every confidence in them. Con-
tinued experience is likely to lead to the further improving and
perfecting of the design.

PERIODICAL TESTING AND MAINTENANCE.

The number of years a well-made inferential meter will run cor-
rectly without attention depends on circumstances, and particularly
on the quality of the water and the consumption. House service
meters, where the water is pure and free from sand, grit or vegetable
matter, are said to register fairly correctly for a number of years.
Their accuracy can be conveniently gauged without disturbing them
by means of portable test meter, whose accuracy is known, fixed by
means of a short hose and Royle’s union to any one tap, all others
being shut off. The readings of the two meters may then be com-
pared. Light testing meters in aluminium cases, registering by one
gallon divisions up to 100 gallons, are made for this purpose.

Unfortunately very little published information is available as to
the working of any class of meter in situ after long periods of use.
The general experience of inferential meters tested prior to repairing, appears to be that they run slow from wear at a regular percentage down to a minimum rate, below which they fall off and run increasingly slow. It does not, however, always follow that meters so tested in the repair shops give a reliable indication of their running prior to removal. Vegetable incrustation, for instance, may become dry and be shaken out in transit, the effect of which would be lost. Magnesia crystals, lime blisters, salt, clay, vegetable matter in suspension, stringy vegetable growth, shells, sand or grit, galvanic action set up by the solder used in the turbine joints, alkaline water attacking and eating through the metal of the turbine, so that water escapes unregistered, are all factors which affect the working of water meters.

The results of some tests made by the writer on 1-inch house service meters in situ, are shown on the accompanying diagram, No. 1. These tests were made by means of a 3/4-inch test meter, as previously described. This meter registered correctly within one per cent. down to 15 gallons per hour, not only when tested in the manufacturer's workshop under the usual 60 lbs. pressure, and by means of the usual discs, but also when discharging through 2 feet 6 inches of 3/4 hose, as found by the writer. But when tested by means of a 36-gallon measure at the conclusion of his experiments, the writer found that it registered correctly down to a rate of 55 gallons per hour only, below which it ran increasingly slow up to 6 per cent. at 20. The curves on diagram No. 1 can therefore only be taken as strictly correct at rates of 55 gallons per hour and upwards.

The general tendency of inferential meters to run slow with wear is illustrated by the hypothetical curve, No. 3, on the diagram. Curves 2, 4 and 5 are said to indicate unusual conditions, and to be such as might be expected if the meter had originally been adjusted to register correctly at a high and low rate only, and not at intermediate rates. It seems strange that the writer should have dropped on three meters showing the same peculiarity, and he regrets that time has not permitted investigation of the reason.

In the case of large meters in country townships, the writer found in one instance that muddy water caused a deposit of clay to form in the casing, which frequently required cleaning out. In other cases lime blisters and rust will form and gradually impede the action of the turbine. In a further instance, where water had been pumped continuously through two 6-inch meters side by side for three years, careful gaugings were made of the water pumped into a 40,000-gallon tank, the mean diameter of which was very carefully measured. It was found that one meter registered about 6 per cent. fast, the other about 5 per cent. slow. After an overhaul they both registered correctly within 1/2 per cent. at a rate of 3500 gallons per hour each, under a head of only 9 inches.

The number of years a meter should be allowed to run without testing, and, if necessary, overhauling, depends again on circumstances. In important cases where all the water consumed is pumped and paid for at a rate per thousand gallons without a mini-
NOTES ON WATER METERS.

113

mum, an overhaul every two years is advisable. While no definite
rule can be laid down to meet all cases, it seems desirable that no
inferential meters in regular use should be allowed to run for more
than 4 or 5 years without attention.

Screens.—Every Siemens meter is provided with a screen to pre-
vent the passage of floating obstructions into the turbine. In the
small-sized meters the only screen is that within the meter casing.
Where the water is of inferior quality, a separate outside screen may
be provided. In the larger sizes a special dirt box is supplied, as
shown in Fig. 18, sheet V. In byepass combinations the small meter
should be provided with an outside screen. By removing the cover
of the dirt box, the screen can be lifted out and cleaned. Every
care should be exercised in replacing it. In one case in the writer’s
experience the screen had been damaged and torn in replacing.
Some fish bones and cinders which had passed through it were found
fixed in one of the turbine waterways, causing the meter to run fast.
Too much attention cannot, therefore, be given to this matter.

SIZE OF METER TO SUIT REQUIREMENTS.

In pumping schemes where the discharge is at a regular rate,
with no small flows, the writer has found that large meters will work
satisfactorily for a long period under as little as 5-feet head. A full-
way meter is preferable in such cases, and its size should be such as
to absorb not more than this amount in discharging at the rate per
hour pumped.

In gravitation supplies where resistance is not of so much conse-
quence, the meter may be of such size as to absorb from 10 to 20
feet head at its average rate of discharge. Where small flows re-
quire to be registered a byepass valve and meter should be
added in all cases of 2 inches and over.

In the case of small service pipes the usual custom to proportion
the meter to the size of the pipes seems to be good practice. Where
the bulk of the discharge is at a slow or dribbling rate, as to water
troughs, a meter of the smallest size is advisable, and a positive meter
is, perhaps, preferable. Finally, it may be considered inadvisable
to adopt meters of such size as will for long periods be called on to
discharge at higher rates than those shown by the horizontal curves
on diagram No. 2.

In conclusion, the writer desires to express his indebtedness to
Mr. John Shephard, of Davies, Shephard and Co., for the figures in
Tables I. and XII., for particulars of the byepass combinations, the
section of the inferential meter, and the use of a ¼-inch test meter.
He is also greatly indebted to Mr. S. S. Soame for the preparation
of the drawings.
The President said they would all agree that it was a valuable and able paper. The subject was one upon which there was not a great deal of information available, and they were indebted to Mr. Bilton for his data. It would be impossible at that late hour to discuss the paper, or until it had been printed and circulated.

Mr. Hill said they had heard a good deal to-night of meters going slow; had the author any figures in regard to meters going too fast? He had lately met with some disquieting instances of steadily advancing consumption without any obvious reason. For instance, a 2-inch meter had increased in 15 months in constant increments from 9000 gallons per week to 30,000 gallons per week. He was going to have the meter examined and would make the result known to the next meeting.

Discussion adjourned.
Author's Tests of 3/4" House Service
Inferential Meters in situ

Diagram 1

Rate of Discharge
Gallons per Hour

Per Cent Slow
Per Cent Fast

375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0

50 40 30 20 10 0 10 20 30 40 50

3 Years
4 Years
5 Years
Normal Line of Horizon
Reversal Line
The circles denote the results of experiments.

Diagram 2

Note. The figures at the top of this table are for the meters shown by full lines; the figures at the bottom are for the meters shown by dotted lines.
WATER METERS

Flow through Siemens Ordinary Turbine Inferential Meters

under Low Heads

Diagram 3
NOTES ON WATER METERS.

WASTE DETECTION
- METER
  'DEACON'

KENT "UNIFORM"
Fig. 3

VOLUME
- OR CAPACITY
  "CROWN"
  "HERSEY"
  METERS

LOWPRESSURE
- METER
  "BASCULE"

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6
POSITIVE METERS

"KENNEDY"

"FROST" OR
"MANCHESTER"

Fig. 7

Fig. 8

"IMPERIAL"

Fig. 9

Fig. 10
NOTES ON WATER METERS.
SIEMENS TURBINE INFERENTIAL METER

TURBINES

ORDINARY

FULLWAY
NOTES ON WATER METERS.

BYE PASS COMBINATION

Fig 18

BYE PASS VALVE

Fig 19

CIRCULAR DIAL

Fig 15

RECTANGULAR DIAL

Fig 16
The usual monthly meeting was held at the rooms on Wednesday, October 3rd, at 8 p.m. In the absence of the President, Vice-President Mr. Jas. Alex. Smith occupied the chair.

The minutes of the September meeting were confirmed.

A motion by Mr. A. G. M. Michell, seconded by Captain G. F. Wilkinson—"That a Committee be appointed to enquire into the best methods of restoring the vitality of the Institute," was put to the meeting, and lost by eight votes to seven.

The Chairman said that in view of the limited time available, and in the absence of the author (Professor Kernot) of the paper on "Railway Gauges," the discussion on this question would be postponed until the succeeding meeting.

Mr. H. J. I. Bilton's paper on "Water Meters" was then partially discussed, the continuation of this discussion also being postponed until November.

At 10.15 the meeting closed.

DISCUSSION.

WATER METERS.

The Chairman said that Mr. Bilton's paper was now open for discussion. He was pleased to see that there were those present who were experts in this matter.

Mr. T. Hill, referring to his remarks at last meeting in regard to steadily increasing registration without apparent cause and his promise to give further information in regard to a case where the consumption had increased from some 10,000 gallons to 30,000 gallons per week in the last eighteen months, exhibited to members a
2-in. Guest and Chrimes' inferential turbine meter, about twenty years old, and explained that it had been cleaned, tested and passed by the Board of Works some three years ago. It had been again removed and tested the day before at Messrs. Davies and Shepherd's on their fine testing apparatus. The first test was at 30 lbs. pressure and running about half full, which gave 100 gallons on the dial for 85 actually measured in the tank at 60 lbs. pressure and a discharge equal to a ¾-in. pipe, the result was the same. A further test running full open with the full pressure in the mains (about 60 lbs.) gave 94 gallons for 100 recorded on the dial. The conditions under which it had been in use were about similar to the first and second tests, so it would appear that it had been registering about 17 to 18 per cent. too fast. After the tests the meter was opened up to see if the cause could be ascertained, and members could see before them the state of rust. (The meter was here passed round for exhibition.) The screen was somewhat choked, and the bottom rusted off, but was acting freely. The apparent cause of the increased registration was some tubercles of rust right opposite the nozzle of the turbine, which much reduced the waterway at that point. The turbine was in good order, and the oil still in the top of the case. The point seemed to stand out prominently that all meters should be wholly of gun metal or some other metal not affected by rust. Mr. Shepherd, who had kindly made the test was present, and would, he hoped, add to the discussion.

THE CHAIRMAN said that he would ask Mr. Shephard, who was with them as a visitor, to give members the benefit of his experience.

Mr. SHEPHARD said the type of meter which was produced was one with which he was very familiar. His firm had been engaged in turning them out for 22 years. It was a striking example of the necessity of some non-corroding material being used as a casing. The instance they had unearthed was somewhat unusual. He thought Mr. Hill had a strong suspicion that if a meter went wrong it worked against the people who used the water. The general tendency was decidedly in favour of the consumer. He was speaking from experience when he made that statement. In the old firm with which he was connected—Messrs. Guest and Chrimes—they tested every meter before taking it to pieces for many years, and their records proved the fact undoubtedly, with regard to that particular meter.

As Mr. Hill had pointed out, one of the reasons that would make a turbine meter go fast was the filling-up of the water ways of the turbine. In this case they looked for that, but there was no obstruction whatever. The turbine was perfectly clean. The only thing they could see was the growth on the side, which came very nearly to the aperture of the water ways, and which almost exactly corresponded in height to the turbine, and they nearly closed the aperture of the waterway.

Speaking from memory, he might say that the Metropolitan Board had adopted the gun-metal case for all meters up to 1½ inches. With a tender regard for the pockets of the consumers, they had not in-
sisted on this course above 1\frac{1}{2} inches. In the Sydney water works they would not fix any meter with an iron case. They even fixed 6 in. fullway meters with a gun-metal case, and paid £80 for an article which previously cost £50. Some makers lined with glass enamel, and others used a brass casing. A thing that was put in the ground and left to take its chance for years should be cased with gun-metal or other non-corrosive metal.

He had joined with Mr. Bilton in testing a meter at his own house. The meter was correct at a speed of about 40 gallons per hour. It was a meter which was found to be registering a little in favour of the consumer, and which he would expect from his experience, at 75 gallons per hour would be very nearly correct. At a speed of 50 gallons it began to register quickly, and more quickly a little lower down, so that it reached 11 per cent. fast at 30 gallons per hour. Of course there must be a point when the speed would get back again to correct registration before it fell off altogether. There was a minimum flow below which it could not register. He might say it was possible that these turbine meters should be so adjusted that they would show no curve at all, but a straight line. The reason why some of them were not so was lack of care and attention, and lack of stringent requirement.

With a meter working at full speed at the rate of flow of an ordinary tap, there was no question as to the amount of water being registered practically correctly. Some years ago the board adopted a standard or minimum rate of flow at which meters must register correctly, before they would be allowed to be fixed. That was an excellent move. It might lead makers to pay more attention to particular rates of flow, and take precautions in their daily work to have a system to show where deviations came in between those rates. No doubt one or two instances of imperfect testing occurred. It would be very unwise to generalise on a few instances here and there. No tests taken haphazard were sufficient. They might serve as indications, but the only real test was the practical working over a series of years. Those things had been put in the ground and left there for ten years, and taken up, and were found to be working surprisingly near the conditions and registration which existed at the time when they were put in. He had seen case after case like that. His idea would be to take off 100 meters in various conditions, and subject them to a test to arrive at a generalisation on the matter. Officials of the water supply authorities had better opportunities than makers had, because they dealt with different makes of meters. Mr. Bilton had exceptional opportunities because of having to deal with the meters belonging to the Railway Department, fixed in many of the municipalities of Victoria, and was therefore enabled to get the experience of varying conditions throughout the country. That, he thought, should be borne in mind when coming to a decision about the action of any particular water meter—to get sufficient cases to accumulate data. Mr. Bilton’s efforts would do a great deal of good, and he was sure that his work would be beneficial.

The question of positive and inferential meters was a burning ques-
DISCUSSION—WATER METERS.

There was a field for both of them. There were terms he would like to criticise. They often heard the expression "positive meter," but he thought that often such a meter was not in accordance with its name. As a matter of fact, what was called an inferential meter might be in effect more of a positive meter than many so-called positive meters. They were merely terms which described a meter which professed to measure the water, and a meter which inferred the quantity from the rotation of the fan or turbine. It was a significant fact that Messrs. Guest and Chrimes had been able to go on for 50 years making a meter of almost identical pattern, although they were disregarding improvements by sticking to iron casing, etc. But still they found a market. The meter produced was one of Guest and Chrimes' manufacture, and was made in England about 25 years ago. He recently noticed in the publications that turbine meters were being made in America, so that they had to come back to the merits of the turbine system in regard to water meters.

The Chairman said that Mr. Ritchie, of the Metropolitan Board, was present by invitation. He had a considerable experience of meter work. Members would be pleased to hear his views.

Mr. Ritchie thanked members for the opportunity they had given him of being present to hear Mr. Bilton's paper, and of contributing to the discussion. He could not profess to be an expert on meters, but one could not be associated with a large number of meters—about 20,000 of them—without acquiring some little knowledge. First of all, he would like to testify to the value of the paper Mr. Bilton had placed before them. Generally speaking, he was in agreement with Mr. Bilton, but differed slightly from him on one point. With regard to the question of dribbles, he fully agreed with the opinions expressed. The local conditions and limitations of any water supply system in question had to be considered—whether there was a substantial minimum rate, what the rate per 100 gallons was, and whether the water was being pumped. In the Melbourne system the minimum rate was high, the water was not pumped, and the rate per 1000 gallons was low; so that there was no necessity for attempting a very fine registration such as is found necessary at Coolgardie and Broken Hill. Their aim was rather to increase the number of meters than to register the finest discharges.

The meter to which Mr. Bilton had specially devoted his attention was, he believed, the best meter of the kind to fulfil the purposes they had in view. In most cases, unless there was a high rate per 1000 gallons charged, the Turbine Inferential Meter was the most satisfactory on the market, but no particular meter was suitable to every case. They had been experimenting for some time past with positive meters, with the view of meeting special cases. He would like to emphasise what Mr. Shephard had said with regard to positive meters. They would give splendid results when they were first fixed, but it depended largely on the condition of the water, and the influences exerted by corrosion, grit, etc., as to whether they would
continue positive. The Frost Meter, alluded to by Mr. Bilton, was in his opinion giving the best results of the lot, but he could not speak from a lengthy experience. The Perth Engineer for Water Supply had recommended this meter to them.

He would hand round a diagram (No. 1) for the information of members, showing the results given by a number of water meters fixed in tandem under severe working conditions by dribbles. The period of test was six months. Though the positive meters gave a very much higher registration, the result obtained from the inferential meters was, under the circumstances, very praiseworthy indeed, and the diagram, far from taking credit from the inferential meter, rather bore out the laudatory remarks passed by Mr. Bilton on that meter.

With regard to the testing of meters in situ, it was, of course, preferable where that was possible; but they had not gone in for the tank testing of meters in situ to any extent. It was very cumbersome and costly to customers, and he did not think it was justified. At any rate, it was a matter for serious consideration as to whether it was necessary in all cases. He did not think in every instance the incrustations in various parts of the meters were dislodged in the course of removal from the ground to the testing-room. Those incrustations were, in the majority of cases, very hard. Removing the meter to the shop did not always result in making it go slower. Quite the contrary, for the recording gear generally benefited from the jolting, and enabled a meter running slow in situ to give a better tank test. Thus matters became largely balanced. With regard to the meter mentioned in diagram No. 1, he was so much surprised with the result that he had thought it necessary to have a few tests in situ with meters fixed for some time, and had had those tests put in diagram form (No. 2), and would pass them round for the information of members. Mr. Bilton had happened to strike two or three exceptional cases.

It was a singular thing to find meters running fast at a flow of 100 gallons. From their experience they had not found this to be a general defect. They had had tests of meters taken out after a great number of years of work, and found the results surprisingly accurate.

The mistake had been made in the past of trying to get a meter to suit all particular cases; and also of endeavouring to take a meter simply at the nominal size of the pipe, without regard to the duty that meter had to perform. It did not follow that a one-inch service necessarily required a one-inch meter. Recently a consumer was laying on a two-inch service, and was much surprised because he would not allow more than a one-inch meter. The fact was that he had estimated that by the time the meter was put on they could not possibly get the discharge of a two-inch meter. Similar mistakes to these had led to some of the past inaccuracies in the working of meters. These matters were now receiving closer consideration.

It was probable they would find positive meters very suitable for certain cases. They were continuing their tests, and doubtless would know more about the matter later on. They believed consumers were getting very fair treatment at the hands of the inferential meters.
Many people thought the water meter was a device of the devil to cheat them, but they were not justified in forming such an opinion. He thought as a general rule the consumer got the best of it.

The Chairman said that it would be impossible to conclude the discussion that evening, but it was open to any member to move that the discussion be postponed until the next meeting.

Mr. D. Buchanan proposed that as the subject was such an interesting one, not only scientifically, but financially, it should be continued at the next meeting.

Agreed to.

Mr. C. W. U. Adamson desired to know whether Mr. Hill's remarks, as to a meter running 15 per cent. fast when discharging at the rate of 85 gallons, were approximate.

Mr. T. Hill said that he had spoken in general terms.

The Chairman said that at Mr. Hill's invitation he had had the opportunity of attending the test of the meter exhibited at Mr. Shephard's works. He had been much pleased with many of the modern appliances there in use, and thought that a visit by the Institute to the factory would be of considerable interest, if Mr. Shephard would kindly permit it.

Mr. Shephard said he would extend a very cordial invitation to members to visit his establishment.

The Chairman thanked Mr. Shephard on behalf of the Institute, and said that the necessary arrangements would be made.

Mr. Adamson asked if it would be possible to get an expression of opinion from Mr. E. A. Whitehead, of Broken Hill, who had a special knowledge of the subject.

Mr. Hill mentioned that reference had been made by Mr. Bilton to oil staying in the top of the cases. They had actual evidence of that when they took the meter to pieces at Mr. Shephard's works. The oil was there, and had been there for three years. It was hard to believe that the oil would continue for such a length of time.

Mr. Clements said he noticed some of the oil had turned to jelly. Was it organic oil? Would it not be advisable to use mineral oils?

Mr. Shephard said that had been tried. For his own part, he thought the detrimental effect of organic oil was very small indeed.

Mr. Hill said there was another matter. Mr. Ritchie had mentioned that the tubecles were always hard. Were they not always soft? These (exhibited) were very like clay.

Mr. Ritchie said some of the tubecles were sufficiently hard that there would be no danger of shaking off. He referred principally to the hard incrustations of the turbine waterway.

Mr. J. A. Smith asked Mr. Shephard whether electro-deposited copper had been tried as a means of prevention of tubercular deposits in the meter cases.

Mr. Shephard said not with copper, but it had been tried with tin. It was fairly good, but it did not answer, unless there was the material under the plate. Eventually the plating would separate from an iron case.
Tests in Situ Turbine Inferential Meters.

September, 1906.

Rate of Discharge

Gallons per Hour

\[ \text{Rate of Discharge} \times \text{Gallons per Hour} \]

\[ \text{Per Cent Slow} \]

\[ \text{Per Cent Fast} \]

\[ \text{Min.} \quad \text{5} \quad \text{Years fixed observations at} \quad 23, 40, 73, 95, 260, 350 \]

Gallons per hour.

\[ \text{Min.} \quad 5 \quad \text{``} \quad \text{``} \quad 35, 70, 100, 230, 450 \]

\[ \text{Min.} \quad 5 \quad \text{``} \quad \text{``} \quad 20, 30, 58, 95, 180, 200, 225, 380 \]

\[ \text{Min.} \quad 8 \quad \text{``} \quad \text{``} \quad 20, 45, 73, 100, 140, 280, 480 \]

\[ \text{Min.} \quad 10 \quad \text{``} \quad \text{``} \quad 20, 40, 70, 225, 450 \]

\[ \text{Min.} \quad 10 \quad \text{``} \quad \text{``} \quad 20, 40, 70, 225, 450 \]

\[ \text{Min.} \quad 8 \quad \text{``} \quad \text{``} \quad 20, 45, 73, 100, 140, 280, 480 \]
Diagram showing results of comparative working tests of Meters coupled together on supply to cattle trough.
A general meeting of the Institute was held at the rooms on Wednesday, November 7th, at 8 p.m. The President (Professor W. C. Kernot) occupied the chair.

The minutes of the October general meeting were confirmed.

The discussions on Professor Kernot's paper on Railway Gauges, and on Mr. Bilton's paper on Water Meters, were continued and concluded, the meeting closing at 10 p.m.

DISCUSSIONS.

WATER METERS.

The President said he considered Mr. Bilton's paper a most valuable and important one. Mr. Bilton had had opportunities of collecting information about water meters which very few people had, and had placed that information before them in a most serviceable form. He thought anyone who was interested in water meters would wish to consult the paper as a starting point. Mr. Ferguson had very kindly brought some old meters, and a new and perfect one for the inspection of members. They were all of the inferential or turbine type, which appeared to be the most satisfactory one to have.
DISCUSSION—WATER METERS.

Mr. R. FERGUSON said he had to compliment Mr. Bilton on the very excellent paper read before the Institute. He thought the paper was one which deserved their serious consideration, seeing that the meter, until recent years at any rate, had been almost a negligible quantity in this city. The outside public had looked upon it as a contrivance for the purpose of robbing them. At the same time the public had always been in the wrong, because the water meter had certainly been on the side of the consumer. But, in the future, from the steps which had been taken, he was certain the public would not get as much water as they did now without paying for it, and that would not only be better for the public, but better for the manufacturers.

He had brought to the meeting a meter as at present used. There were not many positive meters in use in Melbourne. The Siemens' turbine meter was the first to be introduced. It was an inferential meter, and it was the same then as when Siemens introduced it 50 years ago. The only alteration he could find in it was in making it of gun metal, and a few minor details. The turbine had been made of brass in past years. In Melbourne a large number had been made of bronze, which had been used for a good many years.

It was difficult to tell when the meters exhibited got into the condition in which they were found when taken out for inspection. These meters could not have been registering for some time, showing that the public were getting the water freely. They would notice Mr. Bilton spoke of the corrosion in the meters. He had brought the samples produced to show the action of the water on those metals. It was a composition of copper and zinc. They could see the result of the action of the water. His own opinion was that the action was caused principally through the soldering. The old way of soldering them was by the ordinary soldering process—muriatic acid. That caused the zinc to oxidise. It had completely rotted away. To get over that they had introduced bronze metal, and, instead of using solder, nothing but pure tin was employed. They did not use muriatic acid now. These meters had been in use for several years, and none of them showed that tendency to corrosion.

This form of meter was no doubt a good one as far as the high and medium flows were concerned, but when they came to the slow flow, he did not think they were good. When they had 100 lb. pressure and only 30 gallons going out, the friction increased. When it got full of dirt, etc., the friction was increased, and the efficiency of the meter was reduced.

They would find when soldering with muriatic acid, that in nearly everything deterioration commenced at once. The metal used now was a composition of copper and tin. No doubt that was the best metal. Brass was simply used for its cheapness. The meter on the table was one of Guest and Chrimes. It might have been at the dead end of a main, where it got all the sediment. He had proved conclusively that the action of the solder had the effect on the meter which he had previously stated.

His opinion was that the meters should be regularly inspected.
If they were well made at first, and well maintained, they would, he thought, give as much satisfaction as could be obtained from any meter under local conditions. He did not think the meter should be allowed to go more than twelve months without inspection—in fact, after a certain number of gallons had passed through, it should be inspected.

There was the matter of providing the meters. When they went to a store they did not carry the scales or measure with them to get what they wanted. They did not have to pay for their gas meters. If the department supplied the meters he did not think they would have so many complaints. It would be better for the department and also for the public.

The only further thing he could contribute to the discussion was to bring the specimen and show what took place, and the difficulties they had to contend with. The one produced was bronze—a composition of copper and tin, 92 per cent. of copper and 8 per cent. of tin. These had been in use for five or six years, but none had been returned for repair. They did not know how long the drum produced was in that condition before it was taken out. The meters were simply returned, and the drums taken out as members saw them. That was not a special case—he had seen others. It was to be hoped that good metal would get over the difficulty. On making inquiries as to where the meters came from, he found that at the ends of mains meters always got out of repair quicker.

The reason of altering the iron casing of the meters to gun metal was to get rid of the corrosion. Messrs. Guest and Chrimes were still making meters composed entirely of iron. On the Continent this meter was very largely used.

In Germany and Austria there was scarcely any other meter used. The half-inch meter passed 35 gallons per hour before it began to register. None of those meters would stand the test here at all. He had melted plenty of new meters which had been sent to this country, and would not pass the test. So that this inferential meter stood much higher than any other in this country. There was not a meter made yet which would stand all the requirements they had in Melbourne. For instance, this meter was useless for drinking troughs, etc., or where there was a very slow flow. If a fairly good ball cock were introduced that would give a good flow at once. He had had a ball cock working for fifteen years, in which immediately the ball dropped the whole of the water was put on at once, and the full area of this pipe was running into the cistern. With the other cocks the water was dribbling all day, in which case the meter was of no use. For the purpose of household supplies the meter was all right, because in opening the tap a person usually gave about half a turn. Most of their houses were supplied with $\frac{1}{4}$-inch or $\frac{1}{2}$-inch taps. There were 10 threads to the inch of spindle. If they turned it half way they would get more than the area of the meter. A half-inch meter would register down to 12 gallons per hour.

He thought something should be evolved to show that the public were not treated as badly as they thought. The meter on the table was
tested under the Board's conditions. Water engineers as a rule had their own opinion as to how the meters should be tested. In Sydney the method of testing was entirely different from what obtained in Melbourne. The meter produced would run 4 per cent. fast under the Sydney test. Mr. Bilton had not made that test. He was speaking of small flows under 30 gallons per hour through the meter with the disc on the outlet side of the meter. The other test was to take the small flow on the inlet side. When that was done they were simply running the small jet of water into the inner works of the meter, so that the friction was reduced, and the consequence was that the meter would run on the inlet side 4 per cent. faster than the outlet side. At Geelong they tested the meters in the same way. He thought the Institute should record some standard method of testing the meters.

A meter of bronze weighed something like 18 lbs. It would be sold for £4 10s. A meter made in iron would cost almost the same money. If the former meter lasted 20 years, at the end of that time the metal would still be valuable. There would be about 18 lbs. of metal, which to-day was worth £87 per ton. There was only a pound or so of brass in the iron meters. The iron was only worth about £3 per ton as scrap iron. There was a lot of value in the bronze meter after it had run its course.

Mr. Bilton had made reference to the clearance between the drum and the casing of the meters. He had found in iron meters that the corrosion had gone right up to the drum. None of his meters had shown any tendency of that sort yet. It was proven that that meter was superior to the iron casing. It was to be hoped, now that attention had been directed to it, that they would receive better attention. The spindle should be placed perfectly upright, because the top became very much worn on the one side if it were tilted.

Mr. A. F. Smith said the corrosion of the turbine, if compared with other rotating bodies, would indicate electrical action. The acid certainly could not have been distributed over sufficient surface to have brought about the result they saw. There must have been something else. The wash would not do it, because it was coated with mud, which would show that there was no great flow of water. There had been several cases of centrifugal pumps, where there was a similar form of corrosion, where they ran at a high rate of speed. It was well known that the electrical action took place in the rapidly-revolving propeller of a ship at sea. The propeller always set up an electrical current. Another thing which made him think he was right was that to which Mr. Ferguson had drawn attention—the accumulation of muck between the meter and the drum. That indicated that it was an electrical deposit.

Mr. R. O. Thompson said that when in London two years ago, the chemist at the arsenal had a valve from a wet gas meter from Sydney, and found on the valve a special mixture, which he was testing. Before he left they sent to Sydney for some of the water.
The impression was formed that it was the water acting on the valve which had eaten away the valve ring. It was decided to alter the metal to counteract that.

He remembered seeing in London a beautiful model of a swing bridge, which was soldered with muriatic acid, and before the exhibition was over the model fell to pieces. Since then he had never been in favour of soldering anything with muriatic acid. He was pleased that Mr. Ferguson had shown that people were getting a little water without paying for it. The company with which he was connected was one of the largest consumers in the city. They were at the end of one of the mains, and got a large amount of dirt, and were always sending their meters away to be cleaned, at a great expense to themselves. There was no doubt that there was some chemical action going on.

The President thought it was desirable that meters should be tested as far as possible under the conditions in which they were used. As a matter of policy he thought it would be better if the water authorities owned the meters, and kept them in order. It was a vexation to be called upon to bother about getting their meters in order now and again. Why could not the Melbourne and Metropolitan Board of Works keep the meters right? He thought as a consumer he should not be bothered about such matters. In that case, there could be a consistent system of inspection always going on, and people unfortunately situated, as at dead ends, would not be penalised. Mr. Bilton was to be congratulated upon bringing forward a very important subject, and eliciting much important information. It should add value to their transactions. If he required practical information upon water meters he did not know of any text books to go to for the information. He would ask Mr. Bilton to make any further remarks upon the subject which he desired.

Mr. H. J. Bilton said he was very much gratified at the reception his paper had received. When he was asked by the Publication Committee to contribute a paper on some subject, he had said in a rather heated moment that he knew something of water meters. But when it came to be put into writing, he found there was still a great deal to be learned. He must have struck some very peculiar meters when making his own tests. The district they were taken from was far from Melbourne. The pipes were much corroded, and no doubt the meters were also much encrusted. He was pleased Mr. Ritchie had found the meters he tested to give such good results. They were very creditable. They were tested in position. He noticed the worst meter at a discharge of 450 gallons per hour, only registered 9 per cent. fast, and had been in use 10 years. That was a remarkably good result.

In the second diagram a number of meters had been placed in tandem on the pipes of a cattle trough. A half-inch Frost meter registered 12,700 gallons. That meter gave the best results. Next to it in the inferential meters was the half-inch Crown meter, which
gave 8000 gallons, or about two-thirds of that given by the Frost. That was a very good result, for the volume or capacity of the meters. Inferential meters gave 5300 and 5000 respectively for \(\frac{5}{12}\)-in. and \(\frac{4}{12}\)-in. meters, or \(\frac{5}{12}\)-ths of the total amount passed, and the 1-in. gave 4300, or quarter of the total. So that there was a case where, at a slow or dribbling rate of discharge, the inferential meter was registering half of the discharge. That was not at all a bad result for such a severe test.

A fault he had found to be more frequent than any other was that the meters were too large for the work they had to do. For instance, in a 6-inch service, two 6-inch meters were placed side by side. It was found that those meters were working under a head of about 9 inches only, and were not registering correctly. That was one cause of trouble they had had in the past.

He would like to mention the point with reference to the cost of the iron cases. They had a large number of Guest and Chrimes meters with cast iron cases. He hoped in the course of a year or two to have a number of results of tests which would be very interesting as showing the comparative results as compared with gun metal.

There was a point about those meters which interested him greatly. That was as to whether the correct registration of the meter depended on the water jets from the turbine impinging on the casing or not. If it did not impinge on the casing it would be possible to make the case bulb-shaped so as to allow for more incrustation.

With regard to testing meters in the repair shops he differed from opinions expressed. One reason which made him do so was his own experience of cleaning cast iron pipes. On several occasions, supposing pipes to be dirty, they had had the pipes cut open, and they had been reported as quite clean, yet soon afterwards they were again examined and found to be dirty. The reason was that in many cases the incrustation was very soft, and when the pipe was cut the effect of the hammering, etc., was to remove that incrustation. His argument was that the meters were somewhat similar to the pipes he had referred to. When they were in position there might be a good deal of soft sediment on the casing. When the meter was taken out it was not quite emptied of water. During transit that water was shaken about in the meter, and when it reached the shop the meter had been shaken like they would shake a bottle. In any case it was a fortnight before the meters were repaired, and in that time all the incrustation had dried up, and the effect was lost. The only remedy was to test the meters in position, and that was somewhat difficult, especially with a large meter. They had had on several occasions to test large meters in position, and they had a 40,000 gallon tank, in which to measure the water. Without the tank to measure the water he did not see how it was possible to test large meters in position.

They had come to the conclusion that the only way to get correct registration was to take the meters out every two years, whether
they required it or not. The cost of repairs might interest members,
and he had prepared statistics running back a number of years, show-
ing the average cost of repairs. The \( \frac{1}{2} \)-inch, 1-inch, and 1\( \frac{1}{4} \)-inch meters cost on an average 22s. each for repairs. They some-
times put in spare meters while testing meters; \( 1 \frac{1}{2} \)-inch and 2-inch
meters cost about £1 15s. for repairs; 3-inch and 4-inch, £2 10s.; 5-inch, £3; and 6-inch, £4. If these meters were repaired once
every five years the cost of repairing the smaller meters would be
about 4s. 5d. per annum, and the largest meters would not cost more
than £1 per annum. That was not excessive. If the meters were
tested and repaired systematically, he believed they could be done
for much less than 4s. 5d. per annum. He thought the mistake was
made with inferential meters in just putting them in and letting them
go. He knew one case of a meter which had been in use for 17
years, and was running 40 per cent. slow. The turbine was worn
out, and the water was passing through it without being registered.
He also had come across a meter which was registering 40 per cent.
fast. It was taken out and taken to pieces, and it was found that
one of the regulating fans had corroded through and fallen off.
When it was taken to the shop and tested it only showed 18 per
cent. fast. He accounted for that by the incrustation being shaken
off in the removal of the meter.
In the case of positive meters, when they broke down, they cut
off the supply altogether, and thus compelled attention. But the
inferential meter would go on for ever, and the consequence was
it was simply left in. He thought they should be inspected re-
gularly. He had not seen many cases of the fans corroding. He
supposed the reason why they were allowed to go on without in-
spection was because there was always a minimum water rate, which
was seldom exceeded, so that in many cases there was really no
necessity for a meter. A very large proportion of the meters in
Melbourne were unnecessary. The larger meters were not so much
affected by incrustation as smaller ones.

RAILWAY GAUGES.

The President said the only other business was the further dis-
cussion of his paper on Railway Gauges. It was thought by the
Council that it might as well be kept open in case any further in-
formation should crop up. He had received a few letters from friends
to whom he had sent copies of the paper. The Hon. Jas. Bal-
four said he “was present as an invited guest at the opening of the
Hobson’s Bay railway. To get the loaded train to start some had
to get out and shove.” That was not a very dignified way of
starting, but even Stephenson’s engines in England did not behave
very well at first. Mr. Mais had given some very interesting infor-
mation, which had been printed and circulated.
The matter was perfectly clear that the three colonies started
with the intention of having the English gauge. New South Wales
Author/s:
Bilton, Henry John Inwood

Title:
Notes and experiments on water meters (Paper & Discussion)

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