

TABLE IX.
Scheme for rapid analysis of maple syrup.

Determination.	Time required.]		Limits of value.	
	Actual attention.	To reach result.	Extreme.	Ordinary.
Conductivity value 25° C.	5 min.	5 min.	110 to 230	113 to 205
Refractometer reading.....	5 "	5 "	—	—
Total ash, dry basis	7 "	1½ hrs.	0.61 " 1.68	0.69 " 1.47
Alkalinity of soluble ash, dry basis	5 "	½ hr.	41 " 122	48 " 109
Canadian lead number, 5 g. syrup, dry basis	12 "	5 hrs.	1.37 " 6.56	1.51 " 4.55
Winton lead number, 25 g. syrup, wet basis	17 "	9 "	0.79 " 2.70	0.76 " 2.47
Total time required	51 min.	9 hrs.		

adulteration in only two others, neither of which, however, professed to be pure. One of these two was low in all the other values determined, the other in total, ash only.

Maple Sugar-making as an Agricultural Industry.

Maple sugar-making has been from the first, and, so far as one can see, must continue to be, an agricultural industry. The fact that it is only for a few weeks in the spring that sap can be obtained in quantity and of quality suitable for sugar-making and that during those weeks the melting of the snow renders the roads nearly impassable, prevents the organisation of the industry in a manner that would render it possible to use the highly economical evaporating apparatus which is employed in the beet and cane sugar industries. Multiple effect vacuum pans are out of the question for a single farmer or even for the number of farmers that could deliver sap at a central station. The enormous amount of fuel consumed in evaporation at atmospheric pressure is apt to shock the sugar refinery man. With the most modern apparatus from seven to twelve cords of wood are used in the manufacture of a ton of maple sugar. But it must be remembered that the wood is close at hand and can be collected and prepared at very little cost. Two dollars a cord is perhaps a fair estimate of its value. Coal is but little used, and if wood is eventually to be displaced as a fuel it is not unlikely that it will be liquid fuel, rather than coal, which will take its place.

According to the census of 1911, the total production in the Dominion of Canada in 1910 was 12,178,216 pounds of sugar and 1,066,971 gallons of syrup (see Table X.). The

TABLE X.
Canadian Census returns on maple sap products in 1910.

	Sugar lb.	Syrup gallons.	Value \$	Per cent. of total value.
Quebec	9,427,694	984,232	1,680,393	65
Ontario	2,510,267	58,018	831,483	32
New Brunswick	143,779	18,211	37,337	
Nova Scotia	96,315	6,424	19,785	
Prince Edward Island	206	16	82	3
Manitoba	15	20	153	
Dominion of Canada	12,178,216	1,066,971	\$2,569,233	100

combined value was \$2,569,233, of which Quebec contributed nearly two-thirds and Ontario nearly one-third, the other provinces contributing only 3 per cent. altogether. The production of sugar in the United States in 1909 was not two million pounds greater than that in Canada in 1910, but the syrup produced in the States was nearly four times the Canadian output. The total value of the maple products in the United States in 1909 was almost exactly twice that of Canada in 1910.

The production of sugar in the United States in 1909 was 18 per cent. greater and the production of syrup nearly 60 per cent. greater than in 1909. The production of

syrup and sugar in Quebec in 1910 was 35 per cent. greater than in 1900, but the value of the product had increased by only 24 per cent. In Ontario there was a falling-off of 22.5 per cent. in production in 1910 as compared with 1900. It ought to be noted, however, that the annual production in any locality varies considerably from year to year on account of variations in weather and other conditions.

The relative importance of the maple crop in the Province of Quebec as compared with some other farm products is shown in Table XI.

TABLE XI.
Maple compared with other farm products.
Province of Quebec Census of 1911.

Maple sugar and syrup	\$1,680,000
Poultry sold and slaughtered	1,708,000
Sheep, sold and slaughtered	1,583,000
Cream	1,567,000
Fruits, orchard and small	1,470,000
Honey and wax	230,000

Macdonald College, Quebec.

London Section.

Meeting held at Burlington House, on Monday, May 4th, 1914.

PROF. W. R. HODGKINSON IN THE CHAIR.

APPARATUS FOR THE AUTOMATIC MEASURING AND INJECTION OF CHEMICALS.

BY THE HON. R. C. PARSONS, M.A., M.INST.C.E.

Having devoted much attention to the filtration of water on an extensive scale, both by means of the ordinary sand filter, and more recently by the mechanical filter, it was found to be necessary in some instances to add a chemical to the water, previous to its passing through a filter, so as to obtain a clear effluent.

The methods for adding the requisite quantity of chemical in a constant proportion to the water to be treated, although the flow of the latter may vary considerably, form the subject to be discussed in this paper.

In connection with the water supplies of the populous cities of the Argentine Republic, South America, where the water is frequently obtained from the River Plate, extensive filtration plants have been installed. The water of this river is charged with very finely divided alluvial matter, and as is the case with the water of the River Nile, requires special appliances to ensure its being thoroughly cleansed by filtration. In the case of the City of Buenos Ayres, with the Water Works of which the

author was connected as Consulting Engineer some years ago, the consumption of water was 60,000,000 gallons per day, drawn from the River Plate; the filtration was effected entirely by means of gravitation sand filters, and it was found impossible to ensure a clear filtrate without the employment of some form of coagulant.

The chemical experimented with in that case was aluminium sulphate, which when added to the water, previous to its entering the settling pools, was found to yield a clear effluent when passed through sand filters. The use of this chemical has since been constantly continued, and the method of adding it to the water to be treated is by tipping definite quantities of the salt into tanks of known capacity, and from these the solution is pumped into the settling pools with a rapidly regulated arbitrarily by the superintendent in charge.

It will be realised that with this rough and ready method of control there is at times too much chemical added which leads to the corrosion of the water mains throughout the city, and is also deleterious to the health of the population, but at others too little, in which case there is not sufficient to clarify the water.

An equally unsatisfactory method was in operation at the water works of the city of Rosario de Santa Fe, where the consumption of water, derived from the Rio Paraná, now amounts to 12,000,000 gallons per day, but in this case the chemical employed is aluminio-ferric salt.

It was realised by the Directors of the Water Works Company that as the consumption of chemical was considerable, and consequently an important item in the working expenses, it would be advisable to adopt some more scientific method for adding the chemical to the water to be treated. The author was instructed to consider the question, and advise as to what course should be adopted.

In the first instance the various methods then in use for adding chemicals to water, previous to its passing on to filters were examined, and as none appeared to fulfil the necessary requirements, the author devised the apparatus known as the "Tiltometer," a detailed description of which was read before the Society of Dyers and Colourists in March 1912.

An elevation of this instrument is shown in Figure 1, and it may be described as essentially a low pressure

injector, or one which is only capable of injecting the chemical into a main having a head not greater than the elevation of the point, L.

The water flows from the crude liquid tank to that for the treated liquid through a main in which is a Venturi tube, A, of the ordinary type, and as is well known, when a current is flowing through the main a reduction of pressure is produced at any point where the main is contracted in sectional area. This difference of pressure is termed the Venturi head. Thus at the point A the pressure is less than that existing in the main on either side of it. B and C are two vertical cylinders, and these are connected at their lower ends by pipes, one to the contracted main at the point, A, and the other to the main at its normal section.

Within the cylinders, B and C, are plungers, whose weight is greater than that of the water they displace, and of such diameter that they can rise and fall without touching the sides of the cylinders. These plungers are attached to either end of a lever pivotted at its central point on knife edges E. A means of adjustment is provided in the rod connecting one of the plungers to the end of the lever. Attached to this lever, and concentric with its axis, is a cylindrical tank having an opening at the top through which the chemical reagent enters. The height of the solution in it is maintained accurately constant by means of a ball valve. From the circumference of the cylindrical tank extends a projection containing an adjustable orifice which allows the chemical reagent to flow out of the tank and fall into the cup L, from which it enters the water to be treated, flowing along the main. This orifice being in the form of a diamond or one with parallel sides, preserves the same shape for all degrees of opening, and is found to possess a practically constant coefficient of discharge.

It is well known that the difference of pressure recorded in a Venturi tube varies as the square of the velocity of the water flowing along the main in which it is placed, therefore the difference of level in the two cylinders, B and C, varies in the same ratio. The plungers, F and G, rise and fall with these changes of level, and they in their turn rotate the cylindrical tank, the orifice of which thus becomes immersed at a depth below the surface of the solution in the cylindrical tank, depending upon the angle of rotation. Further, the flow of solution through this orifice varies as the square root of the depth of its submersion, consequently for any variation of flow in the water main a similar variation takes place in the flow of the reagent into the mains, and the percentage of chemical added continues constant.

Theoretically, therefore, the action of the apparatus would be perfect if it were possible to avoid certain errors connected with the Venturi effect, and also with the passage of the chemical through the orifice; yet these are so nearly eliminated that the practical error under extreme conditions of working, does not exceed $1\frac{1}{2}$ per cent.

The following are the results of tests made upon a large apparatus constructed substantially as shown in Figure 1, and which has been in constant service for a considerable period:—

TABLE 1.
Gallons per hour.

Water.	Chemical.	Per cent.
610	19.8	3.00
1820	52.2	3.04
1820	57.2	3.14
2390	73.7	3.08

The first column indicates the flow of water in the main. The second the chemical added. The third the ratio of columns one and two

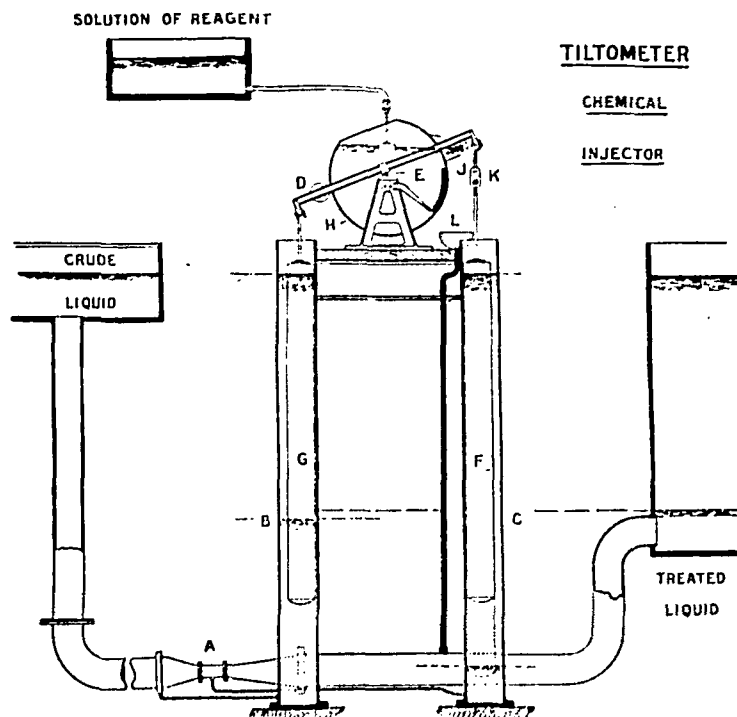


FIG. 1.

As a rule it is advisable to use a standard solution of reagent, and to give a practical example of the working of the apparatus just described, a case may be cited where the flow in the main varies from nothing up to 1,000 gallons per hour, and requires to have 7 grains of aluminiferous salt added to each gallon. In this case the Venturi tube will be 4 inches diameter, narrowing to 2 inches in the throat. The difference of level in the two cylinders B and C, when 1,000 gallons per hour is passing, will be about 2 feet, which will impose a head of about 12 inches upon the orifice J in the cylindrical tank.

The strength of the solution might for simplicity be 1 of aluminiferous salt to 70 of water, or 1,000 grains to the gallon. If therefore 7 gallons of the solution is added to each 1,000 gallons passing through the mains, the required treatment is effected.

The diameter of the orifice J in this case will be about $\frac{3}{32}$ nds of an inch in diameter.

At the Water Works of Rosario above mentioned where two Tiltometers are being installed, the method employed for determining the percentage of chemical to be added to a water, such as that of the River Plate, is by ascertaining the degree of turbidity by the usual method of viewing an object through a column of water, and measuring the length of the column when it becomes invisible. A scale is then prepared which enables the attendant to set the orifice, after which the variation of the flow is taken charge of by the apparatus, automatically. Should the river water become more or less turbid, then the orifice is again adjusted in a similar manner. The volume of chemical passing through the Tiltometer is indicated by the pointer on the side of the cylindrical tank.

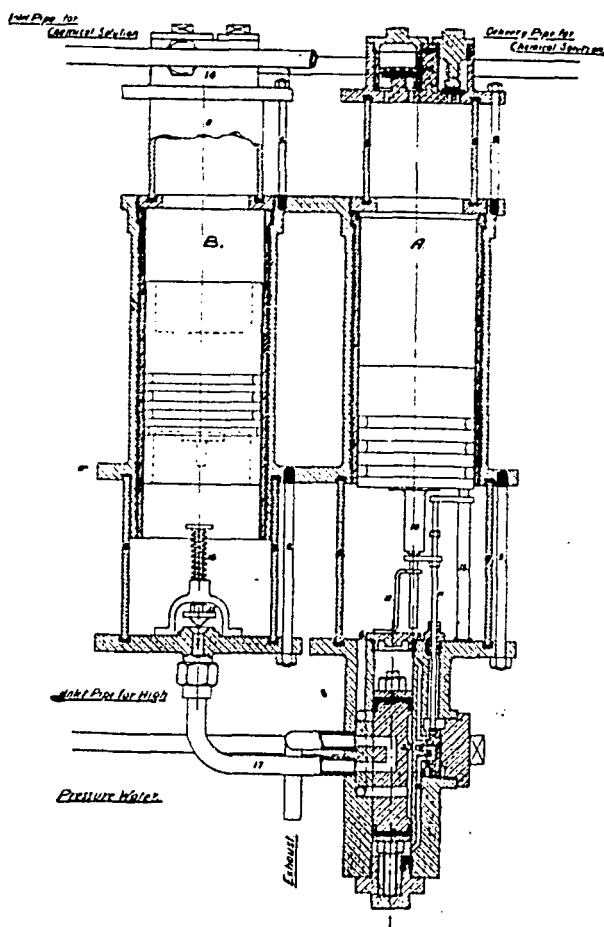


FIG. 2.

Having described the principle and the operation of the "Tiltometer," several of which are in operation and working entirely satisfactorily, the "High Pressure Chemical Injector" will now be explained.

In view of mechanical filtration now being adopted very largely, and with it the chemical treatment of the crude water being found advisable, the injection of the chemical into the water mains under pressure has been found necessary. As the result of numerous investigations and experiments the apparatus which will now be described has been found to yield satisfactory results.

Figure 2 shows a sectional elevation of this apparatus. The motive power of the "High Pressure Chemical Injector" is, as in the "Tiltometer," derived from the difference between the actual pressure in the water main and that in the throat of a Venturi tube inserted therein. This is the best method of obtaining the required difference of pressure, as it involves the least possible loss of head in the mains.

The injecting apparatus consists of two cylinders of equal diameter, in which solid pistons slightly heavier than the fluid they displace, and having wide circumferential grooves, move quite freely; that marked A being termed the working cylinder, whilst that marked B is secondary cylinder. Below the working cylinder are situated the controlling valve gear and valves for the admission and release of the actuating fluid, to and from both cylinders. These consist of a telescopic rod 10 attached to the lower end of the piston in the working cylinder. The lower extremity of this rod is attached to a fork which engages the valve spindle 11, and by means of adjustable tappets on it moves the slide valve (1) each time the piston completes its stroke in either direction. This valve then admits the pressure of the mains alternately to either end of the cylindrical valve (2, 2) and also simultaneously exhausts it from the opposite end. At both ends of this cylindrical valve are cup leathers for preventing leakage occurring past the ends of the valve. In the cylindrical valve, between the cup leathers, are the necessary ports for admitting the working fluid to both cylinders A and B alternately and releasing it from them. Below the secondary cylinder B is an inlet valve kept open by means of a spiral spring 16 until forcibly closed by contact with a projection on the lower end of the piston, on the completion of its downward stroke. Above each cylinder is an upper valve box, each containing an inlet and outlet valve which consist of thin flat discs of pure soft rubber. Between the upper valve boxes and also the lower valve boxes and the two cylinders are provided glass cylinders (8, 8) which are useful for enabling the attendant to observe the important working parts of the apparatus.

The standard solution of chemical to be injected is stored in a tank situated some ten feet above the apparatus, and a pipe connects it with the inlet valves of the upper valve boxes. The inlet pipe for the high pressure water connects the main with the back of the cylindrical valve and the delivery pipe connects the outlet valves of the upper valve boxes with the throat of the Venturi tube. Upon this last-mentioned pipe is the valve (18) of special construction, the orifice of which is diamond shaped, which, as already stated, ensures its preserving the same form at all stages of opening, so as to maintain a practically constant coefficient of flow for all openings.

It should be explained that it is obviously impossible to exhibit in this room the injector forcing chemical into a water main. In order, however, to produce a similar effect, an additional valve is fixed on the outlet pipe beyond the regulating valve. By more or less closing this valve the throat pressure of the main is imitated. The chemical after it passes through the small Venturi is then returned to the chemical tank, and for exhibition the action of the injector is therefore continuous.

In order to prevent any deposit occurring in the passages and chambers, care is taken that still liquid shall not exist at any point. A vortex action is therefore maintained in the chambers by the in and out flow of the chemical, which has proved to be quite effectual.

Action of the apparatus.

The action of the apparatus is as follows:—The pistons A and B being at the lower end of their respective strokes, and the upper valve boxes full of chemical, the working fluid is admitted to the apparatus, and the cylindrical valve then allows it to flow to the under side of piston A. This piston immediately commences to rise, injecting the chemical above, and continuing to do so until it reaches the end of its upward stroke. At this point the rod (10) moves the valve (1) which admits the high pressure water to the lower end of the cylindrical valve, which on rising opens the release port and allows the piston A to descend. The same movement of the cylindrical valve admits the working fluid to the lower end of cylinder B, the piston in which immediately commences to rise, injecting the chemical at the same rate as was previously done by piston A, and continues the process of injection.

The upward movement of piston B only continues until piston A has completed its downward stroke, and is ready to recommence the operation of injection. The cylindrical valve is then moved downwards and piston A again rises, while piston B moves downwards to the end of its stroke so as to be ready to take its place again when piston A has reached the top of its stroke.

With this cycle of operations the injection of the chemical, except during the momentary shifting of the valves, is constant. The stroke of piston A is thus always of constant length, but this is not the case with piston B, the stroke of which is of a variable length, depending upon the rapidity with which the injector is working.

An injector capable of injecting 40 gallons of chemical per hour against any pressure was exhibited at the meeting. Both cylinders were 3 inches diameter, and the stroke of piston A was 4 inches, whilst that of B varied considerably, depending upon the time occupied by the return stroke of piston A.

TABLE 2.

Opening of regulator.	Venturi head ft.	Quantity of Water g.p.m. 3in. main 4 to 1 ratio.	Quantity of chemical g.p.m. weighed.	Per cent- age.
in. ‡	per cent.		per cent.	
	31.8	210	0.633	0.299
	25.7	180	0.533	0.282
	21.3	172	0.500	0.290
	17.9	157	0.450	0.286
	15.2	145	0.410	0.280
	7.88	104	0.309	0.289
	5.38	86	0.250	0.291
	3.68	72	0.209	0.291
	1.18	40	0.110	0.275
	0.650	30	0.087	0.289
‡	32.0	211	0.600	0.284
	23.4	180	0.533	0.296
	18.8	160	0.450	0.270
	11.5	127	0.363	0.286
	5.04	89	0.250	0.281
	2.23	56	0.155	0.277
	0.58	29	0.075	0.260
‡	33.1	215	0.463	0.215
	25.7	180	0.380	0.201
	15.1	145	0.300	0.207
	10.8	122	0.243	0.108
	5.78	90	0.170	0.189
	1.05	38	0.150	0.196
‡	32.0	211	0.266	0.126
	22.1	178	0.225	0.128
	11.8	130	0.163	0.119
	4.46	79	0.100	0.127
	0.92	30	0.045	0.125
‡	30.7	206	0.125	0.061
	19.4	164	0.100	0.061
	9.45	115	0.063	0.055
	3.15	66	0.040	0.061

Careful tests were made with this injector, some of which are given in the above table. The first column indicates the amount that the regulating valve is open. The second is the Venturi pressure actuating the injector. The third is the calculated flow of water through a main to produce

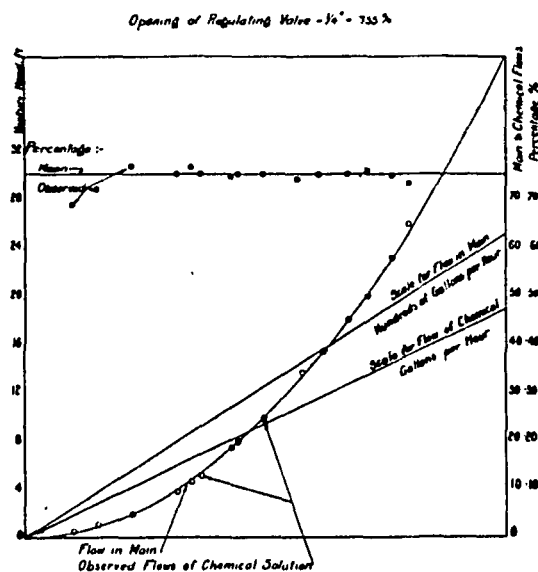
this Venturi pressure. The fourth is the quantity of chemical passed by the injector in gallons per minute as weighed. The fifth is the percentage ratio of the third and fourth columns. These figures indicate that the apparatus gives very accurate results over a tolerably wide range of flow through the main, which in the case in question amounted to a ratio of 1 to 7.

In order to adapt the High Pressure Chemical Injector to practical requirements, it was necessary to provide an easy method for indicating at any moment the quantity of chemical being injected in a given time.

It was found advisable to make use of a small Venturi tube for this purpose, and in Plate III., which is an illustration of the apparatus exhibited, a Venturi tube is attached on the right hand side, with the requisite manometer above it. It will be observed that there is a difference in the height of the columns, indicating that a current of the chemical is passing through the tube, and by reference to the discharge diagram of this Venturi tube, the flow at any time can be ascertained.

On the opposite side of the injector is another manometer, the columns of which are attached, one to the water main, and the other to the throat, of the Venturi tube inserted in it. The difference of the height of these columns when referred to the discharge diagram of this Venturi tube, gives the flow through the main. By comparing the readings from these two manometers the percentage of chemical introduced into the water to be treated is at once ascertained. Should the required percentage not be correct, then by a slight adjustment of the regulating valve on the outlet from the injector, the necessary alteration may be made, which then continues constant, although the flow in the main varies.

The following diagrams A, B, C, D, E, indicate the relative movements of the water in the main and the chemical discharged by the injector. The parabolic curve in each is that universally used for ascertaining the flow through a main in which a Venturi tube is inserted, when the Venturi head is observed on the Manometer on the left hand side of the injector. The tube selected for consideration is one of 3 inches diameter with a throat ratio of 4 to 1. The small circles which form a curve, which practically coincides with this curve, are those of the flow of the chemical as indicated by the Venturi head in the manometer, on the right hand side; the observations on both manometers being taken simultaneously. Both curves practically coincide, showing that the apparatus works with great accuracy.



On these diagrams are also drawn two straight lines starting from the origin, the upper one showing the discharge through the 3 inch main above mentioned when the

Venturi tube in it produces the respective heads on the manometer. The lower line in the same manner indicates the flow of chemical through the small Venturi tube at the various heads shown on its manometer. The horizontal straight line shows the mean percentage of chemical it is desired to inject into the main, and the circles along it indicate the actual observed results, which very nearly coincide with it.

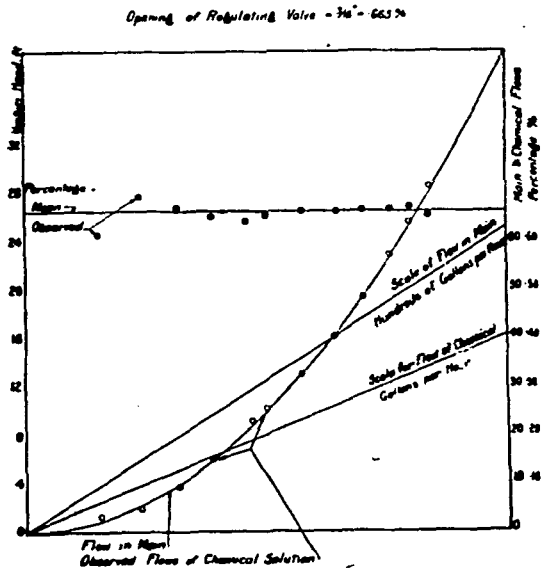


DIAGRAM B.

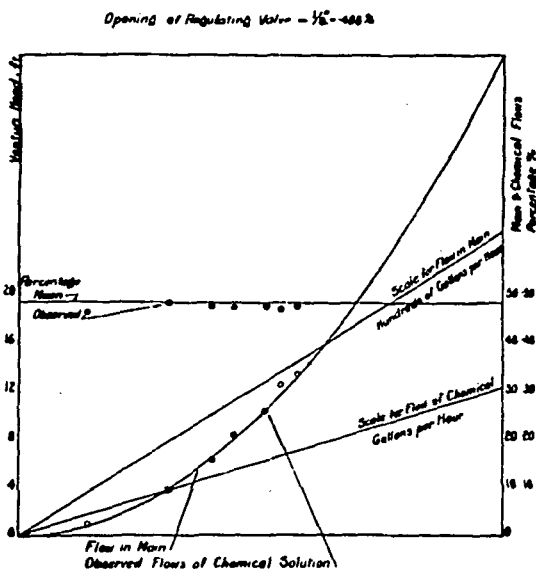


DIAGRAM C.

The results of the tests given in the table, and also those indicated in the diagrams, prove that the apparatus gives very accurate results when working with a range of flow in the main of 1-7, and a variation of percentage of chemical of 1-5, but should greater ranges be required, special arrangements can be made.

The reason for the accuracy of these results being obtained can be easily explained. The Venturi head in the water main varies as the square of the flow, further the fluid friction through the passages of the injector and the regulating valve also vary as the square of the flow.

Further the measurement of the discharge of chemicals is by a Venturi tube, the head of which varies as the square of the flow. Consequently if there was no mechanical friction in the apparatus, it should give practically perfect results, as was the case with the "Tiltometer." The only disturbing influence is any mechanical friction, which, owing to the special construction of the apparatus, is reduced to almost nothing, which is proved by the fact

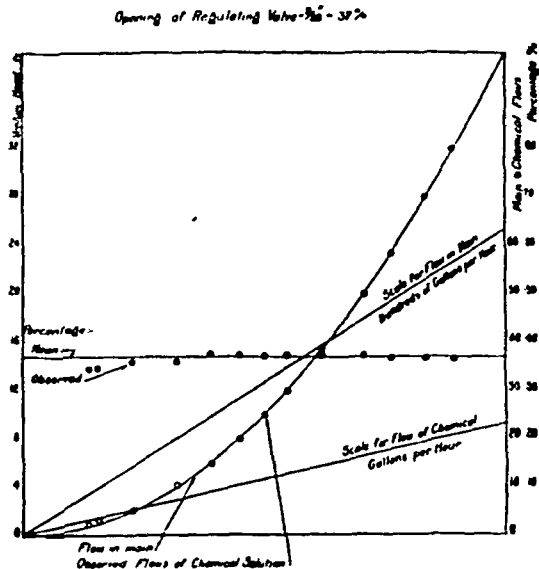


DIAGRAM D.

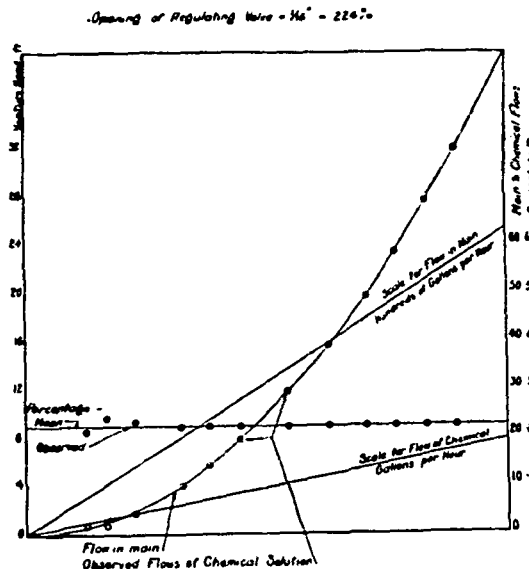


DIAGRAM E.

that the Injector will work with a water pressure of less than $\frac{1}{2}$ an inch of mercury.

The pistons are quite loose fits in the cylinders, and are slightly heavier than the fluid they displace. There is, therefore, a small leak of water past them, which is in an upward direction, except at the conclusion of the downward stroke, when at the moment of reversing the valves, it is a leak of chemical in a downward direction. To prevent any passage of the upper liquid into the lower due to these leaks the piston is provided with deep circumferential grooves in which the fluid due to leakage in

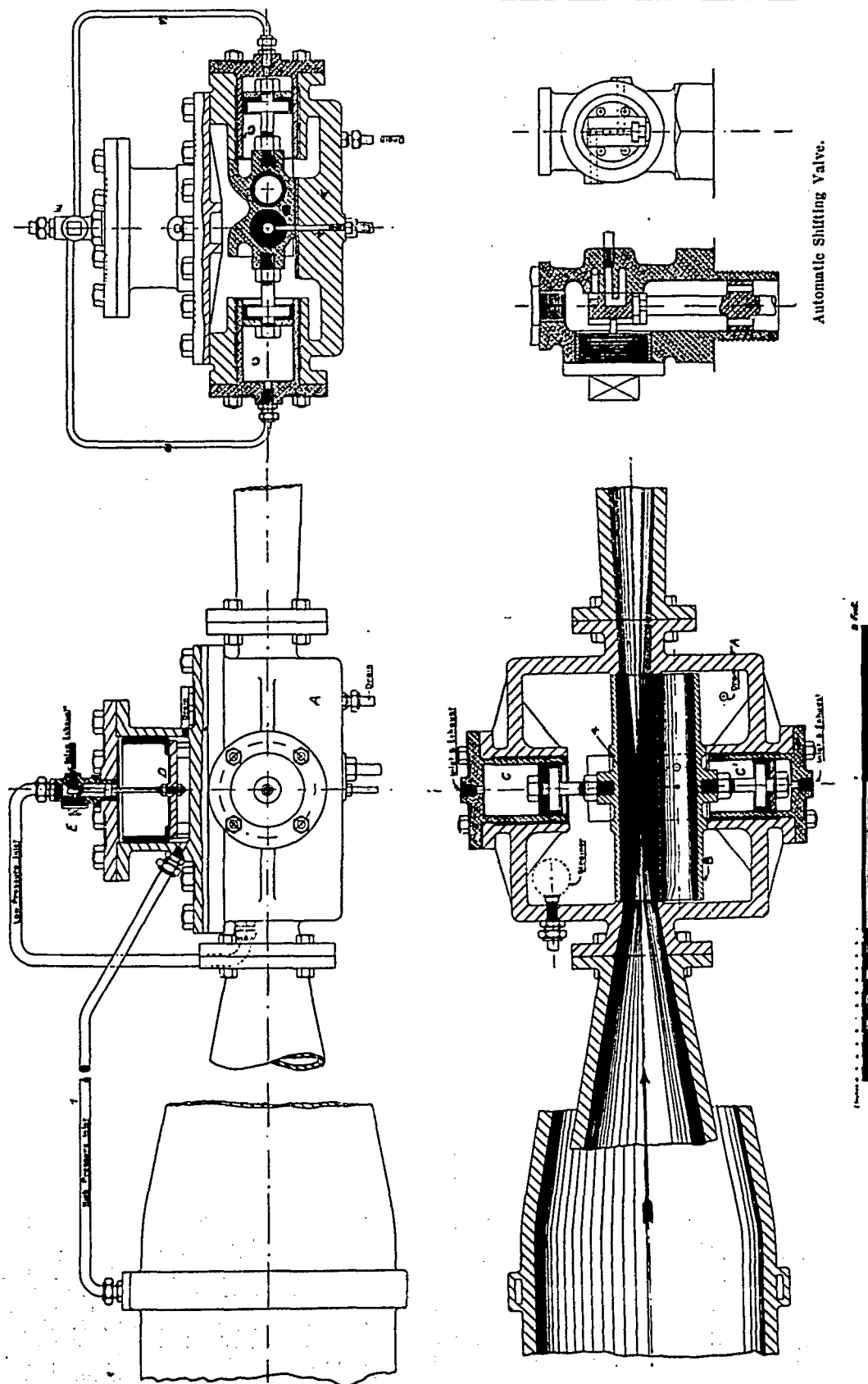


FIG. 3.

a downward direction is stored and is returned by the similar leakage in the upward direction, consequently there is no loss of chemical.

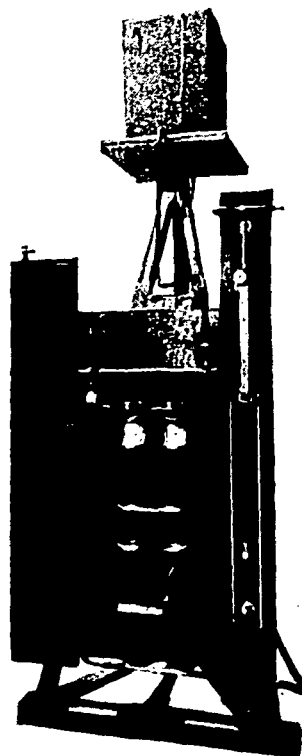
The movement of the cylindrical valve which controls the movement of the pistons is worked entirely by the pressure of the mains, and not by the Venturi head. Consequently it does not interfere with the accurate working of the apparatus.

The apparatus exhibited gave accurate results with a variation of flow in the main up to 1 to 7. There are instances, however, in water supplies where the variation reaches 1 to 30, and the following device can be adopted to meet this requirement.

Figure 3 shows a Venturi tube specially constructed, having a rectangular metal box A, termed the Shuttle Box inserted where the throat is usually situated. Within this box is fitted a moveable sliding piece termed the Shuttle (B), in which there are two cylindrical passages or throats, the ends of both of which are of the same diameter as the Venturi tubes leading away from it on either side. One of these throats is of the same diameter throughout, and the second is contracted in the middle.

If the flow of the water through the main is small then the small throat is used, while when it increases to a definite amount the larger throat is called into operation. This is effected by releasing the water pressure from the outer end of one cylinder (C), or the other (C₁), the internal pressure against both pistons being equal. Assuming that the smaller throat is in operation, and the flow in the main increases, which in turn produces a Venturi head as between the main and the shuttle box, the pressure flows along pipe I under piston D, which is quite a loose fit, and is weighted to any desired amount, preferably equivalent to a Venturi head of 30 feet of water. When this pressure is reached the piston rises and moves the slide valve E, releasing the high pressure water from the end of the cylinder by means of the pipe 2. As soon as the flow in the mains falls to the same above mentioned limit, the piston D falls, and the small throat is again brought into service. The shuttle as it moves to and fro slides upon the flat surface of the box in which there is a port connecting either with the wide or narrow throats, whichever is in operation at the time. This port is connected by a pipe with the outlet ports of the Injector.

As the admission of chemical to the main is much larger when the large throat is in use than when the small one is in service, it is necessary that the operation of changing

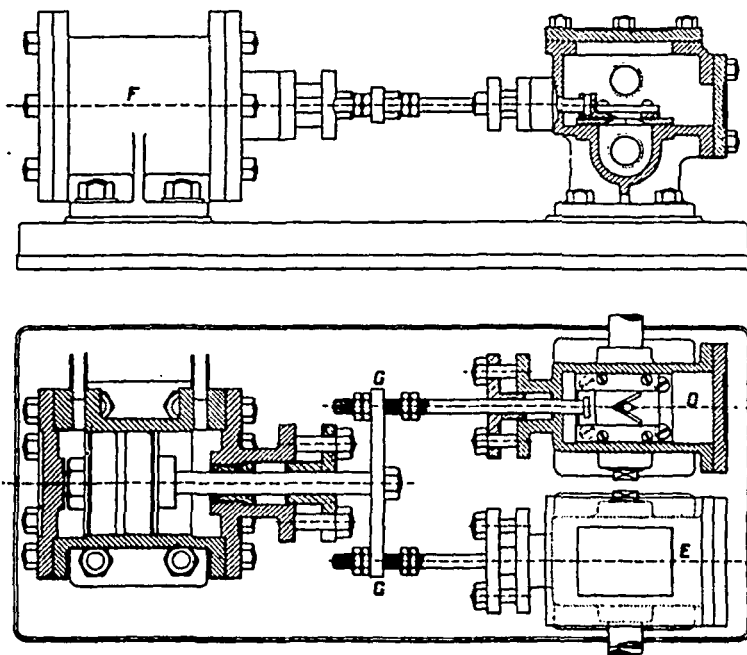


the throats shall also simultaneously change the regulating valve (Fig. 4). This is done by means of cylinder, F, into either end of which the high pressure water is admitted at the same time as to C or C₁. The tappets, G, give the necessary adjustments to regulate the percentage of chemical, and when these are set for any given percentage the remainder of the operations are effected entirely automatically, following the variations in the flow through the main.

In the apparatus exhibited the chemical is milk of lime, composed of whiting 1, water 20, and this has no corrosive action on the brass of which the injector is made. If, however, the chemical be of a corrosive nature then the parts exposed to it are made of vulcanite or one of the non-corrosive alloys.

Special attention has been devoted to producing an injector which, whilst possessing extreme accuracy, is reliable in its action, is not subject to wear and tear, and above all is not costly to manufacture. It is believed that the apparatus exhibited possesses all these qualifications, and can be employed for all purposes where it is required to mix one fluid with another in definite and constant proportions.

Note.—Should any further information be required beyond that contained in the paper, it can be obtained by application to The Stereophagus Pump and Engineering Co., Ltd., 39, Victoria Street, London, S.W.



REGULATING VALVE.
FIG. 4.