

the screen to the double jig machine near the crushing rollers; the 2 and 3½ millimeters to the one opposite; and the fine stuff, 1 and ½ millimeter, to the jig on the end of the building. Each of these six sizes has for its separation four sieves, having a jiggling surface of 16 square feet.

The first sieve of the jig machine discharges very clean galena; the second sieve, galena and zinc-blende mixed; the third sieve, clean zinc ore; the fourth sieve, zinc ore and rock; and the overflow is clean rock. The galena drops from the discharge into boxes, the clean zinc ore from both sides of the jig is spouted to small cars on the end of jigs; and the tailings are spouted to the outside of the building.

The capacity of these works is sixty-five tons per twenty-four hours. The force to run it is one hand feeding the Blake breaker, one hand attending to the jigs, and one hand for removing the clean product to the outside—a total of three hands for one shift. The cost of all the machinery complete, including engine and boiler, was only \$5200.—*Eng. and Min. Jour.*

#### IMPROVED COMPRESSING MACHINE.

THE machine illustrated consists of a heavy steam-hammer operating upon the material contained in one of the group of three steel moulds. The moulds being passed through one-third of a revolution at each movement brings them under the hopper for filling, the steam hammer for

Brans has always been an article of forced sale, because of its bulky nature, being both expensive to store and unprofitable for export or shipment to points distant from the milling centers; whereas bran can now be reduced to one-fifth its natural bulk, rendering it at once a practical and valuable commercial article which freights better than sack flour, as the latter measures about 47 cubic feet to the gross ton, while the consolidated bran measures but 36 cubic feet to the gross ton.

Consolidated bran has proved to be of twofold advantage, since, air and moisture being excluded, it is not liable to damage by climatic effects, and blocks of bran made by this process over two years still remain as sweet and good as when made. This result alone is of immense value, for the reason that bran and other mill products may now be shipped to warm climates or may be kept in store for military campaign purposes for an indefinite time, which is not the case with these materials in their natural condition.

Sawdust, shavings, wood waste, coal dust, screenings, and cotton seed hulls for fuel are consolidated into self coherent blocks by the same means and in the same manner as heretofore described; and something of the industrial revolution about to be created by this method of disposing of the waste products of the saw mills may be appreciated, when it is considered that they represent fully one-third of the log measurement, amounting annually to millions of tons of now more than useless material, much

COMPARATIVE TABLE SHOWING THE REDUCTION OF VARIOUS MATERIALS BY CONSOLIDATION.

	Bulk unconsolidated per ton of 2240 lb.	Bulk consolidated per ton of 2240 lb.	Bulk unconsolidated per ton of 2240 lb.	Bulk consolidated per ton of 2240 lb.	Wt. unconsolidated per cubic foot, lb.	Wt. consolidated per cubic foot, lb.
Bran	172	34	153	31	13	65
Middlings	86	17	76	15	28	70
Ground Feed	86	17	76	15	28	70
Corn Meal	86	17	76	15	28	70
White Pine Sawdust	448	89	400	80	5	60
White Pine Shavings	996	199	900	180	2½	60
Yellow Pine Sawdust	373	74	333	66	6	65
Yellow Pine Shavings	746	148	666	133	3	65
Tan Bark	140	28	125	25	16	64
Cotton compressed	55	11	50	10	4	56
Hay, Straw & Grasses in mow	580	116	500	100	11	56
Hay, in common bale	160	32	142	28	14	55
Bituminous Coal Dust	44	8	40	25	50	80

posing natural stone. The stone made by this process weighs from 150 to 160 pounds per cubic foot, or 10 or 15 pounds more per cubic foot than Ohio sandstone.

The possibilities shown with the few substances before named apply in a greater or less degree to an indefinite number of articles. We have instanced enough concerning the products of this process to excite general interest in the particular mechanical devices by which they are secured.

The Smith Consolidation Co.'s office is at 254 South Water Street, Chicago.

#### THE JOINTING AND TESTING OF GAS MAINS.\*

By C. W. FOLKARD, Assoc. Royal School of Mines.

THE conveyance of fluids through closed pipes under pressure has effected quite a revolution in one of the most important concerns of daily life—viz., water supply—enabling engineers to dispense with the cumbrous and costly aqueducts employed by the ancients; thus reducing the outlay to such an extent as to render the system applicable even to villages. For this purpose sound mains are necessary; otherwise the loss by leakage is a bar to the financial success of the undertakings. Fortunately, however, a serious leak in a water main soon makes itself visible, except under special conditions of soil; but in gas mains this is not the case to anything like the same extent. Sound mains are therefore of the utmost importance to gas companies; and in the present paper it is proposed to examine somewhat in detail the methods of jointing and testing now in use. This is all the more necessary at the present time in consequence of the tendency toward centralization of manufacturing stations; otherwise the leakage from the great length of trunk main necessary for the supply of outlying districts more than counterbalances the increased economy of manufacture in large works.

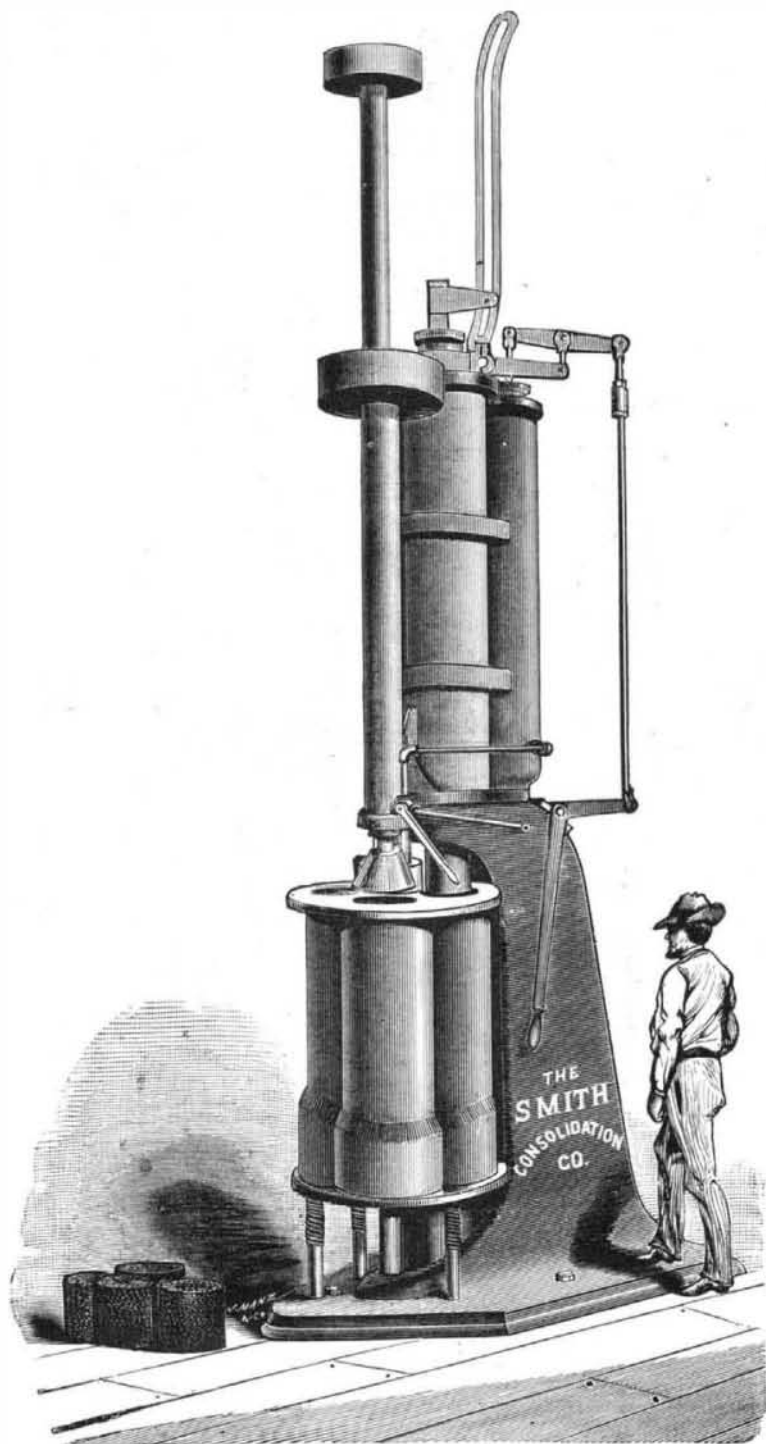
A theoretically perfect main would be one formed in lengths, like lead or composition pipe, by expelling molten lead or alloy through a mandrel. Each length would be jointed to the next by a stuffing-box or other contrivance, to allow of expansion and contraction. Practically, however, the great majority of mains (both water and gas) are of iron jointed with lead; so we will first consider the effect of changes of temperature on the ordinary lead joint.

It is well known by waterworks engineers that leaks regularly occur in certain parts of their districts in the spring and autumn; and if we examine these parts, we shall find that the soil is clay, and so the water finds its way to the surface, and attention is directed to the leak. But it is quite obvious that the same causes are at work all over the country; the difference being that when the soil is porous the water finds its way underground and unnoticed. This view is fully borne out by the fact, that in London, when anything is required to be done in the sewers, a time is always chosen when the service pipes are not charged. Exactly the same thing occurs with gas mains, but unfortunately the effects are seldom apparent until the main is examined; for, owing to the porosity and deodorizing power of the soil, the gas escaping into the atmosphere is composed of the inodorous compounds—marsh gas, hydrogen, and carbonic oxide. Everyone who has taken up a main which has been buried for some years, even when originally well laid, must have been struck with the great number of joints either actually leaking or which have been leaking, as evidenced by the color and smell of the soil around them.

When we examine the theory of the matter, we shall see that it cannot be otherwise. Let us take a 4-inch pipe; the outside of the spigot being 4¼ inches in diameter, the inside of the socket 5½ inches in diameter; the joint being ¾ inch thick. When run with lead and set up, we have a ring of lead ¾ inch thick between two rings of cast iron. When first made it is absolutely gas-tight; but inasmuch as the coefficients of expansion of the two metals differ considerably, changes of temperature are fatal to its soundness. As to the limits of the range of temperature in the ground at about two feet deep, it is well known that in severe winters water mains are frozen solid; we may therefore fairly assume that the temperature of the ground falls to 30° Fahr. in winter, and if we take 60° Fahr. as the maximum in summer, we have a range of 30° Fahr. Iron expands 1/1000 of its length, and lead 1/100 (more than twice as much) for this range; and consequently when the temperature has risen 30° Fahr. the ¾ inch lead ring, instead of being 0.375 inch, tends to become 0.37518 inch. The socket, by the same rise of temperature—viz., 30° Fahr.—becomes 5.5011 inches, and the spigot 4.7509 inches, the space between—viz., 0.7502+2 = 0.3751 for the lead ring. This, however, as we have just seen, has expanded (or would have done if free to do so) to 0.37518 inch; consequently the yielding lead is squeezed out of the joint, which will probably remain tight. But when the action is reversed—viz., by a fall of temperature—it is evident that a space is left between the lead and the socket 0.00008 inch wide, through which gas or water can pass.

It is a well-known fact that large joints, i. e., those in which the interval between the socket and spigot is (say) ¾ instead of ¾ inch—always give a great deal of trouble from leakage, the amount of which is far more than doubled

Lately read before the Gas Institute, Sheffield.



IMPROVED PRESSING MACHINE FOR BRAN, ETC.

consolidating, and the discharging hammer for discharging the mould of the block just formed, in such manner that the three operations occur simultaneously. One blow of the hammer, says the *Industrial World*, usually suffices to consolidate the block, which weighs from ten to thirty pounds, according to the material of which it is composed. Four blocks per minute can readily be made. The capacity of the machine represented is 3,000 pounds of fuel per hour from white pine sawdust.

The process, as applied to the majority of the substances named, consists in heating the material sufficiently to soften the inherent resin, gluten, or bitumen, and, while in this state, subjecting it to the operation of the consolidator. No foreign substance is in any case admixed.

To meet the ordinary requirements of the mills for a machine to compress bran or other offal into packages of such density as to make a freight equal to or better than sack flour, and which will leave the material in its natural condition when removed from the package, the process is modified by the omission of heating the material, and it is spouted directly from the mill to the mould, where it is subjected to the same operation for consolidation, forming a block which has sufficient cohesion, with the assistance of the package into which it is discharged, to retain its density and shape, but which resumes its natural bulk and condition upon being released from the package.

The importance of this invention to the milling interests of the country will be apparent when the results obtained with bran and mill offals are considered.

of which can be manufactured into fuel having an ascertained value of \$3.25 per ton in Chicago. This is done at a total expense of 70 cents per ton for the consolidated blocks on board vessel or cars at place of manufacture.

The value of these blocks as fuel, in comparison with Illinois steam coal, has been found to be such as to induce several large consumers to place standing orders for quantities at the price above named. The blocks possess the further merits of cleanliness, burning almost smokeless and ashless, and entirely clinkerless. For domestic purposes they are especially desirable, as they can be made of any shape or size.

The aggregate possible value of fuel from this source alone defies calculation, and still, in place of being a burden to the manufacturer, it disposes of a nuisance and source of danger about the saw mills, and the expense incident to the construction and operation of costly furnaces or burners with conveyers, etc., for consuming these heretofore valueless products.

This applies with equal force to planing mills, where the presence of an accumulation of shavings is especially hazardous; and it is estimated that the output of the large planing mills of this city during the busy season yields as high as 200 tons of shavings per day.

Cotton seed hulls and much of the straw and grasses abundant in many sections of the West are by the same means reduced to a fuel equaling in value coal or wood.

A superior article of stone of great density and beauty can be produced by machine from any of the elements com-

when the size of the joint is doubled, and the experiments of Poiseuille on the flow of liquids and gases through capillary tubes afford an explanation of this fact. The minute space between the lead joint and the socket caused by change of temperature may be looked upon as a capillary tube 2 or 2½ inches long, and Poiseuille found that in capillary tubes of this length, the flow of gas was proportional to the fourth power of the diameters. Consequently, if this view is correct, the leak caused by variation of temperature in a ¾-inch joint would be four times as great as in a ¾-inch joint, instead of simple double. This, at all events, shows the desirability of putting the large spigots in the large sockets, and not laying the pipes haphazard. Another fruitful cause of leaks is the absence of any provision for the longitudinal expansion and contraction of the main. In subways and other situations where the changes of temperature are great, expansion joints have been found to be indispensable, but this has not been considered necessary underground; consequently the lead joints in old mains are frequently forced outward, and a leak is the result. These unsatisfactory results are a consequence of systematic defiance of physical laws.

At first sight it would seem to be a very easy matter to devise a permanently gas-tight joint; but, unfortunately, this is by no means the case—indeed, I believe there are few more difficult problems. In the first place, it is evident from the foregoing considerations that the use of two metals is inadmissible, owing to their different coefficients of expansion; consequently we are limited to elastic substances like India-rubber or to rust joints for iron mains and soldered or screwed joints for very small mains and services. With regard to India-rubber, it is generally considered that the benzole vapor in the gas would act upon the joint and produce leakage. This, however, is not the case with the vulcanized material; and this form of joint has the advantage of allowing for both longitudinal and transverse expansion and contraction. There is an account of the practical application of the substance as a jointing material for mains in "King's Treatise on Gas Coal" (vol. ii, p. 358); but the results are so extraordinary as to lead to the conclusion that either the station meter must have registered incorrectly, or some mistake has been made in the calculations.

In the case of iron cement there would be no difficulty with regard to the transverse expansion, the material of the pipe and joint being similar; but stuffing boxes would be required at intervals, to allow of longitudinal motion caused by change of temperature. These might be inclosed in small brick pits to allow of tightening up and repacking periodically; but as the motion would be very slight it is probable that if made with asbestos or similar durable material the stuffing boxes would not require attention for many years, and so the brickwork would be unnecessary. To give notice of leakage, a ¾-inch pipe might be brought up to the surface fitted with a cap like a siphon-pipe, and examined periodically. By the use of lead service-pipes laid in wooden troughing it would be possible, in the majority of cases, to dispense with all joints between the main and the main cock in the consumer's house.

The foregoing remarks are merely intended as suggestions. The subject (simple as it seems) is a most difficult one, and requires much careful thought, which its great importance fully justifies.

The disturbance of gas mains by the subsequent operations of contractors for drains, sewers, water mains, etc., is a very important subject, and one on which, in my opinion, legislation is necessary. It is not at all unusual to find small mains broken across by the subsidence of trenches opened for these purposes; but the escape of gas in such cases is so great that attention is soon drawn to the spot. When, however, the result of the subsidence is merely to disturb or partially draw the joints, the leaks may go on for years, and the total loss to the company is probably far greater than when the main is actually broken. The average loss by leakage per joint per diem is about 1 cubic foot; and, judging from the great number of joints which on examination afford evidence of leakage at one time or another, I am of opinion that the bulk of the unaccounted-for gas is lost in such minute leaks as would take place by changes of temperature acting on the iron and lead. It would, I think, be very desirable to pass a law rendering it compulsory (under substantial penalties) upon contractors and others opening public roads to give notice to the local authorities of any main laid bare by their operations. The local board would then communicate with the gas or water company, as the case might be, and a check would be kept upon the way in which the work was done. It might even be specified in what way the main should be protected against subsidence, especially in cases where the line of drain or sewer, etc., made a less angle than (say) 10 degrees with the line of main. Such a law would only be affording a fair protection to companies. At present legislation is entirely on the other side.

Of course such modifications of the existing practice of main-laying would involve additional outlay; but the value of the gas saved by reduced leakage, when capitalized, would be found to represent a very large sum, which would be available for employing more perfect methods of jointing, allowing for expansion and contraction by changes of temperature, etc. Another invention or series of inventions may at any time make the cost of electric lighting equal to or less than that of gas. In such a case the adoption of the one or the other will be simply a matter of convenience and comfort; and few people who have been subjected to the discomfort and annoyance caused by leaky mains or services will hesitate which system of illumination to adopt. This, I venture to think, is another proof of the importance of this question.

We now come to the second division of the subject—viz., the testing of gas mains. This is a far more delicate operation than in the case of water, and unless proper precaution be taken it is very easy to condemn a tight main or pass a leaky one. These remarks apply only to the testing of dead mains (usually of large diameter) with compressed air; small mains being generally tested by filling them with gas and applying a light to each joint. When laid, the main is, of course, full of air at a pressure equal to a column of water 34 feet high or thereabouts. If we pump air into the main till the water gauge shows 18 inches pressure, it is evident that the absolute pressure in the main is 34 feet + 18 inches = 426 inches; and, by Boyle's or Mariotte's law, if the pressure in the main falls by leakage one inch, we know that 1/426 part of the total air in the main has leaked away. Knowing the diameter and length, we can thus easily calculate the leakage in cubic feet per hour for a given fall of the gauge.

The following table shows at a glance the amount of leakage in cubic feet per hour corresponding to a fall of

one inch per hour—viz., from 18 to 17 inches for 100 yards of main of various diameters:

Diameter of Main, Inches.	Area in Square Feet.	Capacity of 100 Yards in Cubic Feet.	Leak in Cubic Feet corresponding to 1 Inch Fall in the Gauge.
4	0.0872	26.16	0.061
6	0.1963	58.90	0.138
9	0.4418	132.54	0.311
12	0.7854	235.62	0.553
18	1.7672	530.16	1.24
24	3.1416	942.48	2.21
30	4.909	1472.70	3.46
36	7.068	2120.60	4.98
48	12.566	3769.90	8.25

If the main is 200 yards long, the leak indicated by one inch fall of the gauge is twice as great. When we have (say) 5 miles of 30-inch main to test, one inch fall on the gauge represents a loss of 304.4 cubic feet, and consequently 1/4 inch fall in an hour represents 30 cubic feet loss per hour, or 720 cubic feet per diem. It is evident, therefore, that at least one hour's duration of test is necessary; and this being so, we must now examine the effects of changes in atmospheric temperature and pressure.

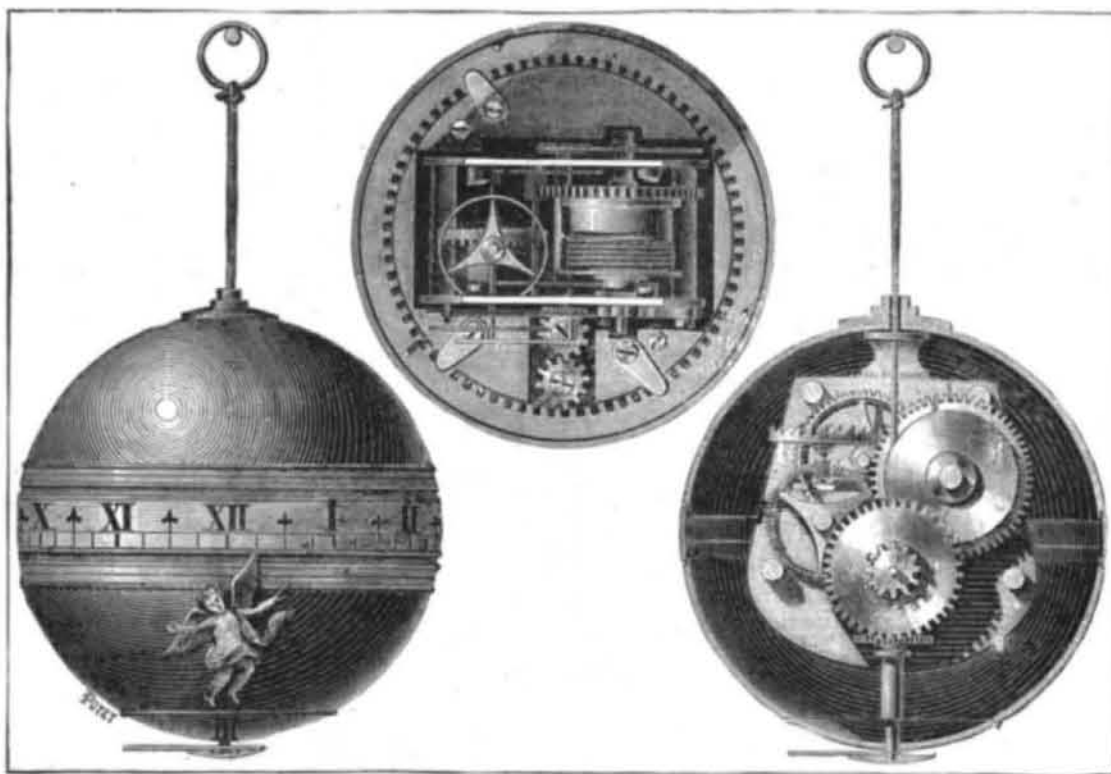
It is generally impossible to test an exposed main satisfactorily in this manner, owing to the rapid changes of temperature; but when the trench is filled in, or even if the main is just covered with soil or water, the hourly changes of atmospheric temperature have no perceptible influence on the gauge. With the variations of the barometer it is otherwise; and to test a large main properly a good barometer (preferably an aneroid) is essential, since variations in the height of the mercurial column to the extent of 0.02 and 0.3 inch of mercury per hour are of daily occurrence, and occasionally the range is much greater. Mercury being about 13 times as heavy as water, bulk for bulk, the above figures correspond to a rise or fall of 0.26 and 0.39 inch per hour on the water-gauge. The main, in fact, acts similarly to a water barometer. When the atmospheric pressure rises, the water in the gauge attached to the main is depressed, and vice versa. Turning to the table, we find that one inch fall per hour in 100 yards of 30-inch main represents a leak of 3.46 cubic feet per hour, and consequently 0.26 inch fall in 5 miles of 30-inch main represents 79 cubic feet per hour. That is to say, 5 miles of perfectly tight 30-inch main would show a leak of 79 cubic feet per hour (1896 cubic feet per diem), owing to a rise of 0.02 inch per hour in the baro-

meter. Indeed, as wet weather is usually accompanied by a falling barometer, the reading of the gauge, when uncorrected for changes in atmospheric pressure, is generally favorable, and is often higher at the end of the test than it was at the beginning. Then, again, the porosity of the metal of which the pipes, and more especially the irregulars (bends, tees, siphons, etc.), are composed is said to be the cause of any leak which may be indicated. Now it is quite true that the bosses made by filling up the holes by which the core was supported are frequently unsound; and it is always advisable to put irregulars under pressure, and paint them over with soap and water, by which any leak is at once detected. But there is no such thing as general porosity. If a leak takes place, it is always at a part of the casting which is composed of drossy metal, or from some other defect equally apparent. Ordinary cast iron is practically impervious to gas or air. So also with regard to the magnitude of the leak or leaks. We may be quite sure that to have an appreciable effect on such a large bulk of air as is contained in several miles of (say) 30-inch main, the escape must be considerable, and no slight bubbles found by applying soap and water to the union or other parts of the testing gauge will be sufficient to cause even 1/4 inch fall per hour (after correction by the aneroid). The joint at fault will be found to have possibly an eighth or a quarter inch hole, from which the air will be issuing with sufficient noise to be heard three or four yards off. This is my own experience, and is fully borne out by theory, which indicates that 1/4 inch fall is represented by a leak of about 16 cubic feet per hour—a very appreciable amount.

Finally, with reference to the degree of soundness practically attainable, I can only state that 5 miles of 30-inch main have been laid, on which there was absolutely no leak whatever, so far as the most careful and prolonged tests (five or six hours) could show; and that which has been done once can be done again. The great thing is to be reasonable in one's expectations; and the only way is to calculate for each testing how many cubic feet per hour a certain fall of the gauge is equivalent to. If this be not done, it is perfectly easy to condemn a 4-inch main because it is losing half a cubic foot per hour, or to pass as sound a 48-inch main which is leaking at the rate of hundreds or even thousands of cubic feet hourly.

#### ANCIENT SPHERICAL CLOCK.

The small clock represented in the annexed cut appears to be of interest because of its rarity. Up to the present



FRENCH SPHERICAL CLOCK OF THE 17TH CENTURY.

metric column. On the other hand, if at the time of testing the atmospheric pressure happened to be falling at the rate of 0.02 inch of mercury per hour, the 5 miles of 30-inch main would apparently be tight, although leaking at the rate of 79 cubic feet per hour.

Before making the one-hour test it is essential to allow half or one hour to elapse after pumping in the air, unless this latter operation has extended over three or four hours. This interval is necessary to allow the air to find its normal temperature, as the act of compression is attended with the evolution of heat; and if a main be pumped up quickly to 18 inches pressure, it will generally be found to lose 0.2 or 0.3 inch in the first half hour or so, afterward remaining stationary, provided it be tight, and no change is taking place in the height of the barometer. Conversely, if a main be pumped up to 20 inches pressure, and then sufficient air is allowed to escape to reduce the pressure to 18 inches, the inclosed air will have been cooled by expansion, and the (comparatively) hot sides of the main will gradually raise the pressure to 18.2 inches. It is thus evident that a loss of 0.2 inch for the first half hour after pumping up might be undetected by testing immediately, and thus a leaky main be passed as sound.

Minute leaks on the gauge are unimportant when testing long lengths of large main, since they rarely amount to 1 cubic foot per hour; and, as we have seen above, this in 5 miles of 30-inch main would be represented by about 0.3 inch on the gauge—quite an inappreciable amount. It is, however, far more satisfactory to have a tight gauge, and a piece of bent glass tube is by far the safest instrument. If the actual head of water be taken, not relying on a mark made on the gauge at the level of the water at the commencement of the test, it is immaterial if some of the water leaks away during the trial.

It is frequently asserted that wet weather is unfavorable for testing mains by compressed air, owing to the great condensation which takes place, whatever that may mean. My experience is in accordance with what theory would indicate—viz., that the dryness or dampness of the atmosphere is without the slightest effect on the results of the testing.

time I have not been able to find it described in any works on clock making, either at the Conservatoire des Arts et Metiers, or the museums, or even among amateurs.

Running by its own weight, and arranged for suspension, it is perfectly adapted for use on a pleasure boat or on a gondola, whence, perhaps, its name "Venetian Ball," notwithstanding its French make. Its construction dates back to the beginning of the seventeenth century. It consists of two hemispheres of gilded copper fixed to an internal ring, and having between them an empty space in which revolves freely a silver circle analogous to the one in revolving circle clocks. This circle carries, engraved upon its surface, the hours, as well as divisions corresponding to the quarters. The hour and its fractions are indicated by the extremity of the wing of an angel fixed in relief on the surface of the lower hemisphere, and which serves as an index or hand.

Beneath the lower hemisphere projects a rod which is in the axis of the ball, and which makes one revolution per hour, and carries a needle that presents itself in front of a dial divided into four parts that correspond to the quarters of an hour. This needle serves at the same time for setting the circle.

The wheelwork, which is mounted in a case between two pillar plates, consists of a fusee and a series of wheels and pinions, as usual, which terminate in a scape-wheel controlled by a verge escapement. With the wheels of this train gear those that revolve the circle and the rod placed in the axis of the ball. The cord which issues from the upper hemisphere, after traversing a tube that guides it, is fixed by one extremity to the cylinder of the fusee. The other extremity serves for suspending the ball. What is peculiar in the arrangement of the fusee is that, while acting as a barrel, it contains a spring which, in measure as the ball descends through its own weight, and the cord unrolls, winds up; so that, as soon as the ball is raised up, the spring reacts, causes the cylinder to revolve, and winds up the cord again. The winding is thus performed automatically, without the use of a key. The balance-wheel is of iron. The scape-wheel is large, as in all watches and clocks whose escapements were made before the discovery of the balance