WATER AND GAS WORKS APPLIANCES

MANUFACTURED BY

R. D. WOOD & CO.

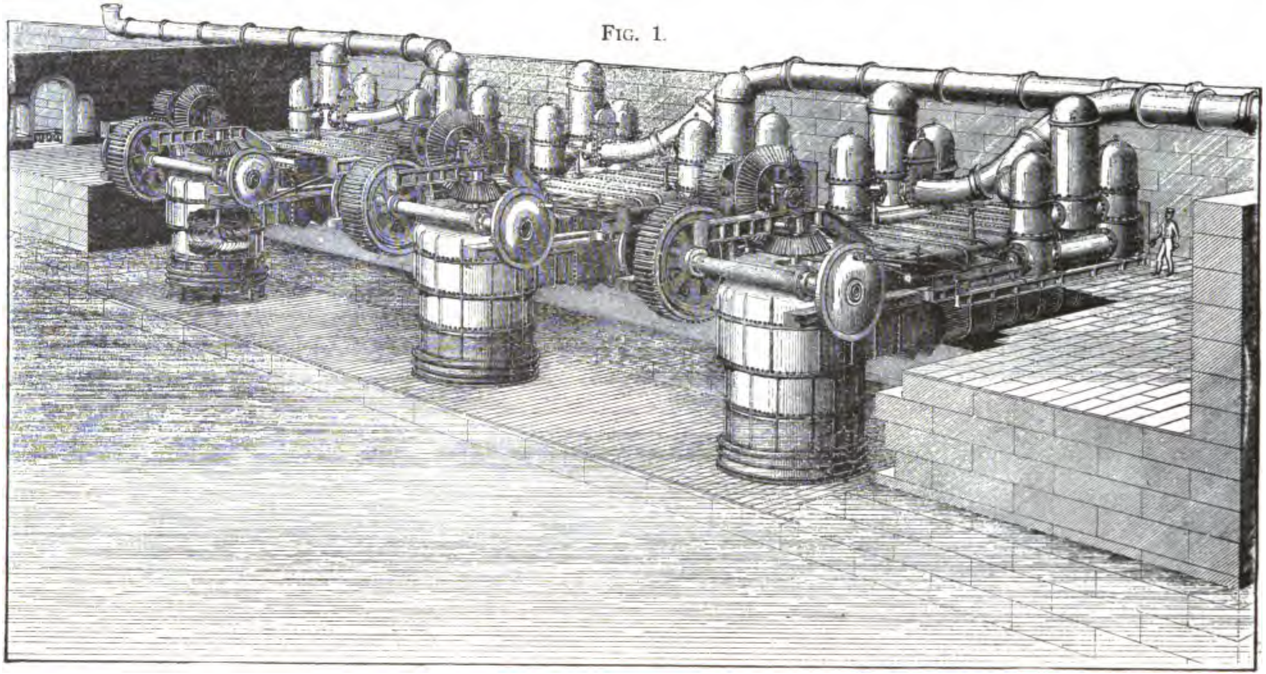
Engineers, Founders, and Machinists,

PHILADELPHIA.

FAIRMOUNT PUMPING MACHINERY, PHILADELPHIA.—Constructed by Emile Geyelin, M. E.

From General Design by Frederick Graff, Chief Engineer.

Fig. 1.



F. F. Maher

WATER AND GAS WORKS

APPLIANCES

MANUFACTURED BY

R. D. WOOD & CO.,

ENGINEERS, FOUNDERS, AND MACHINISTS.

ESTABLISHED 1814.

OUR SPECIALTIES ARE:

CAST-IRON WATER AND GAS PIPES, FIRE-HYDRANTS, LAMP-POSTS, STOP-VALVES FOR WATER AND GAS, TURBINES, HYDRAULIC MACHINERY.

PHILADELPHIA, PA.:
R. D. WOOD & CO.,
OFFICE: 400 CHESTNUT STREET.
FOUNDRIES AND MACHINE SHOPS: Millville and Florence, N. J.
1881.

PREFACE.

SIX years since we issued a small pamphlet that seemed to us quite incomplete and unsystematic; but the edition was called for more rapidly than we had anticipated, and its success indicated that it was acceptable, and in some measure supplied a want. We have in this pamphlet endeavored to respond more fully, and to supply some useful general information, as well as to set forth the special merits of our manufactures.

By permission of the Publisher, we are enabled to insert herein for the benefit of our patrons, a considerable number of excerpts of hydraulic tables and text explanatory thereof from the new and elaborate Treatise upon

American Water Supply Engineering,

by Col. J. T. Fanning, C. E., recently issued by D. Van Nostrand, Publisher of Scientific Books, N. Y.

Since the issue of our previous pamphlet we have greatly enlarged our Foundry and Machine-shop facilities, and are prepared to furnish

Cast-iron Gas and Water Pipes, and Plain Lamp-Posts,

much more rapidly than before; and we have also secured control of the following patented improvements in the gas and water supply departments, which our experience confirms are of the best, each of its kind.

We therefore respectfully call attention to, and are prepared to fill very promptly the largest orders with which we may be favored, for

Geyelin's Jonval Turbines,
Geyelin's Duplex Turbines,
Mathew's Fire Hydrants,
Eddy's Stop Valve, for Water and Gas.
Meter Lamp-Posts,
Graham's Anti-Freezing Lamp-Posts,
Gas Pipe Cap-Joint, for Cement Joints,
Hydraulic Machinery,
Heavy Machine Castings, Gearing and Shafting.

Asking a favorable consideration, and soliciting a special examination of those parts of our little book relating to our manufactures, as well as of the standard merits of those manufactures, we are, respectfully,

R. D. WOOD & CO.

PHILADELPHIA, 3d Mo., 1st, 1877.

In issuing this our Second Edition we have added some tables and other matter, of which we give a list below. They are not included in the general Index.

PHILADELPHIA, 3d Mo., 1st, 1881.

CONTENTS.

INDEX.

TURBINES, PUMPS. AND GEARING.

MANUFACTURED BY R. D. WOOD & CO.

Our Heavy Machinery Manufactures.—We desire to respectfully call attention to the superior class of Turbines and Pumping Machinery now manufactured by us. and to our extensive and excellent foundry and machine-shop facilities for the production of heavy machinery in large quantities. Our exhibits at the recent Centennial Exhibition in Philadelphia, including loam castings for turbines, fourteen feet in diameter, cored out into intricate shapes; large bevel-gears, with machine-shaped teeth; a variety of complete Jonval turbines; and penstock castings and water-pipes of seventy-two inches diameter, were not in their classes excelled in mechanical perfection by any other exhibits. and were by no means equalled in magnitude.

TURBINES.

We are making the manufacture of the *Geyelin-Jonval Turbines* a specialty, and have during a number of years past been enlarging and improving our facilities, and adding new and improved boring mills, and gear-cutting machines with capacity to shape gear-teeth with the nicest accuracy on bevel and spur wheels up to twelve feet diameter, so that we are now prepared to manufacture *turbines*, *pumping machinery*, *gears*, *shafting*, and all classes of *hydraulic machinery* with promptness and with superior workmanship.

Historical Notice of our Turbine.—The Jonval wheel was originated and manufactured in France by the distinguished inventor whose name has remained associated with it, as a successful rival of the justly celebrated, though expensive, Fourneyron turbine. Its first introduction was in the large paper-mill at Pont d'Aspach, near Mulhouse, France, where a committee of the *Société Industrielle de Mulhouse* made an elaborate test of its mechanical efficiency. This pioneer wheel exceeded eighty per cent. in effective duty, according to the report of M. Amedé Rieder, of the committee. This remarkable result, with the simplicity of form, fewness of parts, and perfection of design, in that early day of turbine history, at once drew to the wheel the attention of the most learned mechanicians of Europe.

Soon after the Jonval wheel had established a reputation in France and Great Britain, Mr. Emile Geyelin (now associated with us), who in his profession of Mechanical Engineer had become familiar with their manufacture, under the direction of the inventor, introduced these wheels into America. One of the first of these wheels constructed in America was erected at the well-known powder-works of the Messrs. E. J. Dupont, de Nemours & Co., and was there subjected to a thorough scientific test by a competent committee selected from members of the *Franklin Institute*, who reported an efficiency of .783 per cent.

After the successful introduction of this wheel in this country, the Engineer of the Philadelphia Water-works recommended that one of the Geyelin-Jonval Turbines be substituted for one of the large breast-wheels at the Fairmount pumping-station, and subsequently the Geyelin-Jonval wheels have replaced all the large breast-wheels formerly used at the Fairmount station.

A portion of the wheels, as placed by our engineer, Mr. Geyelin, are shown in the illustration Fig. 1, facing the title-page.

Shortly afterwards, the iron over-shot wheels of the Montreal Water-works began to be replaced by the Geyelin Turbines, notwithstanding the original wheels were constructed by Mr. Fairbairn, in England, the most celebrated constructor of over-shot wheels in the world.

The Geyelin wheels were subsequently adopted for the Richmond and other city water-works, and in many mills in New England, the Middle and Southern States.

Our wheel is thus seen to have been originated by an expert mechanician, introduced here by a skilled mechanical engineer, tested with successful results several times in the hands of the ablest scientific experts, and adopted by leading manufacturers and upon the recommendations of expert hydraulic engineers. It has continued to increase in favor from its first introduction, while its only rival at the start, the Fourneyron, now rarely finds a purchaser, because its cost is so much greater for equal efficiency.

We have taken the liberty to refer thus briefly to the history of the successes, during many years, of our wheel, for the information of those manufacturers who have not already adopted them, and to show their original and continued superiority to the innumerable contrivances and imitations of the Jonval and Fourneyron wheels forced upon the market by extensive advertising, that depend upon cheapness, through lack of finish and lack of special adaptation, for their sale, rather than upon mechanical excellence, and that are to a fearful extent wasting the valuable water-power of the land.

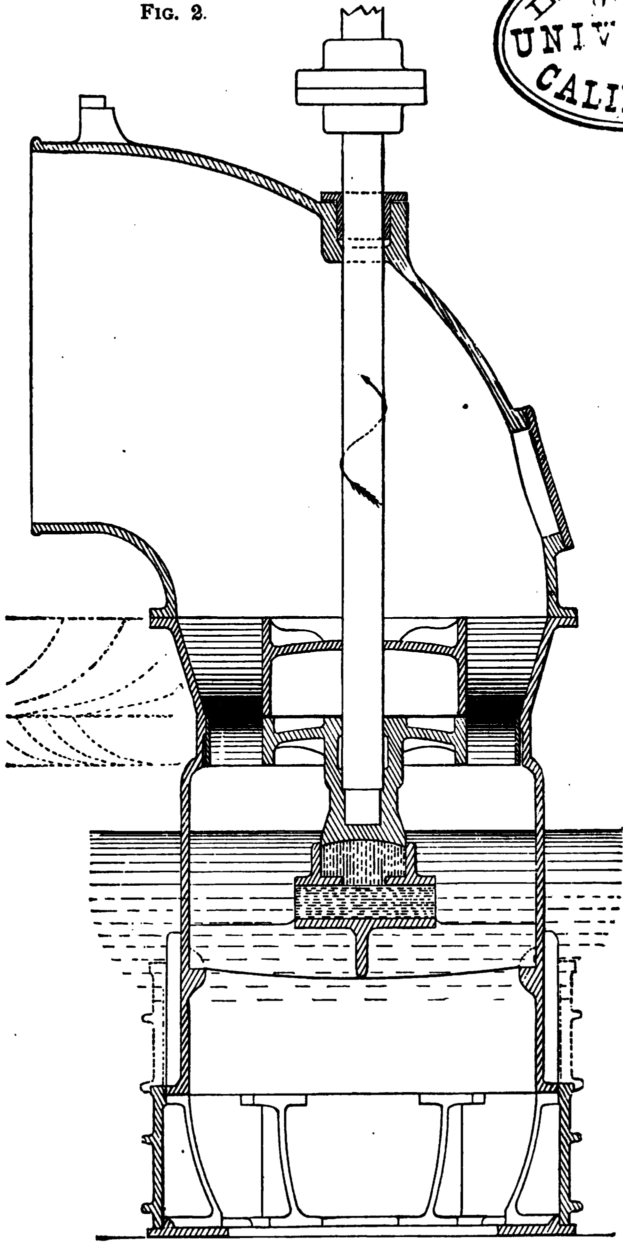
Value of Special Adaptation.—One of the first elements of success in a turbine is accuracy of proportions in its parts.

It is well known that when a turbine is constructed to yield a given power under a given head and is perfectly successful in its proper place, it may not as successfully give a like power under a greater or less head, with less or more water. With each change of head, for a given power, there is change of volume of water required, and change of velocity of water through the wheel, and of velocity of wheel, and of effect of impact of water on the movable buckets, and each such change affects the breadths of the buckets of both stationary and movable wheels, the dimensions of their issues, and the relations of their curves. Turbines, for any given power, cannot be produced with universal excellence for different heads of water from one mould, like the lamp-posts of a great city, but each one, to reach the highest success, should be especially designed for its special work and surrounding circumstances.

The success of our engineer, Mr. Geyelin, during his quarter century of experience among American water-powers, may be attributed very largely to his special studies to adapt every wheel to its particular duty under its given conditions.

Varied Styles of Wheels.—Following out the principle of special adaptation, we are now constructing one style of wheel, with the necessarily varied proportions, for medium heads of water, varying from about six to thirty feet, which is similar in its general arrangement to the original wheel of Jonval, though improved in minor details; a *second*

Fig. 2.



MANCHESTER TURBINES.

Constructed by R. D. Wood & Co., 400 Chestnut St., Philadelphia.

style of wheel for extremely high heads, in which the Jonval principle is applied to two wheels with balanced end thrusts upon a horizontal shaft; a *third* style of inverted wheel for extremely low heads; and a *fourth* style of wheel which we apply with great success to streams with variable supplies of water, or where the power used is variable. In this last wheel is embodied the advantages of the Geyelin Duplex Patent, which is secured exclusively to our use.

Geyelin's Plain Jonval Turbine.—Referring more in detail to these four styles of wheels which we manufacture, we desire to call attention to the remarkable simplicity of design and strength of the few component parts of the first, the plain Jonval wheel, for medium falls of water. Fig. 2 shows an adaptation of a one-hundred horse-power wheel of this class for work under a forty-five feet head, for driving the pumps of the Manchester Water-works. It is similar in general arrangement, with exception of upper part of case, to the Geyelin wheels constructed for the public water-works at Augusta, Ga.; Lancaster, Pa.; Cohoes, N. Y., and other cities, as well as those above mentioned. The controlling gate is a plain section of a cylinder in one piece, easily operated or controlled by a governor, and not liable to get out of order, and is more positively tight when closed than any other class of gate. This wheel may be placed with success at a level between the surfaces of water in the fore-bay and in the tail-race, the case alone being extended beneath the lower water. The movable wheel and guides are therefore readily accessible for examination at any time when the wheel is not in motion. The discharge of water through these wheels is downward, in a general vertical direction, and the bends and distortions of approach and departure of the water is less than in any other wheel. The casing below the wheel may, however, be bent in any direction or continued to any distance that exigencies of the case may require, when there are quicksands or rocks to be avoided in the wheel-pit. Such expedient has been adopted and the water made to discharge horizontally for some distance, then vertically, so as not to endanger foundations of a mill upon a weak or treacherous substratum.

We take pleasure in referring to a series of our turbines of different diameters, recently placed in the Augusta Paper Mills, near Wilmington, Del., as specimens of this class, which are unsurpassed for efficiency or reliability. Their bevel pinions are each provided with feathers and screws, so they can be promptly put in or out of gear as the variations of the stream shall make desirable, and each turbine is suspended upon glass bearings for additional security against wear of the steps.

Double Jonval Turbine.—For heads of from forty-five to one or two hundred feet, our *double Jonval turbine* with horizontal shaft is most admirably adapted. This wheel is shown in Fig. 3. It is seen that the water is admitted between the two wheels and issues in opposite directions. By this arrangement the thrust of the high head is evenly balanced and produces no strain or friction upon the bearings. Among the earliest of the wheels of this class, designed by Mr. Geyelin, was one for a cotton-mill in Saltillo, Mexico. This double wheel is 11 inches in diameter, works under 160 feet head of water, produces 125 horse powers, and propels a cotton-mill of 10,000 spindles with preparation.

Inverted Jonval Turbine.—For low falls our *inverted turbine*, which introduces also the best features of the Jonval wheel, stands unrivaled. They are favorite motors where they have been used, and they have been well tested in flour and saw mills in the Atlantic States. We construct them with either "damper" or "cylinder" gates, as de-

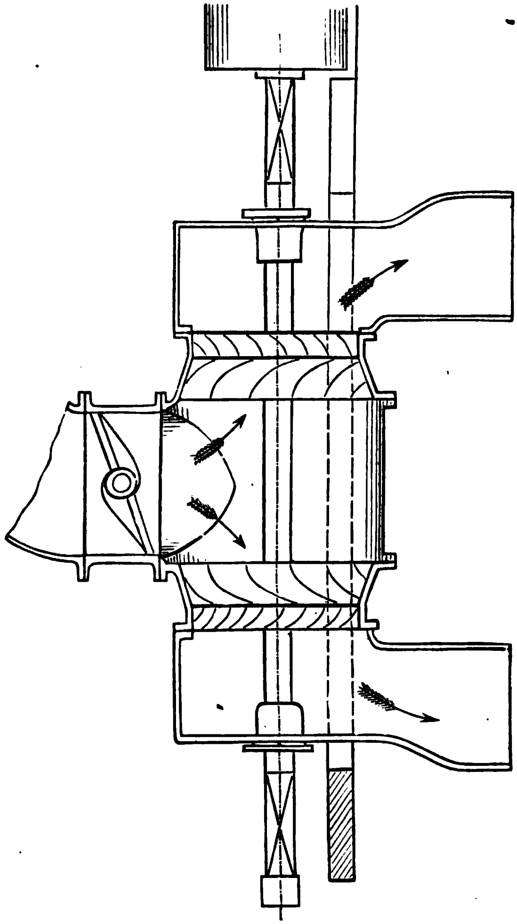


FIG. 8.

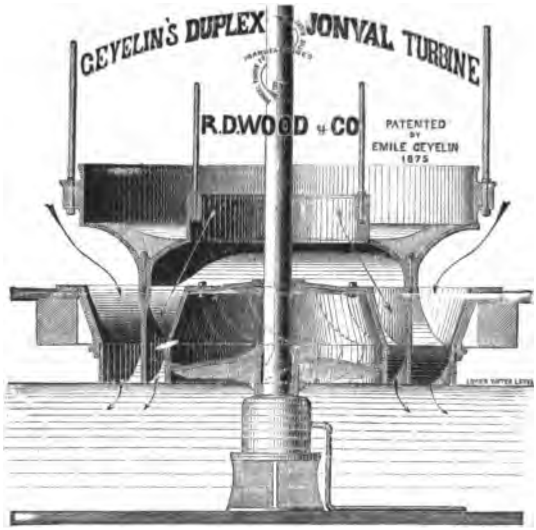
HORIZONTAL DOUBLE TURBINE.

sired. The flow being upward through them, the wheel runs extremely light upon the step.

Geyelin's Duplex Jonval Turbine.—For streams that are variable in flow, and for work that is variable from hour to hour, or from day to day, we now offer *Geyelin's Duplex Jonval*, the most perfect adjustable turbine yet devised that is free from complexity of design and intricate manipulating apparatus. This is a result of many years of study and experiment to meet a special demand, and it has recently been brought to its full perfection, and its valuable features are protected and secured to us by letters patent.

Fig. 4 illustrates one form of this wheel as it is placed in a flume. The stationary and the movable wheels are each divided by a vertical partition, which gives two separate water compartments to each wheel, each having a gate that may be controlled independently. The approach of the column of water to the inner compartment is from within the inner cylindrical gate, and the approach to the outer compartment is from without the outer cylindrical gate, as indicated by the arrows in the figure. Each gate is supported by independent rods, and the gates may be operated independently or in unison. The guides and buckets of each compartment are carefully proportioned and curved for the given head and speed required, and a wheel is thus produced which is capable of yielding three distinct powers, each under favorable conditions for economy of water. The inner compartment, as a perfect wheel, yields the lesser power, and may yield it alone with economy when the outer gate is closed; the outer compartment yields an increased power and may also yield it alone; while the two compartments together yield the maximum power of the wheel, with all the advantages of the plain Jonval. We may in this wheel take advantage of the draft-tube, place the movable wheel above low water level, use the simplest and tightest cylindrical gate, have ease of control of gates by governor, and still have simplicity in form, strength and durability of the few parts required, unexcelled efficiency of action, and comparative economy of manufacture. We apply also to this wheel our improved hydraulic step, which gives lightness of motion and reduces wear to a minimum.

FIG. 4.



Its Superiority for Variable Streams.—None of our streams are entirely free from the annoyances of back-water during times of flood, and lack of water during seasons of drought. We are now able to neutralize the disadvantages of such variability, and without the use of a series of turbines, for we can proportion the larger compartment of the duplex wheel to perform the ordinary work at ordinary stages of the stream, with economy, and the inner compartment to use the diminished supply with economy, and then when the floods come and back up the water in the wheel-pit more than it rises in the fore-bay, we can apply both compartments to the work, and use enough water to give the full required power from the diminished head of water. The same mechanical advantages may be availed of, by use of the Duplex Jonval in those powers, usually of great magnitude, bordering upon tide-water where the ebb and flow in the tail-race constantly changes the available head of water, and where the work of each turbine is constant, as when driving pumping machinery for public water supplies.

Actual Test of comparative results obtained by a "Geyelin Duplex Jonval Turbine" at the Social Mills, Woonsocket, R. I., made in conjunction with a double-cylinder Corliss engine, 30 inches diameter of cylinders. Date of experiment, January 20; 1880.

Total area of discharge in the Turbine, . . .	453·75 sq. in.
Outer division, ...	285·00 sq. in.
Inner division, ...	168·75

The condition of the steam-engine, with Turbine entirely detached, running alone, driving the whole mill, was as follows:

Area of cylinders, ...	699 3434 sq. in.
Speed per minute, ...	572·64 ft.
Average pressure during the test, . . .	37·06 lbs.

Thus showing $\frac{699\ 3434 \times 572{\cdot}64 \times 37{\cdot}06 \times 2}{33000} = 912{\cdot}52$ horse-power.

EXPERIMENT WITH *INNER* DIVISION.

Condition of the steam-engine with the inner division alone open:

Area of cylinders, ...	699·3434
Speed of steam-engine per minute, . . .	572·64 ft.
Average pressure during the experiment .	35·34 lbs.

Showing $\frac{699{\cdot}3434 \times 572{\cdot}64 \times 35{\cdot}34 \times 2}{33000} = 857{\cdot}72.$

The power necessary to drive the mill being 912·52, the power contributed by this *inner* division of the Turbine is thus 912·52 —857·72, or 54·80 horse-power.

EXPERIMENT WITH *OUTER* DIVISION.

Condition of the steam-engine with the outer division alone open:

Area of cylinders, ...	699·3434
Speed of steam-engine per minute, . .	572·64 ft.
Average pressure during the test, . .	33 97 lbs.

Showing $\frac{699{\cdot}3434 \times 572{\cdot}64 \times 33{\cdot}97 \times 2}{33000} = 824{\cdot}48.$

Total power necessary, 912·52 horse-power. The power contributed by this outer division of the Turbine is thus 912·52 —824·48, or 88·04 horse-power.

EXPERIMENT WITH TURBINE *FULL OPEN*.

Condition of the steam-engine when both the *inner and outer divisions were full open:*

Area of steam-cylinders, ...	699·3434 sq. in.
Speed of pistons, ...	572·64 ft. per minute.
Average pressure of steam during the experiment,	31·10 lbs.

Showing $\frac{699\cdot3434 \times 572\cdot64 \times 31\cdot10 \times 2}{33000} = 754\cdot82.$

Total power necessary to propel the mill with steam alone, 912·52 horse-power, thus showing 912·52 —754·82, or **157·70** horse-power.

RESULTS OBTAINED.

	Sq. Inches.		Horse-Power.
Area of discharge in Turbine, small,	**168·75**;	power produced,	**54·80**
" " outer,	**285·00**;	" "	**88·04**
" " total,	**453·75**;	" "	**157·70**

showing that the Turbine, producing the power for which it is calculated, will, with 0·625 per cent. of total amount of water, fall but 11 per cent. below the maximum efficiency of the water used.

It will be noted that the speed of the Turbine, running in conjunction with the steam-engine, necessarily remained the same during the three conditions under which the Turbine operated. In conclusion, it is to be stated that each division has its own gate and gate-motion, whereby, while the Turbine is running and without stopping the mill, the variable quantities of water can be admitted giving the powers above stated.

I hereby certify that the above statement is correct.

CHAS. NOURSE,
Supt. Social Mill.

Expert Tests.—During the very exacting and accurate test ordered by Chief Engineer Fanning of one of the wheels placed by us in the Manchester pumping station, an efficiency of .83 per cent. was shown, with a head of forty-five feet. At the recent Centennial Exhibition in Philadelphia, an elaborate testing apparatus was prepared by the commissioners in the hydraulic annex. In the series of tests with this apparatus, under the direction of Col. Samuel Weber, one of our plain Jonval wheels, venting 1500 cubic feet of water per minute, gave .84 per cent. of useful effect, and a similar Geyelin duplex Jonval turbine, venting at maximum 1598 cubic feet of water per minute, gave a useful effect of .77 per cent. when venting 1040 cubic feet per minute, or less than two-thirds of its maximum capacity. Each of our turbines subjected to the Centennial test were just from the shop and very closely fitted, so that the movable wheels suffered the disadvantage of a slight bind, which reduced appreciably, for the time of test, their mechanical efficiency. Our wheel is therefore seen to maintain its high standing in the hands of the most competent hydraulic experts.

Economy of Hydraulic Power.—The great saving in operating expense where hydraulic power is used at public water-works pumping stations, is conclusively shown in the following extracts from the report of the Philadelphia Water Department for 1875, showing the cost of raising water to the reservoirs per million gallons, viz. :

By Water Power....	Fairmount Works....	Lift 125 feet....	Cost $\$2.28\frac{24}{100}$.
" Steam "	Schuylkill "	" 125 "	" $19.42\frac{68}{100}$.
" " "	Delaware "	" 125 "	" $16.93\frac{7}{100}$.
" " "	Belmont "	" 180 "	" $14.63\frac{89}{100}$.

Glass Suspension-Box.—We would call special attention to Geyelin's patent glass suspension, which is a complete and most reliable substitute for the old-fashioned step in turbines. This glass box is equally applicable to any other heavy upright shafting. Thus, in place of supporting the weight of the water and movable parts of the turbine on a step below the turbine, we suspend it on a circular disk composed of segments of glass, which segments are so arranged as to be movable by means of depressed divisions. These divisions are held down by screws, or otherwise, and, being depressed below the level of the glass segments, form a continuous space all round each segment of which the disk is composed, thereby allowing, while the turbine is in motion, a perfectly free circulation of the lubricating matter with which the space is filled.

On these glass segments, which are stationary, revolves a perfectly true metal ring, which ring is firmly secured to the turbine shaft.

The great advantage which we claim, by using the glass suspension-box in conjunction with or in place of the step, is the avoidance of expensive and disagreeable work in getting below the turbine to readjust or renew the step. The wearing down of steps is especially liable to occur in the early spring, when the water is cold and in many cases charged with grit that cuts the wood. By the use of the glass suspension-box this is entirely avoided, and, since it is placed above the turbine it is as easily taken care of as an ordinary bearing.

MANCHESTER, N. H., Eighth Mo., 4, 1880.

E. GEYELIN, ESQ.:

DEAR SIR — Yours of the 3d, inquiring about how the pumps work, I will answer it by saying they are not excelled in any place or city in this country that I hear from. The greatest improvement at the pumping-station is the glass bearing that was put on the shaft to relieve the step on the water-wheel.

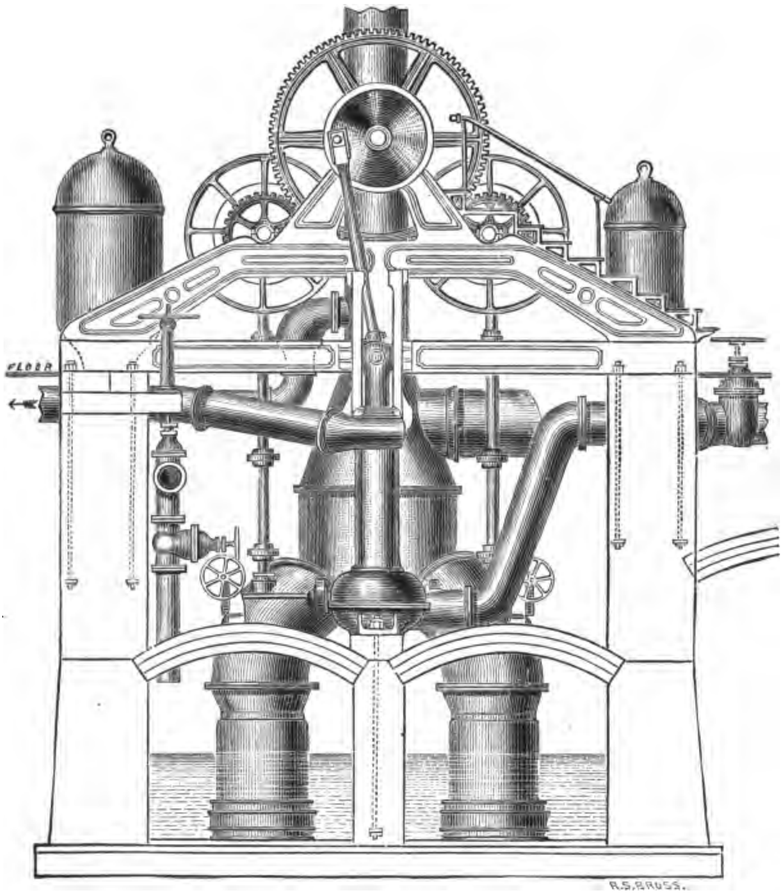
Since you put this suspension bearing on, this wheel has carried both sets of pumps since March, 1878, being over two years, without a thing being done to the bearing or step, and this under a 43-foot head.

You will see, by the reports of 1878 and 1879, that we pump over 7500 hours each year, and used to have to put in two new steps each season; and to-day the same wheel runs just as nicely as it did two years ago last March.

Yours truly,

(Signed) CHAS. K. WALKER.

FIG. 5.



MANCHESTER PUMPING MACHINERY.—CONSTRUCTED BY R. D. WOOD & CO.

FROM GENERAL DESIGN BY J. T. FANNING, CHIEF ENGINEER.

HYDRAULIC MACHINERY.

Fairmount Pumps and Turbines.—The hydraulic pumping machinery erected at the Fairmount station in Philadelphia, by our engineer, Mr. Emile Geyelin, from general designs by Frederick Graff, chief engineer, are the largest of their kind in America. A portion of the works only is shown in Fig. 1. Works similar in design, and for like service, have also been erected under the direction of our engineer in several other cities.

Manchester Pumps.—We take pride in referring to the hydraulic pumping machinery, Fig. 5, of the Manchester, N. H., Water-works, constructed by us from the general designs of Col. Fanning, Chief Engineer, as among our most recent constructions of hydraulic machinery. These works, of 5,000,000 gallons capacity per diem, comprise two pairs of vertical bucket and plunger pumps, each pair having its independent turbine, but so arranged that either turbine may be made to propel either pair, or both pairs of pumps. The ordinary work of these pumps is a uniform delivery of water into the city reservoir, but the design of the chief-engineer adapted them as well to *direct pumping* service, and they were used for such service during a whole season while the reservoir was in process of construction. Each detail was carefully studied, and they are undoubtedly the most admirably adapted set of pumping machinery for direct pressure service yet erected, and their regular work, under the care of C. C. Cole, Esq., the efficient mechanic in charge of the station, proves them equally adapted for the ordinary reservoir service.

To each and all of the above examples we respectfully refer, for illustrations of our ability to adapt our manufactures to their special work, to produce works in our line from the least to the greatest magnitude, and of our facilities for reaching mechanical excellence in all requirements of

TURBINES,

SHAFTING,

GEARS, MORTISE AND BEVEL,

HYDRAULIC MACHINERY, and

HEAVY MACHINE CASTINGS.

Diameters of Turbines.—As a guide to the approximate diameters of our smaller plain Jonval turbines for given powers under given heads, we submit the following table:

TABLE No. 1.
HORSE-POWER OF TURBINES.

DIAMETERS.	HEIGHTS OF FALL.				
	10 Feet.	15 Feet.	20 Feet.	25 Feet.	30 Feet.
Inches.	*Horse Powers.*				
25	9.47	17.25	26.4	37	48.8
30	13.9	25.2	39.6	55.2	72.2
36	19.8	35	54.5	76.9	100
40	24	44	68	95	126
46	32	62	94	135	173
52	40.7	80	120	175	220
57½	53	95	156	218	280
62	67	110	193	262	340

Measurements and Improvements of Water-Powers.—There are such full discussions upon the amount of water that can be made available from given watersheds, measurements of streams, storage of water for power, volumes of flow of streams in droughts and in floods, and of the proportions of waste-weirs and dams in the "Treatise upon Water Supply Engineering," recently published by Van Nostrand, that we cannot do better than to refer the reader to the book for information in detail relating to these matters.

TESTIMONIALS.

PHILADELPHIA, 22d Feb., 1873.

E. GEYELIN, ESQ.:

DEAR SIR—We were the first in the United States to put in a large Jonval Turbine. Since then we have used no other description of water-wheel. We took out very perfect breast-wheels and put in the Jonval. We took out another description of iron water wheel and put in the Jonval. We have six of them now running. We do not think it possible to get a more perfect wheel, when properly made and put in in a proper manner.

It gives us great pleasure to give you this testimonial to good effect of the Jonval Turbine, though we should think that a wheel so thoroughly tried and approved did not need any at this time. Very truly.

(Signed) JESSUP & MOORE.

OFFICE OF HARMONY MILLS,
COHOES, March 15, 1873.

EMILE GEYELIN, ESQ., Philadelphia, Penn.

DEAR SIR—In answer to yours of the 27th, I would say that the four Jonval Turbines we have in use of your make and pattern continue to give good satisfaction Know of no wheels of better construction, or that give better results than these; have been in use the past twelve years, and are as good to-day for work as when first started. Yours truly,

(Signed) D. P. JOHNSTON.

WAUREGAN, March 3, 1873.

E. GEYELIN, ESQ.:

DEAR SIR—The three wheels you made for us some years since are giving good satisfaction, and I do not perceive any diminution of power, by wear or otherwise, from the time since started. The arrangement of them with the gearing and main driving work is considered one of the finest in New England.

We are now doing at least 50 per cent. more work with the same amount of water that we used to do with our former wheels; we are now running some 1200 looms with all the preparation. Yours truly,

(Signed) J. S. ATWOOD, *Agt.*,
W. Mill.

PHILADELPHIA, Feb. 27, 1873.

E. GEYELIN, ESQ.:

DEAR SIR—I have great pleasure in giving my testimony in favor of the Jonval Turbine as constructed by you for use in water-works for pumping water.

The first wheel made by you for that purpose was constructed under contract with you for the Fairmount Water-works, and was started to work Dec., 1851. That wheel has been running almost constantly ever since, sometimes running for a month without an hour's stoppage. The wheel drives a double-acting force-pump, 16 inch diameter, 6 feet stroke, running 12 to 14 revolutions per minute, raising water about 66 feet high.

Since that wheel was started, we have put in six other wheels, of the same kind, but much larger in size, those last built being 10 feet 3 inches diameter each, and driving two double acting pumps, 22 inches diameter each, and 6 ft. stroke.

I have no hesitation in saying that these wheels are perfectly adapted to the work of pumping water, and that they are the most perfect and reliable machines for the purpose, driven by water, that I have seen.

The workmanship upon them is of the best kind, and the proportions for strength and power is highly creditable. I feel certain that this will be fully endorsed by all unprejudiced mechanics.

Very truly yours,

(Signed) FREDERIC GRAFF,

Chief Engineer Water Dept.

LOCALITIES OF WORKS USING GEYELIN-JONVAL TURBINES.

WATER-WORKS.

Fairmount Works, Philadelphia, Pa.
Montreal Water-works, Canada.
Cohoes Water-works, N. Y. State.
Manchester Water-works, N. H.
Richmond Water-works, Va.
Lynchburg Water-works, Va.
Augusta Water-works, Ga.
Lancaster Water-works, Pa.
Wilmington Water-works, Del.

COTTON MILLS.

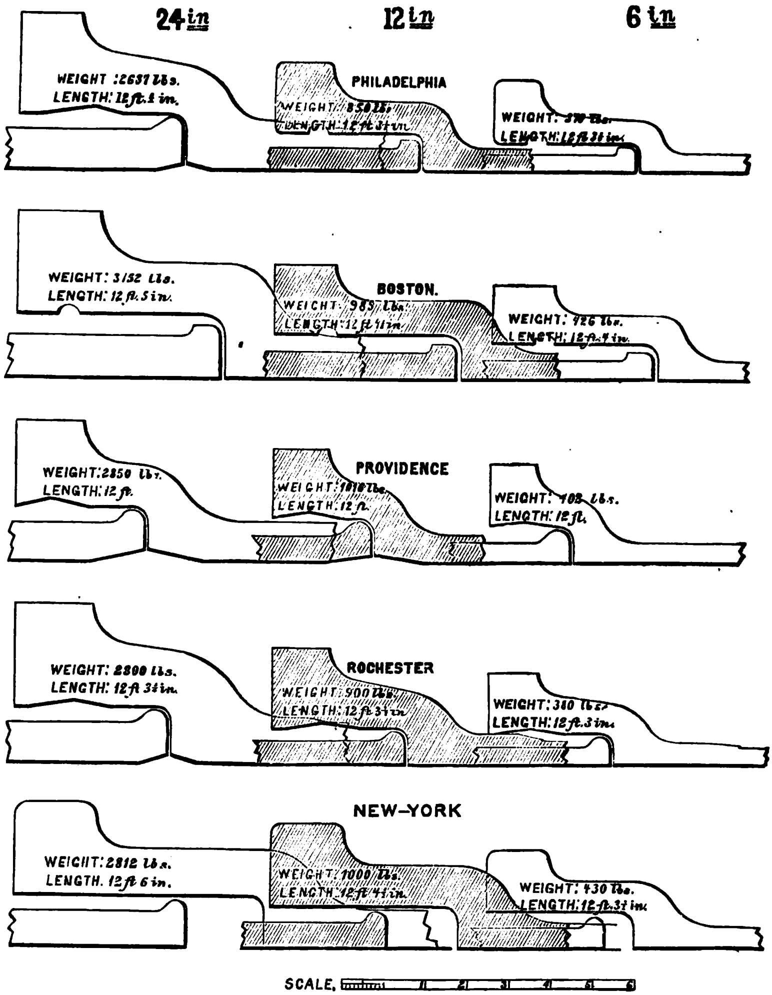
C. A. Dresser, Southbridge, Mass.
Williamsville Manufacturing Co., Wm. A. Atwood, Killingly, Conn.
Wauregan Mills, J. S. Atwood, Wauregan, Conn.
Harmony Mills, Cohoes, N. Y.
Lewiston Mills, Lewiston, Maine.
Bates Mills, Lewiston, Maine.
Green Mf'g Co., Providence, R. I.
Social Mills, Woonsocket, R. I.

PAPER AND OTHER MILLS.

Manning & Peckham, Troy, N. Y.
Jessup & Moore, Philadelphia.
Franklin Manufacturing Co., W. A. Scott, Paterson, N. J.
Millville Mf'g Co., Millville, N. J.
E. J. Du Pont, De Nemours & Co., Wilmington, Del.
Underhill Edge Tool Co., Nashua, N. H.
Oshawa Tool Co., Oshawa, Ont.

AND MANY OTHERS.

Fig. 6.



FORMS OF PIPE SOCKETS.

CAST-IRON PIPES.

SPECIAL CASTINGS.

Stock on Hand.—It is our practice and intention to carry a considerable stock of cast-iron pipes for both gas and water, of the several standards used by our regular customers, so as to be able to fill orders promptly, and were it not for the great *variety* in the standards adopted by the different Departments, as respects forms and dimensions of sockets and spigots, and thicknesses and weights of shells of plain pipes, not to mention the innumerable styles of special castings, we should be able to achieve, in this direction, a success much more gratifying to ourselves and satisfactory to our patrons. This variety, in itself, leads to many annoyances to our customers as well as ourselves, and we are pleased to note an indication of a tendency toward uniformity in the classification of pipes, and of weights of pipe in each class.

Variety of Standards.—As illustrative of the variety of present requirements, we present in Fig. 6 sketches of the sockets of 6, 12, and 24 inch pipes in five cities, with memorandums of their weights and lengths, and we present also tables of the standard thicknesses and weights for different diameters of pipes used in several cities.

TABLE No. 2.

WEIGHTS OF CAST-IRON PIPES AS USED IN SEVERAL CITIES FOR MAXIMUM PRESSURES.

Diameter, inches.	St. Louis.	Pittsburg.	Cincinnati.	Columbus.	Poughkeepsie.	Lawrence.	Troy.	San Francisco.	Atlanta.	Taunton.	Rockford.	San Jose.	Sarnia.	Bangor.	Milwaukee.	Philadelphia.	Ottawa.
	Maximum Head, in feet.																
	R. & S. P.	R. 208	R. 240	D.P. 280	R. 280	R. 160	R. 90	R. 325	D.P.	D. P 280	D.P.		D.P.	D.P. 230	R. & S P. 210	R. 250	D. P. 250
	Average Weights, per lineal foot, in pounds.																
3	17¼	....	23	....	....	....	15	13	.....	.....	.....	....	.....	.....	.....	15	14
4	25	....	31	25	....	....	22	20	20	22	24½	20	20	21¾	.....	19	.. ...
5	....	....	....	.....	....	....	....	....	....	....	.....	21	.....	.....	....	...	25
6	39	43¾	52	38	46¾	34½	35	30	32	41	37	....	30	32¼	35	31	......
8	56½	56⅔	68	50	56	51	45	42	45	53	50	....	45	48¾	50	42	46
10	77¼	77	80	.....	....	70	60	65	57	70	69	50	.....	. ..	....	53	86
12	97½	100	117	100	83½	83⅓	75	75	78	94	88	....	90	80¾	87	71	.....
15	120¼	136¼	..	.....	..	...	....	....	.....	.....	.....	90	.....	.....	.....	....	125
16	.....	....	175	145	134	133½	100	112	170	145	130	....	.....	133½	129½	105	......
20	210	220½	215	210	...	193½	160	160	....	206	.....	....	.....	.....	194	151	.. ...
24	.....	284¼	257	-...	....	250	...	...	... .	.....	.....	....	....	.....	266½	307	202
30	400	410	360	....	....	394	...	...	.....	.....	.....	....	.....	...	351	330	257
36	547	548	479	.....	....	....	....	....	.....	.....	.....	....	.....	.....	.....	422	......
48	891	....	775	.....	....	....	....	....	.....	.....	.....	....	....	.....	.....	585	......

The initial R indicates a reservoir system; the initials D. P. indicate a direct pressure; the initials S. P. indicate stand-pipe.

It will be observed that in these few cities there are twelve different standards of thickness for 6-inch pipes; thirteen standards for 12-inch; eight standards for 20-inch; seven standards for 30-inch, &c.; there is a like variety in designs of sockets; and there are eighteen nominal diameters, from 4 to 48 inch inclusive, to which this range of variation applies. To this list we have to add the consequent variety in the ordinary specials and green-sand work, which swells greatly the total list of patterns and sweeps required for water-pipes at each foundry. Our customers will acknowledge the impossibility of our carrying a stock that will enable us to fill, at sight, orders applying at random in this great variety, and will appreciate the advisability of giving their orders early, with a fair allowance of time for their manufacture and transportation, and we shall always use our best endeavors to fill their orders promptly and with a superior quality of stock, inspected, and tested with adequate water-proof.

Directions for Ordering.—Inquiries for prices of pipes should state whether the pipes are required for the conveyance of *gas* or for *water*. Clear and explicit directions as to *dimensions*, *forms*, and *weights* of water-pipes, accompanying the original order or inquiry, will save delays in correspondence for information, and will enable us to fill orders with the greatest promptitude.

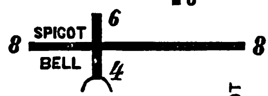
Detail drawings, to scale, and with principal dimensions figured upon them, should accompany orders for special castings of unusual forms.

For the usual forms of pipe specials the following nomenclatures will usually suffice, and will be understood by the trade, and may be written and sketched off-hand in the order:

Branch; Single 6″ on 8″...........

Branch; Double 6″ on 10″ ....

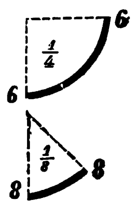
Branch; Double 6″ and 4″ on 8″...



Reducer; 10″ to 8″....

Bend; 6 inch ¼ bend

Bend; 8 inch ⅛ bend, (&c.) ....



Our Facilities.— Our extensive foundries at both Millville and Florence have been fitted up with the most approved cupolas, power cranes, metal flasks, ovens, coating baths, &c.; and our foundrymen, through long experience in our service, have become expert, each in his special work; and we have for a long time given especial attention to the manufacture of intricate loam castings for both pipes and machinery, and have facilities for their production of unsurpassed magnitudes; hence we are fully prepared to execute promptly the largest orders, and to fill orders for the heaviest and most intricate forms of castings, and we cordially invite our patrons to inspect the appliances with which we are producing all classes of pipes up to 72 inches diameter inclusive, and the largest castings required by our American machinists.

Substitutes.—We have been enabled through our long experience, beginning with the very introduction of pipe-founding into this country, and from our frequent improvements in appliances, to reduce the manufacture of pipes to the most systematized methods, and to attain the most exact results in forms, and most desirable qualities of castings, due to the present advanced science of mixture and treatment of metals in the cupola, and the price of iron has fallen from its inflated war rate to a legitimate basis, so there now remains no further reason for the adoption of those temporary pipe expedients of tarred paper, bored logs, laminated woods, thin sheet-iron, &c. The lesser first cost of these substitutes during the war, and the term of high price of iron following, was a great temptation to towns and villages to experiment with them, or certain of them, and a temptation to speculative inventors to push new expedients, and profit by the lack of experience of newly-appointed village committees.

Fortunately for the interests of the towns, and the interests of capital generally, few of these substitutes were even so far accepted as to attract any public notice, even by their failures, except in the midst of the sufferers. Even the one, among all these substitutes, that seemed to contain most of the elements of success, has not generally fulfilled all that was promised for it, and its manufacturers are still experimenting with methods of making joints, especially of the larger sizes, that will stand the jar of street traffic over them, and that will not continually leak in the soft grounds and in the ledge cuts, and about the hydrants, and at the dead ends, and that can successfully withstand high pressures and the frequent water-rams that occur in all pipe systems.

Durability of our Pipes.—The more perfect, durable and reliable cast-iron pipes might be considered as the cheapest even when iron was so expensive, since the present improved method of manufacture has increased their durability to an almost indefinite extent, covering several generations, at least, of the people who are to use them, while on the other hand it remains yet to be established that any one of the substitutes will not have become useless and demand replacement by cast-iron, long before the bonds issued in payment for them reach maturity.

Nothing but Cast-iron used in Large Cities.—Since it has been the smaller towns almost exclusively that have attempted to use the fragile pipes, they alone are suffering, for they are not accepted in New York, Brooklyn, Chicago, Milwaukee, Louisville, Columbus, Cincinnati, Philadelphia, Cleveland, St. Louis, Buffalo, Pittsburgh, or Toledo, where eminent hydraulic engineers have charge of the water departments.

Opinions of Experts.—We quote from a reply of

Hon. A. W. Craven, who was formerly, during many years, Chief Engineer of the Croton Aqueduct Department, New York, as follows:

"*In cast-iron you are dealing with a certainty.* Well authenticated cases of its durability are constantly afforded. Pipe which has been in constant use for one hundred years, and unprotected by any coating, either on its interior or exterior surfaces, has been examined, and to no appreciable extent was there any diminution in its weight or strength. It is the opinion of those engineers who have had most experience in and given most study to this subject that we have not had an opportunity to define the limit to the duration of cast-iron pipe used for aqueduct purposes. . . . *I do not consider it true economy to use any known substitute in any portion of the distribution of a town.*"

John H. Rhodes, Water Purveyor of Brooklyn, N. Y. (who has had many years' experience in the handling of water mains), says:

"In my opinion it is not judicious to lay a substitute for iron pipe of any size in any city, unless upon a plea of cheapness, which can only be justified by a depleted treasury."

Accidents.—To show the likelihood of unsuspected causes of failure in any but the stoutest pipe, we copy accounts of accidents from lightning to cement pipe, taken from the Report of the Manchester Water Company for 1878:

The number of leaks the past year was 226. *Cement pipe*, 207; cast iron, 19.

There have been three bursts on the cement pipe, 2 in 'Squog, caused by lightning, and one on Canal street, with no apparent cause.

And from the Water Commissioners' Report of Fitchburg, 1878:

During a violent thunder-storm on the sixth day of June, two houses were struck by lightning, one on Burnap street and one on Milk street. The electric fluid in both cases followed the service pipes from the buildings to the 4 and 6 inch *wrought iron cement lined* main pipes, and when it reached these mains its path of ruin was fearful. In some cases a length of pipe would be split from end to end, others would be perforated with holes, which, in almost every case, indicated that the fluid passed from the outside to the inside of the pipe. Nearly every joint on the two thousand feet of its course was opened, and one gate and two hydrants were so badly damaged as to be useless. The pipe was replaced by *cast iron pipe*, and the gate and hydrants by new gate and hydrants, the total cost of which was nearly $1700. This loss is added to the maintenance account of the current year. *Three* times our main pipes have been struck by lightning, and each time is more alarmingly suggestive of what accidents may happen from the same cause. Cannot some electrician give us a plan of protection?

ROCKVILLE, CONN., Seventh Mo., 26, 1878.

MESSRS. R. D. WOOD & CO.:

GENTLEMEN—Please forward by Providence (Clyde's) Line 2000 feet of 3-inch coated pipe. The lightning played havoc with our cement main. Yours truly,

J. C. HAMMOND, JR., *Treas. R. Aqd. Co.*

These, it will be observed, all came to our notice in one year.

Just as we are printing this edition of our Catalogue, we have received, unsolicited by us, the following letter:

WARWICK, N. Y., Sept. 29, 1880.

MESSRS. R. D. WOOD & CO.:

GENTLEMEN—About one year ago the undersigned wrote you for prices, as the Water Commissioners of this village wanted 1200 feet of 4-inch iron pipe, 22 pounds to the foot. We did our best to get them to give you the order. They ruled, and in consequence got the Elmira wood pipe; the only difference in the cost then was the lead and work of laying. The consequence is, this *wood pipe* is giving a great deal of trouble—it is continually bursting, We think the time is short when we will have to have iron pipe to replace it. If any of your customers are contending for wood or iron pipe you can refer them to us, or to the Water Commissioners of this village.

Respectfully yours, FINCH & COLWELL.

Also the following, which refers to a class of piping there has lately been considerable effort made to introduce. It is the wrought-iron pipe (so generally made and used for steam- and gas-fitting), in its larger sizes running up as high as twelve inches in diameter, and coated to protect it from rust. It is amply strong to resist pressure when new; but the difficulty in making a secure and safe tap in so thin a pipe, and the greater facility of wrought-iron to corrode on the slightest exposure over that of cast-iron, cause it soon to rapidly rust away, and thus destroy the strength and usefulness of the pipe. The order referred to in the letter below is for one mile and a half of eight and ten inch pipe.

MESSRS. R. D. WOOD & Co. :

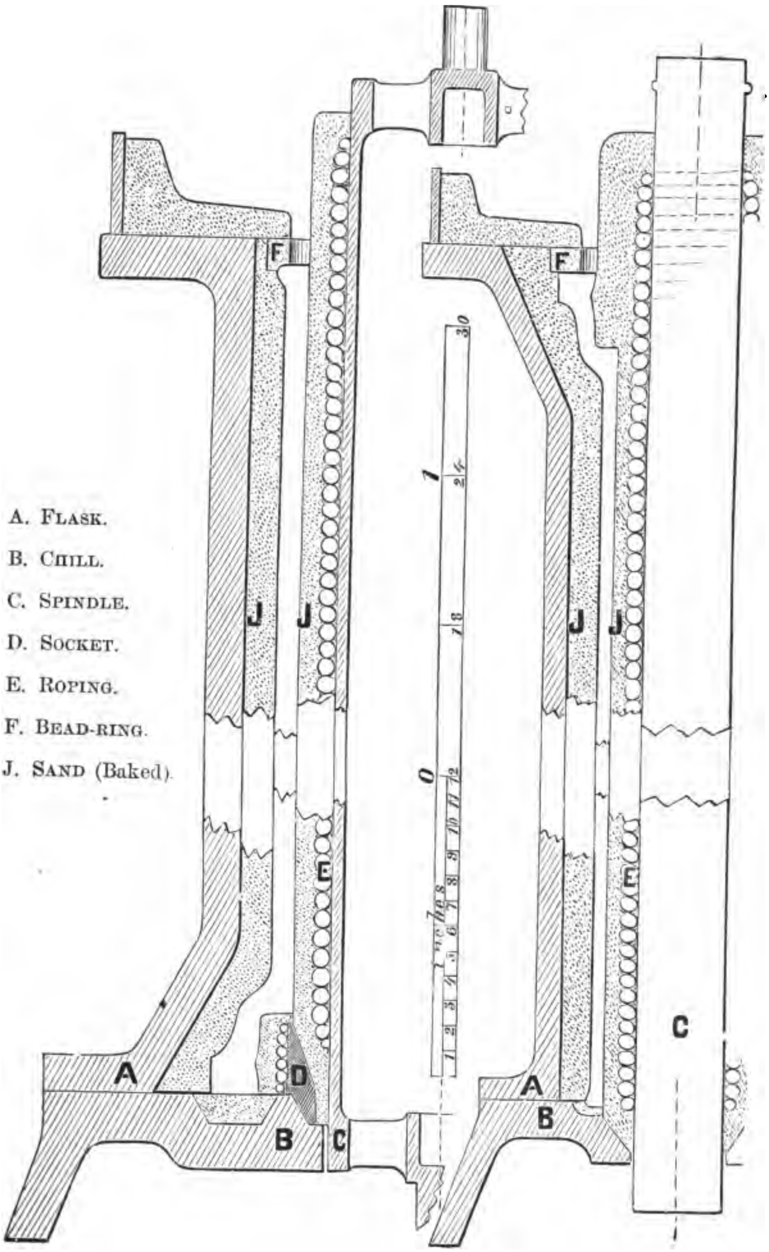
GENTLEMEN—Yours of the 28th at hand. Please ship the pipe as ordered by Mr. —— at the earliest possible moment. In answering yours relative to hydrants, we remarked that we did not intend increasing our pipe-line. The pipe ordered is to replace some already laid. We hope to receive it soon.

Yours truly, —— ——, *Supt.*

There would therefore seem to be nothing so durable and satisfactory for extended use than that which has so well and thoroughly stood the test of time—extending over so many years during which substitutes have again and again come up, been experimented on, tried, found wanting, and finally *always* been replaced with *cast-iron.* No higher testimonial can be offered than this result of actual experience, and it is true economy to profit by it.

Perfected Manufacture.—Some of the advocates of the cheap pipes have boldly proclaimed, as an offset to the weaknesses of their pipes, all the defects that were discovered in the earliest iron castings, while pipe-founding was still in its experimental stage of development, both in Europe and America. Those defects in pipes have long since ceased to exist, except under the hands of inexperienced founders, who have attempted to take up their manufacture from time to time. We who are experienced know how to produce a casting that will be durable, and that is accurate in form and in thickness, and that contains those qualities of strength and toughness that adapts the

Fig. 7. Fig. 8.



PIPE MOULDS.

minimum weights fully to their legitimate service, and this is knowledge that only long experience and close observation can give.

Pipe Moulding.—While we take pleasure in explaining to our customers, who visit our foundries and machine shops, the appliances and methods by which we produce and finish our castings, we have thought also that our distant patrons might be interested in the sectional sketches, Fig. 7 and Fig. 8, of some of our smaller pipe moulds, illustrating the method by which accuracy of form and thickness is secured.

In each sketch, *C* is a cylindrical spindle, about which the core is formed (one half only of each mould section is shown so as to avoid a greater reduction of scale). Around each spindle is first closely wound machine-made roping of straw, and then upon this a covering of tempered sand and clay is firmly packed. The spindle is then revolved in fixed bearings and its covering trimmed, as in a lathe, by a proper form, to the exact shape and dimension of both the interior of the pipe and its socket, and the bevel which is to center it at the bottom of the flask or in the chill. This complete core is then ready to be placed in the drying oven.

The outer case, *A*, is the flask in which the mould is formed. Within the flask is placed and centered a mandrel, the exterior of which conforms exactly to the exterior shape and size of the pipe. Tempered sand and clay are then rammed around the mandrel to form the mould, and the flask is then ready for the drying oven. The metal socket ring, *D*, is also wound with straw roping, covered with sand, and accurately turned. The bead-ring, *F*, is formed in a turned iron mould and dried.

When these several parts are dried and combined for the casting of a pipe, as they are shown in the sketches, the core is accurately centered by the bevel at the bottom and the bead-ring at the top, and the void between the mould and the core conforms accurately to the desired form and dimensions of the complete pipe.

The importance of this nice adjustment will be appreciated by those who buy castings by weight, and have no spare funds for the purchase of surplus iron in badly moulded pipes.

The tempering of the sand and drying of the mould, so as to withstand the trying action of the molten metal, are matters that require the utmost care to ensure perfect castings.

Pouring.—We place these flasks on end in the pit, preparatory to pouring, so as more certainly to secure a solid casting, cylindrical in bore, and of uniform thickness upon all sides.

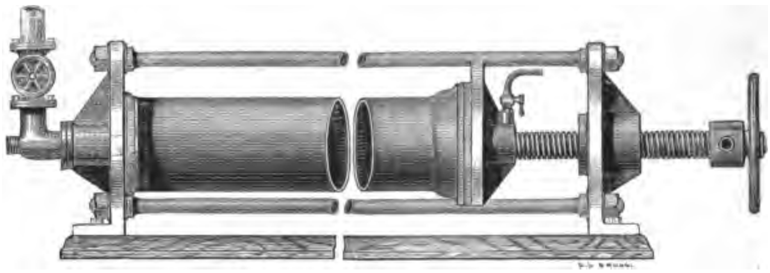
The castings are protected from sudden chills while cooling, and when cool are cleaned and carefully inspected.

Coating.—The pipes are then placed in an oven and heated until the pores of the iron are well opened, when they are immersed in a hot bath of Dr. Smith's Patent Coal-tar Varnish (which is deodorized coal-tar, or coal-tar with the naphtha removed), and are allowed to remain in the bath until a varnish coating has perfectly formed upon the face of the casting.

This varnish preserves the interior and exterior surfaces of the pipe from corrosion, and prevents the adhesion of tubercles or other matter within. It gives also to the interior of the pipe a smooth enamel that reduces the friction of the current and the power required to force it, to the minimum.

Hydraulic Proof.—Before delivering for transportation each pipe is placed in an hydraulic testing machine, and the pipes for water are subjected to a pressure test of three hundred pounds per square inch, and while under pressure carefully examined. If any indications of porousness or any weakness are then found the pipe is condemned and broken up.

FIG. 9.



The perfection of the casting is thus assured before it leaves the foundry yard, as it is in none of the cheap substitutes.

As to the comparative merits of cast-iron pipes, made by our perfected processes, and any one of the substitutes, we would respectfully advise any member of a committee who has doubts, to consult with one of the older hydraulic engineers of experience, say the one in charge of the water-department of the nearest large city, and accept his advice as he would that of his physician or attorney.

Stock kept for Orders, in which Weights are not Given.—In the following tables are given the weights per foot, thicknesses of metal, and depths of bells of pipes, which we shall endeavor to keep in stock, to fill orders in which weights and dimensions are not particularly specified.

These pipes, from 4 inches diameter upward, are made to lay twelve feet net.

We also make 3 inch pipes nine and twelve feet long, and 1½ and 2 inch pipes six feet and eight feet long.

TABLE No. 3.

THICKNESSES AND WEIGHTS OF GAS PIPES, KEPT IN STOCK.

Diameter.	Weight per foot.	Thickness of Metal.	Depth of Bell.	Diameter.	Weight per foot.	Thickness of Metal.	Depth of Bell.
Inches.	*Pounds.*	*Inches.*	*Inches.*	*Inches.*	*Pounds.*	*Inches.*	*Inches.*
1½	4½	5/16	2½	14	80	9/16	4
2	6	5/16	2¾	15	90	9/16	4
3	11	5/16	3	16	100	⅝	4
4	15	⅜	3	20	140	11/16	4
6	25	7/16	3	24	185	¾	4
8	38	7/16	3	30	325	1 1/16	5
10	50	7/16	3¼	36	400	1⅛	5
12	58	7/16	4	48	550	1⅛	5¼

TABLE No. 4.

THICKNESSES AND WEIGHTS OF WATER PIPES, KEPT IN STOCK.

Diameter.	Weight per foot.	Thickness of Metal.	Depth of Bell.	Diameter.	Weight per foot.	Thickness of Metal.	Depth of Bell.
Inches.	*Pounds.*	*Inches.*	*Inches.*	*Inches.*	*Pounds.*	*Inches.*	*Inches.*
1½	4½	5/16	2½	14	100	11/16	4
2	6	5/16	2¾	15	120	¾	4
3	11	5/16	3	16	135	13/16	4
4	22	½	3	20	160	13/16	4
6	32	½	3	24	240	1	4
8	47	9/16	3	30	375	1 3/16	5
10	58	9/16	3	36	450	1¼	5
12	80	⅝	3	48	650	1⅜	5¼

N. B.—We will, of course, make pipes of any weights and depths of bells which may be required.

Competition with Foreign Founders.—We have recently filled a large order for pipes for the city of Ottawa, the capital of the Canadian Dominion. Here we came in direct competition, not only as to price, but as to quality, with the most celebrated of the British foundries. The superiority of our pipes is clearly set forth in the annual report of the Ottawa Commissioners for the year 1876. All the American pipes used in Ottawa were from our own foundry, and all the British pipes were from a Scotch foundry. We quote the following table from the report of T. C. Keefer, Chief Engineer, to show the comparative success and reliability of the two manufactures.

TABLE No 5.

TABLE SHOWING NUMBER, SIZE, AND QUALITY, OF PIPES LAID, AND FAILURES SINCE COMMENCEMENT OF PUMPING, OCTOBER, 1874, TO DECEMBER 31ST, 1875.

OTTAWA WATER-WORKS.

Diameter of Pipe.	Scotch Pipes.			Amer. Pipes, all wide Sockets.	Total No. of Pipes.	Pipes Burst.		Turned and Bored Joints Leaking.	Lead Joints Leaking.	Sand Holes.		Burst by Frost.	Total Failures.
	Turned and bored Joints.	Wide Sockets.	Total.			Scotch.	American.			Scotch.	American.		
3 inches.	879	30	909	766	1675	3	2	2	....	......	......	....	7
5 "	6219	195	6414	3570	9984	38	4	21	17	1	......	14	95
8 "	1593	40	1633	522	2155	11	......	8	2	1	......	....	22
12 "	1020	30	1050	103	1153	6	......	......	1	......	......	....	7
15 "	808	13	821	364	1185	8	......	1	2	......	......	....	11
24 "	16	5	21	......	21	......	......	......	1	......	......	....	1
Hydrants.	......	....	......	.....	......	......	1	......	2	.....	......	....	3
Specials.	......	....	......	......	......	......	......	......	...	......	......	1	1
Total......	10535	313	10848	5325	16173	66	7	32	25	2	......	15	147

Calculated No. of Joints on Distribution, 18,000.

Two-thirds of Pipe from Scotland, chiefly turned and bored.

One-third from United States, all wide sockets (from R. D. Wood & Co.)

Favorable Comments.—Referring to the above table, Mr. Keefer, Chief Engineer, remarks: "A table in the appendix shows the number of failures of pipes, chiefly Scotch. No doubt all these pipes had been proved before shipment, and their defects were such as not to attract attention before they were laid. They were made by the best maker, under the best specification, and were paid for at the highest price. Many were, no doubt, injured by transportation, but others were defective castings. The American pipes are of better iron, and were less exposed in transportation—hence the few failures."

Flexible Joints.—In Figures 10 and 11, we illustrate samples of *flexible joints*. The first is the well-known "Ward's Joint," and the second an improvement upon the "Universal Scotch Joint," and similar in some respects to the Rhodes Joint. These joints are especially useful when pipes are to be laid in deep waters without the use of coffer dams, and in short bends. In the first joint the interior of the bell, and in the second joint the exterior of the spigot, are carefully finished in a lathe to true and smooth spherical segments, and they are, when calked with lead, capable of motion through considerable areas without causing leakage. When pipes with these joints are to be laid beneath water, the joints can be run with lead and driven above the water, and the line lowered as the joints are completed.

Turned and Bored Joints.—The turned and bored joints, which have been extensively used in Scotland and England, and are in use in Hamilton and Ottawa, Canada, have not as yet been favorably received by our American engineers.

Gas-pipe Joints.—Socket joints, with lead calkings, as shown above for water-pipes, are in general use for gas-

Fig. 10.

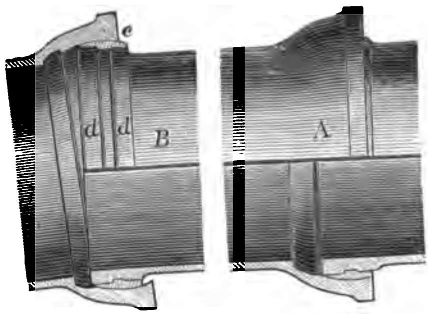
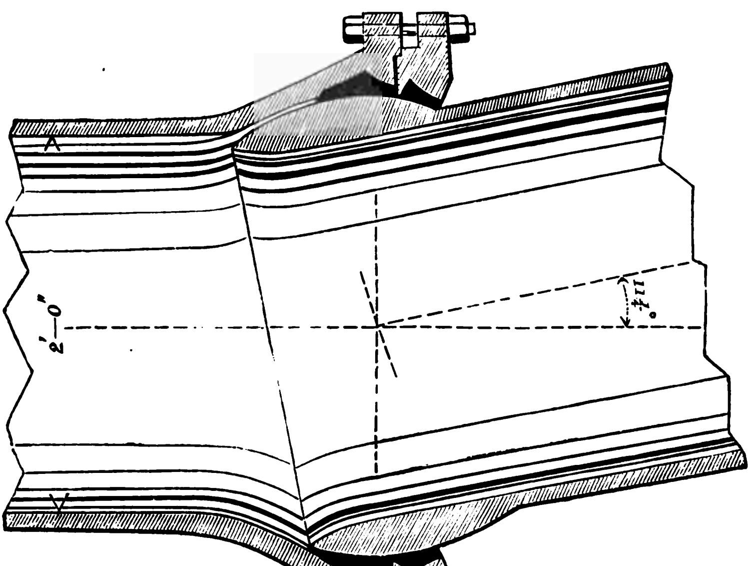


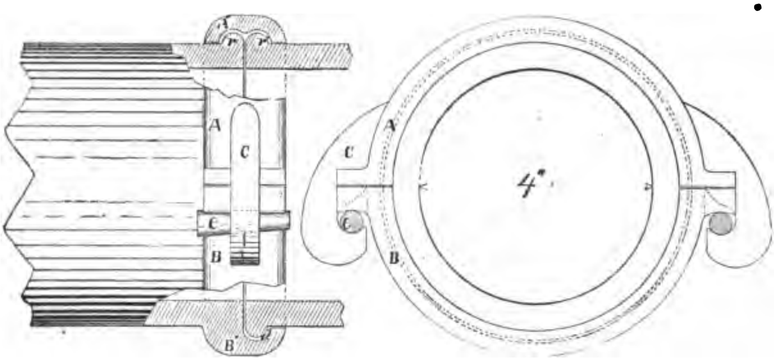
Fig. 11.



pipes also. In certain districts, however, cement is used for the packing in gas-pipe joints as being cheaper. It requires more calking-room, and fully five-eighths inch is allowed in the larger-sized pipes. We have a set of gas-pipe patterns for such cement joints, and can supply them promptly to all parties who may order such.

The thicknesses of gas-pipes of four inch and greater diameter may be found by the formula for thicknesses of water-pipes, given hereafter in the excerpts, by taking the value of p, the symbol for pressure at one pound, or two or three pounds per square inch, as the case may be.

FIG. 12.



Cap-Joint.—In Fig. 12 we illustrate a patent joint for use with cement,* which is secured to our exclusive control. This joint is exceedingly simple, and can be expeditiously filled solid without air-bubbles or porousness. It gives superior facilities for the rapid laying of pipe in the trench; and pipes laid with this joint may be readily taken up for removal or repairs. We recommend its use for sizes up to six inch diameters of pipes especially.

* Roman cement, mixed with water till of the proper consistency, is found to make a good joint packing.

Upon one end of the pipe is cast a semi-socket, *BB'*, extending one-half round the pipe. The bead-ring *r*, completes the circumference at the same end. At the other end a bead-ring, *r'*, is cast entirely round the pipe. The remaining semi-socket *AA'* is cast independent of the pipe, and has projecting hook-shaped lugs, *C*, adapted to pass through slotted lugs on the fixed semi-socket.

The detachable socket is locked upon the fixed socket by the conical pins *e*.

The fixed socket contains a groove, *d*, to receive one-half the length of the complete bead, *r'*. The detachable socket has a double groove to receive the bead *r*, and a like length of the bead *r'*.

When laying the pipe in its trench, the fixed socket is placed at the bottom, and the groove filled with cement joint mortar; then the next pipe is brought into position, and the lower half of its bead pressed into the cement in the groove *d*. The upper portions of the beads are then covered with joint cement, and the detachable socket put on and pressed home, and drawn snugly into place by the pins *e*.

The joint may be easily repacked by a similar process, should occasion ever require it, very few tools being used in the operation.

To our chapter treating upon pipe manufacture we append some excerpts from "Water Supply Engineering," relating to the flow of water in pipes, and to the thicknesses, weights, and preservation of pipes, and supply of water in various cities.

TABLE No. 6.

RESULTS GIVEN BY VARIOUS FORMULAS FOR FLOW OF WATER IN SMOOTH PIPES, UNDER PRESSURE, COMPARED.

DATA.—To find the velocity, given: *Head*, $H = 100$ feet; *Diameter*, $d = 1$ foot; and *Lengths*, l, respectively as follows:

AUTHORITY.	EQUATIONS.	LENGTHS.				
		5 feet.	50 feet.	100 feet.	1000 feet.	10,000 feet.
		Veloc.	*Veloc.*	*Veloc.*	*Veloc.*	*Veloc.*
Equation (11) ..	$v = \left\{ \dfrac{2gH}{(1 + c_r) + m\dfrac{l}{r}} \right\}^{\frac{1}{2}}$	63.463	51.111	43.111	17.386	5.392
Chezy..........	$v = \left\{ \dfrac{ghS}{\frac{1}{2}mlC} \right\}^{\frac{1}{2}}$	223.607	70.710	50.000	15.810	5.000
Du Buat	$v = \dfrac{88.5r^{\frac{1}{2}} - .03}{\left(\dfrac{l}{h}\right)^{\frac{1}{2}} - \text{hyp. log.}\left(\dfrac{l}{h} + 1.6\right)^{\frac{1}{2}}} - .84(r^{\frac{1}{2}} - .03)$	......	102.918	81.510	13.662	3.9781
Prony (*a*)	$v = (9419.75ri + .00665)^{\frac{1}{2}} - .0816$..	216.94	68.54	48.446	15.258	4.770
" (*b*)	$v = (9978.76ri + .02375)^{\frac{1}{2}} - .15412$...........	223.214	70.480	49.792	15.641	4.842
Eytelwein (*a*) ..	$v = (11703.95ri + .01698)^{\frac{1}{2}} - .1308$...........	241.776	76.367	53.960	16.975	5.280
" (*b*) ..	$v = 50 \left\{ \dfrac{dh}{l + 50d} \right\}^{\frac{1}{2}}$	67.40	50.00	40.82	15.427	4.985
Saint Vennant..	$v = 105.926 (ri)^{\frac{11}{21}}$	246.171	73.682	51.247	15.232	4.592
D'Aubuisson (*a*)	$v = (9579ri + .00813)^{\frac{1}{2}} - .0902$	218.758	69.114	48.845	15.384	4.800
" (*b*)	$v = 95.6 \sqrt{ri}$	213.761	67.589	47.804	15.114	4.780
Neville (*a*)	$v = \left\{ \dfrac{Hr}{.0234r + .0001085l} \right\}^{\frac{1}{2}}$..................	62.540	47.080	38.750	14.780	4.780
" (*b*)	$v = 140 (ri)^{\frac{1}{2}} - 11 (ri)^{\frac{1}{3}}$	294.650	90.263	63.070	18.917	5.507
Blackwell......	$v = 47.913 \left\{ \dfrac{hd}{l} \right\}^{\frac{1}{2}}$	214.267	67.715	47.913	15.140	4.791
D'Arcy	$v = \left\{ \dfrac{ri}{.00007726 + \dfrac{.000000162}{r}} \right\}^{\frac{1}{2}}$	244.120	77.133	54.640	17.279	5.464
Leslie	$v = 100 \sqrt{ri}$	223.607	70.710	50.000	15.810	5.000
Jackson	$v = 50c (di)^{\frac{1}{2}}$	223.607	70.710	50.000	15.810	5.000
Hawksley......	$v = 48.045 \left\{ \dfrac{dh}{l + 54d} \right\}^{\frac{1}{2}}$	62.555	47.084	38.724	14.797	4.804

In which C = contour of pipe, in feet;
c = unity for smooth pipes, and is reduced for rough pipes.
d = diam. of pipe, in feet.
H = entire head, in feet.
h = resistance head, in feet.
l = length of pipe, in feet.
m = coefficient of flow.
r = hyd. mean radius, in feet, $= \dfrac{d}{4}$.
S = sectional area of pipe, in square feet.
i = sine of inclination, in feet, $= \dfrac{h}{l}$.
v = velocity of flow, in feet per sec.

Velocity Equation Coefficients.—Experiment shows the coefficient, *m*, to be very variable, changing with change of velocity, with sectional area of pipe, and with condition of interior pipe surface. Some of its values for smooth and rough pipes are given in the following table.

TABLE No. 7.

COEFFICIENTS FOR CLEAN, SLIGHTLY TUBERCULATED, AND FOUL PIPES, OF GIVEN DIAMETERS, AND WITH A COMMON VELOCITY OF 3 FEET PER SECOND. $\left(v = \left\{\frac{2ghd}{(4m)\,l}\right\}^{\frac{1}{2}} = \left\{\frac{2gri}{m}\right\}^{\frac{1}{2}}\right)$.

Hydraulic Mean Radius, $\frac{S}{C} = \frac{d}{4}$	Diameter.		Clean.	Slightly tuberculated.	Foul.
	Feet.	*Inches.*	*Coef., m.*	*Coef., m.*	*Coef., m.*
.0104	.0417	½	0.00753	......	......
.0156	.0625	¾	.00745	......	......
.0208	.0834	1	.00734	0.00982	......
.0312	.1250	1½	.00722	.00940	......
.0364	.1458	1¾	.00707	.00925	......
.0417	.1667	2	.00692	.00910	0.01400
.0625	.2500	3	.00670	.00862	.01300
.0833	.3334	4	.00650	.00825	.01200
.1250	.5000	6	.00623	.00772	.01100
.1667	.6667	8	.00600	.00733	.00922
.2083	.8334	10	.00584	.00706	.00868
.2500	1.0000	12	.00510	.00680	.00828
.2917	1.1667	14	.00554	.00657	.00792
.3333	1.3333	16	.00538	.00636	.00760
.3750	1.5000	18	.00523	.00616	.00733
.4167	1.6667	20	.00509	.00598	.00710
.5000	2.0000	24	.00483	.00567	.00664
.5625	2.2500	27	.00468	.00544	.00635
.6250	2.5000	30	.00452	.00525	.00604
.6875	2.7500	33	.00440	.00507	.00578
.7500	3.0000	36	.00424	.00490	.00554
.8333	3.3333	40	.00407	.00466	.00524
.9167	3.6667	44	.00389	.00443	.00500
1.0000	4.0000	48	.00376	.00422	.00477

FIG. 13.

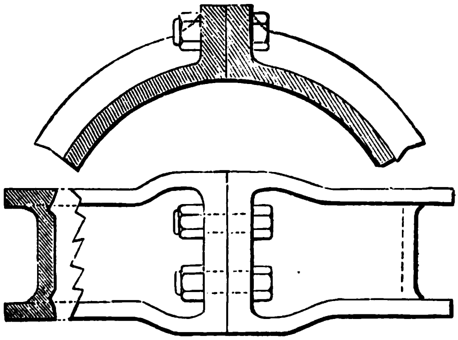


FIG. 14.

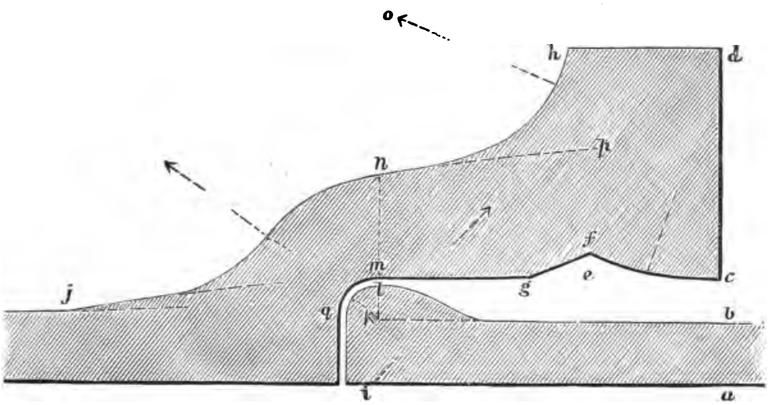
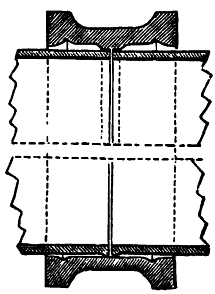


FIG. 15.



PIPE SOCKET, AND SLEEVES,

TABLE No. 8.

Dimensions of Cast-iron Water-pipes. (Fig. 14.)

(Thickness of shell is herein proportioned for 100 lbs. static pressure.)

Diameter.	Length over all.	Thickness of shell. ab	Depth of hub. bq	Joint room. bc	cd	dh	ce	eg	ef	fp	kl	km	mn	ho	qj
in.	′ ″	″	″	″	″	″	″	″	″	″	″	″	″	″	″
4	12–4	7/16	3	5/16	1 1/2	1 1/4	1 1/8	1/2	3/16	3/4	1/4	5/16	3/4	7/8	2
6	12–4	1/2	3	5/16	1 5/8	1 1/4	1 1/8	1/2	3/16	3/4	1/4	5/16	3/4	1	2
8	12–4	17/32	3	5/16	1 3/4	1 1/4	1 1/8	1/2	3/16	3/4	1/4	5/16	3/4	1 1/8	2 1/4
10	12–6	19/32	3	5/16	1 7/8	1 1/4	1 1/8	1/2	3/16	3/4	1/4	5/16	3/4	1 1/8	2 1/4
12	12–6	5/8	3 1/4	5/16	2	1 3/8	1 1/8	1/2	3/16	7/8	1/4	5/16	7/8	1 1/4	2 1/2
14	12–5	11/16	3 1/4	5/16	2 1/8	1 3/8	1 1/8	1/2	3/16	7/8	1/4	5/16	7/8	1 1/4	2 1/2
16	12–5	3/4	3 1/2	3/8	2 1/8	1 5/8	1 3/16	5/8	1/4	7/8	5/16	3/8	7/8	1 1/2	2 3/4
18	12–5	25/32	3 1/2	3/8	2 1/4	1 5/8	1 3/16	5/8	1/4	7/8	5/16	3/8	7/8	1 1/2	2 3/4
20	12–5	27/32	3 1/2	3/8	2 1/4	1 5/8	1 3/16	5/8	1/4	7/8	5/16	3/8	7/8	1 1/2	2 3/4
22	12–5	7/8	3 3/4	3/8	2 1/2	1 3/4	1 3/16	5/8	1/4	1	5/16	3/8	1	1 5/8	3
24	12–5	15/16	3 3/4	3/8	2 1/2	1 3/4	1 3/16	5/8	1/4	1	5/16	3/8	1	1 5/8	3
27	12–6	1	4	7/16	2 3/4	1 7/8	1 1/4	3/4	1/4	1 1/8	3/8	7/16	1 1/8	1 3/4	3 1/4
30	12–6	1 1/16	4	7/16	2 3/4	1 7/8	1 1/4	3/4	1/4	1 1/8	3/8	7/16	1 1/8	1 3/4	3 1/4
33	12–6	1 5/32	4 1/4	7/16	2 3/4	2	1 1/4	3/4	1/4	1 1/8	3/8	7/16	1 1/8	1 7/8	3 1/2
36	12–6	1 7/32	4 1/4	1/2	2 3/4	2	1 1/4	3/4	1/4	1 1/8	7/16	1/2	1 1/8	1 7/8	3 1/2
40	12–6	1 5/16	4 1/2	1/2	2 3/4	2 1/8	1 1/4	3/4	1/4	1 1/4	7/16	1/2	1 1/4	2	3 3/4
44	12–6	1 13/32	4 5/8	1/2	2 7/8	2 1/8	1 1/4	3/4	1/4	1 1/4	7/16	1/2	1 1/4	2	3 3/4
48	12–6	1 1/2	4 3/4	1/2	3	2 1/4	1 1/4	3/4	1/4	1 3/8	7/16	1/2	1 3/8	2	4

TABLE No. 9.

FLANGE DATA OF FLANGED CAST-IRON PIPES.

Diam. of bore of pipe.	Diameter of flange.	Thickness of flange.	Approx. weight of one flange.	No. of bolts.*	Diam. of bolts.	Diameter of circle of bolts.	Distance between centres of bolts.	Common diam. of valve flanges.
Inches.	*Inches.*	*Inches.*	*Pounds.*		*Inches.*	*Decimal inches.*	*Decimal inches.*	*Inches.*
3	$6\frac{1}{2}$	$\frac{11}{16}$	3.45	8	$\frac{7}{16}$	5.6	2.199	8
4	$7\frac{3}{4}$	$\frac{3}{4}$	6.64	10	$\frac{1}{2}$	6.7	2.105	9
6	10	$\frac{13}{16}$	8.56	10	$\frac{9}{16}$	8.9	2.796	11
8	$12\frac{3}{8}$	$\frac{13}{16}$	11.98	12	$\frac{5}{8}$	11.1	2.906	13
10	$14\frac{5}{8}$	$\frac{7}{8}$	16.5	14	$\frac{3}{4}$	13.3	2.985	16
12	17	$\frac{15}{16}$	22.3	14	$\frac{3}{4}$	15.5	3.478	18
14	$19\frac{1}{4}$	1	28.6	16	$\frac{3}{4}$	17.75	3.485	20
16	$21\frac{5}{8}$	$1\frac{1}{16}$	36.8	18	$\frac{3}{4}$	20.0	3.491	22
18	$23\frac{7}{8}$	$1\frac{1}{8}$	45.5	20	$\frac{3}{4}$	22.2	3.487	24
20	$26\frac{1}{4}$	$1\frac{3}{16}$	56.9	20	$\frac{3}{4}$	24.4	3.833	$26\frac{1}{4}$
22	$28\frac{1}{4}$	$1\frac{1}{4}$	62.8	22	$\frac{3}{4}$	26.5	3.784	$28\frac{1}{4}$
24	$30\frac{3}{8}$	$1\frac{1}{4}$	65.4	24	$\frac{7}{8}$	28.6	3.744	$30\frac{3}{8}$
27	$33\frac{5}{8}$	$1\frac{5}{16}$	80.8	26	$\frac{7}{8}$	31.8	3.842	$33\frac{5}{8}$
30	$36\frac{3}{4}$	$1\frac{3}{8}$	95.9	28	$\frac{7}{8}$	35.0	3.927	$36\frac{3}{4}$
33	40	$1\frac{1}{2}$	117	30	$\frac{7}{8}$	38.1	3.990	40
36	$43\frac{1}{2}$	$1\frac{9}{16}$	143	32	$\frac{7}{8}$	41.6	4.084	$43\frac{1}{2}$
40	$47\frac{5}{8}$	$1\frac{5}{8}$	160	34	$\frac{7}{8}$	45.75	4.227	$47\frac{5}{8}$
44	$51\frac{7}{8}$	$1\frac{3}{4}$	197	36	$\frac{7}{8}$	50.0	4.363	$51\frac{7}{8}$
48	56	$1\frac{7}{8}$	224	40	$\frac{7}{8}$	54.1	4.249	56

* The number of bolts given in the table may be decreased when the water pressures and transverse strains upon the bolts are light.

THICKNESSES OF CAST-IRON PIPES.

Formulas of Thickness of Cast-iron Pipes. —The ultimate tenacity of good iron-pipe castings ranges from 16,000 to 20,000 pounds per square inch of section of metal. Their value of *S*, the symbol of tensile strength per square inch, is usually taken at 18,000 pounds, and the coefficient of safety equal to 10, or the term of tensile resistance is taken equal to .1*S*, or if an independent term is introduced in the formula for the effect of water-ram, the coefficient of *S* may be increased to, say .2.

Assuming that the probable or possible *water-ram* will not produce an additional effect greater than that due to a static pressure of 100 pounds per square inch, or head of 230 feet, then the formula for thickness of *cast-iron* pipes may take the form,

$$t = \frac{(h + 230)rw}{(.2S) \times 144} + .333\left(1 - \frac{d}{100}\right) = \frac{(h + 230)dw}{(.4S) \times 144} + .333\left(1 - \frac{d}{100}\right).$$

in which h is the head of water, in feet.

w	"	weight of one cubic foot of water, in lbs.
r	"	internal radius of the pipe, in inches.
d	"	internal diameter of the pipe, in inches.
t	"	thickness of the pipe shell, in inches.
S	"	tenacity of the metal, in pounds per sq. in.

If we substitute a term of pressure per square inch,

$p\ (= .434h)$ for $\frac{hw}{144}$, in the above equations for thickness of cast-iron pipes, they become,

$$t = \frac{(p + 100)r}{.2S} + .333\left(1 - \frac{d}{100}\right) = \frac{(p + 100)d}{.4S} + .333\left(1 - \frac{d}{100}\right).$$

Thicknesses found Graphically.—Since with a constant head, pressure, or assumed stratic strain, the increase of tensile strain upon the shell is proportional with the increase of diameter, and also since the decrease of additional thickness is proportional with the increase of diameter, it is evident that if we compute the thickness of a series of pipes, say from 4-inch to 48-inch diameters, for a given pressure, by a theoretically correct formula, and then plot to scale the results, with diameters as abscissas and thicknesses as ordinates, the extremes of all the ordinates will lie in one straight line; and also, that if the thicknesses for the minimum and maximum diameters of the series be computed and plotted as ordinates, in the same manner, and their extremities be connected by a straight line, the intermediate ordinates, or thicknesses for given diameters as abscissas, will be given to scale. This method greatly facilitates the calculation of thicknesses of a series of "classes" of pipes, and if the ordinates are plotted to large scale, gives a close approximation to accuracy.

454. Table of Thicknesses of Cast-iron Pipes.—The following table gives thicknesses of good, tough, and elastic cast-iron, with $S = 18{,}000$ lbs., for three classes of cast-iron pipes, covering the ordinary range of static pressures of public water supplies.

The thicknesses in the table are based upon the formula,

$$t = \frac{(p + 100)\,d}{.4S} + .333\left(1 - \frac{d}{100}\right).$$

TABLE No. 10.

Thicknesses of Cast-iron Pipes.

(When $S = 18000$ lbs.)

Diameter.	Class A. Pressure, 50 lbs. per square inch, or less. Head, 116 feet. Thicknesses.		Class B. Pressure, 100 lbs. per square inch. Head, 230 feet. Thicknesses.		Class C. Pressure, 130 lbs. per square inch. Head, 300 feet. Thicknesses.	
Inches.	*Inches.*	*Approx. in.*	*Inches.*	*Approx. in.*	*Inches.*	*Approx. in.*
3	.3858	13/32	.4066	13/32	.4191	7/16
4	.4033	13/32	.4311	7/16	.4477	7/16
6	.4383	7/16	.4800	1/2	.5050	1/2
8	.4734	1/2	.5289	17/32	.5622	9/16
10	.5083	1/2	.5777	19/32	.6194	5/8
12	.5433	9/16	.6266	5/8	.6766	11/16
14	.5783	19/32	.6755	11/16	.7338	3/4
16	.6166	5/8	.7277	3/4	.7944	13/16
18	.6483	21/32	.7733	25/32	.8483	27/32
20	.6833	11/16	.8222	27/32	.9055	29/32
22	.7183	23/32	.8711	7/8	.9628	31/32
24	.7533	3/4	.9200	15/16	1.0200	1
27	.8058	13/16	.9933	1	1.1058	1 3/32
30	.8583	7/8	1.0666	1 1/16	1.1916	1 3/16
33	.9108	15/16	1.1400	1 5/32	1.2775	1 9/32
36	.9633	31/32	1.2133	1 7/32	1.3633	1 3/8
40	1.0333	1 1/32	1.3111	1 5/16	1.4778	1 15/32
44	1.1033	1 1/8	1.4088	1 13/32	1.5921	1 19/32
48	1.1733	1 3/16	1.5066	1 1/2	1.7066	1 11/16

In the following table are given the thicknesses of cast-iron pipes, as used by various water departments.

TABLE No. 11.

THICKNESSES OF CAST-IRON PIPES, AS USED IN SEVERAL CITIES.

DIAMETER, INCHES.	PHILADELPHIA.	NEW YORK.	BALTIMORE.	BROOKLYN.	ST. LOUIS.	CHICAGO.	CLEVELAND.	PROVIDENCE.	LOWELL.	ROCHESTER.	FALL RIVER.	ALLEGHENY.	DETROIT.	ALBANY.	MILWAUKEE.	DIAMETER, INCHES.
	Head Pressures for which Pipes are Classed, in feet.															
	115	100	218	120	130	125	150	100	130	150	80	162	100	144	150	
	250	....	....	170	170	...	....	140	170	200	140	....	....	200	200	
	....	....	...	198	....	....	....	180	200	....	260	....	...	....	...	
	Thicknesses of Pipe Shells, in inches.															
4	3/8	....	7/16	....	1/2	1/2	1/2	....	....	1/2	3/8	1/2	7/16	1/2	...	4
6	7/16	1/2	7/16	9/16	17/32	1/2	1/2+	1/2	7/16	5/8	15/32	1/2	7/16	1/2	15/32	6
6	....	....	....	21/32	9/16	....	....	1/2	1/2	7/8	5/8	....	....	5/8	1/2	6
8	7/16+	....	1/2	1/2	9/16	1/2	1/2	1/2	1/2	7/8	17/32	5/8	1/2	1/2	1/2	8
8	....	....	....	21/32	5/8+	....	....	9/16	9/16	....	3/4	....	....	5/8	9/16	8
10	1/2	....	1/2	....	5/8—	5/8	5/8	19/32	....	3/4	19/32	....	1/2	5/8	...	10
12	9/16	5/8	11/16	5/8	21/32	3/4	3/4	9/16	19/32	3/4	5/8	3/4	9/16	5/8	9/16	12
12	....	....	....	13/16	23/32	....	....	21/32	5/8+	1	15/16	....	....	3/4	5/8	12
16	5/8	3/4	13/16	....	....	7/8	3/4+	21/32	11/16—	3/4	3/4	3/4	5/8	3/4	11/16	16
16	....	....	....	....	....	....	....	3/4	3/4	1	1 1/8	....	....	7/8	...	16
20	11/16	3/4	15/16	7/8	13/16	....	7/8	23/32	...	3/4	7/8	1	3/4	....	3/4	20
20	....	....	....	1	15/16+	....	....	27/32	....	1	1 5/16	....	....	....	7/8	20
24	....	7/8	....	....	....	....	7/8+	13/16	13/16	3/4	3/4	1	....	....	15/16	24
24	....	....	....	....	....	....	....	15/16	15/16+	1	1	....	....	....	1	24
30	15/16	1	1 1/8	1 3/32	1 1/32	....	1 1/8	29/32	15/16+	7/8	....	1 1/8	....	....	1	30
30	....	....	....	1 3/8	1 1/4	....	....	1	1 1/8	....	....	....	....	....	1 1/16	30
30	....	....	....	....	....	....	....	1 1/16	1 5/16	1 1/8	....	....	....	....	...	30
36	1 1/8	1	....	1 1/8	1 1/8+	....	1 3/16	1	....	....	....	1 1/8	1	....	...	36
36	....	....	....	....	1 5/8	....	....	1 1/4	....	....	..	....	....	....	...	36
48	....	1 1/4	....	1 5/16	1 3/8	....	....	....	....	....	....	....	....	....	...	48

Table of Equivalent Fractional Expressions.—The following tables of equivalent expressions for fractions of an inch and of a foot, may facilitate pipe calculations:

TABLE No. 12.

PARTS OF AN INCH AND A FOOT, EXPRESSED DECIMALLY.

INCHES.	Equivalent Dec. part of an inch.	Equivalent Dec. part of a foot.
1-32	.03125	.002604
1-16	.06250	.005208
3-32	.09375	.007812
1-8	.12500	.010416
5-32	.15625	.010420
3-16	.18750	.015625
7-32	.21875	.018229
1-4	.25000	.020833
9-32	.28125	.023437
5-16	.31250	.026041
11-32	.34375	.028645
3-8	.37500	.031250
13-32	.40625	.033854
7-16	.43750	.036458
15-32	.46875	.039062
1-2	.50000	.041666
17-32	.53125	.044270
9-16	.56250	.046875
19-32	.59375	.049479
5-8	.62500	.052083
21-32	.65625	.054607
11-16	.68750	.057291
23-32	.71875	.059895
3-4	.75000	.062500
25-32	.78125	.065104
13-16	.81250	.067708
27-32	.84375	.070312
7-8	.87500	.072916
29-32	.90625	.075520
15-16	.93750	.078125
31-32	.96875	.080729
1	1.	.083333

INCHES.	Equivalent Dec. parts of a foot.	Dec. parts of a foot.	Equiv. inches and 32d pts., nearly.
1	.0833	.1	$1\frac{3}{16}$
2	.1667	.2	$2\frac{3}{8}$
3	.2500	.3	$3\frac{19}{32}$
4	.3333	.4	$4\frac{25}{32}$
5	.4167	.5	6
6	.5000	.6	$7\frac{3}{16}$
7	.5833	.7	$8\frac{3}{8}$
8	.6667	.8	$9\frac{19}{32}$
9	.7500	.9	$10\frac{25}{32}$
10	.8333	1.0	12
11	.9167		
12	1.0000		

Cast-Iron Pipes.—According to Crecy,* cast-iron pipes were first generally adopted in London very near the close of the last century. The great fire destroyed many of the lead mains in that city. These were in part replaced by wood pipes, but when water-closets were introduced and more pressure was demanded, the renewals were afterward wholly of iron.

* Encyclopedia of Civil Engineering, p. 549. London, 1865.

TABLE No. 13.

FORMULAS FOR THICKNESS OF CAST-IRON PIPES COMPARED.

Assumed static pressure, 75 lbs. per square inch. Assumed tenacity of metal, 18,000 lbs. per square inch.

AUTHORITY.	EQUATIONS.	DIAMETERS. 4 in.	12 in.	24 in.	48 in.
		Thickness.	Thickness.	Thickness.	Thickness.
		Inches.	*Inches.*	*Inches.*	*Inches.*
Equation (12), § 452..	$t = \frac{(p+100)d}{.4S} + .333\left(1 - \frac{d}{100}\right)$	.4172	.5850	.8367	1.3400
M. Dupuit	$t = (.0016nd) + .013d + .32$	.4055	.5766	.8333	1.3466
J. F. D'Aubuisson...	$t = (.015d) + .395$	.4550	.5750	.7550	1.1150
Julius Weisbach.....	$t = (.00238nd) + .34$	.3899	.4897	.6394	.9389
Dionysius Lardner..	$t = (.007nr) + .38$	.4534	.6002	.8204	1.2608
Thomas Box	$t = \left\{\frac{\sqrt{d}}{10} + .15\right\} + \frac{hd}{25000}$	.3776	.5794	.8069	1.1750
G. L. Molesworth...	$t = (.000054hd) + \left\{\begin{matrix} .37 \text{ for } 4'' \text{ to } 12'' \\ .50 \text{ " } 12 \text{ " } 30 \\ .62 \text{ " } 30 \text{ " } 50 \end{matrix}\right\}$	.4074	.6121	.7242	1.0684
Wm. J. M. Rankine.	$t = \sqrt{\frac{d}{48}}$	.2887	.5000	.7071	1.0000
John Neville	$t = [.0016(n + 10)d] + .32$	.4175	.6126	.9053	1.4902
Thos. Hawksley	$t = .18\sqrt{d}$	.3600	.6235	.8818	1.2470
Baldwin Latham	$t = \frac{whd}{28.8S} + .25$	.3334	.5002	.7504	1.2508
James B. Francis...	$t = (.000058hd) + .0152d + .312$	.4129	.6148	.9176	1.5232
Thos. J. Whitman...	$t = (.0045nd) + .4 - .0011d$	.4900	.6699	.9397	1.4795
M. C. Meigs........	$t = (.0260416d) + .25$	.3542	.5625	.8750	1.5000
J. H. Shedd	$t = (.00008hd) + .01d + .36$..........	.4554	.6461	.9322	1.5000
J. F. Ward..........	$t = (.0002hd) + .30$.................	.4384	.7152	1.1304	1.9608
Jos. P. Davis........	$t = (.00475nd) + .35$................	.4496	.6488	.9476	1.5452

In which t = thickness of pipe wall, in inches.
d = interior diameter of pipe, in inches.
h = head of water, in feet.
w = weight of a cubic foot of water, = 62.5 lbs.
n = number of atmospheres of pressure, at 33 feet each.
p = pressure of water, in pounds per square inch.
S = ultimate tenacity of cast-iron, in pounds per square inch.

Fig. 16.

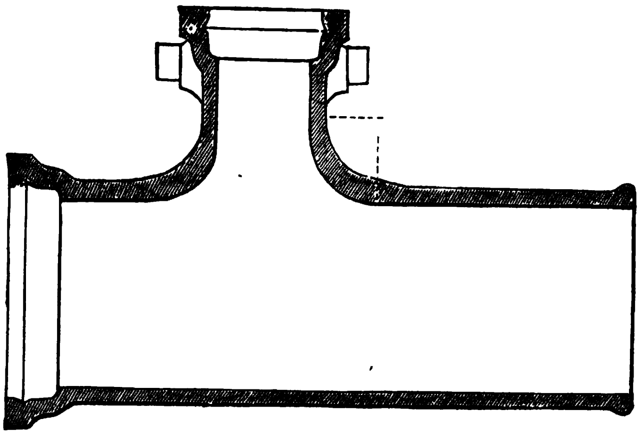


Fig. 17.

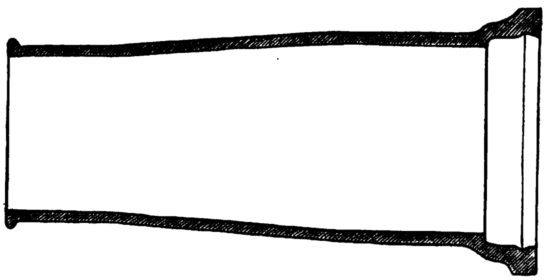
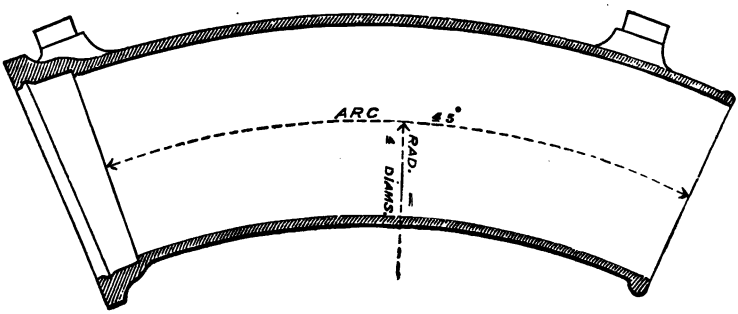


Fig. 18.



WEIGHTS OF CAST-IRON PIPES.

Formulas for Weights of Cast-iron Pipes.— The mean weight of cast-iron is about 450 pounds per cubic foot, or .2604 pounds per cubic inch.

Let d be the diameter of a cast-iron pipe, in inches; t, the thickness of the pipe-shell, in inches; and π the ratio of circumference to diameter ($= 3.1416$); then the cubical volume V_1, in inches, of a pipe-shell (neglecting the weight of hub), is, for each foot in length,

$$V_1 = (d + t) \times t \times \pi \times 12.$$

When the *length* of a pipe is mentioned, it is commonly the length between the outside of the hub and the end of the spigot that is referred to; that is, the total length of the pipe.

The *average* weight of a pipe per foot includes the weight of the hub, which, as thus spoken of, is assumed to be distributed along the pipe.

The weights of the hubs, of general form shown in Fig. 14, and whose dimensions are given in Table No. 8 (p. 50), increase the average weight per foot of the twelve-foot light pipes, approximately, eight per cent.; of the medium pipes, seven and one-half per cent.; and of heavier pipes, seven per cent.

The equation for cubical volume of pipe-metal, including hub, is

$$V = (d + 1.08t) \times t \times \pi \times 12.$$

Let w_1 be the weight per cubic inch of the metal (= .2604 lbs.), and w the *average* weight per foot of the pipe, then we have for equation of average weight per foot, of twelve-foot pipes,

$$w = 12\,(d + 1.08t)\,t\,\pi\,w_1.$$

To compute the average weight per lineal foot of an 18-inch diameter pipe, twelve feet long, and $\frac{21}{32}$ inch thick in the shell, assign the numerical value to the symbols, and the equation is:

$$w = 12\,[18 + (1.08 \times .65625)] \times .65625 \times 3.1416 \times .2604$$
$$= 120.58 \text{ pounds.}$$

In the equation, 12, π, and w_1 are constants, and may be united, and their product (= 9.81687) supply their place in the equation, when the equation for *average weight per foot* is,

$$w = 9.82\,(d + 1.08t) \cdot t;$$

and for the *total weight* of a 12-foot pipe:

$$W = 117.8\,(d + 1.08t) \cdot t.$$

Table of Weights of Cast-iron Pipes.—The following table gives minimum weights of three classes of cast-iron pipes, of good, tough, and elastic cast-iron (with S = 18,000 lbs.), for heads up to 300 ft.; also, approximate weights of lead required per joint for the respective diameters, from 4 to 48 inches, inclusive.

TABLE No. 14.

Minimum Weights of Cast-iron Pipes.

Diameter.	Class A. Head, 116 feet. Pressure, 50 lbs.			Class B. Head, 230 feet. Pressure, 100 lbs.			Class C. Head, 300 feet. Pressure, 130 lbs.			Depth of lead in socket.	Weights of lead per joint.
	Thickness.*	Average weight per lineal foot, $w=9.82\times(d+1.08t)t$.	Total weight of a 12-foot pipe.	Thickness.	Average weight per lineal foot, $w=9.82\times(d+1.075t)t$.	Total weight of a 12-foot pipe.	Thickness.	Average weight per lineal foot, $w=9.82\times(d+1.07t)t$.	Total weight of a 12-foot pipe.		
in.	*in.*	*lbs.*	*lbs.*	*in.*	*lbs.*	*lbs.*	*in.*	*lbs.*	*lbs.*	*in.*	*lbs.*
4	.4033	17.57	211	.4311	18.94	227	.4477	19.69	236	1 7/8	4.25
6	.4383	27.87	334	.4800	30.71	369	.5050	32.43	389	1 7/8	6.25
8	.4734	39.67	476	.5289	44.50	534	.5622	47.49	570	1 7/8	8.25
10	.5083	52.66	632	.5777	60.25	723	.6194	64.85	778	1 7/8	10.25
12	.5433	67.12	805	.6266	76.20	914	.6766	84.53	1014	2	13.00
14	.5783	83.04	996	.6755	97.68	1172	.7338	106.54	1278	2	15.00
16	.6166	100 90	1211	.7277	119.93	1439	.7944	131.45	1577	2 1/4	24.25
18	.6483	119.35	1432	.7733	143.00	1716	.8483	157.51	1890	2 1/4	27.25
20	.6833	139.14	1670	.8222	168.61	2023	.9055	186.45	2237	2 1/4	30.75
22	.7183	160.64	1928	.8711	196.00	2352	.9628	217.74	2613	2 1/4	35.25
24	.7533	183.55	2203	.9200	225.75	2709	1.0200	251.33	3016	2 1/4	38.25
27	.8058	220.53	2646	.9933	273.76	3285	1.1058	306.15	3674	2 3/8	51.25
30	.8583	260.66	3128	1.0666	326.01	3912	1:1916	366.00	4392	2 3/8	56.75
33	.9108	304.00	3648	1.1400	383.13	4598	1.2775	431.15	5174	2 3/8	62.25
36	.9633	350.31	4204	1.2183	444.48	5334	1.3633	501.48	6018	2 1/2	79.50
40	1.0333	417.20	5006	1.3111	533.15	6398	1.4778	603.45	7241	2 1/2	88.75
44	1.1033	489.50	5874	1.4088	629.70	7556	1.5921	714.55	8575	2 5/8	107.75
48	1.1733	567.63	6812	1.5066	734.10	8809	1.7066	835.00	10020	2 5/8	111.00

The following table gives the weights of pipes that have been used by various water departments for their maximum pressures:

* *Vide* thicknesses of pipes in Table No. 10, p. 54.

TABLE No. 18.

WEIGHTS OF CAST-IRON PIPES, AS USED IN SEVERAL CITIES FOR THEIR MAXIMUM PRESSURES.

DIAMETER, INCHES.	PHILADELPHIA.	NEW YORK.	BOSTON.	BALTIMORE.	BROOKLYN.	ST. LOUIS.	CHICAGO.	PROVIDENCE.	LOWELL.	FALL RIVER.	TOLEDO.	ROCHESTER.	OTTAWA.	RICHMOND.	MILWAUKEE.	DIAMETER, INCHES.
	Maximum Head, in feet.															
	R.	R.	R.	R.	R.	R.	S.-P.	R.	R.	S.-P.	S.-P.	R. & D.-P.	D.-P.	R.	R. & S.-P.	
	250	100	180	218	198	170	125	180	200	260	175	200	250	237	200	
	Average Weights, per lineal foot, in pounds.															
3	15	...	13½	12	....	...	......	....	....	......	......	.. ...	14	14	......	3
4	19	24	20	18½	18	....	24½	....	....	24	23½	20	*25	20	......	4
6	31	36	32	28½	39½	35	36⅓	33½	34	43	34	32	......	30	35	6
8	42	....	46	40	55	....	50	49	49	69	48	45	46	45	50	8
10	53	....	....	56	. .	....	......	64⅓	...	87	... ..	53½	......	60	.. . .	10
12	71	86	81	85	90	85	83⅓	85	85	123	85	75	86	100	87	12
14	....	....	....	....	...	...	......	103	....	......	......	......	*125	....	......	14
16	105	....	124	130	....	...	125	128	129⅓	197½	134	113	......	130	129½	16
20	151	170	174	200	208	183	......	178½	182	239	194	165	......	170	194	20
24	307	235	231	....	....	...	250	239	241⅓	257	265	265	202	230	266½	24
30	330	340	337	350	407½	325	......	338	350	......	358	334	257	330	351	30
36	422	405	458	....	400	438	450	472	412	......	.....	......	......	....	......	36
48	585	696	606	....	692	...	......	....	....	......	......	... ..	......	....	......	48

The initials in the horizontal column of heads indicate the systems of pressure, viz., R., reservoir; S.-P., stand-pipe; and D.-P., direct pressure.

COATING OF PIPES.

Favorite Process.—The practice has now become almost universal to treat pipes before shipment from the foundry with a bath of hot coal-pitch varnish, substantially in accordance with Dr. Smith's specification. Many processes for the protection of pipes have been tested by experiment, but this simple process finds most favor at present. We refer to some of the processes that have been experimented with in Europe, as matter of interest.

The Preservation of Pipe Surfaces.—The uncoated iron mains first laid down in London, by the New River Company, were supposed to impart a chalybeate quality to the water, and a wash of lime-water was applied to the interiors of the pipes before laying to remedy this evil.

Before iron pipes had been long in use, in the early part of the present century, in those European towns and cities supplied with soft water, it was discovered that tuberculous accretions had formed so freely upon their interiors as to seriously diminish the volume of flow through the pipes of three, four, and six-inch diameters.

This difficulty, which was so serious as to necessitate the laying of larger distribution pipes than would otherwise have been necessary, engaged the attention of British and continental engineers and chemists from time to time. Many experimental coatings were applied, of silicates and oxides, and the pipes were subjected to baths of hot oil under pressure, with the hope of fully remedying the difficulty. A committee of the British Association also inquired into the matter in connection with the subject of the preservation of iron ships, and instituted valuable experiments, which are described in two reports of Robert Mallet to the Association.

A similar difficulty was experienced with the uncoated iron pipes first laid in Philadelphia and New York.

In the report of the city engineer of Boston, January, 1852, mention is made of some pipes taken up at the South Boston drawbridge, which had been exposed to the flow of Cochituate water nine years.

He remarks that "some of the pipes were covered internally with tubercles which measured about two inches in area on their surfaces, by about three-quarters of an inch in height, while others had scarcely a lump raised in them.

Those which were covered with the tubercles were corroded to a depth of about one-sixteenth of an inch; the iron to that depth cutting with the knife very much like plumbago." Mr. Slade, the engineer, expressed the opinion, after comparing the condition of these pipes with that of pipes examined in 1852, that the corrosion is very energetic at first, but that it gradually decreases in energy year by year.

The process used by Mons. Le Beuffe, civil engineer of Vesoul, France, for the defence of pipes, as communicated* by him to Mr. Kirkwood, chief engineer of the Brooklyn Water-works, "consists of a mixture of linseed oil and beeswax, applied at a high temperature, the pipe being heated and dipped into the hot mixture.

The varnish of M. Crouzière, tested on iron immersed in sea-water at Toulon, by the French navy, consisted of a mixture of sulphur, rosin, tar, gutta-percha, minum, blanch de ceruse, and turpentine. This protected a plate of wrought iron perfectly during the year it was immersed.

A process that has proved very successful for the preservation of iron pipes used to convey acidulated waters from German mines, is as follows:† "The pipes to be coated are first exposed for three hours in a bath of diluted sulphuric or hydrochloric acid, and afterward brushed with water; they then receive an under-coating composed of 34 parts of silica, 15 of borax, and 2 of soda, and are exposed for ten minutes in a retort to a dull red heat. After that the upper coating, consisting of a mixture of 34 parts of feldspar, 19 of silica, 24 of borax, 16 of oxide of tin, 4 of fluorspar, 9 of soda, and 3 of saltpetre, is laid over the interior surface, and the pipes are exposed to a white heat for twenty minutes in a retort, when the enamel perfectly unites

* *Vide* Descriptive Memoir of the Brooklyn Water-works, p. 43. N. Y., 1867.

† *Vide* "Engineering." London, Jan., 1872, p. 45.

with the cast-iron. Before the pipes are quite cooled down, their outside is painted with coal-tar. The above ingredients of the upper coating are melted to a mass in a crucible, and afterwards with little water ground to a fine paste."

Prof. Barff, M.A., proposes to preserve iron (including iron water-pipes) by converting its surfaces into the magnetic or black oxide of iron, which undergoes no change whatever in the presence of moisture and atmospheric oxygen.

He says, "The method which long experience has taught us is the best for carrying out this process for the protection of iron articles, of common use, is to raise the temperature of those articles, in a suitable chamber, say to 500° F., and then pass steam from a suitable generator into this chamber, keeping these articles for five, six, or seven hours, as the case may be, at that temperature in an atmosphere of superheated steam.

"At a temperature of 1200° F., and under an exposure to superheated steam for six or seven hours, the iron surface becomes so changed that it will stand the action of water for any length of time, even if that water be impregnated with the acid fumes of the laboratory."

The first coated pipes used in the United States, were imported from a Glasgow foundry in 1858. These were coated by Dr. Angus Smith's patent process, which had been introduced in England about eight years earlier. Dr. Smith's Coal Pitch Varnish is distilled from coal-tar until the naphtha is entirely removed and the material deodorized, and Dr. Smith recommends the addition of five or six per cent. of linseed oil.

The pitch is carefully heated in a tank that is suitable to receive the pipes to be coated, to a temperature of about

300 degrees, when the pipes are immersed in it and allowed to remain until they attain a temperature of 300° Fah.

A more satisfactory treatment is to heat the pipes in a retort or oven to a temperature of about 310° Fah., and then immerse them in the bath of pitch, which is maintained at a temperature of not less than 210°.

When linseed oil is mixed with the pitch, it has a tendency at high temperature to separate and float upon the pitch. An oil derived by distillation from coal-tar is more frequently substituted for the linseed oil, in practice.

The pipes should be free from rust and strictly clean when they are immersed in the pitch-bath.

Varnishes for Pipes and Iron-work.—A good *tar varnish*, for covering the exteriors of pipes where they are exposed, as in pump and gate houses, and for exposed iron work generally, is mentioned by Ewing Matheson, and is composed as follows: 30 gallons of coal-tar fresh, with all its naphtha retained; 6 lbs. tallow; 1½ lbs. resin; 3 lbs. lampblack; 30 lbs. fresh slacked lime, finely sifted. These ingredients are to be intimately mixed and applied hot. This varnish may be covered with the ordinary linseed-oil paints as occasion requires.

A *black varnish*, that has been recommended for outdoor iron work, is composed as follows: 20 lbs. tar-oil; 5 lbs. asphaltum; 5 lbs. powdered rosin. These are to be mixed hot in an iron kettle, with care to prevent ignition. The varnish may be applied cold.

Approximate Consumption of Water.—In American cities, having well arranged and maintained systems of water supply, and furnishing good wholesome water for domestic use, and clear soft water adapted to the uses of the arts and for mechanical purposes, the average consumption is found to be approximately as follows, in United States gallons:

(*a.*) For ordinary domestic use, not including hose use, 20 gallons per capita per day.

(*b.*) For private stables, including carriage washing, when reckoned on the basis of inhabitants, 3 gallons per capita per day.

(*c.*) For commercial and manufacturing purposes, 5 to 15 gallons per capita per day.

(*d.*) For fountains, drinking and ornamental, 3 to 10 gallons per capita per day.

(*e.*) For fire purposes, $\frac{1}{10}$ gallon per capita per day.

(*f.*) For private hose, sprinkling streets and yards, 10 gallons per capita per day, during the four dryest months of the year.

(*g.*) Waste to prevent freezing of water in service-pipes and house-fixtures, in Northern cities, 10 gallons per capita per day, during the three coldest months of the year.

(*h.*) Waste by leakage of fixtures and pipes, and use for flushing purposes, from 5 gallons per capita per day upward.

The above estimates are on the basis of the total populations of the municipalities.

There will be variations from the above approximate general average, with increased or decreased consumption for each individual town or city, according to its social and business peculiarities.

In the year 1870, the average daily supply to some of the American cities was as follows, in United States gallons:

TABLE No. 16.

WATER SUPPLIED AND PIPING IN SEVERAL CITIES, IN THE YEAR 1870.

CITIES.	POPULATION IN 1870.	SUPPLY PER PERSON, DAILY AVERAGE	SUPPLY PER FAMILY, DAILY AVERAGE.	SUPPLY PER DWELLING, DAILY AVERAGE.	TOTAL DAILY SUPPLY, AVERAGE.	TOTAL MILES OF PIPE MAINS.	MILES OF PIPE PER 1,000 INHABITANTS.
		Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Miles.*	*Miles.*
Baltimore....	267,354	52.81	282.53	350.13	14,122,032	214	0.80
Boston	250,526	60.15	312.78	508.87	15,070,400	194	0.78
Brooklyn	396,099	47.16	233.44	407.46	18,682,219	258	0.65
Buffalo	117,714	58.08	306.08	374.04	6,838,303	56	0.48
Cambridge...	39,634	43.90	220.38	273.94	1,739,869	60	1.64
Charlestown..	28,323	43.90	201.94	282.72	1,243,380	25	0.90
Chicago	298,977	62.32	313.47	417.54	18,633,000	240	0.81
Cincinnati ...	216,239	40.00	201.60	352.40	10,812,609	132	0.61
Cleveland....	92,829	33.24	167.53	184.81	3,085,559	50	0.54
Detroit	79,577	64.24	236.98	348.18	5,112,493	129	1.61
Hartford.....	37,180	65.81	329.71	365.90	2,447,000	48	1.30
Jersey City...	82,546	83.66	414.12	700.23	6,906,056	70	0.85
Louisville....	100,753	28.95	151.99	198.89	2,817,300	58	0.58
Montreal, Can.	117,500	49.00	......	....	5,720,306	96	0.81
Newark......	105,059	20.20	98.17	147.86	2,121,842	52	0.50
New Haven..	50,840	59.00	286.15	370.52	3,000,000	53	1.04
New Orleans .	191,418	30.19	147.63	171.78	5,779,317	58	0.30
New York ...	942,292	90.20	457.31	1,327.74	85,000,000	346	0.37
Philadelphia .	674,022	55.11	290.98	331.21	37,145,385	488	0.71
Salem	24,117	41.46	......	....	1,000,000	35	1.04
St. Louis	310,864	35.38	185.04	277.38	11,000,000	105	0.34
Washington ..	109,199	127.00	650.24	709.93	13,868,273	102	0.93
Worcester....	41,105	48.65	230.60	406.23	2,000,000	45	1.09

Rates Charged for Water in Various Cities.

	House*	Bath.	Water Closet.	Urinal.	Fountains. ⅛ diam.†	Sprinkling.	Brick, per 1000.	Stone, per perch.	Plastering, per 100 yds.	Stables,‡ per stall.	Engines,§ per horse power.	Meter.‖ pr. 1000	Kind of service-pipe.	No. of fire hydrants.	Miles of main.	Mode of supply.
Auburn, N. Y.	$10.50	......	$3.00	......	$30.00	$4.00	10c.	3c.	30c.	....	$2–4	......	....	224	22	Steam and water power.
Augusta, Me.	12.00	$5.00	6.00	......	......	3.00	Cask of lime, 10c.			$3.00	6	......	....	8	3	Gravity.
Boston, Mass.	7.00	5.00	5.00	......	3.00	5.00	"	"	7	2.00	10–6	20 cts.	Lead.	3859	355	Gravity.
Buffalo, N. Y.	15 00	5 00	5.00	$6.00	......	6 cts. per ft.	12½	4	40	2 50	6	30	Cast-iron.	1052	94	Steam.
Chicago, Ill.	14.00	3.00	3.00	3.00	60.00	3 00	6	6	15	2.00	5	30	Lead.	3002	400	Steam.
Cincinnati, Ohio	6.00	6.00	3.00	5.00	......	3.00	10	3		2.00	....	15	Lead.	470	180	Steam.
Cleveland, Ohio	7.50	2.50	2.50	1.25	25.00	....	6½	2⅛	18¾	2.50	2.50	10	Lead.	873	113	Steam.
Concord	6.00	3.00	3.00	3.00	8 00	4.00	Lime, pr. bbl., 6c.			2.00	3	13½	Iron and cement.	94	25⅝	Gravity.
Davenport	12.00	6.00	6.00	6.00	37.00	6.00	12½	5	40	3.00	4–5	30	Galv.	240	22	Steam.
Dayton	4.00	2.00	2.50	1.00	6.00	3.00	5	4	30	1.00	....	20	Lead.	276	32	Steam.
Detroit	8.00	2.00	4.00	2.00	......	5.00	Lime, bbl., 5c.			2.00	....	10	Lead.	681	200	Steam.
Fitchburg	6.00	5.00	5.00	......	......	5.00	" cask, 6			2.00	....	25	Iron and cement.	200	25½	Gravity.
Lawrence	5.50	3 00	4.00	3.00	9 00	10.00	"	"	5	2.00	4	25	....	455	39	Steam.
Lowell	7.00	3.00	3.00	......	......	3.00	"	"	6	2.00	4	......	Rubber, coated.	653	57½	Steam.
Manchester	5.75	2.50	2 50	1.00	......	3.00	"	"	10	1.00	4–6	20	....	303	32	Water-power.
Memphis	6.00	5.00	5.00	5.00	15.00	5.00	10		50	2.00	5	50	Lead and iron.	173	17	Steam.
Milwaukee	6.00	3.00	3.00	5.00	......	3.00	6		30	1.00	4	20	Lead.	644	79	Steam.
Montgomery	12.00	6.00	5.00	5.00	15.00	12.00	....			2.00	8	25	Wrought-iron.	100	10	Steam.
Minneapolis	5.25	1.00	3.00	2.00	6 00	2.00	5	1½	20	1.00	2–4	10	Wrought-iron.	198	16	Water-power.
Muskegon	3.50	2.00	2.00	2.00	7.50	5.00	5	12½	30	1.50	....	12½	Galv.	156	16⅝	Steam.
New London	6.00	3.00	3.00	......	10.00	5.00	Lime, bbl., 12½c.			2.00	3	15	Iron and Cement.	105	21	Gravity.
Newport	9.00	6 00	6.00	......	......	10.00	....			3.00	7	40	Iron.	....	21	Steam.
New Orleans	12.00	3.00	......	......	......	10.00	....			3 00	....	......	Lead.	....	60	Steam.
Northampton	6.00	2.00	2 00	......	......	....	8	5	20	1.00	3	20	....	....	....	Gravity.
Norfolk	7.00	2.00	3.00	1.50	5.00	5.00	10	6	10	1 00	....	30	Cast-iron.	91	29½	Steam.
Portland	12 00	5.00	6.00	......	......	....	Lime, cask, 7c.			3.00	....	40	Galv.	216	55	Gravity.
Poughkeepsie	4.00	1.50	2.00	2.00	8.00	4 00	....			1.00	2.50	15	Lead.	282	17½	Steam.
Pittsfield	7.50	2.50	3.75	......	......	....	7½	2½	25	1.25	3⅛	......	Various.	70	25	Gravity.
Providence	6.00	5.00	5.00	3.00	10.00	5.00	Lime, cask, 8c.			2.00	....	30	Lead.	1103	149	Steam.
Pawtucket	5.00	......	......	......	......	8.00	....			1 50	5	20	Tarred iron.	283	30½	Steam.
Rochester	2.50	2.00	2.00	1.00	12.00	3 00	5	2	20	1.50	3	15	Lead.	812	95½	Gravity and W.-power.
Rockford	5.00	3.00	2.50	2.00	15.00	6 cts. per ft.	10	10	20	1.25	2	25	Iron.	172	23	Steam.
Springfield	8.00	4.00	4.00	2.00	......	5.00	10	5	20	2.00	5	30	Enam.	302	62¾	Gravity.
St. Louis	6.00	3.00	5.00	10.00	......	10 cts. per ft.	10	5	50	2.00	....	20	Lead.	1600	195	Steam.
Syracuse	15.00	5.00	5.00	3.00	25.00	3.00	12½	4	40	2.00	5	35	Lead.	287	....	Gravity and steam.
Taunton	5.00	3.00	5.00	2.00	5.00	5.00	Lime, cask, 6c.			1.50	....	25	Iron and cement.	238	27	Steam.
Worcester	7.00	5.00	4.00	......	......	4.00	....			1.50	....	25	Iron and cement.	601	76½	Steam.

* The charge to a house is often regulated by the character and size of the house. The table is based on a house of six rooms, or costing $1500, or being 25 feet front by 3 stories high, or containing six people.

† The prices given for fountains, a ⅛-jet, playing a limited number of hours daily.

‡ The prices given for stables are for the additional stalls over a certain charge for the first stall.

§ The prices given for horse-power are for additional power over 15 horse-power.

‖ The prices given for metered water are for 3000 gallons per day.

STOP VALVES.

EDDY'S PATENT.

Previous Forms.—It was not till about eleven years ago that the attention of manufacturers was successfully directed to the improvement of stop-gates.

Solid Wedge Valve.—The form then in use was that of a solid wedge, faced on both sides, and owing its tightness to being fitted exactly into its seats, and being forced down hard upon them by the pressure of the screw.

Disadvantages.—Its disadvantages are, that should any obstacle lodge upon either of the seats the valve could not accommodate itself to the obstruction and close tightly, which would also be the case if the screw had become bent by straining, as is often done when difficulty is experienced in opening or closing the valve, because it could not press the wedge forward in the proper line for a perfect fit.

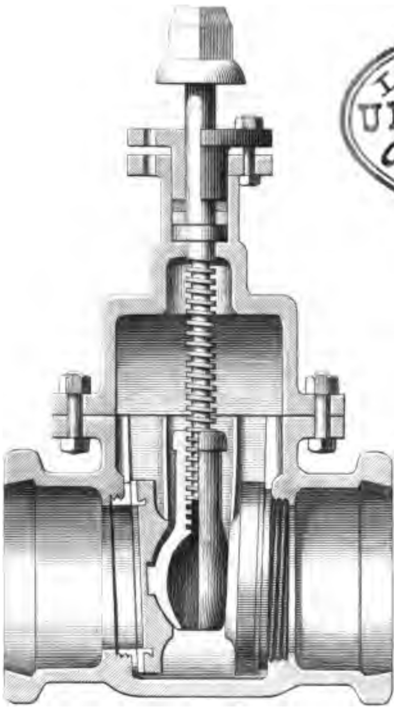
Improvements.—In the efforts to overcome these difficulties the wedge was divided into two plates or disks, each bearing a face, and hinging them to some mover so as to allow of some play and adjustment to the seats when closing, so that at least one of the faces would have a proper bearing, and effectually close the passage.

Eddy Valve.—The valve which embodies these prin-

R. D. WOOD & CO.,

Foundries: { Millville, Florence, } N. J.

PHILADELPHIA, PA.



EDDY STOP VALVE.

Made of all sizes, from 2 to 48 inches diameter.

ciples most thoroughly is the Eddy Patent Valve, Fig. 19, and it accomplishes them as follows:

Complete Adjustability.—1. It will be noticed that the spreader which forces the disks down has the shape of a ball, thus allowing not only a perpendicular play as is the case with a hinge, but also and equally a sideways play, in fact a UNIVERSALITY of adjustment to any obstacle that may be on the seat.

No Dragging on the Seats.—2. The spherical form of the spreader also permits it to rise from the disks immediately on the beginning of opening the valve, thus relieving them from the closing pressure, and preventing completely any dragging of them on their seats. The spherical form accomplishes this much more perfectly than any wedge can.

Center Bearing.—3. The spreader has but a single point of contact with the disks and that at the center. The importance of this in preserving a perfect closure of the passages will be recognized when it is remembered that all valves are tested (or should be) to 250 pounds per square inch before shipment, causing a strain on a 20-inch valve equal to a pressure of 35 gross tons on each disk.

Warping under Pressure.—If the disks take their support at two points on opposite sides, or on a line drawn across their face, it will be seen that the disks will be bent backward at top and bottom, and leaks will then occur. But when the bearing is at one point at the center, the disk yields equally all around, and the tightness of its fit is not impaired, as it only requires to be driven home but a trifle further.

Rotation and Freedom from Wear.—4. It will be noted that the spreader is provided with trunnions which carry the disks up when the valve is opened. The advantage here gained is that the disks, being hung on their centers, are able to revolve while lifting and closing, thus altering every time the valve is closed their position with relation to the seats, and so avoid aggravating by constant wear any scar that may be made, but rather distributing the wear evenly over the whole face, thus materially lengthening the life of the valve.

Cleansing.—It will further be seen that this same circular motion, while distributing the wear, also tends to cleanse the seats of any dirt that may be adhering to them.

Superiority.—These are the distinguishing features that give the Eddy Valve superiority, and are not found in any of the many other valves, whose disks are forced to their seats by wedges, which cause dragging on the faces, and by unequal support at the back allow warping of the disk under pressure.

Claims.—We claim, therefore, for the valve as made by us—

1. Perfect workmanship, every valve being tested before shipment.
2. Great ease in opening without dragging, on account of the shape of the ball.
3. Unequalled tightness of fit.
4. Long wear.

Our Facilities.—Being largely in the foundry business, we are in a position, and have the mechanical facilities, to make these valves with the utmost economy, and our experience in water-works at the same time gives us a knowledge of what is required. We therefore solicit trade for the future, fully believing that upon trial our valve will prove itself superior to any other that is made.

SANITARY SAYINGS.

Dr. Chandler says: "Pure water is hardly second to pure air as a life-giving and life-protecting agent. It is the most potent servant the sanitary authorities can call to their aid."

Baldwin Latham says; "Health is the capital of the laboring man. It is better to give health than alms."

"In the prosecution of sanitary works we have discovered the real 'philosopher's stone,' for such works have added to the average duration of life."

A prominent physician remarked to us that the introduction of wholesome water into his city a few years since, and the consequent abandonment of the use of well water, especially in the tenement-house sections, had seriously affected medical practice in the city.

The doctors have our sympathy, but we rejoice for those who have received the precious tonic, water, and are thus enabled to abandon the potions and save the fees. His remark unfolds a glorious picture of health and happiness from the dissolving view of wretchedness.

The Chief Engineer of Fire Department of the same city informed us that during the four years previous to the construction of the new water-works, the annual losses by fire in the city averaged $4 per inhabitant, or about $125,000. per year; but that during the four years since the introduction of water the annual losses had not exceeded an average of $.75 per capita. Here is an apparent annual saving which equals the operating expense of the water-works and twelve per cent interest on their cost, and the cash income from the works already exceeds four per cent interest on their cost, while the income of health and strength is hardly expressible by a gold standard.

FIRE HYDRANTS.

MATHEWS' PATENT.

Retrospective.—The past twenty years has witnessed important and essential improvements in the arrangement of the parts of fire hydrants. The same twenty years has witnessed also the more general introduction of *high pressures* into public water services, and the more general construction of water-works in northern cities, where the hydrants are subjected to severe tests of deep penetrating frost, and the expansions of earth frozen fast to their cases.

In the year 1800 we find the "fire-plug" of London, a simple branch, turned upward upon the top of the main, enlarged slightly within from the main upward, so that a stand-pipe with nozzle, which was carried by the fire-brigade, could be inserted as occasion demanded. When the stand-pipe was withdrawn, after use, a conical plug of wood, with handle extending to the surface of the ground, was inserted to keep dirt and rubbish from falling into the pipes. Water was shut off from these hydrant branches except during fires, and while the stand-pipe was in place.

In 1803 Frederick Graff, Sr., designed for the then recently constructed Philadelphia water-works, a stand-pipe

R. D. WOOD & CO., PHILADELPHIA.

MATHEWS' FIRE HYDRANT.

intended to remain permanently in position and to be constantly charged with water.

This was a most important advance in the design of fire-plugs, since it gave us a hydrant that in mild climates might remain ready for instant use. Its valve was placed at the bottom of the stand-pipe near the level of the top of the main pipe, and it introduced a drip, or waste, that opened by action of a spring as the main valve closed, so that all water remaining above the main valve in the stand-pipe at once drained off, provided the spring was still in order. This model of hydrant, which was admirable in many respects for use in southern cities, was for many years followed generally in the construction of similar apparatus in other of the larger American cities. The nozzles of these hydrants were generally placed about two feet above the ground surface, so that they might be above obstructions of mud, snow, and ice, and they were generally housed by a covering box of iron or wood, that was removable to afford access to the valve-rod key.

Such was the hydrant, varying but slightly as made by different manufacturers, in general use throughout the United States, when the "Mathew's Hydrant" was first introduced.

Among the many objections to the old style of hydrants, as manufactured in several cities, and the difficulties attending their use, in northern and middle State cities especially, we may mention the following as inseparable from their faulty construction:

Expense and Annoyance.—1. The necessity of *digging them up* in case of accident, or for necessary repairs. This involved great expense, trouble and annoyance in the displacement of sidewalk, curbing and paving, general obstruction of the street, and, in consequence of the long time required in taking them out and replacing them, causing great inconvenience to consumers from stoppage of water in the district where defective hydrants were located.

Destruction by Frost.—2. The frequent breakage in consequence of the frost heaving the boxes surrounding the hydrants, causing them to lift upon the nozzle of the hydrant where it projects through for attachment of hose, and either starting the joint or breaking the hydrant, thus causing leakage, and involving the necessity of digging up the hydrant.

Exposure to Frost.—3. The liability to freeze on account of the imperfect and faulty drip or waste-valves used, and from the circulation of cold air around the body of the hydrant, which could enter freely through the large opening for the nozzle.

Imperfect Waste Apparatus.—4. The excessive waste of water from waste-valves during the opening and closing of hydrants, and particularly while partially open, thus greatly increasing the liability of freezing in consequence of the saturation of the ground around the hydrant. Saturated ground cannot readily and quickly absorb the waste water remaining in the hydrant when the main valve is closed, but, on the contrary, prevents the rapid emptying of chamber so essential to avoid freezing.

Extra Protection in Winter.—5. The necessity, on account of above faults in principles of construction, of packing and covering hydrants in winter with manure, tan-bark, straw, &c., as practised in many cities, to lessen the liability of freezing.

Extra Exposure in Use.—6. The necessity for uncovering top of hydrant box to get at the valve rod, which was very objectionable, as it allowed cold air to fill the box rapidly, and chill the pipe and valve, thus greatly increasing the danger of freezing when the water was shut off.

Our Perfected Hydrant.—In the construction of the "Mathews' Hydrant," Fig. 20, it has been the aim, while introducing many new features of usefulness, to entirely remedy or rather *avoid* these defects and difficulties inherent in the very principles of construction of the old styles of hydrants, and we can point with pride to their present use in about three hundred cities in the United States and Canada, as evidence of the successful application of this invention, and to the appreciation of its advantages as shown in the use of Mathews' Patent Fire Hydrant by more than one-half of the cities of the United States having water-works.

The extensive introduction of these improved hydrants into public use, and the universal recognition of their merits has led to instances of infringement of their valuable features, and attempts to evade the patents by modifications of essential points. Complimentary as such imitations may appear, they are none the less annoying, and we feel it due for the protection of our customers as well as for our own security to append a copy of our patent claims:

Letters Patent issued to W. Race and S. R. C. Mathews, dated January 26, 1858—re-issued to S. R. C. Mathews, July 18, 1871—Patent extended January 26, 1872, and re-issued April 30, 1872. (*Vide* Fig. 20*a*, page 80.)

CLAIMS.

1. A protecting case or jacket (E) surrounding the body of the hydrant, and forming a separate and removable part from the elbow (D), substantially as and for the purpose set forth.

2. The independent case or jacket (E) supported on the arm (D) of the main pipe at or near the junction of the hydrant stock therewith, substantially as shown and described.

3. The annular yoke (B) on the valve rod (C) for steadying the rod (C) and centering the valve (G), and also preventing any vibration of said rod or valve when the hydrant is opened, as set forth.

4. The valve (G) constructed of the two parts (N) (O) and packing (Q) in combination with the rod (C), substantially as and for the purpose set forth.

5. The annular valve (B) and the disk-valve (G) attached to the rod (C) in combination with the escape or leak opening (J) when arranged to operate as and for the purposes set forth.

ALSO—Letters Patent issued to S. R. C. MATHEWS, (Assignee of W. RACE and S. R. C. MATHEWS), November 16, 1869.

CLAIM.

"The detached case (E) so combined and arranged with hydrant (A) as to have an end-play or vertical motion of several inches, to compensate for the heaving by frost, the upper part of same passing outside of main stock of hydrant, so that any change in its position can be easily ascertained and the case driven back to its place without disturbing the hydrant."

Advantages of Mathews' Hydrant.—We desire to call your attention particularly to the following brief summary of the advantages claimed by us in the use of these hydrants, and conceded by our customers, during the most extreme weather or recent severe winters, in the coldest sections of the country.

The Mathews' Patent Fire Hydrants combine all the necessary features to render them certain and reliable in their operation, at all times, for the purposes for which they are used, and particularly in cold climates.

Anti-Freezing.—The outer casing or frost-jacket enclosing the body of the hydrant, and making a telescopic joint therewith, forms a dead-air chamber the whole length of hydrant stock, which, acting as a non-conductor, gives great security against freezing, and obviates the necessity for packing or covering the hydrants in extreme cold weather.

Sliding Case.—The case, having an end-play or vertical motion of several inches independent of hydrant proper, accommodates itself to the upheaval of ground by frost and effectually prevents the heaving and breaking of hydrant or bend so frequent in ordinary hydrants.

Easily taken up.—By this arrangement of casing the hydrant, containing all the working parts, can be taken up for repairs, if necessary, without excavating, the outer case at the same time remaining undisturbed in the ground, and preventing the earth from caving in, thus greatly facilitating and lessening the cost of repairs. The cost and delay of taking up one ordinary hydrant in a severe winter will pay for any additional first cost of frost case many times over.

Automatic Waste.—The positively automatic waste-valve being attached to the valve-rod, renders it impossible to open the main valve without instantly closing the waste orifice, and as certainly opens the waste when the main valve is closed, so that no water is wasted while main valve

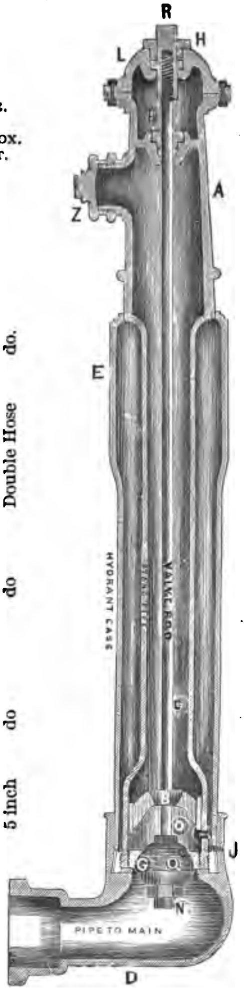
MATHEWS' PATENT FIRE HYDRANT,

MANUFACTURED BY

R. D. WOOD & CO.

Fig. 20*a*.

A—Stock.
B—Ring Valve.
D—Elbow.
F—Stuffing Box.
G—Valve Seat.



H—Top Nut.
L—Cap.
O—Main Valve.
R—Revolving Nut.
Z—Nozzle Cap.

CLASSIFICATION OF HYDRANTS.

3 inch	Stand-Pipe and	Valve-opening,	Single Hose Discharge.
4 inch	do	do	do do.
4 inch	do	do	Double Hose do.
4 inch	do	do	Single Steamer do.
4 inch	do	do	Steamer and Double Hose Discharge.
5 inch	do	do	Single Steamer Discharge.
5 inch	do	do	Double Hose do.

5 inch	Stand-Pipe and	Valve-opening,	Three-way Hose Discharge.
5 inch	do	do	Steamer and Double Hose Discharge.
5 inch	do	do	Double Steamer Discharge.
6 inch	do	do	Single Steamer do.
6 inch	do	do	Double Hose do.
6 inch	do	do	Three-way Hose do.
6 inch	do	do	Steamer and Double Hose Discharge.
6 inch	do	do	Double Steamer Discharge.

Foundries, { Millville, Florence, } N. J.

Office, No. 400 Chestnut Street,
PHILADELPHIA, PA.

is open, and no water remains in stand-pipe when main valve is closed.

No Vibration.—The rod and main valve are held firmly in their places, so there can be no vibration or trembling during the opening or closing of the hydrant.

Simple, and Easily Repaired.—The working parts of hydrant are few in number, simple, strong, durable, and made carefully to fixed gauges, making them interchangeable, so that all ordinary repairs can be made in a few minutes by any workman on the ground when hydrant is taken up, avoiding the delay and expense of machine-shop repairs entirely.

Directions for Ordering Hydrants.—When ordering our hydrants please designate the particular class and size required, in accordance with our classification placed with the illustration of the hydrant on the opposite page, and give us also information as follows:

State depth the pipe is covered, to insure getting the right length of hydrant.

Standard lengths do not exceed 5½ feet to *top of pipe.* For additional depths an additional charge will be made.

Send hose-gauge (part of coupling will answer) so the hydrant-nozzles may be accurately fitted to it.

State size and kind of pipe the hydrants are to connect with.

If any other hydrants are in use, state if they open by turning to right, or left, and give size and shape of nut for wrench.

Setting Hydrants.—We respectfully present the following suggestions relating to the setting, use, and repairs of hydrants:

Take care that the hydrant is perpendicular, and that top of frost-case (E) is not less than four nor more than eight inches above grade of side-walk.

See that the hydrant is provided with perfect drainage. This may be done, preferably, by connecting the waste (J) by a tile drain with the nearest sewer. In the absence of sewers, lay drain to nearest loose or sandy soil, or dig a hole a short distance from the hydrant, and fill with broken stone, so that the contents of hydrant can waste rapidly after closing main valve. When set in loose, sandy, or gravelly soil the drain-pipe may be dispensed with, as the surrounding earth will readily absorb the waste water. In this case it is necessary to fill around the base of hydrant with stone to prevent the waste-orifice (J) becoming filled up or closed by the earth.

The base (D) should rest firmly upon a solid foundation of stone or masonry, and be well braced against the pressure of water at the bend to obviate any danger of starting the joint.

Using and Repairing Hydrants.—When a hydrant is first opened, after setting, the water should be allowed to run until it becomes clear, as if closed too soon, the gravel and dirt left in pipe are likely to become imbedded in the valve and cause leakage.

To take up hydrants in case of necessary repairs, place a chain or stout rope around the body (A) of hydrant immediately below the nozzle, through which pass a couple of levers, six or eight feet long, with which the power of two men is generally sufficient to unscrew the hydrant from its base (D) leaving the case (E) undisturbed in the ground, but as we screw them down very tightly, additional power may sometimes be required. No fear of breakage need be entertained, as the hydrants are made very strong in all their parts.

If the water remaining in hydrant does not run out rapidly after closing main valve, it is evidence that the waste-orifice (J) has become filled up, or that the earth around hydrant is not properly drained. If the first, it can be remedied in a few moments by taking up the hydrant and removing the obstruction.

In extreme cold weather it is not unusual for some of the upper working parts of hydrant to stick together by the action of the frost, and this often gives the erroneous impression that "the hydrant is frozen." In such cases a *very small* quantity of steam injected at the nozzle (not down to the valve) will usually remove the difficulty.

The common practice of injecting large quantities of steam at a high temperature down to the valve is very objectionable and generally ruins the valves.

To get at the stuffing-box (F) unscrew the nut (H) at top (which has a left-hand thread) by turning to the right, then remove revolving or sleeve-nut (R) from the rod. The cap (L) can then be removed by taking out the bolts, leaving stuffing-box exposed. In replacing pieces, put them on in reverse order, first cap, then revolving-nut, and lastly top-nut (H).

The hydrants are well painted before leaving our manufactory, but they become so marred by shipment, handling and setting, that we would advise an extra coat of paint, after setting, in every instance, as not only adding materially to their neatness of appearance, but as a preservative against effects of exposure to the weather.

N. B.—The main valves (unless otherwise ordered) always open by turning to the left, and close by turning to the right. All screws, except top-nut, have right hand thread.

References.—We would refer to the following places having these hydrants in use, from many of which we have testimonials of the highest character in regard to their superiority, and the advantages possessed by them over all others:

Auburn, ... Maine.
Bangor, “
Portland, “
Maine Asylum for Insane.
Concord, . New Hampshire.
Nashua, “
Amoskeag Manufacturing Co.
Bellows Falls, Vermont.
Brandon, “
Burlington, “
Fair Haven, “
Island Pond, “
Rutland, “
Springfield, “
Waterbury, “
Vermont Central R. R. Co.
Bethel, ... Connecticut.
Bridgeport, “
Danbury, “
Greenwich, “
Hartford, “
Meriden, “
Middletown, “
New Britain, “
New Milford, “
Norwalk, “
Rockville, “
Shelton, “
South Norwalk, “
Stamford, “
Thomaston, “
Wolcottville, “
Cambridge, Massachusetts.
Chicopee, “
East Hampton, “
Fitchburg, “
Greenfield, “
Leominster, “
Medford, “
Milford, “
Nantucket, “
New Bedford, “
North Adams, “
Northampton, Massachusetts.
Northbridge, “
Pittsfield, “
South Adams, “
Southbridge, “
S. Hadley Falls, “
Springfield, “
Taunton, “
Wayland, “
Westborough, “
Westfield, “
Worcester, “
East Providence, Rhode Island.
Auburn, ... New York.
Binghamton, “
Brooklyn, “
Clifton Springs, “
College Point, “
Cooperstown, “
Corning, “
Danville, “
Elmira, “
Flushing, “
Gouverneur, “
Gloversville, “
Geneva, “
Ithaca, “
Johnstown, “
Kingsboro, “
Le Roy, “
Lockport, “
Long Island City, “
Medina, “
Middletown, “
Monis, “
Mount Morris, “
Newburg, “
Ogdensburg, “
Peekskill, “
Plattsburgh, “
Port Jervis, “
Port Byron, “
Potsdam, “

Poughkeepsie, New York.
Rochester, "
Saratoga, "
Schenectady, "
Syracuse, "
Tarrytown, "
Troy, "
Unadilla, "
Utica, "
Walton, "
Watertown, "
Waverly, "
West Troy, "
Yonkers, "
Auburn Asylum for Insane.
Long Island R. R. Co.
New York Central R. R. Co.
Bordentown, New Jersey.
Burlington, "
Camden, "
Cape May City, "
Elizabeth City, "
Hackensack, "
Jersey City, "
Kaighn's Point, "
Lambertville, "
Meadow's Station, "
Morristown, "
Mt. Holly, "
Newark, "
New Brunswick, "
Passaic, "
Rahway, "
Trenton, "
Camden & Atlantic R. R. Co.
Millville Manufacturing Co.
Allentown, . Pennsylvania.
Altoona, "
Archbald, "
Berwick, "
Bethlehem, "
Butler, "
Chambersburg, "
Conshohocken, "
Ebensburg, "
Erie, "
Franklin, "
Fullerton, "
Harrisburg, "
Johnstown, "
Kennet Square, Pennsylvania.
Meadville, "
Media, "
Milford, "
Oil City, "
Philadelphia, "
Phœnixville, "
Pittston, "
Reading, "
Renova, "
Scranton, "
Shamokin, "
South Bethlehem, "
Susq'hanna Depot, "
Towanda, "
Tyrone, "
Venango, "
West Chester, "
Wilkesbarre, "
Williamsport, "
Winterburn, "
Centennial Exposition Buildings, Philadelphia.
Lehigh & Wilkesbarre Coal Co.
Penna. Coal Co., Green Ridge.
Pennsylvania R. R. Co.
Wilmington, . . . Delaware.
Akron, ... Ohio.
Bellaire, "
Bellevue, "
Canton, "
Cleveland, "
Columbus, "
Dayton, "
Elyria, "
Mansfield, "
Massillon, "
Middletown, "
New Lisbon, "
Piqua, "
Sandusky, "
Tiffin, "
Toledo, "
West Cleveland, "
Wooster, "
Youngstown, "
Bay City, ... Michigan.
Detroit, "
East Saginaw, "
Grand Rapids, "

Jackson, Michigan.
Kalamazoo, "
Michigan Asylum for Insane.
Michigan Central R. R. Co.
Attica, ... Indiana.
Brazil, "
Connersville, "
Fort Wayne, "
Indianapolis, "
La Porte, "
Mishawakee, "
New Albany, "
Peru, "
South Bend, "
Terre Haute, "
Aurora, ... Illinois.
Bloomington, "
Blue Island, "
Charleston, "
Decatur, "
Lake View, "
Lockport, "
Moline, "
Paris, "
Peoria, "
Quincy, "
Rockford, "
La Crosse, . . Wisconsin.
Milwaukee, "
Racine, "
Cumberland, . Maryland.
Baltimore & Ohio R. R. Co.
Danville, . . . Virginia.
Lynchburg, "
Norfolk, "
Petersburg, "
Richmond, "
Old Dom. Steamship Co.
Wheeling, . West Virginia.
Columbia, . South Carolina.
Atlanta, ... Georgia.
Augusta, "
Macon, "
Rome, "
Savannah, . . . Geórgia.
Georgia Central R. R. Co.
Jacksonville, . Alabama.
Mobile, "
Montgomery, "
Selma, "
Chattanooga, . Tennessee.
Memphis, "
Nashville, "
Anchorage, . Kentucky.
Bowling Green, "
Covington, "
Henderson, "
Louisville, "
Maysville, "
Los Angelos, . California.
Mankato, . . . Minnesota.
Minneapolis, "
Redwing, "
San Antonio, . Texas.
Cedar Rapids, . Iowa.
Clinton, "
Davenport, "
Lyons, "
Muscatine, "
Ottumwa, "
Hannibal, . . . Missouri.
Kansas City, "
St. Joseph, "
New Orleans, . Louisiana.
Columbus, . . Mississippi.
Omaha, ... Nebraska.
Albany, ... Oregon.
Kingston, . . . Canada.
Montreal, "
Ottawa, "
Port Hope, "
Rockland, "
Sarnia, "
Toronto, "
Walkertown, "
Halifax, Nova Scotia.
Moncton, New Brunswick.
Havana, Cuba.

Commendatory Extracts.—We append extracts from a few of the many letters received by us from parties using these hydrants, clearly showing the justice of our claims to to the advantages enumerated above, and warranting our improved manufacture as—

"Mathews' Patent Non-Freezing Hydrant."

BROOKLYN, N. Y., February 29, 1868.

* * * Of the large number of Mathews' Patent Fire Hydrants in use in this city, not one has frozen during the very cold winter just past, or given any trouble in the way of repairs. * * * I deem them the best Fire Hydrants yet brought before the public.

JOHN H. RHODES, *Water Purveyor.*

LOCKPORT, N. Y., March 12, 1868.

* * * Of all the hydrants with which I am acquainted, I should give yours the decided preference.

L. W. BRISTOL, *Chief Eng. Fire Dep't.*

CLEVELAND, O., Augnst 5, 1872.

* * * I am more than pleased with your hydrants, many of which we have in use, and believe them to be the best and most reliable Fire Hydrant yet introduced. JAMES HILL, *Chief Eng. Fire Dep't.*

OGDENSBURG, N. Y., April 28, 1871.

* * * The performance of the Mathews' Fire Hydrants has been entirely satisfactory, as in no single instance have I found them frozen, * * * and take pleasure in recommending them to water companies as being first-class hydrants. A. H. LORD, *Sup't W. W.*

AUBURN, N. Y., May 4, 1872.

It gives us great pleasure to state that during the past severe winter with us, not one of the Mathew's Hydrants, of which we have 140, has been frozen, nor have we had any trouble in keeping them in working condition without any covering or packing. We have now had these hydrants in use six years under the fire pressure of the Holly system. * * * As now made by you they seem to be almost perfect, strong, and not at all likely to get out of order, do not freeze, and I do not see how they are to be improved.

A. H. GOSS, *Sec'y Treas. & Sup't W. W. Co.*

SPRINGFIELD, MASS., June 10, 1872.

* * * It gives us pleasure to state that we consider your hydrants much safer than any others we have in use. During the very severe weather of the past winter, almost, if not all, of every other pattern of hydrants except yours became unserviceable in consequence of freezing. I do not recollect an instance of yours failing in this respect.

C. L. COVELL, *Treas. W. Co.*

NEWARK, N. J., May 3, 1872.

The Mathews' Hydrants furnished by you for these works have given us no trouble this past winter. G. W. BAILEY, *Eng. Newark Aq. Bd.*

AUGUSTA, GA., May 9, 1872.

* * * I am so much pleased with your hydrants in regard to ease of working, simplicity, and, consequently, probable durability, that I propose to use them in all future additions to our works.

THOS. W. CUMMINGS, *Eng. W. W.*

New York has had by official estimate three-fourths of all her hydrants frozen, and upwards of 300 unfit for immediate use, when opened at fires, during January and February (1875) only.

BROOKLYN, N. Y., March 20, 1875.

I take pleasure in stating that we have 126 of your hydrants set, and but one of them was frozen (which was attributable to carelessness). In this respect, as in all others, I deem them reliable.

JOHN H. RHODES, *Water Purveyor.*

POUGHKEEPSIE, N. Y., February 18, 1875.

Yours of the 15th at hand. We have set in this city 281 of your Mathews' Hydrants. The weather has been unusually severe. Three hydrants were frozen—two of these had been used to fill cisterns, the water running from them for an hour or two very slowly. The other hydrant was used at a fire; cap was put on and hydrant not turned full off. Aside from these not a single one of your hydrants has been found frozen, nor do I think they can be frozen, provided ordinary caution is used in the Fall to see that the valves are in order, and when put in, that branch-pipe is at sufficient depth below surface.

Very respectfully,

THEO. W. DAVIS, *Superintendent.*

Boston kept fifty men constantly employed this winter in thawing hydrants.

The Water Commissioners of Concord, N. H., say, in their Annual Report, they

"Take pleasure in testifying to the superiority of R. D. WOOD & Co's Fire Hydrant as adapted to such unprecedentedly cold weather as they have been subjected to during the last sixty days."

Philadelphia reports, through her Chief of Fire Department, "fifty per cent. of the hydrants frozen, and fifteen fires during January and February, 1875, at which delay occurred in securing a supply of water."

From Camden, N. J., we receive the following:

CAMDEN, N. J., March 1, 1875.

It affords me pleasure to certify to the very satisfactory working of the Mathews' Fire Hydrant. During the present severe winter they have continued free from the effects of frost while large numbers of the other hydrants have been frozen. Yours truly,

WILLIAM CALHOUN, *Chief Engineer.*

DETROIT, MICH., February 26, 1875.

In response to your inquiry regarding the test the exceptionally cold weather of the present winter has subjected your hydrants to, it gives me pleasure to state that Mr. GASCOIGNE, our Superintendent of Water, reports that not in a single instance have they failed. The only trouble given has been the slight one of occasionally pounding down the frost jacket as the frost heaves it. FRED. H. SEYMOUR, *Sec'y.*

ROCHESTER, N. Y., February 19, 1875.

We have had very little trouble with your style of hydrant during the cold weather, although we have had over 400 in use. None have frozen except where they were set in area walls, or near lateral sewers, or not at proper depth, and of these very few.

Respectfully yours,

J. NELSON TUBBS, *Chief Eng. Rochester W. W.*

CLEVELAND, O., February 23, 1875.

In reply to your circular of the 15th inst., asking whether any of your hydrants have failed during the recent cold weather, I take pleasure in stating that we have had less trouble with your hydrants than with any others we have in use. Such as have been found frozen have had some obstruction in the waste, but the number found out of order has been comparatively small. Yours respectfully,

JOHN WHITELAW, *Supt. and Engineer.*

TOLEDO, O., February 20, 1875.

We have had but few hydrants frozen ; with proper drainage for carrying off drip, don't think we should have had a single one frozen. We have given them no artificial protection by boxing, or otherwise. Mercury ranged from zero to 18° below for past two weeks.

J. D. COOK, *Chief Eng. and Supt. Toledo W. W.*

ELMIRA, N. Y., February 18, 1875.

We have a number of your hydrants in use, which have given good satisfaction during the extreme cold weather ; have had a large number of fires during the winter. Have had several hydrants frozen, or broken, by frost, but none of yours among the number.

Respectfully yours, ELMIRA WATER WORKS CO. (*per J. M. D.*

AUBURN, N. Y., February 19, 1875.

* * * Your hydrants as now made are unquestionably the best in use, and have stood the test of the present severe weather well. * * * They are strong in all parts, and we have no trouble from breaking.

A. H. GOSS, *Sec. and Treas.*

PLATTSBURGH, N. Y., May 7, 1872.

Your hydrants give unqualified satisfaction. We have 60 ——— Manufacturing Co.'s hydrants. The past winter has been unusually severe, and we have had to replace at least one-third of the cases on those that have been broken at the bottom flange by frost lifting them.

I find the frost does not affect yours, and in any extensions which we may make, we shall use your hydrants.

Yours truly,

S. W. GREGORY, *Supt. W. W.*

SYRACUSE, N. Y., March 7, 1868.

Your hydrants have given entire and perfect satisfaction to our Fire Department since their introduction, and particularly during the recent extreme cold weather; never having frozen, and being always in order and ready for use in case of fire.

We deem these hydrants far superior to the hydrants heretofore in use in this city, and have no hesitancy in recommending them for general use.

PHILIP ECKEL, *Chf. Eng. Fire Dep.*
EDGAR S. MATHEWS, *City Clerk.*

GREENFIELD, MASS., June 3, 1872.

The Mathews' Patent Hydrant with which you furnished our District has given us entire satisfaction. We have had one of the most severe winters ever known here, frost being found here on the 29th day of April six ft. deep. Although in several instances our *pipes leading from the mains* have been frozen, we have in *no case* had our hydrants in the least damaged by frost.

We consider the Mathews' Hydrant the best yet manufactured.

Yours respectfully,

JAMES PORTER, *Supt. Water-Works.*

PITTSFIELD, MASS., May 6, 1872.

* * * I am convinced that the Mathews' Hydrant is the best I know of, and we shall use them altogether hereafter.

Yours, &c.,

W. R. PLUNKETT, *Ch'm Water Com.*

ALLENTOWN, PA., May 7, 1872.

In reply to your favor of 2d inst., inquiring as to how Mathews' Patent Fire Hydrants have stood the test of the past severe winter, I take pleasure in stating that they have given entire satisfaction; not a single one of them having frozen all winter. Yours, T. H. GOOD, *Mayor.*

R. D. WOOD & CO., PHILADELPHIA.

MATHEWS'

DOUBLE-VALVE FIRE HYDRANT.

Mathews' Double-Valve Fire Hydrant.

We invite the attention of hydraulic engineers and officers in charge of water-works generally to what we have no hesitation in pronouncing the most perfect fire hydrant yet introduced.

While the hydrants heretofore manufactured by us, and now in use by about three hundred cities and water-works companies in the United States and Canada, are considered the standard and, for many reasons, the best and most reliable, recent improvements and additions which have been made by our Mr. Mathews seem to warrant us in designating our new hydrant as the most perfect and complete ever brought before the public.

Mr. Mathews' long experience in the manufacture of fire hydrants, and constant study and investigation as to their practical working in different cities, have convinced him that some additional improvements were desirable, to accomplish the following results:

First.—To obtain greater security against leakage from any cause.

Second.—To allow the hydrant to be withdrawn or taken up for repairs in a safe, practicable manner without shutting the water from the district in which the hydrant is located even for a moment.

Third.—That the waste or drip orifice should be entirely covered before the water is let into the hydrant and not uncovered until after the main valve is closed, thus effectually preventing any waste of water while the main valve is open or partially open.

Fourth.—That in case of injury to the main valve, requiring its removal, the hydrant will still work perfectly for all purposes as usual, instead of necessitating the shutting off water from the district until the valve can be repaired or replaced, and preventing the use of the hydrant in case of fire in its vicinity.

Fifth.—That all these operations shall be strictly automatic, and no extra manipulation or dismantling of the hydrant required to obtain access to the mechanism for shutting off the water.

A few hydrants have been made with so-called supplementary valves for the purpose of allowing hydrants to be taken up without shutting off the water from the district by means of the ordinary stop-valves or gates, but they have been objectionable in many respects, and, consequently, have never been used to any extent. Some of these objections, briefly noticed, have been the trouble and necessity of dismantling or removing portions of the hydrant proper to obtain access to the mechanism used for closing the supplemental valve, the difficulty in detaching the hydrant from the supplemental valve and in attaching it again when the hydrant is replaced, the trouble of returning the valve to its place after replacing the hydrant, the vibration and water-ram caused by the loose motion unavoidable in all the automatic valves heretofore used, in addition to the trouble referred to above in detaching and replacing the hydrant and valve.

The necessity for some means to accomplish this removal of hydrant without shutting off water from the district is generally conceded by those in charge of the repairs of hydrants, and has led to the use of stop-valves or gates in the pipe leading to hydrants in many cities, involving great additional expense in the cost of stop-valves, valve-boxes, setting and keeping in order, while they simply answer the purpose of shutting off the water, and do not add in the least to the efficiency of the hydrant.

In the construction of "Mathews' Double-Valve Hydrant," all these difficulties and objections have been overcome, and we invite your careful consideration of the many advantages derived from its use.

First.—It has *two main* or *induction* valves, one above the other, thus giving double security against leakage from any cause.

Second.—The lower valve is so constructed that it acts as a supplemental or auxiliary valve, to allow the hydrant to be taken up without shutting off the water from the district, said valve being entirely separate and disconnected from upper main valve and its rod, and closing automatically when the upper valve is closed or hydrant removed.

Third.—The upper main valve, with its rod and waste-valve, move far enough to allow the waste orifice to be covered entirely before the lower valve begins to open, and in closing the reverse is the case, the lower valve closing and shutting off the water from the main before the waste orifice is uncovered.

Fourth.—Should the upper valve (ordinarily the main valve) be broken or injured in any way, it can be taken off for repairs for any length of time required without impairing the action of the hydrant, as the lower valve then becomes the main valve, opening and closing perfectly in the usual manner of operating the hydrant.

Fifth.—The taking out and replacing of the hydrant is done in precisely the same way as with our ordinary hydrant, the lower or auxiliary valve being entirely self-acting, and requiring no attention whatever in performing its function of shutting off the water.

Sixth.—There is no loose motion in the supplemental valve, and, consequently, no trembling, vibration, or water-ram, so disastrous to water-pipes and joints under high heads.

Seventh.—All the parts are made strong, finished in the best manner, and every part accessible and easily replaced if necessary.

We feel assured that a careful examination of these new features, when combined with those so well known and approved in our past manufacture, will satisfy you that we do not claim too much when we designate this as a PERFECT FIRE HYDRANT.

We continue the manufacture of the original hydrant as heretofore, and would request our customers, in ordering or in asking for quotation of prices, to designate which style they require.

TABLE No. 17.

Elementary Dimensions of Pipes.

Diameter	Diameter.	Contour.	Sectional area.	Hydraulic mean radius.	Cubical contents per lineal foot.
Inches.	*Feet.*	*Feet.*	*Sq. feet.*		*Cubic feet.*
½	.0417	.1310	.001366	.0104	.001366
¾	.0625	.1965	.003068	.0156	.003068
1	.083	.2618	.005454	.0208	.005454
1½	.1250	.3927	.01227	.0312	.01227
1¾	.1458	.4581	.01670	.0364	.01670
2	.1667	.5235	.02232	.0418	.02232
3	.250	.7854	.04909	.0625	.04909
4	.3333	1.047	.08726	.0833	.08726
6	.5000	1.571	.19635	.1250	.19635
8	.6667	2.094	.3490	.1666	.3490
10	.8333	2.618	.5454	.2083	.5454
12	1.0000	3.142	.7854	.2500	.7854
14	1.1667	3.665	1.069	.2916	1.069
16	1.3333	4.189	1.397	.3333	1.397
18	1.5000	4.713	1.767	.3750	1.767
20	1.6667	5.235	2.181	.4166	2.181
24	2.0000	6.283	3.142	.5000	3.142
27	2.2500	7.069	3.976	.5625	3.976
30	2.5000	7.854	4.909	.6250	4.909
33	2.7500	8.639	5.940	.6875	5.940
36	3.0000	9.425	7.069	.7500	7.069
40	3.3333	10.47	8.726	.8333	8.726
44	3.6667	11.52	10.558	.9166	10.558
48	4.0000	12.56	12.567	1.0000	12.567
54	4.5000	14.14	15.905	1.1250	15.905
60	5.0000	15.71	19.635	1.2500	19.635
72	6.0000	19.29	29.607	1.5000	29.607
84	7.0000	21.99	38.484	1.7500	38.484
96	8.0000	25.45	50.265	2.0000	50.265

TABLE No. 18.

Relative Discharging Capacities of Full, Smooth Pipes.

Diam. in feet. $= d$.	Relative discharging powers. $= d^{\frac{5}{2}}$	3	4	6	8	10	12	14	16	18	20	22	24	27	30	33	36	40	44	48	Diam. in inches
4	32.000	....	....	....	....	....	....	....	15.59	11.61	8.92	7.03	5.63	4.21	3.24	2.55	1.65	1.58	1.24	1	48
3.667	25.750	....	....	....	....	....	....	17.50	12.54	9.34	7.17	5.66	4.55	3.39	2.61	2.00	1.65	1.27	1	....	44
3.333	20.235	....	....	....	....	....	20.23	13.47	9.85	7.34	5.64	4.44	3.57	2.66	2.05	1.65	1.26	1	....	....	40
3	15.588	....	....	....	....	....	15.58	8.41	7.59	5.65	4.34	3.43	2.74	2.05	1.53	1 24	1	....	....	....	36
2.750	12.541	....	....	....	34.55	19.78	12.54	8.52	6.11	4.55	3.49	2.73	2.21	1.63	1.27	1	....	....	....	....	33
2.500	9.859	....	....	....	27.09	15.54	9.85	6.54	4.80	3.57	2.74	2.16	1.74	1.29	1	....	....	....	....	....	30
2.250	7.594	....	....	42.95	16.61	9.96	7.59	5.16	3.70	2.75	2.11	1.67	1.34	1	....	....	....	....	....	....	27
2	5.657	....	....	32 00	15.58	8.92	5.65	3 84	2 75	2.05	1.57	1.24	1	....	....	....	....	....	....	....	24
1.833	4.549	....	70.96	25.73	12.53	7.17	4.55	3.09	2.16	1.65	1.26	1	....	....	....	....	....	....	....	....	22
1.667	3.583	....	55.96	20.29	9.88	5.66	3.58	2.43	1.74	1.30	1	....	....	....	....	....	....	....	....	....	20
1.500	2.756	....	42.01	15.58	7.25	4.34	2.75	1.87	1.34	1	....	....	....	....	....	....	....	....	....	....	18
1.333	2.032	65.77	32.01	11.60	5.65	3.23	2.03	1.39	1	....	....	....	....	....	....	....	....	....	....	....	16
1.167	1.471	47.14	22.94	8.32	4.05	2.32	1.47	1	....	....	....	....	....	....	....	....	....	....	....	....	14
1	1	32.05	15.60	5.65	2.75	1.57	1	....	....	....	....	....	....	....	....	....	....	....	....	....	12
.8333	.6339	20.31	9.88	3.58	1.74	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	10
.6667	.3629	11.63	5.66	2.05	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	8
.5000	.1768	5.66	2.75	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	6
.3333	.0641	2.05	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4
.2500	.0312	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	3

ECONOMIC INFLUENCE OF WATER-WORKS ON INSURANCE PREMIUMS.

A schedule of standard rates of insurance and deficiency charges, adopted by the National Board of Underwriters, is as follows:

For standard cities, having gravity water-works, paid steam fire department, fire patrol, fire-alarm telegraph, building law, paved streets, gas for light, coal for fuel, and no inherent exposures, the minimum basis rate for a standard city, on a standard building, is 25 cents.

For deficiency charges add as follows:

If no water supply	15	cents.
If only cisterns, or equivalent	10	"
If system is other than gravity	5	"
If no fire department	25	"
If no volunteer department	10	"
If no steam fire-engines	5	"
If no hook and ladder trucks	5	"
If no fire-patrol	5	"
If no fire-alarm telegraph	5	"
If no police department	5	"
If no paved streets	5	"
If no building law in force	5	"

Table Showing the Mean Velocities of Water Flowing in Uniform Channels.

Fall in Feet per Mile.		Hydraulic Mean Depth and Velocities in Inches per Second.													
Fall.	Inclination, 1 inch.	1 Inch.	2 Inches.	3 Inches.	4 Inches.	5 Inches.	6 Inches.	8 Inches.	10 Inches.	12 Inches.	18 Inches.	24 Inches.	30 Inches.	36 Inches.	48 Inches.
F. I.															
0 1...	63.36...	.85	1.24	1.55	1.80	2.02	2.23	2.58	2.90	3.19	3.57	4.54	5.09	5.59	6.47
0 6...	10.56...	2.55	3.72	4.62	5.37	6.04	6.65	7.72	8.66	9.52	10.67	13.57	15.21	16.69	19.31
1 0...	5.28...	3.77	5.51	6.84	7.96	8.95	9.84	11.43	12.83	14.90	15.81	20.11	22.53	24.72	28.61
2 6...	2.11...	6.29	9.18	11.40	13.28	14.93	16.42	19.64	21.40	23.51	26.36	33.53	37.57	41.22	47.71
5 0...	1.06...	9.25	13.51	16.78	19.53	21.96	24.16	28.05	31.48	34.59	38.79	49.34	55.28	60.66	70.20
10 0...	53...	13.65	19.94	24.76	28.83	32.41	35.65	41.40	46.46	51.04	57.24	72.81	81.58	89.52	103.60
13 2...	40...	15.98	23.34	28.98	33.74	37.93	41 72	48.44	54.37	59.73	66 99	85.21	95.48	104.76	121.25
17 6...	30...	18.83	27.50	34.15	39.75	44.69	49.16	57.08	64.07	70.38	78.94	100.41	102.50	123.44	142.86
26 4...	20...	23.78	34.72	43.12	50.20	56.44	62.08	72.08	80.91	88.88	99.69	126.80	142.07	155.89	180.41
52 8...	10...	35.66	52.07	64.67	75.29	84.64	93.10	108.10	121.33	133.29	149.50	190.15	213.05	233.77	270.55
66 0...	8...	40.70	59.44	73.81	85.93	96.61	106.26	123.38	138.48	152.13	170.63	217.02	243.16	266.81	308.79
88 0...	6...	48.33	70.57	87.63	102 02	114.70	126.16	146.50	164.44	180.66	202.62	257.72	288.76	316.84	366.68
132 0...	4...	61.67	90.06	111.84	130.20	146.38	161.00	186.97	209.85	230.55	258.58	328.90	368.51	404.35	467.96
264 0...	2...	93.84	137.03	170.18	198.12	222.73	244.98	284.44	319.26	350.75	393.39	500.37	560.63	615.16	711.93
528 0...	1...	142.39	207.92	258.21	300.60	337.95	371.71	431.56	484.40	532.17	596.87	759.17	850.60	933.34	1080 16

Daily Flow of Water per Square Mile.

The following extract from the records of the Boston Water Department, at Lake Cochituate, shows how little the per cent. of the rainfall delivered into the watercourses depends upon the total annual precipitation. The table gives the ten years of largest annual rainfall between 1851 and 1876, and the per cent. of the water utilized.

Year.	Inches Rainfall.	Per cent. delivered.	Year.	Inches Rainfall.	Per cent. delivered.
1869	64.34	36	1870	55.89	47
1863	63.30	39	1853	55.73	35
1857	63.10	74	1860	55.44	35
1866	62.32	25	1852	49.93	43
1867	56.25	36	1868	49.71	50

By the percentages of this table, it will be seen that one square mile of area furnished 1,150,000 gallons per day.

Advantages of Large-Sized Pipe over Smaller Ones.

By this table it will be noted that for every 100 feet of pipe of 6 inch diameter, to discharge 1000 gallons per minute, will cause a friction of 3.88 pounds; whereas, to discharge the same quantity of water through a 10-inch pipe, it will only be 0.32 pounds.

Stated as a Rule.—Doubling the size of the pipe decreases the friction less at the same velocity one-half.

Table of Friction-Loss in Pound Pressure for each 100 Feet of Length in Different Size Clean Iron Pipes Discharging Given Quantities of Water per Minute. Also Velocity of Flow in Pipe in Feet per Second.

Galls. discharged per min.	3		4		6		8		10		12		18		20		24		30		
	Velo. in pipes per sec.	Fric. loss in pound.	Velo	Fric.	Velo.	Fric.	Velo.	Fric.	Velo.	Fric.	Velo.	Fric.	Velo.	Fric.	Velo.	Fric.	Velo.	Fric.	Velo.	Fric.	
100	4.54	1.31	2.55	0.33	1.13	0.05	...	...	...	...	...	...	...	...	...	...	...	...	...	...	100
200	9.08	5.02	5.11	1.22	2.27	0.17	...	...	...	...	...	...	...	...	...	...	...	...	...	...	200
300	13.6	11.2	7.66	2.66	3.40	0.37	...	...	...	...	...	...	...	...	...	...	...	...	...	...	300
400	18.2	19.5	10.2	4.73	4.54	0.65	...	...	...	...	...	...	...	...	...	...	...	...	...	...	400
500	27.7	30.8	12.8	7.43	5.67	0.96	3.19	0.25	2.04	0.09	1.42	0.04	0.63	0.005	...	...	...	...	...	...	500
750	...	...	...	...	8.51	2.21	4.79	0.53	3.06	0.18	2.13	0.08	...	...	...	...	...	...	...	...	750
1,000	...	...	...	...	11.3	3.88	6.38	0.94	4.08	0.32	2.84	0.13	1.26	0.020	1.02	0.012	0.72	0.005	0.45	0.002	1,000
1,500	...	...	...	...	...	...	9.57	2.09	6.12	0.70	4.26	0.29	1.89	0.040	...	...	...	...	...	...	1,500
2,000	...	...	...	...	...	...	...	...	8.17	1.23	5.67	0.49	2.52	0.071	2.04	0.042	1.44	0.020	0.91	0.006	2,000
3,000	...	...	...	...	...	...	...	...	...	...	8.51	1.11	3.78	0.150	3.00	0.091	2.16	0.047	1.36	0.012	3,000
4,000	...	...	...	...	...	...	...	...	...	...	...	...	5.04	0.263	4.08	0.158	2.88	0.067	1.82	0.022	4,000
5,000	...	...	...	...	...	...	...	...	...	...	...	...	6.30	0.408	5.11	0.244	3.60	0.102	2.27	0.038	5,000
6,000	...	...	...	...	...	...	...	...	...	...	...	...	7.56	0.588	6.13	0.348	4.32	0.146	2.72	0.048	6,000
7,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7.15	0.472	5.04	0.196	3.18	0.065	7,000
8,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8.17	0.612	5.76	0.255	3.63	0.083	8,000
9,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6.47	0.323	4.08	0.105	9,000
10,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	7.19	0.398	4.54	0.131	10,000

As determined by experiments in Springfield Fire Department, Massachusetts, by Chief Engineer.

DATA ABOUT FIRE STREAMS.

Height of column in feet.	Corresponding pressure in lbs. per square inch.	¾		1		1¼		1½		1¾	
		Height of jet in feet.	Gallons discharged per min.	Height of jet in feet.	Gallons discharged per min.	Height of jet in feet.	Gallons discharged per min.	Height of jet in feet.	Gallons discharged per min.	Height of jet in feet.	Gallons discharged per min.
10	4.3	9.8	32.8	9.8	58.2	9.9	91.	9.9	130.8	9.9	177.6
20	8.6	19.2	46.2	19.4	82.3	19.5	120.4	19.6	184.8	19.6	252.
30	13.0	28.3	55.8	28.6	100.9	29.	157.2	29.1	226.8	29.2	309.6
40	17.3	37.	65.5	37.5	116.5	38.	182.4	38.3	261.6	38.6	356.4
50	21.6	45.	73.3	46.1	130.8	47.	204.	47.4	292.8	48.	408.
60	26.	52.	80.3	54.4	142.8	55.	223.2	50.2	320.4	57.	436.8
70	30.3	60.	86.8	62.4	154.8	64.	241.2	65.	346.8	66.	471.6
80	34.6	67.	92.6	70.	164.4	72.	258.	73.	370.8	74.	505.2
90	39.	73.	98.4	77.	174.0	80.	272.4	82.	393.6	83.	535.2
100	43.3	79.	103.7	84.	183.6	87.	288.	90.	415.2	91.	565.2
120	52.	90.	113.5	97.	201.6	102.	315.6	105.	453.6	107.	626.4
140	60.6	99.	122.4	109.	217.2	116.	340.8	120.	490.8	123.	668.4
160	69.3	106.	131.2	120.	232.9	128.	364.	133.	524.2	137.	713.5
180	78.	112.	139.1	129.	247.1	139.	373.2	141.	556.1	151.	756.9
200	86.6	116.	146.4	137.	260.4	150.	406.8	158.	588.	166.	798.

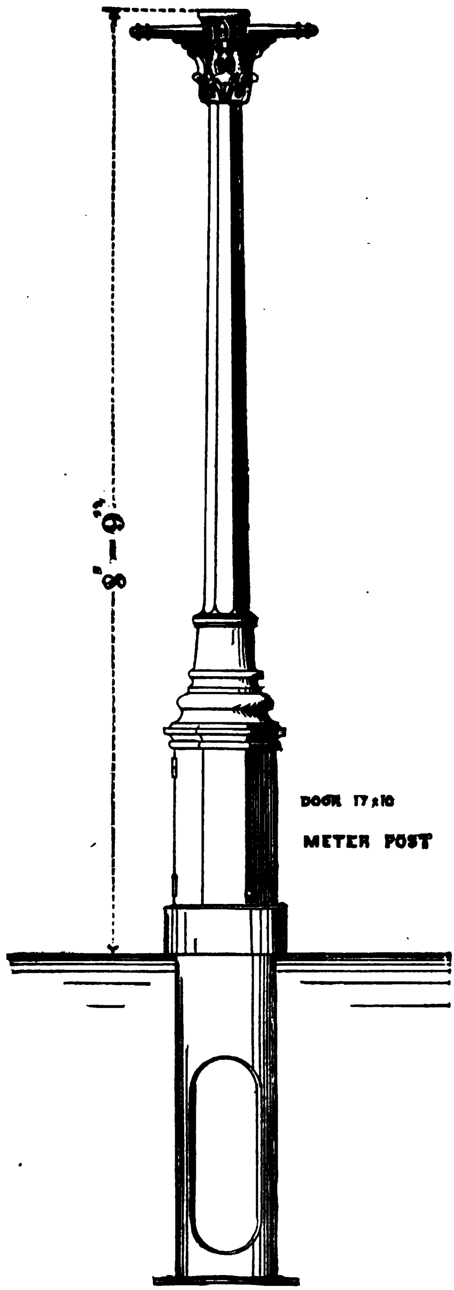
As determined by experiments in Springfield Fire Department, Massachusetts, by Chief Engineer.

Work Done and Power Required for Fire Streams using Leather Hose and Ring Nozzles.

Effective Pressure at Nozzle.	Gallons Discharged per Minute.	Horizontal Distance Reached by Jet.	Vertical Distance Reached by Jet.	Pressure in Pounds Required at Hydrant or Steamer to Maintain Given Effective Pressure at Nozzle with Different Lengths of Hose.									
				100 feet.	200 feet.	300 feet.	400 feet.	500 feet.	600 feet.	700 feet.	800 feet.	900 feet.	1000 feet.
10	60	49	22	13	17	20	23	26	30	33	36	39	43
20	86	69	42	25	29	34	38	43	48	52	57	61	66
30	105	88	61	36	42	48	54	60	66	71	77	83	89
40	121	105	78	47	55	62	69	76	84	91	98	105	113
50	135	121	92	59	67	76	85	93	102	110	119	128	136
60	148	13[illegible]	104	70	80	90	100	110	120	130	140	150	160
70	160	140	115	81	93	104	116	127	139	150	162	173	184
80	171	160	124	93	106	119	131	144	157	170	183	196	208
90	181	168	132	104	118	133	147	161	175	189	204	218	232
100	191	174	136	116	131	147	163	178	194	209	225	241	256

As determined by experiments in Springfield Fire Department, Massachusetts, by Chief Engineer.

Fig. 21.



METER LAMP-POST.

Manufactured by R. D. WOOD & CO.

LAMP-POSTS.

METER LAMP-POSTS.—GRAHAM'S ANTI-FREEZING LAMP-POSTS.

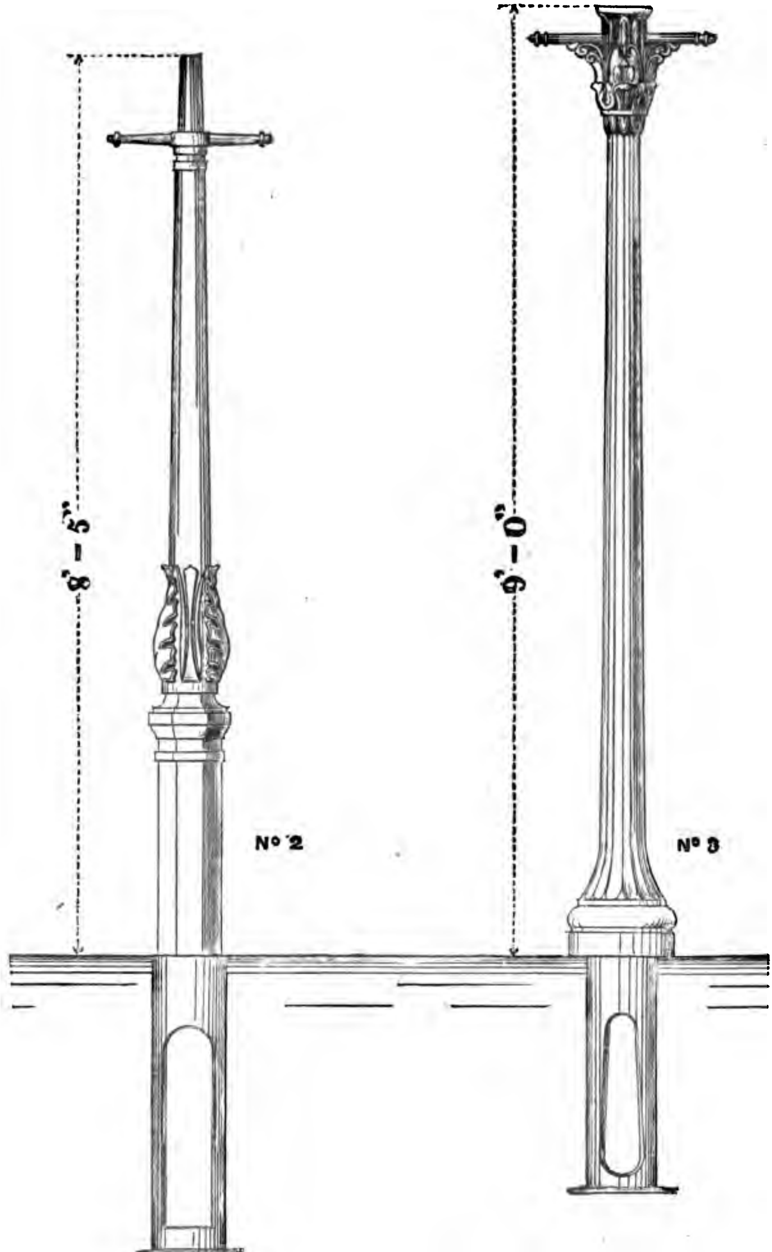
Lamp-Post Designs.—We are prepared to furnish lamp-posts of a variety of styles, some of which are herein illustrated, and to supply them in large or small quantities, as may be required, to gas companies and to corporations. We respectfully solicit an examination of our patterns and our specialties by superintendents of companies, and by committees of common councils that have the selection of posts committed to their supervision.

Our lamp-post department is well organized, so that we are now able to furnish the post at very low rates, and much cheaper than would be possible except under the most systematic management, and with the most favorable facilities.

Meter Lamp-Post.—Our *Meter Post*, Fig. 21, has come into very extensive use throughout the country, and is highly commended as a means of satisfactorily determining the amount of gas consumed for street lighting, and for establishing an equitable basis for the adjustments of accounts between gas companies and city governments.

The meter posts are fitted up in the most substantial

Fig. 22. Fig. 23.



PLAIN LAMP-POSTS.

Manufactured by R. D. WOOD & CO.

manner, and the entrance to the meter chamber is secured by a durable brass tumbler lock with key.

Meters are made for these posts by the prominent meter manufacturers of the country.

Graham's Anti-Freezing Lamp-Post. — We are prepared to apply to our meter-post and each of our post-patterns the principles of the Graham anti-freezing post.

These improved anti-freezing posts, have been extensively and thoroughly tried, with most satisfactory results.

We take pleasure in submitting the few following letters, from among many, indorsing the improvement:—

OFFICE OF THE MILFORD GAS LIGHT CO.,
MILFORD, MASS., Sept. 22, 1870.

MR. GRAHAM,

Dear Sir—In reply to yours of the 19th inst., asking my opinion of your anti freezing lamp-posts, I would say that we have had several in use during the past winter, and that they have needed no repairs. They give perfect satisfaction. Yours truly,

WM. TARBELL, *Supt.*

OFFICE OF THE WOOSTER GAS LIGHT CO.,
WOOSTER, OHIO, Jan. 24, 1871.

J. W. GRAHAM,

Dear Sir—Yours of the 14th instant at hand. In reply I would say that we have tested the six anti-freezing lamp-posts purchased from you, and find them to be all as you represented. Whilst nearly a dozen of our sixty-five posts were frozen down last month and first of this, not one of yours was affected by the heavy frost. Yours truly,

LUCAS FLATTERY, *Sec'y.*

OFFICE OF THE CHILLICOTHE GAS AND COKE CO.,
CHILLICOTHE, OHIO, Feb. 25, 1871.

J. W. GRAHAM,

Dear Sir—After a thorough test, the city has adopted your anti-freezing lamp-post, and during last year your improvement was applied to all the posts in the city. Some of them have been in use since December 1868, and to the present time have given perfect satisfaction, both to the Gas Company and to the city. They do not choke up with dirt or water in the pipes—the severest freezing does not affect them—they require little or no attention—the

lights are always clear and brilliant. We consider them decidedly the best post in use, and do not hesitate to recommend them to others.

Yours respectfully,

WM. POLAND, *President Chillicothe Gas Light and Coke Co.*

GAS MEMORANDA.

We present herein some useful memoranda selected from Haswell, Molesworth, and other sources, and reproduced from our pamphlet of 1870.

Internal lights require 4 cubic feet of gas per hour, and external lights about 5 cubic feet per hour.

Where large or argand burners are used, from 6 to 10 cubic feet will be required.

Each lamp consumes 5 cubic feet per hour. In winter each lamp consumes from 1800 to 2500 cubic feet per month. In summer, from 1000 to 1800 cubic feet per month. Average consumption for each lamp per year, 21,000 cubic feet. For private burners, about 5000 cubic feet.

TABLE No. 19.

SERVICES FOR LAMPS.

2	lamps	40	feet from	main	require	$\frac{3}{8}$	inch	bore of	pipe.
4	"	40	"	"	"	$\frac{1}{2}$	"	"	
6	"	50	"	"	"	$\frac{5}{8}$	"	"	
10	"	100	"	"	"	$\frac{3}{4}$	"	"	
15	"	130	"	"	"	1	"	"	
20	"	150	"	"	"	$1\frac{1}{4}$	"	"	
25	"	180	"	"	"	$1\frac{1}{2}$	"	"	
30	"	200	"	"	"	$1\frac{3}{4}$	"	"	

[*Molesworth.*]

TESTS FOR IMPURITIES IN GAS.

Sulphuretted Hydrogen:—A solution of nitrate of silver and distilled water. Saturate a piece of writing paper in it and hold over a jet of unlighted gas. Pure gas will produce no discoloration. If a brown stain is given the lime in the purifiers should be renewed.

Ammonia:—Litmus paper reddened by acid and applied to a jet of gas as above. If the blue color of the litmus returns, the gas contains ammonia.

Carbonic Acid:—Impregnate water with the gas and add a few drops of sulphuric acid, when minute bubbles of carbonic acid gas will be rapidly disengaged.

Atmospheric Air:—Collect a portion of the gas over mercury and pass up a few drops of caustic potassa, and afterwards a drop or two of a solution of pyrogallic acid. If the liquid assumes a blood-red hue, oxygen, indicating the presence of atmospheric air, is mixed with the gas. —*Muspratt.*

PROPORTIONS FOR VARIOUS LIGHTS.

The relative proportions which the ordinary light-giving materials bear to 1000 cubic feet of 13 candle gas are thus given in Thompson's treatise on the "Nature and Chemical Properties of Coal Gas."

1000 feet of	common	gas =	the light of $44\frac{4}{7}$ lbs. sperm candle.
"	"	"	$48\frac{6}{7}$ lbs. wax candles carefully snuffed.
"	"	"	$5\frac{1}{7}$ lbs. stearic acid candles.
"	"	"	$52\frac{9}{10}$ lbs. best mould candles.
"	"	"	$54\frac{8}{7}$ lbs. best dip candles.
"	"	"	$6\frac{1}{2}$ gals. purified colza oil sp. gr. .888.
"	"	"	$5\frac{9}{10}$ gals. of sperm oil sp. gr. .888.

MOTION OF GAS IN PIPES.

Q=Quantity of gas in cubic feet per hour.
L=Length of pipe in yards.
D=Diameter of pipe in inches.
H=Head of water pressure in inches.
G=Specific gravity of gas=.42.

then

$$Q=1350\ D^2\sqrt{\frac{H.\ D.}{G.\ L.}}$$

$$D=.056\sqrt[5]{\frac{Q^2.\ G.\ L.}{H.}}$$

On the following page we present a table showing the discharge of gas in cubic feet per hour through pipes of various diameters and lengths, and at different pressures, calculated upon the basis of the specific gravity of the gas being .4. The quantities of gas discharged of any other specific gravity may be ascertained by multiplying the quantities indicated in the table by ·6325, (the square root of ·4), and dividing the product by the square root of the specific gravity of the other gas.

The table is also susceptible of being extended to longer and shorter lengths, and to higher pressures, by the application of the following axioms:—

1st. The discharge of gas will be doubled when the length of the pipe is only one-fourth of any of the lengths given in the table.

2d. The discharge of gas will be only one-half when the length of the pipe is four times greater than the lengths given in the table.

3d. The discharge of gas is doubled by the application of four times the pressure.

TABLE No. 20.

TABLE OF DISCHARGES OF GAS, IN CUBIC FEET PER HOUR, THROUGH PIPES OF VARIOUS DIAMETERS AND LENGTHS, AND AT DIFFERENT PRESSURES OF WATER, IN INCHES.

Lengths of Main, in Yards.	1½ in. Diameter.				2 in. Diameter.				3 in. Diameter.			
	Pressures.				Pressures.				Pressures.			
	1.0	1.5	2.	2.5	1.	1.5	2.	2.5	1.	1.5	2.	2.5
	Discharges.				Discharges.				Discharges.			
100	588	720	832	932	1208	1480	1708	1908	3100	4075	4700	5260
150	478	588	680	759	986	1208	1394	1560	2718	3329	3840	4293
200	416	509	590	655	853	1046	1208	1350	2350	2881	3328	3718
300	351	420	478	537	697	853	984	1103	1920	2353	2714	3037
500	263	323	372	416	540	661	762	853	1488	1823	2108	2353
750	215	263	304	340	441	540	624	697	1216	1488	1718	1920
1000	186	228	284	294	381	468	540	534	1054	1289	1488	1644
1250	166	204	236	263	342	419	484	540	942	1155	1332	1354
1500	152	186	215	240	312	381	442	493	859	1052	1216	1357
1750	141	172	199	223	280	353	408	457	795	974	1130	1279
2000	132	161	186	208	270	331	381	427	744	912	1054	1176

Lengths of Main, in Yards.	4 in. Diameter.				6 in. Diameter.			
	Pressures.				Pressures.			
	1.	1.5	2.	2.5	1.	1.5	2.	2.5
	Discharges.				Discharges.			
100	6831	8370	9658	10 800	18 820	23 050	26 600	29 770
150	5580	6830	7888	8817	15 370	18 820	21 700	24 300
200	4829	5920	6826	7674	13 310	16 400	18 800	21 000
300	3944	4829	5577	6233	10 870	13 310	15 370	17 180
500	3055	3740	4320	4829	8418	10 310	11 940	13 310
750	2420	3055	3522	3944	6872	8418	9720	10 870
1000	2160	2646	3052	3413	5950	7290	8420	9410
1250	1932	2366	2732	3052	4340	5320	7540	8415
1500	1761	2160	2490	2789	4860	5970	6860	7672
1750	1634	2000	2310	2582	4500	5500	6360	7115
2000	1530	1870	2150	2415	4209	5155	5970	6655

TABLE OF DISCHARGES OF GAS.—(*Continued*).

Lengths of Main, in Yards.	8 in. Diameter. Pressures. 1.	1.5	2.	2.5	Lengths of Main, in Yards.	10 in. Diameter. Pressures. 1.	1.5	2.	2.5
	Discharges.					Discharges.			
100	38 650	47 350	54 640	61 100	500	30 100	37 100	42 600	47 700
150	31 550	38 640	44 600	49 940	750	24 650	30 190	34 800	39 000
200	27 340	33 460	38 600	43 200	1000	21 640	26 150	30 100	33 750
300	22 310	27 340	31 550	35 270	1500	17 400	21 300	24 760	27 560
500	17 280	21 170	24 400	27 340	2000	15 050	18 500	21 300	23 850
750	14 100	17 280	19 800	22 310	2500	13 175	16 136	18 632	20 880
1000	12 220	14 960	17 280	19 320	3000	12 027	14 561	17 008	19 016
1250	10 940	13 650	15 520	17 280	4000	10 413	12 756	14 729	16 468
1500	9900	12 200	14 040	15 800					
1750	9237	11 300	13 040	14 600					
2000	8640	10 585	12 200	13 670					

Lengths of Main, in Yards.	12 in. Diameter. Pressures. 1.	1.5	2.	2.5	14 in. Diameter. Pressures. 1.	1.5	2.	2.5
	Discharges.				Discharges.			
500	47 600	58 320	67 200	75 240	70 000	85 700	98 800	110 660
750	38 880	47 600	55 000	61 470	57 166	69 990	80 800	90 352
1000	33 660	41 200	47 600	53 240	49 507	60 620	70 000	78 360
1500	27 500	33 600	38 880	43 515	40 400	49 400	57 000	63 940
2000	23 800	29 250	33 600	37 620	35 000	42 600	49 400	55 330
2500	21 190	26 100	30 116	33 631	31 300	38 350	44 280	49 500
3000	19 440	23 800	27 500	30 740	28 580	34 990	40 400	45 170
4000	16 830	20 600	23 800	26 620	24 750	30 310	35 000	39 180

Lengths of Main, in Yards.	16 in. Diameter. Pressures. 1.	1.5	2.	2.5	20 in. Diameter. Pressures. 1.	1.5	2.	2.5
	Discharges.				Discharges.			
500	98 000	120 200	138 240	154 560	170 600	204 600	241 000	270 000
750	79 770	97 740	113 200	128 020	139 600	170 600	197 600	220 400
1000	69 120	84 670	98 000	109 260	120 744	147 900	170 600	191 000
1500	56 600	69 120	79 800	89 230	98 800	120 700	139 600	155 800
2000	49 000	60 100	69 120	77 280	85 300	102 300	124 500	135 000
2500	43 680	53 540	61 824	69 120	76 500	93 500	108 000	120 744
3000	39 885	48 870	56 600	64 000	69 800	85 300	98 800	110 200
4000	34 560	42 340	49 000	54 630	60 370	73 950	85 300	95 500

TABLE OF DISCHARGES OF GAS.—(*Concluded.*)

Lengths of Main, in Yards.	24 in. Diameter.				30 in. Diameter.			
	Pressures.				Pressures.			
	1.	1.5	2.	2.5	1.	1.5	2.	2.5
	Discharges.				Discharges.			
500	271 200	326 000	375 000	425 800	468 000	574 000	664 000	744 200
750	217 200	271 200	310 000	344 000	384 000	468 000	558 900	607 600
1000	189 200	233 280	271 200	301 160	332 000	406 000	468 000	526 000
1500	155 000	190 500	217 200	245 800	272 070	332 760	384 140	457 600
2000	135 600	163 000	187 600	212 900	234 000	287 000	332 000	372 100
2500	119 000	145 500	168 000	194 400	210 000	257 000	298 000	332 000
3000	108 600	135 600	155 000	172 000	192 000	234 000	270 000	303 800
4000	95 350	116 640	135 600	150 580	166 000	203 000	234 000	263 000

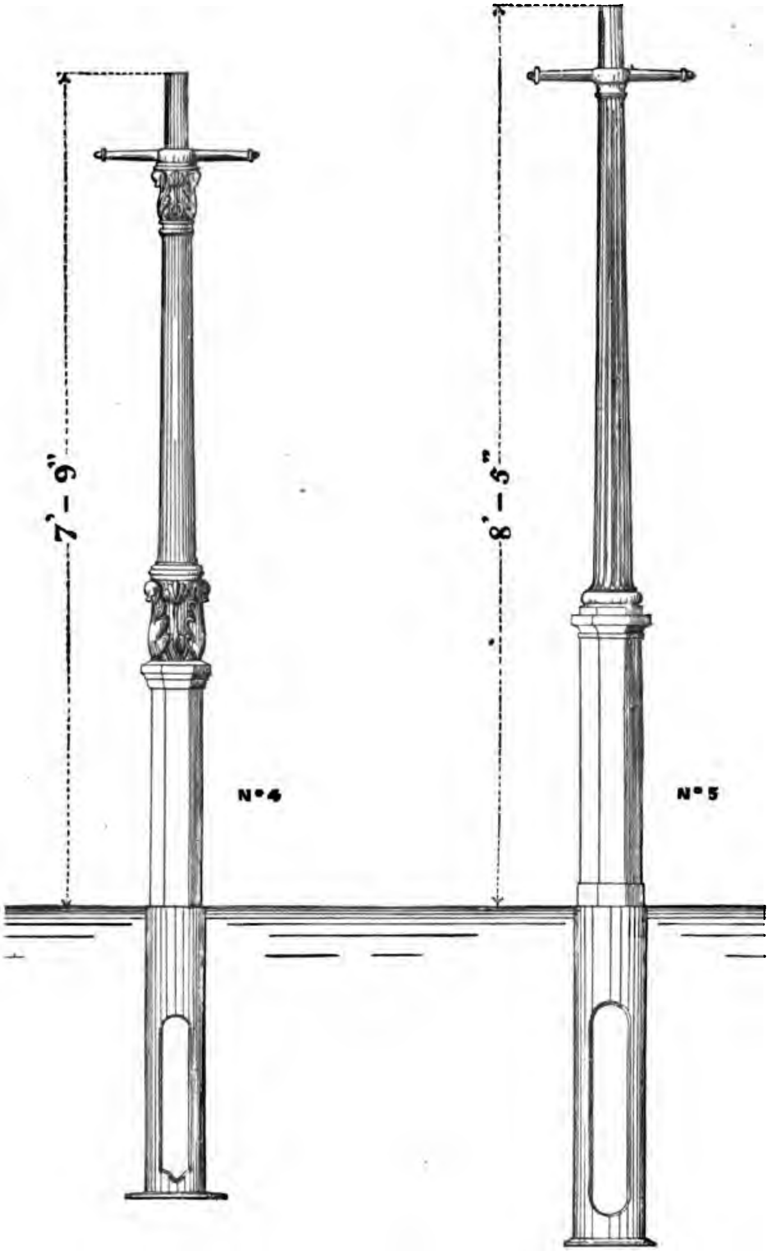
Lengths of Main, in Yards.	36 in. Diameter.			
	Pressures.			
	1.	1.5	2.	2.5
	Discharges.			
500	744 000	912 000	1 212 000	1 256 400
750	606 000	744 000	856 000	1 032 000
1000	530 000	644 000	744 000	832 000
1500	428 500	524 880	606 000	677 630
2000	372 000	456 000	524 880	628 200
2500	332 000	408 000	468 000	530 000
3000	303 000	372 000	428 000	516 000
4000	265 000	322 000	372 000	416 000

USEFUL PRODUCTS OF COAL-GAS MANUFACTURE.

The following observations by Dr. Lyon Playfair, in a lecture delivered before the society of arts, show the various purposes to which the residual products of coal-gas manufacture may be applied.

"The waste and badly-smelling products of gas-making appear almost too bad and fetid for utilization; and yet every one of them chemistry, in its thriftiness, has made almost indispensable to human progress.

Fig. 24. Fig. 25.



PLAIN LAMP-POSTS.

"The badly-smelling tar yields benzole, an ethereal body of great solvent powers, well adapted for preparing varnishes, used largely for making oil of bitter almonds, of value for removing grease-spots, and for cleansing soiled white kid gloves.

"The same tar gives naphtha, so important as a solvent of India-rubber and gutta-percha.

"Coal-tar furnishes the principal ingredient of printers' ink, in the form of lamp-black.

"It substitutes asphalte for pavements.

"It forms a charcoal when mixed with red-hot clay, that acts as a powerful disinfectant.

"When the tar is mixed with coal-dust formerly wasted in mining operations, it forms by pressure an excellent and compact artificial fuel.

"The water condensed with the tar contains much ammonia, readily convertible into sulphate of ammonia, a salt now recognized as being of great importance to agriculture, and employed in many of the arts.

"Cyanides are also present among the products of distillation, and these are readily convertible into the beautiful color known as Prussian blue.

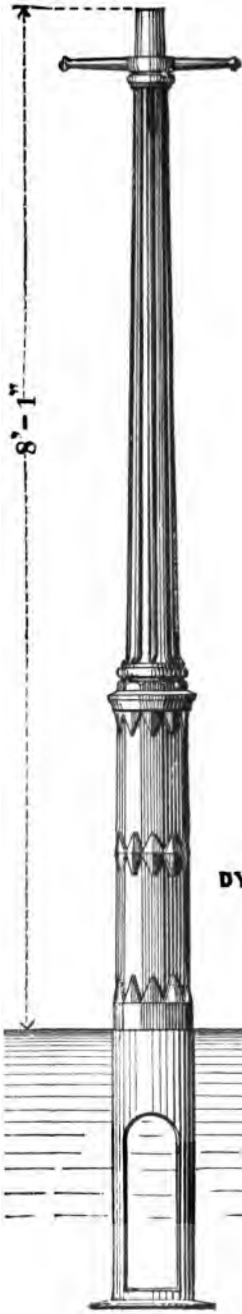
"The naphthaline (an enemy of the gas manufacturer by choking the pipes) may be made into the beautiful red coloring matter closely resembling that from madder. This, by its transformation, promises an important, though, hitherto, not realized useful product.

"Coal, when distilled at a lower temperature than that required to form gas, produces an oil containing paraffine, largely used as an anti-friction oil for light machinery."

Another more recent and very important use to which coal-gas tar is applied is the manufacture of what is known as "Smith's Coal-Tar Varnish," with which cast-iron water-

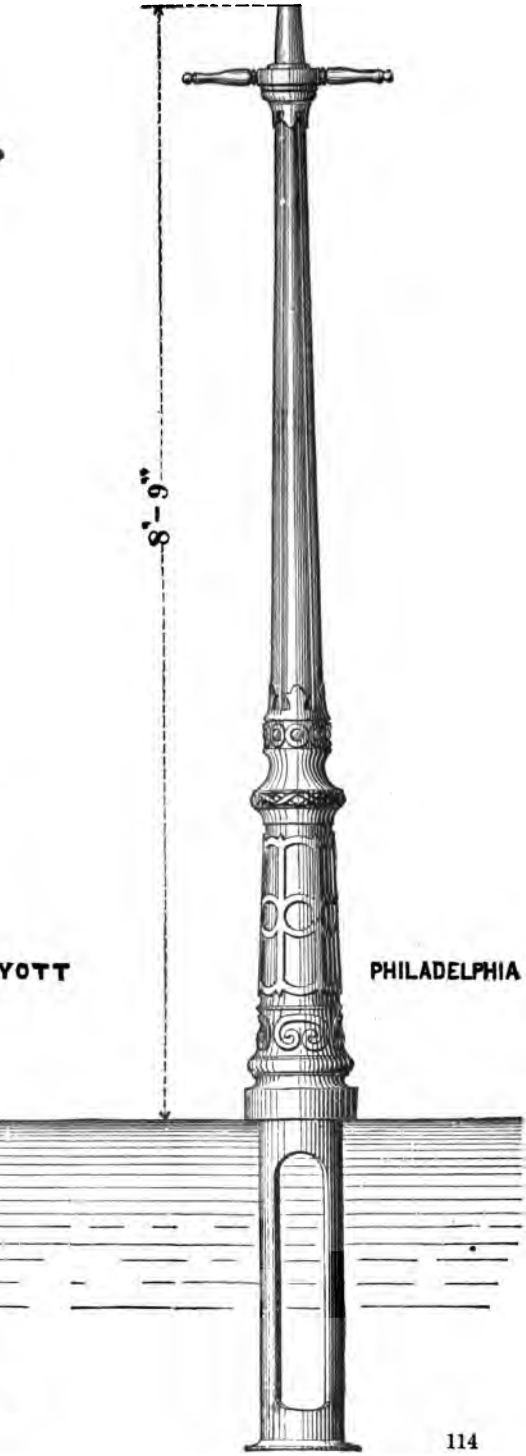
8

Fig. 26.



DYOTT

Fig. 27.



PHILADELPHIA

pipes are now very generally coated before laying in the ground to prevent the formation of tubercles, to which very full reference has been made elsewhere. Tar produced by gas-works is worth from 6 cents to 15 cents per gallon, according to quality and convenience of access to market.

TABLE No. 21.

COMPARATIVE POWER OF SUBSTANCES FOR CONDUCTING HEAT.

Gold	1000	Tin	303.9
Silver	973	Lead	179.6
Platina	981	Marble	23.6
Copper	898.2	Porcelain	12.2
Iron	364.3	Firebrick	11.4
Zinc	363		

Non-conducting substances in the order in which they resist the passage of heat. The best non-conductors being placed first and referred to *slate which is* 100.

Plaster and Sand	18.70	Marble	58.27
Plaster of Paris	20.26	Stock Brick	60.14
Roman Cement	20.88	Brick (Fire)	61.70
Asphalte	45.19	Slate	100.00
Chalk Soft	56.38	Lead	521.34

TABLE No 22.

EXPANSION OF AIR (DALTON)—PRESSURE BEING CONSTANT.

Temp.		Temp.	
32°	1.	75°	1.099
35°	1.007	80°	1.110
40°	1.021	85°	1.121
45°	1.032	90°	1.132
50°	1.043	95°	1.142
55°	1.055	100°	1.152
60°	1.066	200°	1.354
65°	1.077	212°	1.376
70°	1.089	302°	1.558

Fig. 28.

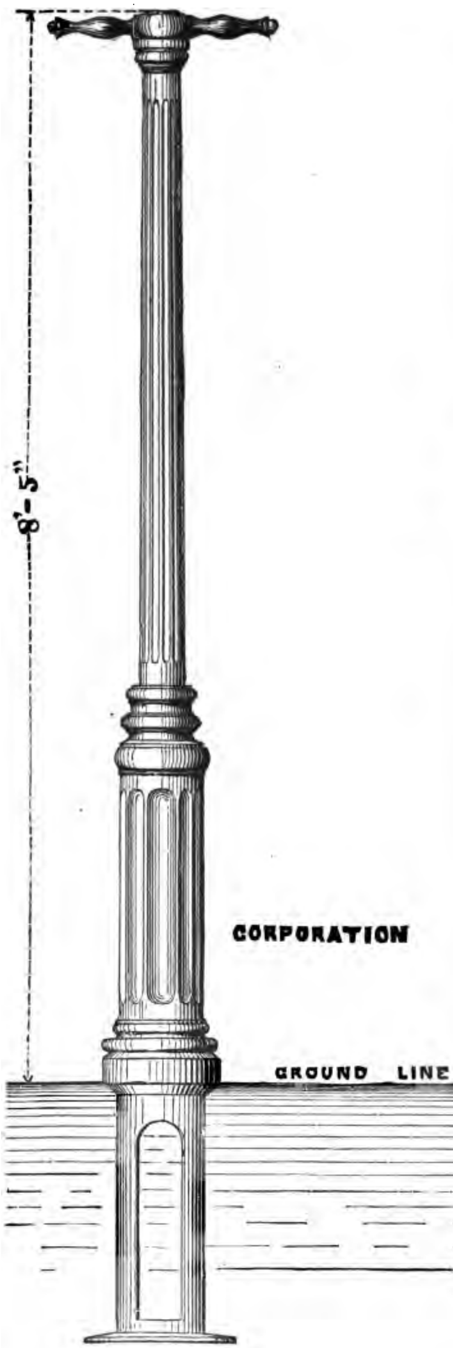


Fig. 29.

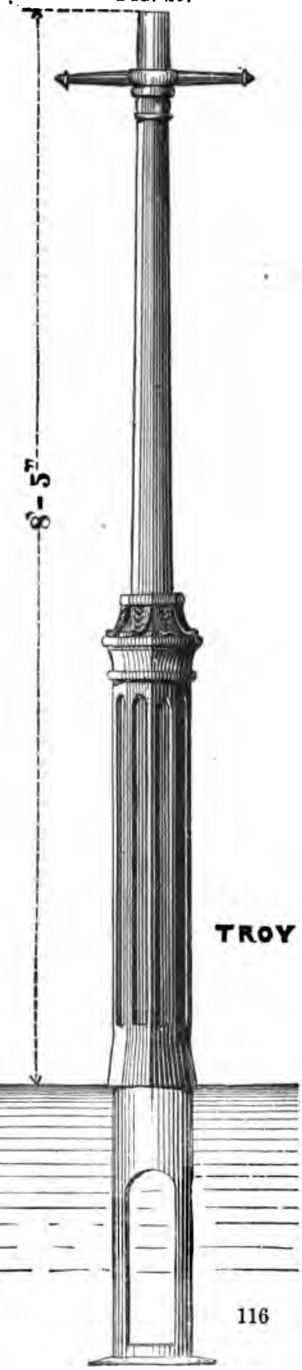


TABLE No. 23.

TABLE OF COMPARATIVE CHARGES, CAPITAL, INCOME, EXPENDITURE AND PROFIT OF THE LONDON GAS COMPANIES AT MIDSUMMER. Reduced from British Money at $4.84 to the Pound Sterling without Premium.

NAMES OF COMPANIES IN ORDER OF FORMATION.	CHARGE FOR 1000 FEET OF GAS.	Capital employed for every $100 of Gas Rent.	Gross Expenditure in Coal for every $100 Gas Rent.	Net Cost of Coal for every $100 Gas Rent, residuary Products deducted.	Working Expenses exclusive of Coal for every $100 Gas Rent.	Gross Cost of Gas for every $100 Gas Rent.	Net Cost of Gas for every $100 Gas Rent.	Net Profit upon every $100 Gas Rent applied to Payment of Interest and Div.	Returns from Coke Tar, Breeze and Liquor for every $100 expended in Coal.	Net Profit per Cost per Annum upon the Capital employed.
Chartered Gas Lt. & Coke Co.	.97 without meter rent in the city ...... $1.09 with " " other districts.	341 18	57 45	37 92	44 29	101 69	82 17	17 81	33 96	5 21
City of London do.	.97 without meter rent..................	455 80	53 76	30 43	45 01	98 77	75 43	24 55	43 41	5 38
Imperial do.	$1.09 with meter rent....	....	....	....	....	....	....	....	....	....
Ratcliff do.	$1.09 with meter rent......................	439 39	53 27	34 13	40 14	93 41	74 28	25 72	35 91	5 84
Phœnix do.	$1.09 with meter rent in city.............. $1.20 " " " rural districts....	418 80	46 25	22 25	49 09	95 34	70 90	28 65	51 85	6 81
Independent do.	$1.09 with meter rent in city	....	....	....	....	....	....	....	....	....
Equitable do.	$1.09 with meter rent in city	476 86	50 32	34 05	43 12	93 42	77 15	22 83	32 31	4 78
South Metropolitan do.	$1.09 with meter rent in city......... $1.21 " " " rural districts....	251 61	48 72	25 78	49 87	98 60	75 66	24 33	47 08	9 66
London do.	$1.09 with meter rent in city............. $1 21 " " " rural districts...	590 08	50 75	22 70	53 21	103 96	75 91	24 07	55 00	4 08
Commercial do.	.97 without meter rent.....	397 94	68 95	49 00	29 06	98 00	78 47	21 93	28 89	5 64
Great Central do.	.97 without meter rent	425 19	...	....	...	....	....	....	....	....
Western Cannel do.	$1.44 with meter rent......................	459 24	46 62	36 50	36 46	83 09	73 80	26 18	19 88	5 73
Surrey Consumers do.	$1.09 with meter rent....	400 83	....	....	....	...	....	....	....	....

MISCELLANEOUS

From Appendix to "Treatise on Water Supply

TABLE

ANALYSES OF VARIOUS

The quantities are expressed in grains per U. S. Gallon of 231 cubic inches, or $58,372\frac{175}{1000}$ grains.	Hudson River, above Albany, N. Y.	Hudson River, above Poughkeepsie, N. Y.	Connecticut River, above Holyoke, Mass.	Connecticut River, above Springfield, Mass.	Schuylkill River, above Philadelphia, Pa.	Croton River, above Croton Dam, N. Y.	Croton River Water in New York Pipes, N. Y.	Saugus River, near Lynn, Mass.
Carbonate of Lime	....	1.059	.85	.90	1.56	2.67	1.52	1.812
" Magnesia	....	....	.56	.67	.60	1.90	.84	....
" Soda	....	2.126	....	....	....	....	....	....
Protocarbonate of Iron	....	....	....	....	....	....	....	....
Chloride of Sodium	.361	.108	.676	.72	.49	.402	....	.480
" Magnesia	.161	....	....	....	....	....	....	....
" Calcium	....	....	...	....	....	.86	.90	....
" Potassium	....	....	.070	.83	....	....	....	....
" " and Sodium	....	....	.090	.75	....	....	....	....
Sulphate of Lime	.980	....	.146	.156	.29	.158	....	.280
" Magnesia	....	....	....	....	....	....	....	...
" Potash	.076	....	....	....	....	....	....	.028
" Potassa	....	....	....	....	.43	.179	....	....
" Soda	....	2.785	....	...	.48	.260	....	.040
Silicate of Potassa	....	....	....	....	....	....	....	....
" Soda	....	....	....	....	....	....	....	....
Nitrate of Lime	....	....	....	....	....	....	....	....
Oxide of Iron	....	3.644	.156	.168	.09	trace	....	trace
Iron Alumina and Phosphates	....	....	....	....	....	....	....	....
Ammonia	....	....	....	....	....	....	....	....
Silica	.408	2.201	.132	.133	.30	.62	.46	1.104
Organic Matter	.699	.776	1.728	1.680	....	.67	....	2.880
Total Solids	2.685	12.699	4.408	6.007	4.24	7.719	3.720	6.624
Soluble Organic Matter	....	....	....	....	....	....	....	....
Solid residue obtained on evaporation	....	....	....	....	....	....	....	....
Free Carbonic Acid	....	....	....	....	....	....	....	....
Hardness, Degree by Clarke's Scale	3.35	....	.43	.51	....	....	....	....

* Notwithstanding the exceeding importance of an intelligent microscopical examination of each proposed domestic water supply, in addition to the chemical analysis, no record of such examination is found accompanying the reports upon the waters herein enumerated. Lenses of the highest microscopical powers should be used for such purpose, and immersion lenses are required in many instances.

To obtain specimens of sedimentary matters, the sample of water may first

MEMORANDA.

Engineering," by J. T. FANNING, C. E.

No. 24

RIVER AND BROOK WATERS.*

Chickopee River, near Springfield, Mass.	Mill River, near Springfield, Mass.	Grand River, above Grand Rapids, Mich.	White River, in Filter Wells on Bank, at Indianapolis, Md.	Fallkill Creek, near Poughkeepsie, N. Y.	Wapinger's Creek, near Poughkeepsie, N. Y.	Lynde Brook, near Worcester, Mass.	Thames River, above London, Eng.	Dee River, near Aberdeen, Scotland.	New River, London, Eng.	Hampstead Water Co.'s Supply, England.	Cowley Brook, near Preston, Eng.	Loud Scales, Preston, England.	Dutton Brook, near Preston, Eng.
.65	1.30	7.18	10.02	.51	6.221	.334	13.13	.709	6.521	4.128	.575	6.131	1.343
.59	.87	1.84	....	....	....	.05	....	....	.909	2.944	.238	.966	.217
...	....	....	.40	.322	4.245	....	....	....	....	....	....	....	....
....	....	....	...	....	....	....	....	...	....	....	.147	.242	.152
.532	.865	....	4.70	1.20	trace	....	1.56	....	1.442	5.662	.938	.550	.970
....	....	....	....	....	....	....	....	...	....	....	.091	....	....
....	....	....	2.37	....	....	.334	....	....	....	....	....	.317	....
.75	.07	1.38	....	....	....	....	....	....	....	1.501	....	....	....
.64	.11	....	....	....	....	....	....	.559	....	....	....	...	....
.13	.260	....	3.00	....	....	....	2.73	.101	2.693	....	.175	.321	.105
....	....	....	....	....	...	....	....	....	....	....	....	....	.394
....	....	....	....	....	...	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	.926	1.167	.287	.133	.159
....	....	....	....	trace	.092	.150	....	...	1.242	12.625	....	.780	.171
....	....	....	....	....	....	....	....	....	....	....	.093	....	....
....	....	....	....	....	....	...	....	....	....	....	.348	...	....
....	....	....	....	...	....	....	....	....	.017	.058	....	....	....
trace	trace	.72	....	1.66	.851	.167	.13	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	trace	trace	....	....	....
....	....	....	....	....	....	....	....	....	trace	trace	...	....	....
.12	trace	1.37	....	trace	.05	.275	.27	....	.417	.058	.425	.334	.401
1.104	3.864	18.75	.50	.15	trace	.417	2.37	....	2.327	1.535	....	....	....
4.516	7.339	31.24	20.99	6.74	11.459	1.727	20.19	....	16.496	29.678	3.317	1.774	3.912
....	....	....	....	....	....	....	....	....	....	....	1.167	1.168	.785
....	....	....	....	....	....	....	....	....	16.327	25.527	3.502	9.340	4.144
....	....	....	....	....	....	....	....	....	6.037	5.562	....	4.633	....
.30	.63	....	....	....	....	....	14.5	....	14.9	9.8	1.25	12	1.50

rest a day in a deep, narrow dish, and then have its clear upper water syphoned off. The remainder of the water may then be poured into a conical glass, such as, or similar to, the graduated glasses used by apothecaries, and then again allowed to rest until the sediment is concentrated, when the greater part of the clear water may be carefully syphoned off and the sediment gathered and transferred to a slide, where it should be protected by a thin glass cover.

TABLE No. 25.

Analysis of various Lake, Spring, and Well Waters.

	Jamaica Pond, near Brooklyn, L. I.	Flax Pond, near Lynn, Mass.	Sluice Pond, near Lynn, Mass.	Breeds Pond, near Lynn, Mass.	Reeds' Lake, near Grand Rapids, Mich.	Lake Konomac, near New London, Conn.	Loch Katrine, near Glasgow, Scotland.	Spring Water, near Clapham, England.	Well at Highgate, England.	Artesian Well, at Hatton, England.	Artesian Well, at Colney Hatch, England.
Carbonate of Lime......	1.092	.700	.400	.600	4.65	.096	....	12.583	....	1.768	5.420
" Magnesia.	.408	.692	.320	.612	1.13	....	.216	11.658	....	.734	1.101
" Soda......	....	....	...	....	....	....	....	....	....	12.677	5.921
Protocarbonate of Iron..	....	....	....	....	....	....	....	....	....	4.00	...
Chloride of Sodium	.244	.612	.408	.504	....	2.18	....	9.556	8.032	7.745	....
" Magnesia ...	.328	....	....	....	....	trace	....	....	....	....	3.553
" Calcium. ...	.120	...	....	....	....	....	.144	....	4.930	....	....
" Potassium...	....	....	....	....	1.62	...	....	....	....	....	....
Alkaline Chlorides......	....	....	....	....	....	....	.433	....	....	....	....
Sulphate of Lime........	.120	.300	.300	.270	....	1.29	.381	12.775	....	....	3.798
" Magnesia...	.288	....	....	.050	....	....	....	....	....	....	....
" Potash......	....	.064	.070	....	....	....	....	....	14.217	trace	2.160
" Potassa.....	....	....	....	....	....	....	....	5.662	....	....	....
" Soda	....	.080	.086	.880	....	....	....	8.776	7.935	8.719	4.811
Phosphate of Lime......	....	....	....	....	trace	....	....	....	....	trace	trace
Nitrate of Lime	...	....	....	....	....	.. .	....	....	33.457	...	....
" Magnesia.....	....	....	....	....	....	....	....	....	14.231	....	....
Oxide of Iron...	.044	.840	trace	.096	.85	.035	trace	....	....	....	....
Ammonia..............	....	....	....	....	....	....	....	....	....	....	....
Silica.........	....	.156	.144	.120	.75	2.43	.170	.200	.747	.042	.559
Organic Matter	.008	2.208	1.344	2.184	8.75	1.80	.900	3.419	....	....	....
Total Solids.......	2.652	5.652	3.072	5.316	17.750	7.831	2.244	64.629	83.549	35.685	27.323
Soluble Organic Matter.	....	....	....	....	....	....	....	....	....	....	.392
Hardness, Degrees by Clark's Scale..........	....	....	....	....	....	....	0.80	....	....	....	....

	Ice from Stagnant Pond.		Water from Cochituate Lake.
	Grains per U. S. Gal.		Grains per U. S. Gal.
	Unfiltered.	*Filtered.*	
Ammonia................................	0.0121	0.0124	0.0020
Albuminoid Ammonia....................	0.0410	.0096	0.0068
Inorganic Matter............	4.55	4.01	1.61
Organic and Volatile Matter	3.33	1.66	1.22
Total solid residue at 212° Fahrenheit..	7.88	5.67	2.83
Chlorine............		1.88	.18
Oxygen required to oxidize organic matter.		0.495	

THE METRIC SYSTEM

OF

WEIGHTS AND MEASURES.

The use of the metric system of measure and weights was legalized in the United States in 1866 by the National Government, and is used in the coast survey by the engineer corps, and to considerable extent in the arts and trades.

Several of the best treatises on theoretical hydraulics give their lengths and volumes in metric measures, and we give their equivalents in United States measures in the following tables.

The *metre*, which is the unit of *length*, *area*, and volume, equals 39.37079 inches or 3.280899 feet in length lineal, and along each edge of its cube.

This unit is, for measures of length, multiplied decimally into the *decametre*, *hectometre*, *kilometre*, and *myriametre*, and is subdivided decimally into the *decimetre*, *centimetre*, and *millimetre*.

The affixes are derived from the Greek for multiplication by ten, and from the Latin for division by ten.

The measures for surface and volume are similarly divided.

The *gramme* is the unit of weight, and it is equal to the weight of a cubic centimetre of water, at its maximum density, in *vacuo*. = .0022046 lbs.

A cubic metre of water, at its maximum density, weighs 2204.6 lbs. avoir.

TABLE No. 26.

Table of French Measures and United States Equivalents.

Measures of Length.

	No. of Metres.	
1 Millimetre.......	.001	= .0393708 inch = .0032809 foot.
1 Centimetre......	.01	= .393708 inch = .032809 foot.
1 Decimetre.......	.1	= 3.93708 inches = .3280899 ft. = .1093633 yd.
1 Metre..........	1	= 39.3708 inches = 3.2808992 ft. = .198842 rod = .0006214 mile.
1 Decametre......	10	= 32.808992 ft. = 1.98842 rods = .0062138 mile.
1 Hectometre......	100	= 328.08992 ft. = 19.88424 rods = .062138 mile.
1 Kilometre.......	1000	= 3280.8992 ft. = 198 8424 rods = .621383 mile.
1 Myriametre......	10000	= 32808.992 ft. = 1988.424 rods = 6.21383 miles.

Measures of Area.

	No. of sq. Metres.	
1 Centiare.........	1	= 10.7643 sq. ft. = 1.196033 sq. yds. = .039538 sq. rod.
1 Deciare.........	10	= 107.643 sq. ft. = .39538 sq. rd. = .002471 acre.
1 Are.............	100	= 1076.43 sq. ft. = 3.95383 sq. rds. = .02471 acre.
1 Decare (not used)	1000	= 10764.3 sq. ft. = 39.5383 sq. rds. = .2471 acre.
1 Hectare.........	10000	= 107643 sq. ft. = 395.383 sq. rds. = 2.471 acres.

Measures of Volume.

	No. of cu. Metres.	
1 Millilitre.... ...	.000001	= .0610279 cubic inch.
1 Centilitre........	.00001	= .610279 cubic inch.
1 Decilitre........	.0001	= 6.10279 cu. ins. = .00353 cu. ft. = .0264165 gal.
1 Litre............	.001	= 61.0279 cu. ins. = .0353136 cu. ft. = .264165 gallon.
1 Decalitre........	.01	= 610.279 cu. ins. = .353136 cu. ft. = .0130791 cu. yard.
1 Hectolitre.......	.1	= 26.4165 gallons = 3.53136 cu. ft. = .130791 cu. yard.
1 Kilolitre........	1	= 264.1651 gallons = 35.313 cu. ft. = 1.30791 cubic yards.

Table of French Measures and United States Equivalents (*Continued*).

Measures of Solidity.

	No. of cu. Metres.	
1 Millistere	.001	= 61.0279 cubic inches = .03532 cubic foot.
1 Centistere.......	.01	= 610.279 cu. ins. = .353166 cu. ft. = .013079 cu. yard.
1 Decistere........	.1	6102.79 cu. ins. = 3.53166 cu. ft. = .130791 cubic yard.
1 Stere............	1	= 61027.9 cu. ins. = 35.3166 cu. ft. = 1.30791 cu. yards.
1 Decastere.......	10	= 353.166 cu. ft. = 13.0791 cu. yards.
1 Hectostere......	100	= 3531.66 cu. ft. = 130.791 cu. yards.
1 Kilostere........	1000	= 35316.6 cu. ft. = 1307.91 cu. yards.

Measures of Weight.

	No. of Grammes.	
1 Milligramme	.001	= .015432 grain.
1 Centigramme....	.01	= .15432 grain.
1 Decigramme.....	.1	= 1.5432 grains = .0035274 oz. Avoir.
1 Gramme.........	1	= 15.432 grs. = .035274 oz. Av. = 002205 lb. Av.
1 Decagramme.....	10	= 154.32 grs. = .35274 oz. Av. = .02205 lb. Av.
1 Hectogramme...	100	= 1543.2 grs. = 3.5274 oz. Av. = .2205 lb Av.
1 Kilogramme.....	1000	= 15432 grs. = 35.274 oz. Av. = 2.205 lbs. Av.
1 Tonne	....	= 2204.737 lbs.

A cubic inch is equal to

.004329 gallon; or .0005787 cu. ft; or 16.38901 millilitres; or 1.638901 centilitres; or .1638901 decilitre; or .016389 litre; cr .016389 millistere; or ·0016389 centistere.

A gallon is equal to

231 cubic inches, .13368 cubic foot; or .031746 liquid barrel; or 3785.513 millilitres; or 378.551 centilitres; or 37.8551 decilitres; or 3.785513 litres; or .3785513 decalitre; or .037855 hectolitre; or .0037855 kilolitre.

A cubic foot is equal to

1728 cubic inches; or 7.48052 liquid gallons; or 6.2321 imperial gallons; or 3.21426 U. S. pecks; or .803564 U. S. struck bushel; or .23748 liquid barrel of 31½ gallons; or 2831.77 centilitres; or 283.177 decilitres: or 28.3177 litres; or 2.83177 decalitres; or .283177 hectolitre; or .0283177 kilolitre; or 28.3177 millisteres; or 2.83177 centisteres; or .283177 decistere; or .0283177 stere.

The imperial gallon is equal to

.16046 cu. feet; or 1.20032 U. S. liquid gallons.

A cubic yard is equal to

46656 cu. inches; or 201.97404 liquid gallons; or 27 cu. feet; or 21.69623 struck bushels; or 764.578 litres; or 76.4578 decalitres; or 7.64578 hectolitres; or .764578 kilolitre; or 764.578 milisteres; or 76.4578 centisteres; or 7.64578 decisteres; or .764578 stere; or .0764578 decastere; or .0076458 hectostere; or .00076458 kilostere.

Table of Units of Heads and Pressures of Water and Equivalents.

(Rankine.)

One foot of water at 52°.3 Fah.	=	62.4	lbs. on the square foot.
" " " "	=	.433	" " " inch.
" " " "	=	.0295	atmosphere.
" " " "	=	.8823	inch of mercury at 32°.
One lb. on the square foot	=	.016026	foot of water.
" " " inch	=	2.308	feet of water.
One atmosphere (= 29.922 in. mercury)	=	33.9	" "
One inch of mercury, at 32°	=	1.1334	" "
One cubic foot of average sea-water	=	1.026	cu. ft. of pure water in weight.
One Fahrenheit degree	=	.55555	Centigrade degree.
One Centigrade degree	=	1.8	Fahrenheit degrees.
Temperature of melting ice	=	32°	on Fahrenheit's scale.
" "	=	0	" Centigrade scale.

TABLE OF AVERAGE WEIGHTS, STRENGTHS, AND ELASTICITIES OF MATERIALS.—(From Trautwine, Neville, and Rankine.)

MATERIALS.	Weight per cu. in.	Weight per cu. ft.	Specific Grav.	Tenacity per sq. in.	Resistance per sq. in. to crushing force.
Woods (seasoned and dry).	*Lbs.*	*Lbs.*		*Lbs.*	*Lbs.*
Iron, cast, cold blast	.02552	441	7.07	16700	106000
" " hot blast	....	440	7.04	13500	108000
" " wrought, sheet or plate	.02807	485	7.77	50000	....
" " " large bars	....	474	7.60	48000	....
Lead, cast	.04152	717	11.44	1800	....
" milled	....	713	11.40	3300	....
Mercury (at 32° Fah., 849 lbs.) (at 212°, 836 lbs.), at 60°	.04896	846	13.58	....	....
Silver	.0373	644	10.31	40900	....
Steel	.02836	490	7.85	120000	....
Tin, cast	.02637	456	7.30	5300	....
Zinc	.02532	437	7.00	7500	....
Earth and Stones (dry).	*Cu. ft.*	*Cu. yd.*			
Asphaltum	87.3	2357	1.4	....	....
Brick, common hard	125	3375	....	280	800
" soft inferior	100	2700	....	....	....
" best pressed	150	4050	....	....	....
Cement, American Rosendale, loose	56	1512	....	....	....
" " Louisville	49.6	1339	....	....	....

TABLE OF AVERAGE WEIGHTS, STRENGTHS, ETC.—(*Continued*).

MATERIALS.	Weight per cu. ft.	Weight per cu. yd.	Specific Grav.	Tenacity per sq. in.	Resistance per sq. in. to crushing force.
	Lbs.	*Lbs.*		*Lbs.*	*Lbs.*
Cement, English Portland	90	2430	....	280	....
" French Boulogne	80	2160	....	....	....
Clay, potter's	119	3213	1.9	....	....
" dry, in lump, loose	63	1701	....	....	....
Concrete	...	.....	....	....	556
Coal, bituminous	84	2268	1.35	....	....
" broken, loose	50	1350	....	....	....
" a ton occupies 43 to 48 cu. ft.	....	....	....	....	....
Earth, loam, loose	75	2025	....	....	....
" " moderately rammed	95	2565	....	....	....
" " as a mud	110	2970	....	....	....
Granite	168	4536	2.69	....	10000
" quarried, in loose piles	96	2592	....	....	....
Gneiss	168	4536	2.69	....	....
" quarried, in loose piles	100	2700	....	....	....
Greenstone	187	5049	....	....	....
" quarried, in loose piles	107	2889	....	....	....
Gravel	100	2700	....	....	....
" moderately rammed, dry	120	3240	1.90	....	....
" " " moist	130	3510	....	....	....
Limestone	168	4536	2.7	....	8333
Lime, ground, loose	53	1431	....	....	....
Marble	165	4455	2.64	....	5500
Masonry, dressed granite, or limestone	165	4455	....	....	....
" well-scabbled mortar rubble of do.	154	4158	....	....	....
" " " dry " " do.	138	3726	....	....	....
" roughly " " " " do.	125	3375	....	....	....
" dressed sandstone	144	3888	....	....	....
" dry rubble "	110	2970	....	....	....
" brickwork, medium	125	3375	....	....	345
" " coarse	100	2700	....	....	....
" " press'd bricks, close joints	140	3780	....	....	....
Marl	110	2970	1.75	....	....
Mortar, cement	103	2781	1.65	50	....
Peat, unpressed	25	675	....	....	....
Sand, loose	100	2700	....	....	....
" shaken	110	2970	1.76	....	....
" wet	125	3375	....	....	....
Sandstone	150	4050	....	....	5000
" quarried, in loose pile	86	2322	....	....	....
Slate	180	4873	2.89	....	12000
Soapstone, or steatite	170	4590	2.73	....	....
Miscellaneous Materials.					
Ice	58.7	1585	0.94	....	200
Leather	...	....	....	4200	....
Oil, linseed	58.68	....	.94	....	....
Petroleum	54.81	....	.878	....	....
Powder, slightly shaken	62.3	....	1.0	....	....
Snow, loose	12	324	....	....	....
" wet and compact	50	1350	....	....	....
Water	62.334	1693	1.0	....	....

FORMULAS FOR SHAFTS.—(Francis.)

Wrought-iron prime movers, with gears:

$$d = \sqrt[3]{\frac{100P}{N}}, \text{ and } P = .01Nd^3.$$

Wrought-iron transmitting shaft:

$$d = \sqrt[3]{\frac{50P}{N}}, \text{ and } P = .02Nd^3.$$

Steel prime mover, with gears:

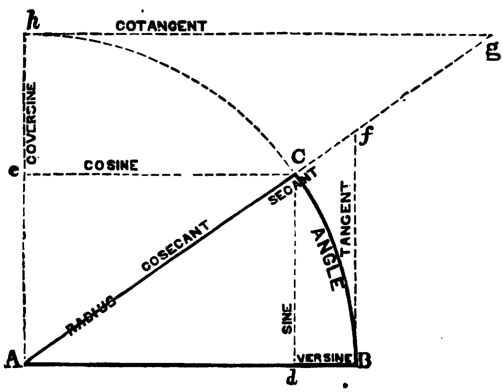
$$d = \sqrt[3]{\frac{62.5P}{N}}, \text{ and } P = .016Nd^3.$$

Steel transmitting shaft:

$$d = \sqrt[3]{\frac{31.25P}{N}}, \text{ and } P = .032Nd^3.$$

In which d = diameter of shaft in inches
N = number of revolutions per minute.
P = horse powers.

TRIGONOMETRICAL EXPRESSIONS.



Radius	= AC.
Sine	= Cd.
Cosine	= Cc.
Tangent	= Bf.
Cctangent	= hg.
Secant	= Af.
Cosecant	= Ag.
Versine	= Bd.
Coversine	= he.

TRIGONOMETRICAL EQUIVALENTS, WHEN RADIUS = 1.

Sine	=	$1 \div$ Cosec.
"	=	Cosin. $\div$ Cotan.
"	=	$\sqrt{(1 - \text{Cosin}^2.)}$
Cosine	=	$1 \div$ Sec.
"	=	Sin. $\div$ Tan.
"	=	Sin. $\times$ Cotan.
"	=	$\sqrt{1 - \text{Sin}^2}$.
Tangent	=	$1 \div$ Cotan.
"	=	Sin. $\div$ Cosin.
Cotangent	=	$1 \div$ Tan.
"	=	Cosin. $\div$ Sin.
Secant	=	$1 \div$ Cosin.
"	=	$\sqrt{1 + \text{Tan}^2}$.
Cosecant	=	$1 \div$ Sin.
"	=	$\sqrt{1 + \text{Cotan}^2}$.
Versine	=	Rad. $-$ Cosin.
Coversine	=	Rad. $-$ Sin.
Complement	=	$90° -$ Angle.
Supplement	=	$180° -$ Angle.

If radius of an arc of any angle is multiplied or divided by any given number, then its several correspondent trigonometrical functions are increased or diminished in like ratio.

Diameter	= Rad.	$\times$	2.
Circumference	= Rad.	$\times$	6.2832.
"	= Diam.	$\times$	3.1416.
Area of circle	= Diam^2.	$\times$	.7854.
Surface of a sphere	= Diam^2.	$\times$	3.1416.
Volume of a sphere	= Diam^3.	$\times$	.5236.

Length of one second of arc	= Rad. $\times$	.0000048.
" " " minute " "	= Rad. $\times$	.0002909.
" " " degree " "	= Rad. $\times$	.0174533.

TABLE No. 28.

VALUES* OF SINES, TANGENTS, ETC., WHEN RADIUS = 1.

Deg.	Sine.	Cover.	Cosec.	Tang't.	Cotan.	Secant.	Versine.	Cosine.	Deg.
0	.00	1.00000	Infinite.	.0	Infinite.	1.00000	0.	1.00000	90
1	.01745	.98255	57.2987	.01745	57.2899	1.00015	.0001	.99984	89
2	.03490	.96510	28.6537	.03492	28.6362	1 00060	.0006	.99939	88
3	.05234	.94766	19.1073	.05241	19.0811	1.00137	.0013	.99863	87
4	.06976	.93024	14.3355	.06993	14.3007	1.00244	.0024	.99756	86
5	.08716	.91284	11.4737	.08749	11.4300	1.00381	.0038	.99619	85
6	.10453	.89547	9 5667	.10510	9.5144	1 00550	.0054	.99452	84
7	.12187	.87813	8.2055	.12278	8.1443	1.00750	.0074	.99255	83
8	.13917	.86083	7.1853	.14054	7.1154	1.00982	.0097	.99027	82
9	.15643	.84356	6.3924	.15838	6.3137	1.01246	.0123	.98769	81
10	.17365	.82635	5.7587	.17633	5.6712	1.01542	.0151	.98481	80
11	.19081	.80919	5.2408	.19438	5 1446	1.01871	.0183	.98163	79
12	.20791	.79209	4.8097	.21255	4.7046	1.02234	.0218	.97815	78
13	.22495	.77504	4 4454	.23087	4.3315	1.02630	.0256	.97437	77
14	.24192	.75807	4.1335	.24933	4.0108	1.03061	.0297	.97030	76
15	.25882	.74113	3.8637	.26795	3.7320	1.03527	.0340	.96593	75
16	.27564	.72435	3.6279	.28674	3.4874	1.04029	.0387	.96126	74
17	.29237	.70762	3.4203	.30573	3.2708	1.04569	.0436	.95630	73
18	.30902	.69093	3.2360	.32492	3.0777	1.05146	.0489	.95106	72
19	.32557	.67413	3.0715	.34433	2.9042	1.05762	.0544	.94552	71
20	.34202	.65797	2.9238	.36397	2.7475	1.06417	.0603	.93969	70
21	.35837	.64163	2.7904	.38385	2.6051	1.07114	.0664	93358	69
22	.37461	.62539	2.6694	.40403	2.4751	1.07853	.0728	.92718	68
23	.39073	.60925	2 5593	.42447	2.3553	1.08636	.0794	.92050	67
24	.40674	.59325	2 4585	.44523	2.2460	1.09463	.0864	.91355	66
25	.42262	.57733	2.3662	.46631	2.1445	1.10337	.0936	.90630	65
26	.43837	.56152	2.2811	.48773	2.0503	1.11260	.1012	.89879	64
27	.45399	.54600	2.2026	.50952	1.9626	1.12232	.1089	.89101	63
28	.46947	.53052	2.1300	.53171	1.8807	1.13257	.1170	.88295	62
29	.48481	.51519	2.0625	.55431	1.8040	1.14335	.1253	.87462	61
30	.50000	.50000	2.0000	.57735	1.7320	1.15470	.1339	.86603	60
31	.51504	.48495	1.9416	.60086	1.6643	1.16663	.1428	.85717	59
32	.52992	.47003	1.8870	.62487	1.6003	1.17917	.1519	.84805	58
33	.54464	.45535	1.8360	.64941	1.5398	1.19236	.1613	.83867	57
34	.55919	.44080	1.7882	.67451	1.4826	1.20621	.1709	.82904	56
35	.57358	.42642	1.7434	.70020	1.4281	1.22077	.1808	.81915	55
36	.58778	.41221	1.7013	.72654	1.3764	1.23606	.1909	.80902	54
37	.60181	.39813	1 6616	.75355	1.3270	1.25213	.2013	.79864	53
38	.61566	.38433	1.6242	.78128	1.2799	1.26901	.2119	.78801	52
39	.62932	.37057	1.5890	.80978	1.2349	1.28675	.2228	.77715	51
40	.64279	.35721	1.5557	.83970	1.1918	1.30540	.2339	.76604	50
41	.65606	.34394	1.5242	.86929	1.1504	1.32501	.2452	.75471	49
42	.66913	.33085	1.4944	.90040	1.1106	1.34563	.2568	.74314	48
43	.68200	.31800	1.4662	.93251	1.0724	1.36732	.2686	.73135	47
44	.69465	.30534	1.4395	.96569	1 0355	1.39016	.2806	.71934	46
45	.70711	.29289	1 4142	1.	1.	1.41421	.2928	.70711	45
	Cosine.	Versine.	Secant.	Cotan.	Tang't.	Cosec.	Cover.	Sine.	

* When the angle exceeds 45°, read upward; the number of degrees will then be found in the right-hand column, and the names of columns at the bottom.

IN RIGHT-ANGLED TRIANGLES.

Base $= \sqrt{Hyp^2. - Perp^2.}$

" $= \sqrt{(Hyp. + Perp.) \times (Hyp. - Perp.)}$

Perpendicular $= \sqrt{Hyp.^2 - Base^2.}$

" $= \sqrt{(Hyp. + Base) \times (Hyp. - Base.)}$

Hypothenuse $= \sqrt{Base^2 + Perp^2.}$

What constitutes a car load (20,000 lbs. weight):

70 bbls. lime; 70 bbls. cement; 90 bbls. flour; 6 cords of hard wood; 7 cords of soft wood; 18 to 20 head of cattle; 9000 feet board measure of plank or joists; 17,000 feet siding; 13,000 feet of flooring; 40,000 shingles; 340 bushels of wheat; 360 bushels of corn; 680 bushels of oats; 360 bushels of Irish potatoes; 121 cu. ft. of granite; 133 cu. ft. sandstone; 6000 bricks; 6 perch rubble stone; 10 tons of coal; 10 tons of cast-iron pipes or special castings.

Lubricator, for slushing heavy gears:

10 gallons, or 3½ pails of tallow; 1 gallon, or ⅓ pail of Neat's foot-oil; 1 quart of black-lead. Melt the tallow, and as it cools, stir in the other ingredients.

For cleaning brass:

Use a mixture of one ounce of muriatic acid and one-half pint of water. Clean with a brush; dry with a piece of linen; and polish with fine wash leather and prepared hartshorn.

Iron cement, for repairing cracks in castings:

Mix ¼ lb. of flour of sulphur and ¼ lb. of powdered sal ammoniac with 25 lbs. of clean dry and fine iron-borings, then moisten to a paste with water and mix thoroughly.

Calk the cement into the joint from both sides until the crack is entirely filled. In heavy castings to be subjected to a great pressure of water, a groove may be cut along a transverse crack, on the side next the pressure, about one-quarter inch deep, with a chisel $\frac{3}{32}$-inch wide, to facilitate the calking in of the cement.

Alloys.—The chemical equivalents of copper, tin, zinc, and lead bear to each other the following proportions, according to *Rankine:*

Copper.	Tin.	Zinc.	Lead.
31.5	59.	32.5	103.5

When these metals are united in alloys their atomic proportions should be maintained in multiples of their respective proportional numbers; otherwise the mixture will lack uniformity and appear mottled in the fracture, and its irregular masses will differ in expansibiiity and elasticity, and tend to disintegration under the influence of heat and motion.

TABLE No. 29.

Materials.	Composition.			
	By Equivalents.		By Weight.	
	Copper.	Tin.	Copper.	Tin.
Very hard bronze	12	1	6.401	1
Hard bronze, for machinery bearings	14	1	6.966	1
Bronze or gun-metal, contracts $\frac{1}{180}$ in cooling	16	1	8.542	1
Bronze, somewhat softer	18	1	9.610	1
Soft bronze, for toothed wheels	20	1	10.678	1
	Copper.	Zinc.	Copper.	Zinc.
Malleable brass	4	1	3.877	1
Ordinary brass, contracts $\frac{1}{60}$ in cooling	2	1	1.938	1
Yellow metal, for sheathing ships	3	2	1.454	1
Spelter solder, for brazing copper and iron	4	3	1.292	1

Babbitt's metal consists of 50 parts of tin, 1 of copper, and 5 of antimony.

Aluminum bronze, containing 95 to 90 parts of copper and 5 to 10 parts of aluminum, is an alloy much stronger than common bronze, and has a tenacity of about 22.6 tons per square inch, while the tenacity of common bronze, or gun-metal, is but about 16 tons.

Manganese bronze is made by incorporating a small proportion of manganese with common bronze. This alloy can be cast, and also can be forged at a red-heat.

A specimen cast at the Royal Gun Factory, Woolwich, in 1876, showed an ultimate strength of 24.3 tons per square inch, an elastic limit of 14 tons, and an elongation of 8.75 per cent. The same quality forged had an ultimate resistance of 29 tons per square inch, an elastic limit of 12 tons, and an elongation of 31.8 per cent. A still harder forged specimen had an ultimate strength of 30.3 tons per square inch, elastic limit of 12 tons, and elongation of 20.75 per cent.

The tough alloy, introduced by Mr. M. P. Parsons, will prove a desirable substitute for the common bronze in hydraulic apparatus, where its superior strength and greater reliability will be especially valuable.

Approximate Bottom Velocities of flow in Channels at which the following Materials begin to Move.

2.5	feet	per	second,	microscopic sand and clay.
.50	"	"	"	fine sand.
1.00	"	"	"	coarse sand.
1.75	"	"	"	pea gravel.
3	"	"	"	smooth nut gravel.
4	"	"	"	1½-inch pebbles.
5	"	"	"	2-inch square brick-bats.

TABLE No. 30.

TENSILE STRENGTH OF CEMENTS AND CEMENT MORTARS, WHEN 7 DAYS OLD, 6 OF WHICH THE CEMENTS WERE IN WATER.

(Compiled from Gillmore.*)

How Mixed.	By Weight.			By Volume, Loosely Measur'd.			By Volume, well shaken.				
	Portland Cement } Weight 120 lbs.	Rosendale Cement.	Sand.	Portland Cement } Weight per U. S. bu., loosely measured, 120 lbs.	Rosendale Cement } Weight per U. S. bu., loosely measured, 56 lbs.	Sand.	Portland Cement.	Rosendale Cement.	Sand.	Tensile strength per square inch.	Crushing wt. per sq. in. } Blocks { 3.5 in. wide. 5.5 in. long. 3.0 in. thick.
										Lbs.	*Lbs.*
Like béton aggloméré	1	—	.25	1	—	.21	1	—	.25	377	—
" common mortar..	1	—	.25	"	—	"	"	—	"	239	—
" béton aggloméré.	1	—	.5	1	—	.42	1	—	.5	320	—
" common mortar..	1	—	.5	"	—	"	"	—	"	222	—
" béton aggloméré.	1	—	1	1	—	.85	1	—	.99	244	—
" common mortar..	1	—	1	"	—	"	"	—	"	197	—
" béton aggloméré.	1	—	1.33	1	—	1.13	1	—	1.3	179	—
" common mortar..	1	—	1.33	"	—	"	"	—	"	129	—
" béton aggloméré.	1	—	2	1	—	1.7	1	—	1.9	138	2804.4
" common mortar..	1	—	2	"	—	"	"	—	"	103	1038.0
" béton aggloméré.	1	—	6	1	—	5	1	—	5.9	66	259.5
" common mortar..	1	—	6	"	—	"	"	—	"	35	—
" béton aggloméré.	1	—	8	1	—	6.8	1	—	7.8	39	259.5
" common mortar..	1	—	8	"	—	"	"	—	"	24	104.7
" béton aggloméré.	1	8	—	1	—	11.6	—	—	—	96	—
" common mortar..	1	8	—	"	—	"	—	—	—	40	—
" béton aggloméré.	1	2	—	1	—	2.9	—	—	—	129	—
" common mortar..	1	2	—	"	—	"	—	—	—	41	—
" béton aggloméré.	—	1	1	—	—	—	—	—	—	51	—
" " "	—	1	2	—	1	1.2	—	1	1.4	40	310.7
" " "	—	1	3	—	1	1.8	—	1	2	33	116.4
" " "	—	1	4	—	1	2.4	—	1	2.8	22	156.0
" " "	—	1	6	—	1	3.6	—	1	4	Less than 10 lbs.	52.4
" " "	—	1	8	—	—	—	—	—	—	—	46.5
" " "	1	—	—	—	—	—	—	—	—	400	2846.7
" common mortar..	1	—	—	—	—	—	—	—	—	—	2579.2
" béton aggloméré.	—	1	—	—	—	—	—	—	—	72	727.3
" common mortar..	—	1	—	—	—	—	—	—	—	—	104.7

* *Vide* Treatise on Coignet Béton, p. 28, *et seq.* New York, 1871.

TABLE No. 31.

Standard Dimensions of Bolts, with Hexagonal Heads and Nuts.

Diameter of bolt in inches.	No. of V threads per in. of length.	Breadth of head. in inches.	Thickn'ss of head in inches.	Breadth of nut in inches.	Thickness of nut in inches.	Weight of round rod per foot in pounds.	Weight of head and nut in pounds.
1/4	20	3/8	1/4	3/8	5/16	.1653	.017
5/16	18	1/2	5/16	1/2	3/8	.2583	.033
3/8	16	5/8	3/8	5/8	7/16	.3720	.057
7/16	14	11/16	7/16	11/16	1/2	.5063	.087
1/2	13	3/4	1/2	3/4	9/16	.6613	.128
9/16	12	7/8	9/16	7/8	5/8	.8370	.190
5/8	11	1	5/8	1	11/16	1.033	.267
3/4	10	1 1/8	3/4	1 1/8	13/16	1.488	.43
7/8	9	1 3/8	7/8	1 3/8	15/16	2.025	.73
1	8	1 1/2	1	1 1/2	1 1/16	2.645	1.10
1 1/8	7	1 3/4	1 1/8	1 3/4	1 3/16	3.348	1.60
1 1/4	7	1 7/8	1 1/4	1 7/8	1 5/16	4.133	2.14
1 3/8	6	2 1/8	1 3/8	2 1/8	1 7/16	5.001	2.95
1 1/2	6	2 1/4	1 1/2	2 1/4	1 9/16	5.952	3.78
1 5/8	5 1/2	2 1/2	1 5/8	2 1/2	1 11/16	6.985	4.70
1 3/4	5	2 5/8	1 3/4	2 5/8	1 13/16	8.101	5.60
1 7/8	5	2 7/8	1 7/8	2 7/8	1 15/16	9.300	7.00
2	4 1/2	3	2	3	2 1/16	10.58	8.75
2 1/4	4 1/2	3 3/8	2 1/4	3 3/8	2 5/16	13.39	12.40
2 1/2	4	3 3/4	2 1/2	3 3/4	2 9/16	16.53	17.00
2 3/4	4	4 1/8	2 3/4	4 1/8	2 13/16	20.01	22.30
3	3 1/2	4 1/2	3	4 1/2	3 1/16	23.81	28.80

WEIGHTS OF LEAD AND TIN LINED SERVICE-PIPES.

Calibre.	AAA. Weight per ft.	AA Weight per ft.	A. Weight per ft.	B. Weight per ft.	C. Weight per ft.	D. Weight per ft.	D. Light. Weight per ft.	E. Weight per ft.	E. Light. Weight per ft.
Inches.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
⅜	1.5	1.3	1.12	1	1.06	0.62	—	0.5	—
½	3	2	1.75	1.25	1	0.81	—	0.7	0.56
⅝	3.5	2.75	2.5	2	1.75	1.5	1.25	1	0.75
¾	4.5	3.5	3	2.25	2	1.75	1.5	1.25	1
1	6	4.75	4	3.25	2.5	2	—	1.5	—
1¼	6.75	5.75	4.75	3.75	3	2.5	—	2	—
1½	9	8	6.25	5	4.25	3.5	—	3.25	—
2	10.75	9	7	6	5.25	4	—	—	—

A manufacturer's circular states that the following quantities of water will be delivered through 500 feet of their pipes, of the respective sizes named, when the fall is ten feet:

Calibre	⅜ inch.	½ inch.	⅝ inch.	¾ inch.	1 inch.	1¼ inch.
Gallons per minute...	.348	.798	1.416	2.222	4.600	6.944
Gallons per 24 hours..	576	1150	2040	3200	6624	10000

A ¾-inch clean service-pipe connected to a ½-inch tap under a hundred feet head, will deliver at the sink, through a common compression bib, ordinarily about three pails of water, or say 8.25 gallons, or 1.1 cu. ft. of water per minute.

Lead is more generally used for service-pipes than any other material, but wrought-iron pipe, lined and coated with cement, or with a vulcanized rubber composition or sundry coal-tar compositions and enamels, have been used to a nearly equal extent within a few years past. Block-tin pipe, tin-lined pipe, and galvanized iron pipe, have been used also to a limited extent.

Lead pipes of weights as in class A are used ordinarily when the head of water on them does not exceed 75 feet; class AA when the head is from 75 to 150 feet; and class AAA when the head, or strain from water-ram, is great.

The strain from water-ram, in service-pipes, is very much dependent on the character of the plumbing with which the services connect.

METERS AND METER RATES, 1875.

CITY.	No. of Meters used.	Rate per 100 cu. ft. Cents.	Kind of Meters.	Furnished by*
Boston, Mass.	974	22½	W.	Water-works.
Baltimore, Md.	320	20	W.	Water-works.
Bridgeport, Conn.	1	26½ to 40	W.	Water-works.
Charlestown, Mass.	180	22½	W.—B. & F.	Water-works.
Chicago, Ill.	1050	13⅛	W.	Water-works.
Cleveland, O.	18	13½ to 21½	W.—B. & F.	Water-works.
Columbus, O.	138	26½	B. & F.—E.—Nav.	Consumer.
Fitchburg, Mass.	25	11¼ to 37½	B. & F.	Consumer.
Fall River, "	4	22½	B. & F.	Consumer.
Hartford, Conn.	6	15 to 22½	B. & F.—D.	Water-works.
Jersey City, N. J.	208	26½	W.	Water-works.
Louisville, Ky.	119	20	W.	Water-works.
Meriden, Conn.	9	26½ to 40	B. & F.	Water-works.
Manchester, N. H.	160	15 to 30	B. & F.—N.	Water-works.
New York, N.Y.	200	12	W.	Consumer.
New London, Conn.	20	26½	N.	Water-works.
New Haven, "	3	22½	N.	Consumer.
New Bedford, Mass.	3	....	B. & F.	Water-works.
Providence, R. I.	1358	22½	B. & F.—W.	Consumer.
Portland, Me.	...	22½ to 37½	B. & F.—W.	Consumer.
Springfield, Mass.	8	22¼	W. & B. & F.	Water-works.
St. Paul, Minn.	40	40 to 64½	B. & F.—N.	Water-works.
San Francisco, Cal.	800	64½ to 133	W.	Water works.
Waterbury, Conn.	8	26½ to 40	W.—B. & F.	Water-works.
Worcester, Mass.	800	11¼ to 18¾	B. & F.	Water-works.

The initials refer to kinds of meters, as follows:

W.—Worthington.
B. & F.—Ball & Fitts.
N.—National Meter Co. (Gem.)
E.—Eagle.
Nav.—Navarro.
D.—Desper.

* A common practice is, for the water-works to furnish the meter and maintain and control it, and to charge the consumer from ten to fifteen per cent. on its original cost, annually, to cover the expense, in addition to the regular meter rate for water consumed.

RESUSCITATION FROM DEATH BY DROWNING.

"Persons may be restored from apparent death by drowning, if proper means are employed, sometimes when they have been under water, and are apparently dead, for fifteen or even thirty minutes. To this end—

1. Treat the patent INSTANTLY, on the spot, in the open air, freely exposing the face, neck, and chest to the breeze, except in severe weather.

2. Send with all speed for medical aid, and for articles of clothing, blankets, etc.

I. To Clear the Throat.

3. Place the patient gently on the face, with one wrist under the forehead.

(All fluids, and the tongue itself, then fall forwards, and leave the entrance into the windpipe free.

II. To Excite Respiration.

4. Turn the patient slightly on his side, and

(I.) Apply snuff, or other irritant, to the nostrils; and

(II.) Dash cold water on the face, previously rubbed briskly until it is warm.

If there be no success, lose no time, but

III. To Imitate Respiration.

5. Replace the patient on the face.

6. Turn the body gently but completely on the side, and a little beyond, and then on the face alternately, repeating these measures DELIBERATELY, EFFICIENTLY, and PERSEVERINGLY, fifteen times in the minute only.

(When the patient reposes on the chest, this cavity is compressed by the weight of the body, and EXPIRATION takes place; when it is turned on the side, this pressure is removed, and INSPIRATION occurs.)

7. When the prone position is resumed, make equable but efficient pressure along the spine, removing it immediately before rotation on the side.

(The first measure augments the EXPIRATION, and the second commences INSPIRATION.)

IV. To Induce Circulation and Warmth, continue these Measures.

8. Rub the limbs upwards, with FIRM PRESSURE and ENERGY, using handkerchiefs, etc.

9. Replace the patient's wet covering by such other covering as can be instantly procured, each bystander supplying a coat or a waistcoat. Meantime, and from time to time,

V. Again, to Excite Inspiration,

10. Let the surface of the body be slapped briskly with the hand; or

11. Let cold water be dashed briskly on the surface, previously rubbed dry and warm.

Avoid all rough usage. Never hold up the body by the feet. Do not roll the body on casks. Do not rub the body with salts or spirits. Do not inject smoke or infusion of tobacco, though clysters of spirits and water may be used.

The means employed should be persisted in for several hours, till there are signs of death."

FORMS

OF

PROPOSAL, SPECIFICATION, AND AGREEMENT,

FOR

PLAIN PIPES AND SPECIAL CASTINGS.

OCCASIONAL applications come to us for blank Forms of Proposal, Specifications and Agreement, for Pipes and Special Castings. We have therefore thought it advisable to have prepared, for the benefit of such inquirers, *forms* that combine the principal points of the standard blanks of the water departments of the large cities.

We trust that these forms, which we present, will be found to include the essential features of the best specifications, in concise language and in systematic arrangement.

We shall be pleased also if they prove suggestive and helpful in the gradual progress toward greater uniformity in the standards for pipes, in the different towns and cities, for this convergence toward uniformity, to be most fully beneficial to both founders and users of pipes, must be through the medium uniformity in specifications, and in designs.

PROPOSAL

FOR PIPES AND SPECIAL CASTINGS.

Made by.......................................

GENTLEMEN: We..................................
....
of the..
in response to your notification that proposals will be received on the...........day of................18....for certain plain pipes and special castings, to be delivered at
....
..................................between the respective days.....................18....and.....................
18....., have carefully examined your submitted schedule of quantities, dimensions and standard weights, and your specifications and form of agreement, and we do hereby propose and agree to enter into and complete an agreement with you in the form and manner indicated in your submitted blank, and to accept and bind ourselves to fulfil each and every of the stipulations therein set forth, and to

manufacture and deliver the pipes and special castings therein enumerated, referred to and described, and to accept in full payment therefor the following prices, which are to be inserted in the price blanks of said agreement, to wit: for all pipes and castings in

		Per ton of 2000 lbs.
Size.	*Weight per Pipe.*	$
"	"	$
"	"	$
"	"	$
"	"	$
"	"	$
"	"	$
"	"	$
"	"	$
"	"	$
Special Castings.		
"	"	$
"	"	$
"	"	$
"	"	$
"	"	$
"	"	$

And we do hereby agree to complete said agreement with you, in said form, within five days after due notice that our proposal is accepted, and we do agree to commence the said manufacture of said pipes and special castings, and to complete the same, and their delivery, according to the provisions of said agreement; provided our proposal shall be accepted.

We do hereby declare that, if the agreement shall be executed as herein proposed, no person other than ourselves, as contracting party, shall have interest in the contract without your approval, and no other party shall have illegitimate or fraudulent interest in, or receive any perquisites or commissions in consequence of, or growing out of said contract.

In witness whereof we have hereunto set our hands and seals this......... ..day of..............A.D. 18....

[SEAL.]

Signed and sealed in presence of }

CONTRACT AND SPECIFICATIONS

FOR FURNISHING

PLAIN PIPES AND SPECIAL CASTINGS.

[*Executed in Duplicate.*]

THIS AGREEMENT, made and concluded this.......... ....day of....................A.D. 18........by and between the....................of.......................... in the County of...............and State of............ by its duly authorized Board of ....of the first part, and.................... ....of the City of......................... ....Founders, of the second part;

WITNESSETH, That the said party of the second part in consideration of the payments, hereinafter mentioned, to be made to them by the said party of the first part, do........for.................and for............assigns, covenant, promise and agree to and with said party of the first part, that............the said party of the second part, shall and will at their own proper cost, manufacture according to the best art and ability of their trade, and according to the true intent and meaning of the specification herein contained, and deliver at...................... ....in the.............of ....in the State of............all the *plain pipes* and *special castings* enumerated in the schedule

herein contained, and does further agree that the said pipes and special castings shall conform fully and strictly with the drawings herein named, prepared to illustrate them, and with such additional detail drawings as shall be presented to further illustrate them, and with the directions to be given explanatory thereof, and be subject to the approval of the Chief Engineer of the said Board of..
and does further agree that said Board of..................
..............................shall be and are hereby authorized to appoint such competent person as they shall deem proper to inspect and test said pipes and special castings, and that they will grant to said engineer and to said inspector at all times during the manufacture of said pipes and castings such facilities, assistance, and test samples as shall be required for full and complete inspections and tests of materials, and to enable him or them to see that said pipes and special castings and their materials and processes correspond fully with the specification herein contained, forming a part of this agreement, and with said drawings and schedules, to wit:

PLAIN PIPES.

Nominal Internal Diameter.	Total Lineal Feet.	Thickness of Shell.	Depth of Hub.	Standard Weight, 12 feet per Pipe.	Approximate Total Gross Weight.
Inches.	*Feet.*	*Inches, decimal.*	*Inches.*	*Pounds.*	*Tons, of 2000 Pounds.*

SPECIFICATION.

Lengths and Forms of Plain Pipes.—The *plain pipes*, of the several diameters named, are to be at least twelve feet in length from the bottom of the hub to the end of the spigot, straight, truly cylindrical, uniform in thickness of shell as herein specified for their respective classes, from hub to spigot, and with interior and exterior surfaces concentric.

Special Castings Defined.—All pipe castings ordered to differ in length from the above specified length of plain pipes, or having additional projections, bends, or variations in diameters of shells from end to end, and all flanged castings, sleeves, caps, and plugs are termed *special castings*.

Strengths of Specials.—The special pipes, of the respective diameters and classes, are to conform in safe tensile resistance to pressure, with the plain pipes they are to join, being duly thickened at flattened parts, reverse curves, and at longitudinal sides of openings, and their thicknesses are to conform with the thicknesses of plain pipes of like respective classes as nearly as is consistent with their safe strengths.

Dimensions.—All plain and special castings are to conform accurately to the forms and dimensions figured upon the general and detail drawings above enumerated and referred to, and to the instructions of said engineer, explanatory thereof.

Changes in Specials.—The said engineer shall have power to change from time to time, as the exigencies of his work shall require, the forms and dimensions, and proportionally the standard weights of the special castings;

provided that when the cost of manufacture shall be increased by such change, said additional cost shall be certified to by said engineer, and allowed by the said party of the first part.

Metals.—The metals of the said castings shall be poured from remelted pigs of good gray iron, such as shall give uniform granulation, and produce tough castings of the most durable character, without undue brittleness, such as may be cut, drilled, and chipped with due ease, and having a tensile strength of not less than 16,000 pounds per square inch.

Character of Castings.—All plain pipes shall be cast in dry sand moulds or flasks placed vertically. All castings shall be sound and smooth, without cold-shuts, swells, lumps, scabs, blisters or sand holes, or other imperfections, and shall be without admixture of cinder, scoriæ or sand.

Cleaning and Protection.—All castings shall be thoroughly cleaned and prepared to receive their coatings without the use of acid or other liquid, and shall be protected from rain and excessive moisture until they are coated.

Joints.—The hub and spigots shall be smooth, and shall conform with sufficiently nice accuracy to the specified and figured dimensions, so that the spigots shall enter easily their full depths into the hubs without a surplus of joint room.

Lugs.—Lugs, of the forms and dimensions delineated, and in such numbers as said engineer shall direct, are to be cast on the ends of those branches, bends, and reducers indicated to receive them in the above schedules.

Limits of Variations.—No payment shall be made for more than five per cent. excess of weight above the specified standards, for pipes less than twelve inch, or more than four per cent. excess of weight above the specified standards for pipes twelve or more inches diameter.

No variation of thickness of the shell over one-eighth of an inch for pipe under twelve inches, and three-sixteenths above that size, will be permitted.

Marks.—Each pipe casting shall have raised upon it the name or initials of its maker, and, if required, figures indicating the year in which it is cast, its class letter, and its arithmetical number in its respective class and of its respective diameter.

The letters and figures shall be cast upon the outside, uniformly in such relative positions as said engineer or inspector shall designate. The letters and figures shall have not less than one and one-half inches length or one-eighth inch relief.

Test Samples.—The founders shall at any time when pouring the metal of the said castings, upon his request, supply the said inspector with test samples of the metal from the ladle, in such mould as he shall present, which samples, if to be removed, shall be weighed and paid for at the lowest special casting rate.

Inspection before Coating.—The said inspector shall be duly notified by said party of the second part, when the process preparatory to the immediate coating of any of the castings is to commence, and each and every of the said castings shall be subject to the examination and approval of said inspector before the process of coating shall be commenced.

Each and every casting shall be free from surface defects and from rust, when placed in the bath.

Coating Materials.—The materials of the *coal-pitch varnish,* to be used in coating the said castings, shall consist of a good and suitable coal-pitch, of about the consistency of tar, deodorized, and freed from its naphtha and volatile constituents, and an approved fixed oil derived from coal-pitch, or linseed oil, in such proportions as shall make a firm and tenacious coating.

Coatings.—The materials, qualities, and proportions of the said coal-pitch varnish, the temperature of the bath at times of immersion and withdrawal of said castings, and the temperature of each of the said castings at time of immersion shall be subject to the approval of said inspector.

After removal from the bath the said castings shall be so dripped as to leave a coating of uniform thickness, without retained puddles or pendant drops of varnish.

The said varnish coating, when cool, shall be smooth, tough, without undue brittleness, tenaciously attached to the castings, and not liable to abrasion with ordinary handling. The said varnish materials in the bath shall be replenished and renewed in due proportions, as often as shall be necessary to produce on each casting a coating such as is above specified.

Imperfect Coatings.—An imperfect and unapproved coating shall not be covered, and shall not be replaced until it has been so fully removed that a new coating shall attach itself tenaciously to the pipe.

Weights.—The weights of pipes, on which payments are based, shall be made after the pipes are coated.

Weighing and Testing.—The said party of the second part shall provide at their own cost in their foundry-yard, an accurate sealed weighing scale, and shall weigh said castings in the presence of, and under the direction of said inspector, and shall plainly mark the weight of each casting upon it with white lead and oil paint; and they shall also provide in their foundry-yard a hydraulic proof-press with accurate attached pressure gauge, and shall test each straight pipe in the presence of and under the direction of said inspector, under a hydraulic pressure of 300 pounds per square inch; or in the case of large castings such given less pressure as said engineer shall designate; and they shall also give said inspector full opportunity and facility to test each straight pipe while under full proof pressure, by hammer test; and they shall also provide without charge such assistance and facilities as said inspector shall require for the testing of the said castings by templets, gauges, and calipers.

Unapproved Castings.—No casting rejected by said inspector at the foundry shall be forwarded; but the right of appeal, by said party of the second part, to said engineer shall exist, and any rejected casting when made satisfactory to said engineer, and approved by him, may be forwarded.

The standard *ton*, in all transactions under this agreement, shall equal 2000 pounds "avoirdupois."

Delivery.—The delivery, by the said party of the second part to the said party of the first part, of the pipes and special castings herein contracted for, at said .... in the ....
......shall commence on or before the .... day of..................A.D. 18....and shall be continued with regularity in about equal monthly quantities; until the entire quantity and respective kinds herein described and referred to shall have been delivered, and the entire quantity shall have been delivered on the ....day of

..................A.D. 18....or within..................
days next previous to said........................day of
....

Order of Delivery.—The pipes and special castings herein contracted for shall be cast, completed, and delivered in the order that said chief engineer shall designate in a written memorandum of instructions.

Contract Untransferable.—The said party of the second part shall not sublet, assign or transfer this contract, or any considerable part thereof, to any other person or persons, without the consent of the said Board of.........
..............................endorsed hereon.

Increase or Decrease of Quantities.—The said Board of..........................reserve the right, and they hereby are confirmed in the right to increase or diminish the total number of pipes or castings named in the schedules herein inserted, or of any individual class of said pipes or castings not exceeding twenty per cent., without vitiating or changing in effect any other provision of this contract. Provided however, that any reduction or increase in any class of plain pipes or special castings desired by the said Board of..............................shall be signified in writing to the said party of the second part, before the manufacture of the pipes or castings of said class, to be delivered, is finished.

Prices.—In consideration of the faithful manufacture and delivery of these said pipes and special castings herein referred to, described, and enumerated, and in consideration of the true and faithful performance and fulfillment of each and every of the provisious of this agreement and specification, the said party of the first part hereby agree to pay to the said party of the second part in good and lawful money of the United States, and the said party of the second part agrees to receive as full compensation for all said pipes and special castings as follows:

Pipes.	*Sizes.*	Per 2240 lbs. $

Branches, Reducers, Caps and Plugs.

Bends and Angle Pieces.

Payments.—And it is hereby further agreed that the said engineer shall, on or before the tenth day of each month, during the delivery of said pipes and castings, make an estimate of the value, according to the prices stated herein, of the pipes and castings delivered and accepted, and that ninety per cent. of the amount of said estimate shall be due, and payable as a partial payment, within five days thereafter by the said party of the first part to the said party of the second part; and also that within twenty days after the full completion of this contract by the said party of the second part, the said engineer shall make a final and complete estimate of all the pipes and castings delivered and accepted under this agreement, and the balance remaining due shall be paid by the said party of the first part to the said party of the second part.

Annulment of Contract.—And it is hereby further agreed that if the said party of the second part shall fail to deliver the said pipes and castings in conformity with the provision of this agreement and specification, or shall not deliver them in the full proportional monthly quantities above specified; and after due notification and remonstrance, in writing, from said engineer shall still fail to conform with the provisions of this agreement and specification, then the said Board of........................as agents of the said party of the first part, may, at their discretion, by due notice served on the said party of the second part, at once suspend the execution of this agreement, and annul the same; and may proceed at once to contract with any other party for the whole or any part or parts of pipes or castings herein enumerated, and remaining undelivered; and such suspension and annulment of this agreement by the said Board of.................................. shall not vitiate or affect the right of said party of the first part to recover any damage arising from the failure of the said party of the second part to fulfill this agreement.

In witness whereof, the said party of the first part by its duly authorized agents, the Board of.................. ....and the said party of the second part, have hereunto set their signatures on this, the day and year first above written.

Board of

Contractor

Signed in the presence of