# WATER

AND

# GAS WORKS APPLIANCES

AND

# PUMPING MACHINERY

# R. D. WOOD & CO.

**PHILADELPHIA** 

ESTABLISHED 1803.

Foundries and Works: Millville, N. J.

Florence, N. J.

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CONSTRUCTORS OF

## GAS AND WATER WORKS

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# NOTICE

We refer to your particular attention, in this volume, the following subjects:

| Commercial Value of Diameters   |              |
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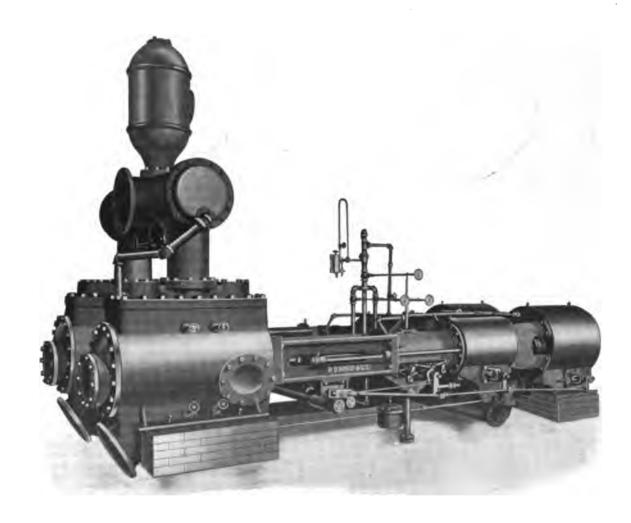
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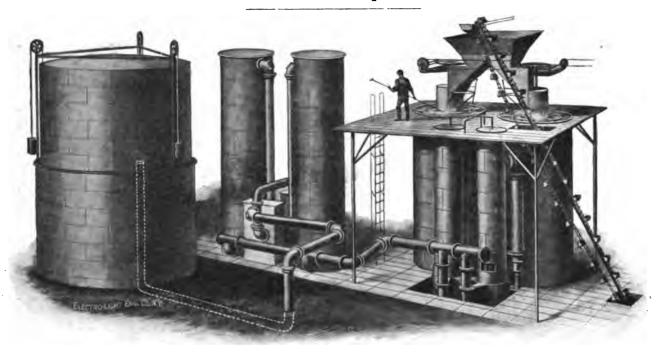
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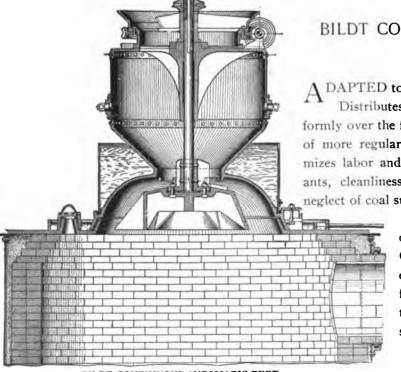
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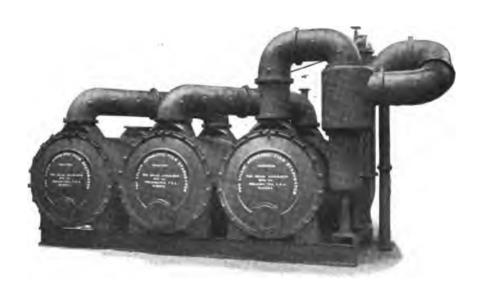
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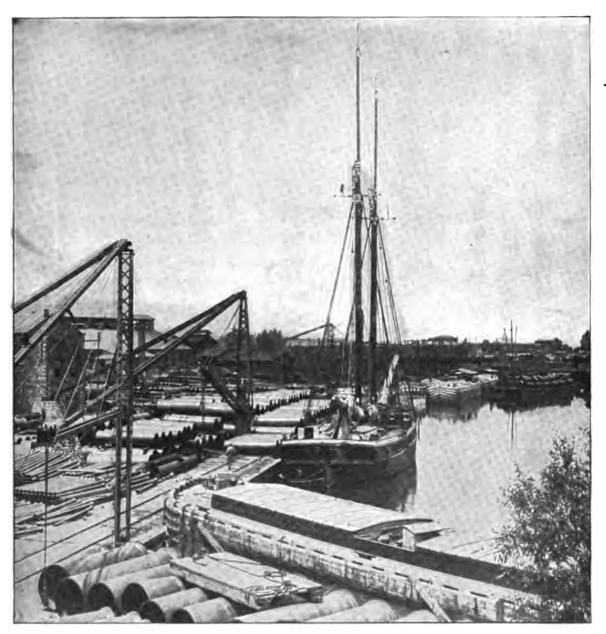
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(Send for Hydraulic Tool Catalogue.)

THE CAMDEN IRON WORKS.

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### WATER AND GAS WORKS APPLIANCES.

THE pamphlets descriptive of "Water and Gas Works Appliances," heretofore issued by us, have been so steadily in demand as to indicate that they have in some measure supplied a want. In this revised and enlarged edition we have aimed in a general way to outline various systems of water supply and kinds of illuminating gas, with the appliances, more especially those made by us, used in connection therewith. The book is in no sense a treatise; but is intended to answer some of the questions often asked of us by persons contemplating the building of new Water and Gas Works. We trust it may not only be of interest to such, but also of assistance to those in charge of established plants, and facilitate the laying out of work, the making of inquiries and the placing of orders. We include certain tables with text explanatory thereof as used in previous editions, which were selected from Fanning's "AmericanWater Supply Engineering" through the courtesy of the publishers.

Our extensive foundries and works at Millville, Florence and Camden, New Jersey, are supplied with the most approved appliances for the manufacture of Cast Iron Pipe of all kinds and sizes, affording a large annual capacity, enabling us to handle successfully the largest contracts; in addition to which we have large facilities for the manufacture of the Mathews' Fire Hydrants and Eddy Valves, the building of Stand Pipes, Tanks and Towers, Turbines and other specialties, including Gas Holders and Gas Apparatus as herein mentioned. The locations of our works admit of shipping via rail or water; and at our disposal are several vessels adapted to the carrying of pipe cargoes.

During recent years, our lines of Producer Gas Apparatus, including the Taylor Gas Producer, and of Hydraulic Tools and Machinery, have grown so much that they require separate pamphlets, which will be furnished upon application.

Since the publication of the edition of 1896 (now exhausted) we have extended our business to the manufacture of Steam Pumping Engines and Centrifugal Pumps. This necessitated the addition of considerable new matter which, together with the revisions and additions to the subjects dealt with in former editions, has greatly augmented this edition of 1901.

R. D. WOOD & CO.

Philadelphia, August, 1901.



#### MANUFACTURERS OF

## CAST IRON PIPE

1" TO 72" DIAMETER.



EIGHT LINES OF 48" CAST IRON PIPE.\*

<sup>\*</sup>From "Water Supply of City of New York," John Wiley & Sons, N.Y.

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### WATER SUPPLY.

THERE is nothing more essential to man than an abundant and permanent supply of pure water, and the facilities afforded to meet this want are an index of the intelligence and thrift of a community. In all that constitutes the social economy, water is an ever-pressing factor—in the home, office, workshop and manufactory, for fire protection and other general uses; its influence, in short, is exerted in almost everything that affects human life and health. A commodity of such vital importance demands most earnest and careful study on the part of those interested in the construction or maintenance of a Public Water Supply; and while we are ready, as far as may be, to reply to all inquiries bearing upon Water Works Appliances and their adaptation and maintenance under varying conditions, we cannot too earnestly urge that the outlining and construction of Water Works be directed by a competent Hydraulic Engineer. No matter how interested one may be to build correctly, or how earnestly personal application is brought to bear upon the problems at issue, it cannot be expected that the principles involved in the design and construction of an efficient Water Supply can be grasped intuitively. They are, rather, secured only as the result of years of study and experience.

We venture, however, to briefly outline various methods or "systems" usually adopted. As before stated, pure water is one of the first essentials, requiring a most careful examination of the various sources of supply and the intelligent consideration of their comparative adaptability.

Purity.—None of the waters of nature are strictly pure; and though some impurities are really beneficial, others often present are not to be tolerated. To say nothing of the possible effect of such impurities upon the public health, the mere suspicion that the water is foul or unwholesome, even though entirely unwarranted, may prove a serious financial disadvantage. Cautious financial expenditure will avoid opposition to inflexible sanitary laws. Chemical science and microscopy are valuable aids in the search for impurities; and as essential to a proper interpretation of its chemical analysis, all contaminating influences should be sought out. For sanitary purposes a chemical examination of potable waters for solids, chlorine and free and albuminoid ammonia generally suffices, but it is better to supplement this by physical tests. To those unfamiliar with their significance the quantities worthy of note are seemingly trivial. To the solids, as such, not over 40 grains per gallon will raise no objection to a supply. 5 to 10 grains of chlorine will excite suspicion and promote further inquiry, especially if conditions point to possible sewage contamination. Absence of chlorine, while indicative of freedom from sewage, is not evidence of general organic purity. However, not more than 1 grain per gallon favors vegetable rather than animal contamination.

Free and albuminoid ammonia indicate organic impurities. The albuminoid ammonia is that arising in analysis from action of chemicals upon the organic matter present, ammonia resulting. .05 or .10 parts of albuminoid ammonia per million of water need not cause alarm. Much free ammonia and .05 of albuminoid, or over .10 of the latter will arouse suspicion, while .15 parts of albuminoid per million will positively condemn it. Metals should not be present in good potable water to more than  $\frac{1}{10}$  to  $\frac{2}{10}$  grains of iron, and less than  $\frac{1}{10}$  grain of lead or copper per gallon. Dependent upon the character of the impregnations and suspended impurities, filtration, subsidation or perhaps aëration may be necessary. Predictions of any value as

to the quantity and quality of water from proposed artesian or driven wells demand a knowledge of local geology and subterranean hydrology, rarely obtainable until the completion and test of the wells.

To obtain the permanent supply, it is necessary to impound and store the rainfall or flow of streams; to draw from a natural lake or river; or from artesian or driven wells. The delivery may be by gravity; pumping to reservoir; pumping to stand pipe or elevated tank; or by pumping direct; these various "systems" being so classed. Local conditions should determine the method employed.

Gravity.—Of the various so-called "systems" for delivering water, that most to be preferred is by *Gravity*, if a permanent and abundant supply at a sufficient elevation is obtainable, as it insures a minimum expenditure for operation and maintenance. A gravity plant usually includes facilities for storage in artificial or natural basins at an elevation which will maintain the required pressure at the point of consumption.

Pumping to Reservoir.—This method of delivery is placed second and contemplates raising the supply to a reservoir at a suitable elevation, from which it flows by gravity into the distribution pipes. Duplicate pumping machinery should be installed to guard against possible failures, and the importance of a large storage capacity is obvious.

Pumping to Stand Pipe.—Where no elevated ground is available upon which to locate a reservoir, a comparatively uniform pressure for ordinary requirements may be secured by pumping to a stand pipe or elevated tank. In case of fire, increased pumping capacity should be instantly available to maintain the elevated supply, and resultant pressure upon the mains.

Pumping Direct is the most artificial, and consequently least to be desired of these "systems." It contemplates pumping the supply directly into the mains under pressure, and among the advantages claimed are, that in the event of fire, the pumps may almost instantly double or treble the pressure (thereby increasing the discharging capacity of all fire hydrants); a saving in outlays for reservoirs or stand pipes, as well as smaller outlay and cost of maintenance for fire apparatus; and the use of fire engines is generally obviated. Against these advantages are an increased outlay for heavier pipe to withstand the greater pressure; increased cost of maintenance; increased outlay for plumbing or pressure regulators to consumers; and the fact that fire protection is entirely dependent on pumps, which in turn must be heavy (and comparatively costly) to meet the excessive and varying requirements.

Water-Power Pumps are especially desirable where sufficient water power to drive turbines is available, as their joint use insures the least possible cost for pumping. *Power pumps, driven by gas engines operated with producer gas* (see page 147), are often a desirable combination.

Mains.—The actual consumption of water for fire purposes in any city per annum, is very insignificant when compared with either the domestic, the irrigation and street sprinkling, or the supplies for manufactories, for the same limit of time. Yet the pipe capacity required for fire service in the distribution mains of a small city exceeds that required for all other purposes. In addition to this, as the city grows, extensions naturally follow; hence the importance of selecting pipes of ample diameter to insure an effective fire protection, and admit of reasonable extensions.

If we examine this question closely, taking for example a length of 1200 feet of distribution pipe in a compactly built-up section of the city, we find, say 40 domestic service-pipes, and a consumption of about 375 gallons each per day, or a total of 15,000 gallons. Making due allowance for 50 per cent. increase of flow at certain hours, we would have a required delivery capacity of 15,1% gallons per minute to cover this whole consumption. On the same 1200 feet of pipe there are say 4 fire hydrants; if, in case of fire, we take from these hydrants only 4 streams in all, of 150 gallons per minute each, we would require a delivery of 600 gallons per minute. In this case, which is not uncommon, the required capacity for the fire service is to that for the remaining service, as 600 to 1510. If the given pipe, 1200 feet long, is six inches in diameter, supplied at both ends, then the delivery for fire at each end is 300 gallons per minute. Referring to the table of frictional heads, on page 30, we find that this quantity requires a velocity of flow of 3.40 feet per second, and consumes head, in friction, at the rate of 8.52 feet per thousand feet. If the 600 gallons per minute must all come from one end, then the pipe should be eight inches diameter, in which case the velocity will be nearly 3.83 feet per second, and the head consumed at the rate of about 8.03 feet per thousand feet of length.

Fire Protection (Capacity and location of hydrants).—Another matter of importance is to select good non-freezing fire hydrants of ample size, and to see to it that they are properly located in sufficiently close proximity. The first cost of hydrants and their maintenance is trifling compared with the greatly increased fire protection. Shorter lengths of hose not only give more efficient fire streams, due to the lessened frictional resistance, but the risk of failure in fire lines is reduced, and the smaller expenditures for new fire hose, result in a material decrease in Fire Department maintenance charges.

Economic Influence of Water Works on Insurance Premiums.—A schedule of standard rates of insurance and deficiency charges, as usually adopted, 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 per \$100 insurance.

TABLE No. 1.

Approximate Deficiency Charges Affecting Insurance Premiums.

| ADD PER \$100.00 INSURANCE      |  |  |  |              |                               |  |  |  |         |  |  |  |  |
|---------------------------------|--|--|--|--------------|-------------------------------|--|--|--|---------|--|--|--|--|
| If no water supply              |  |  |  | 15 cents.    | If no hook and ladder trucks  |  |  |  | 5 cents |  |  |  |  |
| If only cisterns, or equivalent |  |  |  | 10 "         | If no fire patrol             |  |  |  | 5 "     |  |  |  |  |
| If system is other than gravity |  |  |  | 5 <b>'</b> ' | If no fire alarm telegraph .  |  |  |  | 5 ''    |  |  |  |  |
| If no fire department           |  |  |  | 25 "         | If no police department .     |  |  |  | 5 "     |  |  |  |  |
| If no volunteer department      |  |  |  | 10 "         | If no paved streets           |  |  |  | 5 ''    |  |  |  |  |
| If no steam fire engines .      |  |  |  | 5 "          | If no building law in force . |  |  |  | 5 "     |  |  |  |  |

Variations up to 25 per cent. are made, depending on location.



Approximate Consumption of Water.—In American cities, having well-arranged and maintained systems of water supply, the average consumption is found to be approximately as follows, in United States gallons:

(a.) For ordinary domestic service, 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 dryest four months of the year. To offset this in winter, it is well to assume

(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.

(A.) 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 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.

Laying Depth.—The depth to which pipe should be placed in the ground to avoid injury from traffic or frost is dependent on local conditions. Water Works are now so numerous that the practice at several neighboring plants will usually serve as a guide. In different latitudes the depths adopted naturally vary, and are dependent, more or less, on the character of the ground, whether hard or soft; the extent to which it may become saturated by surface waters, and whether the location be much exposed to wind and weather.

Water expands in freezing about  $\frac{1}{12}$  of its bulk, in the ratio of from 1000 to 1086, or 8.55 per cent., and when rigidly confined it is estimated that the expansive force approximates 30,000 pounds per square inch. If the ice in forming is not free to expand longitudinally with the pipe, the resultant pressure would approximate 10,000 pounds per square inch. These figures will serve to emphasize the importance of laying water mains sufficiently deep, or otherwise protecting the pipe against the action of frost. Experience has demonstrated that a "dead air" space is one of the best preventives of frost, and hence it is that a water main laid in a rock-cut trench and covered with broken stone is less liable to freeze than when laid in compact soil.

"Dead ends" should be avoided and circulation maintained for protection against frost, and to prevent the injurious influence of stagnation upon the water.

Service-Pipe.—Connections for conducting water from the street main to the consumers and through buildings are termed service-pipe. For such, lead is the material more generally used than any other, though plain wrought iron pipe, and galvanized iron are employed extensively. Tin-lined lead, tin or lead-lined iron, and cast iron pipe, are also used in many instances and localities.\*

Much interest has been manifested as to the kind of material that should be used for these pipes, especially when water is intended for domestic purposes. With regard to the effect of lead pipe upon water, a large amount of medical and scientific evidence has been produced, a

\*We especially call attention to our line of small diameter (1" to 2½") cast iron bell and spigot pipes (see table page 35), as desirable for use in carrying connections under yards, lawns and for like purposes. They are also used to advantage for connections from mains to curbs, and being of cast iron, they are not nearly so liable to rust out as wrought iron or even galvanized iron piping.



summary of which indicates that soft water acts rapidly and to a dangerous extent upon lead; that wherever water contains lime, soda, potash or other mineral salts, it deposits a crust of that salt on the surface of the lead in the form of an *insoluble carbonate*, and protects its surface from the chemical action that occurs when the water is pure. Generally speaking, the purer the water the greater the danger from lead poison. Where a service of this material is in use, and when water has remained long in the pipe, it should be drawn off sufficiently to thoroughly renew it before any is taken for domestic use; this caution should be particularly observed in the case of a new service. Wauklyn states there can be little doubt that dangerous consequences may be looked for from so small a proportion as  $\frac{1}{10}$  of a grain of lead per gallon of drinking water.

Plain wrought iron service-pipe has the advantage over all others in point of economy of first cost, and in some localities proves quite satisfactory in service. The chief objection to its use is the oxidation of the interior surface, thereby impregnating the water with iron. The acids contained in some waters act in this manner to such an extent as to render a supply through a long service of this material unfit for culinary and laundry purposes. The earth, too, in some localities, also contains acids which are very destructive to this class of pipe. Wrought iron cannot be coated by the process used for the protection of cast mains, as the varnish absorbed by the crystalline nature of the latter scales off when applied to the fibrous surface of the former.

Galvanizing iron pipe protects them in some measure from the corrosion that takes place in plain iron. In the coating of zinc that is applied to the surface, imperfections will be found; at these points, also where the coating is broken by tools of the pipe-fitter, corrosion will take place and destroy the pipe as though it were of plain iron. In fact, the coating once broken, it is not improbable that electrolytic action promotes this corrosive destruction. Galvanizing, however, for a time prevents contact of the water with the iron, thus removing one of the principal objections to wrought iron pipe. Zinc is not entirely free from the action of the acids found in some waters, though such action is very much less liable to occur than in the case of lead. Galvanized pipe has been used, however, and is giving satisfaction, where plain iron and lead pipe had to be abandoned for the reason before stated.

Tin-lined lead pipe consists of lead pipe with a lining of block-tin about  $\frac{1}{82}$  of an inch in thickness. This pipe is more expensive than ordinary lead piping, but has particular merit for the reason that pure tin resists the acids likely to be found in any water supply. On account of the melting point of tin being considerably lower than that of lead, care is necessary in making joints to prevent the tin being disturbed. An English authority recommends the use of cadmium in the solder, rendering it fusible at a much lower temperature and thus preventing the melting away of the tin lining.

Service-Pipe Connections.—Connections between service-pipe and street mains are usually made with a "corporation cock"; this is a brass stop-cock, threaded for screwing in a hole drilled and threaded in the cast main, and fitted with a union joint to connect with the service-pipe. The drilling, tapping and insertion is performed without loss of water by means of tapping machines designed for this purpose. Where a rigid service-pipe is to be joined, the connection should be made by using a short piece of lead pipe, as its flexibility allows the adjustment of the service in the trench without undue strain.

Either at the curb or building line of streets, it is usual to place a second stop-cock in the service-pipe, and inclose the same with a box, thus making the turning on and shutting off of the water accessible to the proper person.

Tests for Pure Water.—The New Jersey State Board of Health has issued the following directions for making simple tests of the purity of drinking-water:

COLOR.—Fill a clean, long bottle made of colorless glass with the water; look through the water at some black object; the water should appear perfectly colorless and free from suspended matter. A muddy or turbid appearance indicates the presence of soluble organic matter or solid matter in suspension.

Odor.—Empty out some of the water, leaving the bottle half full; cork up the bottle and place it for a few hours in a warm place; shake up the water, remove the cork and critically smell the air contained in the bottle. If it has any smell, and especially if the odor is in the least repulsive, the water should be rejected for domestic use. By heating the water to boiling, an odor is evolved sometimes that otherwise does not appear.

TASTE.—Water fresh from the well is usually tasteless, even though it may contain some putrescible organic matter. Water for domestic use should be perfectly tasteless, and remain so even after it has been warmed, since warming often develops a taste in water which is tasteless when cold. If the water at any time has a repulsive or even disagreeable taste, it should be rejected.

As some waters of dangerous quality fail to indicate their impurity either by smell or taste, what is known as the Heisch test is of value: Fill a clean pint bottle three-quarters full with the water to be tested; add to it a half-teaspoonful of clean granulated or crushed loaf sugar; stop the bottle with a glass stopper or a clean cork, and let the bottle stand in the light in a moderately warm room. If in 24 or 48 hours the water becomes cloudy or milky, it is unfit for domestic use. While cloudiness in the water after standing certainly indicates unfitness for use, yet a negative result does not prove the water to be good; because the test often fails to indicate organic matter really present, if phosphates are absent.



HYDRAULIC QUICK-ACTING PUNCH.

## CAST IRON PIPE.

A CCORDING to Crecy,\* cast iron pipe were first generally adopted in London about the close of the last century. The great fire in that city destroyed many of the lead mains, which were in part replaced by wooden pipe; but as the service increased and more pressure was demanded, the renewals were wholly of iron.

The earliest cast iron pipe were 2½ feet in length, with flanged joints and leather gaskets, bolted together. Then followed somewhat longer pipe with screw joints, from which trouble resulted, as the rigidity of the joints prevented expansion and contraction. Cylindrical socket-joints were the next development. These were accurately turned to a slightly conical form, and being luted with a little whiting and tallow were driven together. The lengths of the pipe were subsequently increased to nine feet, and the hub, or bell and spigot joint formed, adapted first to a packing of pine wedges, and later to a packing of lead. The bell and spigot joint, with various slight modifications, continues to be generally used both in this country and abroad, though the turned joint has not been entirely superseded in European practice.

The pine-log water pipes of Philadelphia were generally replaced as early as about 1819; and the joints adopted for the then new cast iron mains did not differ materially from the bell and spigot form now used, though the depth of the bell is somewhat less in present practice. In a caulked joint, the lead will usually have a set of from 1 to 1½ inches, beyond which any increased depth of lead joint is of questionable value; and there is no advantage in giving the hemp packing an excessive depth.

Substitutes for Cast Iron Pipe.—It should be borne in mind that cast iron pipe are by far the most durable and reliable made for underground service, and that nothing but cast iron pipe are used in the larger cities, such as Boston, New York, Philadelphia, etc., as well as in the greater number of cities and towns of the country, while many of the smaller towns which have used substitutes have found it necessary to replace them in recent years with cast iron piping.

Experience in the operating of water works has long since demonstrated how utterly unreliable are Kalamein, cement and other substitutes for cast iron pipe. Years ago their then comparatively low cost induced many works to adopt them; but the fact that such works have almost universally replaced with cast iron these cheaper and inferior classes of piping should serve to discourage and forbid their further use.

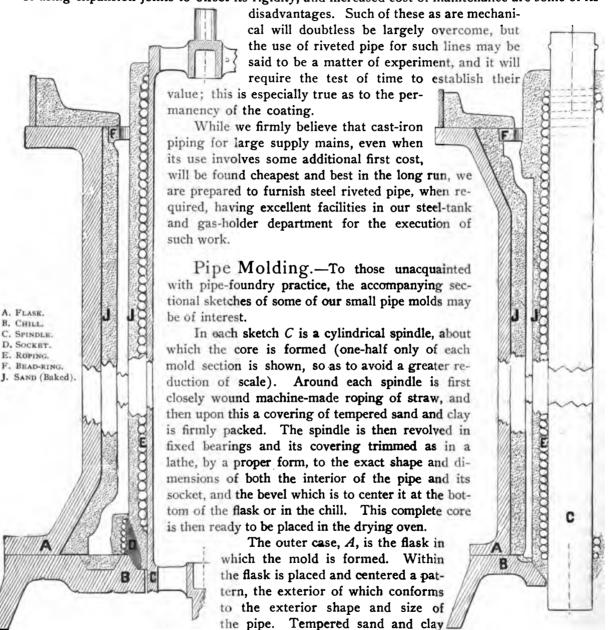
Aside from this, the low cost cast iron piping has reached within recent years has removed the principal reason advanced for the use of such substitutes. The best is always the cheapest when considering a public water supply; and, as stated above, in the larger cities and towns throughout the country cast iron piping only is used for the distribution of water. This recognized merit of cast iron piping, when compared with cheaper and inferior substitutes, will be found to materially appreciate the value of the securities covering a water works plant. If the character and protection which are afforded by an efficient water supply are solely considered, there is no valid reason for the use of other than cast iron piping.

Steel Riveted Pipe.—Within recent years the low cost of steel plates has induced some engineers to use as a substitute for their larger cast iron supply mains, steel riveted pipe, to which nearly, if not all, of the disadvantages attaching to the use of Kalamein piping apply



<sup>\*</sup> Encyclopedia of Civil Engineering, p. 549, London, 1865.

with equal force. Its lack of stability, tendency to corrode, liability to pull apart during cold weather, the difficulty of securing tight joints in riveting up the work in the field, the necessity of using expansion joints to offset its rigidity, and increased cost of maintenance are some of its



are then rammed around the pattern to form the mold, 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 mold and dried.

When these several parts are dried and combined for casting the pipe, as they are shown in the sketches, the core is accurately centered by the bevel at the bottom and bead-ring at the top, and the space between mold and core will then conform accurately to the desired shape and dimensions of the pipe. The tempering of the sand and drying of the mold, so as to withstand the trying action of the molten metals, are matters that require the utmost care to insure perfect castings. The flasks are finally placed on end in the pit, preparatory to pouring, so as to secure a solid casting, cylindrical in bore, and of uniform thickness upon all sides.

The molten metal is then drawn from the cupola into the ladle, and transferred within reach of the pit crane, by means of which it is lifted and poured. After several pipe have been thus cast, the emptied ladle is returned to its truck, and the crane used to quickly lift out the cores, the hay-rope covering having meanwhile been burned away, admitting of their easy withdrawal; and the pipe are thus allowed to contract freely in cooling. As soon as properly cooled the flasks and pipe are together lifted from the pit, when the clamps which have served to hold the sections of the flasks together are removed, and the pipe permitted to pass on to the cleaning skids. Here all adhering sand is removed, and the pipe freed from fins or other irregularities of outline preparatory to inspection and coating. Single flasks are used for pipe of the smaller diameters, while in modern practice, double and sometimes triple flasks are used for pipe of the smaller diameters.

Inspection.—All pipe made by us are carefully inspected at our foundries before coating or testing in the press. While no shipments are made without such inspection, we are ready to afford at all times proper facilities to inspectors sent to our foundries by the purchasers of our pipe.

Coating.—In order to protect water pipe from corrosion and prevent deposits upon the interior walls it is necessary to coat them. In the early days of cast iron piping it was found that tuberculous accretions formed so freely as to seriously diminish the volume of the flow through uncoated pipe, especially those of small diameters. This trouble resulted in experiments on the part of engineers and others, having in view the selection of a suitable coating, and this seems to have been found in Dr. Angus Smith's process, which was first introduced in Glasgow about the year 1850, and consists of a coal-pitch varnish distilled from coal-tar until the naphtha is entirely removed and the material deodorized, to which is added an approved oil in such proportion as to make a firm and tenacious coating.

The pipe and special castings are thoroughly cleaned and prepared to receive their coating without the use of acid or other liquid, and are protected from rain or excessive moisture until coated. It is usual to heat the castings in a retort or oven to a temperature of about 310° F., and then immerse them in a bath of this coating, which is maintained at a temperature of not less than 210°. This coating also gives the interior of the pipe a smooth, enameled finish, which reduces the friction of the current to a minimum.

Testing.—After the pipe are coated they are placed in a proving press, where they are subjected to a water-pressure test of 300 pounds per square inch, and carefully examined while under pressure. This test is only applied to straight pipe of regular lengths, for which the proving press is adapted. It is not practicable to place special castings under a water-pressure test without a very considerable extra expense; hence it is usual to submit such castings only to a careful hammer inspection.



Thickness of Cast Iron Pipe.—A certain thickness of shell is required for each diameter of pipe to insure a perfect filling of the mold before the metal chills or cools, and also to enable the pipe to be safely handled, transported, laid and tapped. In the smaller sizes this thickness is greater than that ordinarily required to sustain the static pressure of the water.

The necessary additional thickness, beyond that required to resist the water pressure, decreases as the diameter of the pipe increases. There must, therefore, be affixed to the formula for thickness of cast iron pipe a term expressing the additional thickness required to be given to the pipe beyond that necessary to resist the pressure of the water, and this term must decrease in value as the diameter increases in value.

It is, however, unwise to take this additional thickness at too low a standard, as the danger of transportation is great and pipe are bulky and heavy, so that as they are frequently handled without much care, and with the impression that, as they are of iron, it can be done with impunity; they often suffer heavy blows from sudden stoppages, and their own weight is the measure of the force of this concussion, as if a foreign body of the same weight had struck them with equal force; this shock, which comes simply from its own weight, when a pipe, as is often the case, weighs one, two, three or more thousands of pounds, is no small matter. Were the casting to receive an equal blow from an outside source no surprise would be expressed at the result, as considerable damage would naturally be expected from the striking force of several thousand pounds, even if moving slowly. Not only should this be borne in mind in determining the proper allowance, but also the fact that a certain increase of thickness is necessary to allow perfect castings to be made. The volume of the metal must be sufficient to retain its heat, avoid cold-shut cracks, and permit the escape of such impurities as may be in the metal or that may come from the mold itself.

Water-Ram in Pipes.—In selecting the thickness of pipe for a given service, it should be borne in mind that in addition to the pressure due to static head, a severe and sudden strain is not infrequently put upon pipe as the result of a so-called "water-ram." What this may be is dependent upon the weight and velocity of the water or other fluid passing through the pipe, and the suddenness of its stoppage. The careless or sudden closing of a valve may easily rupture a line of pipe abundantly strong to withstand ordinary service. It is therefore necessary in dimensioning pipe to allow for extra thickness to withstand this unknown pressure. In the case of hydraulic elevators and other similar service requiring sudden and large draughts of water, unless proper air chambers are employed to cushion the shocks due to the quick closing of valves, there can easily result a strain upon the supply pipe of several hundred pounds per square inch, in addition to the ordinary pressure. Such strain is provided for in the formula given later.

Formulæ for Thicknesses of Cast Iron Pipe.—There is lack of uniformity among the formulæ proposed, and the practice of hydraulic engineers shows corresponding deviations. With the water of a system at rest the pipes are plainly under the static pressure equivalent to the full head. Obviously, this pressure is greater than when the water is flowing through the pipes steadily, the force of gravity then being partially expended in producing this motion and in overcoming frictional resistances.



The static pressure which may be applied safely to a pipe is given by the formula

$$p = \frac{2tS}{5d}$$
 whence  $t = \frac{5dp}{2S}$  in which (as in subsequent formula)

t =thickness of pipe shell, in inches:

d = diameter of pipe, in inches:

p = pressure of water, in pounds per square inch;

S = strength of metal per square inch;

5 = factor of safety.

As already indicated, however, thickness must be determined with reference to possible water-ram, sufficient metal to insure a good casting, provide for wear and endure the shocks incidental to handling. Herein lies the explanation of the varying formulæ proposed by different engineers, as results of their own experiments and practice.

The following formula, in its first term, provides for a water-ram not exceeding the equivalent of 100 pounds (230 feet) static pressure per square inch, while the second term is the addition made for other contingencies.

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

 $t = \frac{(p + 100)d}{.4 S} + .333 \left(1 - \frac{d}{100}\right), \text{ whence the}$  safe working pressure  $p = \frac{.4 S}{d} \left\{t - .333 \left(1 - \frac{d}{100}\right)\right\} - 100.$ 

Formula for Weights of Cast Iron Pipe.—The mean weight of cast iron is about 450 pounds per cubic foot, or .2604 pounds per cubic inch.

Taking all dimensions in inches, let d be the internal diameter of a cast iron pipe; t the thickness of the pipe-shell; then  $\pi$  being the ratio of circumference to diameter (= 3.1416), the cubical  $V_1$  for each foot length of the pipe-shell (neglecting the weight of bell) is

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

This formula may be used also for Flexible Joint piping (design A), adding about 10 per cent. to cover the enlarged bells, plus, as suggested on page 43, such additional thickness as the conditions under which the pipe must be laid and will be in service may require for safety.

When the length of a pipe is mentioned, it is commonly the length between the outside of the bell 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 bell, which, as thus spoken of, is assumed to be distributed along the pipe.

The weights of the bells increase the average weights of 12 feet pipes 7 to 8 per cent., approximately. The general equation for the average weight of 12 feet pipe per lineal foot, including the bell, is

$$W = 9.82 \times (d+t) \times a \times t$$
, or  
= 9.82  $a(d+t)t$  where a is a coefficient varying

with the section of the pipe shell.

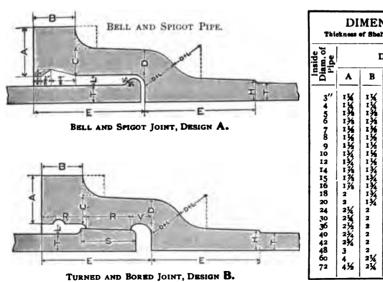
The above equation multiplied by 12 will give, of course, the total weight of a 12 foot pipe. Or, approximately, the weight of a 12 foot length of pipe is equal to 11  $(d \times t)$ .



Variation in Weight.—In recent years there has been a tendency, noticeable in the specifications submitted for tenders, to decrease the percentage of variation either way from the given standards. Those acquainted with pipe-foundry practice will appreciate that these refinements entail extra expense upon the founder, which must ultimately come upon the purchaser, while no real benefit is secured. On the smaller sizes the variation from the given standard selected should not be less than 5 per cent., and on the larger sizes, say 16" and upwards, 4 per cent., both either way on individual pipe. Usually this will result in the total tonnage shipped being within 2½ per cent. of the total weight obtained by multiplying the number of pipe of each size by their respective standard weights, which is doubtless the end desired, and is certainly all that should be expected.

#### GENERAL FORM AND DIMENSIONS OF CAST IRON PIPE.

The practice of engineers varies greatly both as to depth and form of bell, and various standard designs have been adopted by the water and gas interests in some of our large cities. The following cuts, reduced sections of 12" diameter pipes, give with Table No. 2 the form and general dimensions of the "Bell and Spigot," and "Turned and Bored" Pipe-joints. Design A represents the most approved American practice. Dimensions of cast iron pipe socket joints from 3" to 72", corresponding to the letters of the cuts, are given in the table.



Taper of joint, ¼" diameter per 1" of length.

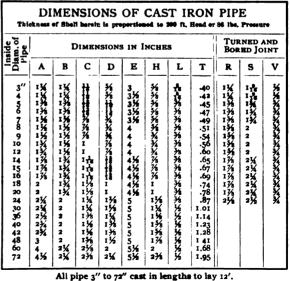


TABLE No. 2.

Thicknesses and Weights of Cast Iron Pipe.—The following table of three classes of cast iron pipe, covering the ordinary range of static pressures of public water supplies, is given to illustrate results derived by formulæ noted on page 23. In ordering, however, the coded and expanded table No. 13, page 40, must be used. Table No. 3 is for good, tough and elastic iron, with S = 18,000, for which value the formula for thickness on page 23 becomes

$$t = \frac{(p + 100) d}{7200} + .333 \left(1 - \frac{d}{100}\right)$$
, where  $p =$  pressure in pounds

per square inch and d = diameter in inches.

The weights are derived by the formula previously given and again noted at the head of each class of pipe and with the factor a selected.

TABLE No. 3.
THICKNESS AND WEIGHTS OF CAST IRON PIPE.

(When S = 18,000 lbs.)

|          |          | CI     | ASS A                        |                     |                | CI              | LASS B                      |           | CLASS C  |               |              |           |  |  |
|----------|----------|--------|------------------------------|---------------------|----------------|-----------------|-----------------------------|-----------|--|---------------|--------------|-----------|--|--|
| <b>a</b> | Pressure |        |                              | inch, or less       | Pres           |                 | bs. per squ                 | are inch  | Pres   |               | lbs. per squ | are inch  |  |  |
| DIAMETER |          |        | d, 116 feet $\times (d+t)$ 1 | · 08.4              |                |                 | d, 230 feet<br>× (d + ℓ : 1 | .075 £    | Head, 300 feet<br>$w = 9.82 \times (d+t)$ 1.07 $t$ |               |              |           |  |  |
| 1        |          | - y,uz |                              |                     | l ———          |                 |                             | .0/3.     |  | - w - y.oz    | A (6 T +)    |           |  |  |
|          | THICKN   | rsses  | Wes                          | GRTS                | Тніск          | N <b>ESSE</b> S | WE                          | IGHT\$    | Тніск  | NESSES        | WE           | IGHTS     |  |  |
| ja.      | Inches   | Approx | Per ft.                      | Per Lgth.           | Inches         | Approx<br>in.   | Per ft.                     | Per Lgih. | Inches   | Approx<br>in. | Per st.      | Per Leth. |  |  |
| 4        | .4033    | 13     | 19.79                        | 237.48              | .4311          | 16              | 21.16                       | 253.92    | -4477  | 16            | 21,96        | 263.52    |  |  |
| 6        | 4383     | 16     | 31.57                        | 378.84              | .4800          | 3/2             | 34-47                       | 413.64    | .5050  | 1/2           | 36.24        | 434.88    |  |  |
| 8        | -4734    | 1/2    | 44-53                        | 534.36              | .5289          | 17              | 49.94                       | 599.28    | .5622  | 16            | 53.10        | 637.20    |  |  |
| 10       | .5083    | 34     | 59-47                        | 713.64              | -5777          | 19              | 67.72                       | 812.64    | .6194  | 5%            | 72.56        | 870.72    |  |  |
| 12       | -5433    | 9      | 75.91                        | 910.92              | .6266          | ₹               | 87.67                       | 1052.04   | .6766  | 118           | 94.62        | 1135.44   |  |  |
| 14       | .5783    | 12     | 93.87                        | 1126.44             | .6755          | H               | 109.85                      | 1318,20   | .7338  | *             | 119.28       | 1431.36   |  |  |
| 16       | .6166    | 3%     | 114.08                       | 1368.96             | .7277          | *               | 134.88                      | 1618.56   | .7944  | 18            | 147.18       | 1766.16   |  |  |
| 18       | .6483    | 31     | 134.61                       | 1615.32             | -7733          | 35              | 160.84                      | 1930.08   | .8483  | 37            | 176.40       | 2116.80   |  |  |
| 20       | .6833    | 11     | 157.30                       | 1887.60             | .8222          | 27<br>32        | 189.74                      | 2276.88   | .9055  | ##            | 208.04       | 2496.48   |  |  |
| 22       | .7183    | 33     | 181.61                       | 2179.32             | .8711          | 7/8             | 230.72                      | 2648.64   | .9628  | ₹ <u>1</u>    | 232,25       | 2926.32   |  |  |
| 24       | ·7533    | 34     | 207.53                       | 2490.36             | .9200          | 18              | 254.11                      | 3049.32   | 1.0200   | 1             | 281.55       | 3378.60   |  |  |
| 27       | .8058    | 18     | 249.42                       | <del>29</del> 93.04 | · <b>993</b> 3 | 1               | 307.97                      | 3695.64   | 1.1058   | 133           | 342.88       | 4114.56   |  |  |
| 30       | .8583    | 36     | 294.78                       | 3537.36             | 1.0666         | 1,18            | 367.09                      | 4405.08   | 1.1916   | 178           | 410.05       | 4920.60   |  |  |
| 33       | .9108    | 15     | <b>322.8</b> 0               | 3874.80             | 1.1400         | 1 5 2           | 431.20                      | 5174.40   | 1.2775   | 13/2          | 483.11       | 5797-32   |  |  |
| 36       | .9633    | *1     | 392.57                       | 4710.84             | 1.2183         | 1 37            | 502.34                      | 6028.08   | 1.3633   | 13%           | 561.94       | 6743.28   |  |  |
| 40       | 1.0333   | 137    | 471.91                       | 5662.92             | 1.3111         | 1 15            | 600.32                      | 7203.84   | 1.4778   | 134           | 676.15       | 8113.80   |  |  |
| 42       | 1.0683   | 116    | 512.35                       | 6148.20             | 1.3599         | 111             | 653.58                      | 7842.96   | 1.5350   | 117           | 737.26       | 8847.12   |  |  |
| 48       | 1.1733   | 1 3    | 642.40                       | 7708.80             | 1.5066         | 13/2            | 826.43                      | 9917.16   | 1.7066   | 111           | 935.86       | 11230.32  |  |  |

<sup>\*</sup>Formula for average weight per lineal foot. Weights are approximate only.



#### 26

### RELATION BETWEEN VELOCITY, VOLUME, ETC.

A = Area of Pipe in square feet.

T = Time in minutes to deliver required discharge.

a = Area of Pipe in square inches.
D = Required discharge in cubic feet.

G = Gallons per lineal foot of pipe.

d = Required discharge in gallons.

V =Velocity of flow in feet per minute.

To find the velocity of flow in feet per minute, to discharge a stated number of cubic feet of water in a given time, Divide the amount of discharge by the area of pipe expressed in square feet, multiplied by the number of minutes; or multiply the required amount of discharge expressed in cubic feet by 144 and divide the product by the area of pipe expressed in square inches, multiplied by the number of minutes.

To find the velocity of flow in feet per minute to discharge a stated number of gallons of water in a given time. Divide the amount of discharge by the number of gallons

contained in one lineal foot of pipe, multiplied by the number of minutes.

To find the area of pipe expressed in square inches, which will deliver a given number of cubic feet of water in so many minutes, Multiply the amount of discharge expressed in cubic feet by 144 and divide the product by the velocity of flow in feet per minute, multiplied by the number of minutes.

To find the approximate diameter of pipe which will deliver a given number of gallons of water in so many minutes. Divide the amount of discharge by the velocity of flow in feet per minute, multiplied by number of minutes. This will give the number of gallons per lineal foot of pipe. By reference to the following table the diameter of the pipe closely approaching this capacity can be found:

$$V = \frac{D}{A \times T}$$

$$V = \frac{D \times 14a}{a \times T}$$

$$V = \frac{d}{G \times T}$$

$$a = \frac{D \times 14}{V \times T}$$

$$G = \frac{d}{V \times T}$$

TABLE No. 4. Inside Dimensions of Pipe.

|        | Inches        |         | Gallons of 231                       |                 | 1             | FERT  | •                                 | Diamete      |
|--------|---------------|---------|--------------------------------------|-----------------|---------------|---|-----------------------------------|--------------|
| Diam.  | Circumference | Area    | Cubic Inches per Lineal Foot of Pipe | Diameter        | Circumference | Cubic Contents per<br>Lineal Foot and<br>Sectional Area | Hydraulic Mean Rad. $\frac{d}{4}$ | in<br>Inches |
| 1/2    | 1.57080       | . 19635 | .0102                                | .0417           | .1310         | .001366   | .0104                             | 1/2          |
| ½<br>¥ | 2.35619       | .44179  | .0230                                | .0625           | .1965         | .003068   | .0156                             | ½<br>¾       |
| ľ      | 3.14159       | .78540  | .0408                                | .083            | .2618         | .005454   | .0208                             | ı~           |
| 11/2   |               | 1.7671  | .0918                                | .1250           | .3927         | .01227  | .0312                             | 1 1/2        |
| 134    | 5.49779       | 2.4053  | .1249                                | . 1458          | .4581         | .01670  | .0364                             | 134          |
| 2      | 6.28319       | 3.1416  | . 1632                               | .1667           | .5235         | .02232  | .0418                             | 2 ~          |
| 3      | 9.42478       | 7.0686  | .3672                                | 250             | .7854         | .04909  | .0625                             | 3            |
| 4      | 12.5664       | 12.566  | .6528                                | ·3333           | 1.047         | .08726  | .0833                             | 4            |
| 6      | 18.8496       | 28.274  | 1.469                                | .5000           | 1.571         | .19635  | .1250                             | Ġ            |
| 8      | 25.1327       | 50.265  | 2.611                                | .6667           | 2.094         | .3490   | .1666                             | 8            |
| 10     | 31.4159       | 78.540  | 4.080                                | .8333           | 2.618         | -5454   | .2083                             | 10           |
| 12     | 37.6991       | 113.10  | 5.875                                | 1.0000          | 3.142         | .7854   | .2500                             | 12           |
| 14     | 43.9823       | 153.94  | 7.997                                | 1.1667          | 3.665         | 1.009   | .2916                             | 14           |
| 16     | 50.2655       | 201.06  | 10.44                                | 1.3333          | 4.189         | 1.397   | -3333                             | 16           |
| 18     | 56.5487       | 254.47  | 13.22                                | 1,5000          | 4.713         | 1.767   | .3750                             | 18           |
| 20     | 62.8319       | 314.16  | 16.32                                | 1.6677          | 5.235         | 2, 181  | .4166                             | 20           |
| 24     | 75.3982       | 452.39  | 23.50                                | 2,0000          | 6.283         | 3.142   | .5000                             | 24           |
| 27     | 84.8230       | 572.56  | 29.74                                | 2,2500          | 7.069         | 3.976   | .5625                             | 27           |
| 30     | 94.2478       | 706.86  | 36.72                                | 2.5000          | 7.854         | 4.909   | .6250                             | 30           |
| 33     | 103.673       | 855.30  | 44-43                                | 2.7500          | 8.639         | 5.940   | .6875                             | 33           |
| 36     | 113.097       | 1017.9  | 52.88                                | 3.0000          | 9.425         | 7.069   | .7500                             | 36           |
| 40     | 125.664       | 1256.6  | 65.28                                | 3.3333          | 10.47         | 8.726   | .8333                             | 40           |
| 44     | 138.230       | 1520 5  | 78.99                                | 3.6667          | 11.52         | 10.558  | .9166                             | 44           |
| 48     | 150.796       | 1809.6  | 94.00                                | 4.0000          | 12.56         | 12.567  | 1.0000                            | 48           |
| 54     | 169.646       | 2290.2  | 118.96                               | 4.5000          | 14.14         | 15.905  | 1.1250                            | 54           |
| 60     | 188.496       | 2827.4  | 146.88                               | 5.0000          | 15.71         | 19.635  | 1.2500                            | 54<br>60     |
| 72     | 226, 195      | 4071.5  | 211.52                               | 6. <b>000</b> 0 | 19.29         | 29.607  | 1.5000                            | 72           |
| 84     | 263.894       | 5541.8  | 287.38                               | . 7.0000        | 21 99         | 38.484  | 1.7500                            | 84           |
| 96     | 301.593       | 7238.2  | 376.00                               | 8.0000          | 25.45         | 50.265  | 2.0000                            | 96           |

Discharging Capacities of Pipes.—Discharging capacities as usually tabulated are based upon formulæ derived from experimental conditions superior to those attained in average practice. Deviations from these conditions arise from differences in the mechanical execution of the work, imperfections in the interior surfaces due to corrosive and incrusting action of the water or other cause. Whatever their character, they all tend to impede flow and emphasize the necessity of selecting diameters delivering quantities much in excess of apparent actual need.

Relative Discharging Capacities.—The accompanying table giving the relative discharging capacities of full, smooth pipes, will facilitate the proper proportioning of systems of pipe distribution. The last vertical column gives the diameters in inches, as does also the hori-

TABLE No. 5.

RELATIVE DISCHARGING CAPACITIES OF FULL, SMOOTH PIPES.

| Diam.<br>in<br>Feet<br>=d | Relative discharging capacities =d1 | 8     | 4     | e<br>e | 8       | 10    | 122   | 14     | 16     | 18    | 20<br>20 | "<br>22 | 24    | 27     | 80     | ,,<br>88 | 86     | 40    | 44    | <b>48</b> | Diam. in<br>Inches |
|---------------------------|-------------------------------------|-------|-------|--------|---------|-------|-------|--------|--------|-------|----------|---------|-------|--------|--------|----------|--------|-------|-------|-----------|--------------------|
| 4.                        | 32.000                              |       |       |        | <b></b> |       |       |        | 15.59  | 11.61 | 8.92     | 7.03    | 5.66  | 4.21   | 3.24   | 2.55     | 2.05   | 1.58  | 1.24  | 1.        | 48                 |
| 3.6667                    | 25.744                              |       |       | ••••   |         |       |       | 17.51  | 12.54  | 9.34  | 7.18     | 5.66    | 4.55  | 3.39   | 2.61   | 2.05     | 1.65   | 1.27  | I.    | *****     | 44                 |
| 3.3333                    | 20.286                              |       |       |        |         |       | 20.29 | 13.80  | 9.88   | 7.36  | 5.66     | 4.46    | 3.59  | 2.67   | 2.05   | 1.62     | 1.30   | I.    |       | ******    | 40                 |
| 3.                        | 15.588                              |       | ••••• |        | •       | 24.59 | 15.59 | 10.60  | 7.59   | 5.66  | 4 35     | 3-43    | 2.76  | 2.05   | 1.58   | I.24     | I.     | ••••  | ••••• |           | 36                 |
| 2.75                      | 12.541                              | ••••• | ••••• |        | 34.56   | 19.78 | 12.54 | 8.53   | 6.11   | 4.55  | 3.50     | 2.76    | 2.22  | 1 65   | 1.27   | I.       | •••••  | ••••• | ••••• | •••••     | 33                 |
| 2.5                       | 9.882                               |       | ••••• |        | 27.23   | 15.59 | 9.98  | 6.72   | 4.81   | 3.59  | 2 76     | 2.17    | 1.75  | 1.30   | I.     |          | •••••  |       | ••••• |           | 30                 |
| 2.25                      | 7-594                               | ••••• |       | 42.95  | 20.93   | 80.11 | 7.59  | 5.17   | 3.70   | 2.76  | 2.12     | 1.67    | 1.34  | 1      | •••••  |          | •••••  | •     | ••••• | •••••     | 27                 |
| 2.                        | 5.657                               |       |       | 32.00  | 15.59   | 8.92  |       | 3.85   | 2.76   | 2.05  | 1.58     | 1.24    | 1.    |        | •••••  |          | •      | 1     | ••••• |           | 24                 |
| 1.8333                    | 4.551                               |       |       | 25.74  | 12.54   | 7.18  | 4.55  | 3.10   | 2.22   | 1.65  | 1.27     | I.      |       | •••••  | •••••  | •••••    | •••••  | ;     | ••••• |           | 22                 |
| 1.6667                    | 3.586                               |       |       | 20.28  | 9.88    | 5.66  | 3.59  | 2.44   | 1.75   | 1.30  | I.       | •••••   | ••••• | •••••  | •••••  |          | •••••  | ,     | ••••• | •         | 20                 |
| 1.5                       | 2.756                               |       |       | 15.59  | 7.59    | 4-35  | 2.76  | 1.87   | 1.34   | I.    | •••••    |         | •     | •      |        |          |        |       | ••••• | •••••     | 18                 |
| 1.3333                    |                                     | 65.80 | 32.03 | 11.61  | 5.66    | 3.24  | 2.05  | 1.40   | I.     | •     | •••••    |         | ••••• | •••••  |        | •••••    | ·····  |       | ••••• | •••••     | 16                 |
| 1.1667                    |                                     |       | 22.93 | 8.31   | 4.05    | 2.32  | 1.47  | 1.     | •••••  | ••••• | •••••    | •••••   | ••••• | •••••  | ****** |          |        | ••••• | ••••• | •••••     | 14                 |
| I.                        |                                     |       | 15.60 | 5.66   | 2.76    | 1.58  | ı.    | ****** | •••••  | •     |          | • ••••  | ••••• | •••••  |        | •••••    | ****** | ••••• | ••••• | •••••     | 12                 |
| .8333                     |                                     | 20.32 | 9.89  | 3.59   | 1.75    | ı.    | ••••• |        |        |       | •••••    |         |       |        |        | •••••    | ••••   | ••••• | ••••• | •••••     | 10                 |
| .6667                     |                                     | 11.63 | 5 66  | 2.05   | 1.      | ••••• |       | •••••  |        | ••••• |          |         |       |        |        |          | •••••  | • • • |       | •••••     |                    |
| ∙5                        | .1768                               | 5.66  | 2.76  | I.     | •••••   | ••••• | ••••• |        | •••••  |       |          | •••••   |       |        |        |          | •••••  |       | ••••• | ******    | 0                  |
| -3333                     | .0641                               | 2.05  | I.    |        |         | ••••• | ••••• | •••••  | ****** | ••••• | •••••    | ••••    |       |        |        | *****    | •••••  | ••••• | •••   | •••••     | 4                  |
| .25                       | .0312                               | 1.    | ••••• | ****** |         | ••••• | ••••• |        | •••••  | ••••• | •••••    |         | ••••• | ****** |        | •••••    |        | ••••• |       | ******    | 3                  |

zontal column at the head of the table. The numbers at the intersections of the diameters in inches of the horizontal and vertical columns give the approximate relative discharging capacities. For instance, if it is desired to know how many smaller pipes a 48" pipe is equal to in discharging capacity, trace along the horizontal line from the 48" diameter in the vertical column, and it will be found that it is equal to 15.59 16" pipes, or 5.66 24" pipes, etc. Also, for other diameters, it will be found that a 6" pipe is equal to 2.76 4" pipes; or 20" pipe is equal to 1.75 16" pipes.

Commercial Value of Diameters.—As the pipe increase in size the discharging capacity increases very much more rapidly than the cost of installation (because the area of the circle increases "as the square," while the ring of metal constituting the pipe increases only in direct proportion to the increase of the diameter), and in a growing community, where the demand on the water supply is larger every year, such increased cost, compared with the subsequent trouble and expense, and often positive danger of a deficient water supply, is wholly insignificant. To bring this matter out more clearly we have prepared the following table:



#### TABLE No. 5A.

#### COMMERCIAL VALUE OF DIAMETERS.

Percentages of Increase in Cost and Capacity and Decrease in Cost per Unit of Capacity se Earger Diameters of Pipe are Used.

|      |   |            | ,        | ,                                       |          |          |             |              |            |             |              |        | ,       |        |            | T                                |
|------|---|------------|----------|---|----------|----------|-------------|--------------|------------|-------------|--------------|--------|---------|--------|------------|----------------------------------|
| Dia. | ä                                       | 4          | <b>.</b> | ď.                                      | *        | **       | 12          | 10           | <b>9</b> 0 | 24          | 80           | 86     | 42      | 48     | <b>6</b> 0 |                                  |
|      |   |            |          |   | <u> </u> |          |             | <del> </del> |            | <del></del> | <b></b>      |        |         |        |            | dinament and                     |
|      | •                                       | <b>3</b> 3 | 54       | 80                                      | *****    | *****    | ***         | ******       | ***        | *****       |              | ••••   | ••••••  | •      | •••••      | *increased cost.                 |
| 8    | 0                                       | 105        | 259      | 466                                     | •••••    | •••••    | •••••       | •••••        | •••••      |             | •••••        | •••••  | •       | •••••  | •••••      | ≰increased capacity.             |
|      | 0                                       | 35         | 57       | 67                                      |          | •••••    | •••••       | •••••        | •••••      | •••••       |              |        |         | •••••  | •••••      | ≱ decreased cost per unit of cap |
|      |   |            |          |   |          |          |             |              |            |             |              |        |         |        |            | 41                               |
| - 1  | •••••                                   | 0          | 31       | 46                                      | 92       |          |             | •••••        | *****      | *****       |              | • •••• | •••••   | *****  |            | ≸ increased cost.                |
| 4    | ******                                  | 0          | 75       | 176                                     | 466      | ······   |             | •••••        | •••••      |             |              | •••••  |         |        |            | ≶ increased capacity.            |
| Ī    | *****                                   | Q          | 3,2      | 47                                      | 668      |          | •••••       |              | ,          | •••••       | •            |        | ,       |        |            | * decreased cost per unit of car |
|      | <u> </u>                                |            |          |   | 4.       |          |             |              |            |             |              |        |         |        |            |                                  |
| _    |   |            | •        | 22                                      | 63       | 104      | •           |              | •••••      | •••••       |              | ****** |         | •••••  |            | ≸ increased cost.                |
| 8    | ******                                  | •••••      | •        | 58                                      | 224      | 466      | •••••       | •            | •••••      | •••••       |              | ***    | •••••   | •••••  |            | s increased capacity.            |
|      | •                                       | •••••      |          | 23                                      | 50       | 64       | •••••       | •••••        |            |             | •••••        | ****** | •••••   | •••••  | ••••       | ≸ decreased cost per unit of ca  |
|      |   |            |          | i                                       |          |          |             |              |            |             |              |        |         |        |            |                                  |
| _    | •••••                                   | *****      | •••••    | ' 0                                     | 33       | 65       | 104         | •••••        | •••••      | ******      | •••••        | ****   | •••••   | *****  |            | ≸ increased cost.                |
| 8    |   | *****      | •••••    | •                                       | 162      | 259      | 466         | ******       |            |             | ****         | •••••  |         | *****  |            | ≶ increased capacity.            |
| ļ    |   | ******     | •••••    | 0                                       | 35       | 54       | 64          | •••••        | •          |             | *****        | •••••  |         | •••••  |            | ∮ decreased cost per unit of cap |
|      |   |            |          |   |          |          |             |              |            |             |              |        |         |        |            |                                  |
|      |   |            | *****    |   | ٥        | 26       | 35          | 115          | ******     |             | ,            | •••••  | ******  | •••••  |            | # increased cost.                |
| 8    | ••••                                    |            |          | •••••                                   | ۰        | 75       | 176         | 466          |            | •••••       | ••••         |        | •••••   | •••••  |            | % increased capacity.            |
|      | } ····· '                               | •••••      | •••••    | •••••                                   | °        | 28       | 44          | 62           | •••••      | •••••       |              | •••••  | •••••   | •••••  |            | ≶ decreased cost per unit of ca  |
|      | !                                       |            |          |   |          |          |             |              |            |             |              |        |         |        |            | d bossessed as t                 |
|      | •••••                                   | •••••      |          |   |          |          | क्ष         | 75           | 132        |             |              |        | •••••   |        |            | # increased cost.                |
| 10   | ******                                  |            |          |   |          | •        | <b>58</b>   | 324          | 464        | •••••       | •••••        | •••••  |         | ****** |            | ≸ increased capacity.            |
|      |   | •••••      | ****     | •••••                                   |          | •        | 32          | 46           | 59         | ******      | ••••••       | ****** | *****   | •••••  |            | ≰ decreased cost per unit of cap |
|      | ·                                       |            | i        | i                                       |          |          |             |              |            |             | l            |        |         |        |            | d2                               |
|      | •••••                                   | ••••       |          | •••••                                   |          | •••••    |             | 41           | 90         | 143         |              | ****** | *****   | ****** |            | ≰ increased cost.                |
| 12   |   | ••••       | •••••    |   | · •••••  | *****    | 0           | 105          | 259        | 466         | ******       | •••••  | •••••   |        |            | ≰ increased capacity.            |
| !    | • | •••••      |          | •••••                                   | •••••    |          | 0           | 32           | 47         | 57          |              | •      | 1       | •      | •••••      | ≸ decreased cost per unit of cap |
|      |   |            |          |   | <u> </u> |          |             |              | l          | l           |              |        |         |        |            |                                  |
|      |   |            |          | • |          | •••••    | •••••       | 9            | 35         | 71          | 141          | ****** | • ••••• |        | •••••      | % increased cost.                |
| 16   |   |            | *****    |   |          | •••••    | •••••       | •            | 75         | 176         | 381          | •••••  |         | ••••   | ******     | ≶ increased capacity.            |
|      |   |            |          | *****                                   |          |          |             | 0            | 23         | 38          | 50           | •••••  |         | •      | *****      | ≶ decreased cost per unit of ca  |
|      |   |            |          |   |          |          |             | i            |            |             | <del> </del> |        |         |        | _          | i                                |
|      |   |            |          | •••••                                   |          |          |             |              | 0          | 26          | 77           | 244    | 213     |        | •          | ≶ increased cost.                |
| 20   |   | •••••      |          |   | ******   | •••••    | *****       | •••••        |            | 58          | 176          | 335    | 539     |        | ••••       | ≸ increased capacity.            |
| ,    | 1                                       |            |          |   |          |          | *****       |              | •          | 20          | 36           | 44     | 51      | ••••   | •••••      | ≸ decreased cost per unit of ca  |
|      | 1                                       |            |          |   |          |          |             | i            |            |             |              |        |         |        |            |                                  |
| ~.   | ;                                       |            | ******   |   |          | •••••    |             |              |            |             | 40           | 90     | 147     | 217    | •••••      | s increased cost.                |
| 24,  | *****                                   |            |          | •••••                                   |          |          |             | ••••         |            | 0           | 75           | 176    | 305     | 466    | •••••      | ≠ increased capacity.            |
| - 1  |   |            |          |   |          |          |             |              |            | 0           | 20           | 31     | 39      | 44     | •••••      | ≰ decreased cost per unit of ca  |
|      | ·                                       |            |          |   |          |          |             |              |            |             |              |        |         | i      |            |                                  |
|      | '                                       | •••••      | •••••    | ••• ••                                  |          | •••••    |             | •••••        |            | •••••       | 0            | 36     | 76      | 127    | 262        | ≶ increased cost.                |
| 80   | ı •••••                                 |            |          | •••••                                   |          |          |             |              |            |             | 0            | 58     | 132     | 324    | 466        | ≶ increased capacity.            |
| i    |   |            | •        | 20220                                   |          |          | ******      |              | •••••      | *****       | •            | 14     | 24      | 30     | 36         |                                  |
|      | ,                                       |            |          | -                                       |          | <u> </u> | i           | i            | !          |             |              | _      |         | a.c    |            | dia                              |
|      |   |            |          |   | i        |          | [           |              |            |             |              | 0      | 29      | 66     | 166        | ≸ increased cost.                |
| 86   |   |            |          | ¦                                       | *****    | •••      |             |              |            |             |              | 0      | 42      | 195    | 259        | s increased capacity.            |
| 1    |   |            |          | •••••                                   |          |          |             | •••••        |            | ••••        |              | •      | 12      | 19     | 26         | ≸ decreased cost per unit of ca  |
|      |   |            |          |   |          |          |             |              | l          |             |              |        |         |        |            | 41                               |
| 40   |   | ******     | i        |   |          |          |             |              |            |             |              | •••••  | 0       | 29     | 105        | ≸ increased cost.                |
| 48   |   | *****      |          |   | *****    | •••••    |             | ••••         |            |             |              |        | 0       | 40     | 144        | ≶ increased capacity.            |
| į    |   | •••••      | •        |   |          |          |             |              | •••••      | •••••       |              |        | ٥       | 8      | 16         | ≰ decreased cost per unit of ca  |
|      |   |            |          | ļ <del></del> -                         |          |          | <del></del> | ·            |            |             |              |        |         | -      |            | di                               |
|      |   |            |          |   |          |          |             |              |            |             |              | •••••  |         | 0      | 59         | % increased cost.                |
| 48   |   |            |          | •••••                                   | •••••    |          |             |              |            |             |              |        |         | 0      | 75         | ≸ increased capacity.            |
| -    | 13                                      |            |          |   |          |          | •••••       | •••••        |            |             | •••••        |        | •••••   | •      | 9          |                                  |
|      |   |            |          |   |          | 1        | 1           | i            | ·          | 1           | !            | 1      |         | i      |            |                                  |
|      |   |            | 1        |   |          | 1        |             | ļ.           | i          | ł           |              | ı      | i .     | l      | l .        | 11                               |
|      |   |            |          |   |          |          |             |              |            |             |              |        |         |        | 0          | ≸ increased cost.                |
| 60   |   |            |          |   |          |          |             |              |            |             |              |        |         |        | 0          |                                  |

In compiling this table we have carefully considered such matters of detail as laying the pipe, making joints and other incidental costs of installation. The percentages of increased cost and capacity, and decreased cost per unit of capacity, are based on using pipe of the diameters as per the horizontal column at the head of table instead of the vertical column at the left. To illustrate, suppose that in a town which, to meet present demand, would require a 6" main it were thought probable that in a few years an 8" main would be demanded. Then we see from the table that the increased cost would be but 33 per cent. for an increased capacity of 105 per cent., and the cost per unit of capacity would decrease 35 per cent. For example, suppose a 6" main would cost \$10,000, and require replacing with an 8" main in ten years, money being worth 4 per cent. per annum. Then, by applying the table, we find the cost of the 8" main would be \$13,300, which, if ten years hence, would be equivalent to \$9000 at the present time or a total equivalent present cost, for a 6" main replaced ten years hence with an 8" main, of \$19,000. Thus, as is apparent, if the 8" main were laid originally there would be a saving to the municipality of \$19,000—\$13,300 = \$5700 or 30 per cent.

Odd or Unusual Diameters.—In the above table we have considered only pipes of regular diameters. Pipe of odd diameters cost more to manufacture, and when the next larger size considered is of odd diameter there would be little or no decrease, and sometimes an actual increase, in the cost per unit of capacity, while there would always be a considerable decrease by the use of the next larger regular size.

Head.—The force causing flow may be an elevation of water expressed as "head," and defined as the vertical distance between the level of the water surface in the reservoir and the level of the center of the discharge opening; or it may be caused by pump pressure expressed in pounds per square inch and convertible into "feet head" on the basis that I pound pressure per square inch = 2.309 feet head, and I foot head = .433 pound pressure per square inch.

Tables 8 and 9, on page 34, give these equivalents up to 1000 feet head and 500 pounds pressure per square inch.

Sub-divisions of Head.—The force derived from the pressure due to head is expended partly in overcoming the resistance of the pipe entrance to the passage of the water, partly in acting against the resistances to flow within the pipe and partly in producing the velocity of flow. Hence these fractional portions of the total force due to head are briefly expressed as Entry Head, Frictional Head and Velocity Head, respectively. For flaring or bell-shaped entrance the Entry Head is inappreciable, and with square edges of entrance is about one-half the Velocity Head. The sum of the Entry and Velocity Heads rarely exceeds one foot.

Frictional Heads in Pipes.—The following table of the frictional heads or loss in head due to friction in pipes of different diameters and 1000 feet long, at given rates of discharge, as prepared by G. A. Ellis and A. H. Howland, are intended to be sufficiently accurate for ordinary use. The curve of resistance is greater than that of M. Darcy and less than that of Eytelwein. The figures are given to the nearest decimal, and are probably within the limits of variation to be found in any two similar cases in practice.

For a longer pipe than 1000 feet, increase the given figures of frictional head in the direct proportion of such additional length, and for a shorter pipe (within reasonable lengths) diminish the figures in the same way.



TABLE No. 6.

FRICTIONAL HEADS AT GIVEN RATES OF DISCHARGE IN CLEAN CAST IRON PIPES FOR EACH 1000 FEET OF LENGTH.

| Gallons<br>harged<br>Minute  | Gallons<br>harged<br>wenty-<br>Hours   | 4-I1  | исн Рі   | PB  | 6-I   | NCH P   | IPE  | 8-I   | исн Р  | IPB  | 10-1   | NCH P  | PIPE  | 12-  | INCH I   | PIPE   | 14-INCH PIPE   |  |   |  |
|--|--|---|--|---|---|---|--|---|--|--|--|--|---|--|--|--|--|--|---|--|
| てでき  |  | Veloc-<br>ity in  | Fric.  | Head  | Veloc-<br>ity in  | Fric.   | Head   | Veloc-<br>ity in  | Fric.  | Head   | Veloc-<br>ity in   | Fric.  | Head  | Veloc-<br>ity in   | Fric.  | Head   | Veloc-<br>ity in   | Fric.  | Head  |  |
| U.S.<br>Disc   | U.S.<br>Disc<br>per four   | Feet  | Feet   | Lbs.  | Feet  | Feet  | Lbs.   | Feet  | Feet   | Lbs.   | Feet   | Feet   | Lbs.  | Feet   | Feet   | Lbs.   | Feet   | Feet   | Lbs.  |  |
| 25<br>50   | 36,000<br>72,000   | .64<br>1.28   | ·59<br>2.01  | .26<br>.87  | .28<br>·57  | .II<br>.32  | .05  | .16   | .04  | .02  | .10  | .02  | .01   | .07<br>.14   | .01<br>.02   |  |  |  |   |  |
| 100  | 144,000  | 2.55  | 7.36   | 3.19  | 1.13  | 1.08  | -47  | .32<br>.64  | .29  | .13  | .41  | .11  | .05   | .28  | .05  | .02  | .21  | .03  | .01   |  |
| 150  | 216,000  | 3.83  | 16.05  | 6.95  | 1.70  | 2.28  | .99  | .96   | .60  | .26  | .61  | .22  | .10   | -43  | .10  | .04  | .31  | .05  | .02   |  |
| 200  | 288,000  | 5.11  | 28.09  | 12.17   | 2.27  | 3.92  | 1.70   | 1.28  | 1.01   | ·44<br>·66   | .82  | .36  | .16   | -57  | .16  | .07  | -42  | .08  | .04   |  |
| 250<br>300   | 360,000<br>432,000   | 7.66  | 43-47<br>62.20   | 18.83<br>26.94  | 2.84<br>3.40  | 6.00<br>8.52  | 2.60<br>3.69   | 1.60  | 1.52   | .92  | 1.02   | •54<br>•75   | .23<br>.32  | .71<br>.85   | .32  | .10  | .52<br>.63   | .12  | .05   |  |
| 350  | 504,000  | 8.94  | 84,26  | 36.50   | 3.40  | 11.48   | 4.97   | 2.23  | 2.85   | 1.24   | 1.43   | .99  | -43   | .99  | -43  | .18  |  | .21  | .09   |  |
| 400  | 576,000  | 10.21   | 109.68   | 47.50   | 4.54  | 14.89   | 6.45   | 2.55  | 3.68   | 1.59   | 1.63   | 1.27   | -55   | 1.13   | -54  | .23  | ·73<br>·83   | .27  | .12   |  |
| 450  | 648,000  | 11.49   | 138.43   | 59.96   | 5.11  | 18.73   | 8.11   | 2.87  | 4.61   | 2,00   | 1.83   | 1.58   | .69   | 1.28   | .67  | .29  | -94  | -33  | .14   |  |
| 500  | 720,000  | 12 77   | 170.53   |   | 5.67  | 23.01   | 9.97   | 3.19  | 5.64   | 2.44   | 2.04   | 1.93   | .84   | 1.42   | .81  | -35  | 1.04   | .40  | .17   |  |
| 600  | 864,000  | 15.32   |  | 106.02  | 6.81  | 32.89   | 14.25  | 3.83  | 8.03   | 3.48   | 2.45<br>2.86   | 2.72   | 1.18  | 1.70   | 1.14   | .49<br>.66   | 1.25   | -55  | .24   |  |
| 700<br>800   | 1,008,000  | 17.87   | 332.36   | 143.98  | 7.94<br>9.08  | 44·54<br>57·95  | 19.08<br>25.10   | 4.47<br>5.09  | 10.83  | 4.69<br>6.08   | 3.27   | 3.66<br>4.73   | 2.05  | 1.98<br>2.27   | 1.52<br>1.96   | .85  | 1.46   | ·73<br>·94   | .32<br>.41  |  |
| 900  | 1,296,000  |   |  |   | 10.21   | 73.12   | 31.67  | 5.74  | 17.68  | 7.69   | 3.68   | 5.93   | 2.57  | 2.55   | 2.45   | 1.06   | 1.88   | 1.17   | .51   |  |
| 1,000  | 1,440,000  |   |  |   | 11.35   | 90.05   | 38.99  | 6.38  | 21.74  | 9.41   | 4.08   | 7.28   | 3.15  | 2.84   | 3.00   | 1.30   | 2.08   | 1.43   | .51<br>.62  |  |
| 1,200  | 1,728,000  | •••••   |  |   | 13.61   | 129.20  | 55.96  | 7.66  | 31.10  | 13.47  | 4.90   | 10.38  | 4.50  | 3.40   | 4.26   | 1.85   | 2.50   | 2.02   | .88   |  |
| 1,400  | 2,016,000  | •••••   | ••   |   | 15.88   | 175.38  | 75-97  | 8.94  | 42.13  | 18.25  | 5.72   | 14.02  | 6.07  | 3.97   | 5.74   | 2.49   | 2.91   | 2.72   | 1.18  |  |
| 1,600<br>1,800   | 2,304,000  |   |  |   | 18.15   | 228.62<br>288.90  | 99.03  | 10.21   | 54.84<br>69.22   | 23.75  | 6.53   | 18.22<br>22.96   | 7.89<br>9.95  | 4.54   | 7.44   | 3.22<br>4.06   | 3.33   | 3.51   | I.52<br>I.91  |  |
| 2,000  | 2,880,000  |   |  |   | 22 69   | 356.22  | 125.14   | 11.47<br>12 77  | 85.27  | 29.98<br>36.93   | 7-35<br>8.17   | 28.25  | 12.34   | 5.11<br>5.67   | 9.36<br>11.50  | 5.00   | 3.75<br>4.17   | 4.4I<br>5.4I   | 2.34  |  |
| 2,500  | 3,600,000  |   |  |   |   |   | 34.30  | 15.96   | 132.70   | 57.49  | 10.21  | 43.87  | 19.00   | 7.00   | 17.82  | 7.72   | 5.21   | 8.35   | 3.62  |  |
| 3,000  | 4.320,000  |   |  |   |   |   |  |   |  | 3,143  | 12.25  | 62.92  | 27.25   | 8.51   | 25.51  | 11.05  | 6.25   | 11.92  | 5 17  |  |
| 3 500  | 5,040,000  |   |  | •••••   | •••••   |   |  |   | •  |  |  |  | •••••   | 9.93   | 34.58  | 14.98  | 7.29   | 16.14  | 6.99  |  |
| 4,000  | 5,760,000  |   | •••••  | •••••   | •••••   |   | • • • •  | ******  |  |  |  | !  |   |  |  |  | 8 34   | 21.00  | 9.10  |  |
| 4,500  | 6,480,000  |   |  | •••••   |   |   |  |   |  |  |  |  | •   |  | <u> </u>   |  | 9.38   | 26.49  | 11.47   |  |
| Gallons<br>charged<br>Minute   | Gallons<br>harged<br>Twenty-   | 16-1  | NCH P  | IPE   | 18-1  | исн Р   | IPE  | 20-1  | NCH P  | IPE  | 24-I   | исн Р  | IPE   | 30-I   | NCH P  | IPE  | 36.1   | NCH P  | IPE   |  |
| Gall<br>Charg<br>Min   | 2 ag ¥   | Veloc-  | Fric.  | Head  | Veloc-  | Fric.   | Head   | Veloc-<br>ity in  | Fric.  | Head   | Veloc-   | Fric.  | Ḥead  | Veloc-<br>ity in   | Fric.  | Head   | Veloc-   | Fric.  | Head  |  |
| U S<br>Dis   | N.S. T. 3  |   |  |   |   |   |  |   |  |  |  |  |   |  |  |  |  |  |   |  |
|  | U.S.G<br>Disch<br>Per Tr   | ity in<br>Feet  | Feet   | Lbs.  | Feet  | Feet  | Lbs.   | Feet  | Feet   | Lbs.   | ity in<br>Feet   | Feet   | Lbs.  | Feet   | Feet   | Lbs.   | ity in<br>Feet   | Feet   | Lbs.  |  |
| 500  | 720,000  | Feet<br>.80   | .22  | .09   | Feet<br>.63   | .13   | .06  | Feet  | .08  | .04  | Feet<br>-35  | .04  | .02   | Feet   | 10.  | .00  | ity in<br>Feet   | 10,  | .00   |  |
| 500<br>1,000   | 720,000  | .80<br>1.60   | .22<br>.76   | .09   | .63<br>1.26   | .13   | .06  | .51<br>1.02   | .08<br>.27   | .04<br>.12   | .35<br>.71   | .04  | .02   | Feet   | 10.  | .00  | reet<br>.16  | ,01<br>,02   | .00.  |  |
| 500<br>1,000<br>1,500  | 720,000<br>1,440,000<br>2,160,000  | .80<br>1.60<br>2.39   | .22<br>.76<br>1.63   | .09<br>-34<br>-71   | .63<br>1.26<br>1.89   | .13<br>.44<br>.93   | .06<br>.19   | .51<br>1.02<br>1.53   | .08<br>.27<br>.56  | .04<br>.12   | ·35<br>.71<br>1.06   | .04<br>.12<br>.24  | .02<br>.05  | .23<br>.45<br>.68  | .01  | .00  | .16<br>.32   | .01<br>.02<br>.04  | .00<br>.01<br>.02   |  |
| 500<br>1,000   | 720,000  | .80<br>1.60   | .22<br>.76<br>1.63<br>2.82   | .09   | .63<br>1.26   | .13<br>.44<br>.93<br>1.60   | .06  | .51<br>1.02<br>1.53<br>2.04   | .08<br>.27<br>.56  | .04<br>.12   | .35<br>.71   | .04  | .02   | Feet   | 10.  | .00  | .16<br>.32<br>.47<br>.63   | ,01<br>,02   | .00.  |  |
| 500<br>1,000<br>1,500<br>2,000<br>2,500<br>3,000   | 720,000<br>1,440,000<br>2,160,000<br>2,880,000<br>3,600,000<br>4,320,000   | .80<br>1.60<br>2.39<br>3.19<br>3.99<br>4.79   | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19   | .09<br>.34<br>.71<br>I.22<br>1.88<br>2.68   | .63<br>1.26<br>1.89<br>2.52<br>3.15<br>3.78   | .13<br>.44<br>.93<br>1.60<br>2.45<br>3.48   | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51   | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06   | .08<br>.27<br>.56<br>.96<br>I.47<br>2.09   | .04<br>.12<br>.24<br>.42<br>.64  | .35<br>.71<br>1.06<br>1.42<br>1.77<br>2.13   | .04<br>.12<br>.24<br>.41<br>.62  | .02<br>.05<br>.10<br>.18<br>.27   | .23<br>.45<br>.68<br>.91<br>1.13   | .01<br>.04<br>.09<br>.15<br>.22  | .00<br>.02<br>.04<br>.06<br>.09  | .16<br>.32<br>.47<br>.63<br>.79  | .01<br>.02<br>.04<br>.06<br>.09  | .00<br>.01<br>.02<br>.03<br>.04   |  |
| 500<br>1,000<br>1,500<br>2,000<br>2,500<br>3,000<br>3,500  | 720,000<br>1,440,000<br>2,160,000<br>2,880,000<br>3,600,000<br>4,320,000<br>5,040,000  | .80<br>1.60<br>2.39<br>3.19<br>3.99<br>4.79<br>5.59                                 | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37                                     | .09<br>.34<br>.71<br>1.22<br>1.88<br>2.68<br>3.63                                 | .63<br>1.26<br>1.89<br>2.52<br>3.15<br>3.78<br>4.41                                 | .13<br>-44<br>-93<br>1.60<br>2.45<br>3.48<br>4.70   | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51<br>2.03   | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06<br>3.57   | .08<br>.27<br>.56<br>.96<br>I.47<br>2.09<br>2.81   | .04<br>.12<br>.24<br>.42<br>.64<br>.90   | .35<br>.71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48   | .04<br>.12<br>.24<br>.41<br>.62<br>.87   | .02<br>.05<br>.10<br>.18<br>.27   | .23<br>.45<br>.68<br>.91<br>1.13<br>1.36   | .01<br>.04<br>.09<br>.15<br>.22<br>.30   | .00<br>.02<br>.04<br>.06<br>.09  | .16<br>.32<br>.47<br>.63<br>.79<br>.95   | .01<br>.02<br>.04<br>.06<br>.09<br>.13   | .00<br>.01<br>.02<br>.03<br>.04<br>.06  |  |
| 500<br>1,000<br>1,500<br>2,000<br>2,500<br>3,000<br>3,500<br>4,000   | 720,000<br>1,440,000<br>2,160,000<br>2,880,000<br>3,600,000<br>4,320,000<br>5,040,000<br>5,760,000   | .80<br>1.60<br>2.39<br>3.19<br>3.99<br>4.79<br>5.59<br>6.38                         | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>10.87                            | .09<br>.34<br>.71<br>1.22<br>1.88<br>2.68<br>3.63<br>4.71                         | .63<br>1.26<br>1.89<br>2.52<br>3.15<br>3.78<br>4.41<br>5.04                         | .13<br>.44<br>.93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09                                   | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51<br>2.03<br>2.64                                 | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06<br>3.57<br>4.08   | .08<br>.27<br>.56<br>.96<br>1.47<br>2.09<br>2.81<br>3.64   | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58   | .35<br>.71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>2.84   | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.50   | .02<br>.05<br>.10<br>.18<br>.27<br>.38<br>.50   | .23<br>.45<br>.68<br>.91<br>1.13<br>1.36<br>1.59   | .01<br>.04<br>.09<br>.15<br>.22<br>.30<br>.40  | .00<br>.02<br>.04<br>.06<br>.09<br>.13   | .16<br>.32<br>.47<br>.63<br>.79<br>.95<br>1.10   | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17  | .00<br>.01<br>.02<br>.03<br>.04<br>.06<br>.07   |  |
| 500<br>1,000<br>1,500<br>2,000<br>2,500<br>3,000<br>3,600<br>4,000<br>4,500  | 720,000<br>1,440,000<br>2,160,000<br>2,880,000<br>3,600,000<br>4,320,000<br>5,040,000<br>6,480,000   | .80<br>1.60<br>2.39<br>3.19<br>3.99<br>4.79<br>5.59<br>6.38<br>7.18                 | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>10.87                            | .09<br>.34<br>.71<br>1.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5.93                 | .63<br>1.26<br>1.89<br>2.52<br>3.15<br>3.78<br>4.41<br>5.04<br>5.67                 | .13<br>.44<br>.93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67                           | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51<br>2.03<br>2.64<br>3.32                         | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06<br>3.57<br>4.08<br>4-59                                 | .08<br>.27<br>.56<br>.96<br>1.47<br>2.09<br>2.81<br>3.64<br>4.58   | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58<br>1.98                                 | .35<br>.71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>2.84<br>3.19   | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.50<br>1.88   | .02<br>.05<br>.10<br>.18<br>.27<br>.58<br>.50<br>.65  | .23<br>.45<br>.68<br>.91<br>1.13<br>1.36<br>1.59<br>1.82<br>2.04   | .01<br>.04<br>.09<br>.15<br>.22<br>.30<br>.40<br>.52   | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22   | .16<br>.32<br>.47<br>.63<br>.79<br>.95<br>I.10<br>I.26<br>I.42   | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22   | .00<br>.01<br>.02<br>.03<br>.04<br>.06<br>.07   |  |
| 500<br>1,000<br>1,500<br>2,000<br>2,500<br>3,000<br>3,500<br>4,000<br>4,500<br>5,000   | 720,000 1,440,000 2,160,000 2,880,000 3,600,000 4,320,000 5,040,000 6,480,000 7,200,000  | .80<br>1.60<br>2.39<br>3.19<br>3.99<br>4.79<br>5.59<br>6.38<br>7.18<br>7.98         | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>10.87<br>13.70<br>16.85          | .09<br>.34<br>.71<br>1.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5.93<br>7.30         | .63<br>1.26<br>1.89<br>2.52<br>3.15<br>3.78<br>4.41<br>5.67<br>6.30                 | .13<br>.44<br>.93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67<br>9.43                   | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51<br>2.03<br>2.64<br>3.32<br>4.08                 | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06<br>3.57<br>4.08<br>4.59<br>5.11                         | .08<br>.27<br>.56<br>.96<br>I.47<br>2.09<br>2.81<br>3.64<br>4.58<br>5.62                                 | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58<br>1.98<br>2.43                         | ·35<br>.71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>2.84<br>3.19<br>3.55   | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.50<br>1.88<br>2.31   | .02<br>.05<br>.10<br>.18<br>.27<br>.38<br>.50   | .23<br>.45<br>.68<br>.91<br>1.13<br>1.36<br>1.59<br>1.82<br>2.04<br>2.27   | .01<br>.04<br>.09<br>.15<br>.22<br>.30<br>.40<br>.52<br>.64  | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.28  | .16<br>.32<br>.47<br>.63<br>.79<br>.95<br>1.10<br>1.26<br>1.42<br>1.58   | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.27  | .00<br>.01<br>.02<br>.03<br>.04<br>.06<br>.07<br>.09  |  |
| 500<br>1,000<br>1,500<br>2,000<br>2,500<br>3,000<br>3,000<br>4,000<br>4,500<br>5,500   | 720,000 1,440,000 2,160,000 2,880,000 3,600,000 4,320,000 5,760,000 6,480,000 7,920,000 8,640,000  | .80<br>1.60<br>2.39<br>3.19<br>3.99<br>4.79<br>5.59<br>6.38<br>7.18                 | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>10.87                            | .09<br>.34<br>.71<br>1.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5.93                 | .63<br>1.26<br>1.89<br>2.52<br>3.15<br>3.78<br>4.41<br>5.04<br>5.67                 | .13<br>.44<br>.93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67                           | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51<br>2.03<br>2.64<br>3.32                         | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06<br>3.57<br>4.08<br>4.59<br>5.62<br>6.13                 | .08<br>.27<br>.56<br>.96<br>I.47<br>2.09<br>2.81<br>3.64<br>4.58<br>5.62<br>6.77<br>8.03                 | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58<br>1.98<br>2.43<br>2.93                 | .35<br>.71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>2.84<br>3.19<br>3.55<br>3.90<br>4.26   | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.50<br>1.88<br>2.31<br>2.77                                 | .02<br>.05<br>.10<br>.18<br>.27<br>.38<br>.50<br>.65<br>.82   | .23<br>.45<br>.68<br>.91<br>1.13<br>1.36<br>1.59<br>1.82<br>2.04<br>2.27<br>2.50<br>2.72   | .01<br>.04<br>.09<br>.15<br>.22<br>.30<br>.40<br>.52   | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.28<br>.34<br>.41  | .16<br>.32<br>.47<br>.63<br>.79<br>.95<br>I.10<br>I.26<br>I.42   | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.27<br>.33   | .00<br>.01<br>.02<br>.03<br>.04<br>.06<br>.07   |  |
| 500<br>1,000<br>1,500<br>2,000<br>2,500<br>3,000<br>3,400<br>4,500<br>4,500<br>5,500<br>6,000<br>7,000   | 720,000<br>*,440,000<br>2,160,000<br>2,880,000<br>3,600,000<br>4,320,000<br>5,760,000<br>6,480,000<br>7,200,000<br>7,920,000<br>8,640,000<br>10,080,000  | .80<br>1.60<br>2.39<br>3.19<br>3.99<br>5.59<br>6.38<br>7.18<br>7.98<br>8.79         | .22<br>.76<br>I.63<br>2.82<br>4.34<br>6.19<br>8.37<br>I0.87<br>I3.70<br>I6.85<br>20.33 | .09<br>.34<br>.71<br>1.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5.93<br>7.30<br>8.71 | .63<br>1.26<br>1.89<br>2.52<br>3.15<br>3.78<br>4.41<br>5.04<br>5.67<br>6.30<br>6.93 | .13<br>.44<br>.93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67<br>9.43<br>11.38<br>13.49 | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51<br>2.03<br>2.64<br>3.32<br>4.08<br>4.92         | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06<br>3.57<br>4.08<br>4.59<br>5.11<br>5.62<br>6.13<br>7.15 | .08<br>.27<br>.56<br>.96<br>I.47<br>2.09<br>2.81<br>3.64<br>4.58<br>5.62<br>6.77<br>8.03<br>10.86        | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58<br>1.98<br>2.43<br>2.93<br>3.48<br>4.71 | 35<br>.71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>2.84<br>3.19<br>3.55<br>3.90<br>4.26<br>4.96                                  | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.50<br>1.88<br>2.31<br>2.77<br>3.28<br>4.43                 | .02<br>.05<br>.10<br>.18<br>.27<br>.58<br>.50<br>.65<br>.82<br>1.00<br>1.42<br>1.92                         | .23<br>.45<br>.68<br>.91<br>1.13<br>1.36<br>1.59<br>1.82<br>2.04<br>2.27<br>2.50<br>2.72<br>3.18                                 | .01<br>.04<br>.09<br>.15<br>.22<br>.30<br>.40<br>.52<br>.64<br>.78<br>.94<br>1.11  | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.28<br>.34<br>.41  | .16<br>.32<br>.47<br>.63<br>.79<br>.95<br>1.10<br>1.26<br>1.42<br>1.73<br>1.89<br>2.21   | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.27<br>.33<br>.39<br>.46   | .00<br>.01<br>.02<br>.03<br>.04<br>.06<br>.07<br>.09<br>.12<br>.14<br>.17   |  |
| 500<br>1,000<br>1,500<br>2,000<br>2,500<br>3,000<br>4,500<br>4,500<br>5,500<br>6,000<br>7,000<br>8,000   | 720,000 1,440,000 2,160,000 2,880,000 3,600,000 4,330,000 5,740,000 5,760,000 6,480,000 7,200,000 7,200,000 8,640,000 10,080,000 11,520,000  | .80<br>1.60<br>2.39<br>3.19<br>4.79<br>5.59<br>6.38<br>7.18<br>7.98<br>8.78         | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>10.87<br>13.70<br>16.85<br>20.33 | .09<br>.34<br>.71<br>I.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5.93<br>7.30<br>8.71 | .63<br>1.26<br>1.89<br>2.52<br>3.15<br>3.78<br>4.41<br>5.67<br>6.30<br>6.93<br>7.57 | .13<br>-44<br>-93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67<br>9.43<br>11.38<br>13.49 | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51<br>2.03<br>2.64<br>3.32<br>4.08<br>4.92<br>5.84 | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06<br>3.57<br>4.08<br>4.59<br>5.11<br>5.62<br>6.13<br>7.15 | .08<br>.27<br>.56<br>.96<br>I.47<br>2.09<br>2.81<br>3.64<br>4.58<br>5.62<br>6.77<br>8.03<br>10.86        | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58<br>1.98<br>2.43<br>2.93<br>3.48<br>4.71 | .35<br>.71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>3.19<br>3.55<br>3.90<br>4.26<br>4.96<br>5.67                                 | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.50<br>1.88<br>2.31<br>2.77<br>3.28<br>4.43<br>5.75         | .02<br>.05<br>.10<br>.18<br>.27<br>.58<br>.50<br>.65<br>.82<br>1.00<br>1.42<br>1.92<br>2.49                 | .23<br>.45<br>.68<br>.91<br>1.36<br>1.36<br>1.82<br>2.04<br>2.27<br>2.50<br>2.72<br>3.63   | .01<br>.04<br>.09<br>.15<br>.22<br>.30<br>.40<br>.52<br>.64<br>.78<br>.94<br>1.11<br>1.49                                    | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.28<br>.34<br>.41<br>.48   | .16<br>.32<br>.47<br>.63<br>.79<br>.95<br>1.10<br>1.26<br>1.42<br>1.58<br>1.73<br>1.89<br>2.21   | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.27<br>.33<br>.39<br>.46   | .00<br>.01<br>.02<br>.03<br>.04<br>.06<br>.07<br>.09<br>.12<br>.14<br>.17<br>.20  |  |
| 500<br>1,000<br>1,500<br>2,000<br>2,500<br>3,000<br>4,000<br>4,000<br>5,000<br>5,500<br>6,000<br>7,000<br>9,000  | 720,000 ',440,000 2,160,000 2,880,000 3,600,000 4,320,000 5,740,000 5,760,000 7,920,000 7,920,000 10,080,000 11,520,000 12,960,000   | .80<br>1.60<br>2.39<br>3.19<br>3.99<br>4.79<br>5.59<br>6.38<br>7.18<br>7.98<br>8.78 | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>10.87<br>13.70<br>16.85<br>20.33 | .09<br>.34<br>.71<br>I.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5.93<br>7.30<br>8.71 | .63<br>1.26<br>1.86<br>2.52<br>3.15<br>3.78<br>4.41<br>5.67<br>6.30<br>6.93<br>7.57 | .13<br>-44<br>-93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67<br>9.43<br>11.38<br>13.49 | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51<br>2.03<br>2.64<br>3.32<br>4.08<br>4.92<br>5.84 | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06<br>3.57<br>4.08<br>4.59<br>5.11<br>5.62<br>6.13<br>7.15 | .08<br>.27<br>.56<br>.96<br>I.47<br>2.09<br>2.81<br>3.64<br>4.58<br>5.62<br>6.77<br>8.03<br>10.86        | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58<br>1.98<br>2.43<br>2.93<br>3.48<br>4.71 | 35<br>.71<br>1.05<br>1.42<br>1.77<br>2.13<br>2.48<br>2.84<br>3.19<br>3.55<br>3.90<br>4.26<br>4.96<br>5.67<br>6.38                  | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.50<br>1.88<br>2.31<br>2.77<br>3.28<br>4.43                 | .02<br>.05<br>.10<br>.18<br>.27<br>.58<br>.50<br>.65<br>.82<br>1.00<br>1.42<br>1.92<br>2.49<br>3.14         | .23<br>.45<br>.68<br>.91<br>1.13<br>1.36<br>1.59<br>1.82<br>2.04<br>2.27<br>2.50<br>2.72<br>3.63<br>4.08                         | .01<br>.04<br>.09<br>.15<br>.22<br>.30<br>.40<br>.52<br>.64<br>.78<br>.94<br>1.11<br>1.49<br>1.93<br>2.43                    | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.28<br>.34<br>.41<br>.48<br>.65<br>.84   | .16<br>.32<br>.47<br>.63<br>.79<br>.95<br>1.10<br>1.26<br>1.42<br>1.58<br>1.73<br>1.89<br>2.21<br>2.52                                 | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.27<br>.33<br>.39<br>.46<br>.62<br>.80   | .00<br>.01<br>.02<br>.03<br>.04<br>.06<br>.07<br>.09<br>.12<br>.14<br>.17<br>.20  |  |
| 500<br>1,000<br>1,500<br>2,000<br>2,500<br>3,000<br>4,000<br>4,000<br>4,000<br>5,000<br>5,000<br>7,000<br>8,000<br>9,000   | 720,000 1,440,000 2,160,000 2,760,000 3,500,000 4,330,000 5,760,000 5,760,000 7,920,000 8,640,000 10,080,000 11,520,000 11,520,000 14,400,000  | .80 1.60 2.39 3.19 3.99 4.79 5.59 6.38 7.18 7.98 8.78                               | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>10.87<br>13.70<br>16.85<br>20.33 | .09<br>.34<br>.71<br>I.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5.93<br>7.30<br>8.71 | .63<br>1.26<br>1.89<br>2.52<br>3.15<br>3.78<br>4.41<br>5.67<br>6.30<br>6.93<br>7.57 | .13<br>-44<br>-93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67<br>9.43<br>11.38<br>13.49 | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51<br>2.03<br>2.64<br>3.32<br>4.08<br>4.92<br>5.84 | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06<br>3.57<br>4.08<br>4.59<br>5.11<br>5.62<br>6.13<br>7.15 | .08<br>.27<br>.56<br>.96<br>I.47<br>2.09<br>2.81<br>3.64<br>4.58<br>5.62<br>6.77<br>8.03<br>10.86        | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58<br>1.98<br>2.43<br>2.93<br>3.48<br>4.71 | .35<br>.71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>3.19<br>3.55<br>3.90<br>4.26<br>4.96<br>5.67                                 | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.50<br>1.88<br>2.31<br>2.77<br>3.28<br>4.43<br>5.75<br>7.25 | .02<br>.05<br>.10<br>.18<br>.27<br>.58<br>.50<br>.65<br>.82<br>1.00<br>1.42<br>1.92<br>2.49                 | .23<br>.45<br>.68<br>.91<br>1.13<br>1.36<br>1.59<br>1.82<br>2.04<br>2.27<br>2.50<br>2.72<br>3.18<br>3.63<br>4.08                 | .01<br>.04<br>.09<br>.15<br>.22<br>.30<br>.40<br>.52<br>.64<br>.78<br>.94<br>1.11<br>1.49<br>2.43<br>2.43                    | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.28<br>.34<br>.41<br>.48<br>.65<br>.84<br>1.05   | .16<br>.32<br>.47<br>.63<br>.79<br>.95<br>1.10<br>1.26<br>1.42<br>1.73<br>1.89<br>2.21<br>2.52<br>2.84<br>3.15                         | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.27<br>.33<br>.46<br>.62<br>.80<br>.100<br>1.23  | .00<br>.01<br>.02<br>.03<br>.04<br>.06<br>.07<br>.09<br>.12<br>.14<br>.17<br>.20  |  |
| 500<br>1,000<br>1,500<br>2,500<br>2,500<br>3,000<br>3,000<br>4,500<br>5,500<br>6,000<br>7,000<br>8,000<br>9,000<br>11,000  | 720,000 ',440,000 2,160,000 2,880,000 3,600,000 4,320,000 5,740,000 5,760,000 7,920,000 7,920,000 10,080,000 11,520,000 12,960,000   | .80<br>1.60<br>2.39<br>3.19<br>3.99<br>4.79<br>5.59<br>6.38<br>7.18<br>7.98<br>8.78 | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>10.87<br>13.70<br>16.85<br>20.33 | .09<br>.34<br>.71<br>I.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5.93<br>7.30<br>8.71 | .63<br>1.26<br>1.86<br>2.52<br>3.15<br>3.78<br>4.41<br>5.67<br>6.30<br>6.93<br>7.57 | .13<br>-44<br>-93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67<br>9.43<br>11.38<br>13.49 | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51<br>2.03<br>2.64<br>3.32<br>4.08<br>4.92<br>5.84 | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06<br>3.57<br>4.08<br>4.59<br>5.11<br>5.62<br>6.13<br>7.15 | .08<br>.27<br>.56<br>.96<br>1.47<br>2.09<br>2.81<br>3.64<br>4.58<br>5.62<br>6.77<br>8.03<br>10.86        | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58<br>1.98<br>2.43<br>2.93<br>3.48<br>4.71 | .35<br>.71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>2.84<br>3.19<br>3.55<br>3.90<br>4.26<br>4.96<br>5.67<br>6.38                 | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.50<br>1.88<br>2.31<br>2.77<br>3.28<br>4.43<br>5.75         | .02<br>.05<br>.10<br>.18<br>.27<br>.58<br>.50<br>.65<br>.82<br>1.00<br>1.42<br>1.92<br>2.49<br>3.14         | .23<br>.45<br>.68<br>.91<br>1.13<br>1.36<br>1.59<br>1.82<br>2.04<br>2.27<br>2.50<br>2.72<br>3.63<br>4.08                         | .01<br>.04<br>.09<br>.15<br>.22<br>.30<br>.40<br>.52<br>.64<br>.78<br>.94<br>1.11<br>1.49<br>1.93<br>2.43                    | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.28<br>.34<br>.41<br>.48<br>.65<br>.84<br>1.05   | .16<br>.32<br>.47<br>.63<br>.79<br>.95<br>1.10<br>1.26<br>1.73<br>1.88<br>1.73<br>1.88<br>1.73<br>2.21<br>2.52<br>2.84<br>3.15<br>3.46 | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.27<br>.33<br>.39<br>.46<br>.62<br>.80   | .00<br>.01<br>.02<br>.03<br>.04<br>.06<br>.07<br>.09<br>.12<br>.14<br>.17<br>.20<br>.27<br>.35<br>.43   |  |
| 500<br>1,000<br>1,500<br>2,000<br>3,000<br>3,000<br>4,000<br>5,500<br>6,000<br>7,000<br>8,000<br>9,000<br>10,000<br>11,000<br>12,000   | 720,000 1,440,000 2,160,000 2,800,000 3,500,000 4,330,000 5,760,000 6,480,000 7,920,000 8,640,000 10,080,000 11,520,000 12,960,000 17,280,000 17,280,000 17,280,000 17,280,000   | .80 1.60 2.39 3.19 3.99 4.79 5.59 6.38 7.18 7.98 8.78                               | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>13.70<br>16.85<br>20.33          | .09<br>.34<br>.71<br>1.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5-93<br>8.71         | .63<br>1.26<br>1.89<br>2.52<br>3.15<br>3.78<br>4.41<br>5.67<br>6.30<br>6.93<br>7.57 | .13<br>-44<br>-93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67<br>9.43<br>11.38<br>13.49 | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51<br>2.03<br>2.64<br>3.32<br>4.08<br>4.92<br>5.84 | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06<br>3.57<br>4.08<br>4.59<br>5.11<br>5.62<br>6.13<br>7.15 | .08<br>.27<br>.56<br>.96<br>.96<br>1.47<br>2.09<br>2.81<br>3.64<br>4.58<br>5.62<br>6.77<br>8.03<br>10.86 | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58<br>1.98<br>2.43<br>2.93<br>3.48<br>4.71 | .35<br>.71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>3.19<br>3.55<br>3.95<br>4.96<br>5.67<br>6.38                                 | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.58<br>2.31<br>2.77<br>3.28<br>4.43<br>5.75<br>7.25         | .02<br>.05<br>.10<br>.18<br>.27<br>.58<br>.50<br>.65<br>.82<br>I.00<br>I.20<br>I.42<br>I.92<br>2.49<br>3.I4 | .23<br>.45<br>.68<br>.91<br>1.13<br>1.35<br>1.59<br>2.04<br>2.27<br>2.50<br>2.72<br>3.18<br>3.63<br>4.08<br>4.54<br>5.00<br>5.44 | .01<br>.04<br>.09<br>.15<br>.22<br>.30<br>.40<br>.54<br>.78<br>.94<br>1.11<br>1.49<br>2.43<br>2.98<br>3.59<br>4.25           | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.22<br>.28<br>.34<br>.41<br>.48<br>.65<br>.84<br>1.05<br>1.29<br>1.55<br>1.85  | .16<br>.32<br>.47<br>.63<br>.79<br>.95<br>1.10<br>1.26<br>1.42<br>1.58<br>1.73<br>1.89<br>2.21<br>2.58<br>3.46<br>3.76                 | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.22<br>.27<br>.33<br>.46<br>.62<br>.80<br>.80<br>.1.00<br>1.23<br>1.47<br>1.74                                       | .00<br>.01<br>.02<br>.04<br>.06<br>.07<br>.09<br>.12<br>.14<br>.17<br>.20<br>.27<br>.35<br>.43<br>.53   |  |
| 500<br>1,000<br>1,500<br>2,000<br>3,000<br>3,000<br>4,500<br>4,500<br>5,500<br>6,000<br>7,000<br>10,000<br>11,000<br>11,000<br>11,000  | 720,000 ',440,000 2,160,000 2,880,000 3,500,000 5,760,000 6,480,000 7,200,000 7,200,000 10,580,000 11,520,000 12,960,000 11,520,000 14,400,000 15,840,000 17,720,000 20,160,000 20,160,000   | .80<br>1.60<br>2.39<br>3.19<br>3.99<br>4.79<br>6.38<br>7.18<br>8.78                 | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>10.87<br>13.70<br>16.85<br>20.33 | .09<br>.34<br>.71<br>1.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5.93<br>7.30<br>8.71 | .633 1.26 1.89 2.52 3.15 3.78 4.41 5.04 5.630 6.93 7.57                             | .13<br>.44<br>.93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67<br>9.43<br>11.38<br>13.49 | .06<br>.19<br>.40<br>.69<br>1.06<br>1.51<br>2.03<br>2.64<br>3.32<br>4.08<br>4.92<br>5.84 | .51<br>1.02<br>1.53<br>2.04<br>2.55<br>3.06<br>3.57<br>4.08<br>4.59<br>5.11<br>5.62<br>7.15         | .08<br>.27<br>.56<br>.96<br>I.47<br>2.89<br>2.81<br>3.64<br>4.58<br>5.62<br>6.77<br>8.03<br>I0.86        | .04<br>.12<br>.24<br>.64<br>.90<br>1.28<br>1.58<br>1.98<br>2.43<br>2.93<br>3.48<br>4.71        | .35<br>.71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>2.84<br>3.19<br>4.26<br>4.96<br>6.39   | .04<br>.12<br>.41<br>.62<br>.87<br>1.16<br>1.50<br>1.88<br>2.31<br>2.77<br>3.28<br>4.43<br>5.75<br>7.25        | .02<br>.05<br>.10<br>.18<br>.27<br>.28<br>.50<br>.65<br>.82<br>1.00<br>1.42<br>1.92<br>2.49<br>3.14         | .23<br>.45<br>.68<br>.91<br>1.36<br>1.59<br>1.82<br>2.04<br>2.27<br>2.50<br>2.72<br>3.63<br>4.08<br>4.54<br>5.90<br>5.44<br>5.90 | .01<br>.04<br>.09<br>.15<br>.22<br>.30<br>.40<br>.54<br>.78<br>.94<br>1.11<br>1.49<br>2.43<br>2.98<br>3.59<br>4.25           | .00<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.28<br>.34<br>.41<br>.48<br>.65<br>.84<br>1.05<br>1.29<br>1.55<br>1.84<br>2.15  | .16<br>.32<br>.47<br>.63<br>.79<br>.95<br>1.10<br>1.26<br>1.42<br>1.73<br>1.89<br>2.21<br>2.84<br>3.15<br>3.78<br>4.49                 | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.27<br>.33<br>.39<br>.46<br>.62<br>.80<br>1.00<br>1.23<br>1.47<br>1.74<br>2.03                         | .00<br>.01<br>.02<br>.04<br>.06<br>.07<br>.09<br>.12<br>.14<br>.17<br>.20<br>.27<br>.43<br>.53<br>.64<br>.75<br>.88                             |  |
| 500<br>1,000<br>1,500<br>2,000<br>3,000<br>3,000<br>4,500<br>5,000<br>6,000<br>7,000<br>8,000<br>10,000<br>11,000<br>11,000<br>11,000<br>11,000                                | 720,000 ',440,000 2,160,000 2,160,000 3,500,000 4,330,000 5,760,000 5,760,000 6,480,000 7,920,000 8,640,000 10,080,000 11,520,000 11,520,000 12,960,000 13,840,000 15,840,000 17,280,000 18,720,000 20,160,000   | .80<br>1.60<br>2.39<br>3.19<br>4.79<br>5.59<br>7.18<br>7.98<br>8.78                 | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>10.87<br>13.70<br>16.85<br>20.33 | .09<br>.34<br>.71<br>1.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5-93<br>8.71         | .63 1.26 1.89 2.52 3.15 3.78 4.41 5.67 6.30 6.93 7.57                               | .13<br>.44<br>.93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67<br>9.43<br>11.38<br>13.49 | .06<br>.19<br>.40<br>.69<br>1.05<br>1.51<br>2.03<br>2.64<br>3.32<br>4.08<br>4.92<br>5.84 | Feet  .51 1.02 1.53 2.04 2.55 3.06 3.57 4.08 4.59 5.11 5.62 6.13 7.15                               | .08<br>.27<br>.56<br>.96<br>.96<br>1.47<br>2.09<br>2.81<br>3.64<br>4.58<br>5.62<br>6.77<br>8.03<br>10.86 | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58<br>1.98<br>2.43<br>2.93<br>3.48<br>4.71 | -35<br>-71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>2.84<br>3.19<br>3.55<br>3.95<br>4.26<br>4.96<br>6.35                         | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.50<br>1.88<br>2.31<br>2.77<br>3.28<br>4.43<br>5.75<br>7.25 | .02<br>.05<br>.10<br>.18<br>.27<br>.50<br>.65<br>.82<br>1.00<br>1.42<br>1.92<br>2.49<br>3.14                | .23<br>.45<br>.68<br>.91<br>1.36<br>1.59<br>2.27<br>2.72<br>3.18<br>3.63<br>4.54<br>5.94<br>4.54<br>5.94<br>6.86                 | .01<br>.09<br>.15<br>.22<br>.30<br>.52<br>.64<br>.94<br>1.11<br>1.93<br>2.43<br>2.98<br>4.25<br>4.97<br>5.75<br>6.58         | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.28<br>.34<br>.41<br>.41<br>.45<br>.1.05<br>1.25<br>1.25<br>1.84<br>2.15<br>2.49                               | .16<br>.32<br>.47<br>.63<br>.79<br>.95<br>1.10<br>1.26<br>1.42<br>1.73<br>1.89<br>2.21<br>2.52<br>2.84<br>3.15<br>4.09<br>4.41<br>4.73 | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.27<br>.33<br>.39<br>.46<br>.62<br>.80<br>1.00<br>1.23<br>1.47<br>1.74<br>2.03<br>2.35                 | .00<br>.01<br>.03<br>.04<br>.06<br>.07<br>.09<br>.12<br>.14<br>.17<br>.20<br>.27<br>.35<br>.43<br>.53<br>.43<br>.53<br>.64<br>.75<br>.88<br>.88 |  |
| 500<br>1,000<br>1,500<br>2,000<br>3,000<br>3,500<br>4,000<br>4,000<br>5,500<br>6,000<br>7,000<br>10,000<br>11,000<br>11,000<br>11,000<br>11,000<br>11,000<br>11,000            | 720,000 1,440,000 2,150,000 2,580,000 3,500,000 4,330,000 5,760,000 6,480,000 7,900,000 8,640,000 11,520,000 11,520,000 11,580,000 11,580,000 11,580,000 11,580,000 11,580,000 21,600,000 21,600,000 21,600,000 21,600,000   | .80 1.60 2.39 3.199 4.79 5.59 6.38 7.18 7.18  | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>10.87<br>13.70<br>16.85<br>20.33 | .09<br>.34<br>.71<br>I.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5.93<br>7.30<br>8.71 | .63 1.26 1.89 2.52 3.15 3.78 4.41 5.67 6.30 6.93 7.57                               | .13<br>.44<br>.93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67<br>9.43<br>11.38<br>13.49 | .06 .19 .40 .69 1.06 1.51 2.03 2.64 .08 4.92 5.84  | Feet  .51 1.02 1.53 2.04 2.55 3.06 3.57 4.08 5.11 5.62 6.13 7.15                                    | .08 .27 .56 .96 .1.47 2.09 2.81 3.64 4.58 5.62 6.77 8.03 10.86   | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>I.22<br>I.58<br>I.98<br>2.43<br>2.93<br>3.48<br>4.71 | -35<br>-71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>2.84<br>2.84<br>3.55<br>3.99<br>3.55<br>3.99<br>4.26<br>4.96<br>5.67<br>6.39 | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.50<br>1.88<br>2.31<br>2.77<br>3.28<br>4.43<br>5.75<br>7.25 | .02<br>.05<br>.10<br>.18<br>.27<br>.58<br>.50<br>.65<br>.82<br>I.00<br>I.42<br>I.92<br>2.49<br>3.I4         | .23<br>.45<br>.68<br>.91<br>1.13<br>1.36<br>1.59<br>1.82<br>2.27<br>2.50<br>2.72<br>3.18<br>3.63<br>4.54<br>5.90<br>6.36<br>6.36 | .01<br>.09<br>.15<br>.22<br>.30<br>.52<br>.64<br>.74<br>.94<br>1.11<br>1.49<br>2.43<br>2.98<br>3.59<br>4.25<br>4.97<br>5.758 | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.28<br>.34<br>.41<br>.48<br>.65<br>.84<br>.1.29<br>.1.55<br>.1.29<br>.1.55<br>.2.49<br>.2.15<br>.2.49<br>.2.28 | 16 .32 .47 .63 .79 .910 1.26 1.42 1.58 1.73 1.821 2.52 2.84 5.346 8.409 4.41 4.73 5.05   | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.27<br>.33<br>.39<br>.46<br>.62<br>.80<br>1.23<br>1.47<br>1.74<br>2.03<br>2.35<br>2.69                 | .00<br>.01<br>.03<br>.04<br>.06<br>.07<br>.09<br>.12<br>.14<br>.17<br>.27<br>.35<br>.43<br>.53<br>.54<br>.75<br>.88<br>.88<br>.102<br>.1132     |  |
| 500<br>1,000<br>1,500<br>2,000<br>3,000<br>4,500<br>4,500<br>5,500<br>6,000<br>7,000<br>10,000<br>11,000<br>11,000<br>11,000<br>11,000<br>11,000<br>11,000<br>11,000<br>11,000 | 720,000 ',440,000 2,160,000 2,160,000 3,500,000 4,330,000 5,760,000 6,480,000 7,920,000 8,640,000 10,080,000 11,520,000 11,520,000 12,960,000 11,520,000 12,960,000 | .80<br>1.60<br>2.39<br>3.19<br>4.79<br>5.59<br>7.18<br>7.98<br>8.78                 | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>10.87<br>13.70<br>16.85<br>20.33 | .09<br>.34<br>.71<br>1.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5-93<br>8.71         | .63 1.26 1.89 2.52 3.15 3.78 4.41 5.67 6.30 6.93 7.57                               | .13<br>.44<br>.93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67<br>9.43<br>11.38<br>13.49 | .06<br>.19<br>.40<br>.69<br>1.05<br>1.51<br>2.03<br>2.64<br>3.32<br>4.08<br>4.92<br>5.84 | Feet  .51 1.02 1.53 2.04 2.55 3.06 3.57 4.08 4.59 5.11 5.62 6.13 7.15                               | .08<br>.27<br>.56<br>.96<br>.96<br>1.47<br>2.09<br>2.81<br>3.64<br>4.58<br>5.62<br>6.77<br>8.03<br>10.86 | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58<br>1.98<br>2.43<br>2.93<br>3.48<br>4.71 | -35<br>-71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>3.19<br>3.59<br>4.26<br>4.96<br>6.39   | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.58<br>2.31<br>2.77<br>3.28<br>4.43<br>5.75<br>7.25         | .02<br>.05<br>.10<br>.18<br>.27<br>.50<br>.65<br>.82<br>1.00<br>1.20<br>1.22<br>2.49<br>3.14                | .23<br>.45<br>.68<br>.91<br>1.36<br>1.59<br>2.27<br>2.72<br>3.18<br>3.63<br>4.54<br>5.94<br>4.54<br>5.94<br>6.86                 | .01<br>.09<br>.15<br>.22<br>.30<br>.52<br>.64<br>.94<br>1.11<br>1.93<br>2.43<br>2.98<br>4.25<br>4.97<br>5.75<br>6.58         | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.28<br>.34<br>.41<br>.41<br>.48<br>.65<br>.84<br>1.05<br>1.29<br>1.55<br>1.84<br>2.49<br>2.85                  | 1ty in Feet .16 .32 .47 .63 .795 1.10 1.26 1.42 1.58 1.78 1.89 2.21 2.52 2.84 3.156 3.78 4.09 4.73 5.36                                | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.27<br>.33<br>.39<br>.46<br>.62<br>.80<br>1.00<br>1.23<br>1.47<br>1.74<br>2.03<br>2.35<br>2.69<br>3.04 | .00<br>.01<br>.03<br>.04<br>.06<br>.07<br>.09<br>.12<br>.14<br>.17<br>.20<br>.27<br>.35<br>.43<br>.53<br>.43<br>.53<br>.64<br>.75<br>.88<br>.88 |  |
| 500<br>1,000<br>1,500<br>2,000<br>3,000<br>3,500<br>4,500<br>5,000<br>6,000<br>7,000<br>8,000<br>9,000<br>10,000<br>11,000<br>12,000<br>12,000<br>14,000<br>15,000             | 720,000 1,440,000 2,150,000 2,580,000 3,500,000 4,330,000 5,760,000 6,480,000 7,900,000 8,640,000 11,520,000 11,520,000 11,580,000 11,580,000 11,580,000 11,580,000 11,580,000 21,600,000 21,600,000 21,600,000 21,600,000   | .80 1.60 2.39 3.199 4.79 5.59 6.38 7.18 7.18  | .22<br>.76<br>1.63<br>2.82<br>4.34<br>6.19<br>8.37<br>13.70<br>16.85<br>20.33          | .09<br>.34<br>.71<br>1.22<br>1.88<br>2.68<br>3.63<br>4.71<br>5.93<br>7.30<br>8.71 | .63<br>1.26<br>1.89<br>2.52<br>3.15<br>3.78<br>4.41<br>5.67<br>6.30<br>7.57         | .13<br>-44<br>-93<br>1.60<br>2.45<br>3.48<br>4.70<br>6.09<br>7.67<br>9.43<br>11.38<br>13.49 | .06<br>.19<br>.40<br>.69<br>1.05<br>2.03<br>2.64<br>3.32<br>4.08<br>4.92<br>5.84         | Feet  .51 1.02 1.53 2.04 2.55 3.06 3.57 4.08 4.59 5.11 5.62 6.13 7.15                               | .08 .27 .56 .96 .96 1.47 2.09 2.81 3.64 4.58 5.62 6.77 8.03 10.86  | .04<br>.12<br>.24<br>.42<br>.64<br>.90<br>1.22<br>1.58<br>1.98<br>2.43<br>2.93<br>3.48<br>4.71 | -35<br>-71<br>1.06<br>1.42<br>1.77<br>2.13<br>2.48<br>2.84<br>2.84<br>3.55<br>3.99<br>3.55<br>3.99<br>4.26<br>4.96<br>5.67<br>6.39 | .04<br>.12<br>.24<br>.41<br>.62<br>.87<br>1.16<br>1.50<br>1.88<br>2.31<br>2.77<br>3.28<br>4.43<br>5.75<br>7.25 | .02<br>.05<br>.10<br>.18<br>.27<br>.58<br>.50<br>.65<br>.82<br>I.00<br>I.42<br>I.92<br>2.49<br>3.I4         | .23<br>.45<br>.68<br>.91<br>1.13<br>1.36<br>1.59<br>1.82<br>2.27<br>2.50<br>2.72<br>3.18<br>3.63<br>4.54<br>5.90<br>6.36<br>6.36 | .01<br>.09<br>.15<br>.22<br>.30<br>.40<br>.52<br>.64<br>.78<br>.94<br>1.11<br>1.93<br>2.43<br>3.59<br>4.25<br>6.58           | .00<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.28<br>.34<br>.41<br>.48<br>.65<br>.84<br>.1.29<br>.1.55<br>.1.29<br>.1.55<br>.2.49<br>.2.15<br>.2.49<br>.2.28 | 16 .32 .47 .63 .79 .910 1.26 1.42 1.58 1.73 1.821 2.52 2.84 5.346 8.409 4.41 4.73 5.05   | .01<br>.02<br>.04<br>.06<br>.09<br>.13<br>.17<br>.22<br>.27<br>.33<br>.39<br>.46<br>.62<br>.80<br>1.23<br>1.47<br>1.74<br>2.03<br>2.35<br>2.69                 | .000<br>.010<br>.020<br>.030<br>.040<br>.050<br>.070<br>.090<br>.122<br>.141<br>.177<br>.200<br>.277<br>.335<br>.644<br>.755<br>.888<br>.1.02   |  |

This table may be used in several ways. First: To determine the maximum discharging capacity of any size of pipe under a given head. Second: To find the diameter of pipe for a given discharge and given head. Third: To ascertain the frictional resistance or loss of pressure for a given rate of discharge. Fourth: The quantity of water flowing in any pipe, from the reduction of pressure.

The velocity head and entrance are not included in the friction head given. For the ordinary low velocities in street mains, these can be omitted without affecting appreciably the general result, but for high velocities the correction should be made. There will be a slight reduction of discharge and velocity, or increase of co-efficient and friction for each valve and branch, and a material change in these respects if the pipes are rough or foul.

The Maximum Discharging Capacity, for instance, of 8500 feet of 6" straight cast iron pipe, under a head of 195 feet, may be found as follows: First ascertain the frictional head for 1000 feet, thus: 195 feet divided by 8.5 equals 22.94 as the frictional head in feet per 1000 feet of pipe. By referring to the table it is shown that approximately 1000 feet of 6" pipe under 23.01 feet head will discharge 500 U. S. gallons of water per minute.

To Find the Diameter of Pipe for a Given Discharge.—If it should be required to deliver 4,250,000 gallons per 24 hours, the distance being 20,000 feet and the head 130 feet; the frictional head per 1000 feet would be 6.5 feet, and the table shows that under 6.19 feet head per 1000 feet a 16" pipe will discharge 4,320,000 gallons, which is sufficiently close for estimating purposes.

To Ascertain the Pressure at any Point in a line of Water Main, given its diameter, rate of discharge and static head against which the water is forced. Assume that 500 gallons of water are to be forced per minute, through 5000 feet of 8" cast iron pipe, laid on an incline to a height of 75 feet; what would be the varying pressure at each 1000 feet from the pumps?

The table shows a frictional head of 5.64 feet per 1000 feet of 8" pipe, discharging 500 gallons per minute. If the distance be 5000 feet, the pressure required to overcome friction would be 5 × 5.64 or 28.20 feet head, and the total resistance head at the pumps would be 28.2 feet plus 75 feet, or 103.2 feet, and for every 1000 feet from the pumps, this head would be diminished 5.64 feet plus the vertical ascent; that is, at 3000 feet from the pumps the resistance head would be 61.92 feet. To reduce resistance head in feet to pounds per square inch, divide by 2.3.

The Volume of Water Flowing in a pipe may be found by ascertaining the loss of pressure or frictional resistance per 1000 feet of pipe. To this end, if two accurate gauges, entirely similar in all respects, be placed 1000 feet apart on a line of level 12" pipe, show a loss of one-half pound, the nearest figures indicate a flow of 600 gallons per minute; if the loss be two and one-half pounds, a flow of 1400 gallons, etc. Due allowance should be made for difference in level between the points of observation.

Maximum Velocities of Flow.—As a general rule, the velocities in given pipes should not exceed, in feet, per second, the rates stated in the following table for the respective diameters:

TABLE No. 7.

MAXIMUM VELOCITIES OF FLOW IN SUPPLY AND DISTRIBUTION PIPES.

| Diameter, in inches          | 4   | в   | 8  | 12  | 16  | 20  | 24  | 80  | 86 |
|------------------------------|-----|-----|----|-----|-----|-----|-----|-----|----|
| Velocity in feet, per second | 2.5 | 2.8 | 3. | 3.5 | 4.2 | 4.7 | 5.3 | 6.2 | 7. |



### FLOW OF WATER IN PIPE.

THE convenience of a graphic illustration for quick and ready reference has induced us to give on the following page a logarithmic diagram relating to the flow of water under pressure in clean iron pipe prepared by Geo. T. Prince, M. Am. Society of C. E., after the design of A. Van Muyden, C. E.

Many of the problems relating to the flow of water in pipes can be solved by means of this diagram with sufficient accuracy to meet the requirements of ordinary practice.

Explanation.—The vertical lines indicate frictional head in feet per 1000 feet of run. The horizontal lines indicate the internal diameter of pipe in inches. The lines slightly inclined to the horizontal indicate capacity of discharge in U. S. gallons per minute. The lines inclined at approximately 45° to the horizontal indicate velocity of flow in feet per second.

Example I.—Given a rate of discharge of 1500 gallons per minute and a diameter of pipe of 12", to find the frictional head per 1000 feet of run and the velocity of flow in feet per second.

We find from the diagram that the inclined line indicating a rate of discharge of 1500 gallons per minute intersects the horizontal line indicating pipe of 12" diameter approximately on the vertical line indicating a frictional head of 6 feet per 1000 feet of run and between the inclined lines indicating 4 and 5 feet velocity per second, or about 4.3 feet per second.

Example II.—Given a discharge of 2000 gallons per minute and a frictional head of 4 feet per 1000 feet of run, to find the required diameter of pipe and velocity of flow.

We find from the diagram that the inclined line indicating a rate of discharge of 2000 gallons per minute intersects the vertical line indicating a frictional head of 4 feet per 1000 feet of run between the horizontal lines indicating 14" and 16" diameter of pipe and near the inclined line indicating a velocity of flow of 4 feet per second. In all cases where the line giving the diameter of pipe is between two standard sizes, the larger pipe should be used; therefore, in the present case the diameter of the pipe should be 16", thus increasing the capacity of discharge to about 2500 gallons per minute.

Example III.—Given a frictional head of 6 feet per 1000 feet of run and a diameter of pipe of 30", to find the rate of discharge and velocity of flow.

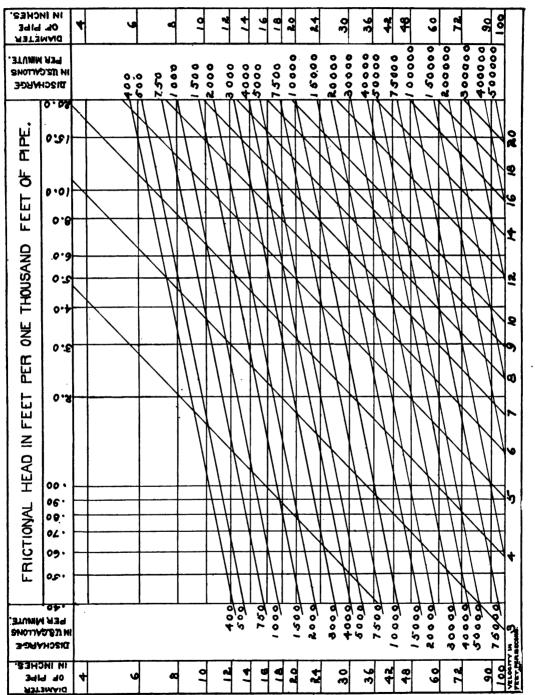
We find the vertical line indicating a frictional head of 6 feet per 1000 feet of run intersects the horizontal line indicating a diameter of pipe of 30" approximately on the inclined line indicating a rate of discharge of 15,000 gallons per minute and between the inclined lines indicating the velocities of 6 and 7 feet per minute, or approximately a velocity of flow of 6.9.

Example IV.—Given a frictional head of 8 feet per 1000 feet of run and a velocity of flow of 7 feet per second to find the diameter of pipe and the rate of discharge.

We find from the diagram that the vertical line indicating a frictional head of 8 feet per 1000 feet of run intersects the inclined line indicating a velocity of flow of 7 feet per second between the horizontal lines indicating pipe of 20" and 24" in diameter. The diameter of pipe would therefore be 24". This pipe with a frictional head of 8 feet per 1000 feet of run would give a discharge of approximately 10,000 gallons per minute.

In determining the size of pipe for given discharge, it should always be remembered that increased resistance will arise caused by corrosion and formations inside the pipe, tending to reduce the discharge from 25 to 40 per cent., which must be added to the required discharge in addition to such allowance as it is always advisable to make for future increase in consumption.





LOGARITHMIC DIAGRAM RELATING TO THE FLOW OF WATER IN CLEAN IRON PIPES UNDER PRESSURE. Prepared by George T. Prince, M. Am. Soc. C. E., after design of A. Van Muyden, C. E.

TABLE No. 8.

For Converting Feet Head of Water into Pressure per Square Inch.

| Feet<br>Head | Pounds per<br>Sq. Inch | Feet<br>Head | Pounds per<br>Sq. Inch | Feet<br>Head | Pounds per<br>Sq. Inch |
|--------------|------------------------|--------------|------------------------|--------------|------------------------|
| 1            | -43                    | 55           | 23.82                  | 190          | 82.29                  |
| 2            | .87                    | 60           | 25.99                  | 200          | 86.62                  |
| 3            | 1.30                   | 65           | 28.15                  | 225          | 97.45                  |
| 4            | 1.73                   | 70           | 30.32                  | 250          | 108.27                 |
| 5            | 2.17                   | 75<br>80     | 32.48                  | 275          | 119.10                 |
|              | 2.60                   | 80           | 34.65                  | 300          | 129.93                 |
| 7            | 3.03                   | 85           | 36.81                  | 325          | 140.75                 |
|              | 3.40                   | 90           | 38.98                  | 350          | 151.58                 |
| 9            | 3.90                   | 95           | 41.14                  | 375          | 162.41                 |
| 10           | 4.33                   | 100          | 43.31                  | 400          | 173.24                 |
| 15           | 6.50                   | 110          | 47.64                  | 500          | 216.55                 |
| 20           | 8.66                   | 120          | 51.97                  | 600          | 259.85                 |
| 25           | 10.83                  | 130          | 56.30                  | 700          | <b>3</b> 03.16         |
| .30          | 12.99                  | 140          | 60.63                  | 800          | 346.47                 |
| <b>3</b> 5   | 15.16                  | 150          | 64.96                  | 900          | 389.78                 |
| 40           | 17.32                  | 160          | 69 29                  | 1000         | 433.c9                 |
| 45           | 19.40                  | 170          | 73 63                  |              |                        |
| 50           | 21 65                  | 180          | 77.96                  |              |                        |

TABLE No. 9.

FOR CONVERTING PRESSURE PER SQUARE INCH INTO FEET HEAD OF WATER.

| Pounds per<br>Sq. Inch |        |          | Feet<br>Head | Pounds per<br>Sq. Inch | Feet<br>Head |  |
|------------------------|--------|----------|--------------|------------------------|--------------|--|
| 1                      | 2.31   | 55<br>60 | 126.99       | 190                    | 438.90       |  |
| 2                      | 4.62   | 60       | 138 54       | 200                    | 461.78       |  |
| 3                      | 6.93   | 65       | 150.08       | 225                    | 519.51       |  |
| 4                      | 9.24   | 70       | 161.63       | 250                    | 577.24       |  |
| 5                      | 11.54  |          | 173.17       | 275                    | 643.06       |  |
| Ĝ                      | 13.85  | 75<br>80 | 184.72       | 300                    | 692.69       |  |
| 7                      | 16.16  | 85       | 196.26       | 325                    | 750.41       |  |
| 7<br>8                 | 18.47  | 9ō       | 207.81       | 350                    | 808.13       |  |
| 9                      | 20.78  | 95       | 219.35       | 375                    | 865.89       |  |
| Io                     | 23.09  | 100      | 230.90       | 400                    | 922.58       |  |
| 15                     | 34.63  | 110      | 253.98       | 500                    | 1154.48      |  |
| 20                     | 46 18  | 120      | 277.07       |                        |              |  |
| 25                     | 57.72  | 130      | 300.16       |                        | ******       |  |
| 30                     | 69.27  | 140      | 323.25       |                        |              |  |
| <b>3</b> 5             | 80 8i  | 150      | 346.34       |                        |              |  |
| 40                     | 92.36  | 160      | 369.43       |                        | ****         |  |
| 45                     | 103 90 | 170      | 392.52       |                        |              |  |
| 50                     | 115.45 | 180      | 415 61       |                        |              |  |

Resistance of Bends.—As will be seen from the following formulæ and tables, under the low velocities usually found in water works systems, the resistance of a bend with an axial radius equal to the diameter of the pipe, is of little moment. It is usually ignored.

Weisbach, in his "Mechanics of Engineering," gives the following formula for additional head in feet,  $h_b$ , necessary to overcome the resistance of one bend.

$$h_b = z \frac{\psi}{180^{\circ}} \times \frac{v^2}{2 g}$$

in which z is a coefficient of resistance,  $\psi$  the arc of the bend in degrees, and  $h_b$  the additional head required.

The value of "z" he reduces by an empirical formula,

$$z = .131 + 1.847 \left(\frac{r}{\bar{R}}\right)^{\frac{7}{4}}$$

in which r is the radius or semi-diameter of the pipe and R the axial radius of curvature of the bend.

For given ratios of r to R, z has the following values for pipe with circular cross-sections:

TABLE No. 10.

COEFFICIENTS OF RESISTANCE IN BENDS.

| $\frac{r}{R}$ | .1 | .15 | .2<br>.138 | .25 | ·3<br>.158 | -35<br>-178 | .4<br>.206 | ·45<br>·244 | ·5<br>·294 | ·55 |
|---------------|----|-----|------------|-----|------------|-------------|------------|-------------|------------|-----|
|               | .6 |     |            |     |            |             |            |             |            |     |



TABLE No. 11.

Showing Head Required to Overcome Resistance from a Circular Curve of 90° under Different Velocities and with Different Degrees of Curvature.

|               |              | VELOCITY IN FEET PER SECOND |      |      |      |      |      |      |       |       |  |  |  |  |
|---------------|--------------|-----------------------------|------|------|------|------|------|------|-------|-------|--|--|--|--|
| $\frac{r}{R}$ | 1            | 2                           | 3    | 4    | 5    | 6    | 7    | 8    | 9     | 10    |  |  |  |  |
| Λ             | HEAD IN FEET |                             |      |      |      |      |      |      |       |       |  |  |  |  |
| .1            | .001         | .004                        | .009 | .016 | .025 | .036 | .049 | .065 | .082  | .101  |  |  |  |  |
| .15           | .001         | .004                        | .009 | .017 | .026 | .038 | .051 | .067 | .084  | .104  |  |  |  |  |
| .2            | .001         | .004                        | .010 | .017 | .027 | .039 | .053 | .069 | .087  | .107  |  |  |  |  |
| .25           | .001         | .004                        | .010 | .018 | .028 | .040 | .055 | .071 | .091  | .112  |  |  |  |  |
| •3            | 100.         | .005                        | .011 | .019 | .031 | .044 | .060 | .078 | .099  | .123  |  |  |  |  |
| ∙35           | .001         | .006                        | .012 | .022 | .035 | .050 | .068 | .088 | .112  | .138  |  |  |  |  |
| •4            | .002         | .006                        | .014 | .026 | .040 | .058 | .078 | .102 | .130  | .160  |  |  |  |  |
| -45           | .002         | .008                        | .017 | .030 | .049 | .068 | .093 | .121 | .154  | .189  |  |  |  |  |
| .5<br>.6      | .002         | .009                        | .021 | .036 | .057 | .082 | .112 | .146 | . 185 | . 228 |  |  |  |  |
| .6            | .003         | .014                        | .031 | .055 | .085 | .123 | .167 | .218 | .277  | .342  |  |  |  |  |
| .7<br>.8      | .005         | .020                        | .046 | .082 | .128 | .185 | .251 | .328 | .415  | .512  |  |  |  |  |
| .8            | .007         | .030                        | .068 | .121 | .189 | .273 | .371 | .485 | .614  | .758  |  |  |  |  |
| .9            | .011         | .044                        | .099 | .175 | .273 | .394 | .536 | .699 | .886  | 1.093 |  |  |  |  |
| 1.0           | .015         | .061                        | .138 | .245 | .384 | -554 | ·753 | .984 | 1.245 | 1.536 |  |  |  |  |

Note.—If the angle of curvature is greater or less than 90°, then increase or diminish the figures in same proportion.

Discharging Capacity of Small Pipes.—The following table shows approximately the number of gallons of water delivered per minute, through pipe of various small sizes, under stated heads H, which are given in terms of the length L, and will be useful in laying out services.

Example.—Given a 2" pipe 133 feet long, how much will it deliver per minute under a head of 100 feet?

The head equals three-quarters of the length. Under the column  $H=\frac{3}{4}$  L and opposite to 2" diameter, we find the answer 173.1 gallons. In the same way we will find that a  $\frac{4}{4}$ " pipe 75 feet long, under a head of 150 feet (H=2L) will discharge approximately 15.4 gallons per minute.

TABLE No. 12.

DISCHARGING CAPACITY OF SMALL PIPES.

| Diam.<br>of<br>Pipe<br>Inches         | H=10 L   | H = 9 T  | H=8L   | H = 7 L   | H = 6 L   | H = 5 L  | H=4L   | H=3L   | H = 2 L  | H = 1% L   | H = 1 $ L$  | H=1% $L$  | H = L  | H = %  | $H = \frac{1}{2}L$  | H= ½ T   | 7 % = H  | $H = \frac{1}{4}L$      | T% = H                  | $H = rac{1}{2}L$  | H= 1/4 T   | $H = \frac{1}{4}L$                       | $H = t_0 L$                             |
|---------------------------------------|--|--|--|---|---|--|--|--|--|--|---|---|--|--|---|--|--|-------------------------|-------------------------|--|--|--|---|
| 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 308.0<br>632.2<br>1104.<br>1745.<br>3581.<br>6247. | 32.7<br>51.7<br>106 0<br>185.2<br>292.1<br>599.7<br>1048.<br>1651.<br>3397.<br>5928. | 30.1<br>48.7<br>100.0<br>174.6<br>275.4<br>566.4<br>987.8<br>1560. | 28.9<br>45.6<br>93.5<br>163.3<br>257.6<br>528.9<br>924.0<br>1460.<br>2996.<br>5227. | 26.5<br>42.2<br>86.6<br>151.2<br>238 5<br>488.1<br>855.4<br>1351.<br>2774.<br>4839. | 24.4<br>38.5<br>79.0<br>138.0<br>217.7<br>447.0<br>780.9<br>1234.<br>2532.<br>4417 | 21.8<br>34.4<br>70.7<br>123.4<br>194.8<br>399.8<br>698.5<br>1103.<br>2265. | 18.9<br>29.8<br>61 2<br>106.9<br>168.7<br>346.3<br>604.9<br>955-5<br>1062. | 15.4<br>24.3<br>50.0<br>87.3<br>137.7<br>282 7<br>493 0<br>780.2<br>1602.<br>2791. | 14.4<br>22.8<br>46.8<br>\$1.6<br>128.8<br>264.4<br>462.0<br>728.8<br>1496. | 13.4<br>21.1<br>43.2<br>75.6<br>119.3<br>248.8<br>427.7<br>674.8<br>1385. | 12.2<br>19.3<br>39.5<br>69.0<br>108.9<br>223.5<br>390.4<br>615.9<br>1264. | 10.9<br>17.2<br>35.3<br>61.7<br>97.4<br>199.9<br>349.2<br>555.5<br>1133. | 9.5<br>14.9<br>30.6<br>53.5<br>84.3<br>173.1<br>302.4<br>477.1<br>979.3<br>1711. | 12.2<br>25.0<br>43.7<br>68.7<br>141.4<br>246.9<br>390.1<br>800.8<br>1394. | 6.3<br>9.9<br>20.4<br>35.6<br>56.2<br>115.4<br>201.6<br>317.8<br>653.8 | 17 7<br>30.9<br>48.7<br>100.<br>174.6<br>275.8<br>566.2<br>987.7 | 246.7<br>506.5<br>883.5 | 225.2<br>463.2<br>806.5 | 4.1<br>6.5<br>13.4<br>23.3<br>36.8<br>75.6<br>132.0<br>208.5<br>428.0<br>746.7 | 21.8<br>34.4<br>70.7<br>123.5<br>195.1<br>399.9<br>698.5 | 66 6<br>116.4<br>183.9<br>377.5<br>658.5 | 30.8<br>63.2<br>110.4<br>174.5<br>358.1 |

This table is from the report of the Rochester (N. Y.) Water Department for 1877.



## ELECTROLYSIS OF CAST IRON PIPE.

THERE is nothing more menacing to the life of cast iron pipe systems (where return electric currents are allowed to pass through them) than electrolysis, and it may most justly be claimed that these electric currents should be taken care of by the parties responsible for them



From Albany, N.Y. Holes Mended with Split Sleeves.

without injury to other interests. It is a subject of first importance to water and gas works engineers to see that this is satisfactorily done.

With present experience it is difficult to say just what effect a current of a given number of



From 6" Main. Milwaukee, Wis.

volts and amperes will have on a line of pipe. It is impossible for the engineer to know even approximately (without great expense) the conditions of his mains where electrolytic action is taking place; thus the gas or water supply of large sections of cities is often endangered by the failure of



mains without previous warning. In one case a 48" water main failed, owing to the effect of electrolysis, leaving a large portion of one of our large Eastern cities without water supply. An-



From 4" Main. Milwaukee, Wis.

other case—the leakage from a gas main—caused an explosion in an adjacent property, destroying the building.



From Gas Main. Gas escaping through hole shown above found its way into a two-story building, causing an explosion and completely wrecking the house.

The soil in which the pipes are laid is second in importance only to the power of the current itself, a weak current often destroying the pipe in a short time (due to salts or dampness in the



From 8" Main. Showing the result of about four years of electrolytic action.

earth), while a much stronger current (in soil practically free therefrom) may not do serious injury for years.

Through the courtesy of Mr. F. A. Davis, of Indianapolis, we give a few extracts from his paper read before the Central States Water Works Association, September 6, 1899, together with illustrations from photographs taken in different cities of this country, showing in a striking manner the effects of electrolysis. Sometimes the effect is not so apparent as indicated by these cuts.

Mr. Davis says, "I have found water mains affected without showing even the breaking of the coating of the pipe. Almost invariably when you find the sand, gravel and earth adhering firmly to your pipe, there is destruction going on, although the pipe itself may show no visible evi-



From 6" Main. Indianapolis Water Co., showing beginning of electrolytic action.

dence of the fact. If you analyze the earth, which is so hard and so firmly attached to your pipe, you will find that the iron of your pipe is being carried into the earth by the electricity, leaving only the carbon. Again, I have found pipe having a graphite color and feeling smooth, but upon removing the earth and running the point of a knife over the metal, the knife entered soft spots in the pipe. This is the beginning of the pitting of the iron.



From 4" Main. Indianapolis Gas Co., Indianapolis, Ind.

"The photograph I present to you is of a cast iron 4" gas main taken out near the power house of the Street Car Company in Indianapolis. The destruction of this pipe is peculiar, and more complete than any I have heretofore seen. Pieces came out of the pipe in places as large as a dol-

lar, and there was no weight to these pieces that had been scooped out by the electricity. Where the spigot end of the pipe enters the bell it has the appearance of burnt iron."

The injury due to electrolysis of course is invariably due to the return currents of the various trolley systems; the points where the currents leave and return to the pipe, or pass again either to the rail or to the power house, are the points where the cast iron is eaten away. Bonding the rails, if effectually done, gives some relief, though whether in this way the rails can be satisfactorily made to take care of the entire return current is uncertain. Bonding the pipe joints (to keep the



Samples of pipe destroyed by electrolysis; some of them in less than eighteen months.

currents from leaving the pipe) may do some good, but it is expensive and is not to be recommended.

The most satisfactory method yet adopted is the use of an insulated return wire, laid in the roadbed, of sufficient size to easily take care of the entire return current, thus avoiding the necessity of the current seeking other channels. This wire may be overhead, but better still, laid in the roadbed or underground conduit.



Effect of electrolysis on an iron water pipe on thirty days' exposure.

Yet it is not the function of the pipe manufacturers or users to say how their pipe shall be protected. The methods to be pursued should be left entirely in the hands of the electric companies, and they be held responsible for any damage that is done.

## CAST IRON BELL AND SPIGOT PIPE.

For WATER AND GAS MAINS, SEWERS, CULVERTS, Etc.

A FULL LINE OF ALL REGULAR SIZES USUALLY IN STOCK.

PRICES ON APPLICATION.



I NQUIRIES should state kind, size, approximate quantity and weight of pipe (or pressure under which they are to be used), and, if possible, the intended service, time and place of delivery desired, etc. Designate the sizes of pipe by inter-

nal diameters: a 36" pipe is 36" inside diameter.

We have long made a specialty of the manufacture of cast iron pipe of all kinds and sizes, our experience dating from the very introduction of piping into this country. Our regular sizes now range from I" to 72" inside diameters, as indicated in the following table, in addition to which we are prepared to make to order when essential odd sizes, such as 22", 27" and 54", though it is desirable to avoid such sizes where possible, as extra expense and delay is usually involved by their use. Our pipe are tested under water pressure at our works before shipment, and we aim to carry in stock, or have in process of manufacture, a full line of all regular sizes of pipe and special castings, so that we are able usually to meet ordinary requirements with promptness, shipping by rail or water.

TABLE No. 13.

|  | BELI             | ANI           | SPIGO              | T PIPE        | : <b>.</b>                          | Fo                 | r                 | VA                       | CER                | t, et             | c.                     | TUR               | NED A             | ND BOR          | ED PI         | PE.                |                  |
|--|------------------|---------------|--------------------|---------------|-------------------------------------|--------------------|-------------------|--------------------------|--------------------|-------------------|------------------------|-------------------|-------------------|-----------------|---------------|--------------------|------------------|
| s of<br>cating<br>er of                                  | Jo               | aying         |                    |               |                                     |                    |                   |                          | KIND AN            |                   | GHT OF                 | PIPE              |                   |                 |               |                    | Pipe             |
| lons of<br>indicat<br>meter o                            | ameter<br>Inches |               | B. & S.<br>T. & B. | Pipe,         | Words:<br><b>Odor</b><br><b>Orb</b> | B. & S.<br>T. & B. | Pipe,             | : Words :<br>Omen<br>Odd | B. & S.<br>T. & B. | Pipe,             | Words :<br>Onus<br>Off | B. & S.<br>T. & B | Pipe,             | Words: Oven Own | Joint         | per Joint,<br>Lbs. | 8 0              |
| Terminations<br>odewords indic<br>Inside Diamete<br>Pipe | Ä.5              | kima<br>gth i |                    | ND, 100 I     |                                     |                    | D, 200<br>SURE, 8 |                          |                    | D, 300<br>SURE, 1 | FEET<br>30 LBS.        |                   | D, 400<br>SURE, 1 |                 | ad per<br>Lbs | Hemp pe<br>Lbs     | Diam.<br>in Inch |
| de v<br>nsid   | Inside<br>Pipe   | Appro         | Thick-             | Weig          | ht per                              | Thick-             | Weig              | ht per                   | Thick-             | Weig              | ght per                | Thick-            | Wei               | ght per         | Lead          | He                 | Inside           |
| రి   |                  | ₹             | ness               | Foot          | Length                              | ness               | Foot              | Length                   | ness               | Foot              | Length                 | ness              | Foot              | Length          |               |                    | . L              |
| abo  | I                | 6             | .22                | 2.8           | 17                                  |                    |                   | · · · · · ·              |                    |                   |                        |                   |                   |                 | 2.00          | .08                | I                |
| abon   | 11/4             | 6             | .23                | 3.5           | 21                                  | •••••              | • • • • • •       |                          |                    | •••••             |                        | •••••             | •••••             | ,               | 2.25          | .09                | 11%              |
| ageo   | 1 1/2            | 8             | .25                | 4.5<br>6.7    | 36<br><b>60</b>                     | i                  | •••••             | •••••                    |                    | •••••             |                        | •••••             | •••••             | •••••           | 2.75<br>3.25  | .10<br>.14         | 172              |
| amer   | 21/2             | 9             | .27                | 8.0           | 72                                  |                    |                   | •••••                    | •••••              |                   | •••••                  |                   |                   |                 | 3.90          | .16                | 21/6             |
| andi   | 3                | 12            | .38                | 13.9          | 167                                 | .42                | 15.4              | 185                      | -45                | 16.7              | 200                    | -45               | 16.7              | 200             | 4.4           | .18                | 3                |
| and  | 31/2             | 12            | -39                | 16.5          | 200                                 | .42                | 18.0              | 215                      | .45                | 18.5              | 220                    | .46               | 20.0              | 240             | 5.0           | .20                | 31/2             |
| ani  | 4                | 12            | .40                | 19.2          | 230                                 | .42                | 20.3              | 243                      | .45                | 21.7              | 260                    | -47               | 22.I              | 265             | 5.5           | .21                | 4                |
| asis   | 5                | 12            | .42                | 24.6          | 295                                 | -45                | 26.3              | 315                      | .48                | 28.2              | 338                    | .51               | 29.6              | 355             | 6.8           | .27                | 5                |
| asti   | 6                | 12            | -43                | 30.4          | 364                                 | .47                | 32.8              | 393                      | .51                | 35.5              | 426                    | -54               | 37.1              | 445             | 8.0           | .31                | 6                |
| cam  | 7                | 12            | -45                | 36.7          | 440                                 | -49                | 40.0              | 480                      | -53                | 43.3              | 520                    | .58               | 46.3              | 555             | 9.8           | -37                | 7 8              |
| eces   | 8                | 12            | -47                | 42.8          | 513                                 | .51                | 47-3              | 567                      | .56                | 52.0              | 624                    | .61               | 55.4              | 665             | 11.5          | -44                |                  |
| ensi   | 9                | 12            | .48                | 49.6          | 595<br>685                          | .54                | 55.8              | 670                      | -59                | 61.3              | 735                    | .64               | 65.0              | <b>780</b>      | 13.0          | .48                | 9                |
| envi   | 10               | 12            | .50                | 57.1          |                                     | .56                | 63.8              | 765                      | .62                | 71.0              | 852                    | .68               | 76.7<br>100.8     | 920             | 14.5<br>18.0  | ·53<br>.61         | 10               |
|  | 1                |               | •53                | 72.5          | 870                                 |                    | 82.1              | 985                      |                    | 92.5              | 1110                   | .75               |                   | 1210            |               |                    |                  |
| erem   | 14               | 12            | .56                | 89.5          | 1074                                | .65                | 102.4             | 1229                     | -73                | 116.6             | 1399                   | .82               | 128.3             | 1540            | 21.5          | .81                | 14               |
| esto   | 15               | 12<br>12      | .58                | 98.3<br>107.8 | 1180                                | .67<br>.69         | 114.2             | 1370                     | .76                | 129.2             | 1550                   | .85<br>.89        | 141.7<br>158.3    | 1700            | 23.0          | .87<br>•94         | 15<br>16         |
| evra   | 18               | 12            | .63                | 107.8         | 1293<br>1532                        | .74                | 124.7<br>149.0    | 1496                     | .79<br>.85         | 143.6<br>172.1    | 1723<br>2065           | .96               | 191.7             | 2300            | 27.0          | 1,00               | 18               |
| idum   | 20               | 12            | .66                | 149.0         | 1788                                | 78                 | 175.3             | 2104                     | .91                | 203.7             | 2444                   | 1.03              | 228.3             | 2740            | 31.5          | 1.25               | 20               |
| imes   | 24               | 12            |                    | 200.6         | 2407                                | .87                | 233.6             | 2803                     | 1.02               | 274.9             | 3299                   | 1.16              | 306.7             | 368o            | 37.0          | 1.50               | 24               |
| iram   | 30               | 12            | .75<br>.87         | 290.2         | 3482                                | 1.01               | 335.6             | 4027                     | 1.19               | 398.6             | 4783                   | 1.37              | 451.7             | 5420            | 51.0          | 2.06               | 30               |
| iria   | 36               | 12            | .98                | 391.6         | 4699                                | 1.14               | 455.0             | 5460                     | 1.36               | 545-3             | 6543                   | 1.58              | 624.2             | 7490            | 75.0          | 3.00               | 36               |
| itis   | 40               | 12            | 1.09               | 483.9         | 5807                                | 1.23               | 543.8             | 6525                     | 1.48               | 654.8             | 7858                   | 1.72              | 754.2             | 9050            | 85.0          | 3.37               | 40               |
| ium  | 42               | 12            | 1.10               | 512.3         | 6147                                | 1.28               | 591.7             | 7100                     | 1.54               | 713.6             | 8563                   | 1.79              | 824 2             | 9890            | 9ŏ.o          | 3.62               | 42               |
| ocon   | 48               | 12            | 1.25               | 665.2         | 7982                                | 1.41               | 745.5             | 8946                     | 1.71               | 904.8             | 10857                  | 1.99              | 1045.8            | 12550           | 110.0         | 4.37               | 48               |
| oran   | 60               | 12            | 1.40               | 916.7         | 11000                               | 1.68               | 1105.0            | 13260                    | 2.05               | 1336.7            | 16040                  | 2.41              | 1580.8            | 18970           | 150.0         | 6.25               | 60               |
| oro ,  | 72               | 12            | 1.60               | 1257.5        | 15090                               | 1.95               | 1538.3            | 18460                    | 2.39               | 1868.3            | 22420                  | 2,82              | 2217.5            | 26610           | 220.0         | 9.00               | 72               |

WEIGHTS, APPROXIMATE ONLY, are per foot of pipe shell inclusive of the bell; those per length are for full length pipes laying about the lengths given in the table and include the bell. Unless otherwise specified, all pipe 4" and above are tested to 300 pounds water pressure per square inch. The table covers both standard "Bell and Spigot" ("B. & S.") and "Turned and Bored" ("T. & B.") Pipe.

See Telegraphic Code, page 152.



Table No. 13A.

BELL AND SPIGOT PIPE.

For GAS, etc.

TURNED AND BORED PIPE.

| Code<br>Word<br>Termin.<br>for Size | Inside<br>Diam.<br>in<br>Inches | Approx.<br>Laying<br>Length<br>in Feet | & Code V<br>B. & S<br>T. & E | WOOD<br>Co.<br>Words:<br>., Edit<br>L, Err<br>ht per<br>Length | Code V<br>B. & S., Emir<br>T. & B., Eim<br>Heavy Wt. | B. & S., Egis<br>T. & B., Ebb | U. G. I. Co.<br>Code Words:<br>B. & S., Even<br>T. & B., Elf |        | Inside Diameter<br>in Inches |
|-------------------------------------|---------------------------------|--|------------------------------|--|--|-------------------------------|--|--------|------------------------------|
| abo                                 | , <u>1</u>                      | 6                                      | 2.8                          | 17   |  | •••••                         | •••••  | •••••  | 1                            |
| abon                                | 134                             | 6                                      | 3.3                          | 21   |  | ••••                          | ••••   | ****** | 11/4                         |
| ageo                                | 11/2                            | 8                                      | 4.0                          | 36   | •••••  | ••••                          | ••••   | ****** | 11/2                         |
| als                                 | 2                               | 9 ;                                    | 6.0                          | 60   | •••••  | •••••                         |  | •••••  | 2                            |
| amer                                | 21/2                            | 9                                      | 8.0                          | 72   | •••••  | •••                           | ••••   |        | 2 1/2                        |
| andi                                | ∣ 3                             | 12                                     | 11.0                         | 132  | •••••  | ••••                          | 173  | 168    | 3.,                          |
| and                                 | 3 1/2                           | 12                                     | 13.3                         | 160  |  | •••••                         |  | ****** | 31/2                         |
| eni                                 | 4                               | 12                                     | 15.5                         | 186  | 260  | 230                           | 228  | 224    | 4                            |
| asis                                | · 5                             | 12                                     | 20.0                         | 240  | ••••   | *****                         |  | 298    | 5                            |
| asti                                | , 6                             | 12                                     | 25.0                         | 300  | 400  | 350                           | 364  | 373    |                              |
| eam                                 | 7                               | 12                                     | 31.3                         | 375  |  | •••••                         | •••••  | ****** | 7 8                          |
| eces                                | 8                               | 12                                     | 38.0                         | 456  | 600  | 500                           | 492  | 522    |                              |
| ensi                                | 9                               | 12                                     | 44.6                         | 535  |  | •••••                         |  |        | 9                            |
| envi                                | 10                              | 12                                     | 50 0                         | 600  | 800  | 675                           | 669  | 746    | 10                           |
| erai                                | 12                              | 12                                     | 58.0                         | 696  | 1000   | 850                           | 906  | 938    | 12                           |
| ere                                 | 14                              | 12                                     | 80.0                         | 960  |  | ••••                          | ******   | 1148   | 14                           |
| erem                                | 15                              | 12                                     | 90.0                         | 1080   |  | *** ***                       | •••••  | •••••  | 15<br>16                     |
| esto                                | 16                              | 12                                     | 100.0                        | I 200  | 1480   | 1300                          | 1334   |        | 10                           |
| evra                                | 18                              | 12                                     | 125.0                        | 1500   | ••••   |                               |  | 1624   | 18                           |
| idum                                | 20                              | 12                                     | 140.0                        | 1680   | 2100   | 1850                          | 1822   |        | 20                           |
| imes                                | 24                              | 12                                     | 196.6                        | 2359   | 2700   | 2400                          | 2398   | 2464   | 24                           |
| irem                                | 30                              | 12                                     | 275.0                        | 3300   | 4000   | 3600                          | 3236   | •••••  | 30                           |

WEIGHTS, APPROXIMATE ONLY, are per foot of pipe shell inclusive of the bell: those per length are for full length pipes laying about the lengths given in the table and include the bell. The table covers both standard "Bell and Spigot" ("B. & S.") and "Turned and Bored" ("T. & B.") Pipe. The general design is the same as for water. Cement joint bells (Code Word-Expand) are usually deeper and have greater joint room; 5" plain bells with 3/8" joint room on 4" and 12" pipe represent approved practice.

9-foot lengths will be supplied to order at an extra charge.

See Telegraphic Code, page 152.

Special Castings.—In the following pages will be found tables giving dimensions and approximate weights of our standard "bell and spigot" or "hubs all around" special castings. These may be of service in the laying out of work, and should be referred to on orders, if it is desired to have special castings to these dimensions. These tables show mainly the BOSTON WATER WORKS STANDARDS, which were adopted after careful consideration. The lines of "REDUCED" SPECIALS will be found attractive to those who desire to purchase special castings at a fixed price per casting.

In addition to Bell and Spigot Piping, we make a specialty of cast iron Flange Pipe. Flange Special Castings, and of pipe and fittings for extra heavy service.

Inquiries and Orders.—Clear and explicit directions as to dimensions, kinds and weights of pipes, whether coated or uncoated, the approximate quantities of each size, and deliveries desired, accompanying the original inquiry or order, will avoid delays in correspondence, and result in the filling of orders with the greatest promptitude.

Cast Iron Pipe for Culvert and Drainage Purposes.—Of recent years the demand for a cheap iron pipe for railroad, culvert and general drainage purposes has steadily increased, not only from points remote from good stone supplies, but also to a very great extent from railways and county roads lying in districts where excellent material is plentiful and cheap. This is because iron pipe is more readily and quickly put in than brick or stone work, and forms a most permanent and practically indestructible water way. In times of high water, the smooth interior surface of the iron pipe offers a minimum resistance, is less liable to be obstructed, can be more readily cleaned, and is not near so likely to be "washed out" as are small brick or stone culverts; and the pipe being in 12-foot lengths, there are fewer joints than when sewer or vitrified pipe (usually made in 2 to 2½-foot lengths) is used;

and then, too, larger diameters are available. We are prepared to furnish pipe in regular sizes and lengths to lay 12 feet up to 72 inches in diameter, and to make to order larger diameters, though usually in shorter lengths.

For culvert and drainage purposes it is usual to furnish pipe of second quality, namely, those that have been rejected for technical defects, but which are in every way suited for this service. Where the location will not admit of the use of pipe of sufficiently large diameter to take care of the maximum flow, it is customary to make up the culvert or drain of two or more parallel lines of pipe. Where the flow is at times likely to be rapid, it is best to protect the embankment at the inlet end of the pipe with a masonry or cement facing, to prevent water working around the pipe. Care should also be used, in laying, to see that the joints are firmly supported.

Instances have been brought to our attention where pipe under high embankments have been crushed or cracked owing to lack of care in laying and selecting them. Heavy pipe only should be used under such embankments, and, in laying, the earth should be closely rammed about them to avoid as far as possible undue settling. In some cases it may be well, in addition to this, to provide temporary wooden struts in the interior of the pipe, to be removed after the natural subsidence of the embankment has occurred.

Sewers.—There is also a continually increasing demand for cast iron pipe for sewerage purposes, and their use for this service is especially commended. While the first cost may be somewhat greater than the brick sewer, it will be more than offset by the adaptability and durability of the cast iron pipe.

We make also a variety of Manhole and Inlet Castings, Valve Boxes, Culvert or Gutter Plates and the miscellaneous castings used in connection with sewers, streets, etc. A portion of these is listed below, while other shapes and sizes from our own patterns or other design are made to order.



MANHOLE OR INLET FRAME AND COVER.

VALVE BOX FRAME AND COVER.

| TAE | 3LE | No. | 13B. |
|-----|-----|-----|------|
|-----|-----|-----|------|

| VALVE BOX Code Word: Main                |                        |                        |          |                                   |  |  |  |  |  |
|--|------------------------|------------------------|----------|-----------------------------------|--|--|--|--|--|
| CodeWord<br>Termina-<br>tion<br>for Size | Frame                  | Opening                | Weight   | Approx.<br>Weight<br>in<br>Pounds |  |  |  |  |  |
|  | 18" x 22"<br>19% x 24¾ | 13" x 17"<br>14% x 19% | 2"<br>2% | 150<br>220                        |  |  |  |  |  |
|  | •••••                  | ••••                   |          |                                   |  |  |  |  |  |
|  |                        |                        | •••••    |                                   |  |  |  |  |  |
| •••••                                    |                        | •••                    |          |                                   |  |  |  |  |  |
| •••••                                    |                        | *** ***                |          |                                   |  |  |  |  |  |
| •••••                                    | •••••                  |                        |          | '                                 |  |  |  |  |  |

| TA | RI | R | Nο | 12C. |
|----|----|---|----|------|

| Co<br>Dime                                | Annray                             |                             |                        |                                 |
|---|------------------------------------|-----------------------------|------------------------|---------------------------------|
| Code Word<br>Termina-<br>tion<br>for Size | Diam.<br>of<br>Opening             | Diam.<br>of<br>Flange       | Height                 | Approx.<br>Weight in<br>Pounds  |
| evra<br>esom<br>edis<br>iner<br>imes      | 18<br>203/4<br>203/4<br>2274<br>24 | 26<br>30¾<br>37<br>37<br>32 | 12<br>8½<br>11½<br>11½ | 300<br>400<br>550<br>550<br>600 |

Lighter Lids supplied when ordered for sidewalk use.

CULVERT OR GUTTER

PLATES.

Floor and Tread Plates for retort houses, furnace and mill uses,

pumping stations, etc.

#### TABLE No. 13D.

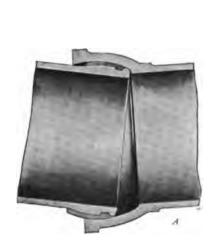
| OR GUT<br>e Word:        | TER PLA                               | TES  |
|--------------------------|---------------------------------------|--|
| Length<br>and<br>Breadth | Outside<br>to<br>Outside<br>of Ribs   | Approx.<br>Weight<br>in<br>Pounds  |
| 16" x 33"                | 133/4                                 | 125<br>135   |
| 16 x 39                  | 133/4                                 | 145  |
|                          | 1                                     | 145<br>82<br>88  |
|                          | Length and Breadth  16" x 33" 16 x 36 | Length and Breadth of Ribs  16" x 33" 13½ 16 x 36 13½ 16 x 39 13½ 24 x 36 16 |



## FLEXIBLE JOINT PIPE.

THE necessity for crossing streams and other water ways, and of laying pipe lines into them has developed various forms of Flexible Joint Pipe adapted to laying under water, and which, when caulked with lead, are capable of motion through several degrees without leakage. The additional outlay for such pipe is inconsiderable when compared with the advantages secured by its use.

The joint A is that usually employed, and admits of the lead gasket moving upon the interior surface of the bell, which is carefully machined. This design is sometimes modified by adding one or more lead grooves upon the spigot end.





The design C is a more expensive joint, intended for the larger sizes of pipe, especially when they are used for conveying water under considerable pressure. This joint has a split retaining ring or collar bolted to the hub, as shown, forming a very secure connection. For large diameters, these C joints made in short lengths may be used for convenience in handling or in connection with a line partly made up of ordinary bell and spigot pipe, though usually resulting in extra expense. Full-length pipe, necessitating fewer joints, are generally to be preferred.

In standard flexible joint piping the maximum deviation permitted by the joint is 10°, from a straight line, taken in any direction.

In selecting the thickness of pipe for a submerged line, the internal pressure under which it will be in service is seldom the determining factor, as ample allowance should be made to minimize the risk of breakage in laying, and to withstand external shocks from floating ice or other objects. The enlarged hubs naturally add materially to the weight of Flexible Joint Piping; and the thicknesses and weights suggested in the following table may be taken as in line with good practice.

TABLE No. 14. FLEXIBLE JOINT PIPE.
Weights are approximate only.

| Code Word<br>Termination | Inside<br>Diam.       | Thick-<br>ness of                      | Code       | le A<br>Word :<br>I <b>an</b> | Styl<br>Code I | e C<br>Word :<br> ol |
|--------------------------|-----------------------|--|------------|-------------------------------|----------------|----------------------|
| Indicating               | of Pipe               | Shell in                               | Weight     | Lead                          | Weight         | Lead                 |
| Inside                   | Inches                | Inches                                 | per        | per                           | per            | per                  |
| Diameter                 | inches                | inches                                 | Length     | Joint                         | Length         | Joint                |
|                          |                       | 1                                      | Lbs.       | Lbs.                          | Lbs.           | Lbs.                 |
|                          |                       |  |            | 203.                          |                |                      |
| ani                      | 4                     | 10                                     | 350        | }                             |                |                      |
| aven                     | 4                     | 7.                                     | 350<br>280 | 10                            | l l            | *****                |
| asti                     | 4<br>6<br>6<br>8<br>8 | ************************************** | 550        | ١ ا                           |                | *****                |
| avi                      | 6                     | ! %                                    | 440        | 15                            | 1              | *****                |
| eces                     | 8                     | \$7                                    | 730        | <b>1</b>                      |                |                      |
| esma                     | 8                     | اثدكا                                  | 590        | 21                            |                |                      |
| envi                     | 10                    | 11                                     | 1000       | <b>5</b> - 1                  | 1              |                      |
| ecer                     | 10                    | ) <u>3</u> 0                           | 830        | 28                            | 1              |                      |
| erai                     | 12                    | 1 13                                   | 1410       | <b>.</b>                      | •••••          |                      |
| ebar                     | 12                    | 1 32 1                                 | 1100       | 38                            |                | •••••                |
| ere                      | 14                    | ₹6<br>%                                | 1770       | {                             |                | •••••                |
| elen                     |                       | 111                                    | 1450       | } 64                          |                | *****                |
| esto                     | 14<br>16              | 1 15                                   | 2190       | {                             | •••••          | •••••                |
| esis                     | 16                    | 19                                     | 1660       | } 77 I                        |                | •••••                |
| EVIA                     | 18                    | _18                                    |            | ≀ ''                          | •••••          | •••••                |
| ecul                     | 18                    | 1 I.,                                  | 2640       | 93                            | •••••          | •••••                |
| idum                     |                       | 1,8                                    | 1900       | } ~ ∣                         | ••••• (        | •••••                |
| icos                     | 20                    | <u>1</u> 126                           | 3220       | 1112                          | 4070           | 104                  |
|                          | 20                    | 19                                     | 2560       | } <b>-</b>                    | 3540           | ,                    |
| imes                     | 24                    | 11/8                                   | 4020       | } 144                         | 5450           | 1 720                |
| isch                     | 24                    | 18                                     | 3440       | } {                           | 4990           | 139                  |
| iram                     | 30                    | 13%                                    | 6190       | } 181 {                       | 8150           | 180                  |
| icum                     | 30                    | I I                                    | 4870       | 5 ***                         | 7030           | 100                  |
| iria                     | 36                    | 15%                                    | 8800       | l a=a                         | 11190          |                      |
| ique                     | 36<br>36              | 15/3                                   | 6770       | 250                           | 9470           | 250                  |
|                          |                       |  |            | ,                             |                | ,                    |

SHORT SECTIONS OF KNUCKLE JOINTS.

DESIGN A.

Made with ordinary bell or flange ends. These short sections are used in making river crossings in connection with regular flange or bell and spigot pipe. The larger sizes with cast iron or steel riveted flange pipe make an excellent arrangement for intakes with floating screen. Flanged joints are drilled only to order.



#### FLEXIBLE JOINT PIPE.

- A. Bell end machined inside.
- C. Spigot end machined outside and fitted with retaining ring or collar, complete with bolts.

Made regularly in lengths to lay about twelve (12) feet.

A full assortment of Flexible Joint Pipe of design A, and of about the weights given in the table, usually in stock.

Design C to order only.

Short sections, design C, of sizes 20" diameter and upward, for laying between ordinary pipe, to order.

INQUIRIES should state the approximate quantity of pipe, the thickness of shell, or weight per length, and delivery desired.

TABLE No. 14A.

KNUCKLE JOINTS, SHORT SECTIONS. STYLE A.

Code Word: Idyl

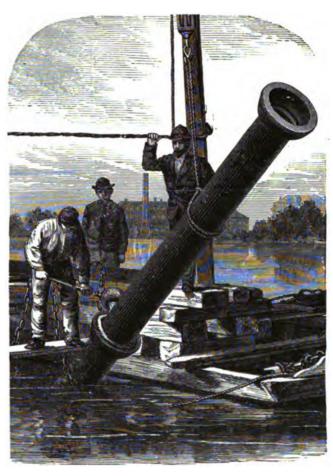
| Code<br>Word<br>Termina-                  | Inside           | Thick-           | Outside<br>Diam. | Lay<br>Leng        | ing<br>th of            | Total            | Weig                             | ximate<br>ht of              |
|---|------------------|------------------|------------------|--------------------|-------------------------|------------------|----------------------------------|------------------------------|
| tion J<br>Indicating O<br>Inside<br>Diam. | Diam.<br>of Pipe | ness of          | of               | Flange<br>and Bell | Flange<br>and<br>Spigot | Laying<br>Length | Joint<br>without<br>Lead<br>Lbs. | Lead<br>per<br>Joint<br>Lbs. |
| aven                                      | 4"               | 18"              | 9"               | 6"                 | 43/2"                   | 101/2"           | 8o                               | 10                           |
| avi                                       | 6                | 1/2              | 11               | 614                | 5                       | 111/2            | 100                              | 15                           |
| enur                                      | 8                | 78               | 131/2            | 7                  | 51/2                    | 121/2            | 160                              | 2Ĭ                           |
| atic                                      | 10               | 1/2              | 16               | 8                  | 61/4                    | 141/4            | 230                              | 28                           |
| aton                                      | 12               | ł i              | 19               | 9                  | 7                       | 16               | 350                              | 38<br>64                     |
| ible                                      | 14               | 34               | 21               | 10                 | 734                     | 1734             | 460                              | č4                           |
| iric                                      | 16               | ₹8               | 231/2            | 11                 | 734<br>814              | 191/2            | 640                              | 77                           |
| son                                       | 18               | 3/4<br>7/6<br>18 | 25               | 12                 | 91/4                    | 211/4            | 800                              | 93                           |
| itti                                      | 20               | I                | 27 1/2           | 13                 | 10                      | 23               | 1050                             | 112                          |
| iter                                      | 24               | 114              | 32               | 141/2              | 11                      | 251/2            | 1410                             | 144                          |
| itum                                      | 30               | 11/4             | 3834             | 17                 | 12                      | 29               | 2300                             | 181                          |
| iteo                                      | 36               | 11/2             | 453/4            | 191/2              | 13                      | 321/2            | 3570                             | 250                          |

Laying.—The location for a flexible joint main should be selected with care, to avoid, as far as may be, the possibility of injury to the pipe, which in shallow streams may result from floating ice or sunken logs, or in deeper waters from navigation. It is often necessary to dredge a trench of sufficient depth to insure the safety of the line. The bottom should be carefully examined and all obstructions removed before laying the pipe, which should rest evenly throughout their length.

Dependent on local conditions, various methods of laying are adopted. When the submerged line is of considerable length and the depth of water sufficient, it is usual to lay the pipe from a barge or float. For large pipe, especially on deep crossings, two floats securely held some few feet apart, and operated as one, may be used to advantage, the pipe being lowered from a platform spanning the breach, instead of over the side. The float should be held in position by lines, so arranged as to admit of readily advancing it as the pipes are laid. There should be space to admit working to advantage, and, if practicable, sufficient to carry a few lengths of pipe on in addition to the usual appliances for laying, which should include suitable means to handle the pipe from the supply barge, to place them in position and to center the spigot end in the bell of

the preceding pipe. A cradle or apron is sometimes secured to the float and extending well below the surface of the water, serves to support the pipe to some extent as it is lowered; or, an A frame with suitable tackle may be used to hold up the "laid" end. In making a joint, after it is carefully yarned, sufficient lead should be used to completely fill the joint at one running. The lead is then driven in the usual manner, after which the joint is "broken" by raising the bell end of the pipe until the lead gasket moves freely in the socket. As each pipe is thus "laid" the float is moved ahead, the pipe slipping down the apron until the bell is in the proper position for entering another pipe.

In some instances, submerged mains have been laid successfully by first placing the pipe on shore so that the line may readily be moved lengthwise into position. After making the joints for a total length sufficient to span the crossing, carefully plugging the two ends, and providing a sufficient number of suitable floats, the main is hauled like a huge rope across the stream. Air pressure is used to test the joints and keep the main free from water should leaks develop; and when all is in readiness, the floats are removed as water is allowed to enter the pipe and it sinks to the bottom.



POURING A JOINT IN MERRIMAC RIVER.\*

In shallow water, flexible joint piping may be laid from A frames, the suspended pipe resting in slings so arranged as to admit of lowering the pipe after the joints are run and caulked.

A stop-valve should be located on each side of the crossing, above the water level. The line may be tested for leaks by closing these valves for a few minutes and then slightly opening the supply. If water passes, leakage is indicated. A more accurate test may be made by applying a gauge between the valves, and noting the pressure before and after closing.

Ordinary repairs may be made by a diver. We may mention, however, a serious failure in which unusual means had finally to be resorted to. A 20" submerged line was entirely pulled apart. The replaced joint, which was first caulked, was covered by a flanged split sleeve, fitted with split glands, secured by bronze bolts, to pack like stuffing boxes, using flax packing, the annular space being afterward filled with cement grouting through pipes tapped into the sleeve and extending above the water level.

Special castings for repairs to submerged lines made promptly to order.

<sup>\*</sup>John F. Ward, Contractor, New York.

## STANDARD SPECIAL CASTINGS.

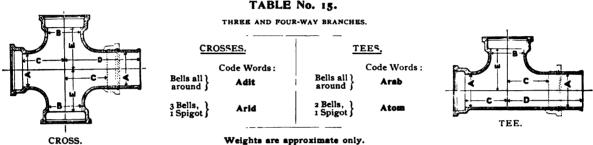
#### BELL AND SPIGOT.

THE following tables of our regular standard bell and one spigot or "bells all around" special castings, give general dimensions and approximate weights. The entire line corresponds closely with the standards adopted by the BOSTON WATER WORKS. We aim to carry a full assortment of these regular specials in stock and in ordering reference should

A dimensions and approximate weights. The entire line corresponds closely with the standards adopted by the Boston Water Works. We aim to carry a full assortment of these regular specials in stock and in ordering reference should be made to this list. In working to special plans, if it be left to us to supply castings which will maintain center lines, the expense of extra pattern work may be materially reduced, if not avoided, and earlier shipments secured.

If Standard Special Castings, conforming strictly to the dimensions given in the table, are especially desired, orders must so specify. The importance of this will be appreciated when it is remembered that the tables herein do not cover by any means all the patterns we carry; hence, in filling the ordinary run of orders, castings from stock may vary. Usually such variations are unimportant.

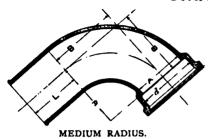
The following tables cover standard American sizes; odd sizes as 7", 9", 15", etc., made to order.



| Weights | are | approximate | only. |
|---------|-----|-------------|-------|
|---------|-----|-------------|-------|

| Code Word<br>Fermination         | Diam.                         | Dim        | ension      | s in In | ches | Appro<br>Weigh            | ximate<br>it, Lbs.        | Code Word<br>Termination         | de Diam.<br>A<br>Inches | Dim      | ension   | s in In | ch <b>es</b> |                           | ximate<br>it, Lbs.       |
|----------------------------------|-------------------------------|------------|-------------|---------|------|---------------------------|---------------------------|----------------------------------|-------------------------|----------|----------|---------|--------------|---------------------------|--------------------------|
| Indicating<br>Inside<br>Diameter | Inside Dian<br>A<br>in Inches | В          | С           | D       | E    | 3-Way,<br>2 or 3<br>Bells | 4-Way,<br>3 or 4<br>Bells | Indicating<br>Inside<br>Diameter | Inside I<br>A<br>in Inc | В        | С        | D       | E            | 3-Way,<br>2 or 3<br>Bells | 4-Way<br>3 or 4<br>Bells |
| andi                             | 3                             | 3          | 10          | 22      | 10   | . 85                      | 115                       | evio                             | ( 16                    | 4        | 17       | 28      | 17           | 660                       | 725                      |
| acit                             | 1 4                           | 3          | 11          | 23      | 11   | 110                       | 140                       | evet                             | 16                      | 5<br>6   | 17       | 28      | 17           | 665                       | 730                      |
| ani                              | 1 7                           | 4          | 11          | 23      | 11   | 125                       | 170                       | evon                             | 16                      |          | 17       | 28      | 17           | 670                       | 73                       |
|                                  |                               |            |             | 1 -     |      | 1                         | - 1                       | evi                              | J 16                    | 8        | 17       | 28      | 17           | 695                       | 79.<br>88                |
| agus                             | 5                             | 3          | 11.5        | 23.5    | 12   | 140                       | 175                       | evez                             | ) 16                    | 10       | 17       | 28      | 17           | 735                       | 88                       |
| acti<br>asis                     | ፈ 5                           | 4          | 11.5        | 23.5    | 12   | 150                       | 195                       | evas                             | 16                      | 12       | 17       | 28      | 17           | 790                       | 98                       |
| <b>4515</b>                      | ( 5                           | 5          | 11.5        | 23.5    | 12   | 160                       | 210                       | eva                              | 16                      | 14       | 17       | 28      | 17           | 850                       | 110                      |
| anes                             | ( 6                           | 3          | 12          | 24      | 12   | 170                       | 205                       | esto                             | [ 16                    | 16       | 17       | 28      | 17           | 905                       | 121                      |
| ance                             | ) 6                           | 4          | 12          | 24      | 12   | 175                       | 210                       | erve                             | ſ 18                    | 4        | 18       | 31      | 18           | 800                       | 85                       |
| amus                             | ) 6                           | 5          | 12          | 24      | 12   | 200                       | 245                       | erst                             | 18                      |          | 18       | 31      | 18           | 815                       | 88                       |
| asti                             | l 6                           | 6          | 12          | 24      | 12   | 205                       | 280                       | erre                             | 18                      | 5<br>6   | 18       | 31      | 18           | 830                       | 91                       |
| enta                             | ſ 8                           | 3          | 13          | 25      | 13   | 205                       | 235                       | eper                             | 18                      | 8        | 18       | 31      | 18           | 860                       | 98                       |
| cbe                              | i š                           | 4          | 13          | 25      | 13   | 225                       | 270                       | eppe                             | 18                      | 10       | 18       | 31      | 18           | 900                       | 105                      |
| eaba                             | { š                           |            | 13          | 25      | 13   | 240                       | 300                       | enno                             | 18                      | 12       | 18       | 31      | 18           | 945                       | 115                      |
| emie                             | l š                           | 5<br>6     | 13          | 25      | 13   | 260                       | 330                       | esen                             | 18                      | 14       | 18       | 31      | 18           | 1005                      | 126                      |
| eces                             | l š                           | 8          | 13          | 25      | 13   | 290                       | 390                       | emen                             | 18                      | 16       | 18       | 31      | 18           | 1065                      | 136                      |
| emur                             | ( 10                          |            | 1 -         | 26      | 14   |                           |                           | evra                             | 18                      | 18       | 18       | 31      | 18           | 1110                      | 148                      |
| emo:                             | 10                            | 4          | 14          | 26      | 14   | 295<br>320                | 345                       | ions                             | Î 20                    | 4        | 19       | 31      | 19           | 950                       | 100                      |
| ebat                             | 1 10                          | 5          | 14          | 26      | 14   |                           | 370<br>410                | ione                             | 20                      |          | 19       | 31      | IQ           | 970                       | 104                      |
| COL                              | 10                            | 8          | 14          | 26      | 14   | 335<br>370                | 470                       | inne                             | 20                      | 5<br>6   | 19       | 31      | 19           | 9,85                      | 107                      |
| enui                             | 10                            | 10         | 14          | 26      | 14   | 400                       |                           | inom                             | 20                      | 8        | 19       | 31      | 19           | 1025                      | 111                      |
|                                  |                               |            | 1 '         | 1       |      |                           | 535                       | imus                             | 20                      | 10       | 19       | 31      | 19           | 1055                      | 121                      |
| eria                             | <b>12</b>                     | 4          | 15          | 27      | 15   | 365                       | 415                       | iez                              | 20                      | 12       | 19       | 31      | 19           | 1100                      | 131                      |
| erez                             | 12                            | 5<br>6     | 15          | 27      | 15   | 380                       | 440                       | idao                             | 20                      | 14       | 19       | 31      | 19           | 1145                      | 141                      |
| eret                             | 12                            |            | 15          | 27      | 15   | 405                       | 475                       | ical                             | 20                      | 16       | 10       | 31      | 19           | 1220                      | 154                      |
| eram                             | 12                            | 8          | 15          | 27      | 15   | 445                       | 545                       | ian                              | 20                      | 18       | 19       | 31      | 19           | 1270                      | 164                      |
| eras                             | 12                            | 10         | 15          | 27      | 15   | 495                       | 625                       | idum                             | 20                      | 20       | 19       | 31      | 19           | 1320                      | 175                      |
| erat                             | 12                            | 12         | 15          | 27      | 15   | 520                       | 675                       | ixit                             |                         |          | 1        | -       | 1            | -                         | 138                      |
| eunt                             | <b>14</b>                     | 4          | 16          | 28      | 16   | 530                       | 58o                       | ipse                             | 24                      | ' 4      | 21       | 33      | 21           | 1320                      | 141                      |
| ete                              | 14                            | , <u>5</u> | 16          | 28      | 16   | 545                       | 610                       | ivor                             | 24                      | , 5<br>6 | 21       | 33      | 21           | 1335                      | 144                      |
| esse                             | 14                            |            | 16          | 28      | 16   | 570                       | 640                       | iven                             | ,                       | . 8      | 21<br>21 | 33      | 21           | 1350<br>1385              | 151                      |
| es                               | ₹ 14                          | 8          | 16          | 28      | 16   | 590                       | 690                       | ivit                             | 24                      | 10       | 21       | 33      | 21           | 1430                      | 160                      |
| ero                              | 14                            | 10         | 16          | 28      | 16   | 625                       | 770                       | ives                             | 24                      | 1 12     | 21       | 33      | 21           | 1475                      | 169                      |
| eris                             | 14                            | 12         | 16          | 28      | 16   | 670                       | 86o                       | ites                             | 24                      | 14       | 21       | 33      | 21           | 1545                      | 182                      |
| ere                              | L 14                          | 14         | <b>k</b> 16 | 28      | 16   | 720                       | 960                       | isti                             | 24                      | 16       | 21       | 33      | 21           | 1605                      | 195                      |
|                                  |                               | i          | 1           |         | 1    | 1                         |                           | iras                             | 24                      | 18       | 21       | 33      | 21           | 1655                      | 205                      |
|                                  |                               | 1          | 1           |         | 1    |                           |                           | ious                             | 24                      | 20       | 21       | 33      | 21           | 1715                      | 217                      |
|                                  |                               | Į.         | 1           | 1       | 1    | •                         | 1                         | imes                             | 24                      | 24       | 21       | 33      | 21           | 1880                      | 250                      |

See Telegraphic Code, page 152.



BELL AND SPIGOT.

For Short Radius Quarter Ben's, see page 52.

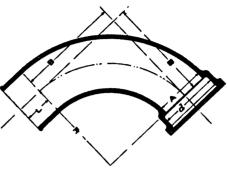
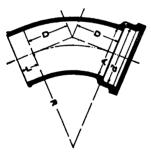


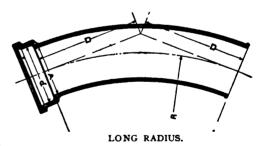
TABLE No. 16.

LONG RADIUS.

| QUARTER  | Bend                            | S<br>ME<br>Lo                           | IDIUM<br>NG                             | Rapiu                         | Code<br>s—Aium<br>Anon                      | Words<br>For<br>H           |   |                                     | Awry<br>Avis   |
|--|---------------------------------|---|---|-------------------------------|---|-----------------------------|---|-------------------------------------|--|
| 6.1.11.1   | ı                               | Me                                      | DIUM 1                                  | RADIU                         | s i   | 1                           | Long  | RADI                                | US   |
| Code Word<br>Termination<br>for Size   | Size<br>A                       | R                                       | В                                       | L                             | Approx.<br>Weight,<br>Lbs.                  | R                           | В   | L                                   | Approx.<br>Weight,<br>Lbs.                                   |
| andi<br>ani<br>asis<br>asti<br>eces<br>envi<br>erai<br>ere<br>esto<br>evra<br>idum<br>imes | 3" 4 5 6 8 10 12 14 16 18 20 24 | 16"<br>16<br>16<br>16<br>16<br>16<br>16 | 16"<br>16<br>16<br>16<br>16<br>16<br>16 | 8"<br>8<br>8<br>8<br>10<br>12 | 55<br>80<br>100<br>125<br>185<br>260<br>330 | 24" 24 24 24 24 24 24 24 30 | 24"<br>24<br>24<br>24<br>24<br>24<br>24<br>24<br>24<br>30 | 6"<br>6<br>6<br>6<br>12<br>12<br>12 | 150<br>215<br>295<br>375<br>530<br>645<br>760<br>880<br>1355 |



For Short Radius Eighth Bends,



MEDIUM RADIUS.

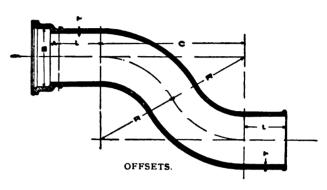
TABLE No. 17.

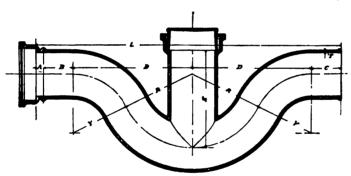
| Code Word                                   |                            | ME                          | IUM R  | ADIUS             | 1                                  | L                           | ong R   | ADIUS                                   |
|---|----------------------------|-----------------------------|--------|-------------------|------------------------------------|-----------------------------|---|---|
| Termination<br>for Size                     | Size<br>A                  | R                           | D      | L                 | Approx.<br>Weight,<br>Lbs.         | R                           | D   | Approx<br>Weight<br>Lbs.                |
| andi<br>ani<br>asis<br>asti<br>eces<br>onvi | 3"<br>4<br>5<br>6<br>8     | 24"<br>24<br>24<br>24<br>24 | 999999 | 4"<br>4<br>4<br>4 | 45<br>65<br>80<br>95<br>135<br>185 |                             |   |   |
| erai<br>ere<br>esto<br>evra<br>idum<br>imes | 12<br>14<br>16<br>18<br>20 | 24<br>24                    | 914    | 4                 | 235                                | 60"<br>60<br>60<br>60<br>60 | 24 1/8"<br>24 1/8<br>24 1/8<br>24 1/8<br>24 1/8 | 400<br>510<br>620<br>725<br>845<br>1125 |

#### BELL AND SPIGOT.

TABLE No. 18.

| Oı                  | FSB1  | rs—c  | ode W   | ord: A                         | nt                                   |  |  |
|---------------------|---|---|---|--------------------------------|--------------------------------------|--|--|
|                     | Арргож  |   |   |                                |                                      |  |  |
| Diam.<br>of<br>Pipe | R   | A   | В   | С                              | L                                    | Т  | Weight<br>in Lbs.  |
| 3 3                 | 8<br>14                                       | 2 2   | 4.6   | 13.86                          | 10<br>10                             | 0.40   | 65<br>75   |
| 4<br>4<br>5         | 14<br>8                                       | 2 2   | 5.8   | 24.25<br>13.86                 | 10<br>10                             | 0.45   | 90<br>110<br>115   |
| 5<br>6<br>6         | 14<br>8<br>14                                 | 2 2 2   | 7.8<br>7.8  | 24.25<br>13.86<br>24.25        | 10<br>10<br>10                       | 0.48<br>0.50<br>0.50   | 140<br>140<br>175  |
|                     | 10<br>15                                      | 2 2 2   | 9.9<br>9.9  | 17.32<br>25.98<br>20.78        | 10<br>10<br>10                       | 0.55<br>0.55<br>0.60   | 215<br>255<br>310  |
| 10<br>12            | 18<br>14                                      | 2 2   | 12.0<br>14.1  | 31.18                          | 10                                   | 0.60   | 375<br>430<br>510  |
|                     | Diam. of Pipe 3 3 4 4 4 5 5 6 6 6 8 8 8 10 10 | Diam. of Pipe R  3 8 3 14 8 4 14 5 8 6 14 8 10 12 10 18 11 11 | Diam. of Pipe R A  3 8 2 3 14 2 4 8 2 4 14 2 5 8 2 6 8 2 6 8 2 6 8 2 6 14 2 8 10 2 8 10 2 10 112 2 10 118 2 112 114 2 | DIMENSIONS IN    Diam. of Pipe | DIMENSIONS IN INCHE    Diam. of Pipe | of Pipe  3 8 2 4.6 13.86 10 3 14 2 4.6 24.25 10 4 8 2 5.8 13.86 10 5 8 2 6.8 13.86 10 5 14 2 5.8 24.25 10 5 14 2 6.8 24.25 10 6 8 2 7.8 13.86 10 6 14 2 7.8 24.25 10 8 10 2 9.9 17.32 10 8 15 2 9.9 25.98 10 10 12 2 12.0 20.78 10 10 18 2 12.0 31.18 10 12 14 2 14.1 24.25 10 | Dimensions in Inches   Diam. of Pipe   R   A   B   C   L   T |





HAND HOLE TRAP FOR DRAINS.
PLAIN TRAPS, WITHOUT HAND HOLE BRANCH.

Y BRANCHES OR LATERALS.

TABLE No. 20.

|       | IA   | ULL  | 140.  | ıy. |
|-------|------|------|-------|-----|
| TRAPS | WITH | BRAN | сн, А | row |

| Code<br>Word           |                     |             | DIME             | NSIONS                  | in Inc                 | HES            |          |                      | Appro<br>Weight | ximate<br>s, Lbs  |
|------------------------|---------------------|-------------|------------------|-------------------------|------------------------|----------------|----------|----------------------|-----------------|-------------------|
| Termin.<br>for<br>Size | Diam.<br>of<br>Pipe | A           | B<br>and<br>C    | D                       | E                      | R              | Y        | L                    | With<br>Branch  | Plain             |
| ani<br>asti<br>eces    | 4<br>6<br>8         | 2<br>2<br>2 | 8<br>8<br>8<br>8 | 24.25<br>27.70          | 16 5<br>19 5           | 14<br>16<br>18 | 14       | 66.5<br>73.4         | 210<br>350      | 150<br>260        |
| envi<br>erai           | 10<br>12            | 2 2 2       | 8                | 30.00<br>31,10<br>32.25 | 22.5<br>24.75<br>26.75 | 19             | 16<br>16 | 78 0<br>80.2<br>82.5 | 530<br>760      | 400<br>560<br>740 |

| Y BRANCHES—Code Word: Ash |                                      |  |  |  |  |  |  |  |  |  |
|---------------------------|--------------------------------------|--|--|--|--|--|--|--|--|--|
| DIME                      | Approx.<br>Weight.                   |  |  |  |  |  |  |  |  |  |
| A                         | B                                    | С  | D  | Pounds   |  |  |  |  |  |  |
| 3                         | 3                                    | 9  | 12   | 80<br>105  |  |  |  |  |  |  |
| 5                         | 3.5                                  | 13.5   | 15   | 140<br>180   |  |  |  |  |  |  |
| 10<br>12                  | 4.5                                  | 18.5   | 23<br>26   | 250<br>360<br>495  |  |  |  |  |  |  |
| 14<br>16<br>18            | 6.5                                  | 24.5<br>27.5   | 30<br>34<br>37   | 700<br>905<br>1090   |  |  |  |  |  |  |
| 20<br>24                  | 7·5<br>8 5                           | 32.5<br>37.5   | 40<br>46   | 1310<br>1920   |  |  |  |  |  |  |
|                           | DIME  A  3 4 5 6 8 10 12 14 16 18 20 | A B  3 3 4 3 3 4 3 3 5 3 4 4 10 4 4 5 12 5 16 6 5 5 16 6 5 7 | DIMENSIONS IN IN  A B C  3 3 9 4 3 10 5 3 12 6 3.5 13.5 8 4 16 10 4.5 18.5 12 5 21 14 5.5 24.5 16 6.5 27.5 18 7 30 | A B C D  3 3 9 12 4 3 10 13 5 3 12 15 6 3.5 13.5 17 8 4 16 20 10 4.5 18.5 23 12 5 21 26 14 5.5 24.5 30 16 6.5 27.5 34 18 7 30 37 |  |  |  |  |  |  |

BELL AND SPIGOT.

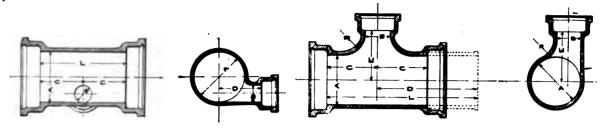
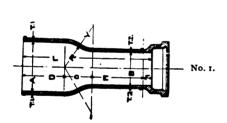


TABLE No. 21.

| В                         |    |          |                  | RAN<br>d: A |    | ES   |
|---------------------------|----|----------|------------------|-------------|----|------|
| . Code<br>Word<br>Termin. | Е  | IMR<br>I | Approx<br>Weight |             |    |      |
| for Size                  | A  | В        | C                | D           | L  | Lbs. |
| ebe                       | 8  | 4        | 10               | 7           | 20 | 205  |
| emur                      | 10 | 4        | 10               | 8           | 20 | 265  |
| eria                      | 12 | 4        | 10               | 10          | 20 | 335  |
| eunt                      | 14 | 4        | 10               | 12          | 20 | 435  |
| evio                      | 16 | 4        | 10               | 12          | 20 | 520  |
| erve                      | 18 | 4        | 10               | 12          | 20 | 585  |
| inva                      | 20 | 6        | 12               | 14          | 24 | 745  |
| ivor                      | 24 | 6        | 12               | 16          | 24 | 985  |

TABLE No. 22.

|                |                                 |   |                  |                           | ES              |  |  |
|----------------|---------------------------------|---|------------------|---------------------------|-----------------|--|--|
|                |                                 | DIMEN   | SIONS IN         | INCHES                    |                 |  | Approx.<br>Weight  |
| A              | В                               | С   | D                | E                         | L               | R  | in<br>Lbs.   |
| 8<br>10<br>12  | 6                               | 12<br>12<br>12                                      | 24<br>24<br>24   | 8<br>11<br>12             | 36<br>36<br>36  | 5<br>5<br>5                                  | 240<br>315<br>385  |
| 16<br>18<br>20 | 6<br>6<br>6                     | 12<br>12<br>12                                      | 24<br>24<br>24   | 15<br>16<br>17            |                 | 5<br>5<br>5                                  | 315<br>385<br>490<br>580<br>670<br>770   |
|                | 8<br>10<br>12<br>14<br>16<br>18 | 8 6<br>10 6<br>12 6<br>14 6<br>16 6<br>18 6<br>20 6 | Cc   DIMEN     C | Code Word   DIMENSIONS IN | Code Word : Alp | DIMENSIONS IN INCHES   A   B   C   D   E   L | Code Word : Alp   DIMENSIONS IN INCHES     R   R       R     R     R     R     R     R     R     R     R     R         R       R |



REDUCERS.

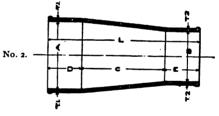


TABLE No. 23A.

| TA                       | ABLE             | No.                         | 23.  |            |
|--------------------------|------------------|-----------------------------|------|------------|
|                          |                  | EDUCI                       |      |            |
| Code Word<br>Termination | Dim              | Approx.<br>Weight<br>in Lbs |      |            |
| for Size                 | A                | В                           | L    | No. 1      |
| acit {                   | 4                | 3                           | 20   | 55         |
| acti {                   | 4<br>5<br>6<br>8 |                             | 21   | 55<br>65   |
| ance                     | 6                | 4<br>6<br>6<br>8<br>6       | 23   | 75         |
| emie {                   |                  | 6                           | 23   | 110        |
| ebat                     | 10               | 6                           | 30   | 155<br>180 |
| eor )                    | 10               | 8                           | 28.6 |            |
| eret                     | 12               | 8                           | 32   | 185        |
| eram {                   | 12               | _                           | 30.6 | 210        |
| eras (                   | 12               | 10                          | 28.8 | 240        |

| 1                        | No 2 R<br>Code W |                      |          |            |  |  |  |
|--------------------------|------------------|----------------------|----------|------------|--|--|--|
| Code Word<br>Termination |                  | Dimensions in Inches |          |            |  |  |  |
| for Size                 | A                | В                    | L        | No. 2      |  |  |  |
| es                       | 14               | 8                    | 36       | 220        |  |  |  |
| ero {                    | 14               | , 10                 | 36       | 245        |  |  |  |
| eris                     | 14               | 12                   | 36       | 270        |  |  |  |
| evez                     | 16               | IO                   | 36       | 285        |  |  |  |
| evas                     | 16               | 12                   | 36<br>36 | 310        |  |  |  |
| eva                      | . 16<br>18       | 14                   | 30       | 335        |  |  |  |
| eppe<br>enno             | 18               | 10                   | 36       | 360        |  |  |  |
| csen                     | 18               |                      | 36<br>36 | 395        |  |  |  |
| emen                     | 18               | 14<br>16             | 36       | 435        |  |  |  |
| iez                      | 20               | 12                   | 42       | 475<br>450 |  |  |  |
| idao                     | 20               | 14                   | 42       | 490        |  |  |  |
| ical                     | 20               | 16                   | 42       | 530        |  |  |  |
| ien                      | 20               | 18                   | 42       | 570        |  |  |  |
| isti                     | 24               | 16                   | 42       | 630        |  |  |  |
| ires <                   | 24               | 18                   | 42       | 675        |  |  |  |
| lous                     | 24               | 20                   | 42       | 720        |  |  |  |

BELL AND SPIGOT.





TABLE No. 25.

|   | PLUGS<br>Code Word: Anol |  |   |                               |  |  |  |  |  |  |  |
|---|--------------------------|--|---|-------------------------------|--|--|--|--|--|--|--|
| Code<br>Word<br>Termin.<br>for Size                 | Diam.<br>of Pipe         | A .                                      | D                                       | Approx.<br>Weight<br>in Lbs.  |  |  |  |  |  |  |  |
| andi<br>ani<br>asis<br>asti<br>eces<br>ensi<br>erai | 3"<br>4<br>5<br>6<br>8   | 3.8"<br>4.9<br>6.0<br>7.0<br>8.1<br>11.2 | 5.5"<br>5.5<br>5.5<br>5.5<br>5.5<br>6.0 | 4<br>6<br>8<br>10<br>13<br>28 |  |  |  |  |  |  |  |





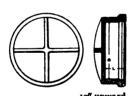


TABLE No. 27.

| CAPS<br>Code Word: Ally  |                                 |   |   |  |  |  |  |  |  |  |  |
|--|---------------------------------|---|---|--|--|--|--|--|--|--|--|
| Code<br>Word<br>Termin.<br>for Size  | Diam.<br>of Pipe                | D   | L   | Approx.<br>Weight<br>in Lbs.                                 |  |  |  |  |  |  |  |
| andi<br>anl<br>asis<br>asti<br>eces<br>envi<br>erai<br>ere<br>esto<br>evra<br>idum<br>imes | 3" 4 5 6 8 10 12 14 16 18 20 24 | 4.60"<br>5.80<br>7.00<br>8.00<br>10.10<br>12.25<br>14.35<br>16.65<br>18.75<br>20.85<br>23.00<br>27.00 | 3-75"<br>3-75<br>3-75<br>3-75<br>5<br>5<br>5<br>5<br>5<br>5 | 18<br>25<br>33<br>40<br>70<br>95<br>125<br>155<br>210<br>240 |  |  |  |  |  |  |  |

TABLE No. 24.

| SP                         | LIT S          | LEEVES         | —Code     | Word        | s { wit!<br>wit! | Branch, A         | \rc<br>\im        |  |
|----------------------------|----------------|----------------|-----------|-------------|------------------|-------------------|-------------------|--|
| Code<br>Word               | Size           | Length         | Branch    | Во          | LTS              | APPROX. WEIGHT    |                   |  |
| Fermin. Siz<br>for<br>Size |                | Deligen        | Diam.     | No.         | Size             | Without<br>Branch | With<br>Branch    |  |
| ani<br>asti                | 4"<br>6        | 10"            | 2"  <br>3 | 6<br>6      | **               | 55<br>120         | 70<br>140         |  |
| eces                       | 8<br>10        | 12<br>13       | 4 4       | 6           | 32<br>23         | 155               | 180<br>220        |  |
| erei<br>esto               | 12<br>14<br>16 | 15<br>16<br>16 | 6         | 8<br>8<br>8 | %<br>%           | 250<br>320<br>365 | 290<br>360<br>405 |  |

Furnished rough or finished; bolts not included unless finished.

TABLE No. 26.



|                                     | SOLID SLEEVES<br>Code Word: Amid |       |     |                              |  |  |  |  |  |  |  |  |
|-------------------------------------|----------------------------------|-------|-----|------------------------------|--|--|--|--|--|--|--|--|
| Code<br>Word<br>Termin.<br>for Size | Diam.<br>of Pipe                 | D     | L   | Approx.<br>Weight<br>in Lbs. |  |  |  |  |  |  |  |  |
| andi                                | 3"                               | 4.60" | 10" | 35                           |  |  |  |  |  |  |  |  |
| ani                                 | 4                                | 5.80  | 10  | 45                           |  |  |  |  |  |  |  |  |
| asis                                | 5                                | 7.00  | 10  | 56                           |  |  |  |  |  |  |  |  |
| asti                                | 6                                | 8.00  | 10  | 45<br>56<br>67               |  |  |  |  |  |  |  |  |
| eces                                | 8                                | 10,10 | 12  | 100                          |  |  |  |  |  |  |  |  |
| envi                                | 10                               | 12.25 | 12  | 130                          |  |  |  |  |  |  |  |  |
| erai                                | 12                               | 14.35 | 14  | 185                          |  |  |  |  |  |  |  |  |
| ere                                 | 14                               | 16 65 | 14  | 225                          |  |  |  |  |  |  |  |  |
| esto                                | 16                               | 18.75 | 15  | 275                          |  |  |  |  |  |  |  |  |
| evra                                | 18                               | 20.85 | 15  | 315                          |  |  |  |  |  |  |  |  |
| idum                                | 20                               | 23 00 | 15  | 350                          |  |  |  |  |  |  |  |  |
| imes                                | 24                               | 27 00 | 15  | 470                          |  |  |  |  |  |  |  |  |





TABLE No. 28.

|                                     |                    | AND SP<br>Word: As |                                 | FLANGE AND BELL<br>Code Word: Amyl  |      |                                      |                                 |  |  |
|-------------------------------------|--------------------|--------------------|---------------------------------|-------------------------------------|------|--------------------------------------|---------------------------------|--|--|
| Code<br>Word<br>Termin.<br>for Size | Size<br>of<br>Pipe | Length             | Approx.<br>Weight<br>in<br>Lbs. | Code<br>Word<br>Termin.<br>for Size | Size | Laying<br>Length<br>Flange<br>& Bell | Approx.<br>Weight<br>in<br>Lbs. |  |  |
| andi                                | 3"                 | 16"                | 30                              | andi                                | 3"   | 4"                                   | 35                              |  |  |
| eni                                 | 4                  | 16                 | 40                              | ani                                 | 4    | 1 4 1                                | 45                              |  |  |
| asis                                | -                  | 16                 | 50<br>60                        | 2515                                | . Š  | ا نا                                 | 55                              |  |  |
| asti                                | <b>5</b>           | 16                 |                                 | asti                                | 6    | ' 4 '                                | 45<br>55<br>65<br>80            |  |  |
| cam                                 |                    | 16                 | 8o                              | ea m                                | 7    | . 4                                  | 80                              |  |  |
| ece s                               | 7 8                | 16                 | 95                              | eces                                | 8    | 4 .                                  | 90                              |  |  |
| ensi                                | ¦ 9                | 16                 | 110                             | ensi                                | 9    | 4                                    | 105                             |  |  |
| envi                                | IÓ                 | 18                 | 145                             | envi                                | 10   | 6                                    | 140                             |  |  |
| erai                                | 12                 | 18                 | 190                             | erai                                | 12   | 6                                    | 185                             |  |  |
| cre                                 | 14                 | 18                 | 235                             | ere                                 | 14   | 6                                    | 230                             |  |  |
| erem                                | 15                 | 18                 | 260                             | erem                                | 15   | 6                                    | 250                             |  |  |
| esto                                | 16                 | 20                 | 320                             | esto                                | 16   | 6 '                                  | 290                             |  |  |
| evra                                | 18                 | 20                 | 365                             | evra                                | 18   | 6                                    | 315                             |  |  |
| idum                                | 20                 | 20                 | 440                             | idum                                | 20   | 6                                    | 370                             |  |  |
| iner                                | 22                 | 20                 | 510                             | iner                                | 22   | 6                                    | 430                             |  |  |
| imes                                | 24                 | 24                 | 690                             | imes                                | 24   | 6                                    | 500                             |  |  |

For Standard Flange Specials, see pages 56 to 58 inclusive.



## "REDUCED" SPECIALS.

(Trade-Mark Registered.)

BELLS ALL AROUND.

PRICE LIST.

SOLD BY\_THE PIECE.



TABLE No. 30.

| TA                                   | BLE No. 29             | ).                                   |
|--------------------------------------|------------------------|--------------------------------------|
| TEES-                                | -Code Word: A          | kin                                  |
| Code Word<br>Termination<br>for Size | Sizes in<br>Inches     | Price                                |
| andi<br>ani                          | 3 × 3 × 3<br>4 × 4 × 4 | \$1.96                               |
| acit                                 | 3                      | 2.96<br>2.69                         |
| asis<br>acti                         | 5×5×5                  | 3.46<br>3.19                         |
| agus                                 | 6x6x6                  | 2.02                                 |
| asti<br>amus                         | 5                      | 4-44<br>4-16                         |
| ance                                 | 4                      | 3.88<br>3.60                         |
| eces<br>emie                         | 8x8x8                  | 5-93<br>5-34<br>5-05<br>4-76         |
| emie<br>emie                         | 6<br>5                 | 5.34                                 |
| ebe<br>enta                          | 4                      | 4.76                                 |
| envi                                 | 10 X 10 X 10           | 4.47<br>8.94<br>7.82<br>7.20<br>6.89 |
| eor<br>ebat                          | 8<br>6                 | 7.82                                 |
| emo                                  | 5                      | 6.89                                 |
| emur<br>erai                         | 12 X 12 X 12           | 6.58<br>12.00<br>10.85               |
| eras<br>eram                         | 10<br>8                | 0.70                                 |
| eret                                 | ő                      | 8.54                                 |
| erez<br>eria                         | 5                      | 7.96<br>7.38                         |
| ere<br>eris                          | 14×14×14               | 22.00<br>19.81                       |
| ero                                  | 10                     | 17.02                                |
| es<br>esse                           | 8                      | 15.42                                |
| ete                                  | 5                      | 13.23<br>12.69                       |
| eunt<br>esto                         | 16x 16x 16             | 12.04<br>25.00                       |
| eva<br>cvas                          | 14<br>12               | 22.72                                |
| evez                                 | 10                     | 20.52<br>18.28                       |
| evi<br>evon                          | 8<br>6                 | 16.04<br>13.80                       |
| evet<br>evio                         | 5                      | 13.18<br>12.56                       |
| evra                                 | 18 x 18 x 18           | 32.00                                |
| emen<br>esen                         | 16<br>14               | 29.71<br>27.42                       |
| enno<br>eppe                         | 12<br>10               | 24.13<br>21.84                       |
| eper                                 | 8                      | 19.55                                |
| erre<br>erst                         | 6<br>5                 | 18.26                                |
| erve<br>idum                         | 4<br>20 x 20 x 20      | 17.62                                |
| len                                  | 18                     | 41.00<br>36.66                       |
| ical<br>idao                         | 16<br>14               | 36,66<br>32,32<br>27,98              |
| iez<br>imus                          | 12<br>10               | 23.64                                |
| inom                                 | 8                      | 21.30<br>19.96                       |
| inva<br>ione                         | 6<br>5                 | 19.96<br>18.45<br>17.87<br>17.28     |
| ions                                 | . 4                    | 17.28                                |
| imes                                 | 24 X 24 X 24<br>20     | 57.00                                |
| iras<br>isti                         | 18<br>16               | 50.62<br>46.16                       |
| ites                                 | 14                     | 43.20                                |
| ives<br>Ivit                         | 10                     | 40.24<br>36.78                       |
| iven<br>ivor                         | 8                      | 34.32<br>32.86                       |
| ipse                                 | 5                      | 32.13                                |
| ixit                                 | <u> </u>               | 31.4C                                |

"REDUCED" Specials are put on the market with a view of meeting a demand for specials sold at a fixed price per piece, instead of so much per pound, as in the case with regular specials.

They are intended to be used with regular bell and spigot pipe. The use of bells all around will generally be found to be convenient and economical, as short pieces of pipe cut to place specials in required positions can be conveniently used.

They are made as short as practicable to effectively make the required combination of outlets. The bells are of the same inside dimensions as for regular specials.

In ordering from these lists specify "Reduced" Specials.

Sizes up to 24" usually in stock.

Prices on sizes above 24" and on combinations not given in tables, as well as discount from list price, sent on application.

See Telegraphic Code, page 152.

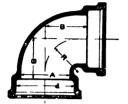


|                                      | S—Code Word:                 | Acid                    |
|--------------------------------------|------------------------------|-------------------------|
| Code Word<br>Termination<br>for Bize | Sizes in<br>Inches           | Price                   |
| andi<br>ani<br>acit                  | 3×3×3×3<br>4×4×4×4           | \$2.46<br>3.21          |
| acit                                 | 3×3<br>5×5×5×5               | 2.94                    |
| asis<br>acti                         | 5×5×5×5<br>4×4               | 4.46<br>3.94            |
| agus<br>asti                         | 6x6x6x6                      | 3.94<br>3.67            |
| amus                                 | 5×5                          | 5.19<br>4.78            |
| ance<br>anes                         | 4×4                          | 4.38<br>4.00            |
| eces                                 | 3x3<br>8x8x8x8<br>6x6        | 7.43                    |
| emie<br>eaba                         | 6 x 6<br>5 x 5               | 7.43<br>6.34<br>6.03    |
| ebe                                  | 4×4                          | 5.72<br>5.41            |
| enta                                 | 3 x 3<br>10 x 10 x 10 x 10   |                         |
| 80r                                  | 8 x 8 l                      | 0 22                    |
| ebat<br>emo                          | 6x 6<br>5x 5                 | 8.70<br>8.14            |
| emur                                 | 4× 4                         | 8.14<br>7.58            |
| erai<br>eras                         | 12X 12X 12X 12<br>10 X 10    | 14.00<br>12.85          |
| eram<br>eret                         | 8 x 8<br>6 x 6               | 11.70                   |
| erez                                 | 5 × 5                        | 10.54<br>9.96           |
| eria<br>ere                          | 4 X 4<br>14 X 14 X 14 X 14   | 9.38<br>23.00           |
| eris                                 | 12 X 12                      | 20.81                   |
| ero<br>es                            | 10 x 10<br>8 x 8             | 18.62<br>16.42          |
| <b>0556</b>                          | 6 x 6                        | 14.23                   |
| ete<br>eunt                          | 5 × 5                        | 13.69<br>13.04<br>26.00 |
| esto                                 | 16 x 16 x 16 x 16            | 26.00                   |
| eva                                  | 14 X 14<br>12 X 12           | 23.72<br>21.52          |
| evez                                 | 10 X 10                      | 21.52<br>19.28          |
| evi<br>evon                          | 8 x 8<br>6 x 6               | 17.04<br>14.80          |
| evet<br>evio                         | 5 × 5                        | 14.18<br>13.56          |
| evra                                 | 18x 18x 16x 18               | 34.00                   |
| emen                                 | 16 x 16                      | 31.71<br>29.42          |
| enno                                 | 12 X 12                      | 26.13                   |
| eper -                               | 10 x 10<br>8 x 8             | 22.84                   |
| erre                                 | 6x 6                         | 20.55<br>19.26<br>18.62 |
| erst<br>erve                         | 5× 5                         | 17.97                   |
| idum<br>ien                          | 20 x 20 x 20 x 20<br>18 x 18 | 44.00                   |
| ical                                 | 16 x 16                      | 39.66<br>35.32          |
| idao<br>iez                          | 14 X 14<br>12 X 12           | 30.98<br>26.64          |
| lmus                                 | 10 x 10                      | 23.30                   |
| inom<br>inva                         | 8 x 8<br>6 x 6               | 21.96                   |
| ione                                 | 5 × 5                        | 20.45<br>19.87<br>19.28 |
| ions<br>imes                         | 4 X 4<br>24 X 24 X 24 X 24   | 00.00                   |
| ious                                 | 20 X 20<br>18 X 18           | 57.08<br>52.62          |
| iras<br>isti                         | 16 x 16                      | 48.10                   |
| ites<br>ives                         | 14 X 14<br>12 X 12           | 43.70<br>40.24          |
| ivit                                 | 10 X 10                      | 37.78                   |
| iven<br>ivor                         | 8 x 8<br>6 x 6               | 36.32<br>33.86          |
| ipse                                 | 5 × 5                        | 33.13                   |
| ixit                                 | 4 × 4                        | 32.40                   |

"REDUCED" SPECIALS.—(Continued).
BENDS.

"Double Hubs."

SHORT RADIUS.



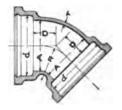


TABLE No. 31.

|  | QUARTER BENDS (90°)<br>Code Word: Aden                          |   |  |  |  | EIGHTH BENDS (45°)<br>Code Word: Aver                           |   |  |  |  |  |
|--|---|---|--|--|--|---|---|--|--|--|--|
| Code<br>Word<br>Term.  | A   | R   | В  | Price  | Code<br>Word<br>Term.  | A   | R   | D  | Price  |  |  |
| andi<br>ani<br>asis<br>asti<br>eces<br>envi<br>erai<br>ere<br>esto<br>evra<br>idum<br>imes | 3<br>4<br>5<br>6<br>8<br>10<br>12<br>14<br>16<br>18<br>20<br>24 | 4<br>4<br>4<br>6<br>6<br>6<br>8<br>10<br>10<br>12<br>12<br>14 | 4<br>4<br>5<br>6<br>8<br>8<br>10<br>12<br>12<br>14<br>14<br>16 | \$1.25<br>1.75<br>2.30<br>3.00<br>5.00<br>8.00<br>11.00<br>16.00<br>20.00<br>24.00<br>28.00<br>40.00 | andi<br>ani<br>asis<br>asti<br>eces<br>envi<br>erai<br>ere<br>esto<br>evra<br>idum<br>imes | 3<br>4<br>5<br>6<br>8<br>10<br>12<br>14<br>16<br>18<br>20<br>24 | 4<br>4<br>5<br>6<br>8<br>10<br>12<br>14<br>16<br>18<br>20<br>24 | 15/8<br>15/8<br>21/2<br>31/8<br>41/8<br>51/8<br>71/8<br>71/8 | \$1.25<br>1.75<br>2.30<br>3.00<br>4.50<br>7.20<br>10.00<br>14.50<br>18.00<br>21.60<br>25.50<br>36 00 |  |  |

For Long Radius Bends, see page 47.

In ordering from above Lists, specify "Reduced" Specials.

TABLE No. 32.

|                                  | REDUC                 | ERS-C                | ode Word : Ajar  |                      |
|----------------------------------|-----------------------|----------------------|--|----------------------|
| Code Word<br>Termin.<br>for Size | Diam.<br>in<br>Inches | Price<br>Each        | Code Word   Diam.<br>Termin.   in<br>for Size   Inches | Price<br>Each        |
| acit<br>anen<br>acti             | 4 to 3                | \$1.23<br>1.46       | eris { 14 to 12 ero { 10                               | \$7.23<br>8.02       |
| agus<br>amus                     | 5 to 4<br>6 to 5      | 1.70<br>1.80<br>2.90 | eva { 16 to 14 evas 12 evez                            | 6.90<br>7.90<br>9.18 |
| ance<br>anes<br>emie             | 8 to 6                | 2.17<br>2.40<br>2.65 | emen (18 to 16   | 12.10<br>12.50       |
| eaba<br>ebe<br>eor               | 5<br>4<br>10 to 8     | 3.00<br>3.40<br>3.59 | esen 14<br>enno 12<br>ian 20 to 18                     | 13.00                |
| ebat<br>emo<br>eras              | 6<br>5                | 3.96<br>4.20<br>4.50 | ical (24 to 20   | 16.15                |
| eram<br>eret                     | 8 6                   | 5.12<br>6.00         |  | 23.35<br>23.85       |

Short Reducers in this line of "Reduced" Specials are made to a taper of 6" per foot of length, with double bells. For longer Reducers, see page 49.

TABLE No. 32A.

|                             | SLEE<br>Code Wo      |        | ct                              | CAPS—Code Word: Add<br>PLUGS " " Adaw |                      |        |        |  |  |
|-----------------------------|----------------------|--------|---------------------------------|---------------------------------------|----------------------|--------|--------|--|--|
| Code                        | Diam.                | PRICE  | E EACH                          | Code                                  | Diam.                | PRICE  | EACH   |  |  |
| Word<br>Termin,<br>for Sise | in<br>Inch <b>es</b> | Solid  | Split<br>(includ-<br>ing Bolts) | Word<br>Termin.<br>for Size           | in<br>Inch <b>es</b> | Caps   | Plugs  |  |  |
| ais                         | 2                    | \$0.75 | \$1.25                          | ais                                   | 2                    |        | \$0.15 |  |  |
| andi                        | 3                    | 1.00   | 1.75                            | andi                                  | 3                    | \$0.75 | .25    |  |  |
| eni                         | 1 4                  | 1.25   | 2.25                            | ani                                   | 4                    | 1.00   | -35    |  |  |
| asis                        | 5                    | 1.50   | 2.65                            | asis                                  | ş                    | 1.25   | -45    |  |  |
| asti                        | 5<br>6<br>8          | 1.75   | 3.00                            | asti                                  | 6                    | 1.50   | .50    |  |  |
| eces                        |                      | 3.00   | 5.00                            | eces                                  | 8 ,                  | 2.25   | -75    |  |  |
| envi                        | 10                   | 4.25   | 6.00                            | envi                                  | 10                   | 3.00   | 1.50   |  |  |
| erai                        | 12                   | 5.50   | 7.00                            | erai                                  | 12                   | 3.75   | 2.00   |  |  |
| ere                         | 14                   | 7.00   | 10.00                           | ere                                   | 14<br>16             | 5.50   | 2.50   |  |  |
| esto                        | 16                   | 8.00   | 12.50                           | esto                                  |                      | 7.25   | 3.25   |  |  |
| evra                        | 18                   | 11.75  | 15.25                           | evra                                  | 18                   | 9.25   | 4.00   |  |  |
| idum                        | 20                   | 13.00  | 18.00                           | idum                                  | 20                   | 12.00  | 5.00   |  |  |
| imes                        | 24                   | 17.00  | 20.00                           | imes                                  | 24                   | 16.00  | 7.00   |  |  |

In ordering from these lists, specify "Reduced" Specials.

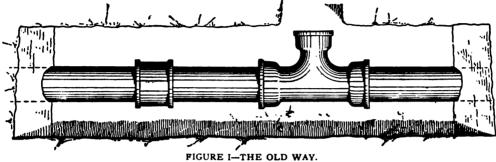
See Telegraphic Code, page 152.

## "CUTTING-IN" SPECIALS.

[DUNHAM PATENT, 1892.]

R. D. WOOD & CO., Sole MAKERS.

MADE in 4" to 16" diameters, inclusive, and especially designed for use where it is necessary to cut a street main for setting an extra hydrant, the opening of a new street, or for the introduction of any other large service.



The accompanying cuts illustrate the advantage of the "Cutting-in" Special, one end of which is enlarged back of the bell, and with its face made slightly oblique to the axis of the Special. Thus it is readily inserted as

shown and necessitates but two joints.

At the back of the bell and parallel to its face there is a projection or rib which fits the main pipe and forms a stop for the yarn. The Special is so made as to be adapted to varying thicknesses of pipes and presents no difficulty in making up.

Among the advantages in the use of this Special are diminished excavations, saving

in joints and labor, absence of holding and blocking up of pieces, variation of an inch or two in length of piece cut out without causing trouble and lessened length of time the water needs to be shut off. In addition, the "Cutting-in" Special may be used as an ordinary special if necessary, and where there is any uncertainty as to the location of side streets, it is cheaper to make the work continuous and "cut-in" branches with this Special as required.

We also make SHORT LENGTHS OF PIPE with the PATENTED BELL and a SPIGOT or with the PATENTED BELL and an ORDINARY BELL END. Where a change of grade or alignment is not sufficient to require a curved pipe, this form of short pipe admirably answers the purpose. With them also a break can be repaired without a sleeve with the least excavation and with but one extra joint. Regular sizes usually in stock.

Prices upon application.

FIGURE II-THE NEW WAY.

TABLE No. 32B.

| St   | 'ANDARI  |  | CUTTING ord: Afa                                    |                                    | EES   |  |  |
|--|--|--|---|------------------------------------|---|--|--|
| Code Word  | Diam.  | Laying                                       | Approx.   | WILL TAKE PIPE OF                  |   |  |  |
| Indication Indicating Inside Diameter                      | in<br>Inches   | Length<br>in<br>Inches                       | Weight<br>in Lbs.                                   | Inside<br>Diam.<br>Inches          | Thickness<br>Inches   |  |  |
| andi<br>ani<br>asti<br>eces<br>envi<br>erai<br>ere<br>esto | 3 X 3<br>4 X 4<br>6 X 6<br>8 X 8<br>10 X 10<br>12 X 12<br>14 X 14<br>16 X 16 | 16<br>19<br>21<br>23<br>24<br>24<br>31<br>31 | 90<br>100<br>190<br>290<br>380<br>580<br>780<br>950 | 3<br>4<br>6<br>8<br>10<br>12<br>14 | 15 to 18 25 to 38 35 to 34 15 to 38 15 to 38 15 to 38 15 to 18 15 to 18 |  |  |

Side outlets of different diameter than main run, to order only. These may be specified by adding to the code word that termination which indicates the size of main run and side outlet desired as obtained in first and ninth columns of Table No. 15, on page 46. For example a 10" x 10" x 6" would be indicated by Afarchet.

See Telegraphic Code, page 152.

## STANDARD FLANGE PIPE

AND

#### SPECIAL CASTINGS.



R. D. Wood & Co.'s
STANDARD DRILLING OFF
CENTER IN MULTIPLES
OF FOUR.

AVING equipped our shops with special appliances for the manufacture of Standard Flange Pipe and Fittings, we are able to fill orders promptly when our regular dimensions are adhered to, and we usually carry in stock or have in process of manufacture sizes from 4" to 24" diameter, inclusive, in sufficient quantities to fill the ordinary run of orders. While we are prepared to meet requirements of our customers as to weights and flange dimensions, variations from our standard, especially in flange diameters and drilling, necessarily involve delays and usually increased expenditures.

Weight of Pipe.—Owing to the rigidity of joints, experience shows that flange pipe should be markedly heavier than bell and spigot pipe for the

same pressure, even for the lightest service; and in no case would we recommend the use of lighter pipe than that listed for 25 pounds water pressure. In the preparation of the following

table we have given careful consideration to this point, and believe the weights given to be in accordance with the best practice. We are prepared to furnish to order heavier flange pipe for higher pressures than listed.

Laying.—Flange pipe are regularly made in 12-foot lengths, and in laying out full lengths should be used as far as practicable. By furnishing a general plan and leaving it to us to maintain center lines, using as far as may be our own patterns for specials (which we have in great variety in addition to the standards listed), outlays for pattern work may be avoided or reduced to a minimum.



Careful alignment with reference to drilling is essential, the top of each flange being notched to facilitate this. A certain clearance is allowed for bolts in bolt holes, and if this clearance or play is continually taken up in one direction the pipe line is twisted. This twist would divert the intended angle of direction of a connecting flange special or bolt holes would not match.

If a fixed total length of a line of flange pipe must be maintained, it is usually best to order a short length after the rest of the pipe is in place, as the amount taken up by gaskets may be more or less the allowance made.

Inspection and Testing.—Flange pipe of full length are carefully inspected and tested to 300 pounds per square inch hydrostatic pressure with the same appliances as are used for bell and spigot pipe.

Coating.—Customers will please state whether Flange Pipe and Fittings are to be coated or uncoated. Water pipe are usually coated, while pipe for steam and gas are uncoated.

Tongue and Groove Flange Pipe.—Though somewhat more expensive, for heavy pressures, and especially for steam, flanges with tongues and grooves are sometimes preferred. For details of this joint see Table No. 36, page 59.

Realizing the demand for greater uniformity in flanged diameters and drilling among different manufacturers, we have, with the principal Eastern Valve Companies, adopted the Standard of the National Association of Master Steam and Hot Water Fitters and the American Society of Mechanical Engineers, as per tables below.

All drilling is off centers, and in multiples of four, permitting quarter turns.

The diameter of flanges and bolt circles and the number of bolts per joint is that adopted for high pressures; the diameters of bolts given for 25 pounds and 50 pounds per square inch are for low pressures, and those given for 100 pounds and 150 pounds per square inch are for high pressures.

TABLE No. 33. STANDARD FLANGE PIPE.

| Word ation for Diam.   | le Dlam.   | ge m.   | eter of<br>Circle   | r of<br>lange   |  |  | Code Wo  | ord : Iro   |                        |   | ING WE                                 |   | Code W  | ord: Ir   |                                |  | e Diam.<br>Pipe   |
|--|--|---|---|---|--|--|--|---|------------------------|---|--|---|---|---|--------------------------------|--|---|
| D E S  | 문  | 의를<br>기를  | a di  | a Pe  |  | BAD, 60  |  | PRESSUI<br> Weight  | RE, 25 LI              |   |  | EAD, 115  |   | PRESSU<br> Weight   | RE, 50 L                       |  | 급   |
| Code Word<br>Termination for<br>Inside Diam.   | Inside   | Outside Diam<br>of Flange   | Diam<br>Bolt (  | Number<br>Bolts in Fig  | Thick-<br>ness<br>of Pipe              | Foot   | ht per<br>Length   | ol,   | Diam.<br>of Bolts      | Weight<br>of Bolts<br>and Nuts<br>per Joint   | Thick-<br>ness<br>of Pipe              | Foot  | ht per<br>Length  | of  | Diam.<br>of Bolts              | Weight<br>of Boits<br>and Nuts<br>per Joint  | Inside<br>of P  |
| andi<br>ani<br>asis<br>asti<br>eam<br>ecas<br>ensi<br>envi<br>eral<br>ere<br>eren<br>esto<br>eyra<br>idum<br>imes<br>iria<br>itis<br>ium<br>ocon | 3" 4<br>5 6<br>7 8 9<br>10 12 14 15 16 18 20 22 24 36 40 42 48 | 7½" 9 10 11 12½ 15 16 19 21 22½ 23½ 25 27½ 25 25 25 25 25 25 25 25 25 25 25 25 25                   | 67<br>74<br>844<br>944<br>1044<br>1134<br>1134<br>1134<br>20<br>214<br>224<br>225<br>274<br>294<br>474<br>494<br>56 | 4<br>8<br>8<br>8<br>8<br>12<br>12<br>12<br>16<br>16<br>16<br>20<br>20<br>28<br>32<br>32<br>33<br>44 | *************************              | 13.0<br>17.3<br>22.3<br>27.8<br>33.7<br>33.6<br>52.5<br>66.4<br>91.8<br>82.9<br>91.8<br>135.8<br>118.8<br>135.8<br>148.2<br>260.2<br>260.2<br>451.7<br>568.8 | 168<br>225<br>288<br>357<br>433<br>593<br>679<br>869<br>1081<br>1190<br>1268<br>1269<br>2376<br>3409<br>5522<br>6011<br>7602         | 6.1<br>8.6<br>10.8<br>11.8<br>15.5<br>17.4<br>22.2<br>24.6<br>36.3<br>42.9<br>48.8<br>557.0<br>69.7<br>795.8<br>143.1<br>209.3<br>275.8<br>205.8<br>388.3 | WEEKE THE STRUCKSCHOOL | 1.1<br>1.8<br>3.8<br>3.9<br>3.9<br>3.9<br>6.1<br>9.4<br>9.6<br>20.8<br>20.8<br>20.8<br>20.8<br>20.8<br>20.8<br>20.8<br>20.8 | 41744433338686027788838151353          | 13.7<br>18.7<br>24.7<br>30.5<br>38.3<br>44.3<br>50.2<br>78.0<br>94.9<br>107.7<br>118.0<br>141.7<br>107.4<br>195.4<br>224.7<br>335.9<br>344.3<br>538.4<br>578.0<br>732.8 | 177<br>242<br>318<br>391<br>494<br>559<br>776<br>1017<br>1233<br>1401<br>1538<br>1828<br>2158<br>2520<br>2915<br>4243<br>7628<br>7714<br>7628 | 6.3<br>9.0<br>10.8<br>12.5<br>17.0<br>18.9<br>24.2<br>26.7<br>40.5<br>54.3<br>63.8<br>79.7<br>109.5<br>109.5<br>109.5<br>144.9<br>345.9 | NANCES HANDERS HANDERS HANDERS | 1.1<br>1.8<br>3.8<br>4.0<br>4.0<br>6.1<br>9.8<br>10.0<br>15.9<br>21.5<br>22.2<br>32.7<br>41.4<br>42.5<br>82.5<br>82.5<br>134.1<br>134.1<br>134.1<br>1230.0 | 3456789011150180224956428   |
| Code Word<br>Fermination for<br>Inside Diam.   | Inside Diam.<br>of Pipe  | Outside Diam.<br>of Flange  | eter of<br>Circle   | Number of   | HE                                     | IAD, 230   | Code Wo  | ord: Isis   | WORDS                  |   |  | IGHT O  | F PIPE<br>Code We<br>FEET:  |   | s<br>re, 150 L                 | .26.   | Dlam:<br>Pipe   |
| dina de I  | - F  | 충문  | E C   | g a   | Thick-                                 |  | ht per   | Weight  | <u> </u>               | Welchs  | Thick-                                 |   | ht per  | Weight  | 1                              |  | ide 1   |
| Code<br>Termin<br>Insid  | Insi   | Outs  | Diam<br>Bolt (  | Nu<br>Bolts   | ness<br>of Pipe                        | Foot   | Length   | of<br>Single<br>Flange  | Diam.<br>of Bolts      | of Bolts<br>and Nuts<br>per Joint   | ness<br>of Pipe                        | Foot  | Length  | ot<br>Single<br>Flange  | Diam.<br>of Bolts              | Weight<br>of Bolts<br>and Nuts<br>per Joint  | Inside<br>of I  |
| andi<br>ani<br>asis<br>asti<br>eam<br>eces<br>ensi<br>envi<br>eral<br>ere<br>erem<br>esto<br>evra<br>idum<br>iner<br>imes<br>iram                | 3" 4 5 6 7 8 9 10 12 14 15 16 18 20 22 24 30                   | 7½"<br>9<br>10<br>11<br>13½<br>13½<br>15<br>16<br>19<br>21<br>22½<br>23½<br>25<br>27½<br>29½<br>38¾ | 6" 7 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1  | 4<br>4<br>8<br>8<br>8<br>8<br>12<br>12<br>12<br>12<br>16<br>16<br>20<br>20<br>28                    | ************************************** | 14-5<br>20.1<br>26-4<br>33-3<br>41-5<br>67-7<br>58-5<br>111-5<br>123-9<br>138-7<br>197-3<br>230-2<br>265-5<br>392-5  | 187<br>260<br>340<br>426<br>534<br>637<br>754<br>873<br>1150<br>1443<br>1606<br>1800<br>2141<br>2544<br>2950<br>3428<br>5078<br>6980 | 6.5<br>9.5<br>11.4<br>13.2<br>17.9<br>20.3<br>25.9<br>29.0<br>44.1<br>59.4<br>67.7<br>70.2<br>88.1<br>99.0<br>121.0                                       | KKKKKKKK "XXXXXXXXXX   | 1.9<br>3.0<br>6.2<br>6.5<br>6.5<br>9.9<br>15.8<br>16.1<br>23.1<br>33.6<br>45.0<br>57.6<br>75.2<br>131.6                     | ************************************** | 15.2<br>21.6<br>28.7<br>36.7<br>54.2<br>64.5<br>74.5<br>74.5<br>140.3<br>157.9<br>190.2<br>225.0<br>268.1<br>456.7  | 196<br>279<br>368<br>460<br>574<br>693<br>829<br>955<br>1283<br>1616<br>1812<br>2042<br>2435<br>2890<br>3431<br>3976<br>5877                  | 6.7<br>9-9<br>12.0<br>13.7<br>21.4<br>27.5<br>30.0<br>64.1<br>73.6<br>75.5<br>95.2<br>107.0<br>131.7                                    | KANASOOONKA KANOOOONKA         | 1.9<br>3.1<br>6.4<br>6.5<br>6.7<br>16.1<br>16.5<br>34.9<br>47.9<br>849.0<br>849.0  | 34<br>556<br>78<br>90<br>12<br>14<br>15<br>16<br>18<br>20<br>22<br>24<br>30 |

Weights are approximate only.

weights are approximate only.

Notes.—5", 7", 9" and 15" are odd sizes, made to order only. 4" to 24" usually in stock, regularly made in 12' lengths, faced ½" short to allow for gasket. Bolts and Gaskets furnished only on order. The flanges are finished approximately 1% times the thickness of pipe+½". Drilling is ¼" larger for ½" bolts; and ½" larger for ½ bolts and above, than corresponding bolt diameters and all drilling is in fours or multiples thereof.

The pressures given above are for water; when pipes are required for steam, the pressure should not exceed 3/3 of that given in table. See Telegraphic Code, page 152.



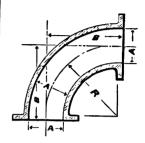
## STANDARD FLANGE PIPE SPECIALS—(Continued).

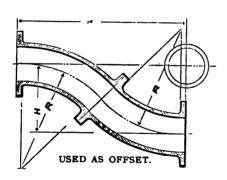
### BENDS.

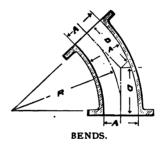
SHORT, MEDIUM OR LONG RADIUS.

TABLE No. 34.

| Quarte                  | BEN      | DS—Cod  | e Words      | Short  <br>  Mediu<br>  Long |        | dem<br>bex For<br>bis | Bends wi                   | th Hand |              | inca<br>inly<br>fily       |
|-------------------------|----------|---------|--------------|------------------------------|--------|-----------------------|----------------------------|---------|--------------|----------------------------|
| Code Word               | DIAM     | ETERS   | SHORT        | RADIUS                       | ME     | DIUM RA               | DIUS                       | L       | NG RAD       | ius.                       |
| Termination<br>for Size | A        | Flanges | В            | Approx.<br>Weight,<br>Lbs.   | В      | R                     | Approx.<br>Weight,<br>Lbs. | В       | R            | Approx.<br>Weight,<br>Lbs. |
| andl                    | 3"       | 7½"     | 5½"          | 35                           | 111/6" | 101/4"                | 45                         | .1756"  | 161/4"       | 60                         |
| eni                     | 4        | 9       | 6            | 45<br>60                     | 1156   | 11                    | 60                         | 17.5    | 17           | 75                         |
| asis<br>asti            | ş        | 10      | 7.           |                              | 121/4  | 111/2                 | 75                         | 18%     | 17%          | 100                        |
| cam                     | 9        | 121/4   | 7%           | 70<br>95                     | 1214   | 1216                  | 95<br>125                  | 19%     | 18%          | 125<br>160                 |
| eces                    | é        | 13%     | 81/2         | 110                          | 13%    | 13                    | 150                        | 19%     | 19           | 190                        |
| ensi                    | 9        | 15      | 9½<br>10½    | 145                          | 151/2  | 14%                   | 195                        | 21 1/4  | 2014         |                            |
| envi                    | 10       |         | 101/2        | 175                          | 16     | 15<br>16              | 230                        | 22      | 21           | 250<br>285                 |
| erai                    | 12       | 19      | 111/2        | 255                          | 17.    |                       | 320                        | 23.     | 22           | 400                        |
| ere                     | 14       | 21      | 13           | 340                          | 181/6  | 17                    | 415                        | 247     | 23           | 510<br>585                 |
| erem<br>esto            | 15<br>16 | 221/    | 14           | 395                          | 1814   | 171/2                 | 475<br>585                 | 24%     | 23 1/2<br>26 | 585                        |
| esto                    | 18       | 2578    | 157          | 455                          | 2278   | 20                    | 705                        | 27.8    | 27           | 855                        |
| Idum                    | 20       | 27%     | 1514<br>1614 | 545<br>680                   | 23%    | 22                    | 795<br>885                 | 29%     | 27<br>28     | 705<br>855<br>1050         |
| iner                    | 22       | 291/2   | 18           | 835                          | 241/2  | 23                    | 1045                       | 30%     | 29           | 1245                       |
| imes                    | 24       | 32      | 19%          | 1040                         | 2576   | 24                    | 1245                       | 31%     | 30           | 1500                       |







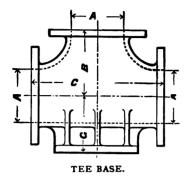


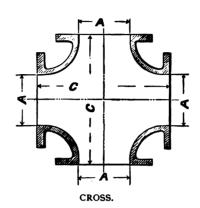
Furnished in all regular sizes, medium or long radius.

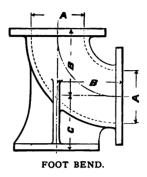
TABLE No. 34A.

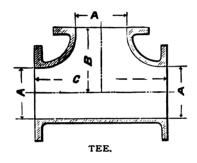
|                         |           | Eigh:     | гн. Вв                     | NDS-Co                     | de Word                     | s:{Sho<br>Med<br>Lor | rt Radius,<br>lium ''<br>g '' | iced<br>its<br>idly |                              |                            |
|-------------------------|-----------|-----------|----------------------------|----------------------------|-----------------------------|----------------------|-------------------------------|---------------------|------------------------------|----------------------------|
| Code Word               | DIAMETERS |           | SHORT                      | RADIUS                     | ME                          | DIUM R.              | ADIUS                         | Lo                  | NG RAI                       | DIUS                       |
| Termination<br>for Size | A         | Flanges   | D                          | Approx.<br>Weight,<br>Lbs. | D                           | R                    | Apprez.<br>Weight,<br>Lbs.    | D                   | R                            | Approx.<br>Weight,<br>Lbs. |
| andi                    | 3"        | 752"      | 3"                         | 30                         | 5%"<br>6%<br>7%<br>8%<br>8% | 12"                  | 35                            | 81/6"               | 18"                          | 45                         |
| eni                     | 4         | 9         | 31/4                       | 40<br>50<br>60<br>80       | 61/2                        | 14<br>16             | 50<br>65<br>80                | 9.                  | 20                           | 55<br>75<br>95<br>130      |
| asis<br>asti            | ş         | 10        | 3%<br>4%<br>5%<br>5%<br>5% | 50                         | 723                         | 16<br>18             | 25                            | 9%<br>10%<br>11%    | 22                           | 75                         |
| cam                     | 7         | 121/2     | 472                        | 80                         | 832                         | 19                   | 105                           | 1132                | 24<br>26                     | 130                        |
| eces                    | á         | 13%       | 51/                        | 95                         | 672                         | 20                   | 130                           | 121/4               | 28                           | 155                        |
| ensi                    | 9         |           | 53%                        | 115                        | 9½<br>9%                    | 21                   | 160                           | 13%                 | 30                           | 200                        |
| envi                    | 10        | 15        | 5%                         | 135                        | 10                          | 22                   | 185                           | 14%                 | 32                           | 240                        |
| erai                    | 12        | 19        | 61/2                       | 205                        | 11                          | 24<br>26             | 275                           | 151%                | 34                           | 335                        |
| ere                     | 14        | 31        | 7%                         | 260                        | 113%                        |                      | 355                           |                     | 36                           | 435                        |
| erem                    | 15<br>16  | 221/2     | 7%<br>7%<br>7%             | 300                        | 123/8                       | 27<br>28             | 400                           | 161/6               | 34<br>36<br>37<br><b>3</b> 8 | 490<br>565<br>680          |
| esto                    | 16<br>18  | 2372      | 773                        | 345                        | 12%                         |                      | 470<br>560                    | 17                  | 35<br>40                     | 202                        |
| evra<br>idum            | · 20      | 25<br>27½ | 71/4                       | 385                        | 1374                        | 30<br>32             |                               | 18%                 | 42                           | 850                        |
| ìner                    | 22        | 29%       | 10                         | 510<br>625                 | 153                         | 74                   | 705<br>850                    | 201/8               |                              | 1030                       |
| imes                    | 24        | 32        | 10%                        | 775                        | 15%                         | 34<br>36             | 1040                          | 21 1/2              | 45<br>48                     | 1270                       |

## STANDARD FLANGE PIPE SPECIALS.—(Continued).









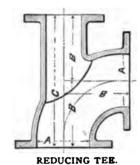


TABLE No. 35.

Code Words: Code Words:

|   | TRE   | Bases,                                     | iik             |   |   | FOOT  | BEND  | , ivy   |   |  |  |  |
|---|---|--|-----------------|---|---|---|---|---|---|--|--|--|
| antion of   | DIAM  | RTERS                                      | Dim             | ENSI  | ONS APPROX. WEIGHTS, LBS.                                     |   |   |   |   |  |  |  |
| Termina<br>Indicat<br>Size  | A   | Flan ges                                   | В               | С   | G   | Tees  | Crosses   | Poot<br>Bends   | Tee<br>Base   |  |  |  |
| andi<br>ani<br>asis<br>asti<br>eam<br>eces<br>ensi<br>envi<br>erai<br>ere<br>erem<br>esto<br>evra<br>idum | 3 <sup>#</sup> 4 5 7 8 9 10 12 14 15 16 18 20 | 7%" 9 10 11 12½ 13½ 15 16 19 21 22½ 25 27½ | 077889011344556 | 11" 12 14 15 16 17 19 21 23 26 28 29 31 33 36 | 5%<br>5%<br>6%<br>77%<br>8<br>9<br>10<br>12<br>13<br>14<br>15 | 50<br>65<br>85<br>105<br>145<br>170<br>215<br>265<br>385<br>595<br>680<br>810 | 65<br>80<br>115<br>135<br>180<br>210<br>280<br>335<br>480<br>625<br>730<br>840<br>990<br>1225 | 55<br>65<br>85<br>100<br>135<br>160<br>205<br>250<br>360<br>480<br>565<br>640<br>765<br>945 | 65<br>85<br>105<br>135<br>175<br>210<br>265<br>325<br>463<br>745<br>850<br>1010<br>1240 |  |  |  |
| iner  | 22  | 29½<br>32                                  | 18<br>1914      | 36<br>39                                      | 171/2   | 1240<br>1540  | 1490<br>1855  | 1145  | 1530<br>1885  |  |  |  |

TABLE No. 35A.

| Code Word: REDUCING TEES fon                                       |   |   |   |  |  |  |  |  |  |  |  |
|--|---|---|---|--|--|--|--|--|--|--|--|
| ermination<br>indicating<br>Size                                   | Sı                                      | ZB  | DIAM<br>O<br>FLAI   | Approx.<br>Weight                      |  |  |  |  |  |  |  |
| Tal.   | Body                                    | Arm   | Body  | Arm                                    | Lbs.   |  |  |  |  |  |  |
| acit acti ance amei emie eiie eor eras eris evor eva emen ian itie | 47 5 6 7 8 9 10 12 14 15 16 18 20 22 24 | 3" 4<br>4 4<br>6 6<br>6 8<br>10<br>12<br>12<br>14<br>16<br>18<br>20 | 9" 10<br>11 12 13 15<br>15<br>16<br>19<br>21 12 12 13 12 13 12 13 12 13 12 13 12 13 12 13 13 13 13 13 13 13 13 13 13 13 13 13 | 7½" 9 9 11 11 13½ 16 19 19 23½ 25½ 27½ | 60<br>80<br>95<br>135<br>155<br>190<br>250<br>360<br>490<br>560<br>815<br>1010<br>1260<br>1495 |  |  |  |  |  |  |

Note.—The approximate Weights of Tees; Crosses, etc., in above table are based on branches or arms being of the same diameter as the run; and such castings with smaller arms remain of same lengths of run and arm; thus, a 12" x 12" x 8" tee is of the same lengths C and B as a 12" x 12" x 12". All weights are approximate only. All flanges faced. Drilling to order only. 5", 7", 9" and 15" are odd sizes made to order only. Regular sizes up to 16" inclusive usually in stock or in process.

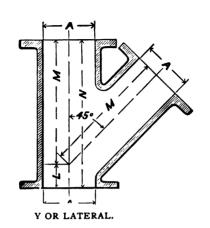
Standard Drilling off center. For Standard Flange dimensions, see Flange Pipe Table No. 35, page 55.

All specials proportioned for 100 pounds maximum working water pressure. Steel Specials for extra heavy pressure to order.

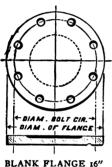
See Telegraphic Code, page 152.

## STANDARD FLANGE PIPE SPECIALS—(Continued).

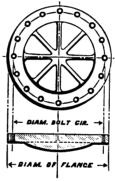
TABLE No. 35B.



|   |   | Y OR<br>Code   | Lati<br>Word                                  |   |   |   |
|---|---|--|---|---|---|---|
| 9 9 9   | DIAM                                      | ETERS  | Dı  | MENSIC  | )NS   | Apprex.   |
| Termina-<br>tion<br>Indicating<br>Size  | A   | Planges  | L   | M   | N   | Weight,<br>Lbs.   |
| andi<br>ani<br>asis<br>asti<br>easti<br>eces<br>ensi<br>ervi<br>erai<br>ere<br>esto<br>evra<br>idum<br>iner<br>imes | 3" 4 5 6 7 8 9 10 12 14 15 16 18 20 22 24 | 7½" 9 10 11 12½ 13½ 15 16 19 21 22½ 23½ 25 27½ 29½ 33² | 3"<br>3 3 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 | 11" 12 13 14½ 16 17 18½ 21 23½ 27 28½ 35 37½ 41 | 14"<br>15<br>16<br>18<br>20<br>21<br>23<br>25<br>28<br>28<br>28<br>32<br>34<br>34<br>42<br>43<br>44<br>49<br>49 | 60<br>80<br>100<br>135<br>200<br>240<br>300<br>375<br>545<br>745<br>870<br>1015<br>1250<br>1575<br>1920<br>2405 |







BLANK FLANGE OVER 16".

SCREW FLANGE.

TABLE No. 35C.

| S  | LANK<br>CREW   | FLAN         | GES, I                                 | mp } C                             | ode Wo   | ords   |  |  |  |
|--|--|--------------|--|------------------------------------|--|--|--|--|--|
| SCREW  | FLANC  | BS: F        | or Wro                                 | ight Iro                           | n Pipe   | BLANK<br>PLANGES   |  |  |  |
| an an a  | DIMENSIONS Approx                                      |              |  |                                    |  |  |  |  |  |
| Termin<br>tion<br>Indicat  | eter   | 0            | P                                      | s                                  | Weight,<br>Lbs.  | Approx.<br>Weight,<br>Lbs.   |  |  |  |
| andi<br>ani<br>asis<br>asti<br>eam<br>occes<br>ensi<br>envi<br>eral<br>ere<br>erem<br>esto<br>evra<br>idum<br>iner<br>imes | 3" 4<br>56 78 9<br>10 12<br>14 15<br>16 18 20<br>22 24 | KY XXXXXXXXX | ************************************** | 4%" 5% 6% 7% 8% 9% 10% 112 14% 16% | 12<br>14<br>16<br>20<br>30<br>35<br>47<br>45<br>65<br>80<br>95 | 13<br>17<br>22<br>30<br>45<br>50<br>70<br>100<br>135<br>155<br>180<br>240<br>300<br>380<br>470 |  |  |  |

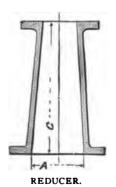
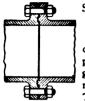


TABLE No. 35D.

| Rei   | DUCERS  | Code Wor  | rd:  |
|---|---|---|--|
| Termination<br>Indicating<br>Sine   | Size  | Diam.<br>of<br>Flanges  | Weights of<br>Brandard<br>Lengths, Lbc.                                      |
| acit<br>acti<br>ance<br>amei<br>emie<br>eile<br>eor<br>eras<br>eris<br>evor<br>eva<br>emen<br>ian<br>itie | 4" to 3" 5 " 4 6 " 4 7 " 6 8 " 6 9 " 6 10 " 8 12 " 10 14 " 12 15 " 12 16 " 14 18 " 16 20 " 18 22 " 20 24 " 20 | 9"and7\%" 10 " 9. 11 " 9 11 \ " 9 11 \ " 11 13\%" 11 15 " 11 16 " 13\% 19 " 16 22\ " 19 22\\" 19 22\\" 21 23\\" 23\\" 27\\" 27\\ 32 " 27\\" | 45<br>60<br>65<br>95<br>135<br>175<br>255<br>359<br>475<br>595<br>735<br>910 |

#### STANDARD FLANGE PIPE SPECIALS—(Continued).

#### TABLE No. 36.



in table..

STANDARD TONGUE AND GROOVE FLANGE PIPE.

Flange with Tongue is of standard thickness (see page 54). Flange with groove is ofstandard thickness, plus depth of groove. This increases the weight over standard flanges by the amounts given

| Stan  | DARD T                                | ONGUE A   | ND GROOV<br>Code Word                             |   | E DIMENS           | SIONS  |
|---|---------------------------------------|---|---|---|--------------------|--|
| Code Word<br>Termination  | Size                                  | Diam.   | Tono  | UE AND GI                               | ROOVE              | Extra<br>Weight, Lbs.  |
| for Inside<br>Diameter  | Pipe                                  | Flange  | Diam. at<br>Center                                | Width                                   | Height or<br>Depth | Add per pair<br>of Flanges   |
| andi ani asis asti eam eces ensi envi eral ere erem esto evra idum imer | 3" 4 56 7 8 9 10 12 14 15 18 20 22 24 | 7½" 9 10 11 12½ 13½ 15 16 19 21 22½ 23½ 25 27½ 29½ 32 | 4%" 5% 6% 7% 8% 9% 10% 11% 13% 16 16% 17% 21% 23% | KHAKKAKAKAKAKAKAKAKAKAKAKAKAKAKAKAKAKAK | n''                | 2<br>2½<br>3<br>3½<br>6½<br>7<br>9<br>10<br>14<br>15<br>21<br>23<br>28<br>38<br>43 |

#### HIGH PRESSURE MAINS.

WE make a specialty of furnishing complete lines of High Pressure Mains of cast iron or steel piping, with fittings, valves, etc. Inquiries for estimates should

be accompanied by drawings, showing in plan and elevation center lines of piping required, location of valves, etc. State maximum working pressure and the time and place of delivery desired.

HIGH PRESSURE CAST IRON PIPE JOINT made to order complete with bolts, washers and packing rings.

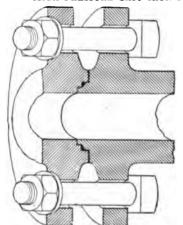
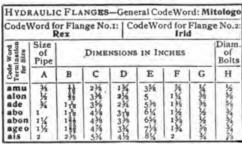
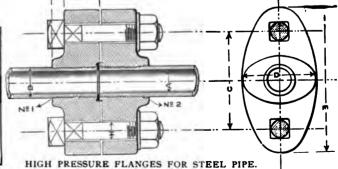


TABLE No. 37.

| CAST I   | RON F                             | IYDRAU                           | LIC PR              | ESSURE  | Pipė-                           | -Genera  | Code W                              | /ord: Miti  | regent   |  |  |
|--|-----------------------------------|----------------------------------|---------------------|---|---------------------------------|--|-------------------------------------|---|--|--|--|
| For pressure<br>Tested to<br>Cod                                 | s up to 1<br>o 2000 lb<br>le Word | ocolbs.p<br>s. per sq<br>l: Ivan | er sq. in.<br>. in. | For pressures up to 2000 lbs. per sq. in. Tested to 4000 lbs. per sq. in. Code Word: Item |                                 |  |                                     |   |  |  |  |
| Code Word<br>Termina.  | Size                              | Thick:<br>Pi<br>for Pres         |                     | Bo  | eter of<br>olts<br>ssure of     | in Le  | ade<br>ngths<br>ssure of            | Longth, inci  | e Weight per<br>uding Roits,<br>nd Gaskets<br>esure of   |  |  |
| for Inside<br>Diameter   | Pipe                              | rooo lbs.<br>per []"             |                     |   | 2000 lbs.<br>per 🗀"             |  | 2000 lbs.<br>  per []"              | 1000 lbs.<br>per []"  | 2000 lbs.<br>per □"  |  |  |
| ageo<br>als<br>amer<br>andi<br>and<br>ani<br>asis<br>asti<br>cam | 1 1/4" 2 2 1/4 3 3 1/4 4 5 6 7    | ""<br>"%<br>""<br>""<br>""<br>"" | 1%<br>1%<br>1%      | ***<br>**<br>**<br>**<br>**<br>**<br>**<br>**<br>**                                       | 36"<br>134<br>134<br>134<br>134 | 6 ft.<br>8 "<br>10 "<br>10 "<br>10 "<br>12 "<br>12 " | 6 ft.<br>8 "<br>8 "<br>10 "<br>10 " | 72 lbs. 153 " 228 " 401 " 545 " 659 " 1151 " 1367 " 1713 " 2108 " | 122 lbs. 281 4436 44 436 44 1051 44 1377 47 1377 47 17 17 17 17 17 17 17 17 17 17 17 17 17 |  |  |







Threaded for Extra Strong Pipe and furnished complete with bolts. Adapted for pressure up to 1500 lbs. per square inch. Flanges for heavier pressures to order. Inquiries should give inside and outside diameter of steel pipe that will be used and state maximum pressure.

Hydraulic Valves.—The Hydraulic Valves here illustrated are designed for hard and continuous service under high pressure. They are especially adapted for use in steel works and for hydraulic tools generally.



11/ THREE-WAY HYDRAULIC VALVE. (From Photograph.)

These valves, I" and larger, are proportioned for a pressure of 1000 The 1" and 2" sizes are adapted for 1500 pounds per square inch. pounds per square inch. Prices for higher pressures on application.

3-Way or 4-Way.—Each has one spindle only, giving the 4-way valve but one-half the cup packings required in other modern valves.

Every Valve has a clear passage throughout, equal to the area indicated by its size. The 1", 1" and I" sizes are in Solid Bronze Shells, with screw pipe connections. The 11" and larger are in Cast Iron Shells, Bronze-lined, with flange connections.

They are the most

Perfectly Balanced and the Easiest Working Valves yet introduced. The arrangement of leather cups gives the utmost durability; usually many times the life of cups in the Critchlow or other similar types. A worn cup is easily renewed in five minutes.

The Valves are

Built with the Greatest Care under rigid inspection, and only the finest grade of materials used throughout.

Pulpit Valves.—The accompanying cut illustrates our general adaptation of Hydraulic Valves and manifolds to steel works pulpits, or wherever it is necessary or desirable to group

> several valves for operating a number of machines from the same stand.



HYDRAULIC PULPIT VALVES WITH PRESSURE AND EXHAUST MANIFOLDS.



HIGH PRESSURE FLANGES FOR STEEL



CAST IRON HYDRAULIC PRESSURE

For detail of sizes and section of joint, see page 59.

Hydraulic Tool Pamphlet with full description of above and general line of hydraulic work sent on application.

## CAST IRON COLUMNS

W<sup>E</sup> have a variety of patterns for cast iron columns, and are also prepared to furnish to order, machined as required, columns of the heaviest class and for special requirements.

We further offer a line of columns made from regular cast iron bell and spigot pipes, supplemented with suitable top and bottom plates, making neat and substantial columns. The ends of pipes are machined to insure even bearings for top and bottom plates. Below we give a table giving approximate Weights and Capacities of these pipe columns. The diameters given are the inside diameters of the pipe. Heavier or lighter pipe, or pipe of larger diameter, than those listed may be used, making a proper allowance for capacity.

TABLE No. 39.

| Add weight                             | of base and top          | castings to r | nake approxim       | ate weight o | IPE COLUMN<br>f complete pip<br>with a factor of | e column. O | wing to possible     | le variations | in thickness         |
|--|--------------------------|---------------|---------------------|--------------|--|-------------|----------------------|---------------|----------------------|
|  | Made up<br>from          |               | Pipe<br>ord : Con   |              | Pipe<br>ord: Car                                 |             | Pipe<br>ord: Call    |               | Pipe<br>ord: Cot     |
| Code Word<br>Termination<br>for Length | Base and Top<br>Castings | veight,       | Square<br>60 Pounds |              | Square<br>95 Pounds                              |             | Square<br>140 Pounds |               | Square<br>200 pounds |
|  | Length                   | Weight        | Capacity            | Weight       | Capacity   | Weight      | Capacity             | Weight        | Capacity             |
| eler                                   | 6' 0''                   | 135           | 38,400              | 222          | 71,800   | 288         | 90,500               | 396           | 126,500              |
| elit                                   | 6 6                      | 145           | 37,000              | 239          | 69,800   | 310         | 90,500               | 427           | 126,500              |
| elor                                   | 7 0                      | 155           | 35,600              | 256          | 69,200   | 332         | 90,500               | 457           | 126,500              |
| emit                                   | 7 6                      | 165           | 34, 200             | 273          | 67,600   | 354         | 90,500               | 488           | 126,500              |
| emol                                   | 8 o                      | 175           | 32,900              | 290          | 65,500   | 376         | 90,500               | 518           | 126,500              |
| enra                                   | 8 6                      | 185           | 31,500              | 307          | 64,500   | 398         | 90,500               | 549           | 126,500              |
| ensi                                   | 90                       | 195           | 30,300              | 324          | 62,900   | 420         | 90,500               | 579           | 126,500              |
| enol                                   | 96                       | 205           | 29,000              | 341          | 61,300   | 444         | 89, 100              | 610           | 126,500              |
| envi                                   | 10 0                     | 215           | 27,800              | 358          | 59,700   | 466         | 87,400               | 640           | 126,500              |
| eon                                    | 10 6                     | 225           | 26,600              | 375          | 58, 100  | 488         | 85,700               | 671           | 126,500              |
| eomi                                   | 11 0                     | 235           | 25,500              | 392          | 56,500   | 510         | 84,200               | 701           | 126,500              |
| erut                                   | 11 6                     | 245           | 24,400              | 409          | 54,900   | 532         | 82,500               | 732           | 124,900              |
| eral                                   | . 12 0                   | 355           | 23,300              | 426          | 53,400   | 554         | 81,000               | 762           | 123,400              |
| erpe                                   | 12 6                     | 265           | 22,400              | 443          | 51,800   | 576         | 79,200               | 793           | 121,800              |

## THE MATHEWS' PATENT FIRE HYDRANT.

SINGLE AND DOUBLE VALVE.

W E have so long made a specialty of the manufacture of the Mathews' Patent Fire Hydrant, which is now so extensively used and so well known as a standard article, that were it not for the new friends we hope to make for it, the description of it might safely be omitted. It has been our constant aim to perfect these hydrants in every way, and as now made they are unequaled in efficiency, strength and simplicity of construction. All parts are made strictly to standard templets, insuring absolute interchangeability.

The constant increase in the annual sales of our hydrants, and their use at this time by over one thousand Water Works, inculding many of the most prominent in the country, is the best evidence of the appreciation in which they are held.



REGULAR HYDRANT.

4"

VALVE-OPENING.

#### MATHEWS' BRONZE-LINED HYDRANT.

Patented July 12, 1898.

WE invite particular attention to the above hydrant, shown in cut on right side of page, and claim that it is in every way the most perfect hydrant that has yet been made. It possesses every element of excellence found in our previous manufacture, together with many new features suggested by our experience of nearly half of a century in this special branch of manufacture. With our method of



BRONZE-LINED "1898'
HYDRANT.
4½", 5" and 6"
VALVE-OPENING.

inclosing the working parts in Bronze, we consider these hydrants practically indestructible.

All the bronze-lined hydrants will have the year "1898" cast on the stock above top of case to distinguish them from others of our manufacture.

In consequence of the rapidly growing demand for large hydrants, we have decided to make these in sizes with  $4\frac{1}{2}$ -inch, 5-inch and 6-inch valve-openings only. Those with 4-inch valve-opening will not be changed. These sizes are exclusive of the area of valve-rod.

Heavy sliding frost cases are on all hydrants of our manufacture.

ADVANTAGES.—In briefly stating some of the advantages of the *Mathews' Hydrant*, attention is especially directed to its anti-freezing qualities.

THE OUTSIDE CASING, the upper end of which makes a telescopic joint with the body or post of the hydrant, adds finish and strength. Below the ground line it serves to form a dead-air chamber around the hydrant stock, thus providing a non-conductor, affording great security against freezing, and obviating the necessity for packing or covering the hydrant in extreme cold weather, making the hydrant one especially adapted for service in cold climates. The case has an end play or vertical motion of several inches independently of the hydrant proper, and accommodates itself to the upheaval of the ground by frost, effectually preventing the heaving and breaking of the hydrant or foot-bend.

This sliding case is invariably furnished with the Mathews' Hydrants, even when they are intended for service in warm climates, as it serves a further purpose; admitting of the removal of the hydrant stock with all the working parts of the hydrant, including waste valve, etc., when it may be necessary to inspect or repair them, without digging up the ground about the hydrant; thus greatly facilitating and lessening the cost of repairs.

AUTOMATIC WASTE VALVE.—The waste valve of the Mathews' Hydrant is positively automatic, being so attached to the valve-rod that when the main valve is open the waste must be closed; and when the main valve is closed the waste is open, allowing the waste water to escape from the stand-pipe. The guides of the waste valve are closely fitted to grooves in the lower end of the stand-pipe, so there is no trembling or vibration in opening or closing the hydrants under any pressure, the rod and main valve being held rigidly to the center.

THE MAIN VALVE is made of the best oak-tanned sole leather, thoroughly hammered and pressed, then turned in a lathe on its own centers to fixed gauges, making them readily interchangeable. Being turned to conical form to fit the beveled valve seats, the closing of the hydrant is so gradual that there is no possibility of the "water hammer" so common in other hydrants. As the valve opens downward against the pressure of the water, the pressure is utilized in closing and holding the valve in place, and prevents any loss of water or flooding of streets in case the hydrant stock should by any means be broken.

The Mathews' Patent Double Valve Fire Hydrant.—The increased demand for the *Double Valve Fire Hydrant* has induced us to perfect our facilities for the manufacture of this admirable device, and we would particularly call attention to the many advantages obtained by its use. Briefly stated, these are:

Double Security against leakage by the use of two main (or induction) valves, one above the other. 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. The said valve being entirely separate and disconnected from the upper main valve and its rod, and closing automatically when the upper valve is closed, allows the hydrant to be removed without the use of gates, thus avoiding much extra expense and trouble.

The waste orifice is entirely closed before the water is let into the hydrant, and is not uncovered until after the lower main valve is closed, effectually preventing any waste of water when the hydrant is in use, or only partially open.

Should the upper (or main) valve be broken, or injured in any way, it can be taken off for repairs, for any length of time required, and replaced at leisure, 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; so that the water need not be shut off for an instant from the district, and the hydrant is always ready for use. The taking out and replacing of the hydrant is done in precisely the same way as with our ordinary hydrant, the lower or auxiliary



NOZZLE CUT-OFF.

valve being entirely self-acting, and requiring no manipulation whatever in performing its function of shutting off the water.

Hydrants with Secondary Gates.—Although our customers usually prefer to use our Double Valve Hydrant when desiring one which may be removed without shutting off the water from the main, others prefer an Independent or Secondary Gate Valve in the pipe leading from the main. generally placed between the curbing and base of hydrant. We are prepared to make this class of hydrant with the valve bolted on the elbow, or bend, of hydrant, and to supply Gate Boxes for any depth of covering.

THE DOUBLE VALVE HYDRANT. The working parts of the Mathews' Hydrant,

single or double valve, have been carefully designed, are simple, strong and durable, and as few in number as it has been practicable to make them. With a few duplicate parts in stock, it is possible to make ordinary repairs with promptness, and at small expense. Attention is especially called to the full directions for ordering, setting, using and repairing the Mathews' Hydrant, and for the ordering of duplicate parts. (See page 66.)

### MATHEWS' PATENT FIRE HYDRANTS.

TABLE No. 40

|  |                      |   | TABLE NO.   | 40.                                       |  |  |  |   |   |
|--|----------------------|---|---|---|--|--|--|---|---|
|  |                      | Code Words, ) Hall,   | SIFICATION OF L<br>Single Valve Hydra<br>Double Valve Hydra | nt<br>with Ind<br>int                     | S.—Writ<br>ependent<br>ependent                    | Cut-off  | ounts  |   |   |
| Code<br>Word<br>Term, for                    | Valve<br>Opening     | SINGLE VALVE HYDRANTS WITH  | PATENT SLIDING  | LK  |  |  | NT TO BOT  |   | IPE                                       |
| Size and<br>Detail                           |                      | FROST CASES   |   | <b>ba</b> 2½ or 3 ft.                     | be 3½ or<br>4 ft.                                  | bl 4½ or<br>5 ft.                                  | <b>bo</b> 5½ or 6 ft.                              | bu 7 ft.                                  | by 8 ft.                                  |
| ani<br>aler                                  | 4 4                  | One-Hose Discharge Two-Hose "   |   | \$30 00<br>32,00                          | \$31.00<br>33.00                                   | \$32.00<br>34.00                                   | \$33 00<br>35.00                                   | \$35 00<br>37 00                          | \$37.00<br>39.00                          |
| aker<br>ate<br>esem<br>eiem                  | 4½<br>4½<br>4½<br>4½ | Steamer "   |   | 36.00<br>36.00<br>38.00<br>40.00          | 37.00<br>37.00<br>39.00<br>41.00                   | 38.00<br>38.00<br>40.00<br>42.00                   | 3 .00<br>39.00<br>41 00<br>43 00                   | 41 00<br>41,00<br>43.00<br>45.00          | 43.00<br>43.00<br>45.00<br>47.00          |
| asis ing ispe onte oner                      | 5<br>5<br>5<br>5     | Two-Hose "  |   | 42 00<br>42 00<br>44 00<br>44 00<br>46 00 | 43.00<br>43.00<br>45.00<br>45.00<br>47.00          | 44.00<br>44.00<br>46.00<br>46.00<br>48.00          | 45.00<br>45.00<br>47.00<br>47.00<br>49.00          | 47.00<br>47.00<br>49.00<br>49.00<br>51.00 | 49.00<br>49.00<br>51.00<br>51.00          |
| asti<br>aise<br>efen<br>erat<br>odon<br>omei | 5<br>6<br>6<br>6     | " Discharge Two-Hose " Three-Hose " Four-Hose " Steamer and Two-Hose Discharge Double Steamer Discharge |   | 46 00<br>46.00<br>48.00<br>50.00<br>50.00 | 48.00<br>48.00<br>50.00<br>52.00<br>52.00<br>52.00 | 50 00<br>50.00<br>52 00<br>54.00<br>54.00<br>54.00 | 52.00<br>52.00<br>54.00<br>56.00<br>56.00<br>56.00 | 55 00<br>55.00<br>57 00<br>59 00<br>59 00 | 58.00<br>58.00<br>60.00<br>62.00<br>62.00 |

NOTE.—When ordering, specify whether Single or Double Valve Hydrants are required. State depth from pavement to bottom of pipe to insure getting the right length of Hydrant. Send hose gauge (part of coupling will answer) so that the Hydrant nozzle may be accurately fitted to it. State size and kind of pipe the Hydrants are to connect with. If other Hydrants are in use, state if they open by turning to the right or lest, and give size and shape of nut for wrench. For new places, unless otherwise specified, Hydrants are sent to open by turning to the lest.

Double Valve Hydrants.—Add to above to make list price, 4" and 4%", \$12.00; 5" and 6", \$15.00 each.

Patent Independent Nozzle Cut-off.—Add to list for ordinary 2\%"nozzle, \$4.00 per nozzle; for steamer (4") nozzle, \$6.00 per nozzle. Secondary Gates for Hydrants.—List prices. 4", to connect with 4" or 6" pipe, \$12.00. 6", to connect with 6" pipe, \$18.00.

Discount on all the above the same as on Hydrants.

Secondary Gate Boxes.—\$1.00, \$1.50 and \$2.00, net, according to length. Flush Hydrants and Tropical Hydrants.—Prices on application.

List of Cities and Towns using the Mathews' Hydrants furnished when desired.



Discount.....per cent.

Discount ..... .. per cent.

### FIRE-BOAT HYDRANTS.

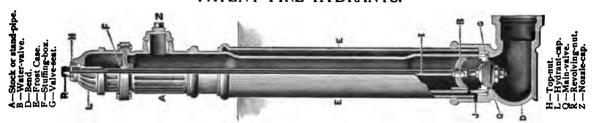
These very strong and efficient hydrants, taking water at the direct pressure of fire-boat pumps and independent of the ordinary water supply, have proved of valuable assistance in putting out fires because of the great power applied and the large flow of water.

They are very carefully and substantially made, are provided with our Patent Independent Nozzle Cut-Off Valves, and when required are supplied with Automatic Air Relief Valves.

We make these Hydrants in two sizes, 6 and 8-inch Stand-Pipe and Connection, with outlets as ordered and for any depth of pipe covering required. The 6-inch is made with bell or flanged connection, the 8-inch flanged only, unless otherwise ordered.

Full description and prices sent on application.

# DIRECTIONS FOR ORDERING, SETTING AND USING MATHEWS' PATENT FIRE HYDRANTS.



Length of hydrant.

Hose-gauge for nozzles.

Supply-pipe. Open to right or left. Size of nut.

Ordering repairs.

Height of frost-case.

Drainage of hydrant.

Securing base.

Bracing.

First using.

Dirt and Gravel in

pipes.

Taking up for repairs.

Case left in ground.

Clogging of wasteorifice. Defective drainage.

Sticking of parts in cold weather.

Use of steam to thaw out hydrants. Repacking stuffing-box.

Double-Valve Hydrants.

Painting after setting.

Hydrants open to left.

When ordering.—To insure getting right length of hydrants, state distance from level of side-walk to bottom of pipe connection. This is usually six inches to one foot more than depth of pipe-covering.

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 turn by turning to right or eft, and give size and shape of nut for wrench.

In ordering repairs for hydrants, please state in what year they were purchased, if possible, as some slight changes in details have been unavoidable.

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

is not less than two 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. It is well to make the trench large enough, in any case, to allow a filling of 10" to 12" of broken stone or coarse gravel to be placed around the bottom of the hydrant, and extending up above the waste-orifice, to prevent obstruction.

The base (D) should rest firmly upon a solid foundation, 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 stock (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, or by opening the hydrant about one full turn of the wrench, so that waste-valve is partially closed, and with nozzle-caps screwed on tightly, the pressure of the water will generally free the waste-orifice from any obstruction.

In extreme cold weather it is not unusual for some of the upper working parts of the hydrants 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 few taps with the hammer on the nut when wrench is applied, or, if steamers are used, a very small quantity of the 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) take out the bolts from cap (L) and the whole top can then be unscrewed from rod without disturbing the revolving or top-nuts.

Double-Valve Hydrants are taken up and repaired in the same manner, only it is not necessary to shut off the water from the mains. This is done by the supplemental-valve which works automatically, requiring no closing of stop-gates.

All hydrants are well painted before leaving our Works, 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 the 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 have right-hand thread except top-nut (H), which is unscrewed by turning in opposite direction from that required to open hydrant-valve.



## TABLE No. 40A. Flush or Surface Hydrants.

| Code                     |                  |                                 | LENGTH                             | FROM PAVEME                        | NT TO BOTTO                        | M OF PIPE                          |
|--------------------------|------------------|---------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| Word<br>Termina-<br>tion | Valve<br>Opening | CLASSIFICATION AND PRICE LIST   | Code Word:<br>Hint<br>2½ or 3 feet | Code Word:<br>Heel<br>3½ or 4 feet | Code Word:<br>Hart<br>4½ or 5 feet | Code Word:<br>Host<br>5½ or 6 feet |
| ove                      | 5"               | Two-Hose Discharges             | \$42.00                            | \$43.00                            | \$44.00                            | \$45.00                            |
| oval                     | 5"               | Steamer and One-Hose Discharges | 44.00                              | 45.00                              | 46.00                              | 47.00                              |
| ovas                     | 5"               | " " Two " "                     | 46.00                              | 47.00                              | 48.00                              | 49.00                              |
| ovit                     | 5"               | Double Steamer Discharge        | 46.00                              | 47.00                              | 48.00                              | 49.00                              |

5" FLUSH is HYDRANT.

The above cut and list serve as an illustration of this type of hydrant. In general finish and construction of working parts, they are essentially similar to the Mathews' Fire Hydrant described on pages 62 to 66 inclusive.

Discount on application.

#### Bronze SIAMESE COUPLINGS.







TABLE No. 40B.

| Code<br>Words |             |       |        | PRICE    | LIST    |       |       |        |          |         |
|---------------|-------------|-------|--------|----------|---------|-------|-------|--------|----------|---------|
| Hit           | One 21/2" I | .00se | Female | Coupling | g, with | 1 Two | 2½″1  | Male ( | Coupling | \$12.00 |
| Hoax          | Two 21/2"   | **    | 44     | **       | **      | One   | 21/2" | **     | **       | 14.00   |
| Hub           | One 4"      | ••    | **     | **       | 44      | Two   | 2½"   | "      | 44       | 15.00   |

Other styles to order. Prices upon application.



BRONZE GATE VALVES FOR HOSE NOZZLES.

## INDEPENDENT GATE VALVES FOR HYDRANT NOZZLES, ETC.

These gates are made of bronze, are compact, light and of neat appearance. When carried on hose carriages they may be attached to nozzles of any hydrant and are coming into general use for such purpose, as also in the service of large buildings, manufactories. etc. They may be supplied with or without loose couplings, or cap and chain attachments.

For 21/2 inch nozzle . . \$15.00.

#### CAST STEEL COMBINATION

WRENCHES AND SPANNER.



The larger end of wrench is made to fit top-nuts on all sizes of our hydrants. We keep in stock to fit nuts in opening hydrants the following:

For 5-sided nuts, 1% and 1% inch.
Code word: Hear.
For 4-sided nuts, % and 1 inch.
Code word Hour.

## TROPICAL HYDRANT. Code word: Hot.



Prices on application.

Our Tropical Hydrant has been used extensively in Cuba and South America. Extra lengths for deeper pipe covering made to order.

TABLE No. 41.

PRESSURE REQUIRED FOR FIRE STREAMS THROUGH RUBBER HOSE.

| essure<br>le                    | ns<br>ed per<br>te              | Horizontal<br>Distance Reached<br>by Jet | Vertical Distance<br>Reached by Jet | Press    | ure in Pou | ınds at Hy  |            | Steamer to<br>different I |            |             | ective Pre  | essure at 1 | Nozzle     |
|---------------------------------|---------------------------------|--|-------------------------------------|----------|------------|-------------|------------|---------------------------|------------|-------------|-------------|-------------|------------|
| Effective Pressure<br>at Nozzle | Gallons<br>scharged 1<br>Minute | orizon<br>oce Re<br>by Jet               | al Di                               |          |            |             | U          | sing a 1"                 | Ring Noz   | zle ,       |             |             |            |
| Effect                          | Disci                           | H <sub>e</sub><br>Dista                  | Vertic<br>Rea                       | 100 ft.  | 200 ft.    | 300 ft.     | 400 ft.    | 500 ft.                   | 600 ft.    | 700 ft.     | 800 ft.     | 900 ft.     | 1000 ft    |
| 10                              | 60                              | 49                                       | 22                                  | 12       | 13         | 15          | 17         | 18                        | 20         | 22          | 23          | 25          | 47         |
| 20                              | 86                              | 69                                       | 42                                  | 23       | 26         | 28          | 31         | 34                        | 37         | 40          | 42          | 45          | 48         |
| 30                              | 105                             | 88                                       | 61                                  | 34       | 38         | 42          | 46         | 50                        | 54         | 58          | 62          | 66          | 70         |
| 40                              | 121                             | 105                                      | 78                                  | 45       | 50         | 56          | 61         | 66                        | 71<br>88   | 76          | 82          | 87          | 92         |
| 50                              | 135                             | 121                                      | 92                                  | 56<br>68 | 63         | 69<br>83    | 76<br>91   | 98                        | 106        | 95          | 10I<br>12I  | 108<br>120  | 114        |
| 60                              | 148                             | 136                                      | 104                                 | 79       | 75<br>88   | 97          | 106        | 115                       | 100<br>124 | 133         | 142         | 151         | 137<br>160 |
| 70<br>80                        | 160<br>171                      | 149<br>160                               | 115<br>124                          | 90       | 101        | 111         | 121        | 131                       | 142        | 152         | 162         | 172         | 183        |
| 90                              | 181                             | 168                                      | 132                                 | 102      | 113        | 125         | 136        | 148                       | 159        | 171         | 182         | 194         | 205        |
| 100                             | 191                             | 174                                      | 136                                 | 113      | 126        | 139         | 152        | 164                       | 177        | 190         | 203         | 216         | 229        |
|                                 |                                 | -/-                                      | =                                   |          |            | =           | <b>J</b> - |                           | ·          |             |             | _ =         |            |
|                                 |                                 |  |                                     |          | Usir       | nga 1⅓″ ]   | Ring Noza  | zle                       |            |             |             |             |            |
| 10                              | 76                              | 49                                       | 22                                  | 12       | 15         | 17          | 19         | 22                        | 24         | 26          | 29          | 31          | 33         |
| 20                              | 108                             | 70<br>89                                 | 43                                  | 24       | 28         | 33          | 37         | 41                        | 45         | 49          | 54          | 58          | 62         |
| 30                              | 132                             |  | 62                                  | 36       | 42         | 48          | 55         | 61                        | 67         | 73          | 79          | 85          | 92         |
| 40                              | 153                             | 108                                      | 79                                  | 48       | 56         | 65          | 73         | 81                        | 89         | 97          | 106         | 114         | 122        |
| 50                              | 171                             | 125                                      | 94                                  | 60       | 71         | 81          | 91         | IOI                       | 112        | 122         | 132         | 142         | 153        |
| 60                              | 188                             | 140                                      | 108                                 | 72       | 85         | 97          | 110        | 122                       | 134        | 147         | 159         | 172         | 184        |
| 7°                              | 202                             | 154                                      | 121                                 | 84       | 99         | 113         | 147        | 142<br>163                | 157<br>180 | 171         | 213         | 200<br>220  | 214<br>246 |
| 80                              | 216                             | 165                                      | 131<br>141                          | 100      | 113        | 130<br>146  | 165        | 183                       | 202        | 221         | 239         | 258         | 277        |
| 90<br>1 <b>0</b> 0              | 229<br>242                      | 174<br>181                               | 141                                 | 121      | 142        | 163         | 184        | 205                       | 226        | 247         | 268         | 288         |            |
|                                 |                                 |  | • -                                 |          | Usir       | ng a 1½" ]  | Ring Noz   | zle                       |            | <del></del> | <del></del> |             | <u>'</u>   |
| 10                              | 95                              | 49                                       |                                     | 13       | 17         | 20          | 23         | 27                        | 30         | 33          | 37          | 40          | 43         |
| 20                              | 134                             | 71                                       | 43                                  | 26       | 33         | .39         | 45         | 52                        | 58         | 64          | 71          | 77          | 83         |
| 30                              | 164                             | 92                                       | 63                                  | 39       | 49         | 58          | 68         | 77                        | 86         | 96          | 105         | 115         | 124        |
| 40                              | 189                             | 112                                      | 8ō                                  | 53       | 65         | 78          | 90         | 103                       | 116        | 128         | 141         | 153         | 166        |
| 50                              | 211                             | 130                                      | 95                                  | 66       | 82         | 97          | 113        | 129                       | 145        | 161         | 177         | 193         | 208        |
| 60                              | 232                             | 146                                      | 110                                 | 79       | 98         | 118         | 137        | 156                       | 175        | 194         | 214         | 233         | 252        |
| 70                              | 250                             | 160                                      | 123                                 | 92       | 115        | 137         | 160        | 182                       | 204        | 227         | 249         | 271         | ••••       |
| 80                              | 268                             | 172                                      | 135                                 | 106      | 132        | 157         | 183<br>209 | 209<br>235                | 235        |             |             | •••••       |            |
| 90                              | 284                             | 182                                      | 146                                 | 119      | 148        | 177         | 229        | 233                       |            |             |             | ·····       |            |
| 100                             | 299                             | 190                                      | 155                                 | 132      | 103        |             |            |                           |            | <u> </u>    |             | · ·····     |            |
|                                 |                                 |  |                                     |          | Usi        | ng a 13%″ : | Ring Noza  | zle                       |            |             |             |             |            |
| 10                              | 114                             | 49                                       | 23                                  | 15       | 19         | 24          | 29         | 33                        | 38         | 43          | 37          | 51          | 56         |
| 20                              | 16i                             | 72                                       | 43                                  | 29       | 38         | 47          | 56         | 65                        | 75         | 84          | 93          | 102         | III        |
| 30                              | 198                             | 95                                       | 63                                  | 44       | 58         | 72          | 85         | 99                        | 113        | 127         | 141         | 155         | 169        |
| 40                              | 228                             | 116                                      | 82                                  | 58       | 77         | 95          | 114        | 132                       | 151        | 169         | 188         | 207         | 225        |
| 50                              | 255                             | 135                                      | 99                                  | 73<br>88 | 97         | 120         | 144        | 167                       | 190        | 214         | 237         | 260         |            |
| 60                              | 280                             | 153                                      | 115                                 |          | 116        | 144         | 173        | 201                       | 229        |             | ••••        | •••••       | ••••       |
| 70                              | 302                             | 169                                      | 128                                 | 102      | 136        | 169         | 202        | 235                       | •••••      | •••••       | ••••        | ••••        | *****      |
| 80                              | 323                             | 183                                      | 141                                 |          | 156        | 194<br>218  | 232        |                           |            |             |             |             | *****      |
| 90<br>100                       | 343<br>361                      | 194<br>203                               | 152<br>162                          | 133      | 196        | 210         |            |                           |            |             | •••••       |             |            |
| 100                             | J                               | , ~~s                                    |                                     |          | • 70       |             | 1          | 1                         |            |             |             |             |            |

As determined by experiments made in the Springfield, Mass., Fire Department by Chief Engineer A. P. Leshure.

TABLE No. 42.

Theoretical Discharge of Circular Orifices or Nozzles.—Diameters in Inches.

| Head      |                | Velocity of<br>Discharge |      | No. of United States Gallons of 231 Cubic Inches Discharged per Minute |      |      |              |              |              |              |            |            |            |                   |                   |                   |                   |                   |                   |              |          |
|-----------|----------------|--------------------------|------|--|------|------|--------------|--------------|--------------|--------------|------------|------------|------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------|----------|
| Lbs.      | Feet           | in Feet<br>per Second    | 76   | 3%   | ₩.   | ×    | 76           | %            | 3%           | *            | %          | 1          | 11/6       | 114               | 13%               | 13%               | 11/4              | 2                 | 21/4              | 21/4         | Lbs      |
| 10        | 23.1           | 38.58                    | 0.37 | 1.48   | 3.30 | 5.90 | 13.2         | 23.6<br>28.7 | 36.8         | 53.2<br>65.1 | 72.2       | 94,4       | 119        | 148<br>181        | 178<br>218        | 212.              | 289               | 378<br>463        | 478<br>586<br>676 | 590          | 10<br>15 |
| 15        | 34.7           | 47.25                    | 0.45 |  | 4.02 | 7.23 | 16.2         |              | 45.0         |              | 88.4       | 116        | 146        |                   |                   | 300               | 354<br>409        | 534               | 300               | 723<br>835   | 30       |
| 20        | 46.2           | 54-55                    | 0.52 | 2.09   | 4.66 | 8.35 |              | 33-4         | 52.0<br>58.2 | 75.3<br>84.1 | 102<br>114 | 134<br>149 | 189        | 209               | 252<br>282        | 326               | 457               | 507               | 756               | 933          | 25       |
| 35        | 57.8           | 60.99<br>66.82           | 0.58 | 2.33   | 5.23 | 9.33 | 20.9         | 37.2<br>40.9 | 50.2         |              | 125        | 164        | 207        | 233<br>256        | 309               | 336<br>368        | 501               | 597<br>654        | 756<br>828        | 1022         | 30       |
| 30<br>35  | 69.3<br>80.0   | 72.16                    | 0.69 | 2.56<br>2.76   | 5.71 | 11.0 | 24.7         | 44.2         | 63.7<br>68.8 | 99.6         |            |            | 223        | 276               | 334               | 397               | 541               | 707               | 895               | 1104         | 35       |
| 32        | 92.4           | 77.14                    | 0.74 | 2.95   | 6.60 | 11.8 | 26.4         | 47.2         | 73.6         | 106          | 144        | 177<br>189 | 239        | 295               | 357               | 425               | 541<br>578<br>613 | 707<br>755<br>801 | 956               | 1180         | 40       |
| 45        | 104.0          | 81.83                    | 0.78 | 3.13   | 6.99 | 12.5 | 28.0         | 50.2         | 73.6<br>78.1 | 113          | 153        | 200        | 253<br>267 | 313               | 357<br>378        | 450               | 613               | 801               | 1014              | 1252         | 45       |
| 50        | 115.5          | 86.26                    | 0.82 | 3.30   | 7.37 | 13.2 | 29.5         | 52.8         |              |              | 161        | 211        | 267        | 330               | 399<br>418        | 475<br>498        | 646<br>678        | 845<br>886        | 1069              | 1320         | 50       |
| \$5<br>60 | 127.1          | 90.46                    | 0.86 | 3.46   | 7.73 | 13.8 | 30.9         | 55-4         | 86.3         | 125          | 169        | 221        | 280        | 346               |                   | 498               | 678               |                   | 1122              | 1385         | 55<br>60 |
|           | 138.6          | 94.49                    | 0.90 | 3.46<br>3.62   | 8.08 | 14.5 | 32.3         | 57.8         | 90.1         | 130          | 177        | 231        | 293        | 362               | 437               | 520               | 708               | 925               | 1171              | 1446         | 65       |
| 65        | 150.2          | 98.35                    | 0.94 | 3.77   | 8.40 | 15.1 | 33.6         | 60.2         | 93.8         |              |            | 241        | 305<br>316 | 377               | 455               | 542<br>562<br>582 | 737<br>765        | 963               | 1219              | 1506<br>1561 | 70       |
| 70        | 161.7          | 102.06                   | 0.97 | 3.91   | 8.73 | 15.6 | 34.9         | 62.5         |              | 141          | 191        | 250        | 310        | 391               | 472<br>488        | 302               | 703               | 999<br>1034       | 1309              | 1616         | 75       |
| 75        | 173.3          | 105.65                   | 1.01 | 4.04   | 9.03 | 16.2 | 36.1         | 64.6         | 101          | 146          | 198        | 259<br>267 | 327        | 404               | 504               | 601               | 792<br>818        | 1068              | 1352              | 1669         | 75<br>80 |
|           |                | 109.11                   | 1.04 | 4.18   | 9.33 | 16.7 | 37.8         | 68.8         | 104          | 150<br>155   | 204        | 275        | 338<br>348 | 431               | 520               | 620               | 843               | 1101              | 1394              | 1720         | 85       |
| 85        | 196.4          | 112.46                   | 1.07 | 4.31   | 9.62 | 17.2 | 38.5<br>39.6 | 70.8         |              | 160          | 217        | 275<br>283 | 358        | 443               | 535               | 637               | 867               | 1133              | 1434              | 1770         | 90       |
| 90<br>95  | 207.9          | 115.72                   | 1.13 | 4-43<br>4-55   | 10.2 | 17.7 | 40.7         | 72.8         | 113          | 164          | 223        | 29I        | 358<br>368 | 455               | 550               | 655               | 891               | 1164              | 1474              | 1820         | 95       |
| 100       | 231 I          | 121.08                   | 1.16 | 4.67   | 10.4 | 18.7 | 41.7         | 74.6         | 116          | 168          | 228        | 299        | 378<br>387 | 467               | 564               | 672<br>688        | 914               | 1194              | 1512              | 1866         | 100      |
| 105       | 242.6          | 125.00                   | 1.10 | 4.78   | 10.7 | 19.1 | 42.8         | 76.5         | 119          | 172          | 234        | 306        | 387        | 455<br>467<br>478 | 550<br>564<br>578 |                   | 937               | 1224              | 1549              | 1912         | 105      |
| 110       | 254.2          | 127.94                   | 1.22 |  | 10.9 | 19.6 | 43.8         | 78.3         | 122          | 177          | 239        | 313        | 396        | 490               | 591<br>605        | 705               | 959<br>980        | 1253<br>1281      | 1586              | 1957         | 110      |
| 115       | 265.7          | 130.82                   | 1.25 |  | 11.2 | 20.0 | 44.8         | 80.1         | 125          | 181          | 245        | 320        | 405        | 501               | 605               | 720               |                   |                   | 1621              | 2002         | 115      |
| 120       | 277.3<br>288.8 | 133.63                   | 1.27 | 5.12   | 11.4 | 20.4 | 45.7         | 81.8         | 127          | 184<br>188   | 250        | 327        | 414        | 512               | 618               | 736               | 1001              | 1308              | 1656              | 2044         | 120      |
| 125       |                | 136.38                   | 1.30 |  | 11.7 | 20.9 | 46.7         | 83.5         | 130          |              | 255        | 334        | 422        | 522               | 630               | 751<br>766        | 1022              | 1335<br>1362      | 1691              | 2128         | 130      |
| 130       | 300.4          | 139.08                   | 1.33 | 5.32   | 11.9 | 21.3 | 47.6         | 85.1         | 133          | 192          | 260        | 341        | 431        | 532               | 643               | 700               | 1042              | 1302              | 1724              | 2.20         | 1 -30    |

Note.—The actual discharge will be less than the theoretical one given above, varying with the form of nozzle or tube through which the water flows. For a ring nozzle 64 per cent., and for a good form of tapering smooth nozzle about 82 per cent., can be assumed as the actual discharge.

## GATE VALVES.

FOR WATER, GAS, OIL AND STEAM.

THE manufacture of GATE VALVES is also a specialty, undertaken many



GATE VALVE.

years ago, the growing output necessitating from time to time a material increase in the facilities of the Valve Department. All GATE VALVES made by us are tested before shipment to 300 pounds water pressure, and will be found to be carefully built to standard templets. Except when intended for gas, or otherwise ordered, all of our GATE VALVES are bronze mounted and have solid bronze metal stems. They are strongly built and of such design as to admit of a full open way, giving unobstructed passage for the full pipe capacity. In being double faced the chance of leakage is diminished two-fold. The spherical shape of the disc holder or ball allows the discs to adjust themselves to any sediment that may become attached to the brass seats, thus insuring tightness. The discs, being independent and free to revolve on the trunnions, never come back to the same point, and thus constant wear on any one point is pre- GATE VALVE vented, and the valves are consequently most durable. The SCREW AND YOKE. valves open easily because the ball moves away from the discs, leaving them loose before lifting them. In valves of 20" diameter and upward, especially where the pressure is considerable, by-pass valves will be found of advantage, insuring as they do greater ease in opening under heavy pressure.

#### TABLE No. 43.

#### IRON BODY, BRONZE MOUNTED GATE VALVES.

Tested to 300 lbs. water pressure.

Bell, Flange or Screw Ends for water, gas or other use.

| 1              |      | le Wor               | Valve<br>ds { Be<br>Fl<br>Sc<br>lbs. wa | ange<br>rew |         | nside Scr<br>Vail<br>Van<br>Vast | rew            | Outside S<br>and You<br>Veer<br>Vent<br>Void | ke             | scount             |          |  |
|----------------|------|----------------------|---|-------------|---------|----------------------------------|----------------|--|----------------|--------------------|----------|--|
| Code           |      | DIMENSIONS IN INCHES |   |             |         |                                  | LIST PRICES.   |  |                |                    |          |  |
| Word<br>Term'n | Size | Bells                |   | Fla         | nges    | Out to<br>Out of                 |                |  |                | Add for<br>Outside |          |  |
| for<br>Size    |      | End to<br>End        | Laying<br>Longth                        | Diam.       | Face to | Screw                            | Bell           | Flange                                       | Screw          | Screw<br>and Yoke  | Size     |  |
| ais<br>andi    | 2"   | 9%<br>10%            | 3½<br>4½<br>5¾                          | 6 7%        | 7       | 614                              | \$10.00        | \$11.00                                      | \$10.50        | \$7.50             | 2"       |  |
| ani            | 3    | 111%                 | 122                                     | 9778        | 10      | 7%<br>10                         | 15.00<br>19.00 | 20.00  | 15.50<br>19.50 | 8.50               | 3        |  |
| asis           | 3    | 12                   | 874                                     | 10          | 10%     | 12                               | 25.00          | 26.50  | 26.00          | 12.00              | 3        |  |
| asti           | ş    | 1334                 | 61/4                                    | 11          | 11      | 121/4                            | 31.00          | 33.00  | 32.00          | 15.00              | ð        |  |
| 00 M           | 7    | 14                   | 7                                       | 1214        | 11%     | 121/2                            | 37.00          | 39.00  | 39.00          | 17.00              | 7        |  |
| eces           | 8    | 14%                  | 7%                                      | 13%         | 12      | 13                               | 45.00          | 47.00  | 48.00          | 20.00              | 8        |  |
| ensi           | 9    | 15                   | 8                                       | 15          | 12%     | 14                               | 58.00          | 62.00  | 64.00          | 22.00              | 9        |  |
| envi<br>erai   | 10   | 16%                  | 81/4                                    | 19          | 13%     | 15%                              | 83.00          | 67.00<br>87.00                               | 69.00          | 24.00<br>27.00     | IO<br>I2 |  |

Unless otherwise ordered, all Valves are sent arranged to open by turning to the right.

For larger diameters, see page 72.

This applies to geared valves also.

#### VALVE INDICATORS.

For use wherever it is desirable or necessary to know position of gate.

They are of simple design, compact and so placed as to escape injury or disarrangement.

#### Angle Valves.

These are simply the Gate Valves of standard make provided with elbow as shown.



VALVE INDICATOR
AS ATTACHED TO VALVE



ANGLE VALVE.

#### TABLE No. 44.

| FOR GATE V            |          |                                    |                     |                                  |   |  |
|-----------------------|----------|------------------------------------|---------------------|----------------------------------|---|--|
| Code Word<br>Termina- | Size     | Code Word:<br>Vim                  | Code Word :<br>Vary | Code Word:<br>Vat                | Code Word :<br>Vein<br>Companion<br>Flanges, per pair |  |
| tion<br>for Size      | of Valve | Indicator Attach-<br>ment to Valve | Angle Valves        | Sliding Stem and<br>Lever Valves |   |  |
| ani                   | 4"       | \$5.00                             | \$2.50              | \$4.50                           | \$4.75  |  |
| asis                  | 5        | 5.50                               | 3.25                | 5.50                             | 6.00  |  |
| asti                  | 6        | 6.00                               | 4.00                | 5.50<br>6,00                     | 7.50  |  |
| cam                   | 7        | 6.50                               | 5.00                | 7.00                             | 9.00  |  |
| eces                  | 8        | 7.00                               | 6.00                | 8.00                             | 10.50   |  |
| ensi                  | 9        | 8.00                               | 7.50                |                                  | 13.00   |  |
| envi                  | 10       | 10.00                              | 9.00                |                                  | 16.00   |  |
| erai                  | 12       | 12.00                              | 12.00               |                                  | 20.00   |  |

This design gives a quick-acting valve, opened or closed by one movement and which may be secured in desired position by a locking wheel or lever. Furnished with either flanged or screwed ends.

It is objectionable where it may cause injurious water ram.

#### COMPANION FLANGES.

These may be supplied with or without tongue or grooved flanges and calking seams.

# ADJUSTABLE VALVE AND SERVICE BOXES.

PHESE boxes will be found to admirably meet the requirements of those who desire a substantial Valve Box, easily set and readily adjustable to variations in

In ordering, state size of valve, depth of trench, etc.,
and if for water or gas.
ops lettered to order.
Discount on application. Tops lettered to order.

## SERVICE BOXES.

Code word: Vamp; Code word terminations for lengths same as for Valve Boxes.

Service Boxes are made in same lengths as Valve Boxes. Inside diameter of upper case, 3".

Prices upon application.

| A                                | Code Wo                                     |                                  |                           |                                |
|----------------------------------|---|----------------------------------|---------------------------|--------------------------------|
| Code<br>Word<br>ermina-<br>tion. | Length<br>Adjustable<br>from                | Inside<br>Diam,<br>Upper<br>Case | Diam.<br>at Box<br>Bottom | List<br>Prices<br>Each         |
| isti<br>imes<br>iria<br>ocon     | 16" to 24"<br>24 " 32<br>36 " 60<br>48 " 72 | 61/8<br>61/8<br>61/8             | 8"<br>83%<br>83%<br>83%   | \$4.50<br>5.00<br>7.00<br>8.00 |

11.00

TABLE No. 45.

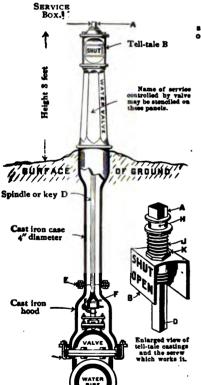
# THE INDICATOR VALVE POST.

(Patented.)

THE STANDARD OF THE ASSOCIATED FACTORY MUTUAL INSURANCE COMPANIES.

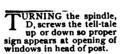
R. D. WOOD & Co., PHILADELPHIA, SOLE MAKERS.

Designed especially for use with Water Valves connected with the Fire Service in Mill and Factory Yards, etc.



SECTION OF STYLE A.

This Post shows plainly to every passer-by whether the valve is open or shut. It avoids the delay of hunting for a flush gate box hidden under snow or dirt, or the delay of opening a frozen gate-box cover.



The square spindle, D, slides freely in a square hole extending through the screw, J. Thus settlement or lifting by frost does not affect tell-tale.

All bearings and rubbing surfaces are rust-proof, being bushed with brass.

Screw, J, is the only part requiring to be changed to fit the various sizes and makes of valves.

In city streets the post can be set at curb-stone line like a hydrant and thus no obstruction results.



LIST PRICE: 5-ft. lengths and less, Style A, \$40. For each additional foot of length, Add \$1.00 to List. A lock-nasp, to seal valve against tampering, furnished if desired. A hand wheel also furnished, if desired, as an extra.

This Indicator Post can this indicator rost can be applied to any ordinary make of valve up to 16", and is furnished combined with valve, or separate, or can be applied to valves already in use.

In ordering, specify depth from ground line to bottom of pipe in trench; size and make of valve; size and make of valve; and whether valve opens by turning to right or left; also give number of turns required to open valve. Posts supplied for any make of valve.



ADJUSTABLE VALVE BOX.

LIST PRICE: 5-ft. lengths and less, Style B, \$30. For each additional foot of length, Add \$1.00 to List.

#### INDICATOR VALVE POST "B."

We desire to call your attention to our new Indicator Post, "Style B," which we are now prepared to manufacture. This Post embodies all the principles of the one designated as "Style A," but is not quite as heavy and is more simple in construction. It will be found equally as serviceable and durable, while less expensive.

## GATE VALVES WITH GEARING.

IRON BODIES, BRASS OR BRONZE MOUNTED.

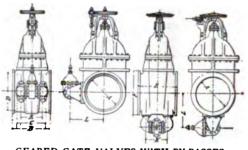
HESE Valves of larger diameters are designed with due regard for requisite strength and rigidity of shell and working parts, while, as a result of extended experience and test, superior qualities of bronze and composition are used for stems, seats, etc. When used under heavy pressures it is found that use of mechanical devices within the shell to facilitate operation of the gate are not wholly reliable, and in case of derangement are inaccessible. Some form of By-Pass Relief is now generally regarded as necessary, although sometimes supplemented by internal rollers or similar device.

The accompanying cuts illustrate general forms of valves and styles of gearing and gear brackets on valves 16" and above. It is not customary to gear valves below 16". We list the valves with and without By-Pass Relief.

TABLE No. 46.

|  | G                                       | EARED                                   |   |  | VES WI                                  |                                  | y-Pass                                      | ES.                                       |   |  |
|--|---|---|---|--|---|----------------------------------|---|---|---|--|
| Word<br>ation for<br>ze                              | Size                                    | HUB Code Word: Vend                     |   | Code   | NGE<br>Word:                            | BY-PASS                          |   |   |   |  |
| Code Wo  | A                                       | End to<br>End<br>B                      | Laying<br>Length<br>C                   | Diame-<br>ter<br>F                           | Face to<br>Face                         | Diam.<br>of<br>By-<br>Pass       | Center to<br>Center<br>K                    | By-Pass to<br>ValveCen.<br>L              | Size                                    |  |
| esto<br>evra<br>idum<br>iner<br>imes<br>iram<br>iria | 16"<br>18<br>20<br>22<br>24<br>30<br>36 | 25"<br>27<br>27<br>29<br>29<br>35<br>39 | 17"<br>19<br>19<br>21<br>21<br>26<br>29 | 23½"<br>25<br>27½<br>29½<br>32<br>38¾<br>45¾ | 26"<br>.8<br>28<br>30<br>30<br>36<br>40 | 4"<br>4<br>4<br>5<br>5<br>6<br>8 | 12½"<br>14½<br>14½<br>16<br>16<br>16<br>19½ | 19½"<br>20<br>21<br>24<br>24<br>28<br>34½ | 16"<br>18<br>20<br>22<br>24<br>30<br>36 |  |

40", 42", 48", 54" and 60" Valves to order.

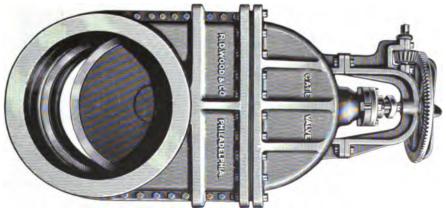


GEARED GATE VALVES WITH BY-PASSES.

#### TABLE No. 47.

| _   | Mounte  |                           |                          | ALVES   | eared   |
|---|---|---------------------------|--------------------------|---|---|
|   |   | н                         | UB                       | FLA   | NGE   |
| Code<br>Word<br>Termina-                    | Size  |                           | Word:                    | Code V  |   |
| tion<br>for Size                            | S.Le  | End<br>to<br>End          | Laying<br>Length         | Diame-<br>ter   | Face<br>to<br>Face                                  |
| ere erem esto evra idum iner imes iram iria | *14"<br>*15<br>16<br>18<br>20<br>22<br>24<br>30<br>36 | 17½" 18 18 20 20 21 21 25 | 9½" 10 10 12 12 13 13 16 | 21"<br>22½<br>23½<br>25<br>27½<br>29½<br>32<br>38½<br>45¾ | 15"<br>16<br>16<br>18<br>18<br>20<br>20<br>25<br>28 |

\* Not Geared.



BEVEL GEARED 36" GATE VALVE WITHOUT BY-PASS.

16" to 36" geared valve, vertical or horizontal, as required. Flanged Valves drilled to order only.

Unless otherwise ordered, valves are sent arranged to open to the right.



GATE VALVE WITH BY-PASS AND SPUR GEARING.



Special Service Valves.—We are prepared to supply large cast iron or steel body valves for special service either to our own or other design. Two types are here illustrated,



Valve, Steel Body, with Hydraulic Lift and INDICATOR.

VALVE STANDARDS.



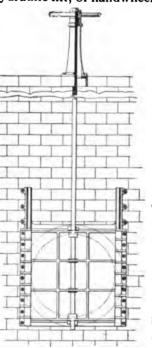
With or without Indicators or Rising Stem. Inquiries should state size of valve and, if indicator is desired, give direction in which stem turns to open valve and exact number of turns required.



#### Valves to this general design not less than 48".

## SLUICE GATES.

PRASS mounted. To bolt to wall. Frames to suit surroundings. To operate by hydraulic lift, or handwheel, as shown. They are



made regularly in 12" to 60" sizes, with round or square opening, and should be used only for light pressures, against the back of the gate.

Inquiries should state diameter of the pipe and whether with without through wall. If the former, the wall thickness and whether flange or hub connection is desired. Also give distance from center of pipe to top of wall and how operated.



Valve, WITH HYDRAULIC LIFT AND WITH OR WITHOUT BY-PASS.

A RRANGED to operate under 40 pounds pressure and upward. Built to suit local conditions. Inquiries suit local conditions. Inquiries should specify whether it is desired to operate by direct pressure from the main (stating the pressure), or by pump. Also, whether valve is to stand vertically or lie horizontally; and to have hub or flanged ends. See Table No. 46 for general dimensions of valves with by-passes.

Prices on application.

# CHECK AND FOOT VALVES, SCREENS, ETC.



HORIZONTAL OR VERTICAL CHECK.
STYLE A.

Horizontal and Vertical Check Valves.—These are of iron body, brass mounted, with either bell or flanged ends, of simple, substantial construction and gate readily accessible in case of need. Vertical Check Valves may be supplied with gate plate and cluster of valves if desired. Flange Check Valves are drilled to order only. Large diameter check valves to order with bypasses.

#### TABLE No. 48.

|                          | Сн          | ck V   | LVES-              | Brass                  | Moun           | TED.           | STYLE            | A                |                |
|--------------------------|-------------|--|--------------------|------------------------|----------------|----------------|------------------|------------------|----------------|
|                          |             | н  | UB                 | FLA                    | NGE            |                |                  |                  |                |
| Code<br>Word<br>Termina- | Size        |  | Code Word:<br>Veal |                        | Word:          | PF             | Size             |                  |                |
| tion<br>for Size         |             | End to<br>End                                | Laying<br>Length   | Diam.                  | Face to        | Hub            | Flange           | Screw            |                |
| andí<br>ani              | 3"          | 141/4"                                       | 83//"<br>113/6     | 7%"                    | 10"            | \$22.00        | \$24.00<br>31.00 | \$22.00<br>28.00 | 3"             |
| esis<br>esti             | 4<br>5<br>8 | 19%<br>19%<br>23                             | 111/4              | 9<br>10<br>11          | 13             | 35.00<br>40.00 | 38.00<br>44.00   | 36.00<br>42.50   | 5 6 8          |
| eces<br>envi             | 8           | 27 2814                                      | 19 201/2           | 131/2<br>16            | 15<br>18<br>20 | 54.00<br>80.00 | 59.00<br>86.00   | 56.50<br>88.00   | 8              |
| eras<br>ere              | 12<br>14    |  | 26<br>26           | 19<br>21               | 26<br>27       | 115.00         | 122.00           | 126.00           | 12<br>14<br>16 |
| esto                     | 16<br>18    | 34<br>34<br>38<br>39<br>43<br>48<br>54<br>58 | 30<br>31           | 23 1/2<br>25<br>27 1/4 | 30<br>32<br>36 | •••••          |                  |                  | 18             |
| idum<br>iner<br>imes     | 20<br>22    | 48   | 35<br>40<br>46     | 291/2                  | 40             |                |                  | · :::::          | 20<br>22<br>24 |
| iram                     | 24<br>30    | 25   | 59                 | 32<br>38¾              | 44<br>56       |                |                  |                  | 30             |

Discount and prices on sizes above 12" on application.

Foot Valves of larger sizes supplied if desired with gate plate and cluster valves. Valves with bell or flanged ends. Flange valves faced but not drilled and sent without screens unless otherwise ordered. These screens are of ample area for use with valves under ordinary conditions. Prices on sizes above 12" on application.

#### TABLE No. 49.

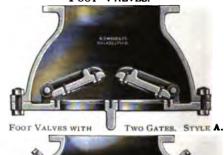
|   | Fo  | OT VA  | LVES.  | STYLE                                      | : A   |                                      | Basket Screens<br>Code Word: Viol                |   |                                    |  |   |
|---|---|--|--|--|---|--------------------------------------|--|---|------------------------------------|--|---|
| Code<br>Word<br>Termina-<br>tion<br>for Size                | Size  | FLANGES  Code Word: Volt                         |  | pth<br>udin <b>g</b><br>tib                | Prices<br>red (with-<br>Screen)                         | eter of<br>reen                      | th to  | PRICE L                                 |                                    | Size                                   |   |
|   | Size  | Pipe<br>Connec-<br>tion                          | Bottom<br>or<br>Screen                             | Face<br>to<br>Face                         | Depth<br>Includin<br>Rib                                | Flange<br>out S                      | Diameter<br>Screen                               | 28                                      | Copper                             | Galvan-<br>ized<br>Iron                |   |
| asti<br>eces<br>envi<br>erai<br>ere<br>esto<br>evra<br>idum | 6"<br>8<br>10<br>12<br>14<br>16<br>18<br>20 | 11"<br>13½<br>16<br>19<br>21<br>23½<br>25<br>27½ | 17½"<br>20½<br>23½<br>26<br>30<br>33½<br>36<br>38½ | 8%" 10 11 11 13 15 15 15 17 16 19 16 21 16 | 11 %<br>13½<br>1411<br>1611<br>18%<br>20¼<br>23¾<br>25¾ | \$48.00<br>76.00<br>110.00<br>140.00 | 13"<br>16<br>18<br>21½<br>25<br>27½<br>31<br>33½ | 5½"<br>6½<br>9<br>10<br>12<br>14½<br>16 | \$26.00<br>33.00<br>41.00<br>51.00 | \$23.00<br>30.00<br>38.00<br>44.00<br> | 6"<br>8<br>10<br>12<br>14<br>16<br>18<br>20 |

Discount.....per cent.

Discount.....per cent.



VERTICAL CHECK WITH GATE PLATE AND VALVE CLUSTER.
RELIEF VALVES ON LARGER SIZES.
Prices on application.
FOOT VALVES.





FOOT VALVE WITH VALVES IN CLUSTER AND PLATE SCREEN. STYLE B. Prices on application.

# FOOT VALVE BASKET SCREENS.



These screens are furnished with cast iron flange and in either copperor galvanized iron sheets with  $\frac{1}{12}$  perforations. Plate screens are sometimes furnished instead of Basket screen, but the former style only when ordered.





INTAKE SCREENS.

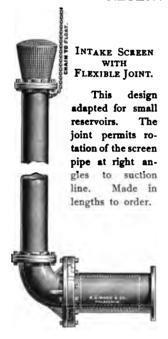
These Screens are regularly made of copper or galvanized iron sheets, with  $\frac{7}{16}$ " perforations.

Flanges drilled to order only.

## TABLE No. 50.

|                  | Disc | INTAK<br>counts and p | E SCREEN   |                        |          | ication            |      |
|------------------|------|-----------------------|------------|------------------------|----------|--------------------|------|
| Code Word        | P    | IP <b>E</b>           | I area Rad | Depth                  | PRIC     | E LIST             |      |
| tion<br>for Size | Size | Diameter of Flange    |            | from Face<br>of Flange | Copper   | Galvanized<br>Iron | Size |
| asti             | 6′′  | 11"                   | 8½′′       | 9"                     | \$30.00  | \$27.00            | 6′′  |
| eces             | 8    | 13                    | 12         | 12                     | 39.00    | 35.00              | 8    |
| envi             | 10   | 13<br>16              | 15         | 14                     | 48.00    | 41.00              | 10   |
| erai             | 12   | 18                    | 15<br>18   | 16                     | 56.00    | 48.00              | 12   |
| ere              | 14   | 21                    | 21         | 18                     | **.****  |                    | 14   |
| esto             | 16   | 23                    | 23         | 21                     | •••••    |                    | 16   |
| evra             | 18   | 25                    | 25         | 25<br>28               |          |                    | 18   |
| idum             | 20   | 27                    | 27         | 28                     | ******** |                    | 20   |
| imes             | 24   | 32                    | 32         | 34                     | •••••    |                    | 24   |

# RESERVOIR AND PUMP-HOUSE CONNECTIONS.



FISH TRAPS.

These are provided with a hand hole (not shown in cut) to permit cleaning.

Our standard designs meet the requirements in all essential details, while special work is made to the plans of customers.

INTAKE CAGES OR HOOD RACKS.

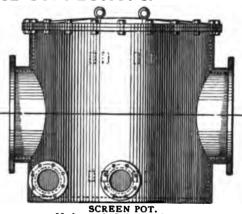
SCREEN POTS.

COPPER SCREENS.

SLUICE GATES.

FOOT AND CHECK VALVES.

Valve House Fittings.



SCREEN FOI.

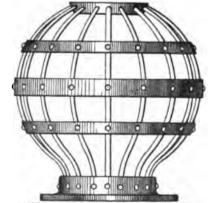
Made regularly in two sizes.

No. 1, Body (Oval) . 3'3" long x 2'6" wide x 3'6" high.

'2' " x 3'1½" x 4'

Two Screens.--Inlet and outlet as required.

Special sizes to order.



INTAKE CAGES OR HOOD RACKS.
Standard for 24"pipe; 4'5"high x4'0" inside diam. of middle ring.
Several sizes to order.

# PRESSURE RELIEF VALVE.

THERE is probably no greater menace to the life of a system of water mains than the excessive pressures caused by "water hammer."

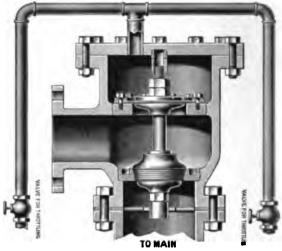
This valve effectually removes all liability of broken mains from this cause, and is self-acting. It automatically allows the escape of sufficient water to prevent excessive pressure within the main in the event of a water hammer, and utilizes the pressure in the main in closing.

Claims, briefly stated, are:

SAFETY AGAINST EXCESSIVE PRESSURE.
STRENGTH AND SIMPLICITY OF CONSTRUCTION.

ADAPTABILITY TO ANY POSITION UPON THE MAIN.

APPLICATION TO GAS AND LIQUIDS ALIKE.



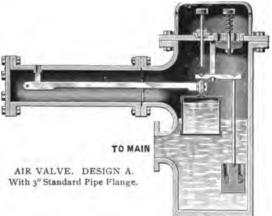
PRESSURE RELIEF VALVE.

For convenience in repairs it would be well to place an intermediate gate valve between the main and Pressure Relief Valve.

#### AIR VALVE. DESIGN A.

THE ill effects due to the accumulation of air in water mains are too well known to require discussion. The purpose of this valve is to guard against this difficulty by collecting and

automatically discharging from the mains any air contained therein.



The usual form of valves of this character employ ball floats of hammered copper, which experience teaches are unreliable, because such floats sooner or later become water-logged, allowing water to escape, oftentimes undermining pavements and causing other damage.

Because of such continued disastrous effects following the use of ball floats, the particular design employed in this new valve has been deduced. Instead of a hollow ball, the float consists really of a pail of water, and when half submerged in water the air escape is just closed. As air accumulates

and the water level lowers, the float is virtually heavier in the difference between the volume of air and water displaced, and a contra-condition pertains where air is expelled and the water level raised.

Provision is made for the automatic entrance of air when the main is being drained, and also for the escape of air in large quantity, as when refilling the main.

If the valve is to operate under pressures exceeding one hundred pounds per square inch the float should be counter-balanced when submerged more than one-half, and in extreme cases this adjustment should be made with the float wholly submerged to provide for the unbalanced pressure at air escape outlet.

Claims, briefly stated, are:

SIMPLICITY OF CONSTRUCTION.

POSITIVENESS OF ACTION.

FREEDOM FROM WATER-LOGGED FLOATS.

ACCESSIBILITY FOR INTERNAL INSPECTION.

EXTENSIVENESS IN ITS APPLICATION TO LIQUIDS.

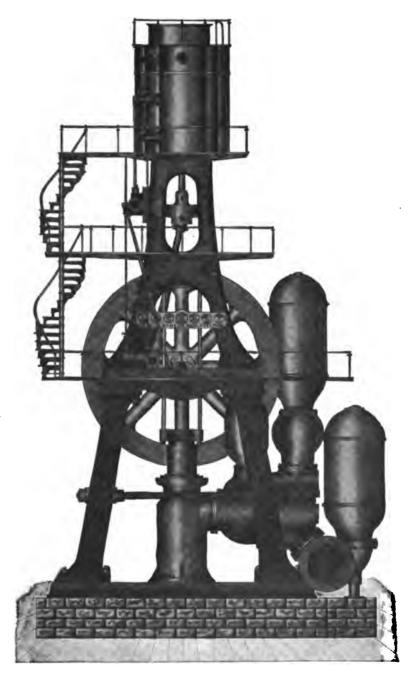
For convenience in repairs it would be well to place an intermediate gate valve between the main and air valve.

# AIR VALVE. DESIGN B.



AIR VALVE. DESIGN B. With 3" Standard Pipe Flange.

THIS is a much less expensive valve than design "A." It is arranged with an internal float, consisting of a hollow hard rubber ball covered with soft rubber, in a cast iron float chamber. As the pipe is filling with water the float rests on the perforated plate at the bottom of the float chamber and allows the air to escape through the small orifice at the top. As the water fills the float chamber it raises the float until it closes the orifice; should air again enter the valve the float will drop and allow it to escape.



VERTICAL CRANK AND FLY-WHEEL PUMPING ENGINE.

# STEAM PUMPING ENGINES.

A FTER nearly a century of association with the water-works interests of this country, we feel that we have hardly to explain our recent entry upon this field, as it is a perfectly natural progression.

With shops located where the best mechanical work of the age is done, and with modern equipment, we have every advantage and facility for building high-class machinery.

Having connections already established with the water works, private and municipal, throughout the world, we feel we need no introduction other than to say that we are building steam-pumping engines.

We are advocates of no type, but will construct both crank-and-fly-wheel and direct-acting engines, either vertical or horizontal. We have no new and startling designs to offer, believing the general lines upon which the successful engines of to-day are constructed are the best. Whatever we do build, however, will be of the very highest excellence in point of design and workmanship, and our endeavor will be to add something to the best records with each successive engine.

We have associated with us men who have designed and built the very engines that have so far achieved the highest records, and they have but to do a little better than they have done in the past to enable us to present a better engine than has been built.

The city of Cincinnati has awarded us, after careful investigation of competitive designs, a contract for four engines each of thirty million gallons capacity. These engines are of the vertical triple expansion type, standing in a pit eighty-five feet deep, and when completed will probably be the heaviest engines in existence and representative of the very highest type known to-day.

Our contract includes boilers, stokers, economizers and traveling crane for a plant entire in every detail, and it is safe to say that it will not only be the largest new plant in existence, but the most complete.

It so often happens that water-works commissioners, or other officers of a city government, and officers of water companies who have no technical knowledge of a pumping engine, are called upon to decide between different bidders having varied designs, that we have thought it would be interesting, and possibly useful, if they had at hand a brief description and definition of the technical terms used in connection with a pumping engine.

It is wholly for this class of readers that we publish the following:

Crank and Fly-Wheel Pumping Engine.—This term embraces all the numerous forms where a crank and fly-wheel are used, and, unlike the direct-acting engine, is not in its present state of perfection the result of any one or more inventions, but is an evolution from the primitive mode of attaching an ordinary steam engine to a pump.

The perfected engine of this type of to-day is simply a specially designed crank and fly-wheel steam engine attached to a well-designed pump. The function of the fly-wheel is described elsewhere.

Other Types of Pumping Engine.—There are several other forms of pumping engines, such as the Cornish and Beam engine, which we will not further mention, as they



are obsolete, having been driven out of the field because of their expensive construction and low duty record in comparison with what is known as the crank-and-fly-wheel and direct-acting engine.

The Direct-Acting Pumping Engine.—To Henry R. Worthington and to Charles C. Worthington, father and son, must be accorded the credit almost wholly for the introduction of and the present state of efficiency of this type of pumping engine.

In 1840 Mr. Worthington, Sr., was engaged in experiments with a steam canal boat. Passing through the locks, or when the machinery was at rest from any cause, the attached boiler feed pump was stopped. The result was the devising of an independent steam feeding pump. This device, patented in 1841, was the first machine to have a steam and water piston attached to each end of a rod, and was the beginning of the direct-action system of pumping. In 1854 he built the first water-works engine of this type for Savannah, Ga.; and in 1863 brought out at Charleston, Mass., the "Duplex" engine, which "fairly deserves to be placed first among the hydraulic inventions of the century."

It was not claimed for this engine that it was as economical in fuel as the crank-and-fly-wheel type, but when considering the low first cost the increase in fuel, it was claimed, was more than compensated for by saving in interest.

In 1885 the world lost a great engineer in the death of Henry R. Worthington, but his work was at once taken up by his son.

By the invention of the compensating cylinders in connection with the direct-acting engine in 1886, it may safely be said that the second "great hydraulic invention" was made; and coming at a time when the crank-and-fly-wheel engine had been simplified, cheapened and improved by increasing the economic duty, this invention saved the direct-acting type, as it could now remain in the field with a claim of duty equal to any engine built.

With this advent came a new era in the history of the pumping engine, and the contest between the two types became more and more spirited as they met on a common ground, each claiming superiority as new records of individual engines were made.

The success of the Worthington engine abroad may safely be said to have been greater than any American machine.

It is to be regretted that Mr. Worthington, having wholly retired from business and every connection with the company bearing his name, must leave the further development of this engine to other hands and other brains, and we have taken up the work with the feeling that there is a large field for this type and that it may still reach even a higher point in efficiency.

In doing this, we have associated with us a number of Mr. Worthington's personal staff; one of whom, from the advent of the high-duty engine, has been in charge of his water-works department, and the other, under him, as chief designer in most all his larger plants.

In the construction of engines of the crank-and-fly-wheel type, we have engaged the services of an engineer long associated with the E. P. Allis Company in their department of pumping engines.

Duty.—The fuel economy of a pumping engine, or the work it is able to accomplish on a given expenditure of heat, is expressed by the word "duty." In 1778 Bolton & Watt introduced their engines into the mines of Cornwall, often taking their pay out of profits resulting from saving in fuel, so a standard of performance was necessary. This was established by Watt, who gave it the name of "duty."

In determining the duty of pumping engines, three methods of computation have been used: First. The number of pounds of water lifted one foot high by the consumption of 100 pounds of coal.

Second. By the number of pounds of water lifted one foot high by the consumption of 1000 pounds of steam. This unit is the precise equivalent of 100 pounds of coal, where each pound of coal evaporates 10 pounds of steam.

Third. By the number of pounds of water lifted one foot high by the consumption of 1,000,000 heat units. This unit is the precise equivalent of 100 pounds of coal, where each pound of coal imparts 10,000 heat units to the water in the boiler, or where the evaporation is 10.355 pounds from and at 212° F. per pound of fuel.

TABLE No. 51.

Table of Pounds of Coal per Horse Power per Hour and Equivalent Duty.

| Pounds of Coal per<br>Horse Power<br>per Hour | Equivalent Duty in<br>Foot Pounds | Pounds of Coal per<br>Horse Power<br>per Hour | Equivalent Duty in<br>Foot Pounds | Pounds of Coal per<br>Horse Power<br>per Hour | Equivalent Duty in<br>Foot Pounds |
|---|-----------------------------------|---|-----------------------------------|---|-----------------------------------|
| 36.6  | 5 million                         | 2.83  | 70 million                        | 1.468   | 135 million                       |
| 19.8  | 10 "                              | 2.64  | 75 ''                             | 1.414   | 140 "                             |
| 13.2  | 15 "                              | 2.475   | 8o ''                             | 1.366   | 145 "                             |
| 9.9   | 20 "                              | 2.33  | 85 "                              | 1.32  | 150 "                             |
| 7.92  | 25 "                              | 2.2   | 90 "                              | 1.277   | 155 "                             |
| 6.6   | 30 "                              | 2.08  | 95 "                              | 1.238   | 160 "                             |
| 5.66  | 35 ''                             | 1.98  | 100 "                             | 1.2   | 165 "                             |
| 4-95  | 40 ''                             | 1.885   | 105 "                             | 1.165   | 170 "                             |
| 4.4   | 45 ''                             | 1.8   | 110 "                             | 1.131   | 175 "                             |
| 3.96  | 50 "                              | 1.725   | 115 "                             | 1,1   | 180 "                             |
| 3.6   | 55 ''                             | 1.65  | 120 "                             | 1   | 198 "                             |
| 3-3   | 60 ''                             | 1.587   | 125 ''                            |   |                                   |
| 3.05  | 65 "                              | 1.523   | 130 "                             |   |                                   |

The work done in foot pounds is expressed as the area of the pump plunger (corrected for area of rod) multiplied by the gross pressure against which the pump is working (measured by a pressure gauge on the rising main, to which reading is added the pressure due to height of gauge above surface of water in well), multiplied by the average length of stroke of the plunger in feet, multiplied by the total number of single strokes the pump plunger makes during the trial.

The total number of heat units consumed is found by the weight of the water supplied to the boiler by the feed pump, multiplied by the total heat of the steam at the working pressure, reckoned from the temperature of the feed water, making any correction that may be necessary for moisture or superheating.

Capacity.—Is the quantity of water a pumping engine will deliver in a given time,—usually expressed in million gallons in twenty-four hours.

TABLE No. 52.

Table of Size of Water Main for Given Capacity in Million Gallons per 24 Hours.

| Diameter of Delivery<br>Main | Capacity in Million<br>Gallons per 24<br>Hours | Diameter of Delivery<br>Main | Capacity in Million<br>Gallons per 24<br>Hours |
|------------------------------|--|------------------------------|--|
| 10"                          | I  | 30′′                         | 10   |
| 12                           | 2  | 30                           | 12   |
| 16                           | 3  | 36                           | 15   |
| 18                           | 4  | 40                           | 20   |
| 20                           | 5  | 42                           | 25   |
| 20                           | 6  | 48                           | 30   |
| 24                           | 8  | :<br>                        |  |

NOTE.—This table is based on water velocity of about 4 feet per second, which is good American practice.

Steam Expansion.—The principle of the law of expanding steam was discovered by James Watt.

It may be described by supposing an upright cylinder three feet long connected with a steam boiler. This cylinder is fitted with a steam-tight piston which is loaded with ten 10-pound weights. Steam is admitted below the loaded piston until it is raised one foot. Then the valve connecting the boiler is closed. The steam pressure holds this load suspended; but if a valve is opened to the air, the steam will exhaust and the load fall back to the bottom of the cylinder. The work done by the steam was to raise 100 pounds one foot high, and this would represent an engine having one-foot stroke, getting steam at full length of stroke (with no cut-off) and working against 100 pounds.

If, however, the steam confined in the cylinder, instead of being exhausted, is retained, and one weight taken off, the piston would go up a little, and the remaining 90 pounds be held suspended; and if another weight was taken off, the remaining 80 pounds would be little farther; and so on, until the piston reached the end of the cylinder, or had been raised two feet from the point where the steam valve was closed.

The weights lifted in these two feet would represent the work done by expansion of steam. In a steam engine, this would then represent an engine having three feet stroke, and cutting off at one-third of the stroke.

Steam Card is a card on which the steam pressure graphically is shown at all points of the stroke.

Water Card is a card on which the water pressure graphically is shown at all points of the stroke.

Steam Indicator is the apparatus by means of which steam and water cards are taken.

High-Pressure Engine is a form of engine that has only one steam cylinder, and the steam used at full boiler pressure throughout the entire stroke.

Compound Engine is a form of engine that has two steam cylinders, a high and low pressure. After steam has been used in the high-pressure cylinder, it passes to the low-pressure, where it is again used, then exhausted into the open air or a condenser. (See Condenser.)

Cross Compound Engine is a form of engine with the high and low-pressure cylinders placed side by side, joined to separate water plungers.

Triple Expansion Engine is a form of engine that has three steam cylinders, a high, an intermediate and a low-pressure cylinder, and the steam is used successively in each cylinder before passing to the next, the same as in the compound engine.

Crank and Fly-Wheel Engine is that form of engine where a fly wheel is interposed, driven by a crank connected to the piston rod. The function of this wheel is to assist the steam piston to the completion of the stroke. The energy given the wheel at the beginning of the stroke is given off at the end, thus economizing in steam, as it enables the cut-off to be closed at an earlier point in the stroke.

Direct-Acting Engine is a form of engine where the steam pistons and water plunger are directly connected, and the steam pressure acting upon the steam pistons is exerting its power directly upon the water plunger.

Duplex Engine is a form of engine where two engines having water cylinders of the same size, and steam cylinders of equal size, are placed side by side. These engines working in unison, but moving in opposite directions, to insure a steady flow of water.

Tandem Engine is that form of compound or triple expansion engine where the steam cylinders are placed in line, with all steam pistons directly connected to one water plunger.

Power Pump is a form of pump which is driven by a power which is separate from the pump, such as a water or electric power.

High-Pressure Cylinder is the first cylinder receiving steam from the boiler, and at full boiler pressure.

Intermediate Cylinder is the second cylinder in a triple expansion engine, where the steam is used after leaving the high-pressure cylinder. The driving steam pressure in this cylinder is usually somewhat less than one-half the boiler pressure, and the area of its piston is from two and one-half to three times the area of the high-pressure cylinder.

Low-Pressure Cylinder is the third cylinder in a triple expansion and second in a compound engine, and receives its steam from the intermediate cylinder in the triple and from the high in the compound. The steam pressure in this cylinder is usually about one-sixth that of the initial pressure in the boilers, varying in proportion to the areas of the two pistons.



Steam Ports are passages in the steam cylinder through which steam is admitted and exhausted.

Valve Gear and Steam Valves are mechanical appliances controlling the admission of steam to the cylinders and exhaust from the same.

Cut-off is a mechanical device to close the admission steam valves before the steam pistons have completed their stroke, after which the power in the engine is due to the expansion of the steam, assisted by the fly wheel, or compensating device.

Steam Jacket is a steam-tight casing placed around the steam cylinders and the space filled with steam, reducing the condensation and retaining heat in cylinders, as the dryer the steam and the more heat retained, the greater its efficiency.

Reheater is a cylinder placed between two steam cylinders and receiving the exhaust steam. In this cylinder is located a coiled tube through which steam of a higher pressure than the exhaust is passed, thus preventing it from losing heat.

Condenser is an appliance whereby the steam after leaving the engine is returned to water, thus leaving a vacuum behind the steam piston and reducing the resistance against which it must work on the return stroke.

Air Pump removes this water from the condenser, together with any air which may have entered the steam cylinders through stuffing boxes or joints. This hot water is usually returned to the boiler by a boiler feed pump.

Plunger Chamber.—Space in the water cylinder confined between the suction and delivery valves.

Plunger.—A piston working in the plunger chambers, alternately sucking in and forcing out the water.

Suction Chamber.—Chamber below suction valves through which water is drawn into the pump.

Discharge Chamber.—Above the delivery valve through which water is discharged.

Water Valves.—Valves usually made of composition or metal with rubber face controlling the passages of water through the pump.

Air Chamber.—A closed cylinder placed on the suction or discharge pipe, near the engine, in a vertical position. The accumulation of air in the top of this chamber prevents shock in the operation of the engine, owing to the elasticity of the air when the water pressure is brought upon it.

Fly Wheel.—See Crank and Fly Wheel Engine, page 83.



Compensating Cylinders.—This appliance is only applicable to the direct-acting engine, and consists of two small oscillating cylinders attached to the plunger rod. These cylinders and connections are filled with water, or other liquid. Compressed air is admitted to maintain a constant load on the pistons in these cylinders. These pistons act in such a way as to resist at the first half of the stroke and assist on the last half, in effect performing the functions of a fly wheel.

Outside Packed Water End is that type of water end in which the plungers are working in stuffing boxes fitted with glands adjustable from the outside; that is, the packing may be renewed or set up without removing any heads from the water end. This type is used mostly where gritty, muddy or sandy water is to be pumped.

Internally Packed Water End is that type of water end in which the plungers are working in stuffing boxes fitted with glands placed inside the water cylinders; the packing cannot be renewed or adjusted without first removing the water cylinder heads or manhole plates suitable for that purpose.

Plunger and Ring-Water End is that type of water end in which the plungers are working in long metallic cylinders. This type is used mostly where clear water under moderate pressure, say not exceeding 325 feet, is pumped.

Slip is the leakage of water through the plunger packing and water valves.

Plunger Displacement is the amount of water delivered by one plunger in one stroke.

Weir Measurement is a method of determining the amount of water pumped by passing it through a measured space.

Reservoir System is that system by which the water supply is pumped to a reservoir at a suitable elevation, from which it flows by gravity into the distributing pipes.

Stand Pipe System is that system by which water, in addition to being pumped direct into the distributing pipes, is also connected to an open standpipe of such height as the water pressure requires. The object of this standpipe is to maintain a steady pressure and avoid pulsation in the water mains. In addition to the foregoing, standpipes of larger sizes also serve as a reservoir.

Direct Pumping is that system of supply by which the water is pumped direct into the distributing pipes without the use of a standpipe or reservoir.

Explanation of Cost Table.—To obtain the cost of pumping water, in dollars and cents, the capacity, pressure, duty and cost of coal per ton (2000 pounds) being given:

Trace from the right-hand line (water pressure in pounds) vertically to the diagonal line of given duty, then horizontally to the diagonal line of given cost of coal, thence downward to the cost of coal per million gallons; multiply this by the number of million gallons desired, and the result will be the total cost of pumping.

From the above table comparison may be quickly made of the relative cost at any given duties, which, multiplied by the number of million gallons pumped annually, will give the economical result of investment of capital.

TABLE No. 53.

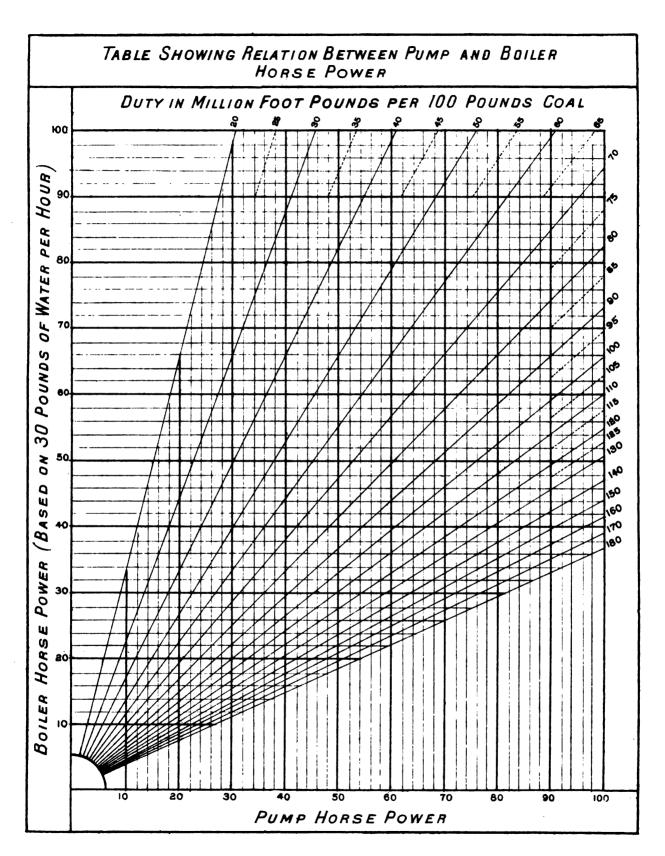
Table of Horse Powers Required to Pump One Million Gallons of Water from 10 to 209 Pounds.

|   | 10 lb. | 20 lb. | 30 1ъ. | 40 lb. | 50 lb. | 60 Ib. | 70 lb. | 80 lb. | 90 lb. | 100 lb | 110 lb. | 120 lb. | 130 lb. | 140 lb. | 150 lb | 160 lb | 170 lb. | 180 lb | 190 lb. | 200 1ъ |
|---|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|---------|---------|--------|--------|---------|--------|---------|--------|
| _ | 4.05   | 8.1    | 12.1   | 16.2   | 20.3   | 24.3   | 28.4   | 32.4   | 36.5   | 40.5   | 44.6    | 48.6    | 52.7    | 56.7    | 60.8   | 64.8   | 68.9    | 73.0   | 77.0    | 81.1   |
| I | 4.46   | 8.5    | 12.5   | 16.6   | 20.7   | 24.7   | 28.8   | 32.8   | 36.9   | 40.9   | 45.0    | 49.0    | 53.1    | 57.1    | 61.2   | 65.3   | 69.3    | 73-4   | 77-4    | 81.5   |
| 2 | 4.86   | 8.9    | 13.0   | 17.0   | 21.1   | 25.1   | 29.2   | 33.2   | 37-3   | 41.3   | 45.4    | 49.4    | 53.5    | 57-5    | 61.6   | 65.7   | 69.7    | 73.8   | 77.8    | 81.9   |
| 3 | 5.27   | 9.3    | 13.4   | 17.4   | 21.5   | 25.5   | 29.6   | 33.6   | 37-7   | 41.7   | 45.8    | 49.8    | 53.9    | 58.o    | 62.0   | 66.1   | 70. I   | 74.2   | 78.2    | 82.3   |
| 4 | 5.67   | 9.7    | 13.8   | 17.8   | 21.9   | 25.9   | 30 O   | 34.0   | 38.1   | 42.I   | 46.2    | 50.3    | 54-3    | 58.4    | 62.4   | 66.5   | 70.5    | 74.6   | 78.6    | 82.7   |
| 5 | 6.08   | 10.1   | 14.2   | 18.2   | 22.3   | 26.3   | 30.4   | 34 4   | 38.5   | 42.6   | 46.6    | 50.7    | 54-7    | 58.8    | 62.8   | 66.8   | 70.9    | 75.0   | 79.0    | 83.1   |
| 6 | 6.48   | 10.5   | 14.6   | 18.6   | 22.7   | 26.7   | 30.8   | 34.8   | 38.9   | 43.0   | 47.0    | 51.1    | 55.1    | 59.2    | 63.2   | 67.3   | 71.3    | 75-4   | 79.4    | 83.5   |
| 7 | 6.89   | 10.9   | 15.0   | 19.0   | 23.1   | 27.1   | 31.2   | 35.3   | 39.3   | 43.4   | 47-4    | 51.5    | 55.5    | 59.6    | 63.6   | 67.7   | 71.7    | 75.8   | 79.8    | 83.9   |
| 8 | 7.30   | 11.3   | 15.4   | 19.4   | 23.5   | 27.6   | 31.6   | 35.7   | 39.7   | 43.8   | 47.8    | 51.9    | 55.9    | 60.0    | 64.0   | 68. ı  | 72.1    | 76.2   | 80.3    | 84.3   |
| 9 | 7.70   | 11.7   | 15.8   | 19.8   | 23.9   | 28.0   | 32.0   | 36.1   | 40. I  | 44.2   | 48.2    | 52.3    | 56.3    | 60.4    | 64.4   | 68.5   | 72.6    | 76.6   | 80.7    | 84.7   |

Explanation of Chart of Boiler Horse Power.—To determine boiler horse power required, the capacity, duty and water pressure being given:

Find on table above the pump horse power of one million gallons at a given pressure; multiply the same by the number of million gallons required, and this will give the total pump horse power. Having this, trace on the following diagram from the lower line (pump horse power) vertically to the diagonal line of given duty, then horizontally to the required boiler horse power.

It will be observed that at seventy million foot pounds, the pump and boiler horse power are about equal, and as the duty increases the variation becomes greater.



# CENTRIFUGAL PUMPS.

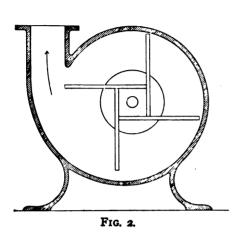


Fig. 1.

Introduction.— it is pretty well established that the first practical Centrifugal Pump was invented in this country in 1818. Its design laid down general principles of construction which have formed the basis of all subsequent development, as carried on simultaneously by European and American engineers.

As a matter of historical interest, we reproduce (Fig. 2, page 88) a cross section of this so-called "Massachusetts Pump"; also a similar view (Fig. 3, page 88) of our own Pump, illustrating the earliest and latest designs in this branch of machinery.

It has been our endeavor to eliminate from our Pumps all defects discernible in the designs of our predecessors, and, while incorporating their best features, to add all necessary new and desirable elements.





F1G. 3.

Glossary of Terms.—We give below definitions of terms most commonly used, which are peculiar to Centrifugal Pumps:—

VOLUTE.—That portion of the Pump casing, spiral in form and section, through which the water flows to the discharge opening after leaving the impeller.

Y-Branch.—That portion of the Pump casing which serves to divide the suction flow into two parts, thus admitting water simultaneously to both suction elbows.

IMPELLER.—The fan or disc with blades, or wings, which, mounted on the shaft, and revolving between the two side plates, produces the flow of water.

OPEN IMPELLER.—One having a single web connecting the wings and dividing them symmetrically through their middle plane at right angles to the shaft.

CLOSED IMPELLER.—One with central web smaller than in the open impeller, and which has also two additional webs or discs connecting the corresponding sides of the wings with central opening for the entrance of the suction.

Whirlpool Chamber.—That portion of the waterways between the tips of the impeller wings and the inside of volute proper.

THROAT.—That portion of volute which has the smallest cross section, but closely adjacent to the discharge opening.

SLIPPAGE.—Relative amount of water which falls back through the clearance spaces between impeller edges and side plates.

Suction Lift.—Total head, including friction against which water has to be lifted.

DISCHARGE HEAD.—Total pressure, including friction against which water has to be forced. Total Lift or Head.—The sum of the total suction lift and discharge head.

WATER HORSE POWER.—The effective work accomplished in raising average discharge capacity through the total lift. This equals the product of the two quantities reduced to foot pounds per minute, divided by 33,000.

Brake Horse Power.—Actual work applied to the Pump shaft in foot pounds per minute, divided by 33,000.

Pump Efficiency.—Percentage of actual work applied to the Pump shaft and transformed into effective work accomplished. This equals the quotient of the water horse power by the brake horse power.

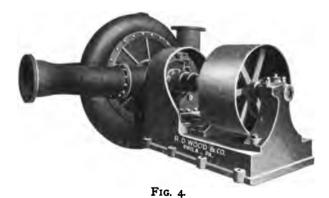
DUTY.—This term, applied to Centrifugal Pumps, indicates the number of foot pounds per hour of effective work accomplished by the Pump for each thousand pounds of steam consumed by the engine furnishing the power. This equals the product of the water horse power and 1,980,000,000 divided by the product of the corresponding indicated horse power of the engine and its steam consumption per indicated horse power per hour.

General Construction.—Centrifugal Pumps are either single or double suction in form. The preference, in most cases, is for the double suction type, as with the entrance of the water equally into both sides, there is no end thrust, whatever variations of pressure may occur on either suction or discharge lines.

A side suction Pump may be balanced for any constant suction pressure, but a thrust bearing would always be necessary where the suction pressure is variable.

The term "horizontal" or "vertical" as applied to Centrifugal Pumps indicates that the shaft occupies that relative position. This distinction refers wholly to position and not design, as either kind may be single or double suction.

Vertical pumps are generally made single suction to save the horizontal space which would be required by the Y-branch of a double suction Pump, and inasmuch as the weight of the revolving impeller and shaft require a thrust bearing, this can be proportioned to also take care of the unbalanced pressure due to the single opening.



For supporting horizontal Pumps a hood base may be used (see Fig. 4, page 89, and Fig. 8, page 95), which permits the use of a swivel joint so that the position of the suction and discharge openings may be altered at will even while the Pump is operating; or a plain cast-iron base (see Fig. 7, page 95) on which the volute casing is supported by flanged brackets.

A special construction used only for our smallest pumps is shown in Fig. 9, page 96, where the suction pipes are used as supports, while a suction box is cored out of the cast-iron base.

Vertical Pumps are usually supported on flanged feet, cast directly on the under side of the volute.

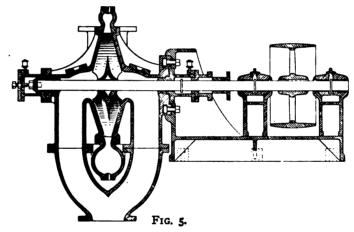
Centrifugal Pumps are generally driven by pulley and belt, or by direct connection. Belt-driven Pumps have a pulley mounted on the Pump shaft and supported on the extended base.

For direct connection to engine or motor, a larger sub-base is provided, and the two shafts are connected by a flanged coupling.

Gearing is never advocated except for Vertical Pumps, where mitre or bevel gears may be used for transmitting the necessary power from a Horizontal to a Vertical Shaft.

Direct connection on same vertical shaft of submerged pumps and electric motors makes a most satisfactory arrangement where electric power is available. (See Fig. 10, page 96.)

General Principles of Operation.—The principle by which a Centrifugal Pump operates is briefly this: The Pump casing being filled with water, the revolution of the impeller imparts a similar rotary motion to the water contained between its radial wings, and produces, partly by the centrifugal force due to the rotation, and partly by the radial component of the force of impact between the wings and the water, a radial flow of the water from the center toward the periphery of the impeller. This radial flow produces a corresponding movement of the water in the suction elbows and Y-branch toward the center of the impeller in order to prevent the formation of a vacuum at that point, and when there this water follows the same



radial direction of flow as is described above. In this way a constant suction flow is produced and maintained up to a higher lift, even, than a direct-acting pump is capable of, due, of course, to the fact that in the latter case the flow is pulsating, and the inertia of the water has to be overcome twice in each stroke. The radial flow of the water between the impeller wings, combined with its rotary motion, results in a spiral path for each particle of the water, so that on leaving the tips of the impeller wings the flow is almost tangential, and the change from a radial flow along the impeller wings to a rotary flow in the volute is effected with little or no losses due to impact. The whirlpool chamber assists further in effecting this result. It will also be clear that the volute is given a variable cross section increasing gradually toward the discharge opening, so that the lineal velocity of flow will remain constant in spite of the increments of volume added opposite each point in the periphery of the impeller.

Therefore, since the operation of Centrifugal Pumps is dependent on the centrifugal force and impact imparted to the water by the rotation of the Pump impeller, it follows that the amount of work done will depend upon the speed of this rotation. Without going into any analytical or mathematical discussions, it is important to note the general relations existing between the three chief variables,—viz, Head, Volume and Speed. There are three principal cases:—

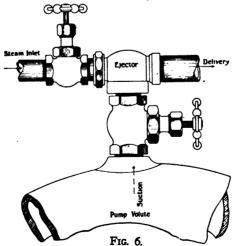
- as a simple function one of the other. In a direct-acting Pump, the action is one of displacement, and the volume is simply and directly proportional to the number of displacements per minute, or to the speed. The principle of the Centrifugal Pump, however, has nothing to do with direct displacement, and the volume is considerably affected by a comparatively slight change in speed, though the variations are always in the same direction.
- 2d. For a constant volume, the speed required to operate against a given head will be a function of the square root of the head. The demonstration of this starts with the law of falling bodies, and the formulæ are readily deduced, except for the constants in them which must be determined experimentally, and which depend largely on the design of the Pump itself.
- 3d. With a pump running at a constant speed, the volume is dependent on the head, and we have a relation similar to the one between volume and speed (in Case I) except that a greater change even takes place in the volume for a change of head, and the variations are in the opposite direction. The practical results of these properties are considered under "Instructions for Operating."

Priming and Priming Devices.—A Centrifugal Pump requires to be filled with the fluid to be pumped before its operation can begin. In some cases, the Pump will be so installed that the fluid will flow into the pump casing under outside pressure; but if this is not the case, the operation of "priming" or filling the Pump becomes necessary. Local conditions will determine which of the following two methods should be used to accomplish this:—

1st. Some form of Air Pump connected to the highest point of the Pump volute, which will draw the air and water up into the Pump and suction pipe from below. If steam is available, the simplest way is to mount an ordinary steam ejector directly on the Pump casing; but if not, any other form of air pump may be used.

The operation is as follows (see Fig. 6, page 91):—

The Pump is running at its proper speed, with a valve, which must be located in the discharge line as near as possible to the Pump, tightly closed. The air pump or ejector is then



started and operated continuously until all the air is exhausted, and water flows from the discharge of the primer. As soon as the flow begins, open the valve in the discharge pipe gradually,

and close the connection between the primer and the Centrifugal Pump. This latter must be done before shutting down the primer. With this method, it is necessary to prime the Pump each time it is started.

2d. A Foot Valve located at the submerged end of the suction pipe, which enables the Pump and suction pipe to be filled with water from above.

This method is much simpler. Before starting the Pump a sufficient quantity of water is admitted, generally through a hole at the top of the volute, to completely fill same. After filling, care must always be taken to make the volute again air-tight before starting the Pump. So long as the foot-valve remains tight a single priming is sufficient; the Pump will commence pumping immediately whenever started.

Classification.—It has long been evident to engineers that Centrifugal Pumps are not mere "hardware," and that, with intelligent and proper proportioning of the elements of their designs for the particular service to be performed, the usefulness and general application of centrifugal pumping machinery could be greatly extended. Following this thought, we have adopted the subjoined system of classification, from which, with occasional slight modifications, we can furnish our customers with apparatus specially adapted to successfully perform any required duty which is possible for a Centrifugal Pump.

#### SERVICE.

| I. | CLASS | P | indicating | Pressure I | Pumps, | 60 to        | 100  | feet, | total head. |
|----|-------|---|------------|------------|--------|--------------|------|-------|-------------|
|    | "     | H | "          | High Lift  | : "    | <b>40</b> to | 60   | "     | "           |
|    | "     | M | "          | Medium "   | "      | <b>20</b> to | 40   | "     | "           |
|    | "     | L | . "        | Low "      | "      | o to         | 20   | "     | "           |
|    | "     | D | . "        | Dredging   | "      | o to         | бо   | "     | "           |
|    | "     | T | . "        | Pulp       | 66     | any          | head | l.    |             |
|    | "     | Q | . "        | Special    | "      | 60           |      |       |             |

#### DRIVING POWER.

| 2. | 1 YPE | в | indicating | Beit-dri | ven Pumps.         |                         |
|----|-------|---|------------|----------|--------------------|-------------------------|
|    | 66    | S | "          | Pumps    | Direct-connected t | o Steam Engine.         |
|    | "     | G | 66         | "        | "                  | Gas or Gasoline Engine. |
|    | "     | E | "          | "        | "                  | Electric Motor.         |
|    | "     | w | 66         | 44       | "                  | Hydraulic Motor.        |
|    | "     | X | . "        | Geared   | Pumps.             |                         |

#### CONSTRUCTION DESIGN.

| 3. | FORM | ZO | indicating | Horizontal | Shaft | and | Single Suct | ion.  |
|----|------|----|------------|------------|-------|-----|-------------|-------|
|    | "    | ZY | "          | "          | 46    | 66  | Double Ope  | ning. |
|    | "    | vo | "          | Vertical   | "     | "   | Single '    | •     |
|    | 66   | vv | 44         | "          | 66    | "   | Double 9    | 16    |

C also (when prefixed to either of these Forms) indicating Compound Pump of that particular form.

An example of the application of the above would be: "No. 6. Class M, Type B, Form ZY," designating a horizontal, double suction, belt-driven Pump for medium lift, having a discharge opening 6 inches in diameter.

We are prepared to furnish any and all Pumps comprised in this classification in sizes from I inch to 72 inches diameter of discharge opening. The discharge capacities of the respective sizes are given in the subjoined table, together with a note of the amount of power required on the Pump shaft to produce the desired results.

TABLE No. 54.

| No. of Pump<br>and Diameter<br>of Pump Dis-<br>charge in Inches | ECONOMIC RATINGS*                               |   |  |   |
|---|---|---|--|---|
|   | At Flow of 10 Feet per Second in Discharge Pipe |   | At Flow of 12 Feet per Second in<br>Discharge Pipe |   |
|   | Capacity in Gallons<br>per Minute               | Horse-power required on Pump Shaft per Foot of Lift | Capacity in Gallons<br>per Minute                  | Horse-power required<br>on Pump Shaft per<br>Foot of Lift |
| 1   | 24  | .03   | 29   | .04   |
| 13%   | 55  | .06   | 66   | .07   |
| 2   | 98  | .09   | 118  | .11   |
| 3   | 220   | .18   | 264  | .22   |
| 4   | 392   | .27   | 470  | .32   |
| 5   | 612   | .39   | 734  | .47   |
| 6   | 881   | .51   | 1,058  | .61   |
| 7   | 1,200   | .65   | 1,439  | .78   |
| 8   | 1,567   | .79   | 1,880  | •95   |
| 10  | 2,448   | 1.19  | 2,938  | 1.43  |
| 12  | 3,525   | 1.62  | 4,230  | 1.94  |
| 15  | 5,508   | 2.40  | 6,610  | 2.88  |
| 18  | 7,932   | 3.40  | 9,518  | 4.07  |
| 20  | 9,792   | 4.12  | 11,750   | 4.95  |
| 24  | 14,100  | 5.84  | 16,921   | 7.00  |
| 30  | 22,032  | 8.97  | 26,438   | 10.77   |
| <b>32</b>   | 25,067  | 10.05   | 30,081   | 12.06   |
| 36  | 31,726  | 12.72   | 38,071   | 15.26   |
| 42  | 43, 183   | 17.04   | 51,819   | 20.46   |
| 45  | 49,572  | 19.56   | 59,486   | 23.47   |
| 48  | 56,402  | 21.91   | 67,682   | 26.29   |
| 54  | 71,383  | 27.73   | 85,660   | 33.28   |
| 60  | 88, 128   | 34.24   | 105,753  | 41.09   |
| 72  | 126,904   | 49.30   | 152,285  | 59.16   |

\*Note.—While capacity ratings are lower than those given by some manufacturers, experience has shown that an increased discharge can only be obtained at a loss of efficiency and economy. The additional cost of the next larger size pump will be more than compensated for by the saving in fuel.

Our horse-power ratings are based on a minimum efficiency for the pump under average conditions. Under favorable conditions, the efficiency will generally be materially increased, and the horse-power ratings correspondingly diminished.

We are prepared to make guarantees in each case where we have been advised of detailed conditions.



Special Features of Our Centrifugal Pump.—Our Pumps are the result of an increasing demand for high-grade Centrifugal Pumping Machinery.

Three elements of design have been especially considered with the view to produce highest efficiency.

- 1st. The waterways are so proportioned as to offer the least resistance to the flow of the water.
- 2d. The "slippage" has been reduced to a minimum by decreasing the clearance between the sides of the impeller blades and the adjacent side plates. A method of adjusting end motion accomplishes this by means of collars at the outer end of the shaft, so that the impeller is fixed, midway between the side plates, and a minimum clearance permitted without danger of contact between side plates and impeller. Accurate machine work also assists in making possible this result.
- 3d. Following the lead of manufacturers of electrical and other high-speed machinery, we have equipped all our Pumps with ring-oiling bearings, the one at the outer end closed, and that at the inner end fitted with a stuffing-box and gland for the passage of the shaft.

We would also call attention to the ease with which our Pumps can be taken apart and single parts replaced, or changes made in the direction of the suction and discharge openings. The removable character of the side plates which are bolted to the volute casing makes any desired angle between the two openings obtainable; or the volute and impeller may be reversed completely, thereby changing the "hand" of the pump. The diameter of the side plates is also made slightly larger than the impeller, so that the latter may be readily removed without disturbing fixed suction or discharge connections.

A further safeguard to our customers is found in our new and complete TESTING PLANT, which enables us to give working tests to all our product before making shipment, thereby assuring ourselves, as well as our customers, of the ability of our apparatus to fulfill their requirements.

Services for which Centrifugal Pumps are peculiarly adapted.—
Irrigation.—An irrigation problem generally consists in handling large quantities of water
against a comparatively low head, whether the latter is a direct lift or a friction head produced
by a long horizontal pipe line, both of which conditions are most favorable for Centrifugal
Pumps. The added fact that the usefulness of the water is in no wise injured by sediment and
other mechanical impurities which it may contain leads to the use of such water and gives
another strong reason for their adoption for this service. No valves to clog and get out of order,
simplicity of machinery, and a considerable saving in first cost and also in running expense are
convincing arguments.

DRY DOCKS.—The economic use of dry docks depends on the rapidity with which the water may be pumped out of the dock. No form of pumping machinery can, for its size, handle a given volume of water so quickly as can Centrifugal Pumping Machinery; and careful design in the Pumps themselves, and careful selection of the driving machinery, have enabled us to overcome the difficulties arising from the extremely variable head against which it becomes necessary to operate. The machinery installed by us for the United States Government at the New York Navy Yard is an excellent example of the latest improved practice for graving docks, while our installation for the Morse Iron Works and Dry Dock Company, of Brooklyn, N. Y., illustrates similarly the best methods of handling the floating dry dock problem.

FILTRATION.—For a system using a sedimentation basin, water is pumped into it from the source of supply against a comparatively low head. This form of pumping is one of the legitimate specialties of the Centrifugal Pump, both as regards economy of operation and saving in cost of installation. Plants of this description have already been installed in many large cities where the source of supply is such as to require filtration.

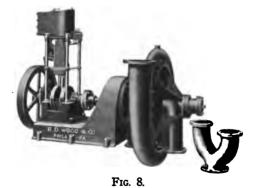
SEWAGE.—Formerly it was the constant problem of engineers to handle sewage by directacting pumps without having them out of service quarter of the time for cleaning and repair



Fig. 7.

purposes. The main difficulties were, of course, with the valves, which would not only become clogged, due to the presence of solid matter in suspension, but whose contact surfaces would deteriorate rapidly under the chemical action of organic impurities also present.

The use of Centrifugals for this purpose has revolutionized all this, and to-day they constitute the accepted type of machinery for handling sewage. Intercepting sewerage systems in connection with distant disposal beds always require pumps, unless the country happens to



be peculiarly adapted to permit the natural flow of the sewage, which is rarely the case. The Atlantic City Sewerage Company are using two of our Pumps to accomplish the above results, the distance conveyed being some two miles, and the total head, including friction, about 80 feet. (See Fig. 7, page 95.)

COFFER DAMS AND EXCAVATING.—A necessary part of a contractor's outfit to-day is one or more Centrifugal Pumps,—at least, if he ever does any foundation work near any water. The muddy, dirty character of the water found in such excavations and inside of coffer dams makes a "valved" pump a very expensive luxury to maintain, while not interfering in the least with the proper operation of a Centrifugal. The comparatively small cost of this form of

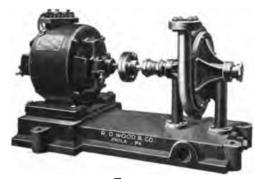


Fig. 9.

machinery is an added inducement, when of necessity it has to lie idle more or less of the time. The portability of these pumps, together with the ease with which the direction of the suction and discharge pipes may be altered to suit different local conditions, makes them specially desirable for this purpose. (See Fig. 8, page 95.)

BILGE AND OTHER SUMP WATER.—For bilge water, the surface-condenser, circulating pump may have a side connection to enable it to handle the bilge also. For sump water, seepage water, or cellar drainage, as required in buildings whose cellars or sub-cellars are lower



Fig. 10.

than the street sewers, our small direct-connected electric pumps (see Figs. 9 and 10, page 96) are particularly desirable, though steam or belt-driven ones may be used if preferred.

House Tanks.—For high buildings whose upper stories are beyond the reach of city water pressure, a tank on the roof, kept filled by one of our electric pumps (Fig. 9), automatically controlled, forms a convenient means of supply. Exceedingly simple automatic devices, controlled by the water level in the tank, will start or stop the pump, which, being connected directly with the city mains, is always primed, and hence requires no attention except occasional lubrication. Any kind of motor or current may be used. Country houses may be given running water by a similar installation if connected to a nearby source of supply; in which case, however, a foot valve has to be added to keep the pump always primed.

GENERAL FACTORY USE.—Manufacturers who require a more or less constant washing as a part of their processes will find it advantageous to use Centrifugals for their pumps, as they will most readily supply a continuous stream of large volume.

Dredging and Wrecking.—Specially constructed Centrifugal Pumps are extensively used for this service. They require proportionately larger waterways, and generally a lining of steel to resist the impact of rocks and other hard solids. In many cases upward of 20 per cent. of solid matter can be handled economically by this method. The extraordinary rapidity with which this work can be performed by pumping, as well as the comparative economy both of installation and operation, commends this method for use where for many years chain, clamshell and scoop dredges had held the field exclusively. A special advantage of this method over other forms of dredging lies in the ability to deliver the material (if desired) to distant points through long pipe lines, thus combining in a single operation the dredging and disposal of the material. The application of the above (among others) to deepening channels and reclaiming lands is especially apparent.

HANDLING PULP AND OTHER SEMI-FLUIDS, OIL AND HEAVY LIQUIDS.—Centrifugals have been used for these purposes for many years, and with satisfactory results.

Other Applications.—While the above list represents a number of the present uses to which centrifugal pumps have been put, it by no means covers the ground, and new applications are continually coming to hand.

Any service requiring a large volume of water, against a head not exceeding 100 feet, especially if the fluid to be handled contains dirt, grit or other solid matter in suspension, is the acknowledged field of the Centrifugal pump. If the head exceeds 100 feet, the use of compound pumps (i.e., two or more simple pumps arranged tandem) enables much higher pressure to be successfully overcome.

We especially desire that engineers and others having difficult pumping problems to solve will permit us to assist them with a view toward using Centrifugal Pumps for their purpose, even though the application seems to be new or special.

Instructions for Inquiries or Orders.—In sending us inquiries or orders, we particularly request that the following information be furnished, so that we may be certain that the most serviceable apparatus is supplied to our customers.

- 1. Number of Units required.
- 2. Description of Service.
- 3. Steady or Intermittent.
- 4. Discharge Capacity each, in U. S. gallon or dirty.
- 5. Character of Water:—salt or fresh, cleans per minute.

- 6. Number of Position. (See table below.)
- 7. Details of suction line:—diameter of pipe, horizontal and vertical length, and kind, number and radius of all bends.
  - 8. Ditto for discharge line.
- 9. Measured heads, suction, discharge and total; (suction and discharge heads to be measured down and up from the level of top of pump foundation).
  - 10. Method of priming.
- 11. Method of driving, by belt, gears or direct-connected, and if the latter, whether by steam, gas, electric or water power.
- 12. If steam, state type of Engine, vertical or horizontal, simple, compound or multiple, condensing or non-condensing; also type of governor, available pressure at throttle, amount of steam available, and other limitations.
- 13. If gas, state pressure, and also if cooling water and ignition current are also to be furnished.
- 14. If electric, state character of current, voltage, phase and frequency; also if automatic attachments are desired, and any other limitations.
  - 15. If water power, give any and all available data.

As our recommendations are always based on the information received from our customers, it is important that this should be as full and explicit as possible.

Answer Question 6 by reference to the following table:

TABLE OF POSITION, LOOKING FROM SIDE OPPOSITE TO DRIVING SHAFT.

(ANSWERING QUESTION No. 6.)

Fig. 11.

NOTE.—Pumps will be furnished "right-hand" and assembled, as shown in position No. 9, and swiveled in most convenient form for shipment, unless otherwise specified.



Suggestions for Installing and Handling.—A Centrifugal Pump is not an air pump, and cannot be made to even hold its column of water if air bubbles are present in any quantity in the suction pipe. It follows that for successful operation the suction pipe must be made absolutely air-tight throughout its entire length. For this reason, the shorter the suction line can be made, the simpler becomes the installation.

In no case should the top of the suction elbows of the pump be more than 26 feet above the lowest level of the water to be pumped.

In laying out both suction and discharge piping, care should be taken to use only long-radius bends. It is also desirable that both suction and discharge pipes should be somewhat larger in diameter than the pump openings, especially in pipes of any length. By following these suggestions, the friction head will be largely reduced, and thereby a very considerable saving effected in first cost of the machinery, as well as in subsequent cost of operation.

There is one characteristic of a centrifugal pump which seems anomalous, when compared with ordinary reciprocating pumps,—viz., that with a constant speed of operation, a reduction of the head pumped against will increase the load on the pump. This is due to the fact that the volume of discharge increases inversely as some function of the square of the head, so that the work done (i. e., weight of water × height of lift) will necessarily increase under diminished head, provided speed remains constant. Hence, we will see that if it is necessary to decrease the load on a centrifugal pump, it can be accomplished by increasing the head or, of course, decreasing the speed. If this is borne in mind, many seeming difficulties may be readily overcome.

Efficiencies.—The old idea that Centrifugal Pumps are uneconomical and inefficient is rapidly disappearing under the results secured by modern designs and better workmanship. For heads up to 50 feet, Centrifugal Pump efficiencies compare favorably with those of directacting pumps, while the reduced comparative cost goes far toward making up the difference against higher heads.

In determining efficiencies, the following precautions should be observed:

Suction head should be measured by a vacuum (or pressure) gauge connected to the highest point of one of the suction elbows of the pump.

Discharge head should be measured by a pressure gauge connected to a point of the pump volute just inside the discharge flange.

Total head should be taken as the algebraic sum of these two quantities plus or minus the vertical distance between the points of connection of the two gauges with the pump casing.

The volume (and consequent weight) of water pumped should be measured by weir or other satisfactory method, and the effective work done or the Water horse power computed.

The Brake horse power consumed on the pump shaft should be measured by a Prony brake or transmission dynamometer, after which we readily obtain the Pump efficiency,—viz., the quotient of the Water horse power by the Brake horse power.

Economic Expenditure for Pumping Machinery.—It has been customary, hitherto, to consider only the cost of coal consumption in estimating the economic value of pumping machinery, but this method is manifestly defective. The interest and depreciation on the investment, to say nothing of the labor charges and cost of operation (other than coal), are important factors when different types of machinery are being compared. Recent developments have shown that this form of pump may be most successfully used for small water



works systems, maintaining a pressure of 50 pounds per square inch in the mains; and that while its Duty in million foot pounds may be considerably less than that obtainable from high-duty steam pumping engines, the total costs per annum, computed as above, may show a balance in favor of the centrifugal installation. The complete formula should be taken as

$$\frac{A \times w \times H \times p}{20 \times D} + F (i+d) + L + M = C$$

in which

A=Total number of gallons pumped per year.

w=Weight of a U. S. gallon (approx. 8.34 pounds).

H=Average total head in feet pumped against.

p=Cost of coal per ton of 2000 pounds.

D=Average duty in foot pounds per 100 pounds of coal.

F=Total investment=first cost of machinery.

i=Rate of interest on investment.

d=Rate of depreciation=reciprocal of the life of machinery.

L=Yearly cost of operating labor.

M=Yearly cost of miscellaneous expenses of operation.

C=Total cost per annum.

In addition to the above considerations, simplicity of construction, maximum freedom from probability of accidents, and ease and celerity with which repairs can be made, should be considered in determining on any new installation.

Capacity, Lift, Efficiency and Power.—The chart given on following page forms a very convenient and rapid method of determining any one of the above elements if the remaining three are known. Its principal use will be found in determining the amount of power required on pump shaft when the capacity, lift and efficiency are given. Example:—A 15-inch Pump is required to deliver 6000 U. S. gallons per minute against 40 feet total head, at an efficiency of 60 per cent. Start up the vertical line opposite 6000 gallons until it intersects the diagonal marked 40 feet; then horizontally until the 60 per cent. diagonal is met; and finally down vertically to the horse-power scale, which will be found to be in this case 101 horse power. By selecting the correct one of the four horizontal scales of gallons and horse power, any capacity from 2 to 100,000 gallons per minute, and any power from  $\frac{1}{10}$  to 5000 horse power may be computed, care being always taken to use the corresponding scales as indicated by the arrows.

ioi

works syste its Duty in

steam pum . in favor of in which A=Tcw=WH=Ap=Co: D=A F=Tci=Rat d=RaL=Ye M=YC=TcIn ad from prob be conside: Capa a very con three are 1 on pump s required t of 60 per marked 40 tically to ' lecting the

from 2 to computed,



260,000 GALLON TANK ON STEEL TOWER.

Tank, 30' diameter x 45' deep. | Tower, 45' diameter at base x 100' high. Digitized by



STAND PIPE.
'diameter x 110' high.

STAND PIPES, TANKS AND TOWERS.
STEEL RIVETED PIPE.

Iron Roofs and Floors,

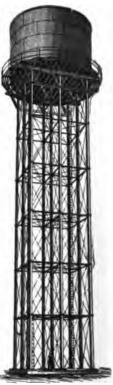
Traveling Cranes for Pump Houses.

STEEL INTAKE WELLS AND CONNECTIONS.

#### TABLE No. 55.

TABLE SHOWING THE CAPACITY OF STAND PIPES, TANKS AND CISTERNS FOR EACH FOOT IN DEPTH.

| Diameter<br>in Feet | Gallons | Diameter<br>in Feet | Gallons | Diameter<br>in Feet | Gallons  |
|---------------------|---------|---------------------|---------|---------------------|----------|
| 2.                  | 23.50   | 7.                  | 287.87  | 14.                 | 1151.48  |
| 2.5                 | 36.72   | 7·5<br>8.           | 330.47  | 15.                 | 1321.91  |
| 3.                  | 52.88   |                     | 376.00  | 20.                 | 2350.00  |
| 3.5                 | 71.96   | 8.5                 | 424.47  | 25.                 | 3671.95  |
| 4.                  | 94.00   | 9.                  | 475.88  | 30.                 | 5287.66  |
| 4.5                 | 118.97  | 9.5                 | 530.23  | 35· i               | 7197.06  |
| 5.                  | 146.87  | 10.                 | 587.52  | 40.                 | 9400.00  |
| 5·5<br>6.           | 177.72  | II.                 | 710.90  | 45.                 | 11896.98 |
| 6.                  | 211.52  | 12.                 | 846.08  | 50.                 | 14687.96 |
| 6.5                 | 248.23  | 13.                 | 992.91  | 75.                 | 33048.10 |



From photograph of Tank 20' x 30', on support 100' high.

Stand Pipes.—Excellent facilities for the building of Stand Pipes, Tanks, etc., are afforded in the Gas Holder Department at our Camden Works. Designs, specifications and prices upon application, which may be secured the more promptly if for usual sizes. We are prepared however to meet any requirements in this line, including the heaviest work—a steel tank recently completed is 190' diameter × 50' deep, the bottom course of plates 1\frac{3}{4}" thick.

TABLE No. 56.
STAND PIPES AND TANKS.

| STAND PIPES  | Pressure<br>at Base [_''           | TANKS | TOWERS  |
|--|------------------------------------|-------|---|
| 15' and 20' diameter x 100' high<br>15', 20' " 25' " x 125' "<br>20', 25' " 30' " x 150' " | 43.3 lbs.   20<br>54.1 "<br>64.9 " |       | Proportioned<br>to suit the re-<br>quirements of<br>purchasers. |

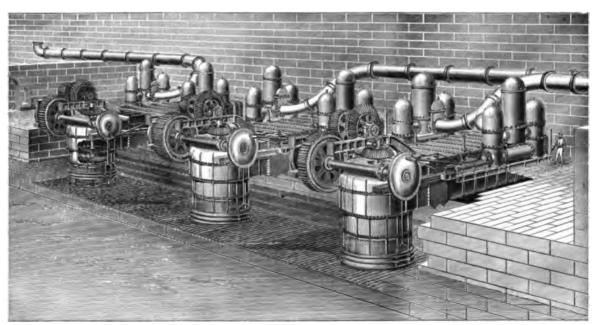
To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by 43.3(Approximately, every foot elevation is called equal to one-half pound pressure per square inch.)

To find the capacity of a cylinder or tank in gallons. Multiplying the area in inches by the depth in inches will give the total number of cubic inches; divide the amount by 231 (which is the cubical contents of a gallon in inches), and the product is the capacity.

# THE GEYELIN-JONVAL TURBINE

FOR DRIVING WATER-POWER PUMPS, ELECTRICAL GENERATORS AND MILL MACHINERY.

HISTORICAL NOTICE.—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 80 per cent. in effective duty, according to the report of M. Amedé Rieder, of the



FAIRMOUNT PUMPING MACHINERY, PHILADELPHIA.—CONSTRUCTED BY EMILE GEYELIN, M. E. FROM GENERAL DESIGN BY FREDERICE GRAFF, CHIEF ENGINEER.

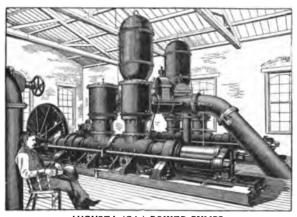
committee. This remarkable result, with the simplicity of form, fewness of parts, and perfection of design, in that early day of turbine history, atonce drew to the wheel the attention of the most learned mechanicians of Europe.

Soon after the Jonval Wheel had established a reputation in France and Great Britain, Mr. Emile Geyelin (associated with us until his death in the summer of 1900), 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 78.3 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 replaced all the large breast-wheels formerly used at the Fairmount Station.

The manufacture of the Geyelin-Jonval Turbines is a specialty for which our large machine and erecting shops afford excellent facilities; and the turbines we are now building embody in their design the result of very many years' experience. It is our aim to carefully study the requirements of customers, so as to adapt each wheel to the special duty for which it may be intended; and following out this practice of special adaptation we are now constructing several types of wheels.

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



AUGUSTA (GA.) POWER PUMPS. DRIVEN BY GEYELIN-JONVAL TURBINES.

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 issue, and the relations of their curves. Turbines, for any given power, cannot be produced with universal excellence for different heads of water from one mold, but each, to reach the highest success, should be especially designed for its special work and surrounding circumstances.

It is seldom that a stream from which the supply for power is drawn is entirely free from the annoyances of back-water during times of

flood, or lack of water during seasons of drought. For such variable streams we offer a *Duplex Turbine* with a larger compartment to operate with economy at ordinary stages of the stream, and an inner compartment to be used under a diminished supply; while in times of flood, with the water backed up in the wheel pit, more than it rises in the fore-bay, both compartments may be utilized under the diminished head to obtain full power. This type of wheel may also be used to advantage for locations bordering upon tide water, where the ebb and flow in the tail-race constantly changes the available head, and the work of the turbine is constant, as when driving pumping machinery for public water supplies.

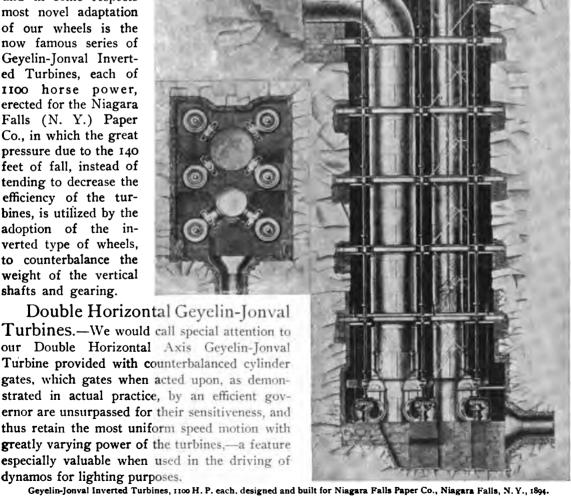
Numerous dynamo-metric tests have shown the high efficiency of the Geyelin-Jonval Turbines, and their general adaptability and durability in all classes of service. They have been successfully adapted to the driving of cotton, woolen and paper mills, pumping and electrical

machinery, and we might point to many installations throughout the country. It will suffice, however, to mention the three large turbines (1884) for driving the John P. King Mill, Augusta, Ga.; also the pumping machinery and turbines at the Augusta (Ga.) Water Works; the Montreal (Canada) Water Works; the Water-

town (N. Y.) Water Works; Augusta (Me.) Water Works; and the Man-

chester (N. H.) Water Works; some of which have been in operation forty years or more.

One of the latest and in some respects most novel adaptation of our wheels is the now famous series of Geyelin-Jonval Inverted Turbines, each of 1100 horse power, erected for the Niagara Falls (N. Y.) Paper Co., in which the great pressure due to the 140 feet of fall, instead of tending to decrease the efficiency of the turbines, is utilized by the adoption of the inverted type of wheels, to counterbalance the weight of the vertical shafts and gearing.



By examining the accompanying cut, it will be noticed that the two gates admitting water to the two turbines opposite to each other counterbalance each other; further, that in each case these gates are very close to the revolving wheels.

The end pressure, which in a single wheel would be so great as almost to preclude the possibility of being moved by any governor, becomes in the double wheels and gates placed opposite to each other perfectly balanced.

We would also call attention to the water bearing grooved joints between the two revolving parts and the stationary parts of the turbines, thereby reducing to a minimum the waste of water when the turbines are in operation. This style of double horizontal turbine can in many instances

be especially designed to be attached directly to the dynamo.

By making the movable wheels bronze and using selfoiling bearings resting on substantial girders, attain steady а motion even for great powers, showing no indication of tremor-a most desirable thing for the vitality of dynamos.

These turbines are especially adapted for service under heads of from 10 to 100 or 200 feet, where high velocity is desired, as in driving dynamos, cotton and paper mill machinery, etc. We believe these Geyelin-Jonval Turbines were the first to be used in pairs horizontally, the



first installation that we know of being a pair of horizontal turbines built by our Mr. Geyelin some 40 years ago for use in Saltillo, Mexico, which were of 120 horse power under a head of 160 feet. Even under comparatively low heads these horizontal turbines can be adapted to give efficient service.

These horizontal turbines have also been successfully adapted to the driving of water power pumping machinery, the turbines being so connected that one or both may be utilized for driving; when one turbine is running the in-thrust is taken up by our Glass Suspension Bearing, and neutralized when both turbines are working.

An example of an installation of this kind is shown in the illustration of the pair of power

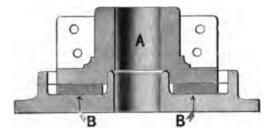
pumps and turbines built by us for the Willimantic (Ct.) Water Works, the general design of which was supplied by J. T. Fanning, Esq., the well-known engineer.

The Geyelin Patent Glass Suspension forms a complete and most reliable step or bearing for turbines and is equally applicable to any other heavy vertical shafting. Thus, in place of supporting the weight of the water and movable parts of the turbine on a step below the turbine, it is carried on a circular disc, composed of segments of glass, so arranged as to be movable by means of depressed divisions, which form a continuous space around each segment of which the disc is composed, allowing, while the turbine is in motion, a perfectly free circulation of the lubricating matter with which the space is filled. Firmly secured to the turbine shaft is a perfectly true metal ring, which revolves upon these stationary glass segments.

One great advantage which we may claim for this Glass Suspension Box in conjunction with, or in place of the ordinary step, is the avoidance of expensive and disagreeable work in going 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



GEYELIN PATENT GLASS SUSPENSION.
PLAN SHOWING THE GLASS DISCS B B IN THEIR STATIONARY SEAT.



Cross Section, Showing the Revolving Disc A Resting on the Glass Discs B B.

the wood. By the use of a Glass Suspension Box this may be avoided, and since the box is placed above the turbine, it is readily accessible. These Glass Suspension Bearings may be supplied to turbines of other makes, as well as our own.

Table No. 57, page 108, gives the horse powers developed by single wheels of given diameters, under static head at 80 per cent. efficiency. Where double wheels are used, proper allowance should be made.

If it is desired to ascertain the volume of water required to pass the wheel per minute to develop a stated horse power, it may be obtained by the formula:

$$Q = \underbrace{H.P. \times 660}_{h}$$

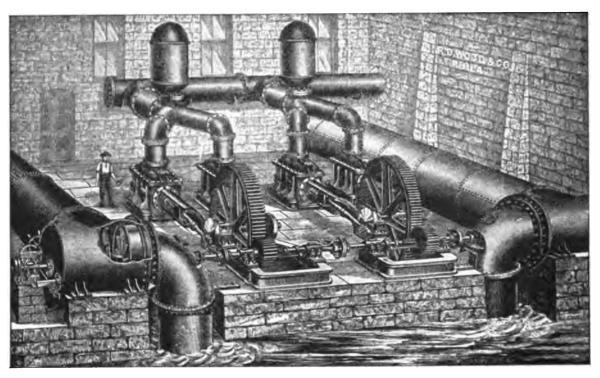
The following formula gives the horse power available when the quantity of water and the head are known, assuming that it passes through a turbine of 80 per cent. efficiency:

H. P. = 
$$\frac{Q \times h \times 62.5 \times .8}{33,000}$$
 or =  $\frac{Q \times h}{660}$ 

In the above formulæ Q = cubic feet of water passing wheel per minute; h = vertical head

in feet above the wheel; weight of a cubic foot of water is taken as 62.5 pounds; and efficiency of wheel at 80 per cent. While the table is limited to moderate heads and powers, we are prepared to undertake the heaviest work of this class, and make a specialty of adapting our wheels to the special location and service for which they may be intended.

INQUIRIES should state the maximum effective horse powers desired at a given maximum



WILLIMANTIC PUMPS AND TURBINES-Capacity, 3,000,000 Gallons.

speed; the available head and volume of water, with any variations therein; and indicate whether vertical or horizontal wheels are preferred.

Measurements and Improvements of Water Powers.—In a "Treatise on Hydraulic and Water Supply Engineering," by J. T. Fanning, Engineer, published by Van Nostrand, New York, there will be found full discussions upon the amount of water that can be made available from given watersheds, measurements of streams, storage of water for power,

TABLE No. 57.

Horse Powers of Turbines, Single Wheels,
Smaller Sizes.

| Diameter in inches | HEIGHTS OF FALL |         |             |         |         |  |  |  |  |  |
|--------------------|-----------------|---------|-------------|---------|---------|--|--|--|--|--|
| Single<br>Wheel    | 10 Feet         | 15 Feet | 20 Feet     | 25 Feet | 30 Feet |  |  |  |  |  |
|                    | HORSE POWERS    |         |             |         |         |  |  |  |  |  |
| 25                 | 9.47            | 17.25   | 26.4        | 37      | 48.8    |  |  |  |  |  |
| 25<br>30<br>36     | 139             | 25.2    | 396         | 55.2    | 72.2    |  |  |  |  |  |
| 36                 | 19.8            | 35      | 54.5        | 76.9    | 100     |  |  |  |  |  |
| 40<br>46           | 24              | 44      | <b>68</b> ) | 85      | 126     |  |  |  |  |  |
| 46                 | 32              | 62      | 94          | 135     | 173     |  |  |  |  |  |
| 52                 | 40.7            | 8o      | 120         | 175     | 220     |  |  |  |  |  |
| 57½<br>62          | 53              | 95      | 156         | 218     | 280     |  |  |  |  |  |
| 62                 | 67              | 110     | 193         | 262     | 340     |  |  |  |  |  |

volumes of flow of streams in droughts and in floods, and of the proportions of waste-weirs and dams; and we refer to that book for information in detail relating to these matters.

Useful Memoranda.—Greatest density of water is at 39.2° F., at which one cubic foot weighs 62.425 pounds.

One cubic foot of fresh water at 62° F. weighs 62.355 pounds.

One cubic foot of fresh water at 62° F. contains 7.4805 United States gallons.

One United States gallon of fresh water contains 231 cubic inches.

One United States gallon of fresh water weighs 8.3311 pounds.

One Imperial (British) gallon of fresh water =1.20032 United States gallons.

One cubic foot of average sea water equals in weight 1.028 cubic feet of pure fresh water.

2.31 feet depth of water at 62° F. will produce one pound pressure per square inch.

To ascertain pressure per square inch of a column of water, divide its height in feet by 2.31, or multiply by .433, and vice versa multiply the pressure per square inch by 2.31 to find the head in feet.

One inch of rainfall on an acre equals 3630 cubic feet or 27,154 gallons, and on a square mile 2,323,200 cubic feet or 17,378,607 gallons.

The average percentage of rainfall delivered into streams, according to reports of Boston and New York Water Departments, is from 45 to 50 per cent.

Note.—The average yield from a square mile of the combined watersheds of Sudbury, Cochituate and Mystic (Boston Water Department), extending over a term of 13 years, was 1.539 cubic feet per second; that of the Sudbury alone, during 20 years, was 1.637 cubic feet, and of the Croton (N. Y.) watershed for 17 years, 1.68 cubic feet per second. (See paper by Mr. Desmond Fitz Gerald, Trans. Am. Soc. C. E., Vol. XXVIII, p. 253; also, Eng. News, Oct. 20, 1892, p. 366, and March 7, 1895, p. 158.)

Approximate bottom velocities of flow in channels at which the following specified materials begin to move:

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.25 feet per second microscopic
sand and clay.
3.00 " " smooth nut gravel.

.50 feet per second fine sand.
4.00 " " " 1½ inch pebbles.

1.00 " " coarse sand.
5.00 " " 2 inch brickbats.
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One gallon of water raised one foot equals  $8\frac{1}{3}$  foot pounds, hence 1000 gallons raised 50 feet will be 1000  $\times$  50  $\times$   $8\frac{1}{3}$  = 416,666 foot pounds.

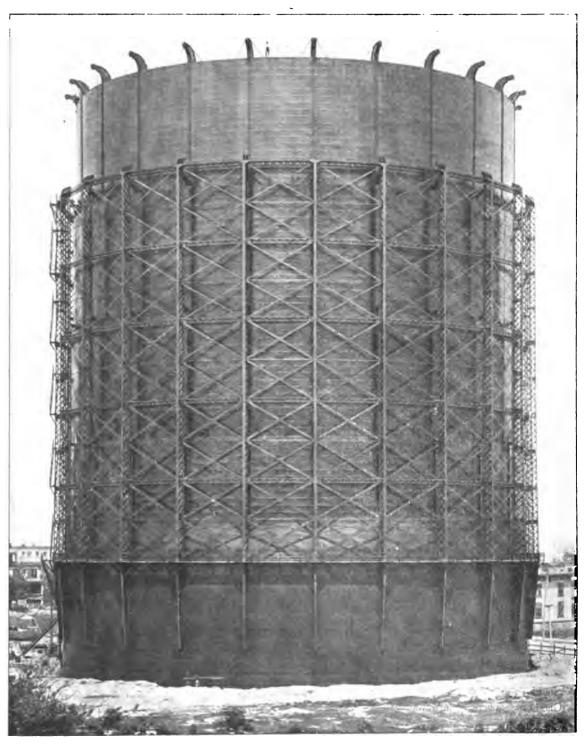
The British Thermal Unit (B. T. U.) is 778 foot pounds, called "Joule's equivalent." It represents the energy necessary to raise one pound of water 1° F.

One horse power equals 33,000 foot pounds, or 42.75 B. T. U. per minute.

One horse power = 746 watts = approximately 34 kilowatt.

One kilowatt = 1.34 horse power.





FOUR-LIFT GAS HOLDER AND STEEL TANK-5,000,000 cubic feet capacity.

## GAS WORKS APPLIANCES.

GAS-LIGHTING has been used for over 100 years, as it was in the year 1792 that William Murdoch first applied gas as a substitute for the ordinary illuminants—candles and oil—lighting his house and office at Redruth, Cornwall, England, with a gas made from coal; and it seems to be generally conceded that this honor of having made the first practical application of gas-lighting belongs to him. The unveiling, not very long since, of a bust of Murdoch at Abbey Craig, near Stirling, Scotland, was an interesting event and well-merited honor. When we think of this first application of gas in comparison with its almost universal use in these days for lighting, cooking, ventilating, heating and power purposes, we are impressed with the great benefits that have accrued to mankind through this wonderful discovery.

Since the first introduction of gas into the United States, at Baltimore about 1821, its manufacture in this country, as well as throughout the world, has grown to enormous proportions, and is apparently steadily increasing in spite of the fact that in recent years the electric light has become a more and more formidable competitor. It is too soon to predict which will obtain ultimate supremacy, as improvements in both are of frequent occurrence, but those in the manufacture and burning of gas tend to show that it has every chance of maintaining its position as the cheapest, best, and most reliable illuminant for general purposes. To the competition with the electric light, however, have been due many improvements, resulting in a very material increase in the light-giving power of gas; and, bearing this competition in mind, may we not look confidently for still greater progress? Many companies have found, as a result of these improvements, that, instead of a decrease, the competition with the electric light has resulted in a material increase in their consumption; and, whether this may continue or not, it would seem that, should there be a material loss as a result of the application of electricity to purposes and in places where it is more suitable than gas, it will be more than made up by the numerous new uses to which gas is now being put; as it is an undeniable fact that the demand for gas for cooking, heating, ventilating and power purposes is rapidly increasing, while the greatly increased luminosity and economy of the incandescent gas lamp has given new impetus to this mode of lighting. Space, however, forbids discussing a subject about which much has been and might be written, and covering which there is any amount of literature accessible to those who seek it.

Those who have in mind the introduction of gas to any city or town requiring a new plant, and are themselves unfamiliar with the gas business, will do well to entrust the preliminaries to a competent Gas Engineer, as the money expended for his services will undoubtedly be more than saved in having the plant properly proportioned to present and probable future needs. Then, too, there are many questions as to the kind of gas, character of apparatus, and other details which are more or less affected by location and other surroundings, which such an Engineer could readily determine. One of these, for instance, will probably be whether it is best to make coal gas or water gas, or both; and for small works, where only one or the other can be used to advantage, the decision will largely depend upon the prices of coals and oils; while for the larger works it is often well to make both coal gas and water gas. In this combination, the fact that the coke derived from the benches can be utilized, if necessary, in the water gas generators, is of importance; while many Superintendents, in retaining coal gas, look to the increased uses for

residuals as a means of materially reducing the cost of their output. In general, the location for a gas plant should be as near as possible at the lowest part of the section to be supplied, in order that the advantage of the natural increase in pressure in passing to higher portions of the district may be secured; due consideration being had for the accessibility of water or rail transportation, an important factor. Ample space admits of economical working, and possible extensions; substantial buildings and apparatus of approved design being cheapest in the long run.

Coal Gas.—Many materials have been used in the manufacture of gas. All vegetable and animal substances when exposed in closed retorts to a red heat undergo destructive distillation, yielding gas, tar and water, and leaving a residuum of charcoal or coke. Coal, however, has stood the test of a century, and is indisputably the best material; and while the cannels yield the richest gas—in England having to some extent been used exclusively—coking coal is chiefly used, owing to its abundance, cheapness and the quality of the coke that results from its distillation. The character of the coal determines the quality of the gas, and when this is deficient, the luminosity is increased by the use of certain proportions of cannels or other enriching materials; although their use results in an increased cost for each candle power thus obtained. Thus a question for Gas Companies to determine is as to how much the commercial value of their gas is increased when it is raised above, say, twenty candle power.

The manufacture of coal gas is nowadays such a familiar process—that it seems almost unnecessary to describe it. However, it may be well to refer to those features of first importance and to briefly describe the three distinct operations—Distillation, or Carbonization, of the coal; Condensation of tar, water, etc.; Purification by the removal of various gaseous impurities, such as ammonia, carbonic acid, sulphuretted hydrogen, and other sulphur compounds.

Coal.—The most satisfactory preliminary test of a coal is by a diminutive gas apparatus capable of treating a few pounds of coal and so disposed as to permit measurement of the gas and by-products. Chemical examination alone affords insufficient data. While a "proximate analysis," showing specific gravity, moisture, volatile matter, fixed carbon, ash and sulphur, affords some criterion of its value, about the only advantage of an "ultimate" or elementary analysis is the knowledge of the percentage of free hydrogen present; poor gas coals have less than 4 per cent., and those very rich over 5 per cent.

Some varieties yield their gas more readily than others, but it serves economy to use it as soon as possible after mining. Long storage or weathering diminishes yield of gas and impairs its quality. Much moisture lowers the heat of retorts, promotes the formation of condensable constituents, produces less gas of poorer quality and liberates a portion of the sulphur which otherwise would be retained by the coke. Protection during necessary storage is, therefore, very desirable, and should be secured with efficient ventilation to guard against spontaneous ignition.

The yield of Pennsylvania gas coals in present practice is something over 10,500 cubic feet of eighteen candle power gas per gross ton, depending very much, however, upon the general conditions surrounding the plant.

Carbonization.—Although the increased use of residuals has mitigated the evils of faulty practice, no more important operation than this enters into gas manufacture; the success of an installation primarily depending upon the results here obtained.

Particular attention to the retorts and their settings is essential for those high and regular heats productive of maximum yield with minimum expenditure of fuel.



Retorts.—The clay retort for continuous service represents approved practice, the exhauster having largely overcome the former troublesome facility of carbon deposition under high heats and pressures. As compared with cast iron, they are cheaper, more durable and withstand a higher heat without injury. Although not worked advantageously at the most efficient temperature for gas generation, cast iron retorts are employed for irregular or intermittent service under which conditions clay retorts are liable to crack.

Strength, durability, power of carbonization and area of retort walls exposed to liberated gas are among the factors determining choice of size and shape. The "round" shape excels in the first two qualities, but is inferior to the "D," or oval, form as a carbonizer, the "D" form being in most common use.

Settings.—The retorts are nested in groups or benches, and present great variety in design of setting, some of the more recent designs being arranged through-way or with inclined retorts—as notably in French practice—though these last have not been used to any extent in this country. The tendency here, in large works especially, is the adoption of such labor-saving devices as stoking and drawing machines, which, used in connection with benches of the most approved design, have effected great economies. In American practice it seems to be the rule, not devoid of objectionable features, to dispense with the main flue and chimney above the retorts as found generally in Europe, the draught through the opening in the crown being deemed sufficient. The furnaces under the retorts are of the ordinary "direct fired," "generator" and "regenerative" (sometimes called recuperative) type. In direct firing coke is generally selected for heating the retorts, but when this finds a ready market, and tar is of low value, the latter may be as readily used; and where both coke and tar are in demand, at good prices, a cheap grade of steam coal is sometimes employed. As fuel, I gallon of tar equals about 20 pounds of coke.

Direct firing, however, has inherent disadvantages which no skill of manipulation can overcome. The merit of economy and facility of control of gaseous firing is shown by the rapidly increasing adoption of the "generator" or so-called "regenerative" system.

The former employs either a separate gas producer, or the furnace is converted into one by construction to carry a considerable depth of fuel and by restricting its "primary" air supply. The "secondary" air, that necessary to complete combustion, is suitably introduced adjacent to gas ports, the whole disposed along the full length of the setting, thus avoiding intense local heating and irregular distribution.

The "regenerative" system differs from this only in preheating the secondary air by the hot waste gases, and generally by the continuous rather than the reversal system.

Particularly in Europe, gaseous firing has been introduced with marked economy of fuel, of maintenance and of labor, while good, even and rapid heats develop a greater yield per mouth-piece. In works of moderate size, and then only with skillful care, 25 per cent. of the coke yield is consumed as fuel. Gaseous firing gives results 10 to 40 per cent. better, depending upon the size of plant and the skill of management with which it is compared.

Distillation.—As soon as the retort is charged destructive distillation begins, and, while modified by the freshness and moisture of the coal, its products are primarily dependent upon the intensity and duration of the heat applied. It is important that this be carefully regulated. The importance of this is manifest when it is recalled that from the same coal a few hundred or thousands of cubic feet of gas may be obtained by variation of the temperature of distillation. Too low a temperature results in too large a proportion of condensable vapors, which appear in

the form of oil and tar with a small yield of high power gas but an inferior coke, while too high a temperature injures the quality of the gas by decomposing it into non-luminous marsh gas and hydrogen with deposition of carbon. The outer layers of the coal first undergo distillation, yielding condensable vapors rich in carbon; which in passing through the red-hot retort on their way out are decomposed into fixed gases of high illuminating power. As the heat continues, the outer layers of coal are converted into coke, which is soon raised to a red heat, while at the same time the interior of the charge becomes heated and the vapors produced in passing through the red-hot layer of coke are in turn converted into a fixed gas; and as each successive portion of the vapor passes through a larger surface of the red-hot coke, it is more and more completely decomposed, resulting in a reduced percentage of carbon, and consequent illuminating power; the quality of gas deteriorating as the process of distillation continues, until finally little besides hydrogen is evolved. If this final temperature is prolonged unduly, large amounts of carbon disulphide are evolved, a very objectionable and troublesome impurity. While the gas is usually generated in a retort heated to a temperature of over 2000°, the fixed gas as it rises from the retort to the hydraulic main seldom has a temperature reaching 10 per cent, of this. This difference results largely from the fact that the volatile matter of the coal absorbs a large amount of heat in assuming the form of gas; this heat becoming latent in the gas, while the balance is lost through radiation.

From the hydraulic main the gas now passes to the condenser; thence it passes to the scrubber and on to the purifiers and holder; once in the holder, it is ready for distribution.

The successful operation of the plan naturally depends upon the skill and experience of those in charge of it; and it is needless to say there are many minor devices of more or less importance, for special purposes, required to complete the plant, that have not been mentioned in the above brief outline of the process of manufacture.

Water Gas.—What is generally called water gas has only been utilized commercially within the past twenty or twenty-five years, and is usually obtained by passing steam through a bed of incandescent anthracite coal, oven or gas coke of good quality—either of which contains about 85 to 90 per cent. of carbon. Water gas, therefore, results from the chemical fact that carbon in an incandescent condition has so strong an affinity for oxygen that it will decompose steam composed of hydrogen and oxygen, combining with the oxygen to form carbonic oxide, while the remaining constituent, hydrogen gas, is freed, and mixing with the carbonic oxide forms what is called "Water Gas." This, however, lacks illuminating power, so that water gas, as it is known to commerce, is that enriched by having added to it a proportion of hydro-carbons in gaseous form, usually secured from petroleum or some of its products. These enriching or "carburetting" agents are introduced, then vaporized and fixed by heat during the process of manufacture; in this country Lima Oil and Naphtha are generally used for this purpose.

In general, a water gas plant may be said to consist of a generator, carburetter and superheater, in which is made the fixed gas, whence it passes through the condensing, scrubbing and purifying apparatus to the holder, substantially as if it were coal gas. There are various processes for the manufacture of water gas, practically all of which depend upon the same principle, but differ more or less in the design and construction of their apparatus, and to a greater or less extent as to economy of operation. The most approved designs are those which produce a fixed gas, and at the same time enrich it effectively and economically.<sup>1</sup> The general opinion seems to be

In large water gas plants, 35 to 45 pounds of coal or coke including boiler fuel, and from 3½ to 5 gallons of oil per 1000 cubic feet, varying with candle power desired, are required. In small works the consumption of coal or coke per 1000 cubic feet of gas is increased considerably, while the proportion of oil used remains about the same.

that of the various types of apparatus now offered, that which employs two fixing chambers and directs the steam blast through the fire bed when this has been brought to incandescence, gives the best results as to economy in oil and fuel, and also as to make per square foot of grate area.

As previously suggested, there is an advantage secured in making water gas and coal gas in the same plant-mixing the two gases at the exhauster. In the first place, surplus coke may be used in the water gas generator, and the apparatus utilized to make up for variations in the output, as in winter and on dark nights—thus allowing the coal benches to run continuously. Again, water gas is a most excellent means of introducing a larger percentage of heavy hydrocarbons into coal gas. This mixing of the two gases must be done cautiously, and with a thorough understanding of their analysis, otherwise the candle power of the output may be lowered, and there may be trouble from smoke. A valuable feature of a water gas plant is the relief holder, from which the exhauster draws a supply, when gas making ceases, as between "runs," thus insuring a steady flow of gas and preventing the blowing of purifier seals, as well as variations in the meter water level. The manufacture and adaptation of Water Gas Generating Apparatus to the various requirements of Gas Companies is a special field, covered by various well-known concerns making a specialty of it; but as manufacturers of the heavier apparatus and appliances used in the manufacture, storage and distribution of gas, we are prepared to include Water Gas Apparatus of any standard make, in connection with other appliances required for the extension or reconstruction of works, or in the installation of entirely new gas plants.

Retort Coke Oven Gas.—The manufacture of coke by the new systems of Retort ovens, with recovery of the gas and by-products, has become of great importance, and promises to grow to large proportions where conditions are favorable. The wasteful process of the Bee Hive oven method of coke manufacture, in which the valuable gases produced are lost, is replaced by the use of an apparatus of such size and arrangement that great economies are secured. The output of coke per ton of coal is increased; the time of coking is very much lessened; the larger bulk in which the materials and products are handled warrants the use of labor-saving machinery, and, the gas and residuals being recovered, they are obtained at a cost much below that which is usual in illuminating gas plants.

To secure favorable results, not less than twenty ovens should be established in one system. This warrants the use of machinery for the economical handling of the materials; the charging and discharging of the coking ovens being done with especial quickness. A plant of such size is necessary to warrant the installation of purifying and converting apparatus to properly utilize the gas and other by-products. A Retort oven plant consists essentially of a series of chambers placed side by side, approximately 30 feet long, 6 feet deep and 16 to 20 inches wide. This size admits of a charge of about six tons of coal. The coal may be of the cheapest forms; low-grade Nova Scotia is used in some most successful plants. The advantage which this offers is that many deposits of coal otherwise of little value can be utilized, although local conditions as to the character of the market for the coke, whether for domestic use or for manufacturing, have important bearing.

The walls of the chambers consist of hollow firebrick tiles, so joined as to form complete flues about the oven. At each end are doors which allow of the discharge of the entire body of coke in a short time by the operation of a mechanical discharger; the mass of some four or five tons being discharged and the oven refilled from overhead cars in ten to twelve minutes in good working.

The ovens are tightly sealed, having been kept at high temperature by burning of fuel gas mixed with a proportion of heated air in the surrounding flues, and distillation at once begins. The first gas to come off is of good illuminating quality,—having a candle power of sixteen to eighteen,—continuing so for about ten hours of the necessary time for proper coking. This requires twenty-six to twenty-eight hours with suitable coal and working. The gas retains its calorific quality, however, but the quantity given off during the last hours is small and available only for fuel purposes.

The volume of gas produced per ton of coal coked varies of course with the character of the coal. It is usually from 10,000 to 10,500 cubic feet, of which about 45 per cent. is available for use for illuminating without enrichment. With enriching, the entire output might be used and producer gas be used in heating the coking ovens.

The gas is carried off from the tops of coking chambers into hydraulic mains, and to the purifying, storing and distributing apparatus usual in gas plants. Special appliances are used to separate the early rich gas from the later output.

The matter of coal supply, the size and character of demand for the gas and its residuals and for the coke have great bearing on the question of establishing such plants. The limit of twenty ovens as being the smallest which could be profitably established is fixed by the best authorities. With favorable conditions, however, the process shows very excellent results and promises to be most important in the future.

Residuals.—This term comprises those products of gas manufacture which do not enter into the illuminant or from which it is desirable to eliminate them. The attention that has been given in recent years to finding additional uses and a ready sale for residual products, warrants the hope, especially where coal is obtained cheaply, that the day is not far distant when the value of these by-products will quite equal the cost of gas in the holder, so that, without sacrifice of profits, reduced prices and a consequent increased consumption of gas may result; and it is not too much to say that in a well-designed and carefully operated gas plant, waste products are practically eliminated.

Coke.—Generally speaking, the essential conditions for successful gas making are unfavorable to the production of a coke best adapted for metallurgical purposes, although it is occasionally so used. The high temperature and prolonged heat which result in a denser, harder and brighter product of coke are conditions which favor dissociation of valuable illuminants and increase of impurities in the gas. However, to the well-known use of gas coke for domestic purposes, is added, in works making coal and water gas, its possible use in the water gas generators; but this depends upon the relative value of anthracite coal and coke at the works.

Gas carbon is the hard and dense incrustation of carbon upon the interior of the retorts and a common source of the carbon employed electrically.

The liquid portion of the distillate is chiefly tar and ammoniacal liquor.

Tar.—The temperature of distillation has marked influence upon the quantity, and especially the quality of the tar. High temperatures diminish its quantity, but increase its specific gravity with a larger proportion of pitch and less of the lighter oils. Although its production varies considerably with the character of the coal and plant, the average yield per ton of ordinary gas coal is about 11 to 13 gallons, with a specific gravity of from 1.120 to 1.2; while per ton of cannel coal the yield runs up to about 17 gallons with a specific gravity of .980 to 1.060.

In most works the manufacture of tar is confined to the making of pitch for paving, roofing and similar purposes, and distillation for light and heavy oils, in which, with efficient apparatus and care, the dangers of explosion and fire incident to these processes are almost entirely avoided. Benzole, naphtha and lamp black are well-known tar products, and tar is the basis of most of our coloring matters. It is interesting to note in this connection, in a German work (1892) on "Coal-Tar Coloring matters," by Drs. Schultz and Julius, 392 coloring matters are now listed.

Ammoniacal Liquor is another residual, the quantity and strength of which, as obtained from the scrubber, varies considerably with the character of the coal and efficiency of the scrubbing apparatus. It is a complex aqueous solution of ammonium compounds arising from the absorbent action of water upon the gaseous ammonia of the retort and the solvent action of this solution upon the other gaseous impurities. With approved appliances 30 to 40 gallons of 8 to 12 ounce liquor may be secured.

The value of these residuals varies considerably in different localities; but if their full value is to be obtained, they must be converted into carbonate of ammonia, sulphate of ammonia, benzole, carbolic acid, anthracene, creosote oil and other by-products, many of which are now commercial necessities and obtainable alone from gas plants. Indeed, so valuable are some of these by-products that plants have been constructed for their sole production, in some instances even wasting the gas. Naturally the obtaining of these ultimate products means more or less expenditure for apparatus, and whether or not it is best to undertake their manufacture must necessarily depend on local and other conditions. While we have thus barely touched upon this subject of Residuals, too much consideration and study cannot be given to it, as it presents a wide field for profitable research.

Sulphate of Ammonia.—One of the most simple processes is the manufacture of sulphate of ammonia, which results from the treatment of ammoniacal liquor with sulphuric acid, and which, even in small works, may be profitably undertaken—the apparatus required being comparatively inexpensive. Sulphate of ammonia finds a ready sale to Chemical Works and may be used to advantage in agriculture, as it is one of the strongest of fertilizers.

Oxide of Iron.—After it has served its purpose in the purifiers, is known as "spent" oxide of iron, and is of value for the sulphur it contains; which may vary from about 50 to 75 per cent., depending on the methods followed in operating the purifiers; and its value varies accordingly.

Condensation.—This naturally results from cooling the gas and aims at an early removal of those ingredients which cannot be retained in the gas, and which later would foul the purifying apparatus and distributing mains. It begins as the gases reach the ascension pipes to the hydraulic main, wherein from 30 to 50 per cent. of the condensable constituents are deposited. The heavy tars thus collected in the hydraulic main should be quickly withdrawn, as they have an absorptive action upon illuminants; and the gases should not be permitted to pass through them, the dip pipes being preferably sealed by ammoniacal liquor.

Subsequent condensation should proceed very slowly, to which end the gas from the hydraulic main may be passed through slightly inclined piping about the retort house before



reaching the condenser. Thus a larger proportion of hydro-carbons are permanently retained in the gas. It is essential, however, that at no stage of the condensation should the temperature of the gas fall below 50° F., otherwise the lighter hydro-carbons may be involved in the condensation, materially weakening the gas—a loss the greater the richer the gas, and a serious factor if the freezing point be reached. It is important, therefore, that there be such disposition of valves, connections and means for temperature observations as shall make the installation easy of control. It is essential that condensation be proportioned to the make of gas in order that the scrubbers may work efficiently and not throw extra duty upon the purifiers.

There are many well-known types of condensers. For small works, generally what are known as Atmospherical Condensers of either the vertical, annular or horizontal class are used; while in larger plants, tubular water cooled types of wrought or cast iron are generally adopted. The "Pelouze & Audouin" Tar Condenser differs materially from those mentioned, and is an excellent device. It approaches the annular type, and consists of an outer cast iron cylindrical drum with the usual connections, containing two inner cylinders of perforated sheet iron, one within the other, forming a concentric annular space between them. The inmost cylinder is perforated with very small holes, and the outer sheet iron cylinder with slots of larger size, but so placed as to afford a solid surface opposite the small holes in the inner sheet, in passing which the gas and vapors strike the solid surface and the tar globules, being broken, become condensed and flow down into the tar-well connection, while the gas passes out through the slots in this intermediate or outer sheet iron cylinder, and thence through the outlet pipe. An important feature is that the double condensing cylinder is so carried as to rise and fall with the pressure in the annular space, the liquor at the bottom of which forms a seal, resulting in a varying area as required, and insuring a more complete separation of tar than is found in other forms of condensers.

The deposition of Naphthalene in a solid state in the mains and works connections often causes trouble. While not soluble in water, it may be easily removed by steaming out with Naphtha Vapor, or using that liquid at obstructed points; and a gas which yields an undesirable amount of Naphthalene may usually be enriched and made to retain the whole or a part of the Naphthalene in suspension within it, thus insuring increased luminosity. Its deposition is doubtless due to a partial distillation of a portion of the tar made in the highly heated clay retorts; and in some measure to the character of the coal used. It seems to be conceded that Naphthalene is not deposited under ordinary conditions of temperature and pressure, when the gas has been deprived as far as possible of aqueous vapor; and that the dryer the gas the greater its illuminating power. This has further been proven by the fact that gas sent to supply an outlying holder, in passing through a long length of main, gradually loses the greater portion of its moisture without depositing the hydro-carbons, and often shows a marked increase in luminosity. It follows, therefore, that the condensing apparatus should be as perfect as possible.

Area Required for Atmospherical Condensers.—Including the piping from hydraulic main, from 10 to 14 square feet of condensing surface per 1000 cu. ft. of maximum make per 24 hours are required, it being assumed that the condenser is housed. This allows for a reasonable increase in output, and is in line with the practice of well-known engineers. For present output only 8 to 10 square feet is sufficient.



Tubular Condensers consisting of wrought iron tubes surrounded by water, enclosed in a cylindrical wrought iron shell, are made with 5 square feet of tube surface for each thousand feet of nominal make of gas in 24 hours.

Exhausters.—There are three distinct types of Exhausters—rotary, reciprocating and steam-jet—the first and last being generally used in this country, the latter in small works. In all except the smallest plants an exhauster is deemed an essential feature, in that its use decreases fuel consumption, increases the output per pound of coal and the life of the retorts, as well as improving the quality of the gas. Mechanically, they should be perfectly tight, and, in operation, care taken for a proper degree of exhaustion. Insufficient exhaustion decreases the advantages above outlined, while too great exhaustion draws air and furnace gases into the system. We are prepared to furnish the various standard makes of Exhausters with appurtenances, by-passes and connections.

The Washer and Scrubber.—Before the introduction of the more efficient types of scrubbers, the washer, as a separate device, had a place in well-organized plants, but it is now generally used as a part of the various forms of tower or spray scrubbers; while in the various types of rotary scrubbers, the washer, as a distinctive apparatus, disappears altogether. The purpose of the scrubber is to remove the ammonia from gas, owing to its corrosive effect on fittings, and value as a residual. This is secured by taking advantage of the strong affinity between ammonia and water.

Tower Scrubbers are usually a cast or wrought iron vertical cylinder of a height several times its diameter (in large plants working more effectively in pairs), in which the gas is caused to rise through the filling of either broken brick, coke, stones or similar material in bulk or in layers, which is kept saturated by water trickling from a distributor in the head of the scrubber. A more durable and, in the end, cheaper filling consists of thin boards or slats on edge in crossed layers, in that it does not foul, will last indefinitely, and, as arranged, breaks up the gas more effectively than other fillings.

A Tower Scrubber is usually proportioned to have an aggregate cubical contents of at least 9 feet per 1000 cubic feet of gas, maximum make per 24 hours. A works with a maximum winter make of 500,000 cubic feet per 24 hours would require  $500 \times 9 = 4500$  feet cubical contents, requiring, say, two scrubbers, each  $7' \times 60'$ .

Small Scrubbers, consisting of a cylindrical wrought iron shell filled with wooden slats, or with trays for coke, are made with a volume of 2 cubic feet per thousand feet daily make of gas. These scrubbers remove the ammonia, but do not produce salable liquor.

Rotary Scrubbers.—A more effective washer-scrubber is the rotary type, in which the gas is more or less thoroughly deprived of ammonia and to some extent of other objectionable compounds. Of these, we are confident the Mitchell Scrubber, as made by ourselves, is the most efficient apparatus of the kind yet introduced, and we therefore call particular attention to it.



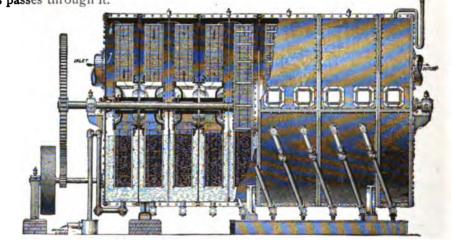
#### THE MITCHELL SCRUBBER.

Patented 1889.

THE Mitchell Scrubber consists of a series of cast iron sections varying in number and sizes with the capacity of the machine. The shaft passes horizontally through the center of these chambers and is connected at one end with a small engine or suitable gearing, which furnishes motive power. Each section contains a wheel, or wheels, consisting of ½" ashwood pieces held in a horizontal position across the wheel; the clearance between the pieces being about ½"; the wheels being securely fastened to the shaft. Clear water at the rate of 10 gallons per ton of coal carbonized is admitted at one end (the gas outlet end), and after passing through the intermediate chambers and constantly increasing in strength, is drawn off at the other end of the machine. The central shaft revolves at the rate of five turns or less per minute, and the wheels containing the ashwood sticks, in rotating with it, have their lower halves constantly immersed in the liquid,

while their upper portion always presents a thoroughly wetted surface for the absorption of the ammonia as the gas passes through it.

The scrubbing surface being of wood, the machine is much more effective than others, carrying up more water and consequently bringing the gas into contact with drops of water as they fall from one scrubbing surface to another; the position of the sticks is such as to insure perfect washing and scrubbing. As the



machine is round, the tar is all at the bottom and can be completely drawn off—a very important point—and then, too, the over-flow pipes are placed on the outside so as to admit of ready inspection and cleaning.

The machine requires a minimum amount of power to drive it, as the wheels are as light as it is possible to make them; and will absolutely remove all the ammonia and one-third of the carbonic acid and sulphuretted hydrogen from the gas, thereby reducing the labor of purifying, and the value of the ammoniacal liquors produced by this machine will pay for it in about two years. As compared with the tower scrubber, less power is required than to pump water into the tower scrubber, and the expense of coke, wood or other scrubbing material is wholly saved, and the cost and nuisance of occasionally replacing it are entirely avoided. A further advantage is that the machine can be increased in capacity at any time by adding one or more sections, lengthening the shaft, and increasing the driving attachments.

The value of the Mitchell Scrubber will be better appreciated by noting the following results obtained by its use. In one year at a works carbonizing 20,000 tons of coal per year, 26 cents per ton, or \$5200, was realized for the ammoniacal liquor which had been allowed to waste

before the introduction of the Mitchell Scrubber. At a small works, favorably located, carbonizing 2454 tons of coal, 34 cents per ton, or \$834.36, was realized in producing sulphate of ammonia.

Many companies sell their ammoniacal liquor to ammonia manufacturers, who pay on the basis of so much per ton of coal carbonized, or a price per 100 liquor ounces; although, as suggested above, many now manufacture sulphate of ammonia, the process being a simple and generally profitable one, requiring a comparatively slight expenditure for apparatus, and but ordinary labor.

For every ton of coal carbonized about 40 gallons of 6-ounce liquor should be obtained.  $40 \times 6 = 240$  liquor ounces, meaning that it will take 240 ounces of sulphuric acid, specific gravity 1.845, to neutralize the ammonia contained in the 40 gallons of 6-ounce liquor. Thus 10-ounce liquor is ammoniacal liquor of such a strength that 10 ounces of sulphuric acid of a specific gravity of 1.845 are required to neutralize the ammonia contained in a gallon of it.

In general it may be said that it will pay in a works carbonizing 2000 tons, or even less, of coal per annum, to put in a plant for the manufacture of sulphate of ammonia, for which there is always a market. About 22½ pounds of sulphate per ton of coal may usually be obtained, the value of which varies somewhat with the locality.

Larger works should concentrate the liquor, or, better, work it into aqua ammonia direct, for which there is a large and increasing demand from cold-storage, ice-making plants, etc. Aqua Ammonia is usually packed and stored, preparatory for shipment, in iron drums holding about 750 pounds each. It is called stronger—water ammonia (26 degrees) and contains 28.6 per cent. of NH<sub>3</sub>—and is chemically pure.

The necessity of having efficient scrubbing apparatus, aside from the value of the residuals that may be obtained, cannot be too strongly urged. As before stated, the Mitchell Scrubber may be depended upon to remove all of the ammonia and one-third of the carbonic acid and sulphuretted hydrogen from the gas, insuring increased candle power and a longer life to meters and fixtures.

Manipulation of the Mitchell Scrubber.—Fill the machine with water to the proper levels; then start up the machine and pass gas through it, allowing it to run until the strength of the liquor at the inlet is about 4° by the Twaddel's Hydrometer; then allow cool fresh water to enter at the gas outlet, regulating the supply at the rate of one gallon for every 1000 cubic feet of gas made. The best results are obtained when the temperature of the gas entering the machine is as near 60° as possible. The tar should be drained off from the machine so that the wheels revolve only in water. Tar has no affinity for ammonia.

Water at a mean temperature and pressure (60° F., barometer 30") absorbs 783 times its volume of ammoniacal gas; that is, undiluted ammoniacal gas. When the latter is mixed with other gases, as in the case with coal gas, the power to arrest it is not nearly so great. The power of absorption decreases with increase of temperature, and is lost at 183° F.

Tar Well.—The tar well or storage tank may be built of brick, if care be used in its construction, but a tank of wrought or cast iron is for many reasons to be preferred; while either should be so covered in and protected as to avoid possible loss of ammonia by evaporation, and the entrance of drainage. This storage well should have a capacity to take care of



from 6 to 8 months' maximum make of tar, and should be supplemented and sealed by a smaller tank or enlarged drip-pot into which various tar-pipes should dip; while a suitable connection leads to the storage vessel. As tar at about 90° F. will give off hydrocarbon vapor, it is essential that it should pass into the storage tank at a lower temperature, to avoid the danger incident to a possible gas explosion.

Purification.—Coal gas as it passes from the retorts contains certain impurities; notably carbonic acid, sulphuretted hydrogen, bi-sulphide of carbon and other sulphur compounds, in addition to which tar vapor and ammonia gas are present in no small degree; but these latter are wholly removed if the scrubbing apparatus be well designed, and, in fact, are partially condensed in the hydraulic main and connections before reaching the condenser. As it leaves the scrubber, however, the greater part of the first named impurities are still found in the gas, the treatment thus far having only slightly affected them, necessitating the further purification obtained by passing the gas through purifiers.

TABLE No. 58.

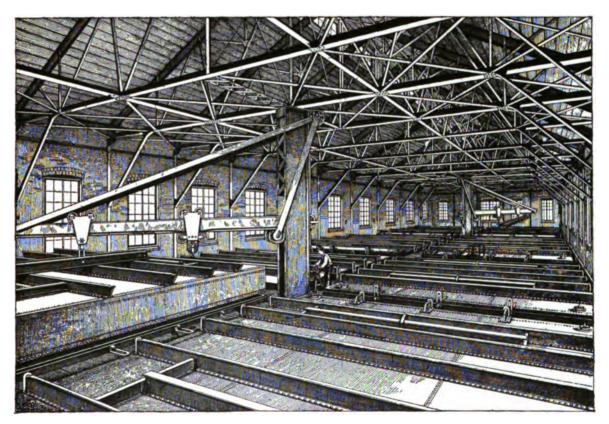
CAPACITIES AND DIMENSIONS OF MITCHELL SCRUBBERS.

| :                     |     | SCRUBBIN | ig wh               | EELS                            |     |                  | BODY     |                    |  |  |  |
|-----------------------|-----|----------|---------------------|---------------------------------|-----|------------------|----------|--------------------|--|--|--|
| Capacity per 24 Hours | No. | Diameter | Rev.<br>per<br>Min. | Capacity each,<br>in Cubic Feet | нР. | Connec-<br>tions | Diameter | Length<br>Over All |  |  |  |
| 75,000                | 4   | 3' 6"    | 6                   | 20,000                          | 3   | 8//              | 4' 3½"   | 6' 0''             |  |  |  |
| 100,000               | 4   | 4 0      | 6                   | 25,000                          | 3   | 8                | 5 0 .    | 6 91/2             |  |  |  |
| 150,000               | 6   | 40       | 6                   | 25,000                          | 3   | 8                | 5 0      | 9 11               |  |  |  |
| 200,000               | 8   | 4 0      | 6                   | 25,000                          | 3   | 10               | 5 0      | 13 01/2            |  |  |  |
| 250,000               | 10  | 4 0      | 6                   | 25,000                          | 3   | 10               | 5 0      | 16 2               |  |  |  |
| 300,000               | 4   | 6 o      | 4                   | 75,000                          | 4   | 10               | 7 3      | 7 0                |  |  |  |
| 450,000               | 6   | 6 0      | 4                   | 75,000                          | 1 4 | . 12             | 7 3      | 10 21/2            |  |  |  |
| 600,000               | 8   | 6 o      | 4                   | 75,000                          | 4   | 16               | 7 3      | 13 4%              |  |  |  |
| 750,000               | 10  | 6 o      | 4                   | 75,000                          | 4   | 16               | 7 3      | 16 7               |  |  |  |
| 1,000,000             | 6   | 8 o      | 4                   | 150,000                         | 4   | 20               | 96       | 10 21/2            |  |  |  |
| 1,250,000             | 8   | 8 o      | 4                   | 150,000                         | 4   | 20               | 96       | 13 434             |  |  |  |
| 1,500,000             | 10  | 8 o      | <b>'</b> 4          | 150,000                         | . 4 | 20               | 96       | 16 7               |  |  |  |
| 1,750,000             | 12  | 8 o      | , 4                 | 150,000                         | 4   | 20               | 96       | 19 914             |  |  |  |
| 1,200,000             | 4   | 10 6     | , 3                 | 300,000                         | 7   | 24               | 12 8     | 7 8                |  |  |  |
| 1,800,000             | , 6 | 10 6     | ! 3                 | 300,000                         | . 7 | 24               | 12 8     | 11 0               |  |  |  |
| 2,400,000             | 8   | 10 6     | 3                   | 300,000                         | 7   | . 24             | 12 8     | 14 4               |  |  |  |
| 3.000,000             | 10  | 10 6     | 3                   | 300,000                         | 7   | 30               | 12 8     | 14 4<br>17 8       |  |  |  |
| 3,600,000             | 12  | 10 6     | 3                   | 300,000                         | 7   | 30               | 12 8     | 2I O               |  |  |  |

It is customary to locate the purifiers in a separate building or Purifier House, which should be of ample dimensions, properly ventilated, and provided with wall lanterns. Provision should also be made for the economical handling of purifying material, and if this be the oxide of iron, it is generally found convenient to revivify it in the space beneath the boxes, which, in any event, should be of sufficient height to admit of ready access to the connections, center seal or valves. The boxes are rectangular in shape, made of cast iron, with sheet iron covers, held in place by suitable fastenings. They should be of such dimensions as to insure ample superficial area to take care of an increased production, care being taken to provide a sufficient depth of seal. It is very important to have boxes of ample capacity; and, in figuring on the size of boxes required, it is always best to take somewhat over the maximum daily make of gas as a basis.

The purifiers are generally grouped in sets of four (arranged in a square or in a line,

depending upon the space available), so connected that three boxes may always remain in service, while the material in the fourth is being renewed. In some cases it has been found useful to add a second set of two boxes, depending on the oxide of iron in the first set to first remove the sulphuretted hydrogen, and on a charge of lime in the second set to then remove the carbonic acid gas. The ordinary dry center seal is generally preferred to the hydraulic center valve, owing to the ease and rapidity with which the changes may be made; and, for ready access, it is usually placed at such a level that the lid or hood may be lifted off on to the floor between the boxes. Instead of the center seal some engineers prefer to use four-way valves, or connections controlled by a set of single valves, having in view the simplifying of the connections and convenience of



control. The Mitchell Center Seal (see page 126) possesses features worthy of consideration, and seems to fulfill every requirement.

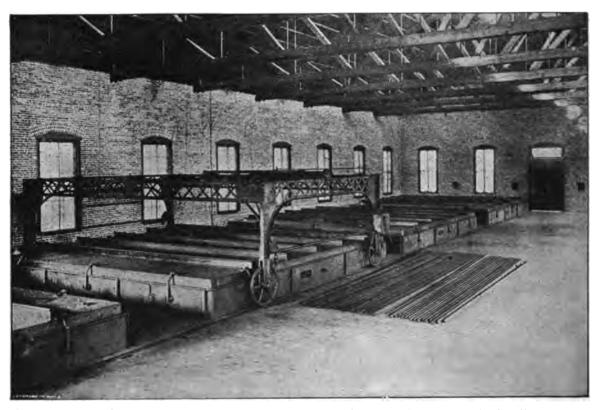
The box covers are usually readily handled by a hydraulic cover carriage, which is so arranged as to evenly lift the cover from at least four points at once, thus avoiding such undue strains as would be liable to cause trouble.

Purifiers.—The above cut and one on next page illustrate two methods of handling purifier covers; that above shows in part a set of eight (8) purifiers, each  $24' \times 30' \times 5'$  6" deep, having 24" connections, as completed by us. A novel feature is the method of handling the covers by our patent hydraulic lifting jib crane, instead of using hydraulic cover carriages, which we are

prepared to supply when preferred. Our facilities for the building of purifiers of any capacity and to meet any requirements are unequaled. Inquiries should state the dimensions of the boxes required, whether arranged in a line or in a square, the approximate inside dimensions of the building in which they are to be erected and the height from the ground line to the floor of the purifier room; also whether the tender shall include the columns and beams for supporting the boxes, and any other particulars that may affect the cost.

The cut below is from a photograph of a set of four purifiers  $(24' \times 24' \times 3'6'')$  as built by us, arranged in a line, with hydraulic cover carriage.

We are prepared to supply purifiers of any size, complete in all respects and erected ready



for service, with the Mitchell or our regular center seal, or a valve system, hydraulic or other cover-handling devices, conveying apparatus, etc.

Wall Lanterns.—Made regularly in three sizes for 16", 20" and 24" walls, with uniform bodies and varying only in lengths of hoods. Front light  $8'' \times 9\frac{\pi}{8}$ "; doors  $9'' \times 13\frac{1}{2}$ "; door sight  $2'' \times 5$ ". Prices on application.

Size of Purifiers.—In determining the size of purifiers required, take at least the maximum daily make of gas as a basis.

Four purifiers, three always in action, the maximum daily (24 hours) make of gas, divided by 1000 and multiplied by the constant .6, will give the superficial area in feet of each purifier. In small works, where there is no exhauster, the constant .7 (to .8) is preferable.

Materials Used for Purification.—As to materials used for purification, hydrate of lime, properly prepared, gives better results than quick-lime, and is more generally used; though its use is limited in some sections, owing to the obnoxious odors arising from the spent material. This nuisance may be avoided by the recalcination of the spent lime, a patented process requiring special kilns. It has the advantage over oxide of iron of taking out H<sub>2</sub>S, CO<sub>2</sub> and the sulphur compounds, while the oxide of iron takes out the sulphuretted hydrogen only.

Oxide of iron seems to be preferred in this country; but, while it has a strong affinity for sulphuretted hydrogen, it will not take up the carbonic acid and bi-sulphide of carbon, although the latter is to some extent absorbed by the freed sulphur present in the oxide of iron after the latter has been in use for a while. As generally used, oxide of iron contains 30 to 40 per cent. of water, and the fact that it may be repeatedly revivified and used over and over again is a decided advantage.

When the hydrated peroxide of iron becomes fully charged with sulphuretted hydrogen it becomes sulphide of iron, which on exposure to air absorbs oxygen and changes from a black to its original reddish brown color, or, if much charged with sulphur, to a dirty green, the sulphur being freed and deposited in the material. This has a market value, and should generally be replaced by fresh oxide when, owing to repeated exposures, the sulphur deposit increases to about 50 per cent. by weight.

When it becomes necessary to revivify fresh oxide, care should be taken not to expose it to air until it is possible to promptly empty the purifier, as until used two or three times it so rapidly absorbs oxygen as to often become intensely heated, with possible damage to the box and screens; and in practice it is thought best to allow the foul material to remain as dumped from the box over night before spreading. Small amounts of ammonia or cyanogen in oxide boxes are detrimental, retarding action and interfering with revivification.

As may be supposed, there have been many methods, of more or less merit, devised for, or to assist in, gas purification, but none of them have, so far, come into general use.

Oxide of Iron.—The composition of a good quality of Oxide of Iron, dried at 212° F. (King):

```
      Ferric Oxide.
      .60 to 70 per cent.

      Organic Matter.
      .15 " 25 "

      Silica
      .4 " 6 "

      Alumina
      .1 "
```

Quick-Lime.—When ordinary limestone (carbonate of lime) is burned in a kiln the heat expels the carbonic acid, producing quick or caustic lime (oxide of calcium), which nearly doubles in bulk when slaked.

Hydrate of Lime is wet lime, in the proportion of one part water to three of lime, and weighs, when prepared by screening for use in purifiers, about 92 pounds per bushel.

About I bushel of quick-lime, worked into properly prepared hydrate of lime, is required to purify the gas produced from I ton of ordinary gas coal.

Weight and Measurement of Lime.



Impurities.—Coal Gas in a crude state contains as impurities principally:

Tar Vapor.
Ammoniacal Gas, I per cent. by volume.
Carbonic Acid, 2½ to 3 per cent. by volume.
Sulphuretted Hydrogen, I to 2 per cent. by volume.
Bi-Sulphide of Carbon.

Tests for Impurities in Gas.—Ammonia.—Litmus paper, reddened by acid and held over a jet of unlighted gas; if the blue color of the litmus returns the gas contains ammonia.

If yellow tumeric paper be slightly moistened with water and held over a jet of unlighted gas and turned to a brown color, ammonia is in the gas.

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

Or pass through a solution of pure barytes; if the gas contains carbonic acid, carbonate of barytes will be precipitated; or pass the gas through clear lime water, and carbonate of lime will be precipitated.

Sulphuretted Hydrogen.—Saturate a piece of writing paper in a solution in distilled water and acetate of lead or nitrate of silver, 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.

Bi-Sulphide of Carbon.—The presence of this impurity can only be detected by means of special apparatus, of which there are several types.

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

### THE MITCHELL CENTER SEAL.

Patented 1889.



THIS Center Seal is the design of the well-known Gas Engineer, K. M. Mitchell, and is so arranged that four purifier boxes can be operated together, and three, two or one of the boxes may be used at a time; it being possible with this center seal to bring any purifier box, after the same has been emptied and recharged, back into the circuit without cutting out any of the other boxes. Hence by its adoption the capacity of purifier plants can be increased about one-third above what it is possible to obtain with the ordinary center seal, in which one box is always kept idle. The Mitchell Center Seal resembles in its essential features the ordinary type of center seal with this difference:—that on the top of its main cap is mounted a smaller auxiliary cap, by revolving which into different positions, the operator can readily place in circuit the number of boxes desired; while on the other hand he can control the order in the circuit by turning the main cap. In other words, a certain position of the auxiliary cap in relation to the main cap always corresponds to a certain number of boxes in use, entirely independent of the position of the main cap; while a fixed position of the main cap invariably indicates the first box in the series, thus making the operation of the Mitchell Center Seal fully as simple and readily understood as the old style center seal. In addition to this the Mitchell Center Seal possesses the valuable feature of admitting of a perfectly free flow of the gas in any position, as no passages are contracted to a smaller area than that of the pipes leading to and from the center seal. This seal has only to be seen by Gas Engineers to be thoroughly appreciated, and we venture the assertion that a center seal

system which allows of all or any number of the purifiers to be put into action will be generally preferred. The extra first cost is small as compared with the greatly increased capacity of the plant.

Center Seals.—We also supply a complete line of the ordinary type of *Center Seal*, arranged to operate three of a set of four purifiers together. The Mitchell Seal, however, is especially commended, as its use insures a marked increase in the working capacity of the boxes controlled. Both types made in all regular sizes. Prices upon application.

The Station Meter. —The make of gas is usually measured and recorded by passing it through a meter before it reaches the holder. This station meter is generally located in a separate room or house, often containing, in addition, the governor, pressure gauges, photometer etc.; and this room should be kept at an even temperature.

meter, etc.; and this room should be kept at an even temperature. The meter is always of the wet type, and usually consists of a cast iron cylindrical meter case, filled with water up to a

TABLE No. 59.
CAPACITY OF STATION METERS.

|                  | INTERNAL DIMENSIONS |   |        |    |    |     | CAPACITY IN CU. FT. |        |          |                 |
|------------------|---------------------|---|--------|----|----|-----|---------------------|--------|----------|-----------------|
|                  | IN                  |   | EKNAL  | וט | M  | ENS | 10                  | NS     | Per Hour | Per 24<br>Hours |
| 3                | feet                | : |        | by | 3  | fee | t                   |        | 1,250    | 30,000          |
| 3                | "                   | 6 | inches | "  | 3  | "   | ∙6                  | inches | 2,175    | 52,200          |
| 4                | "                   |   |        | "  | 4  | "   |                     |        | 3,400    | 81,600          |
| 4                | 66                  | 6 | "      | "  | 4  | **  | 6                   | "      | 5,000    | 120,000         |
| 5                | "                   |   |        | "  | 5  | "   |                     |        | 6,800    | 163,200         |
| 4<br>5<br>5<br>6 | "                   | 6 | 6.6    | "  | 5  | "   | 6                   | "      | 8,650    | 207,600         |
| ĕ                | "                   |   |        | "  | ĕ  | "   |                     |        | 10,800   | 259,200         |
| 6                | "                   | 6 | "      | "  | 6  | "   | 6                   |        | 13,000   | 312,000         |
| 7                | 6.6                 |   |        | "  | 7  | "   |                     |        | 16,700   | 400,800         |
| 7                | "                   | 6 | "      | "  | 7  |     | 6                   | "      | 19,300   | 463,200         |
| 7<br>8           | 46                  |   |        | "  | 8  | ••  |                     |        | 21,875   | 525,000         |
|                  | "                   |   |        | "  | q  | "   |                     |        | 28,650   | 687,600         |
| 9<br>10          | "                   |   |        | "  | ΙÓ | "   |                     |        | 36,450   | 875,000         |
| 11               | • •                 |   |        | "  |    |     |                     |        | 46,875   | 1,125,000       |
| 12               | "                   |   |        | "  | 12 | "   |                     |        | 62,5CO   | 1,600,000       |

certain line, and in which a tin measuring drum is revolved by the pressure of the gas upon the water. This drum is separated into several compartments of equal dimensions, so arranged that each passes gas to its full capacity as the drum revolves; and by suitable recording mechanism the quantity of gas is recorded. It is essential that the water-line in the meter be kept at the proper level, to insure accurate service; as variations above or below this line respectively diminish or increase the drum capacity. Of equal importance is a permanent and level foundation; and the meter connections should include a by-pass. No gas works can afford to be without a station meter. as it reliably checks the details of manufacture and makes it possible to ascertain the actual percentage of gas that is lost in leakage.

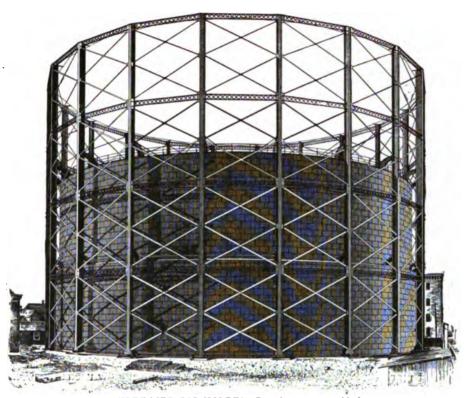
Station Meters are now made in sizes ranging from 3' to 18' diameter. The accompanying table gives the capacities of regular sizes up to 12' diameter, inclusive. The manufacture of meters is a specialty, handled by well-known makers, to many of whom we supply the meter cases. We will include any desired make of meter in contracts for extensions or new gas works.

To Find the Capacity of Meters.—Multiply the number of light the meter is called by 10; this gives maximum capacity of meter in feet per hour. For instance, take a 100-light meter; multiply 100 by 10, will give 1000 feet per hour as its maximum capacity.

Registration and Temperature.—The temperature at which gas is registered materially affects the quantity of gas indicated by the Station Meter. The volume of a gas (law of Charles) varies in proportion to its absolute temperature (absolute zero being 459.2° F.); therefore the actual amount of expansion or contraction is constant for each degree variation, and is  $1000 \times \frac{1}{519.2} = 1.926$  cubic feet per 1000 cubic feet for gas at the standard temperature (60° F.), and with the barometer at 30", or say about 1 per cent. for every 5° at ordinary atmospheric temperatures; hence 10,000 cubic feet of gas registered at 60° would at 70° become 10,193 cubic feet.

Weight of Gas of Standard Volume (60° F., 30" Bar.).—Multiply the quantity in feet by the specific gravity and the product by .0764, the weight in pounds of one cubic foot of air at 60° F. The result will be the weight of the gas in pounds avoirdupois.

Specific Gravity of Gas.—Various methods are employed to determine the Specific Gravity of Gas (see Newbigging's Hand Book for Gas Engineers). All depend on dividing the weight of a given volume of gas by weight of same volume of air, thus:—call the weight of a closed vessel, when filled with air, A; when filled with gas, G; and when exhausted, E; then  $(G-E) \div (A-E)$  gives Specific Gravity of Gas, or its weight as compared with the weight of an equal volume of air. Corrections for temperature, pressure and moisture must be made to bring result to standard conditions as explained in book referred to above.



A THREE-LIFT GAS HOLDER-Capacity, 3,100,000 cubic feet.

# GAS HOLDERS.

BY means of the holder, gas made during the day is stored for use, insuring distribution under uniform pressure. All works should have a holder capacity equal to at least the maximum make per twenty-four hours, while additional storage capacity insures convenience and economy of working. The holder may be single lift or telescopic—that is of two, three or more lifts, there being numerous examples of two and three-lift holders, while four-lift constructions have only recently been resorted to. The storage capacity required, allowing for increase in consumption, present or prospective value of real estate, and space available, are factors that should be carefully considered in determining the size of a holder. There seems to be practically no limit to size; a holder with four lifts, of 8,000,000 cubic feet capacity, having been erected several years since at London; and more recently at East Greenwich for one of the London Companies, a holder of 12,000,000 cubic feet capacity has been completed. This latter holder is also remarkable in having six lifts, each 30' deep by about 300' diameter, two of which pass above the frame. The cut on page 68 is from a photograph of a four-lift holder of something over 5,000,000 cubic feet capacity, with a steel tank about 190' diameter by 50' deep, built by us, which is especially notable in being up to this time (1890) the largest holder in the United

States, and having the largest steel tank in the world. It is also the first holder of importance in the United States to have the inner or first section arranged to pass out above the guide frame, which is carried up for three sections only. More recently (1895-96) we erected a four-lift holder of something over four and one-quarter millions cubic feet capacity with a steel tank 195' diameter by 40' deep. In this holder the guide frame extends to the full height for the four lifts.

Holders.—Single-lift holders are now generally used for capacities under 100,000 cubic feet, and such holders having their diameters equal to two or two and one-half times their height, are of the best proportion, area of sheeting considered. In the early days of gas-holder construction there were some notable exceptions to this rule, some still in service having a diameter as much as seven times their height. Where a light pressure is desired without reducing the thickness of the sheeting, it may be obtained by increasing the diameter and reducing the depth of the holder, and vice versa; that is, the pressure does not necessarily indicate heavy sheeting, in that a holder of very thin metal may give a heavy pressure, if of small diameter and great depth. Double-lift telescopic holders are usually proportioned with a diameter equal to four to five times the depth of each section, and this proportion is generally followed for triple-lift holders, although, in the case of large holders, local conditions are likely to cause more or less variation.

Non-trussed crowns are now generally preferred; flat tops being used for holders of the smaller class, and spherical crowns for those of the larger diameters, supported when the holder is down by a frame work built in the tank, and having a rise equal to about one-twentieth the diameter. In American practice, with few exceptions, trussing has been done away with; and it may be said there have been many radical changes in holder design during the past two decades. Probably the most marked are found in the various types of framing now used; the old ornamental cast iron and cylindrical wrought iron types of columns, having become almost obsolete, are replaced by the more modern frames of wrought iron or steel solid web or latticed columns and girders, securely braced and tied.

Wind Pressures.—In designing a holder frame it is difficult to determine the strength required, as the data as to wind pressures on large surfaces is very incomplete; and it is hard to form any idea of what pressure a violent storm exerts upon a holder. An anemometer to give the correct reading of all velocities of wind has not been constructed, and at present observers correct the readings by tables derived from experiments.

From the instruments in use by the Weather Bureau of the U. S. Signal Service, Table No. 59A, by Prof. Marvin, in charge of the Instrument Room, Washington, D. C., is given. See report of Chief Signal Officer U. S. A. for 1890; also Prof. Marvin's article in *Engineering News*, December 13, 1890.

Other experimenters have arrived at formulæ with different co-efficients; but, in general, it may be stated that the most careful experiments tend to results in substantial agreement with the above, which has the authority of the usage of the U. S. Signal Service, with its wide field of observation, skilled observers and excellent instruments. Table No. 59B gives the maximum velocities and pressures of wind as observed at Philadelphia from 1873 to 1894.

At New York, in the same period the maximum is 14.4 pounds per square foot. At Cleveland, Ohio, in the same period, the pressure due to the maximum observed velocity is 10.36 pounds per square foot.

The tables of pressures usually found in handbooks, etc., are generally based upon earlier observations, and are not substantiated by the more recent observations with more reliable and complete apparatus. As has been frequently demonstrated, especially at the Forth Bridge observations, extending over a period of six years, the pressure of wind, per square foot, on large surfaces is not so great as on smaller ones. In these observations the maximum pressure on the large plate was 27 pounds per square foot, and on the two small plates, 35 and 41 pounds per square foot respectively. See London Engineering, February 28, 1890. As holders expose large areas, the above observed reduction in force of pressure would indicate that with these structures the calculated pressure would exceed the actual by at least 25 per cent.

#### TABLE No. 59A.

TABLE FOR OBTAINING CORRECT WIND VELOCITIES AND PRESSURES.

Wind velocities, as indicated by the Robinson anemometer. corrected to true velocities. (Miles per hour.)

| Indicated<br>Velocity | <b>→ o</b> | + 1  | + 2   | + 3  | + 4          | + 5          | + 6  | + 7  | 8    | + 9  |
|-----------------------|------------|------|-------|------|--------------|--------------|------|------|------|------|
| o                     |            |      |       |      |              | 5.1          | 6.0  | 6.9  | 7.8  | 8.7  |
| 10                    | 9.6        | 10.4 | 11.3  | 12.1 | 12.9         | 13.8         | 14.6 | 15.4 | 16.2 | 17.0 |
| 20                    | 17.8       | 18.6 | 19.4  | 20.2 | 21.0         | 21.8         | 22.6 | 23.4 | 24.2 | 24.9 |
| 30                    | 25.7       | 26.5 | 27.3  | 28.0 | 28,8         | 29.6         | 30.3 | 31.1 | 31.8 | 32.6 |
| 40                    | 33.3       | 34.I | 34.8  | 35.6 | <b>3</b> 6.3 | 37.1         | 37.8 | 38.5 | 39.3 | 40.0 |
| 50                    | 40.8       | 41.5 | 42.2  | 43.0 | 43.7         | 44-4         | 45.I | 45-9 | 46.6 | 47-3 |
| 60                    | 48.0       | 48.7 | 49.4  | 50.2 | 50.9         | 51.6         | 52.3 | 53.0 | 53.8 | 54-5 |
| 70                    | 55.2       | 55-9 | 56.6  | 57.3 | 58.0         | 58.7<br>65.8 | 59-4 | 60.1 | 60.8 | 61.5 |
| 80                    | 62.2       | 62.9 | 63.6  | 64.3 | 65.0         | 65.8         | 66.4 | 67.I | 67.8 | 68.5 |
| 90                    | 69.2       |      | ••••• |      |              |              |      |      |      |      |

Note.—Corrections need not be applied for velocities of below 11 miles per hour, where fractions of miles are not desired.

Experiments have also been made by this Bureau to determine the relation between wind velocities and pressure on plates, or plane surfaces, exposed normally, i. e., placed at right angles to the direction of the wind. From these experiments, taking into account the corrected velocities as given by the above table, it is found that wird pressures are not so great as generally computed heretofore, and are quite accurately given by the following equation:

P=.0040 SV<sup>3</sup>.
P=pressure, in pounds avoirdupois.
S=surface, in square feet.
V=corrected velocity of wind, in miles per hour.

There are no reliable observations of wind pressures greater than 32 pounds over very large surfaces, say over 300 square feet of area. When greater pressures have been reported, they have been without statements of such damage to neighboring structures, as has occurred in many storms during which it is known no such pressures obtained. The latest and most complete compilation of observations and experiments bearing upon this subject is found in Capt. Bixby's report to the War Department, September 30, 1894, reprinted in Engineering News, New York, March 14, 1895.

TABLE No. 50B. HIGHEST WIND VELOCITIES AS GIVEN BY THE U. S. WEATHER BUREAU FROM 1872 TO 1894 AT P. O. BUILDING, PHILADELPHIA.

| Highest<br>Velocity in the<br>Month of | Occurred in the<br>Years of       | Velocity Recorded by<br>Anemometer | Corrected Velocity as per Table | Corresponding Press<br>per Square Foot |
|--|-----------------------------------|------------------------------------|---------------------------------|--|
| January<br>February                    | 1878 and 1885<br>1876, 1880, 1886 | 52 miles per hour<br>48 ""         | 42.2 miles per hour<br>39.3     | 7.13 lbs. per sq. ft<br>6.18 " "       |
| March                                  | 1888                              | 60 "                               | 48 " "                          | 9.22 '' ''                             |
| April                                  | 1879                              | 50 " "                             | 40.8 "                          | 6.67 " "                               |
| May                                    | 1889                              | 50 " "<br>60 " "                   | 48 " "                          | 9.22 '' ''                             |
| June                                   | 1889                              | 46 " "                             | 37.8 " "                        | 5.72 " "                               |
| July                                   | 1876                              | 40 " "                             | 33.3 " "                        | 4.44 '' ''                             |
| August                                 | 1893                              | 55 " "                             | 44.4 " "                        | 7.89 "                                 |
| September                              | 1889                              | 55 " "                             |                                 | 7.64 "                                 |
| October                                | 1876                              | 34 (( ((                           | 43.7 " " " " "                  |  |
| November                               |                                   | 54 " "<br>75 " "                   |                                 | 13.74 " "                              |
| December                               | 1873<br>1876                      | 63 " "                             | 52.3 " "                        | 10.94 " "                              |

Cylindrical surfaces are considered as exposing the diametrical plane (measured by the diameter multiplied by the length of axis), to a pressure of from .5 to .6 of that due to the velocity of the wind. Gas holders designed with the usual factor of safety to resist a wind pressure of 16 pounds on a plane surface of the area of the diametrical projection, withstand and work properly during the most severe storms. See table No. 61.

The proper number of columns for a holder of given diameter is still somewhat a matter of opinion, English practice seeming to favor a greater number of columns, especially for large diameters; but one column for every ten feet of diameter may be said to be in line with good practice, increasing this ratio somewhat in holders above about 150 feet diameter. During recent years, on holders of the smaller diameters particularly, owing to the low cost of rolled beams, frames having I beam standards, using a greater number than above suggested, with suitable



DOUBLE-LIFT HOLDER-180,000 cubic feet capacity, in steel tank.

lateral and diagonal bracing, have found favor. The increased number of standards or columns form just so many more points of support, while the general character of the design affords a very stiff frame for a minimum weight of metal. An example of this construction, as built by us, is illustrated on this page. Now that an exhauster and governor are used in almost all works, it is seldom that counter-balancing has to be reresorted to; and when it is, it is usually due to conditions growing out of location, or to equalize the pressure between holders.

The practice of covering holders in brick or iron tower-

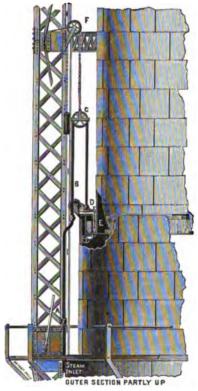
like housings seems to be losing its hold, and while it has some advantages, especially for holders located in sections liable to extreme cold, the expense is considerable; holders as now constructed and protected readily go through the most severe winters.

The Cutler Anti-freezing Device for Gas Holder Cups.—In consequence of the serious inconvenience and danger incident to the freezing of water in gas holder cups, the apparatus shown in the accompanying cuts, and for which we are the sole licensees for the United States, was devised for warming and circulating the water by the admission of steam or hot water at convenient intervals around the circumference of the holder. By reference to the cuts, it will be seen that A is an iron steam pipe with controlling cock; B is a flexible steam pipe; C is a sheave carrying the flexible pipe; D is a steam pipe extending all around the grip and secured thereto; E is a branch steam pipe at intervals extending into the cup and controlled by special valves or pipe D; and E is a sheave carrying counter-balance. The flexible

steam supply pipe B adjusts itself to the varying position of grip automatically by revolving the sheave C. The counter-balance keeps the flexible pipe B taut in all positions.

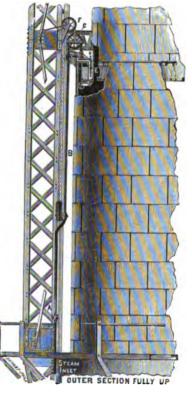
In addition to its use in preventing the formation of ice, the Cutler device can be used for refilling the cup when the water is lowered through leakage or high winds, thus affording a ready means of rapidly restoring the requisite seal and obviating loss and possible danger from the leakage of gas. The arrangement is extremely simple, self-acting, readily applied, and, in practice, answers its purpose in every way.

Tanks.—Holders, in this country, are generally built with steel tanks on concrete foundations, or in tanks of brick or stone masonry wholly or partially below the ground level; and although similar tanks are used abroad, other constructions, such as those wholly or partially of concrete or of cast iron, are not infrequently used; and, in some instances, in locations where real



estate is costly, cast iron tanks with domed bottoms are used, the space beneath the dome being utilized as a worshop or storehouse. Annular tanks made by excavating and lining with cast iron or masonry a circular cutting or trench, with the central space lowered sufficiently to allow a few inches of water over it—have been used to a limited extent.

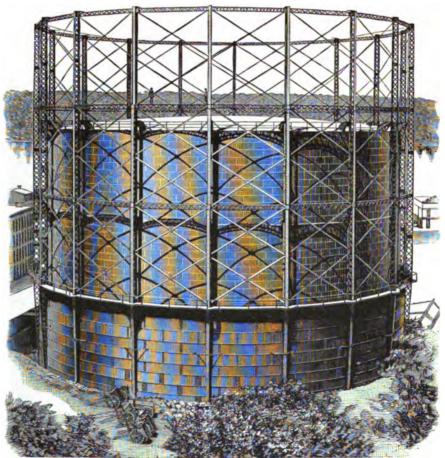
Metal Tanks.—Holders are now almost universally built with steel tanks in this country. The metal tank is usually placed upon a concrete foundation laid upon the leveled surface of solid ground, and has the great advantage of being readily kept tight in locations where masonry tanks would be a constant source of trouble and loss. Then, too, they offer a means of complet-



ing a holder and tank more promptly than would be possible if the masonry tank be adopted—an important consideration at times. In some instances old holders with troublesome or leaky masonry tanks have been replaced by holders in metal tanks built upon the same location after filling up the masonry tanks. A leaky tank is expensive; a leakage of ten gallons of water per minute from a tank, for instance, will amount in one year to \$1051.20—figuring at two cents per 100 gallons.

The experience acquired by us in the design and construction of many large metal tanks, including the largest now in existence, coupled with a most careful study of the subject, enables

us to undertake such work with confidence. Our practice is to use mild steel, rolled under carefully prepared specifications, requiring in part that the steel shall have an ultimate tensile strength within 55,000 to 65,000 pounds; an elongation of 20 to 25 per cent. in eight inches, with an elastic limit of not less than 50 per cent. of its ultimate tensile strength. While steel of a higher tensile strength may be obtained at a lower first cost, the softer steel is to be preferred, as less liable to injury in shop manipulations, and more reliable when placed in the structure. Possible injury incident to the working of hard steel is very difficult to detect, notwithstanding the closest inspection, hence its unreliability. Mild steel, of the quality described,



THREE-LIFT HOLDER WITH STEEL TANK-2,000,000 cubic feet capacity.

may be punched and bent with safety up to a thickness of  $\frac{3}{4}$  of an inch, though, to further reduce the risk of possible injury in working, we drill plates of  $\frac{5}{8}$  of an inch and over. It is in accord with the best practice to submit such plates to a limit stress of 16,000 pounds per square inch of net section. In the vertical joints we aim to secure the greatest possible percentage of the original strength of plate, using in heavy work special butt straps, and securing an efficiency of about 90 per cent.; more can be obtained but at greater total cost. To fill the hole perfectly is the all important point in upsetting rivets, and this can only be done with certainty by hydraulic machinery.

Rivets \(\frac{3}{4}\)" and over cannot be readily and economically driven by hand where first-class work is required, such as is necessary for absolute tightness.

Our equipment of hydraulic portable riveting machinery, which we have ourselves especially designed and built for this purpose (in connection with our Hydraulic Tool Department), including, as it does, the most powerful riveters in existence that we know of, warrants us in stating that we can readily work with steel rivets up to and including 12" diameter. This we have



HYDRAULIC RIVETER.

already done; work of larger dimensions has not been called for, but should the occasion arise we are prepared to decide its practicability.

Masonry Tanks.—Holders are now seldom built in masonry tanks, except when old holders are replaced: and in some cases, as already noted, old masonry tanks are refilled and replaced by steel tanks. In masonry tanks, in order to save excavation, it is usual to leave a central cone or mound.

Brick tanks should always be built in a most thorough manner, and the brick laid in cement mortar; a good proportion for which is one portion of Portland or Rosendale cement to two of sand. One barrel of cement in mortar of these proportions will lay from 600 to 750 bricks in a tank wall; and one man should lay on an average about 1000 bricks per day on a tank wall 24 inches thick. The building material of the locality where a tank is to be constructed will generally be found to be the cheapest and best that can be used. Where tanks are elevated in part above ground, the top of the bank, if of earth, should be about seven feet wide from the inside of the tank, and sloped on the side not less than one and one-half horizontal to one vertical. The proportion for a concrete

foundation and tank bottom may be one of cement to four of sand, gravel and broken stone; and one and three-quarters barrels of cement will make one cubic yard of concrete of these proportions; while the sand should be in such proportions as to fill up the interstices in the stone and gravel.

An interesting discussion on metal gas holder tanks as compared with masonry tanks will be found in the paper by Alten S. Miller, Engineer, presented at the May, 1895, Pittsburg meeting of the American Gas Light Association.

Inquiries.—Our facilities admit of building gas holders up to the largest sizes, to our own designs or otherwise. Inquiries should state general dimensions, or capacity and space available; the pressure with gas desired; whether to be built with a metal tank or to go in a masonry tank; size of inlet and outlet; and particulars as to location and accessibility to rail or water transportation.

Care of Holders.—The cups should at all times be kept free from obstructions, while special care should be taken in winter to prevent freezing. (See page 132.) To avoid serious strains to the holder, it is also important to keep the crown free from snow. Telescopic holders especially should be provided with ladders and suitable guard rails around the crown; and such holders, during high winds, are steadiest when all sections are cupped.

Holders and metal tanks should be painted at regular intervals, dependent upon atmospheric and other local conditions. Leaks may usually be stopped by coating with hot tar, over which dry sand or cement should then be sieved and worked in with a stiff brush.

Pressure of Holders.—The following formulæ will serve for approximate calculations of Gas Holder weights, pressures and diameters:

W =Weight of holder in pounds, including water in the cups, necessary to produce a pressure of P inches of water, the holder being full of gas.

P = Pressure in inches of water, holder filled with gas, gauge located at ground level.

D =Diameter of holder in feet.

H = Height of holder when fully inflated.

g =Specific gravity of the gas.

$$W = 4.09 D [P + .01472 H (1-g)]$$

$$P = \frac{W - .01472 H (1-g) (4.09 D^{2})}{4.09 D^{2}}$$

$$D = \sqrt{\frac{W}{4.09 [P + .01472 H (1-g)]}}$$

Inlet and Outlet Pipes should be of ample size. It is in line with good practice to have such pipes 25 per cent., and even 50 per cent., larger than the works and yard connections; and in holders of large capacity to use duplicate sets; or at least three pipes, by-passed. If pipes of just sufficient size for present use are adopted, in any prosperous plant there is almost sure to arise later on the necessity of replacing them; the great difficulty and expense of which may be avoided in using large connections in the first instance.

Works and yard connections should also be of ample size. Never less than 8", even in the smallest works.

#### INTERIOR OVERFLOW FOR GAS HOLDER CUPS.

Matton Patent, 1893.

HIS device consists of a U-shaped wrought iron pipe, having one vertical arm longer than the other, and of sufficient length to terminate at the point at which it is desired to have the water overflow. The lower or shorter arm is connected by means of a quarter bend to the shell, a horizontally placed nozzle with the inner end flared being passed through the shell and screwed into it. When the water runs into the upper or longer arm it will gradually fill up the shorter arm, until the water overflows through the nozzle into the interior of the tank. The water between water levels in the two arms is supported by the gas pressure, forming a seal; and it is therefore necessary that the distance from the bottom of the nozzle to the top of the longer arm shall be in excess of the gas pressure. When the water in the cup rises to a height which causes it to overflow into the longer pipe arm, it is evident that the additional water which enters the pipe will overcome the resistance of the gas, causing a corresponding overflow out of the shorter pipe-arm into the tank. The flared nozzle is of such a length that the water will drip down into the holder tank without touching the shell of the holder, a point of some importance, in that if the water were allowed to drip against the shell sheets it would follow the lower edge of the cup channel to the nearest bottom roller bracket, and from there be transmitted probably to the leg of the outer shell, possibly causing trouble through the formation of ice during the winter months. In the cup an angle iron guard is placed against the shell of the holder in close proximity to the overflow, in order to prevent the latter from fouling the grip sheet of the next section when the holder cups; the overflow is so arranged as to be readily detachable for cleaning purposes, which attention is rarely needed.

We recommend the use of not less than three of these patent overflows for each holder cup.



Their use will prevent the formation of ice outside of the holder shells, and during the winter months will take care of the increased volume of water due to condensation of the steam required to keep the cups free from ice.

Inquiries should state dimensions of cups and holder pressures. The overflow can be readily applied to holders in process of erection.

## MATTON SELF-SEALING RETORT MOUTHPIECE.

Patented 1803.



The following sizes regularly made: 14" x 24" and 15" x 26". Other sizes to order.

THIS Retort Mouthpiece possesses the novel and valuable feature of having the closing pressures applied at both ends as well as at the center of the lid. By reference to the cut it will be seen that the central pressure is obtained by actuating a screw in the cotter bar as usual, the outward thrust of the screw on the cotter bar being transmitted by a simple device to each end of the lid. It will also be noticed that the cotter bar is hinged to the outer ends of short levers which carry the lid on their inner ends, the levers being pivoted on pins held by the stationary lugs. The thrust of the cotter bar away from the lid, in being taken up by

the outer ends of the levers, will tend to force the inner ends of these levers carrying the lid against the face of the mouthpiece; and in substantially the same manner the reaction of the cotter bar at the outer end is likewise transmitted to the lid, also tending to press it against the face of the mouthpiece; thus the outward pressure or thrust of the screw, which would otherwise be expended without useful effect on its own supports, is utilized to apply additional closing pressure to the ends of the lids. This additional force does not in the least diminish the primary pressure obtained by the screw at the center, but is a distinct gain in the Matton Retort Mouthpiece over the ordinary lid. By varying the lengths of the outer and inner arms of the levers, the proportion of this gain can be made as desired. In the lid shown in our illustration, the additional pressure at each end will equal the primary pressure on the screw, making the total closing pres-

sure on the lid equivalent to three times the primary pressure. The free end of the cotter bar can be easily disengaged from the latch in opening the lid, by releasing the pressure of the central screw, which involves no more labor than in opening the ordinary self-sealing lids. Instead of the screw, an eccentric cam can be mounted on the cotter bar with the same effect; and the lids can be thus arranged when so desired. The Matton Retort Mouthpiece is regularly made in two sizes, of which prices will be furnished on application. Special sizes to order.



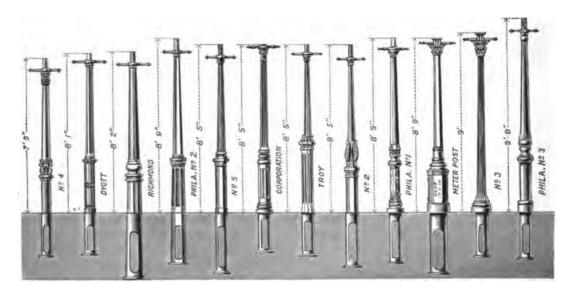
MITCHELL PATENT MOUTHPIECE.

Mitchell Patent Mouthpiece.—This retort mouthpiece is a well-known patented device which we are prepared to furnish in regular sizes,  $14'' \times 24''$  and  $15'' \times 26''$ , with oval cast iron or pressed steel lids.

Bench Work.—We are prepared to furnish promptly, to order, complete sets of Bench Work castings. Inquiries should state size of retorts, type of mouthpiece preferred, and give general dimensions of setting.

Cast Iron Retorts.—Prices on application.

#### LAMP POSTS.



THE cut shows twelve designs of Lamp Posts which we are prepared to furnish promptly; in addition to which our facilities are such that we can supply promptly posts to the special designs of purchasers. We aim to carry a stock of the following patterns for immediate shipment:

DYOTT, No. 5, and PHILADELPHIA, No. 1 and No. 5.

We also furnish *Meter Posts*, which are recommended as a means of satisfactorily determining the amount of gas consumed for street lighting; thus establishing an equitable basis for settlement. These posts have a door 17" by 10", fitted with a durable brass tumbler lock and key, and meters for them may be obtained from leading meter manufacturers.

TABLE No. 62.

| Code Word Termina-                                      | LAMP POST<br>F. O. B. Foundry | TS—Code Word: Post Discount on application                                   |   |   |  |  |  |  |
|---|-------------------------------|--|---|---|--|--|--|--|
| for Style   | Name                          | Average Height   | Нвіднт  | PRICE EACH  |  |  |  |  |
| ais andi ani asis abo avic aret aron amet asti eam eces | No. 2                         | 275 pounds 235 " 235 " 235 " 175 " 235 " 250 " 250 " 250 " 275 " 275 " 425 " | 8 feet 5 inches 9 " 0 " 7 " 9 " 8 " 5 " 8 " 1 inch 8 " 9 inches 8 " 5 " 9 " 8 " 8 " 9 " 8 " 5 " 8 " 5 " | \$11.00<br>10.00<br>10.00<br>10.00<br>8.00<br>10.00<br>10.50<br>10.50<br>11.00<br>11.00 |  |  |  |  |

#### MAINS.

CAST Iron Pipe are almost exclusively used for gas mains, and connections in and about gas works. These are similar to those used for water, though uncoated and usually lighter in weight. The tables on pages 40 to 59, inclusive, give dimensions of



pipe and specials, as used for gas and water, though the "gas weights" in table No. 13A, page 41, are somewhat lighter than now ordinarily used in the best practice, especially for small diameters. Flange pipe for gas should be about as heavy as medium weight water pipe, owing to the rigidity of joints and

uncertain character of supports; and as Standard Flange Pipe (see page 55) and specials of the usual water weights are generally in stock, they are often used for gas to advantage, delivery and even cost considered.

The Motion of Gas in Pipes may be calculated by the formulæ:

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.

Then 
$$Q = 1350 \ D^2 \sqrt{\frac{H \times D}{G \times L}}$$
 Coal gas, sp. gr., .42, 
$$Q = 2100 \ D^2 \sqrt{\frac{H \times D}{L}}$$
 Water gas, sp. gr., .60 to .70 
$$Q = 1675 \ D^2 \sqrt{\frac{H \times D}{L}}$$
 
$$D = .056 \quad \sqrt[8]{\frac{Q^2 \times G \times L}{H}}$$

The following tables give the discharge in cubic feet per hour through pipe 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. Water gas may be taken .65, and capacity of pipe 20 per cent. less than in the following tables.

The table is also susceptible of being extended to longer and shorter lengths, and to higher

pressures, by the application of the following laws:

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. 63.

Discharges of Gas, in Cubic Feet per Hour, through Pipe of Various Diameters and Lengths, and at Different Pressures of Water, in Inches.

| Specific Gravit | y .4. S | See above | notes. |
|-----------------|---------|-----------|--------|
|-----------------|---------|-----------|--------|

|                  |      | 1½ In. I     | DIAMETER    |                  |                | 2 In. D | IAMETER        |        |           | 3 IN. D        | AMETER |         |
|------------------|------|--------------|-------------|------------------|----------------|---------|----------------|--------|-----------|----------------|--------|---------|
| Lengths of Main, |      | Pres         | sures       |                  | Pressures      |         |                |        | Pressures |                |        |         |
| in Yards         | I.   | 1.5          | 2.          | 2.5              | I.             | 1.5     | 2.             | 2.5    | I.        | 1.5            | 2.     | 2.5     |
|                  |      | Discl        | narges      |                  |                | Discl   | narges         |        |           | Disch          | arges  | _       |
| 100              | 588  | 720          | 832         | 932              | 1208           | 1480    | 1708           | 1908   | 3100      | 4075           | 4700   | 5260    |
| 150              | 478  | 588          | <b>68</b> o | 759              | 986            | 1 208   | 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              | <b>381</b>     | 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     | 4 <b>0</b> 8   | 457    | 795       | 974            | 1130   | 1279    |
| 2000             | 132  | 161          | 186         | 208              | 270            | 331     | 381            | 427    | 744       | 912            | 1054   | 1176    |
|                  |      | 4 In. D      | IAMETER     | · <del>=</del> - | '- <del></del> | 6 In. D | IAMETER        |        |           | 8 In. Di       | AMETER |         |
| 100              | 6831 | 8370         | 9658        | 10 800           | 18 820         | 23 050  | 26 <b>6</b> 00 | 29 770 | 38 650    | 47 350         | 54 640 | 61 10   |
| 150              | 558o | 6830         | 7888        | 8817             | 15 370         | 18 820  | 21 700         | 24 300 | 31 550    | 38 640         | 44 600 | . 49 94 |
| 200              | 4829 | 5920         | 6826        | 7674             | 13 310         | 16 400  | 18 800         | 21 000 | 27 340    | 33 460         | 38 600 | 43 20   |
| 300              | 3944 | 4829         | 5577        | 6233             | 10 870         | 13 310  | 15 370         | 17 180 | 22 310    | 27 340         | 31 550 | 35 27   |
| 500              | 3055 | 3740         | 4320        | 4829             | 8418           | 10 310  | 11940          | 13310  | 17 280    | 21 170         | 24 400 | 27 34   |
| 750              | 2420 | <b>3</b> 055 | 3522        | 3944             | 6872           | 8418    | 9720           | 10870  | 14 100    | 17 280         | 19 800 | 22 31   |
| 1000             | 2160 | 2646         | 3052        | 3413             | 5950           | 7290    | 8420           | 9410   | 12 220    | 14 <b>96</b> 0 | 17 280 | 19 32   |
| 1250             | 1932 | <b>236</b> 6 | 2732        | 3052             | 4340           | 5320    | 7540           | 8415   | 10 940    | 13 650         | 15 520 | 17 28   |
| 1500             | 1761 | 2160         | 2490        | 2789             | 4860           | 5970    | 68 <b>6</b> 0  | 7672   | 9900      | I 2 200        | 14 040 | 1580    |
| 1750             | 1634 | 2000         | 2310        | 2582             | 4500           | 5500    | 6 <b>36</b> 0  | 7115   | 9237      | 11 300         | 13 040 | 14 60   |
| 2000             | 1530 | 1870         | 2150        | 2415             | 4209           | 5155    | 5970           | 6655   | 8640      | 10 585         | 12 200 | 1367    |

#### DISCHARGES OF GAS—(Continued).

TABLE No. 63—(Continued).

|                   |                  |             | 10 I | n. Di | AMB   | ER           |            | į           |             |              | 12       | In. D        | IAME  | TER         |                |     |              |             | 14   | In. D        | IAME  | TER         |       |            |
|-------------------|------------------|-------------|------|-------|-------|--------------|------------|-------------|-------------|--------------|----------|--------------|-------|-------------|----------------|-----|--------------|-------------|------|--------------|-------|-------------|-------|------------|
| Lengths of        |                  |             |      | Press | sures |              |            |             |             |              |          | Pres         | sures | 3           |                |     |              |             |      | Pre          | sure  | s           |       |            |
| Main,<br>in Yards | -                | 1.          | 1    | .5    | 2     | ·.           | 2          | .5          |             | 1.           | 1        | .5           | 1     | 2.          | 2              | .5  |              | ı.          | Π    | 1.5          | Ī     | 2.          | 1     | 2 5        |
| m raius           |                  | -           |      | Disch | arge  | 8            | <u>'</u>   |             |             |              | <u> </u> | Discl        | narge | \$          | <u></u> -      |     | -            |             | •    | Disc         | harge | :s          | •     |            |
| 500               | 30               | 100         | 37   | 100   | 42    | 600          | 47         | 700         | 47          | 600          | 58       | 320          | 67    | 200         | 75             | 240 | 70           | 000         | 85   | 700          | 98    | 800         | 110   | 660        |
| 750               | 24               | 650         | 30   | 190   | 34    | 800          | 39         | 000         | 38          | 8 <b>8</b> 0 | 47       | <b>60</b> 0  | 55    | 000         | 61             | 470 | 57           | 166         | 69   | 990          | 80    | 800         | 90    | 35         |
| 1000              | 21               | 640         | 26   | 150   | 30    | 100          | 33         | 750         | 33          | 66o          | 41       | <b>20</b> 0  | 47    | 600         | 53             | 240 | 49           | 507         | 60   | 620          | 70    | 000         | 78    | 360        |
| 1500              | 17               | 400         | 21   | 300   | 24    | 7 <b>6</b> 0 | 27         | 560         | 27          | 500          | 33       | 600          | 38    | <b>88</b> o | 43             | 515 | 40           | 400         | 49   | 400          | 57    | 000         | 63    | 940        |
| 2000              | 15               | 050         | 18   | 500   | 21    | 300          | 23         | 850         | 23          | 8 <b>0</b> 0 | 29       | 250          | 33    | <b>60</b> 0 | 37             | 620 | 35           | 000         | 42   | <b>60</b> 0  | 49    | 400         | 55    | 339        |
| 2500              | 13               | 175         | 16   | 136   | 18    | 632          | 20         | 88o         | 2[          | 190          | 26       | 100          | 30    | 116         | 33             | 631 | 31           | 300         | 38   | 350          | 44    | 280         | 49    | 500        |
| 3000              | 12               | 027         | 14   | 561 h | 17    | 800          | 19         | 016         | 19          | 440          | 23       | 800          | 27    | 500         | 30             | 740 | 28           | 580         | 34   | 990          | 40    | 400         | 45    | 170        |
| 4000              | 10               | 413         | 12   | 756   | 14    | 729          | 16         | <b>46</b> 8 | 16          | 8 <b>30</b>  | 20       | 600          | 23    | 800         | 26             | 620 | 24           | <b>75</b> 0 | 30   | 310          | 35    | 000         | 39    | 180        |
|                   | <del>'==</del> - |             | 16 I | n. Di | AME   | ΓER          | <u> </u>   |             | <del></del> | ===          | 20       | În. D        | IAME  | TER         |                |     | <del>'</del> |             | 24   | In, D        | IAME  | TER         |       | ==         |
| 500               | 98               | 000         | 120  | 200   | 138   | 240          | 154        | 560         | 170         | 600          | 204      | <b>60</b> 0  | 241   | 000         | 270            | 000 | 271          | 200         | 326  | 000          | 375   | 000         | 425   | 80         |
| 750               | 79               | 770         | 1    | 740   |       |              | ١          | 1           | ł           |              | i        | _            | 1     | _           | 1              |     | İ            |             | i    |              | 1     |             | 1     | . 00       |
| 1000              | -                | 120         | 1 .  | 670   | _     | 000          | 1          |             |             |              | 1        |              |       | _           | i              | 000 |              |             | 1    | _            | 1     |             |       | 16         |
| 1500              | 56               | 600         | 69   | 120   | 79    | 8 <b>0</b> 0 | 89         | 230         | 98          | 800          | 120      | 700          | 139   | 600         | 155            | 800 | 155          | 000         | 190  | 5 <b>0</b> 0 | 217   | 200         | 245   | 80         |
| 2000              | 49               | 000         | 60   | 100   | 69    | 120          | 77         | 280         | 1 -         |              | l        |              | 1     |             | 1              | 000 |              | _           |      | -            | 1 -   | _           | 1     | 90         |
| 2500              | 43               | 68o         | 53   | 540   | 61    | 824          | 69         | 120         | 76          | 500          | 93       | 5 <b>0</b> 0 | 108   | 000         | 120            | 744 | 119          | 000         | 145  | 500          | 168   | 000         | 194   | 40         |
| 3000              | 39               | 885         | 48   | 870   | 56    | 600          | 64         | 000         | 69          | 800          | 85       | 300          | 98    | 800         | 110            | 200 | 108          | 600         | 135  | 600          | 155   | 000         | 172   | 00         |
| 4000              | 34               | <b>56</b> 0 | 42   | 340   | 49    | 000          | 54         | 630         | 60          | 370          | 73       | 950          | 85    | 300         | 95             | 500 | 95           | 350         | 116  | 640          | 135   | <b>60</b> 0 | 150   | 58         |
|                   |                  |             |      |       | 30 IN | . Dia        | METE       | SR.         | ===         |              |          |              |       |             |                |     | 36 I         | n. Di       | AMB  | TER.         |       |             |       |            |
| Lengths of        |                  |             |      |       | F     | ressu        | ıres       |             |             |              |          | - -          |       |             |                |     |              | Press       | ures |              |       |             |       |            |
| Main,<br>in Yards |                  | I.          | T    | 1     | 5     | _ _          | 2          |             |             | 2            | . 5      |              | -     | 1.          | 1              |     | 1.5          |             |      | 2.           |       |             | 2.5   |            |
|                   |                  |             |      |       | D     | ischa        | rges       |             |             |              |          | 1            |       |             |                |     | 1            | Disch       | arge | 3            |       |             |       |            |
| 500               | 4                | 58 o        | 00   | 574   | 000   | <u>.</u>     | 664        | 000         |             | 744          | 200      |              | 744   | 1 000       | ,              | 91  | 2 00         | 0           | 1 2  | 12 0         | 00    | 1:          | 256   | <b>400</b> |
| 750               | 3                | 84 o        | œ    | 468   | 000   | o            | 558        | 900         | -           | 607          | 600      |              | 606   | 000         | <b>,</b>       | 74  | 4 00         | 0           | 8    | 356 o        | 00    | 1           | 032 ( | 000        |
| 1000              | 3.               | 32 0        | 00   | 406   | 000   | <b>o</b>     | <b>468</b> | 000         |             | 526          | 000      |              | 530   | 000         | <b>)</b>       | 64  | 4 00         | 0           | 7    | 44 0         | 00    | 1           | 832 ( | 000        |
| 15 <b>0</b> 0     | 2                | 72 0        | 70   | 332   | 760   | 0            | 384        | 140         |             | 457          | 600      | ļ            | 428   | 3 500       | •              | 52  | 4 88         | 0           | 6    | <b>606</b> 0 | 00    | (           | 577 ( | 630        |
| 2000              | 2                | 34 O        | oo ¦ | 287   | 000   | o            | 332        | 000         |             | 372          | 100      |              | 372   | 900         | )              | 45  | 6 <b>o</b> o | 0           |      | 24 8         | 80    | 1           | 528 : | 200        |
| 2500              | 2                | 10 0        | 00   | 257   | 000   | <b>o</b>     | 298        | 000         | ĺ           | 332          | 000      | 1            | 332   | 000         | <b>,</b> :     | 40  | 8 <b>o</b> o | • [         | 4    | 68 o         | 00    | :           | 530 ( | 000        |
| 3000              | , I              | 92 00       | 00 . | 234   | 000   | o            | 270        | 000         | j           | 303          | 800      | İ            | 303   | 3 000       | ,              | 37  | 2 00         | 0           | 4    | 28 o         | 00    | :           | 516 0 | 000        |
| 4000              | . 10             | 56 o        | oo ! | 203   | 000   | o i          | 234        | 000         |             | 263          | 000      | 1            | 26    | 5 000       | ) <sup> </sup> | 32: | 2 00         | o İ         | 3    | 72 0         | 00    | 1           | 416   | 000        |

Care and judgment are necessary in the use of such tables as the above in determining the sizes of mains requisite in gas-producer installations. Frequently such piping is erected without any provision in the way of dust catchers. As a result the distribution of the dust, etc., along the line materially reduces the free area of the pipe, requiring stoppage for removing and for which ample and readily accessible means should be provided.

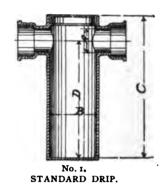


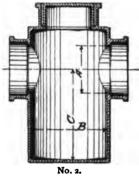
## STANDARD DRIPS OR SYPHONS

OF THE SOCIETY OF GAS LIGHTING.

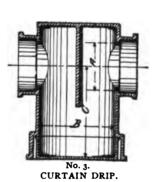
#### TABLE No. 60.

|                                      | Code Word: Axis |               |            |            |                     |                                |  |  |  |  |
|--------------------------------------|-----------------|---------------|------------|------------|---------------------|--------------------------------|--|--|--|--|
| Code Word<br>Termination<br>for Size | Drip<br>A       | Diameter<br>B | Depth<br>C | Depth<br>D | Gallons<br>Capacity | Approx.<br>Weight in<br>Pounds |  |  |  |  |
| andi                                 | 3′′             | 12"           | 30′′       | 241/2"     | 111/4               | 270                            |  |  |  |  |
| ani                                  | 4               | 12            | 30         | 24         | 10¾                 | 280                            |  |  |  |  |
| asti                                 | 6               | 12            | 30         | 23         | 9¾                  | 290                            |  |  |  |  |
| eces                                 | 8               | 12            | 30         | 22         | 8¾                  | 300                            |  |  |  |  |
| envi                                 | 10              | 12            | 36         | 27         | 10¾                 | 380                            |  |  |  |  |
| erai                                 | 12              | 12            | 36         | 25¾        | 9¾                  | 430                            |  |  |  |  |
| esto                                 | 16              | 16            | 42         | 291/2      | 18¾                 | 620                            |  |  |  |  |









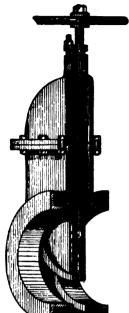


No. 4.
FLANGED TOP DRIP, WITH TAR PIPE.

#### TABLE No. 61.

| Code Word<br>Termination | Drip | Diameter | Depth  | Gallons  | APPROXIMATE WEIGHT |          |  |
|--------------------------|------|----------|--------|----------|--------------------|----------|--|
| for Size                 | A    | В        | C      | Capacity | Nos. 2 and 3       | No. 4    |  |
| ais                      | 2''  | 10"      | 201/2" | 65%      | 200 lbs            | 230 lbs. |  |
| andi                     | 3    | 10       | 20 1/2 | 61/2     | 220 ''             | 245 "    |  |
| ani                      | 4    | IO       | 20     | 61/8     | 235 ''             | 250 ''   |  |
| asti                     | 6    | 12       | 24     | 10       | 410 "              | 370 "    |  |
| eces                     | 8    | 12       | 24     | 9¾       | 450 "              | 390 "    |  |
| envi                     | 10   | 16       | 223/8  | 151/8    | 670 ''             | 610 "    |  |
| erai                     | 12   | 16       | 223/8  | 121/2    | 78o ''             | 640 ''   |  |
| esto                     | 16   | 20       | 28     | 27       | 1200 ''            | 1030"    |  |
| idum                     | 20   | 26       | 30     | 46       | 1700 ''            | 1500 "   |  |
| imes                     | 24   | 30       | 36     | 73       | 2800 ''            | 2130 "   |  |
| iram                     | 30   | 32       | 42     | 94       | 3600 ''            | 2850 "   |  |
| iria                     | 36   | 38       | 45     | 132      | 4060 "             | 3650 ''  |  |

Capacities in gallons figured from bottoms of connecting arms.



### GAS VALVES.

FLANGE, HUB OR SCREW ENDS.

THESE valves are intended for use in and about Gas Works, and will be found well adapted to such service. They are strongly built and not liable to get out of order. Usually in stock. Prices on application.

TABLE No. 66.

| CodeWord<br>Termina- | CAMDEN GAS VALVES—Code Word: { Gail, Flange Ends Gain, Bell Ends |                    |                         |                 |                  |                                     |                                   |                   |  |  |  |
|----------------------|--|--------------------|-------------------------|-----------------|------------------|-------------------------------------|-----------------------------------|-------------------|--|--|--|
| tion<br>for Size     | Size   | Diam. of<br>Flange | Diam. of<br>Bolt Circle | No. of<br>Bolts | Size of<br>Bolts | Dist.<br>face to face<br>of Flanges | Dist.<br>face to face<br>of Bells | Depth of<br>Bells |  |  |  |
| asti                 | 6′′  | 11"                | 91/8"                   | 4               | ₹′′              | 9"                                  | 111/2"                            | 4"                |  |  |  |
| eces                 | 8  | 13                 | 111/8                   | 8               | 5∕8              | 9                                   | 12                                | 4                 |  |  |  |
| envi                 | 10   | 16                 | 13¾                     | 8               | 5∕8              | 10                                  | 1234                              | 4                 |  |  |  |
| erai                 | 12   | 18                 | 15¾                     | 8               | 5/8              | 12                                  | 131/2                             | 4                 |  |  |  |
| esto                 | 16   | 221/2              | 20                      | 12              | *                | 14                                  | 1414                              | 4                 |  |  |  |
| idum                 | 20   | 27                 | 24 1/2                  | 16              | *                | 141/2                               | 15                                | 4                 |  |  |  |
| imes                 | 24   | 31                 | 281/2                   | 16              | 34               | 15                                  | 151/2                             | 4                 |  |  |  |

Inquiries should state whether with bell, flange or screw ends. Unless otherwise ordered, valves are sent arranged to open by turning to the left; hand wheels on flanged valves and top nuts on hub-end valves. Other sizes and styles to order.

TABLE No. 67.

Volume, Density and Pressure of Air at Various Temperatures.

|       | Volume at At        | mos. Pressure       | Density lbs. per                 | Pressure at C       | Constant Volume      |
|-------|---------------------|---------------------|----------------------------------|---------------------|----------------------|
| Pahr. | Cubic Feet in 1 lb. | Comparative<br>Vol. | Cubic Foot at<br>Atmos. Pressure | Lbs. per<br>Sq. In. | Comparative<br>Pres. |
| 0     | 11.583              | .881                | .086331                          | 12.96               | .881                 |
| 32    | 12.387              | -943                | .080728                          | 13.86               | .943                 |
| 40    | 12.586              | .958                | .079439                          | 14.08               | .958                 |
| 50    | 12.840              | -977                | .077884                          | 14 36               | -977                 |
| 62    | 13.141              | 1.000               | .076097                          | 14.70               | 1.000                |
| 70    | 13.342              | 1.015               | ·0 <b>74950</b>                  | 14.92               | 1.015                |
| 8o    | 13 593              | 1.034               | .073565                          | 15.21               | 1.034                |
| 90    | 13.845              | 1.054               | .072230                          | 15.49               | 1.054                |
| 100   | 14.096              | 1.073               | .070942                          | 15.7 <b>7</b>       | 1.073                |
| 110   | 14.344              | 1.092               | .069721'                         | 16.0 <b>5</b>       | 1.092                |
| 120   | 14.592              | 1.111               | .068500                          | 16.33               | 1.111                |
| 130   | 14.846              | 1.130               | .067361                          | <b>16</b> .61       | 1.130                |
| 140   | 15.100              | 1.149               | .066221                          | 16.89               | 1.149                |
| 150   | 15.351              | 1.168               | .065155                          | 17.19               | 1.168                |
| 160   | 15.603              | 1.187               | .064088                          | 17.50               | 1.187                |
| 170   | 15.854              | 1.206               | .063089                          | 17.76               | 1.206                |
| 180   | 16.106              | 1.226               | .062090                          | 18.02               | 1.226                |
| 200   | 16.606              | 1.264               | .050210                          | 18.58               | 1.264                |
| 210   | 16.860              | 1.283               | .059313                          | 18.86               | 1.283                |
| 212   | 16.910              | 1.287               | .059135                          | 18.92               | 1.287                |

#### TABLE No. 68.

Number of Volumes of Various Gases which one hundred Volumes of Water at 60° Fahr. and 30" Barometric pressure can absorb.—(Dr. Frankland.)

| Ammonia               | 78.000 | volumes. | Oxygen .         |   |      |      | 3.7 V | olumes. |
|-----------------------|--------|----------|------------------|---|------|------|-------|---------|
| Sulphurous acid .     | 3,300  | "        | Carbonic oxide   |   |      |      | 1.56  | "       |
| Sulphuretted hydrogen | 253    | "        | Nitrogen .       |   |      |      | 1.56  | "       |
| Carbonic acid         | 100    | "        | Hydrogen .       |   |      |      | 1.56  | **      |
| Olefiant gas*         | 12.5   | 66       | Light carburette | d | hydr | ogen | 1.60  | "       |

Air consists principally of a mixture of two gases, Oxygen and Nitrogen, in the proportion, by volume, of about one part Oxygen to four parts Nitrogen, and by weight one part of Oxygen to three and one-third parts of Nitrogen; there being also a small amount of Aqueous Vapor and Carbonic Acid Gas.

Water is composed of two gases, Hydrogen and Oxygen, in the proportion, by volume, of two parts Hydrogen to one part Oxygen, and by weight one part of Hydrogen to eight parts of Oxygen.

Oxygen is the active principle of air, and is the supporter of combustion. An atmosphere of pure Oxygen is too intense for animal life and requires dilution; it would cause a fire so hot that few materials could withstand the heat.

Nitrogen is a gas that will not support combustion, and by its presence in the air serves to dilute the Oxygen.

Hydrogen is the lightest gas known, and in burning produces per pound the greatest amount of heat.

Specific Heat of Gas.—The ratio of the quantity of heat which will raise I pound of gas I° Fahr. to that which will raise I pound of water I° Fahr. is called its specific heat; its average value for air or illuminating gases is, at constant pressure, .24.

Unit of Heat (British Thermal Unit) is that quantity of heat which will raise I pound of water 1° Fahr.; hence (as specific heat of air = .24) I unit of heat will raise  $1 \div .24 = 4.17$  pounds; or (I cubic foot of air weighing .076 pounds at  $60^{\circ}$  Fahr.) I heat unit will raise  $\frac{1}{6}+\frac{1}{6}=54.9$  cubic feet of air 1° Fahr. at  $60^{\circ}$  Fahr. If at other temperatures, see Density Table (No. 67, page 143).

Buoyancy of Gas at Holder Pressures.—When the pressure resulting from a column of gas lighter than air is considered—as in a gas holder for instance—then the higher the elevation at which the pressure is read the greater will be the pressure as recorded by a water gauge; this is also true when considering the differences of level in the district served; that is, the higher levels will have a greater gas pressure. Hence the advantage secured, other things being equal, in placing a holder on the lowest possible level (see page 145).

If a gas holder is filled with air and floating in a tank, the weight of water which it displaces is equal to the weight of the holder itself; in other words, the water level outside the holder stands above the water level inside the holder; and the volume of water represented by the area of the holder, multiplied by the difference in height of the two water levels, will weigh the same as the holder. If the holder is filled with gas, however, the displacement becomes less because of the buoyancy of the gas. The reverse would be true if gas were heavier than air.

If a pressure gauge is placed on the crown of the holder, the gauge will give the same read-

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<sup>\*</sup> Illuminating hydrocarbons, not determined, but probably more soluble than olefant gas.

When water has been saturated with one gas and exposed to the influence of a second, it usually allows a portion of the first to escape while it absorbs an equivalent quantity of the second. In this way a small portion of not easily soluble gas can expel a large volume of an easily soluble one.

ing, whether the holder is filled with air or gas; in other words, the upward pressure under the crown is equal to the weight of the holder itself, regardless of the contents of the holder. If the gauge is placed at the base of the holder, it will indicate a pressure which is as much less than that indicated at the crown, as the internal column of gas is lighter than an equal column of air outside the holder.

Hence it will be seen that the higher the holder when fully inflated the greater will be the difference between the weight of gas inside of it and the weight of an equivalent volume of air outside of it, and consequently a corresponding difference between pressure with gas and with air.

If a holder when filled with air is 100' high and registers say 6" pressure at ground level, then when filled with gas the reading of gauge will be reduced by the difference in weight of a column of air 100' high and a column of gas 100' high. The air column will weigh  $.0767 \times 100 = 7.67$  pounds per square foot. The column of gas (specific gravity .4) will weight  $.0767 \times .4 \times 100 =$ 

3.07 pounds; and the difference is therefore 4.6 pounds per square foot; reduced to inches of water this becomes  $4.6 \div 5.2$  = nearly  $\frac{9}{10}$  of an inch (5.2 pounds is the pressure of 1" of water per square foot). The gas pressure will therefore read  $6" - \frac{9}{10}" = 5\frac{1}{10}"$  instead of 6".

It is important to bear these facts in mind when reading holder specifications, also to note the effect they have on the difference between a holder in metal tank as compared with same in masonry tank. The height of the holder is increased in the former case by the height of the tank, and it is, consequently, essential to note where the gauge is to be placed when read; also whether the specified pressure is with air or gas. The reading should always be made at ground level.

Variation in Specific Gravity due to Pressure.

—The above figures and all computations based on specific gravity are affected appreciably by the pressure of the gas, thus:

TABLE No. 69.

Table Showing Gain of Gas
Pressure by Elevation.

| Specific<br>Gravity | *Gauge<br>Increase per<br>100' Elevation | Elevation at<br>which Gauge<br>shows I"<br>Increase |
|---------------------|--|---|
| 1 00(air)           | 0.000′′                                  |   |
| .70                 | .440                                     | 227'  |
| .65                 | .515                                     | 194   |
| . <b>6</b> 0        | .588                                     | 170   |
| .50                 | ·735                                     | 136   |
| .45                 | .806                                     | 124   |
| .40                 | .884                                     | 113   |

\*This column also shows the Loss of Pressure in Holders when filled with gas as compared with air, per 100' height of holder.

normal atmospheric pressure = 30" of mercury = about 400 inches water; hence, if gas is at a pressure of 10" above atmosphere its specific gravity will be increased  $\frac{10}{400} = \frac{1}{40}$  or  $2\frac{1}{2}$  per cent., and gas having specific gravity .4 at atmospheric pressure will have .41 at 10" pressure.

One Atmosphere = 14.7 pounds per square inch = 2116 pounds per square foot = 29.922 inches of mercury = 33.9 feet of water (406").

One Thousand Cubic Feet of Gas at specific gravity .4 weighs at 60° Fahr. and 30" pressure, 30.6 pounds; and at specific gravity .7 weighs 53.5 pounds. (Thus: .0764 × 1000 × specific gravity = pounds.)

One Inch of Water = about 69 feet of air = .036 pounds per square inch = 5.2 pounds per square foot.

One Gallon = 231 cubic inches. One Cubic Foot = 7\frac{1}{2} gallons, nearly.

Sheet Metals.—In addition to the table, No. 66, giving the Birmingham Gauge, we also give table No. 67, of the U. S. Standard Gauge, which is included in an Act establishing a standard gauge for sheet and plate iron and steel:—Public No. 137:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That for the purpose of securing uniformity the following is established as the

only standard gauge for sheet and plate iron and steel in the United States of America. On and after July 1, 1893, the same and no other shall be used in determining duties and taxes levied by the United States of America on sheet and plate iron and steel. But this act shall not be construed to increase duties upon any articles which may be imported. In the practical use and application of the standard gauge hereby established a variation of 2½ per cent. either way may be allowed.

Approved March 3, 1893. See Table No. 71.

TABLE No. 70.

WEIGHT OF SHEET METALS.

Weight of one square foot of Rolled, or Sheet Iron, Steel,
Copper, or Brass Plates.

TABLE No. 71.
U. S. STANDARD GAUGE
FOR SHEET AND PLATE IRON AND STEEL.

|                 |                | BIRMIN           | GHAM GA                        | UGE              | 1              |
|-----------------|----------------|------------------|--------------------------------|------------------|----------------|
|                 | FOR            | IRON, WIRE,      | SHEET IRON                     | AND STEE         |                |
| For ro          | lled lead      | multiply co      | opper by 1.3:<br>on by the dec | and for zine     | c, multiply    |
| No. of<br>Gauge | Thick-<br>ness | lron             | Steel                          | Copper           | Brass          |
|                 | In.            | Lbs.             | Lbs.                           | Lbs.             | Lbs.           |
| 000             | -425.          | 17.0531          | 17.2805                        | 19.2525          | 18.1900        |
| 00              | .380           | 15.2475          | 15.4508                        | 17.2140          | 16.2640        |
| 0               | -340           | 13.6425          | 13.8244                        | 15.4020          | 14.5520        |
| 1               | -300           | 12.0375          | 12.198                         | 13.5900          | 12.8400        |
| 2               | .284           | 11.3955          | 11.5474                        | 12.8652          | 12.1552        |
| 3               | .259           | 10.3924          | 10.5309                        | 11.7327          | 11.0852        |
| 4               | .238           | 9-5497<br>8-8275 | 9.6771                         | 10.7814          | 10.1864        |
| 5               | .220           | 8.8275           | 8.9452                         | 9.9660           | 9.4160         |
| 345678          | .203           | 8.1454           | 8.254                          | 9.1959<br>8.1540 | 8.6884         |
| 7               | .180           | 7.2225           | 7.3188                         | 8.1540           | 7.7040         |
|                 | .165           | 6.6206           | 6.7089                         | 7-4745           | 7.0620         |
| 9               | .148           | 5.9385           | 6.0177                         | 6.7044           | 6.3344         |
| to              | .134           | 5.3767           | 5.4484                         | 6.0702           | 5.7352         |
| 11              | 120 م          | 4.815            | 4.8792                         | 5.4360           | 5.1360         |
| 12              | .109           | 4-3736           | 4.4319                         | 4-9377           | 4.6052         |
| 13              | •025           | 3.8119           | 3.8627                         | 4-3035           | 4.0660         |
| 14              | .083           | 3.3304           | 3.3748                         | 3-7599           | 3-5524         |
| 15<br>16        | .072           | 2.889            | 2.9275                         | 3.2616           | 3.0816         |
|                 | .065           | 2.6081           | 2.6429                         | 2.9445           | 2.7820         |
| 17<br>18        | .058           | 2.3272           | 2.3583                         | 2.6274           | 2.4824         |
|                 | .049           | 1.9661           | 1.9923                         | 2.2197           | 2.0972         |
| 19              | .042           | 1.6852           | 1.7077                         | 1.9026           | 1.7976         |
| 20              | .o35           | 1.4044           | 1.4231                         | 1.5855           | 1.4980         |
| 21              | .032           | 1.284            | 1.3011                         | 1.4496           | 1.3696         |
| 22              | .028           | 1.1235           | 1.1385                         | 1.2684           | 1.1984         |
| 23              | .025           | 1.0031           | 1.0165                         | 1.1325           | 1.0700         |
| 24              | .022           | .8827            | .8945                          | .9966            | .9413          |
| 25<br>26        | .020           | .8025            | .8132                          | .ģó6o            | .8560          |
|                 | .018           | .7222            | .7319                          | .8154            | -7704          |
| 27<br>28        | .016           | .642             | .6506                          | .7428            | .6848          |
|                 | .014           | .5617            | .5692                          | .6342            | -5992          |
| 29              | .013           | .5216            | .5286                          | .5889            | -5564          |
| 30              | .012           | .4815            | -4879                          | .5436            | .5136          |
| 31              | ,010           | .4012            | 4066                           | -4530            | -4280          |
| 32              | .009           | .3611            | .3659                          | -4077            | .3852          |
| 33              | .008           | .321             | -3253                          | .3624            | -3424          |
| 34              | .007           | .2809            | .2846                          | .3171            | .2996          |
| 35<br>36        | .005           | ,2006<br>,1605   | .2033<br>.1626                 | .2205<br>.1812   | .2140<br>.1712 |
|                 | Gravity        | 7.704            | 7.806                          | 8.698            | 8.218          |
|                 | Cu. Ft.        | 481.250          | 487.750                        | 543.600          | 513.600        |
|                 | " In.          | .2787            | .2823                          | .3146            | .2972          |
|                 | . 10.          | .2707            | .2023                          | .3140            | .2972          |

|                            | Тніс           | KNESS                 | We          | GHT                       |                      |
|----------------------------|----------------|-----------------------|-------------|---------------------------|----------------------|
| Number                     |                | Approx.               | Weight per  | Walahaaa                  | Number               |
| of                         | Thickness      |                       | Square Foot | Weight per<br>Square Foot | of                   |
| Gauge                      | _ in           | in Decimal            | in Ounces   | in Pounds                 | Gauge                |
|                            | Fractions      | Parts                 |             | Avoirdupois               | _                    |
|                            | or an Inch     | of an Inch            |             |                           |                      |
| 0000000                    | 1-2            | -5                    | 320         | 20.00                     | 0000000              |
| 000000                     | 15-32          | .46875                | 300         | 18.75                     | 000000               |
| 00000                      | 7-16           | <b>-4</b> 37 <b>5</b> | 280<br>260  | 17.50                     | 00000                |
| 0000                       | 13-32<br>3-8   | .40625                | 240         | 16.25                     | 0000                 |
| w                          | 11-32          | ·375<br>·34375        | 220         | 15.<br>13.75              | 900                  |
| ۱ %                        | 5-16           | .3125                 | 200         | 12.50                     | w o                  |
| l i                        | 9-32           | .28125                | 180         | 11.25                     | ī                    |
| 2                          | 17-64          | .265625               | 170         | 10.625                    | 1 2                  |
|                            | 1-4            | .25                   | 160         | IO.                       |                      |
| 3<br>4<br>5<br>6<br>7<br>8 | 15-64          | ·234375               | 150         | 2·37 <b>5</b>             | 345678               |
| 5                          | 7-32           | .21875                | 140         | 8.75                      | 5                    |
| 9                          | 13-64          | .203125               | 130         | 8.125                     | 6                    |
| 1 7                        | 3-16           | .1875                 | 120<br>110  | 7.5<br>6.875              | 7                    |
|                            |                | .17875                | 110         | 6.25                      |                      |
| 9                          | 5-32           | .15625<br>.140625     |             | 5.625                     | 9                    |
| 1 11                       | 1-8            | .125                  | 90<br>80    | 5.                        | 11.                  |
| 1 12                       | 7-64           | .109375               | 70          | 4.375                     | 12                   |
| 13                         | 3-32           | .09375                | 60          | 3.75                      | 13                   |
| 14                         | 5-64           | .078125               | 50          | 3.125                     | 14                   |
| 15                         | 9-128          | .0703125              | 45          | 2.8125                    | 15<br>16             |
|                            | 1-16           | .0625                 | 40          | 2.5                       | 16                   |
| 17                         | 9-160          | .05625                | 36          | 2.25                      | 17                   |
|                            | 1-20           | .05                   | 32<br>28    | 2                         |                      |
| 19                         | 7-160<br>3-80  | .04375                | 20          | 1.75                      | 19<br>20             |
| 20                         |                | .0375                 | 24          | 1.50                      | 20                   |
| 21 22                      | 11-320<br>1-32 | .034375<br>.03125     | 20          | 1.375<br>1.25             | 22                   |
| 23                         | 9-320          | .03125                | 18          | 1.125                     | 23                   |
| 24                         | 1-40           | .025                  | 16          | I I.                      | 24                   |
|                            | 7-320          | .021875               | 14          | .875                      |                      |
| 25<br>26                   | 3-160          | .01875                | 12          | .75<br>.6875              | 25<br>26             |
| 27                         | 11-640         | .0171875              | 11          | .6875                     | 27<br>28             |
|                            | I-64           | .015625               | 10          | .625                      |                      |
| 29                         | 9-640          | .0140525              | 3           | .5625                     | 29                   |
| 30                         | 1-80           | .0125                 |             | •5                        | 30                   |
| 31                         | 7-640          | .0109375              | 614         | -4375<br>-40625           | 31                   |
| 32<br>33                   | 3-320          | .01015625             | 673         | -375                      | 32                   |
| 33                         | 11-1280        | .00559375             | 51/2        | 34375                     | 33                   |
| 1 34                       | 5-640          | .0078125              | ! 5         | .3125                     | 35                   |
| 35<br>36                   | 9-1280         | .00703125             | 4 1/2       | .28125                    | 33<br>34<br>35<br>36 |
| I 37                       | 17-2560        | .006640625            |             | .265625                   | 37<br>38             |
| 37<br>38                   | 1-160          | .00625                | 4           | .25                       | 38                   |
|                            | <u> </u>       |                       | <u> </u>    |                           |                      |

Anthracite Coal, market sizes, loose, averages 52 to 56 pounds per cubic foot; moderately shaken, 56 to 60 pounds. A heaped bushel, 77 to 83 pounds, loose. A long ton requires from 40 to 43 cubic feet storage room.

Crude Petroleum weighs about 55 pounds per cubic foot. Naphtha about 53 pounds. Bituminous Coal, broken, loose, weighs 47 to 52 pounds per cubic foot; moderately shaken, 51 to 56. Heaped bushel, loose, 70 to 78. A ton occupies 43 to 48 cubic feet.

Coal exposed to weather rapidly deteriorates in value, experiments in gas coals indicating a loss as high as 50 per cent. in nine months. It undergoes slow combustion, which is accompanied by generation of heat; sometimes to a dangerous extent, when piled in large heaps, unless carefully watched.

The Standard Bushel, as adopted by the American Gas Light Association, is a measure of 18½" diameter by 8" deep, containing 2150.42 cubic inches. The heaped bushel is the same with the capacity in addition of a cone 10½"

TABLE No. 72.

| Name of Mine, Coal  | Yield   | Yield  | Candle   | Candle   | Where or by Whom   |
|---|---|--|--|--|--|
| or Company  | Per Ton   | Per Lb.  | Power  | Feet   | Tested   |
| Montauk Taylor Co. Straughn Utopla. Blacksburg. Coal Valley. Upper Creek. Cannelton Cannel. Monongahela Monongahela Murphy Run. Penn. Youghiogheny. Old Virginia Blacksburg. Westmoreland. Taylor County. "" Youghlogheny Cannelton Cannel. Breckenridge Cannel | 12360<br>12960<br>13020<br>11520<br>12340<br>12510<br>11648<br>11390<br>12067<br>12215<br>10414<br>11787<br>11883<br>12563<br>11666<br>11621<br>12000 | 5.22<br>5.49<br>5.78<br>5.72<br>5.50<br>5.50<br>5.30<br>5.36<br>5.30<br>5.45<br>4.64<br>5.30<br>5.45<br>5.45<br>5.45<br>5.45<br>5.45<br>5.45<br>6.23 | 16.11<br>14.97<br>15.96<br>16.75<br>16.00<br>16.37<br>36.55<br>15.00<br>18.95<br>15.05<br>14.47<br>13.28<br>14.19<br>16.33<br>14.19<br>16.33<br>15.61<br>37.00 | 84.00<br>88.44<br>92.24<br>95.81<br>82.24<br>90.03<br>203.94<br>78.00<br>96.26<br>80.96<br>78.56<br>79.53<br>75.30<br>91.44<br>88.23<br>196.47<br>343.65 | Prof. Rickets & Sloan  """"""""""""""""""""""""""""""""""" |

By S. F. Benson, Engineer.

capacity in addition of a cone  $19\frac{1}{2}$ " diameter and 6" high, or a total of 2747.70 cubic inches. An ordinary heaped bushel =  $1\frac{1}{4}$  struck bushels = 2688 cubic inches = 10 gallons dry measure.

Dry Coke weighs 23 to 32 pounds per cubic foot; 35 to 42 pounds per heaped bushel, averaging 38; require 80 to 97 cubic feet per long ton storage room. One ton of coal usually produces about 40 bushels of coke.

A Ton of Caking Coal properly carbonized produces about 11,200 cubic feet of 16

| Candle gas<br>Tar<br>Liquor<br>Sulphuretted hydro | = 375 pounds.<br>= 101 "<br>= 110 "<br>gen = 7 " | Carbonic acid<br>Ammonia<br>Coke<br>Waste | $= 31  = 2\frac{1}{2}$ $= 1560  = 53\frac{1}{2}$ | pound<br>" |
|---|--|---|--|------------|
|   | •  |   | 2240   | 44         |

The average chemical composition of such coal may be assumed about as follows.

|          |   | <br>1 | , |               | on cour may be us. | <br>ca a | Jul | us | LOHIC | , u . |
|----------|---|-------|---|---------------|--------------------|----------|-----|----|-------|-------|
| Carbon.  | • |       |   | <b>8</b> 1.80 | Sulphur            |          |     |    |       | 1.70  |
| Hydrogen |   |       |   | 6.00          | Oxygen             |          |     |    |       | 2.58  |
| Nitrogen |   |       | • | 1.28          | Ash                |          |     |    |       | 6.64  |

TABLE No. 73.

| AVERAGE VOLUMETRIC ANALYSES OF GASES   |           |         |         |              |         |  |  |  |  |  |
|--|-----------|---------|---------|--------------|---------|--|--|--|--|--|
|  | Natural   | Coal    | Water   | PRODUCER GAS |         |  |  |  |  |  |
|  | Gas       | Gas     | Gas     | Anthra.      | Bitu.   |  |  |  |  |  |
| CO, Carbon Monoxide  | 0.50      | 6.0     | 45.0    | 27.0         | 27.0    |  |  |  |  |  |
| H, Hydrogen  | 2.18      | 46.0    | 45.0    | 12.0         | 12.0    |  |  |  |  |  |
| CH <sub>4</sub> , Marsh Gas  | 92.6      | 40.0    | 2.0     | 1.2          | 2.5     |  |  |  |  |  |
| C.H., Olefiant Gas   | 0.31      | 4.0     |         |              | 0.4     |  |  |  |  |  |
| C <sub>2</sub> H <sub>4</sub> , Olefiant Gas<br>CO <sub>2</sub> , Carbon Dioxide | 0.26      | 0.5     | 4.0     | 2.5          | 2.5     |  |  |  |  |  |
| N, Nitrogen  | 3.61      | 1.5     | 2.0     | 57.0         | 55.3    |  |  |  |  |  |
| O, Oxygen  | 0.34      | 0.5     | 0.5     | 0.3          | 0.3     |  |  |  |  |  |
| Vapor  |           | 1.5     | 1.5     |              |         |  |  |  |  |  |
| Pounds in 1000 cubic feet  | 45.6      | 32.0    | 45.6    | 65.6         | 65.9    |  |  |  |  |  |
| H. U. in 100 cubic feet  | 1,100,000 | 735,000 | 322,000 | 137,455      | 156.917 |  |  |  |  |  |

20 of coal gas.

Producer Gas is much heavier than either natural, coal or water gases, due to the large percentage of nitrogen it contains. Its specific gravity averages about .86, or over twice that of coal gas, and nearly 50 per cent. greater than natural or water gases. Its average characteristics and composition by volume are shown by the accompanying Table No. 73.

While the weakest of the four gases listed, yet it is the cheapest. One pound of coal will produce about 85 cubic feet of it as against

Gas Engines require about 15 to 20 cubic feet of illuminating gas per indicated horse power per hour, or 100 to 125 cubic feet of producer gas. They are now the most economical motors made, having demonstrated their ability to give a horse power for less fuel than the best steam engines. A duty of one horse power per hour for less than one pound of coal has been attained in engines of 50 horse power and above using producer gas.

#### BUILDING MATERIALS.

Cubic feet per ton of various materials:

Loose earth . . 24. Coarse sand . . 18.6 Common soil . 15.6 Clay . . . 18.6 Earth, with gravel . 17.8 Clay, with gravel . 14.4

A Perch = 22 cubic feet in wall = 440 bricks or  $12'' \times 16'' \times 16\frac{1}{4}$ .

No. of Bricks required for walls of various thicknesses per square foot of face:

HICKNESS. No. of BRICKS. THICKNESS. No. of BRICKS. THICKNESS. No. of BRICKS 4" 7 123/4" 21 211/2" 35 8/4 14 17 28 253/4 42 Bricks, 81/4" × 4" × 2". A hard, full-size brick weighs 5 pounds. 450 = one long ton.

One Cubic Foot Brick Work = 125 pounds and contains about 20 bricks with \* mortar joint. One thousand bricks require 4 cubic feet (3\frac{1}{2} struck bushels) lime and 16 to 20 cubic feet sand.

Mortar; 1 of quicklime to 4 or 5 of clean, sharp sand.

TABLE No. 74.

Table of Fractions with their Corresponding Decimals.

| 1 inch015625        | 17 inch                                    | #\$ inch515625         | 12 inch  |
|---------------------|--|------------------------|--|
| <del>]</del> "03125 | 3 <sup>9</sup> "                           | 17 "53125              | <del>35</del> "                                      |
| <del>\$</del> "     | ll : ' ····· ··· · · · · · · · · · · · · · | <del>85</del> "546875  | \$\frac{1}{6}\frac{1}{4}\tag{4}\tag{4}\tag{5}\tag{5} |
| 16 "0625            | 18 "                                       | 18 "                   | 18 "8125   |
| \$ ''               | <del>11</del> "                            | ₹} " ······ .578125    | §§ "   |
| <del>1</del> "09375 | 11 " ······· ·34375                        | 19 " ·········· ·59375 | <del>37</del> "                                      |
| 7 '                 | <del>23</del> " ······ ·359375             | <sup>홍호</sup> ''609375 | §§ ''859375  |
| ½ " ······ .125     | <i>¾</i> s " ··········· ·375              | 5 <del>8</del> "625    | <i>7</i> ∕s "875                                     |
| 84 "                | <sup>25</sup> "                            | <del>1</del> "         | <del>\$</del> 7 ''                                   |
| 3 '                 | 13 ' ··········· .40625                    | <del>}</del> "         | <del>}}</del> ''                                     |
| 11 "171875          | <del>}</del> "                             | <b>å</b> ₹ "           | §å "921875   |
| 1875 ···            | 7 ' ············ ·4375                     | <del>11 ''68</del> 75  | ˈ <del>1</del> 8 " ······ ·9375                      |
| 1                   | <del>12</del> "453125                      | <del>8</del>           | §¼ "   |
| <del>7</del> "21875 | <del>11 ''</del>                           | ₹¥ "                   | <del>§1</del> "                                      |
| 11 "                | <del>81</del> " ······· .484375            | <del>17</del> "        | ₹ <b>‡ ''984375</b>                                  |
| ¥ " ········ ·25    | ¾ " ······· ·5                             | ¾ " ····· 75           | I "I.O   |

TABLE No. 75.

THE INCH AND EIGHTHS OF AN INCH REDUCED TO THE DECIMALS OF A FOOT.

|     | 0      | 1      | Ω      | 8      | 4      | 5      | 6      | 7      | 8      | 9      | 10     | 11     |       |
|-----|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| 0   | 0.0000 | 0.0833 | 0.1667 | 0.2500 | 0.3333 | 0.4167 | 0.5000 | 0.5853 | o.6667 | 0.75CC | 0.8333 | 0.9167 | 0     |
| ₹   | .0104  | .0937  | .1771  | .2604  | .3438  | .4271  | .5104  | .5938  | .6771  | .7604  | .8438  | .9271  | . 3/8 |
| ×   | .0208  | .1042  | .1875  | .2708  | .3542  | -4375  | .5208  | .6042  | .6875  | .7708  |        | -9375  | ×     |
| 3∕8 | .0312  | .1146  | .1979  | .2813  | .3646  |        | .5313  |        | .6979  | .7813  | .8646  | -9479  | 3/8   |
| 3/2 | .0417  | .1250  | .2083  |        | .3750  |        | -5417  |        | .7083  | .7917  | .8750  | .9583  | 1/2   |
| ₹6  | .0521  | .1354  | .2188  | .3021  | .3854  |        |        | .6354  | .7188  | .8021  | .8854  | .9688  | 3%    |
| 34  | .0625  | .1458  | .2292  | .3125  | .3958  | .4792  | .5625  |        |        | .8125  |        | .9762  | *     |
| ₹   | .0729  | .1563  | .2396  | .3229  |        |        | .5729  |        |        |        |        | .9896  | 7/8   |

TABLE No. 76.

| Weight of a Cubic Foot of Substances        |                            |  |                         |  |  |  |  |  |  |  |
|---|----------------------------|--|-------------------------|--|--|--|--|--|--|--|
| Names of Substances                         | Average<br>Weight,<br>Lbs. | Names of Substances                                    | Averag<br>Weigh<br>Lbs. |  |  |  |  |  |  |  |
| Aluminum                                    | 162                        | Lime, quick, ground, thoroughly shaken                 | 75                      |  |  |  |  |  |  |  |
| Anthracite, solid, of Pennsylvania          | 93                         | " " per struck bushel                                  |                         |  |  |  |  |  |  |  |
| " broken, loose                             | 54                         | Limestones and Marbles                                 | 168                     |  |  |  |  |  |  |  |
| " moderately shaken                         | 58                         | " " loose, in irregular fragments                      | 99                      |  |  |  |  |  |  |  |
| " heaped bushel, loose                      | (80)                       | Magnesium  |                         |  |  |  |  |  |  |  |
| Ash, American white, dry                    | 38                         | Mahogany, Spanish, dry                                 | : -                     |  |  |  |  |  |  |  |
| Asphaltum                                   | _                          | " Honduras, dry  | 35                      |  |  |  |  |  |  |  |
| Brass (Copper and Zinc), cast               |                            | Maple, dry   | 49                      |  |  |  |  |  |  |  |
| " rolled                                    | 524                        | Marbles, see Limestones.                               |                         |  |  |  |  |  |  |  |
| Brick, best pressed                         | 150                        | Masonry, of granite or limestones, well dressed        | 165                     |  |  |  |  |  |  |  |
| " common hard                               | 125                        | " " mortar rubble                                      |                         |  |  |  |  |  |  |  |
| " soft, inferior                            | 100                        | " "dry rubble (well scabbled)                          |                         |  |  |  |  |  |  |  |
| Brickwork, press brick                      | 140                        | " sandstone, well dressed                              | 144                     |  |  |  |  |  |  |  |
| " ordinary                                  | 112                        | Mercury at 32° Fahrenheit                              | 849                     |  |  |  |  |  |  |  |
| Cement, hydraulic, ground, loose, Rosendale | 56                         | Mica   | 183                     |  |  |  |  |  |  |  |
| " " Louisville                              | 50                         | Mortar, hardened                                       | 103                     |  |  |  |  |  |  |  |
| " " " Portland                              | 90                         | Mud, dry, close  | •                       |  |  |  |  |  |  |  |
| Cherry, dry                                 | 42                         | " wet, fluid, maximum                                  | 120                     |  |  |  |  |  |  |  |
| Chestnut, dry                               | 41                         | Oak, live, dry   | 59                      |  |  |  |  |  |  |  |
| Clay, potters', dry                         | 119                        | " white, dry   | 50                      |  |  |  |  |  |  |  |
| " in lump, loose                            | 63                         | " other kinds  | 32 to                   |  |  |  |  |  |  |  |
| Coal, bituminous, solid                     | 84                         | Petroleum  | 55                      |  |  |  |  |  |  |  |
| " broken, loose                             | 49                         | Pine, white, dry                                       | 25                      |  |  |  |  |  |  |  |
| " heaped bushel, loose                      | (74)                       | " yellow, Northern                                     | 25<br>34                |  |  |  |  |  |  |  |
| Coke, loose, of good coal                   | 27                         | " " Southern   |                         |  |  |  |  |  |  |  |
| " heaped bushel                             | (40)                       | Platinum   | 45                      |  |  |  |  |  |  |  |
| Copper, cast                                | 542                        | Quartz, common, pure                                   | 1342<br>165             |  |  |  |  |  |  |  |
| " rolled                                    | 548                        | Rosin  | 69                      |  |  |  |  |  |  |  |
| Earth, common loam, dry, loose              | 76                         | Salt, coarse, Syracuse, N. Y                           | -                       |  |  |  |  |  |  |  |
| " " moderately rammed                       | -                          | " Liverpool, fine, for table use                       | 45                      |  |  |  |  |  |  |  |
| " as a soft, flowing mud                    | 95<br>108                  | Sand, of pure quartz, dry, loose                       | 49                      |  |  |  |  |  |  |  |
| Ebony, dry                                  |                            | " well shaken  | -                       |  |  |  |  |  |  |  |
| Elm, dry                                    | 76<br>                     |  |                         |  |  |  |  |  |  |  |
| Flint                                       | 35<br>162                  | " perfectly wet  |                         |  |  |  |  |  |  |  |
| Glass, common window                        |                            | Shales, red or black                                   | 151                     |  |  |  |  |  |  |  |
| Gneiss, common                              | 157                        | Silver   | 162                     |  |  |  |  |  |  |  |
| Gold, cast, pure, or 24 carat               | 168                        | Slate  | 655                     |  |  |  |  |  |  |  |
| " pure, hammered                            | 1204                       |  | 175                     |  |  |  |  |  |  |  |
| Granite                                     | 1217                       | Snow, freshly fallen "moistened and compacted by rain  | 5 to                    |  |  |  |  |  |  |  |
| Gravel, about the same as sand, which see.  | 170                        | Spruce, dry  | 15 to 5                 |  |  |  |  |  |  |  |
| Gypsum (plaster of paris)                   | 140                        | Steel  | 25                      |  |  |  |  |  |  |  |
| Hemlock, dry                                | 142                        | , =  | 490                     |  |  |  |  |  |  |  |
| Tickory, dry                                | 25                         | Sycamore, dry  | 125                     |  |  |  |  |  |  |  |
| Hornblende, black                           | 53                         | Tar  | 37                      |  |  |  |  |  |  |  |
| ce  | 203                        |  | 62                      |  |  |  |  |  |  |  |
| ron, cast                                   | 58.7                       |  | 459                     |  |  |  |  |  |  |  |
| " wrought                                   | 450                        | Turf, or Peat, dry, unpressed                          | 20 to 3                 |  |  |  |  |  |  |  |
| <del>_</del>                                | 480                        | Walnut, black, dry                                     | 38<br>601               |  |  |  |  |  |  |  |
| eadignum Vitæ, dry                          | 711 '                      | Water, pure rain or distilled, at 60° Fahrenheit " sea | 623<br>64               |  |  |  |  |  |  |  |
|   | 83                         |  |                         |  |  |  |  |  |  |  |

Green timbers usually weigh from one-fifth to one half more than dry.

## TABLE No. 77. CUSTOMARY UNITED STATES WEIGHTS AND MEASURES WITH THEIR EQUIVALENTS IN THE METRIC SYSTEM

|  |                        |                     |                           | MEASURES                  | OF LEN | 4GTH                   |                  |             |             |                |                  |
|--|------------------------|---------------------|---------------------------|---------------------------|--------|------------------------|------------------|-------------|-------------|----------------|------------------|
| Unit   | Millimeter             | Centimete           | r Meter                   | Kilometer                 | ,!     | Unit                   | Inch             | F           | oot         | Yard           | Mile             |
| Inch   | 25.4000                | 2.5400              | .02540                    |                           | Milli  | meter                  | .039370          | ·           |             |                |                  |
| Foot   | 304.801                | 30.480              | .30480                    |                           |        | meter                  |                  |             | 2808        |                |                  |
| Yard   |                        |                     | .91440                    |                           | Mete   | r                      |                  |             | 8083        | 1.09361        | .00062           |
| Mile   |                        |                     | 1609.35                   | 1 60935                   |        | net <b>e</b> r         |                  |             |             | 1093.61        | .62137           |
|  |                        |                     |                           | MEASURES                  | of Sur | FACE                   |                  |             |             |                |                  |
| Unit   | Square<br>Millimeter   | Square<br>Centimete | Square<br>Meter           | Hectare                   |        | Unit                   | Squar<br>Inch    | e Sq        | uare<br>oot | Square<br>Yard | Acre             |
| Square Inch  | 645.2                  | 6.452               |                           | <br>                      | Squa   | re Millim <b>e</b> ter | .00155           | •           |             |                |                  |
| Square Foot  |                        | 929.0               | .0929                     |                           | Squa   | re Centimeter          | 0.1550           | .10         | 0764        |                | •••••            |
| Square Yard  |                        |                     | 0.836                     |                           | -      | re Meter               |                  |             | .764        | 1.196          |                  |
| Acre   | •••••                  |                     |                           | 0.4047                    | -      | are                    |                  |             |             |                | 2.471            |
|  |                        |                     | = === -                   | MEASURES                  | or Vo  | LUME                   | ==-              |             | _           |                |                  |
| Unit   | Cubic<br>Centimeter    | Cubic<br>Decimeter  | Cubic<br>Meter            | ' Cord                    | -, -   | Unit                   | Cubic<br>Inch    |             | bic         | Cubic<br>Yard  | Cord             |
| Cubic Inch   | 16.387                 |                     |                           |                           | Cubic  | Centimeter.            | 0610             |             |             | - -            |                  |
| Cubic Foot   |                        | 28.32               | .02832                    | *******                   | Cubic  | Decimeter              | 61.023           |             | 3531        |                |                  |
| Cubic Yard   |                        |                     | .765                      |                           | 4      | Meter                  | -                | , ,         | .314        | 1.308          |                  |
| Cord   |                        |                     |                           | .906                      | Cord   |                        |                  | 1           |             |                | 1.1036           |
|  |                        |                     |                           | MEASURES                  | OF CAP | ACITY                  |                  |             |             |                |                  |
| Unit   | Milliliter<br>or Cubic | Liter               | Hectoliter                | <br>  Unit                | Fluid  | PINT                   |                  | QU          | ART         | Gallon         | Bushe            |
|  | Centimeter             |                     | cctomer                   | ·                         | Ounce  | Liquid                 | Dry              | Liquid      | Dry         | Junion         |                  |
| Fluid Ounce  | 29.57                  | .02957              |                           | Milliliter                | .03382 |                        |                  |             |             |                | ;- <u></u>       |
| Pint, Liquid                                       | 473.17                 | -47317              | 1                         | Liter                     | 33.818 | 2.1134                 | 1.8161           | 1.0567      | .90810      | .26417         | ·                |
|  |                        | 55063               |                           | Decaliter                 |        |                        | •••••            | 10.567      | 9.0810      | 2.6417         | .28375           |
| Pint, Dry  |                        |                     |                           | 77 12                     | •••••  | 1                      |                  |             |             | 26.417         | 2.837            |
| Pint, Dry  |                        | .94636              |                           | Hectoliter                |        |                        |                  |             | 1           | 1              | 37.              |
| Pint, Dry<br>Quart, Liquid                         |                        | 1 1                 |                           | Hectonter                 | •••••  |                        |                  |             | :           | 1              |                  |
| Pint, Dry  |                        | .94636<br>1.1012    | .35242                    | Hectoliter                | •••••  |                        | 1                |             | İ           |                |                  |
| Pint, Dry<br>Quart, Liquid<br>Quart, Dry           |                        | 1.1012              |                           | MEASURES                  |        | пент                   |                  | <del></del> | <u> </u>    |                | <u> </u>         |
| Pint, Dry<br>Quart, Liquid<br>Quart, Dry<br>Bushel |                        | 1.1012              | ·35242                    | MEASURES                  | OF WE  | Unit                   | Grain            |             |             | voirdu-        | Ton<br>(2240 Lbs |
| Pint, Dry  | Milli-<br>gramme       | 1.1012              | .35242<br>Kilo-           | MEASURES                  | of We  |                        | Grain<br>.01543  | pois        |             |                |                  |
| Pint, Dry  | Milli-<br>gramme       | Gramme .06479       | .35242<br>Kilo-<br>gramme | MEASURES Tonne, MetricTon | of We  | Unit                   | .01543           | pois        | Ounce po    | is Pound       | (2240 Lbs        |
| Pint, Dry  | Milli-<br>gramme       | Gramme              |                           | MEASURES Tonne, MetricTon | OF WE  | Unit                   | .01543<br>15.432 | pois<br>    | Ounce po    | ois Pound      | (2240 Lbs        |

- 1 cubic centimeter of water = 1 gramme; 1000 cubic centimeters of water = 1 liter = 1 kilogramme = 2.2046 lbs.
  1 gramme per square millimeter = 1.422 lbs. per square inch; 1 lb. per square inch = .070308 kilogrammes per square centimeter.
  1.0335 kilogrammes per square centimeter = 1 atmosphere = 14 7 lbs. per square inch = .760 millimeters of mercury column.
  1 horse power = 4562.33 kilogramme meters per minute = 1.01385 metric horse-power.

|               | DIAMETERS OF PIPES IN INCHES TO MILLIMETERS |         |                       |                |                         |                |                         |                |                            |   |  |  |
|---------------|---|---------|-----------------------|----------------|-------------------------|----------------|-------------------------|----------------|----------------------------|---|--|--|
| Inch          | Millimeter                                  | Inch    | Millimeter            | Inch           | Millimeter              | Inch           | Millimeter              | Inch           | Millimeter                 |   |  |  |
| 1<br>1½<br>1½ | 25.4<br>31.75<br>38.10                      | 3 3 1/2 | 76.2<br>88.9<br>101.6 | 7 8            | 177 8<br>203.2<br>228.6 | 15<br>16<br>18 | 381.0<br>406.4<br>457.2 | 36<br>40<br>42 | 914.4<br>1016.0<br>1066 8  | Millimeters × .03937 = Inches. Inches × 25.4 = Millimeters. |  |  |
| 2 21/2        | 50.8  | 5 6     | 127.0<br>152.4        | 10<br>12<br>14 | 254.0<br>304.8<br>355.6 | 20 24 30       | 508.0<br>609.6<br>762.0 | 48<br>60<br>72 | 1219.2<br>1524.0<br>1828.8 | 1000 Millimeters = 1 Meter = 39.37 Inches.                  |  |  |

SHIPPING MEASURE.

U. S. Shipping Ton = 40 cubic feet = 32.143 U. S. bushels = 31.16 imperial bushels. British Shipping Ton = 42 cubic feet = 32.719 imperial bushels = 33.75 U. S. bushels.



#### TABLE No. 78.

10 Cents = 1 Dime, \$0.10. 10 Dimes = 1 Dollar, \$1.00

10 Dollars = 1 Eagle, \$10.00. 20 Dollars = 1 Double Eagle, \$20.00.

|   |                   |  | 10.                                      | <del></del>   |
|---|-------------------|--|--|---|
| COUNTRY   | STANDARD          | Monetary unit  | Value in<br>Terms of U.S.<br>Gold Dollar | Coins   |
| Argentine Republic  | Gold and silver   | Peso   |  | Gold: argentine (\$4.824) and ½ argentine. Silver: peso and divisions.  |
| Austria-Hungary   | Gold              | Crown  | .203                                     | Gold: former system—4 florins (\$1.929), 8 florins (\$3.858), duction (\$2.287) and 4 ducats (\$9.149). Silver: 1 and 2 floring                 |
| Belgium   | Gold and silver   | Franc  | .193                                     | (Gold: present system—20 crowns (\$4.052), 10 crowns (\$2.026). Gold: 10 and 20 francs. Silver: 5 francs.                                       |
| Bolivia   | Silver            | Boliviano  | 418                                      | Silver: boliviano and divisions.  |
| Brazil  | Gold              | Milreis  | .546                                     | Gold: 5, 10 and 20 milreis. Silver: ½, 1 and 2 milreis.   |
| British Possessions, N.<br>A. (except Newf'nd)<br>Central Amer. States— | Gold              | Dollar   | 1.000                                    | 140.1   |
| Costa Rica  |                   |  |  | Gold: 2, 5, 10 and 20 colons (\$9,307). Silver: 5, 10, 25 and centimos.   |
| British Honduras  | !                 |  | 1  | 1   |
| Honduras<br>Nicaragua   | Silver            | Peso   | 418                                      | Silver: peso and divisions.   |
| Chile   | Gold              | Peso   | 365                                      | Gold: escudo (\$1.825), doubloon (\$3.650) and condor (\$7.300) Silver: peso and divisions.   |
|   | ١.                | ( Amoy   | 676                                      | ( Suver: peso and divisions.  |
|   | 1                 | Canton<br>Chefoo<br>Chin Kiang.<br>Fuchau<br>Haikwan } | 646<br>660<br>625                        | I<br>'  |
| China   | Silver            | Hongkong<br>Niuchwang.<br>Ningpo                       | 632<br>. (*)<br>634<br>650               |   |
| Colombia  | <br> <br>  Ciliar | Shanghai<br>Swatow<br>Takau<br>Tientsin                | 624<br>680<br>655                        | Gold: condor (\$9.647) and double condor. Silver: peso.   |
| Cuba  | Gold and silver   | Peso   | 926                                      | Gold: centen (\$5.017). Silver: peso.   |
| Denmark<br>Ecuador  | Gold              | Crown  | . ,268                                   | Gold: 10 and 20 crowns.  Gold: condor (\$0.647) and double condor. Silver: sucre as   |
| Egypt   |                   |  |  | divisions.  Gold: pound (100 piasters), 5, 10, 20 and 50 piasters. Silver:  2, 5, 10 and 20 piasters,   |
| Finland   | Gold              | Mark   | 193                                      | Gold: 20 marks (\$3.859), 10 marks (\$1.93). Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs.  |
| France<br>German Empire   | Gold and silver   | Franc  | 193                                      | Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs. Gold: 5, 10 and 20 marks.   |
| Great Britain   | Gold              | Pound sterling   | 4.866                                    | Gold: sovereign (pound sterling) and ½ sovereign.   |
| Greece  |                   |  |  | Gold: 5, 10, 20, 50 and 100 drachmas. Silver: 5 drachmas.   |
| Haiti   | Silver            | Rupeet   | 965                                      | Silver: gourde. Gold: mohur (\$7.105). Silver: rupee and divisions.   |
| Italy   | Gold and silver   | Lira   | . 102                                    | Gold: 5, 10, 20, 50 and 100 lire Silver: 5 lire. Gold: 5, 10 and 20 yen. Silver: 10, 20 and 50 sen.   |
| apan  | Gold              | Yen  | 498                                      | Gold: 5, 10 and 20 yen. Silver: 10, 20 and 50 sen.  |
| Liberia<br>Mexico   |                   |  |  | Gold: dollar (\$0.983), 21/2, 5, 10 and 20 dollars. Silver: doll  |
| Netherlands   |                   |  |  | (or peso) and divisions. Gold: 10 florins Silver: ½, 1 and 2½ florins.  |
| Newfoundland  | Gold              | Dollar   | 1.014                                    | Gold: 2 dollars (\$2.027).  |
| Norway<br>Persia  | Gold              | Crown  | 268                                      | Gold: 10 and 20 crowns.   |
| Persia<br>Peru  | Silver            | Kran   | .077                                     | Gold: ½, 1 and 2 tomans (\$3.409). Silver: ½,½, 1, 2 and 5 kran<br>Silver: sol and divisions.   |
| Portugal  | Gold              | Milreis  | 1.080                                    | Gold: 1 2 Sand to milreis   |
| Russia  |                   |  |  | Gold: imperial. 15 rubles (\$7.718), and 1/2 imperial, 71/2 ruble (\$3.859). Silver: 1/2, 1/2 and 1 ruble. Gold: 25 pesetas. Silver: 5 pesetas. |
| Spain   | Gold and silver   | Peseta   | .193                                     | Gold: 25 pesetas. Silver: 5 pesetas.  |
| Sweden  | Gold              | Crown  | 268                                      | Gold: 10 and 20 crowns.   |
| Switzerland   | Gold and silver   | Franc  | .193                                     | Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs.   |
| Turkey<br>Uruguay   | Gold              | Peso   | .044<br>1.034                            | Gold: 25, 50, 100. 250 and 500 piasters. Gold: peso. Silver: peso and divisions. Gold: 5, 10, 20, 50 and 100 bolivars. Silver: 5 bolivars.      |
| Venezuela   |                   |  |  |   |

<sup>\*</sup>The "British dollar" has the same legal value as the Mexican dollar in Hongkong, the Straits Settlements and Labuan †Value of the Rupee to be determined by Consular Certificate.



#### EXPLANATION OF CODING.

THE Coding (suggested in our circular) consists of a word designating the character of the article wanted. Such word is placed at the heading of the different tables.

The size of each article is designated by the affix placed opposite the different dimensions. Combining these two in one word will designate the article, its character, size, etc. For example: 6" Bell and Spigot Water Pipe for 200 ft. Head—Omen-asti. To be written Omenasti. In order to express quantities, prefix the letter "L" when lengths are wanted, or the letter "F" when feet are desired. Thus:

1000 lengths, 6" B. & S. for 200 ft. Head would be—1000 Lomenasti.

500 feet """ "" "500 Fomenasti.

To designate uncoated castings, insert the letter "U." Thus:

500 ft. uncoated, 6" B. & S., suitable for 200 ft. Head of water, would be—500 F-u-omen-asti.

To be written—Fuomenasti.

These combinations of letters will in no instance exceed ten letters. They can therefore be

written as one word, and will be accepted as such by the Cable Companies

If Turned and Bored (T. & B.) instead of Bell and Spigot (B. & S.) are wanted, the use of the word "Odd" instead of "Omen" in the above combination will call for Turned and Bored pipe being sent (see Table No. 13, page 3), and the word would therefore read "500 Fuoddasti," as meaning—500 ft. uncoated 6" pipe, Turned and Bored, suitable for 200 ft. Head.

Find of the various sizes of the different articles has its own off.

Each of the various sizes of the different articles has its own affix.

### WORDS FOR USE IN TELEGRAPHING.

| Bugler Will telegraph you shortly.              | Friscare Freights advancing.                         |
|---|--|
| Bulged We have no reply to our letter.          | Festario " declining.                                |
| <b>Bulimy</b> We have no reply to our telegram. | Fretting Owing to advance in freights.               |
| Bulltrout As we have other offers for pipe in   | Fromage " decline " "                                |
| stock for deliveries quoted, reply.             | Framable What is the rate of freight?                |
| Bumboat Are we likely to secure order?          | Foxery I (we) have engaged freight per steamer.      |
| Bunnian We cannot enter order except at an ad-  | Foxglove I (we) " " sailing                          |
| vance of——.                                     | vessel.  |
| Culbous Write us promptly regarding—.           | Foxtail I (we) cannot engage freight per steamer.    |
| Cuneiform . Can charter suitable vessel.        | Foxtrap . I (we) " " " sailing                       |
| Cunning Cannot charter suitable vessel.         | vessel.  |
| Cupbearer . " " under.                          | Foundling . Engage freight per steamer for.          |
| Champagne .I (we) have not chartered.           | Foundry " " sailing vessel for.                      |
| Cullotte Subject to confirmation by you.        | Foulerie Rate of freight per steamer is.             |
| Culprit " " immediate confirmation.             | Foulness " " " sailing vessel is.                    |
| Cultrated. How long will it take to complete?   | Foster At which rate of freight can you ship?        |
| Culture Will be completed in time.              | Household . Unless you hear from us to the contrary. |
| Cumbersome " take about 2 weeks to complete.    | Houseleek . " we " " you " "                         |
| Cumbrous . " " a month " "                      | Pommeling . Telegraph lowest possible price (s).     |
| Cumshaw " " 2 months" "                         | Pondering . Will accept order (s) same price as      |
| Cumulus   | others, F. O. B.                                     |
| Cuneated . Expect to complete.                  | Porcelain At what price can you supply C. F. & I.?   |
| Diluent What discount on?                       | Porcine " " " " ex-ship?                             |
| Diaphne Discount on —— is.                      | Porridge Telegraph price at which you can            |
| Deluge Immediate delivery.                      | duplicate order (s) of.                              |
| Demency For future "                            | Portliness . The price to include—per cent. com-     |
| Demasquer . Delivery within.                    | mission to me (us).                                  |
| Demenage . Future delivery.                     | Poulterer Can supply F. O. B. at following prices.   |
| Demur What delivery do you require?             | Poultry " " C. F. I. " " "                           |
| Demonvir . Will you promise delivery here by?   | Pouncet " ex-ship " "                                |
| Denaiton . If you send orders by—shall be able  | Quelling Please telegraph approximate quantity.      |
| to get delivery by?                             | Slavishly Shall I (we) ship by steamer or sailing    |
| Denevon . Telegraph full details.               | vessel?  |
| Deneiger What is the diameter of—?              | Slayer Ship by steamer.                              |
| Dogwood The document (s) has (have) been sent.  | Sleaving " " every steamer until further advice.     |
| Doigtier  | Sleeveless . " " sailing vessel.                     |
| Dolaire will be lorwarded by                    | Slice " all you possibly can.                        |
| next mail.                                      | Slipperily Have arranged to ship by next steamer.    |
| Foolery Forward immediately by steamer.         | Slipshod . " to ship by next sailing vessel.         |
| Foolhardy . " sailing vessel.                   | Superior to sup by next saming vesses.               |

## CODE.

| -  |           | •  | 0.1.322-3  |
|--|-----------|--|------------|
|  | ode Word. |  | Code Word. |
| BLOW OFF BRANCHES                        | Ask       | HYDRANTS-Mathews' Patent Fire, Single    |            |
| CAPS                                     | Ally      | Valve, with Independent                  | LF _ 21    |
| " —Reduced                               | Add       | Cut-off                                  | Hail       |
| Crosses—(bells all around)               | Adit      | INDICATOR ATTACHMENT FOR GATE VALVES,    | Vim        |
| " (flanged)                              | Inn       | INLET OR MANHOLE FRAMES AND COVERS,      | lrk        |
| " Reduced                                | Acid      | INTAKE SCREENS                           | Vex        |
| " (three bells and one spigot)           | Arid      | LAMP POSTS                               | Post       |
| COLUMNS, PIPE—(eight inches inside dia.) | Cail      | LATERALS OR Y BRANCHES—(bell ends) .     | Ash        |
| " " (four " " ")                         | Con       | LATERALS OR Y BRANCHES—(flange ends) .   | lsm        |
| " " (six " " " " )                       | Саг       | MANHOLE OR INLET FRAMES AND COVERS,      | lrk        |
| " (six " " " " " )                       | Cot       | Offsets—(bell and spigot)                | Ant        |
| Coupling—One 21/2" Loose Female Coup-    |           | PIPE-Bell and Spigot Gas, Boston Gas     |            |
| ling with Two 21/2" Male                 |           | Light Co. Standard, heavy weight,        | Emir       |
| Couplings                                | Hit       | " Bell and Spigot Gas, Boston Gas        |            |
| " One 4" Loose Female Coupling           |           | Light Co. Standard, light weight,        | Egis       |
| with Two 2½" Male Coup-                  | •         | " Bell and Spigot Gas, for Cement        | -6.0       |
|  | Hub       |  | Expand     |
| lings                                    | HUD       | Joints                                   | Lapand     |
| " Two 2½" Loose Female Coup-             |           | Deli and Spigot Gas, London (Eng.)       | Emit       |
| lings with One 21/2" Male                | W         | Gas Light and Coke Co. Standard,         |            |
| Coupling                                 | Hoax      | Dell and Spigot Gas, K. D. Wood &        |            |
| DRIPS OR SYPHONS—No. 1, Standard         | Axis      | Co. Standard                             | Edit       |
| 2, Ordinary                              | Away      | " Bell and Spigot Gas, U. G. I. Co.      | _          |
| J, Courtain                              | Avow      | Standard                                 | Even       |
| " " " 4, Flanged Tops                    |           | " Bell and Spigot Water, for 100 ft.     |            |
| with Tar Pipe.                           | Arew      | Head, or 43 lbs. per sq. in. Pres-       |            |
| Eighth Bends-(bell and spigot, long      |           | sure                                     | Odor       |
| radius)                                  | Axit      | " Bell and Spigot Water, for 200 ft.     |            |
| " (bell and spigot, medium               |           | Head, or 86 lbs. per sq. in. Pres-       |            |
| radius)                                  | Arch      | sure                                     | Omen       |
| " (flanged, long radius).                | Idly      | " Bell and Spigot Water, for 300 ft.     |            |
| " (" medium ").                          | Its       | Head, or 130 lbs. per sq. in. Pres-      |            |
| " " (" short ").                         | Iced      | sure                                     | Onus       |
| " " Reduced                              | Aver      | " Bell and Spigot Water, for 400 ft.     | Onas       |
| " "Flange and Bell Pieces                |           | Head, or 173 lbs. per sq. in. Pres-      |            |
| " " " Spigot "                           | Arii      | , , ,                                    | Oven       |
| TP D11                                   | -         | sure                                     | Oven       |
|  | Imp       | rianged, for oo it. Head, or 25 ibs.     | I          |
| " Companion (pairs)                      | Vein      | per sq. in. Water Pressure               | Iron       |
| nydraulic No. I (with groove)            | Rex       | Flanged, 101 115 It. 11cad, 01 50 10s.   | 1-1-       |
| 2 ( tongue)                              | Irid      | per sq. in. Water Pressure               | Iris       |
| Screw                                    | ink       | " Flanged, for 230 ft. Head, or 100 lbs. |            |
| FLEXIBLE JOINTS—(bell and spigot ends) . |           | per sq. in. Water Pressure               |            |
| " (bell ends)                            | Idle      | " Flanged, for 350 ft. Head, or 150 lbs. |            |
| " " (flange ends)                        | ldyl      | per sq. in. Water Pressure               | Ides       |
| FOOT BENDS—(nanged)                      | Ivy       | " Flexible Joint—Design A                | Iman       |
| HYDRANT BRANCHES—(bells all around) .    | Alp       | " " " C                                  | Idol       |
| HYDRANTS—Flush or Surface, 2½ ft., or 3½ |           | " Hydraulic Pressure, for Pressures up   |            |
| ft. from Pavement to Bottom              |           | to 1000 lbs. per sq. in                  | Ivan       |
| of Pipe                                  | Hint      | " Hydraulic Pressure, for Pressures up   |            |
| " Flush or Surface, 3½ ft., or 4         |           | to 2000 lbs. per sq. in                  |            |
| ft. from Pavement to Bottom              |           | " Tongue and Groove Flange               |            |
| of Pipe                                  | Heel      | " Turned and Bored Gas, Boston Gas       |            |
| " Flush or Surface, 41/2 ft., or 5       |           | Light Co. Standard, heavy weight,        |            |
| ft. from Pavement to Bottom              |           | " Turned and Bored Gas, Boston Gas       |            |
| of Pipe                                  | Hart      | Light Co. Standard, light weight,        |            |
| " Flush or Surface, 51/2 ft., or 6       |           | " Turned and Bored Gas, London           |            |
| ft. from Pavement to Bottom              |           | (Eng.) Gas Light and Coke Co.            | •          |
| - f T):                                  | Host      |  |            |
| " Mathews' Patent Fire, Double           | IIVDL     | " Turned and Bored Gas, R. D. Wood       | Lind       |
| Valve                                    | Hark      | Turned and bored Gas, R. D. Wood         | E          |
| vaive                                    | HAIR      | & Co. Standard                           | Err        |
| Mathews Fatent File, Double              |           | Turned and Bored Gas, O. G. 1. Co.       |            |
| Valve, with Independent                  | H1        | Standard                                 |            |
| Cut-off                                  | Hurl      | Turned and Bored Water, for 100 it.      |            |
| Mathews ratent rife, Single              | UL        | Head, or 43 lbs. per sq. in. Pres-       |            |
| Valve                                    | Herb      | sure                                     | Orb        |
|  |           |  |            |

| Name. Code Word.  | Name. Code Word.   |
|---|--|
| PIPE—Turned and Bored Water, for 200 ft.  | SLEEVES—Split with Branches Arc  " without " Aim                           |
| Head, or 86 lbs. per sq. in. Pressure Odd   | TEE BASES—(flanged)  |
| " Turned and Bored Water, for 300 ft.   | TERS—(bells all around) Arab   |
| Head, or 130 lbs. per sq. in. Pres-   | " (flanged)  |
| sure Off "Turned and Bored Water, for 400 ft.                                       | Reduced  |
| Head, or 173 lbs. per sq. in. Pressure Own  | " (two bells and one spigot) Atom  |
| PLUGS Anol  | TRAPS—with Branches (bell and spigot) Arow                                 |
| " Reduced Adam QUARTER BENDS—(bell and spigot, long                                 | " without " " " Arm VALVE BOXES—Adjustable Vest                            |
| radius) Anon  | VALVE BOX FRAMES AND COVERS Main   |
| " (bell and spigot, medium  | VALVES—Camden Gas (bell ends) Gall   |
| radius) Alum<br>" (flanged, long radius) . Ibis                                     | " " (flanged) Gain " Check (bell ends) Veal                                |
| " (flanged, medium ra-  | " " (flanged) Vow  |
| dius)   | " Foot " Volt  |
| " " (flanged, short radius) . Idem " " Reduced Aden                                 | " Gate, Angle (flanged) Vary " " Geared for 16" dia. and                   |
| " with Hand-holes (bell -   | larger (bell ends) Veil  |
| and spigot, long ra-  | " Geared for 16" dia. and  |
| dius) Avis<br>" with Hand-holes (bell   | larger (flanged) Vain " " Geared with By-Passes                            |
| and spigot, medium  | (bell ends) Vend   |
| radius) Awry  | " Geared with By-Passes  |
| with Hand-holes (flanged, long radius) Illy   | (flanged) View " with Inside Screws (bell                                  |
| " with Hand-holes   | ends) <b>Vail</b>  |
| (flanged, medium ra-  | " with Inside Screws (flanged  |
| dius) Inly<br>" with Hand-holes   | ends) Van " with Inside Screws (screw                                      |
| (flanged, short ra-   | ends) Vast   |
| dius) Inca  | " "with Outside Screws and Yokes (bell ends) Veer                          |
| " (flanged) Icon REDUCERS No. 1—(bell and spigot) Ark                               | Yokes (bell ends) Veer " with Outside Screws and                           |
| " " 2—(spigot ends) And   | Yokes (flanged) Vent   |
| Reduced Ajar<br>Screens—Basket Voil   | " "with Outside Screws and Yokes (screw ends) Void                         |
| "Intake Vex   | " Sliding Stem and Lever (flanged) Vat                                     |
| SLEEVES—Reduced Act   | Y Branches or Laterals (bells all around) Ash                              |
| " Solid Amid  | " " " (flanged) lsm  |
| CODE '  | WORDS.   |
| Acid . Reduced Crosses.   | Arch . Eighth Bends (bell and spigot, medium                               |
| Act . " Sleeves. Adaw . " Plugs.  | radius).<br>Arew , Flanged Top Drip or Syphon with Tar                     |
| Adaw . "Plugs. Add . "Caps.   | Pipe (No. 4).  |
| Aden . " Quarter Bends.   | Arid. Crosses (three bells and one spigot).                                |
| Adit . Crosses (bells all around).  Aim . Split Sleeves without Branches.           | Aril . Flange and Spigot Pieces.  Ark . Reducers (bell and spigot).        |
| Ajar . Reduced Reducers.  | Arm . Traps without Branches (bell and spigot).                            |
| Akin . " Tees.  | Arow. "with Branches (bell and spigot).                                    |
| Ally . Caps. Alp . Hydrant Branches (bells all around).                             | Ash . Y Branches or Laterals (bells all around).  Ask . Blow-off Branches. |
| Alum . Quarter Bends (bell and spigot, medium                                       | Atom. Tees (two bells and one spigot).                                     |
| radius).<br>Amid . Solid Sleeves.   | Aver . Reduced Eighth Bends.   |
| Amid . Solid Sleeves.  Amyl . Flange and Bell Pieces.                               | Avis . Quarter Bends with Hand-holes (bell and spigot, long radius).       |
| And . Reducers (spigot ends).   | Avow. Courtain Drips or Syphons (No. 3).                                   |
| Anon. Quarter Bends (bell and spigot, long radius).                                 | Away. Ordinary " " (No. 2).  Awry. Quarter Bends with Hand-holes (bell and |
| Anol . Plugs.   | Awry. Quarter Bends with Hand-holes (bell and spigot, medium radius).      |
| Ant . Offsets (bell and spigot).  | Axis . Standard Drips or Syphons (No. 1).                                  |
| Apt . Eighth Bends (bell and spigot, long radius).  Arab . Tees (bells all around). | Call . Pipe Columns (eight inches inside dia.). Car . " (six " ").         |
| Arc . Split Sleeves with Branches.  | Con . " " (four " " ").  |
|   | •  |

Vow .

Check

Pipe Columns (ten inches inside dia.). Turned and Bored Gas Pipe, Boston Gas Cat Ink Ebb Inly Light Co. Standard, light weight. Bell and Spigot Gas Pipe, R. D. Wood & Co. Standard. Edit Inn Ion Bell and Spigot Gas Pipe, Boston Gas Light Co. Standard, light weight. Turned and Bored Gas Pipe, U. G. I. Co. Egis . Irid Iris EIb Standard. Irk Elm Turned and Bored Gas Pipe, Boston Gas Iron Light Co. Standard, heavy weight.

Bell and Spigot Gas Pipe, Boston Gas
Light Co. Standard, heavy weight.

Bell and Spigot Gas Pipe, London, Eng., Emir . Isis Emit . Ism Gas Light and Coke Co. Standard. Itch Turned and Bored Gas Pipe, London, Eng., End Item . Gas Light and Coke Co. Standard. Err Turned and Bored Gas Pipe, R. D. Wood & Its Co. Standard. Ivan . Even . Bell and Spigot Gas Pipe, U. G. I. Co. Standard. lvy Expand Bell and Spigot Gas Pipe for cement joints. Main . Gall . Camden Gas Valves (bell ends).
" " (flanged). Odd . Gain Mathews' Patent Fire Hydrant, Single Valve, with Independent Cut-off. Mathews' Patent Fire Hydrant, Double Hail Odor . Hark . Off Valve. Flush or Surface Hydrants, 4½ feet or 5 feet from Pavement to Bottom of Pipe. Hart . Omen . Onus . Heel . Flush or Surface Hydrants, 31/2 feet or 4 feet from Pavement to Bottom of Pipe. Mathews' Patent Fire Hydrant, Single Огь Herb . Valve. Flush or Surface Hydrants, 21/2 feet or 3 Oven . Hint . feet from Pavement to Bottom of Pipe. One 2½" Loose Female Coupling with Two 2½" Male Couplings.
Two 2½" Loose Female Couplings with Hit Own . Post . Hoax . One 21/2" Male Coupling. Rex Vail Flush or Surface Hydrants, 5½ feet to 6 feet from Pavement to Bottom of Pipe. Host . Vain One 4" Loose Female Coupling with Two 21/2" Male Couplings. Hub Van Vary Hurl Mathews' Patent Fire Hydrant, Double Vast Valve with Independent Cut-off. Vat Quarter Bends (flanged, medium radius). Ibex Veal long Ibis Veer " Iced Eighth short Reducers (flanged). Icon Vell lcv Idem Quarter Bends (flanged, short radius). Vein Flange Pipe for 350 feet Head or 150 lbs. per sq. in. Water Pressure. Ides Vend . Flexible Joints (bell ends). Eighth Bends (flanged, long radius). Flexible Joint Pipe, Design "C". Idle Vent . Idly Idol Vest . (flanged ends). (bell and spigot ends). Idyl Vex llex View . Tee Bases (flanged). Iik Quarter Bends with Hand-holes (flanged, Iliv Vim long radius) Void . Flexible Joint Pipe, Design "A". Blank Flanges. Voil Imp Quarter Bends with Hand-holes (flanged, Inca Volt

long radius).

Screw Flanges. Quarter Bends with Hand-holes (flanged, medium radius). Crosses (flanged) Reducing Tees (flanged).

Hydraulic Flanges No. 2 (with Tongue).

Flange Pipe for 115 feet Head or 50 lbs.

per sq. in. Water Pressure. Manhole or Inlet Frames and Covers. Flange Pipe for 60 feet Head or 25 lbs. per sq. in. Water Pressure. Flange Pipe for 230 feet Head or 100 lbs. per sq. in. Water Pressure. Y Branches or Laterals (flanged). Tongue and Groove Flange Pipe. C. I. Hydraulic Pressure Pipe for Pressures up to 2000 lbs. per sq. in. Eighth Bends (flanged, medium radius) C. I. Hydraulic Pressure Pipe for Pressures up to 1000 lbs. per sq. in. Foot Bends (flanged). Valve Box Frames and Covers.
Turned and Bored Water Pipe for 200 feet Head or 86 lbs. per sq. in. Pressure. Bell and Spigot Water Pipe for 100 feet Head or 43 lbs. per sq. in. Pressure.

Turned and Bored Water Pipe for 300 feet
Head or 130 lbs. per sq. in. Pressure.

Bell and Spigot Water Pipe for 200 feet Head or 86 lbs. per sq. in. Pressure. Bell and Spigot Water Pipe for 300 feet Head or 130 lbs. per sq. in. Pressure. Turned and Bored Water Pipe for 100 feet Head or 43 lbs. per sq. in. Pressure. Bell and Spigot Water Pipe for 400 feet Head or 173 lbs. per sq. in. Pressure. Turned and Bored Water Pipe for 400 feet Head or 173 lbs. per sq. in. Pressure. Lamp Posts. Hydraulic Flanges No. 1 (with Groove).
Gate Valves with Inside Screws (bell ends).
Gate Valves, Geared for 16" Dia. and
Larger (flanged). GateValves with Inside Screws (flanged ends). Angle Valves (flanged) Gate Valves with Inside Screws (screw ends). Check Valves (bell ends).

Gate Valves with Outside Screws and
Yokes (bell ends). Gate Valves, Geared for 16" Dia. and Larger (bell ends). Companion Flanges (pairs). Geared Gate Valves with By-Passes (bell ends). Gate Valves with Outside Screws and Yokes (flanged). Adjustable Valve Boxes. Intake Screens. Geared Gate Valves with By-Passes (flange ends). Indicator Attachments for Gate Valves. Valves with Outside Screws and Yokes (screw ends). Basket Screens. Foot Valves (flanged).

#### FORMS OF

# PROPOSAL, SPECIFICATION AND AGREEMENT FOR

### CAST IRON PIPE AND SPECIAL CASTINGS.

In the preparation of the following blank forms of Proposal, Specifications and Agreement, we have carefully examined the standard proposals, specifications, etc., issued by the Water Departments of the leading American and Foreign Cities, and have adopted those requirements which we think to be most fair and just to both the purchaser and manufacturer and will insure the best results, and we feel confident that they will be found to cover all the essential requirements of modern practice.

We shall be pleased if they prove suggestive and helpful in the gradual progress towards greater uniformity in the standards for pipes and specials. This convergence towards a general standard, which would undoubtedly be highly beneficial to both manufacturers and users of pipe, must be through the medium of uniformity in specifications.

#### **PROPOSAL**

то

FOR

#### FURNISHING CAST IRON PIPE AND SPECIAL CASTINGS.

The undersigned, as bidders, declare that they are the only persons interested in the Proposal, and that this proposal is made without any collusion with any other person, firm or corporation; that they have carefully examined the annexed proposed form of contract, and propose and agree that they will contract with the ......in accordance with the specifications herewith.

|      | ITEM.—For allinch straight              | pipethe | sum   | of              |
|------|---|---------|-------|-----------------|
| (\$. | ) per ton of 2000 pounds.               |         |       |                 |
|      | ITEM.—For allinch straight              | pipethe | sum   | of              |
| (\$. | ) per ton of 2000 pounds.               |         |       |                 |
|      | ITEM.—For allinch straight              | pipethe | sum   | of              |
| (\$. | ) per ton of 2000 pounds.               |         |       |                 |
|      | ITEM.—For all special castings, the sum | ofper   | ton c | of 2000 pounds. |

If this proposal shall be accepted by the......within ten days from date hereof, the undersigned agree to execute contract within six days (not including Sunday) from date of receiving notice that the contract is ready for signature.

(Signature of bidder.)



## **CONTRACT**

FOR

## FURNISHING CAST IRON WATER PIPE AND SPECIAL CASTINGS.

| THIS AGREEMENT, made and concluded thisday ofin the year One Thousand Nine Hundredbetweenof the City ofand in the State of, of the  |  |  |  |
|---|--|--|--|
| first part andof the City ofand in the State ofof the second part   |  |  |  |
| WITNESSETH, that the said party of the second part agrees, and by these presents does agree, with the said party of the first part for the considerations hereinafter mentioned, at his own proper cost and expense, to do all the work and furnish all the material called for by this Agreement, at the prices, in the manner and under the conditions named in the following specifications: |  |  |  |
|   |  |  |  |
| SPECIFICATIONS.   |  |  |  |
|   |  |  |  |
| I. The work to be done consists of furnishing, sound and complete in all respects, and in strict conformity with all the conditions and requirements of this contract and these specifications, the following pipes and special castings.   |  |  |  |
| tons of inch straight pipe  |  |  |  |
| tons of inch straight pipe  |  |  |  |
| tons ofinch straight pipe   |  |  |  |
| tons of special castings, more or less, as may be.  |  |  |  |
| with the above pipes, consisting of branches, bends, reducers, caps, curved pipes, sleeves, and all or any other special castings directed by the Engineer in this connection.  |  |  |  |
| 2. All pipes and other castings shall be delivered  |  |  |  |
| ***************************************   |  |  |  |
|   |  |  |  |
| If required by the Engineer, the pipes and special castings shall be delivered to other points than those above specified, in which case the prices paid the Contractor shall be increased or decreased in accordance with the increase or decrease of the cost to the Contractor due to such change.   |  |  |  |

3. Every pipe and special casting shall have cast upon it the initials of the maker's name, and the year

in which it was cast.

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4. The pipes shall be made with hubs and spigots, which shall accurately conform in shape and dimensions to the drawings furnished by the......or our regular standard,

They shall be circular in section, and the inner and outer surfaces shall not be eccentric by more than .08 of an inch.

They shall be of the specified dimensions in internal diameter from end to end. The straight pipe shall be practically 12 feet in length, exclusive of the sockets.

The sockets and spigots will be tested by circular gauges, and no pipe shall be received which is defective in joint room from any cause The joint room for each size shall not vary more than .08 of an inch from the dimensions given in Paragraph 6.

5. The standard joint room, weight and thickness of the straight pipe shall be as follows:

#### LENGTH OF PIPE, EXCLUSIVE OF SOCKET. TWELVE FEET.

| Inside Diameter<br>of Pipe in Inches | Depth of Socket<br>in Inches | Thickness of Joint for<br>Caulking in Inches | Thickness in Inches | Standard Weight,<br>Lbs.                | Hydrostatic Test<br>Pressure, Lbs.      |
|--------------------------------------|------------------------------|--|---------------------|---|---|
| ·····                                | ······                       |  |                     |   | *************************************** |
|                                      |                              | , *************************************      |                     | *                                       |   |
|                                      |                              |  |                     |   |   |
| ••••••                               |                              |  |                     | *************************************** | ******************************          |

6. When the pipe vary from the exact length of 12 feet, the weight given in section 5 shall be modified in accordance therewith.

Defective spigot ends on pipes 12" or more in diameter may be cut off in the lathe and an appropriate shaped band shrunk into a groove cut in the end of the pipe, as shown below. Not more than 8% of the total number of accepted pipes of each size shall be cut and banded, and no pipe will be accepted which is less than II feet in length, exclusive of the socket.

7. No payment shall be made for more than 5% excess of weight above the specified standards, for pipes less than 12 inch, or more than 4% excess of weight above the specified standards for pipes 12 or more inches in diameter.

All pipes shall be rejected which fall 5% below the specified standards for pipe less than 12 inches, or more than 4% below the specified standard for pipes 12 or more inches in diameter.

Whenever it is especially agreed, the total weight of all the pipes contracted for shall not vary more than 2% from the total of the standard weights.

No special castings shall be accepted the weight of which is less than the standard weight by more than 10%, and no excess above the standard weight of more than 10% shall be paid for.

8. The metal shall be of such character as to make a pipe strong, tough, of even grain, and soft enough to satisfactorily bear drilling and cutting, and of at least 16,000 pounds tensile strength per square inch.

Specimen bars of the metal used, each being 26 inches long by 2 inches wide and 1 inch thick, shall be cast without charge as often as the Engineer may direct. These bars, when placed flatwise upon supports 24 inches apart and loaded in the center, shall support a load of 1900 pounds, and show a deflection of not less than .3 of an inch before breaking. Should the dimensions of the bars differ from those given above, a proper allowance therefor shall be made in the results of the tests.

9. All straight pipes 4 inches and over shall be cast in dry sand moulds in a vertical position, the socket end downward.

The pipe shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

- 10. The pipes and special castings shall be smooth, free from lumps, scales, blisters, sand-holes and other imperfections, and no plugging or filling will be allowed.
- 11. All pipes and special casting shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust.
- 12. Unless otherwise directed, every pipe and special casting shall be coated inside and out with coal tar pitch varnish.

The varnish shall be made from coal tar, distilled until the naphtha is entirely removed and the material deodorized. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300 degrees Fahrenheit, immediately before it is dipped, and shall possess not less than this temperature at the time it is put in the vat. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature

The varnish shall be heated to a temperature of 300 degrees Fahrenheit, and shall be maintained at this temperature during the time the casting is immersed.

Fresh pitch and oil shall be added when necessary, to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the Engineer.

After being coated the pipes shall be carefully drained of the surplus varnish. Any pipe or special casting that is to be recoated shall first be thoroughly scraped and cleaned.

- 13. When the coating has become hard the straight pipes shall be subjected to a proof by hydrostatic pressure, and, if required, they shall also be subjected to a hammer-test under this pressure. The pressures to which the different sizes and classes of pipes shall be subjected are stated in Section 5.
- 14. The Contractor shall provide all tools, materials and men necessary for the proper testing, inspection and weighing at the foundry of the pipes and special castings.
- 15. The pipes and special castings shall be weighed for payment under the supervision of the Inspector after the application of the coal-tar pitch varnish, and the weight of each pipe and special casting shall be conspicuously painted in white on the inside before delivery. Care shall be taken to have the painting done after the coating has become hard.
  - 16. The ton shall be the net ton of two thousand (2000) pounds.
- 17. The......shall be at liberty at all times to inspect the material at the foundry, and the moulding, casting and coating of the pipes and special castings. The forms, sizes, uniformity and condition of all pipes and other castings herein referred to shall be subjected to his inspection and approval.

The Contractor shall commence to deliver the pipes and special castings on or tefore......and shall continue to deliver them with regularity by the following schedule until......when the total quantity required by the contract shall have been delivered.



| DATE   | Number of Tons to be Delivered on or Before the Given Dates  |  |
|--|--|--|
| DAIL   | Straight Pipe  | Special Castings   |
| ······································   |  | •  |
| ***************************************  |  |  |
|  |  | ***  |
|  |  |  |
| Theshall pay as full comp<br>this contract, and for well and faithfull   |  | •  |
| For allinch str<br>ton of 2000 pounds.   | raight pipethe sum of  | (\$) per   |
| For allinch str<br>ton of 2000 pounds.   | aight pipethe sum of   | (\$) per   |
| For allinch str<br>ton of 2000 pounds.   | aight pipethe sum of   | (\$) per   |
| For all special casting t  | he sum of(\$) p  | er ton of 2000 pounds.   |
| The prices per ton, above mentioned Section 12 of the specifications, and all ing at the foundry of the pipes and specifications are all ing at the foundry of the pipes and specifications. Theshall once in each mamount of the work done to the time Theshall retain 10% of substituted in accordance with the provisions. Theshall, after the completion amount of work done under the condays after such final estimate is so made under the contract, after deducting the ments shall be subject to correction in IN WITNESS WHEREOF, the page 12 of the page 13 of the page 14 of the page 15 of the page 15 of the page 16 of the page 16 of the page 17 of the page 17 of the page 18 of the pa | the labor and expenses attending call castings, except the salary of nonth make or cause to have mad of such estimate and the value chestimated value as part security to the Contractor, while carrying of this contract, after deducting on of the contract, make or caustract and the value thereof, and and is approved bypay refrom all previous payments. At the final estimate and payment. | the inspection, proving and weighthe Inspector.  e an estimate in writing of the total thereof.  by for the fulfillment of this contracting on the work, the balance not registerefrom all previous payments. See to have made a final estimate of the |
| ••••••   |  |  |
| ••••   |  |  |
| ,  | Water Board of   |  |
| •.••••   | •••••••••••  |  |
| ••••••••••   |  |  |

CONTRACTOR.



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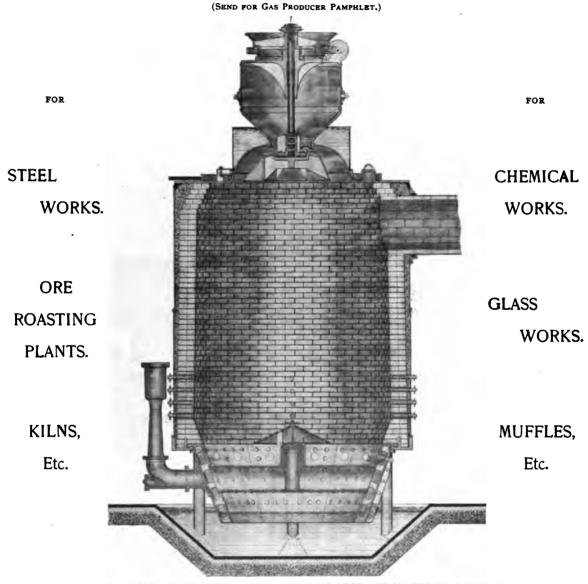


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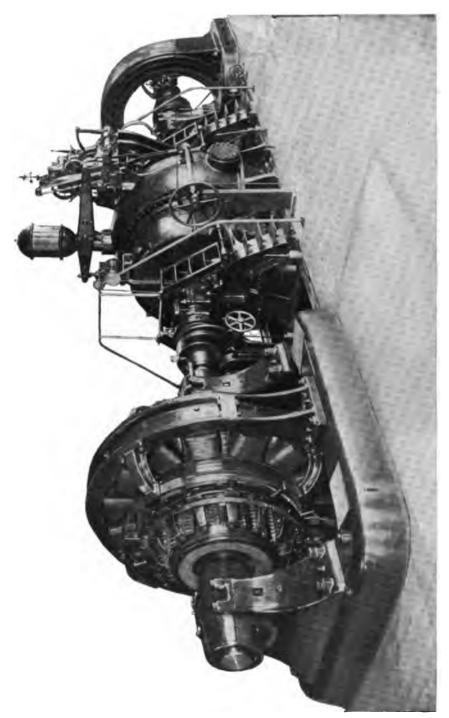


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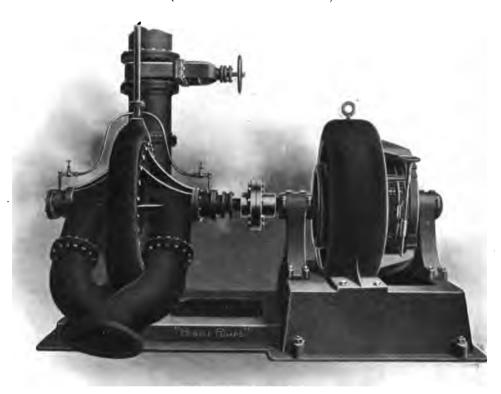
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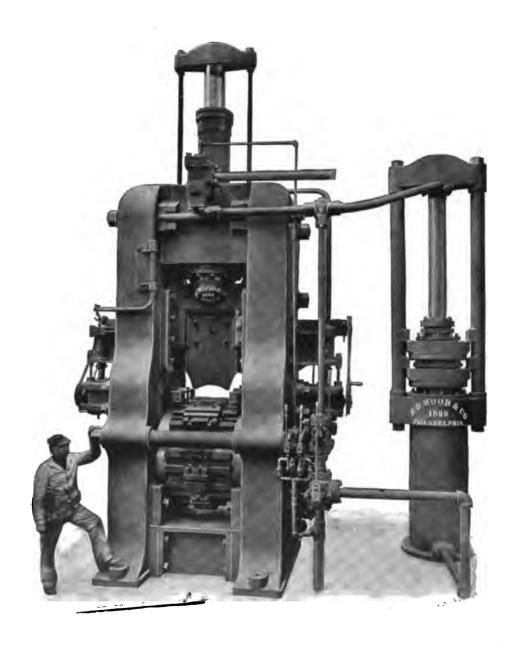


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