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WOODEN STAVE PIPE

ALLEN'S PATENT.

No. 359,590.

Issued March 22, 1887.

BUILT BY

THE EXCELSIOR WOODEN PIPE CO.

204 FRONT STREET,

SAN FRANCISCO, CAL.

C. A. HOOPER & Co., Agents.

D. C. HENNY, Manager and Engineer.

SAN FRANCISCO.

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PREFACE.

THIS book is intended to call the attention of the public to our wooden stave pipe, and to furnish such general information in regard to it as will make its construction and its many advantages easily understood.

The list of prices is applicable to certain pressures only, and is given as a sample and for the purpose of general comparison with other classes of pipe. This pipe is so readily accommodated to the special needs of each occasion, as regards thickness of wood, banding, etc., that it was found impracticable to furnish a more complete list of prices.

For making definite estimates a number of data are required, as is shown on blank question sheets, which we furnish upon application. These sheets being filled out and returned to us, we will promptly furnish estimates of cost.

Tables on carrying capacity of wooden pipes are appended, which we hope may be of value to engineers. They were especially prepared for this book, and should be used with such restrictions as are set forth in their preface.

PRICE LIST OF REDWOOD WATER PIPE.

Banded every 12 inches.

Including cost of erection and reasonable distance of hauling, but exclusive of cost of excavation and back filling, and of freight from San Francisco.

Inside Diameter.	Staves from	Thickness Finished Stave.	Diameter Steel Bands.		Price per Lb. Foot.	Weight per Lb. Foot.		Safe Head.
			inches	Straight. Upset.		WOOD.	METAL.	
12 inches.	2 x 6	1 1/8 inches.	12	Straight.	\$0.70	14 lbs.	2.5 lbs.	25 feet.
16 "	2 x 6	1 1/8 "	16	"	0.85	18 "	2.8 "	20 "
20 "	2 x 6	1 1/8 "	20	"	1.15	23 "	6.2 "	25 "
24 "	2 x 6	1 1/8 "	24	"	1.35	28 "	7.0 "	25 "
30 "	2 x 6	1 1/8 "	30	"	1.60	34 "	8.0 "	25 "
36 "	2 x 6	1 1/8 "	36	"	1.80	41 "	9.1 "	25 "
42 "	2 x 6	1 1/8 "	42	"	2.05	50 "	10.3 "	22 "
48 "	2 x 6	1 1/8 "	48	"	2.30	56 "	11.5 "	20 "
54 "	3 x 8	2 1/8 "	54	"	3.80	111 "	22.8 "	25 "
60 "	3 x 8	2 1/8 "	60	"	4.20	123 "	24.5 "	24 "
72 "	3 x 8	2 1/8 "	72	"	5.00	154 "	28.0 "	20 "
84 "	3 x 8	2 1/8 "	84	"	6.90	241 "	45.6 "	25 "
96 "	4 x 10	3 1/8 "	96	"	7.80	274 "	51.3 "	22 "
108 "	4 x 10	3 1/8 "	108	"	9.60	318 "	74.4 "	25 "
120 "	4 x 10	3 1/8 "	120	"	10.60	353 "	82.0 "	22 "

Note.—For Eastern points a saving in freight on steel rods and a lower price of castings will partly or entirely compensate for an increase of freight on lumber. Exact prices for any point will be furnished upon application.

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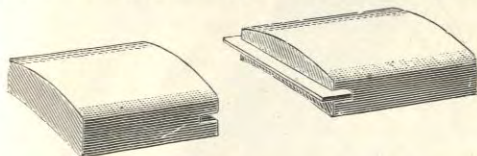
SOME ADVANTAGES OF OUR WOODEN STAVE PIPE.

- It is cheaper than any other equally durable pressure pipe.
- It is more durable than sheet-iron or steel pipe.
- It is cleaner than any other pressure pipe.
- It has greater carrying capacity.
- It retains its capacity.
- It does not form incrustations or tubercles.
- It never bursts.
- It will not break by settlement.
- It can be laid to true curves.
- It is easily tapped.
- It can be built in a trench with six inches of water.
- It can easily be taken up, without straining or damaging any parts.
- It can be easily repaired.
- It can be made to any diameter.
- It is equally strong throughout, the banding being graduated to the pressure.
- It is continuous.
- It requires no derricks to lay it.
- Its parts can be lowered in closely braced trenches.
- Its parts are light and easily handled, and can be cheaply transported over the most mountainous and inaccessible country.

DESCRIPTION OF PIPE.

The pipe is composed of wooden staves, banded with steel hoops.

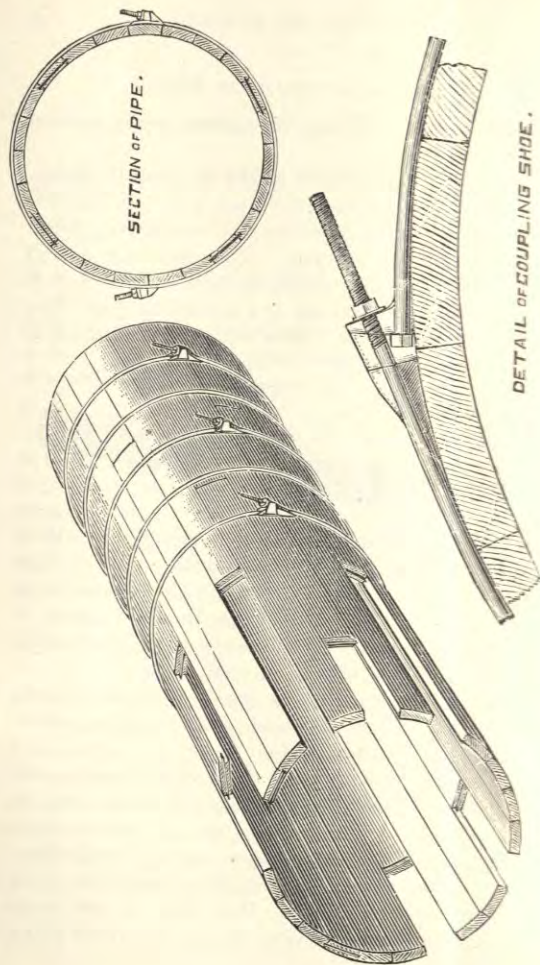
The staves are dressed on the flat sides to circles, and on the edges to radial lines, a certain number of these staves completing a true circular ring, forming the shell of the pipe. The staves are cut off square at the ends, and have a saw kerf cut across the face for the insertion of a metallic tongue. The width of the kerf is a little less than the thickness



of the tongue, and its depth is slightly less than half the width of the tongue, which is driven into place by light taps of a hammer. The tongue being cut about a quarter inch longer than the width of the stave, the ends penetrate the adjoining staves, thus securing a tight butt joint.

The staves are built in the pipe so as to break joints, and no two adjoining joints are placed nearer each other than twenty-four inches.

The bands are of round steel, with a head at one end, and a thread, from three to six inches long, at the other end. The two ends are held together by a cast or malleable iron shoe or saddle. The bottom of the shoe is shaped to a circle to make it fit upon the outside of the pipe. Both ends of the bands drop into the casting from the top, shoulders being



provided for the head and nut to rest against. The strain of the band produces a straight pull on the casting; and the entire band, when in place, lies in a plane, perpendicular to the direction of the pipe. The turning of the nut tightens the band and pulls the staves together. When the bands are spaced for high pressure the power of the numerous nuts turned up at even moderate tension, is sufficient to crush the wood and collapse it, if carelessly exerted. The effect of this construction, when the bands are at proper tension, is to produce a stiff, hollow beam of wood of enormous strength, and which for rigidity against flattening is only equaled by cast-iron pipe.

METHOD OF CONSTRUCTION.

This pipe is never built in the shop and sent out in sections like other pipe, but is invariably constructed in the trench where it is to lie. This trench is usually cut fifteen to eighteen inches wider at the bottom than the outer diameter of the pipe, to give standing room for the workmen on each side. Two "U" shaped outside forms are placed on blocks, ten or twelve feet apart; and the staves, forming the lower half of the pipe, are laid in place so as to make the ends break joint. In the half-circular cradle thus formed, inside forms are placed, and the remaining staves are put in place. Bands are then put on and tightened up, while the pipe is carefully rounded out; so that no stave projects beyond the adjoining staves, and the pipe is perfectly round and smooth. The nuts are turned by means of a brace-wrench with socket end. It is usual to place the bands in such a manner on the



ERECTION OF PIPE.

pipe as to bring the shoes upon the upper half, alternating on one side and the other side of the pipe, with the nuts on top of the shoes and the threaded ends of the rods running up. This facilitates the work of cinching, and leaves the castings easy of access.

After this first section is erected the earth is tamped under and around it, and the trench back-filled to hold it firm in its place. The outside and inside forms are then removed, and the pipe is ready to be extended in both directions. First the clips are inserted in the slotted ends of the staves, then the outside form is put on block, and the lower half of the next section is built up. Then the inside form is put in place and the upper half of the section built, the staves being driven up with a light hammer, and care being taken to secure a proper breaking of joints. Then the bands are put on and tightened, whilst the pipe is carefully rounded out. Then the staves are driven up with a heavy sledge and driving stick, a work that requires the utmost care, as the butt ends of all the staves must come to a perfect bearing. Thus the work of erection may continue, the first gang being followed up by the "back cinchers," who square up such bands as are not perpendicular to the direction of the pipe, by hammering on the staves bring them to a more perfect bearing, and secure this bearing by still further tightening of the bands. Immediately after the final cinching the trench is back-filled sufficient to cover the pipe, care being taken to tamp the earth thoroughly under and alongside the pipe to prevent settling.



NO. 1. PREPARING FOR BUCKLE

Where two gangs meet from opposite directions a "buckle" is made, the staves of the closing section being cut about one - sixteenth of an inch longer than the place in which they are to fit. Thus the staves buckle out until the tightening of the rods pulls them together.

The construction of this pipe seems simple to those not acquainted with it, but years of experience have proven that great skill and conscientious care are required to produce water - tight work, and that there are a great many little niceties to be observed in construction which make all the difference between success and failure.

CONNECTIONS.

Connection is made with cast - iron pipes or gates by means of a special casting, provided at one end with a spigot or bell for ordinary lead connection, and at the other end with a bell of sufficient size and depth for the wooden pipe to enter it about seven inches and leave a space of about one - fourth inch between the outside of the wood and the inside of the bell, this space to be caulked for its full depth with oakum.

Where large branch lines are to be taken off the wood main, connection is made by means of a special casting or "T" of cast-iron with bell-ends. Taps from three to six inches diameter are made by a cast-iron saddle "T" of segmental form, resting on the pipe and held in place by the bands with a gasket of rubber or lead between the pipe and saddle. Smaller taps are made by boring a hole and inserting a corporation cock or a nipple with lock nut.

Check valves for the admission of air when the pressure is suddenly relieved, air valves, blow-off gates and stand-pipes should be placed where required. Gradual changes of size may be made by the tapering of one or more staves; and the end of the pipe can in a similar manner be made funnel-shaped to facilitate the entrance of the water.

BANDING.

The bands around the pipe answer the following purposes:

First—They pull the staves together, preserve the shape of the pipe and make the seam joints tight.

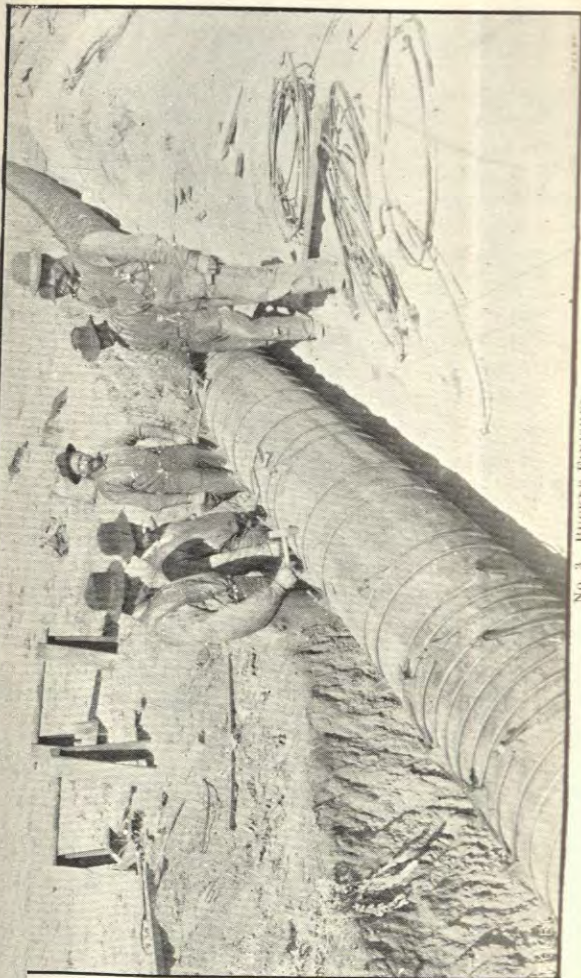
Second—They prevent the pipe from bursting when the water is under pressure.

Third—They provide supports for the staves sufficiently close together to prevent them from bending out or being indented to an excessive degree.

For a pipe line laid on grade it depends upon the thickness of the wood, the character of the ground and the superincumbent load as to how close the bands should be spaced. In favorable circumstances a spacing of eighteen inches from center to center will be sufficient, provided that good material is tamped around the pipe to give it an even bearing.

For pressure pipe, all the purposes which the bands are designed to serve should be taken into account, when calculating the spacing of the bands. In a general way we can state, however, that if the diameter of the bands is duly proportioned to the size of the pipe, and they are figured for bursting strain alone with a factor of safety of four, the





No. 3. BUCKER FINISHED.

bands are then spaced sufficiently close to leave the staves safe from undue strains. The strength of the rods should be figured in their weakest section. The factor of safety to be used must necessarily be left to the judgment of the engineer, who should take into consideration the strains which may come on the pipe, other than those caused by the static water pressure, such as water hammer, strains due to action of the pipe as a beam or arch, etc. We would suggest, however, that the factor of safety should not be smaller than four.

MATERIALS.

Wood.—The wood used for pipe staves should be sound and clear, free of knots, shakes and other imperfections. It should be strong enough to resist crushing under a firm tensile strain on the bands, and should not soften or become spongy when saturated. It should contain no pitch, and should not shrink or swell excessively. The wood that has been most largely used in pipes built during the last few years is California redwood, for reasons which are explained in another part of this book. The staves are dressed with the utmost care and are shipped in box cars. After unloading they are stacked and not strung out along the trench until immediately before being used.

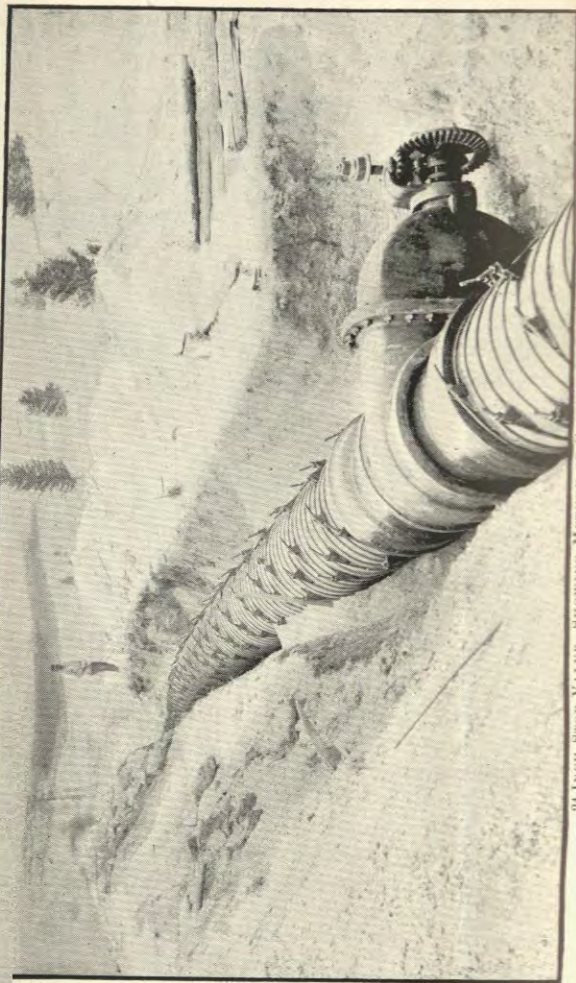
Bands.—The bands are made of mild steel, having a tensile strain of from 58,000 to 65,000 pounds per square inch, according to their size, with an elongation in eight inches of twenty per cent. or over. At one end they have heads, the rods being slightly swelled under the heads. At the other

end threads are cut, from three to six inches in length, for which distance rods, one-half inch or more in diameter, are upset, to leave the full strength of the rods available. On large pipe two segmental bands are used, one with two heads and the other with two threaded ends, requiring two shoes to complete the circle. The bands are shipped as straight rods, tied up in bundles. They are delivered on the line and there bent on bending tables. They are then coated with red oxide paint, or dipped in a special preparation of asphaltum.

Shoes.—The shoes are made of best tough cast-iron or of the best quality of malleable iron. They are run through the rumbler to free them of sharp edges, splints and tags. They are coated with paint or asphaltum, the same as the bands.

Clips.—The clips, or concealed metallic tongues, are sometimes shipped ready cut and boxed, or they are shipped as band iron in bundles and cut on the work with eccentric shears. They are one and a half inches wide and of No. 12 or No. 10 B. W. G. iron, according to size of pipe.

24 INCH SHIP VALVE SHOWING METHOD OF CONNECTION WITH WOODEN PIPE.





WOODEN PIPE REDUCING FROM 24 TO 20 INCHES TO CONNECT WITH
20-INCH IRON PIPE.

USES OF WOODEN STAVE PIPE.

Domestic Water Supply.

Our pipe is especially adapted for long supply mains. Its cheapness in comparison with other kinds of pipe enables cities to obtain their supply from sources both pure and of sufficient elevation to render the use of expensive pumping plants superfluous. In a report of the Pueblo Gravity Water Company, dated October, 1891, Mr. James D. Schuyler, Civil Engineer of Los Angeles, Cal., recommends this pipe. We quote:

"This recommendation has been made for the following reasons:

"*First*—After thoroughly investigating the history of wooden pipe as laid for seven years past in Colorado, and after examining a number of lines in use, I have come to the conclusion that, if the bands are properly coated and the pipe kept full of water, it is practically indestructible, and certainly has a longer life than sheet-iron or steel-riveted pipe.

"*Second*—The interest on the *difference* in cost between wood and cast-iron pipe of the same capacity will replace the wood pipe every ten years, which I think is but a fraction of the life of wood



COMPOUND CURVE.

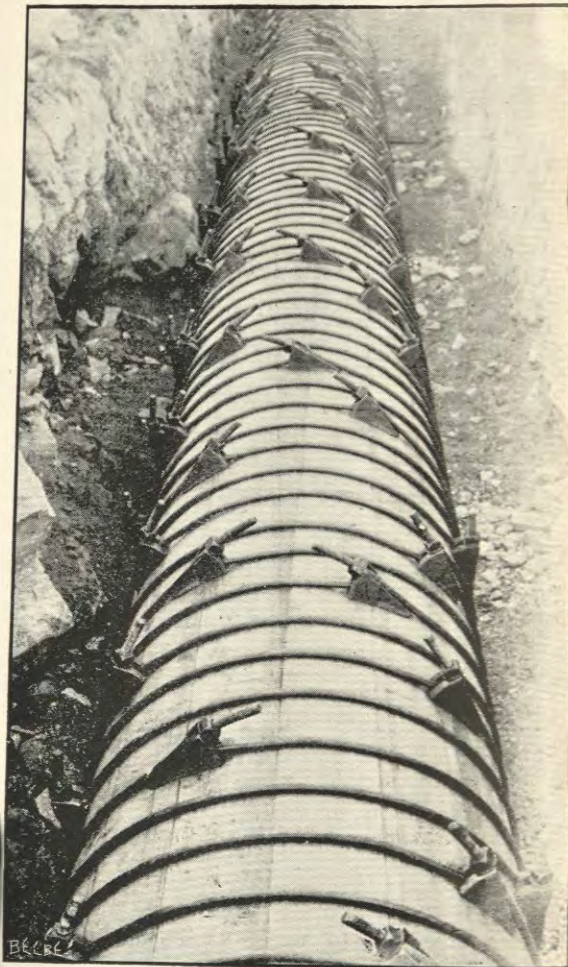
pipe, and therefore it would be a prodigal waste of money to put the amount of capital necessary to lay cast-iron mains into the enterprise.

*“Third—*The wood pipe is cleaner, does not become foul, does not rust, does not fill with tubercles that diminish the capacity year by year, has no yarn to rot and contaminate the water, will not break by settlement, will not burst so readily under water hammer, and so long as it lasts is in every respect cleaner and more desirable.”

The comparison of cost between wood and cast-iron refers to a twenty-four-inch pipe. The same engineer in his report to the Citizens' Water Company of Denver says of the sixteen miles of thirty-inch wooden pipe, constructed in 1890, from Platte Cañon to Denver, that interest at six per cent. on the difference in cost would permit of the reconstruction of the entire line of wooden pipe every five and one-half years, as against cast-iron pipe, and every nine and one-third years, as against wrought-iron pipe. Nearly all of this pipe line is under a head exceeding fifty feet, and on a portion of it the head is 210 feet.

The Denver Water Company (a corporation distinct from the Citizens' Water Company) receives its entire supply through wooden stave pipe from the Platte River, through three and one-fifth miles of forty-eight-inch wooden pipe, built in 1884, and from Cherry Creek through five and three-fourths miles of thirty-seven-inch wooden pipe, built in 1887.

The following is a list of cities in which our wooden pipe is used for main water-works conduits:



CHANGE FROM 15 TO 16 STAVES IN 24-INCH PIPE.

NAME.	Diameter in Inches	Length in Miles.	Max Head in Feet.	Date of Construction.
Denver, Colo....	12-48	53.3	210	1883-1892
Cheyenne, Wyo...	24-30	2.6	60	1889
Ogden, Utah....	24	4.0	60	1890
Provo, Utah....	14	3.7	165	1891
E. Denver, Colo..	12	3.0		1891
Butte, Mont.....	24	9.0	200	1892
Pocatello, Idaho.	14	0.6	50	1892
Logan, Utah....	18	1.6	75	1893

TESTIMONIALS.

PORTLAND, OR., Jan. 5, 1894.

*Excelsior Wooden Pipe Co.,**No. 204 Front St., San Francisco:*

DEAR SIRs—In your prospectus I notice that you have quoted from a report which I made to the Pueblo Gravity Water Company of Pueblo, Colo., certain reasons, which I advanced, for recommending the adoption of wooden stave pipe for the main conduit. Subsequent experience which I have had in the construction and maintenance of that class of pipe entirely sustains and corroborates the conclusions therein set forth.

As consulting engineer of the Citizens' Water Company, I advised the construction of a second conduit, consisting of about three miles of 30-inch, 15 miles of 34-inch and two miles of 44-inch wooden stave pipe, in addition to the first conduit of some 16 miles of 30-inch pipe of the same class, built in 1889-90. These lines (constituting the second conduit) were put in use immediately after completion in 1892, and have given entire satisfaction. The 34-inch pipe withstands a maximum head of 11 feet, and the 44-inch a maximum of 165 feet witho

leakage. Wherever the pipe in service was examined it was found to be saturated with a slight moisture on the outer surface that could be brought out as a trickling ooze by scraping the outer skin. A section of the first conduit was cut out where the two lines crossed, and the wood was found to be in perfect condition, showing no sign of unsoundness, either inside or out, but it had lost its buoyancy and would sink in water like so much lead. The wood was Texas yellow pine. For large conduits where pressure is moderate, the wooden stave pipe must certainly come into general use, because of its economy and durability as compared with any other material at present known.

Yours very truly,

JAS. D. SCHUYLER.

BUTTE CITY WATER COMPANY. }

BUTTE, MONT., Dec. 23, 1893. }

To whom it may concern:

The Excelsior Redwood Company built about nine miles of their California redwood pipe for this company during the fall of 1892. This was a 24-inch pipe, extending from the main reservoir to within three miles of the city. This pipe has been in operation for the past year without interruption. The pipe is designed and banded for pressures varying between 200 feet maximum and 100 feet minimum. At the time of completion, owing to the fact that our dam was not completed, we were unable to test it to the full static pressure for which it had been built; however, by the use of the city pumps we raised the pressure to within thirty-five feet of the required static head.

I take pleasure in stating that it has fulfilled all the requirements claimed for it by the company.

The leakage under the test was considerable at first in actual quantity of water, though very small when the length of the pipe was taken into consideration. One week after starting the water through, however, there were no visible leaks on the whole line, and in fact there were no large leaks at any

place, either during the test or afterwards, many of them being a mere seepage, which stopped as soon as the wood became thoroughly saturated with water. During the twelve months of operation no defects have shown themselves, and I am much pleased with the pipe in every particular.

During the last winter we had considerable trouble for two or three weeks with ice getting into the pipe. This, however, was from no fault of the pipe, and we were enabled to take the pipe apart at different places with much less expense than we could have done had it been a metal pipe.

An examination of the pipe at different places during the last few months shows it to be in perfect condition; the wood apparently is thoroughly water soaked, and I see no reason why the life of the pipe does not depend on the life of the steel bands. If my theory is correct, I see no reason why the pipe could not be made as good as new, when we find the bands beginning to rust, by replacing the banding entirely.

I have no hesitancy in recommending the pipe for any like service, and will be pleased at any time to give any information asked in regard to it.

EUGENE CARROLL, Supt.

AGRICULTURAL COLLEGE OF UTAH, }

LOGAN, UTAH, Dec. 27, 1893. }

D. C. HENNY, C. E.,

Manager Excelsior Wooden Pipe Co.,

San Francisco, Cal.:

DEAR SIR—I take some pride in the fact that I was the first to introduce wooden stave pipe in Utah, and perhaps on the Pacific Slope.

During an experience of seven or eight years with this kind of piping the conviction has gradually grown upon me that it is just what we need to help us develop the resources of this great arid domain. With us "water is king," and any contrivance that will enable the irrigator, mill-owner or municipality to conduct water cheaply and well is certain to become popular.

Its use in irrigation works has but just begun. In a few years, when our irrigation engineers become more familiar with its use, small wooden flumes on trestles and rectangular boxes held together by wooden yokes for inverted siphons will be considered bad engineering.

Again, in the development of our water privileges, rendered valuable on account of the electrical transmission of power, the old-fashioned mill-race and low-pressure water-wheels are being substituted for high heads and circumferential wheels. Such construction requires pipes; few companies can afford iron pipes, and hence the development of these enterprises will depend to a large extent upon the use that is made of some cheaper piping like the one under consideration.

In regard to water-works systems, my experience with the pipe manufactured by you has been entirely satisfactory. In the four mile conduit for Ogden water-works the water has never been turned out of the pipe since it was first filled, over three years ago, and a cast-iron pipe could not have cost less in annual operating expenses.

Wishing you every success, I am,

Yours respectfully,

SAM'L FORTIER,

Professor of Civil and Hydraulic Engineering.

LOGAN, UTAH, Dec. 26, 1893.

Excelsior Wooden Pipe Co., San Francisco:

GENTLEMEN—Yours of the 18th inst. is duly at hand, and we up to the present time are well satisfied with our wooden pipe line. No leak or other defect has as yet shown itself, though the whole line is in use for over six months and tested to its full capacity. We are up to now perfectly satisfied.

Wishing you success, we are,

Respectfully,

JAMES ADAMS,

Chairman Water Committee.

C. SCHAUB,

Engineer in Charge.

POCATELLO, IDAHO, Jan. 4, 1894.

Excelsior Wooden Pipe Co., San Francisco, Cal.:

GENTLEMEN—In the summer of 1892 you furnished us with all the required material for about 3,250 feet of 14-inch redwood stave pressure pipe. This pipe was needed in connection with our main supply conduit for the city water-works. It has been in uninterrupted use ever since and has given us good satisfaction.

CALDWELL & CALDWELL,
Lessees Pocatello Water Company.

DENVER, COLO., January 8, 1892.

Excelsior Redwood Co., San Francisco, Cal.:

GENTLEMEN—The redwood water pipe built by us for the city of Provo, Utah, proves satisfactory in every respect. The lumber furnished therefor by your agents, Messrs. C. A. Hooper & Co., was clear and milled to perfect proportions, so that there was no trouble in building the pipe in the trench, and there were no leaks that gave trouble in stopping. Redwood is undoubtedly the best for pipe.

Respectfully,

RHODES BROS., Contractors.

DENVER, COLO., January 12, 1894.

The Excelsior Wooden Pipe Co., San Francisco, Cal.:

GENTLEMEN—In response to your request for a testimonial as to the use of wooden stave water pipe in this city and vicinity, it gives me pleasure to record the history of that class of pipe, as far as experience has developed it in this neighborhood.

For the past eight or nine years the entire water supply of Denver has been brought to the city through the "Allen patent" wooden pipes. The first line, three and one-half miles long, forty-eight inches in diameter, was built in 1884. This was followed by a second conduit thirty-seven inches in diameter, five and three-fourths miles long, some two years later. Both of these lines are still in use and apparently in good condition. They are now the property of the American Water Works Com

pany, successors to the original Denver Water Company.

The Citizens' Water Company, organized in 1889, constructed in that year and the spring of 1890 the longest wooden pipe line in the State — from Platte Cañon to the city. It is thirty inches in diameter, and has, in places, to withstand a pressure of 220 feet. It has been operated continuously since its completion, and has never given any trouble, to my knowledge. Where it traverses the streets of the city, there has been little or no complaint of leakage. The company has during the last year finished the construction of a second conduit, thirty-four inches in diameter. It has a maximum pressure of 150 feet. There are now some seventy miles of wood pipe leading to the city, all of which, as far as my observation goes, is in satisfactory condition.

With those familiar with its construction and its apparent great durability, wooden pipe maintains an excellent reputation in this section, and it is becoming recognized by engineers as a valuable and economical substitute for iron pipe under certain conditions.

Yours truly,

J. B. HUNTER,
City Engineer.

DENVER, COLO., January 13, 1893.

The Excelsior Wooden Pipe Co., San Francisco, Cal.:

GENTLEMEN—The use of wooden stave water pipe, as constructed at Denver, being a novelty to many engineers having to deal with the supply of water through pipes, has awakened much interest among them, and caused many inquiries to reach me from various sources.

It is, perhaps, but natural that this office should be looked to for advice relating to the use of wood pipe, because no doubt it is generally supposed that matters pertaining to the supply of water for our city rest, at least in part, with this department, and because of the fact that such pipe has been, perhaps, more extensively used in connection with the water supply in this city than anywhere else.

For the last eight years the entire water supply for Denver has reached the city through wooden conduits of the style of construction as patented by C. P. Allen. In some instances, I am told, they are working under a pressure due to a head of from 100 to 200 feet without showing any very serious weakness or appreciable leakage. This not occurring in the pipe of more recent construction, and where many improvements over the original style of construction have been adopted. I would say that so long as wooden pipes, such as you now make, are kept filled with water, they bid fair to resist decay for an indefinite period, and judging from the *purity* and *healthfulness* of the water daily consumed by our citizens, there would seem to be no objectionable contaminating features due to the wood connected with their use. I am also credibly informed that no difficulties are experienced in keeping joints tight, or in stopping any leakage that might occur. Therefore, it seems to me where a large body of water is to be gotten from the source of supply to a remote point of delivery quickly, and at the same time cheaply, and where very high pressures do not have to be provided for, your pipe is just the thing to be used.

Respectfully,

H. F. MERRYWEATHER,
Engineer Board of Public Works.

DENVER, COLO., January 16, 1894.

The Excelsior Wooden Pipe Co., San Francisco, Cal.:

GENTLEMEN—This company, when it began the construction of its gravity system for supplying this city with water, after careful and exhaustive investigations as to the merits of the "Allen" patent wooden stave pipe, adopted it exclusively for conveying water to the city limits for distribution through its pipe system. The company now has in constant use about forty-five miles of this pipe varying in diameter from thirty to forty-four inches. In some places along the line it is under a pressure of 150 to 200 feet head. In no case has it caused

any trouble on account of breakage or repairs. As a conduit for water, we consider it superior to cast iron pipe; first, because of its perfect cleanliness; second, its carrying capacity being from ten to twenty per cent. more than that of iron pipe because of less friction; third, it is so easily and inexpensively repaired; fourth, it is so much more economical in construction, the average cost being not to exceed one-fourth that of cast iron pipe.

We know of its having been constantly in use for a period of ten years without showing any perceptible signs of decay, and from our knowledge of it we believe it to be absolutely indestructible, so long as it is in constant use and filled with water. Our faith in its efficiency and durability is proven by the fact that this company has already expended over \$2,500,000 on a water system which depends entirely on the "Allen" pipe as a conduit for the constant supply of water, conducted a distance of more than twenty miles from the source of supply to the city limits.

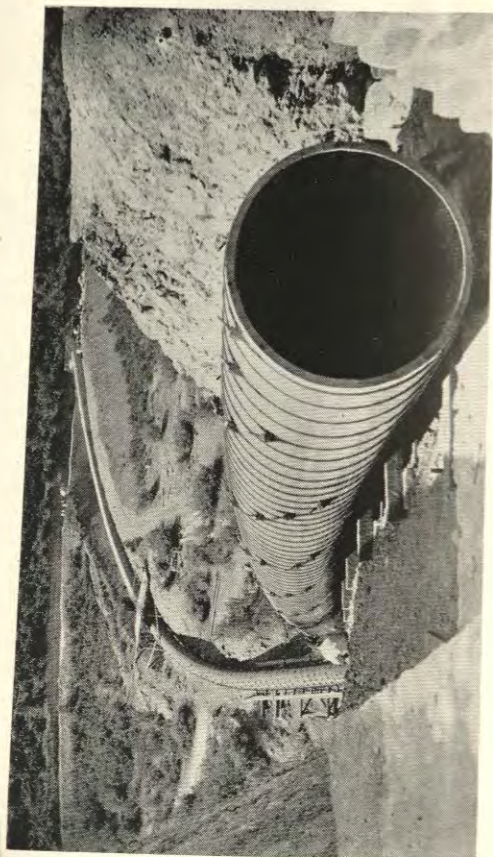
Very truly yours,

THE CITIZENS' WATER COMPANY,
RICHARD HOLME, Manager.

Irrigation.

Wooden flumes, which carry irrigation water on grade over rivers and depressions, are a familiar feature of irrigation canals. They have some serious disadvantages, which render different methods of conveying the water very desirable. Exposed as they are to the action of the wind and sun, the wood warps and cracks, and since they are alternately wet and dry the wood rots quickly. The trestles upon which they rest form an obstruction to the water in the creeks over which they cross, which, when coming down in freshets, endangers the entire structure. To overcome these objections there have been used, in exceptional cases, inverted siphons, with rectangular cross-section, built in the manner of a long horizontal pen stock. They cannot be made to withstand great internal pressure, however, and are therefore confined to situations where the dip below the grade line of the canal is slight. In ordinary cases, where the dip is more than eight or ten feet, these structures are out of the question. On some of the canals constructed during the last few years wooden pipe has been used with great success.

The pipe, when buried in the ground, is protected from the action of the atmosphere, and leaves no obstructions to the flow of surface water over it. It may be kept full of water the year round, or where danger of freezing exists the water may be drawn off through a gate at the bottom, at the end of the irrigation season. In places where flumes with ordinary height of trestle can be used, an inverted siphon will often be found more economical.

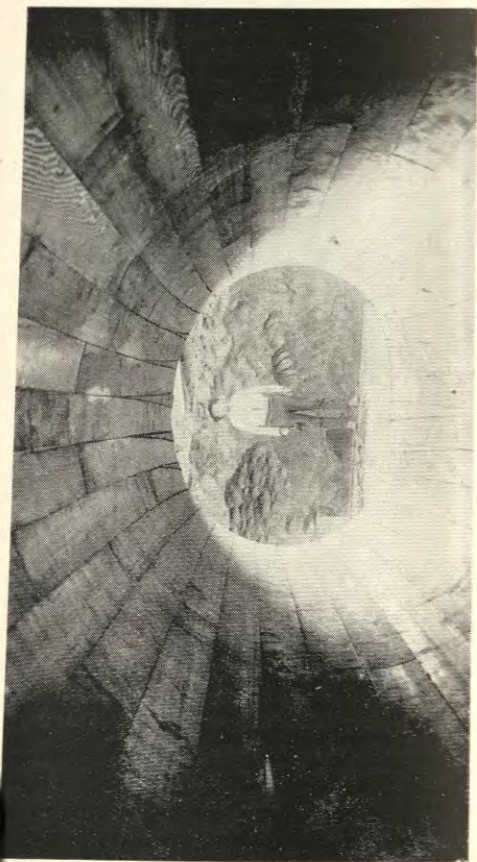


52-INCH INVERTED SIPHON.

Where the dip is so great as to put fluming out of the question, a straight pipe line may be run across, frequently saving many miles of canal. Where water is developed from underground sources it is of importance that water collected at great expense should all be saved and not be allowed to seep away in the ground before reaching its destination, to which clear water is particularly liable. Pipe lines instead of canals are for this reason best adapted to conduct this water. They will also save whatever evaporation there may be from the open ditches, will do away with the troublesome growth of algae in this kind of water and with the annual expense of cleaning, and will admit of a continued flow during the winter season by filling storage reservoirs. There is also a saving in the cost of right of way, as they do not show on the surface, and may often be laid for long distances along the county roads.

When water is put upon the land by pumping, pump mains are required, for which our pipe thoroughly recommends itself on account of its relative small cost and great carrying capacity. It offers not the temptation, for the sake of saving in cost of construction, to adopt too small a size of pipe, as the cost of our pipe does not increase with its diameter as fast as do other kinds of pipe. Thus a continual saving in fuel and operating expenses results, which may make all the difference between a money-making and a money-losing enterprise.

A notable instance of a successful irrigation pumping plant is furnished by the works built near Yuma, Arizona, by Messrs. Blaisdell & Hicks, who combined costly pumping machinery of the greatest



INSIDE OF FLARING END OF 72-INCH INVERTED SIPHON.

efficiency with a large wooden main pipe, thus securing marvelous economy in fuel consumption.

Our pipe has been used for irrigation, as is shown in the following list:

NAME.	Diameter in Inches.	Length in Miles.	Max. Head in Feet.	Date of Construction.
Maxwell Grant, N. M. . . .	72	0.07	25	1889
Fort Garland, Colo.	37 & 48	0.06	10	1889
Berkley Lake, Denver. . . .	24	1.13	70	1889
Bessemer Ditch, Pueblo. . .	54	0.80	70	1890
Parachute, Colo.	16 & 32	0.25	50	1892
Gothenburg, Neb.	72	0.20	38	1892
Yuma, Ariz.	26	2.75	92	1893
Bear Valley Irr. Co., Redlands, Cal.	52	0.43	162	1893
Kern County Land Co., Bakersfield, Cal.	72	0.03	12	1893

TESTIMONIALS.

SAN FRANCISCO, December 26, 1893.

MR. D. C. HENNY, C. E.,

Manager Excelsior Wooden Pipe Co.,

San Francisco, Cal.:

DEAR SIR—The three wooden pressure pipes put in by your company for the Bear Valley Irrigation Company in the line of the Santa Ana Canal in San Bernardino County, Cal., under my supervision, have now been under pressure and in use for several months.

They are 52 inch (inside) diameter pipes, and are under about 61, 158 and 162 feet maximum heads of pressure, respectively, and aggregate about 2,400 feet in length.

It gives me pleasure to say that this pipe job has been exceptionally well done and that the result is satisfactory and gratifying.

Respectfully yours,

WM. HAM. HALL,
Chief Engineer Bear Valley Irrigation Co.

OFFICE OF KERN COUNTY LAND COMPANY, }
BAKERSFIELD, CAL., Jan. 25, 1894. }

Excelsior Wooden Pipe Co., San Francisco:

GENTLEMEN—The 72-inch pipe placed by your company for the purpose of passing the Lerdo Canal under the bed of Poso Creek is very satisfactory. It will undoubtedly answer the purpose much better than any other structure that could have been made of lumber, and costs less money.

We will use the same kind of pipe, 48 inch in diameter, to pass the water under the railroad.

Yours truly,

WALTER JAMES,
Chief Engineer Kern Co. Land Co.

YUMA WATER AND LIGHT COMPANY, }
YUMA, ARIZ., Dec. 22, 1893. }

D. C. HENNY, Manager,

Excelsior Wooden Pipe Co., San Francisco, Cal.:

DEAR SIR—The 26-inch Allen patent wooden pipe laid by us in December, 1892, is giving entire satisfaction. It is used as a force main to connect our 8,000,000 gallon pump with a reservoir on Yuma heights, two miles distant. The maximum working pressure is forty pounds.

H. W. BLAISDELL, Manager.

L. A. HICKS, Engineer.

THE RIVERSIDE ORCHARD AND IRRIGATION Co., }
RIFLE, COLO., Dec. 20, 1893. }

Excelsior Wooden Pipe Co., San Francisco, Cal.:

GENTLEMEN—We think it due to you to state that the two sections of wooden pipe which you placed last spring in connection with our irrigating canal—one 32-inch diameter and 949 feet in length; the other 16-inch diameter and 175 feet in length—have proven entirely adequate to the use for which intended, have given us no trouble, and have not leaked a particle. As you are aware, our canal is about twenty-five miles long, and at the two points where your pipe was placed it was impracticable to convey water by any ordinary method. We are now convinced that it would have been better for us to have used your pipe in some places where fluming was built.

H. W. HALLETT, Pres't.

Water Power.

With the development of electric machinery water power is beginning to be utilized on a large scale in mining and other operations. The construction of flumes in mountainous districts, frequently along the face of rocky bluffs, is often a tedious and expensive undertaking. Sometimes the construction of flumes is out of the question, where a gradual descent of the country leaves no opportunity to support them, except by means of trestling. In such places our pipe will be found both expedient and economical. Being covered over they may be relied upon at all seasons, since neither frost nor snow can interfere with the steady flow of the water. For hydraulic mining wooden pipes will compare favorably with the light sheet-iron pipes, possessing the same advantage of being easily taken up and erected elsewhere.

Our pipe is also peculiarly adapted to the carrying of acidulated or saline waters, as there is no metal exposed on the inside of the pipe, and for large drains and sewers.

DURABILITY.

The fact that wood, where in frequent intermittent contact with water, is observed to rot fast, is no evidence that it does so when continually submerged. Hundreds of important stone structures depend for their stability and support on wooden piles; and when the precaution was taken to use none but good material, and to keep it below low water level, no trouble has been experienced. These structures have stood the test of time, some of them for many centuries, and where parts have been removed, and old piles taken up, they have been found to be sound. Wooden-bored water pipes of small diameter have been largely used in England and in some of our Eastern cities, and when dug up, after many years of service, they have been found as sound and clean as when they were put in. In 1829 a line of two miles of wooden pipe was laid, with three-inch bore, at Fayetteville, N. C. It is sound yet, and in constant use. A six-foot pipe, built of pine staves, at Manchester, N. H., in 1874, appears to be in good condition. A description of this pipe may be found in Fanning's "Treatise on Hydraulic and Water Supply Engineering." Referring to this pipe, Mr. Fanning, under date of November 11, 1891, writes:

"The conduit lies in wet ground, and, so far as I know, remains in good condition."

Mr. Hull of Connecticut, who has had an experience of over forty years with large wooden stave pipe, states, in his letter to *Engineering News* (June 20, 1891), that he estimates the life of wooden pipe, when entirely exposed and the air circulating round

it, at from forty to fifty years, and that he considers its life indefinite when buried under ground.

If it be admitted that the life of wooden stave pipe depends upon that of the steel bands (and all experience and testimony points that way), it can be readily understood why its durability is greater than that of sheet metal pipe. In the latter the metal is spread out in a thin sheet with a surface, very large compared to its thickness, whereas the bands of the wooden stave pipe being made of round steel, combine a maximum area with a minimum surface, so that the proportionate effect of corrosion must be much smaller than in the case of sheet metal. But even, regardless of this important advantage and supposing the proportionate corrosion to be the same in both cases, the rusting of the bands may continue until they are actually too weak to resist the strains, before leakage would result, while, on the contrary, sheet metal pipe, rusting in spots, would commence leaking and have to be abandoned long before the full strength of the metal would be called upon.

As regards the effect of wear of water, when carrying sand upon the soft wooden staves, which has sometimes been advanced as an objection to wooden pipe, as being likely to shorten its life, we can do no better than quote from the able report of Mr. S. Fortier, consulting engineer of the Ogden Bench Canal and Water Company:

"Wooden stave pipe is now extensively used throughout the arid west and wherever care has been exercised in its construction has produced excellent results. Its experimental days are past and

we now know that it can be built under heads varying from grade to 150 feet without leaking. For a time it was thought that a stave pipe would soon decay but the best practice of late years has demonstrated the fact that when laid below the grade line and consequently kept full of water it is practically indestructable. There was but one thing lacking to prove its general durability, viz., the wear on the staves caused by sediment and gravel in the water. Nearly three years ago the author began experimenting in this direction with a view of determining the amount of wear in such piping. A stave pipe 24 inches in diameter built of California redwood, was laid on a steep grade and water allowed to flow continuously through it. The water seldom covered or touched upon more than four of the bottom staves and had a minimum velocity of 18 feet per second. The character of the water was also the same as regards sediment as that flowing in Ogden River. At the end of two years, portions of the bottom staves were removed, and, when their thickness after being dried was compared with other staves in the same section of pipe that had never been subjected to any wear, no appreciable diminution in thickness could be observed. The velocity of flow in pipe conduits seldom exceeds six feet per second, so that the amount of wear in the case of the test, the velocity being 18 feet per second, would be about equal to the wear in a conduit on a medium grade during a period of six years."

GENERAL INFORMATION ABOUT CALIFORNIA REDWOOD.

The California Redwood belongs to the family "*Sequoia*," part of the great class of *Coniferae*. The *Sequoia* family, although at one time widely distributed, has at present but two forms surviving, both in California — the "*Sequoia gigantea*," or famous Big Tree, occurring on the southern slope of the Sierra, in the central part of the State, over a few thousand acres all told, and the "*Sequoia sempervirens*," or Redwood, being found along the coast, principally in Humboldt County, where it has come to its greatest present development, some in Del Norte County, and reaching south into Mendocino County, where it gets harder, but where the trees do not grow to the magnificent proportions observed farther north. There is also some redwood south of San Francisco, in Santa Cruz County, but the trees are mostly small and stunted as compared with the Humboldt trees.

The trees cut for milling run from three to sixteen feet in diameter and from 150 to 300 feet in height, a large proportion measuring from six to eight feet through, and being free from limbs for half their height.

Why California Redwood is the Most Desirable Material for Pipe Staves.

The lumber cuts up about 60 per cent. clear, so that, contrary to what is the case with other woods, clear redwood is the grade which it is easiest to ob-

tain in large quantities. The wood is close-grained and does not contain pitch, which would be driven out by the water and leave the wood open and porous. To illustrate the water-tightness of redwood, it may be mentioned that small wire-wrapped stave pipe, with a finished thickness of staves of five-eighths inches, is now in use and proves tight under a working pressure of ninety-five feet, while a testing pressure of two hundred feet caused but a slight oozing through the wood.

Redwood is not as brittle as some pine woods and does not become warped in the sun. Its durability under the most trying conditions is remarkable, which is especially of importance when used in pipes, which are at times to run partly full. It does not shrink and swell as much as pine or other soft woods, so that a certain number of staves will always complete the full circle, rendering superfluous the use of a filler, often required in the construction of pine stave pipes, to make up for excessive shrinkage after milling, thus saving in the cost of labor and producing a more perfect pipe.

Redwood is softer and more compressible than other woods, which is in ordinary cases of pipe construction a decided advantage, for when swelling takes place the bands can sink in the wood without damaging it, thus preventing excessive strains on the bands, and the softness of the wood makes it possible to take up by proper cinching any slight unevenness in the width of the stave which might result from uneven shrinkage at milling.

TABLES ON FLOW THROUGH WOODEN STAVE PIPE.

PREFACE.

It is well known that the carrying capacity of water pipe depends upon the smoothness of its interior surface. In this respect wooden pipe not only surpasses all other pressure pipe in the market, when it is new, but its capacity does not decrease by use, as is the case with wrought-iron and steel pipe, and especially with cast-iron pipe. Our pipe will carry from ten to twenty per cent. more water than new iron or steel pipe.

The following tables are based on the Ganguillet and Kutter formula,

$$v = \frac{41.6 + \frac{.00281}{i} + \frac{1.811}{n}}{1 + \left(41.6 + \frac{.00281}{i}\right) \frac{n}{\sqrt{R}}} \sqrt{Ri}$$

in which

v is the mean velocity in feet per second;

R is one-fourth of the diameter in feet;

i is the hydraulic slope;

n is the coefficient of roughness.

The authors of this formula established the value of n for dressed lumber in open channels at .009. Experiments with wooden stave pipe have shown that results agree more nearly with a value for n of .010. Therefore in the following tables the value of the coefficient of roughness n has been taken at .010.

The tables may be used—

First—To ascertain the loss of head or frictional resistance within any size pipe, while discharging given quantities of water.

Second—To find the maximum quantity of water which any size pipe will discharge under a given head.

Third—To determine the size of pipe required to conduct a given quantity of water under a given head.

The total head required to force water into and through a line of pipe consists of three parts:

h_1 . The head required to impart velocity to the water.

h_2 . The head required to overcome resistance of contraction at the point of entrance.

h_3 . The head required to overcome frictional resistance in the pipe itself.

h_1 is solely dependent upon the velocity of the water in the pipe, and is given in the first columns of the tables. h_2 depends upon the facility with which the water enters the pipe, and may be found from h_1 as follows:

Pipe projecting into reservoir $h_2 = 0.96 h_1$.

Pipe flush with side of reservoir $h_2 = 0.47 h_1$.

Pipe with funnel-shaped intake $h_2 = 0.06 h_1$.

h_3 is directly proportionate to the length of the pipe, and becomes all-important for long pipe lines in which case h_1 and h_2 may often be entirely neglected. This is not the case with short pipe line such as siphons for irrigation canals, especially the water is to attain a high rate of speed.

The tables are based on the assumption of pipe lines perfectly straight, both as regards alignment and grade.

TWELVE INCH PIPE

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.00	0.52	0.4	0.10	0.53	0.26
0.01	0.59	0.5	0.12	0.64	0.30
0.01	0.66	0.5	0.15	0.79	0.34
0.01	0.79	0.6	0.2	1.06	0.40
0.02	0.99	0.8	0.3	1.58	0.50
0.02	1.16	0.9	0.4	2.11	0.59
0.03	1.32	1.0	0.5	2.64	0.67
0.03	1.45	1.1	0.6	3.17	0.74
0.04	1.57	1.2	0.7	3.70	0.80
0.04	1.68	1.3	0.8	4.22	0.85
0.05	1.78	1.4	0.9	4.75	0.90
0.05	1.88	1.5	1.0	5.28	0.95
0.08	2.32	1.8	1.5	7.92	1.18
0.11	2.70	2.1	2	10.56	1.37
0.17	3.32	2.6	3	15.84	1.68
0.23	3.83	3.0	4	21.12	1.94
0.28	4.28	3.4	5	26.40	2.17
0.34	4.69	3.7	6	31.68	2.38
0.40	5.06	4.0	7	36.96	2.57
0.45	5.41	4.3	8	42.24	2.75
0.51	5.74	4.5	9	47.54	2.91
0.57	6.05	4.7	10	52.80	3.07
0.68	6.62	5.2	12	63.36	3.36
0.80	7.16	5.6	14	73.92	3.63
0.91	7.65	6.0	16	84.48	3.88
1.0	8.11	6.4	18	95.04	4.12
1.1	8.55	6.7	20	105.60	4.34

FOURTEEN INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.01	0.59	0.6	0.10	0.53	0.41
0.01	0.67	0.7	0.12	0.64	0.46
0.01	0.74	0.8	0.15	0.79	0.51
0.01	0.88	1.0	0.2	1.06	0.61
0.02	1.10	1.2	0.3	1.58	0.76
0.03	1.30	1.4	0.4	2.11	0.90
0.03	1.47	1.6	0.5	2.64	1.01
0.04	1.62	1.8	0.6	3.17	1.12
0.05	1.76	1.9	0.7	3.70	1.22
0.05	1.88	2.0	0.8	4.22	1.30
0.06	1.99	2.1	0.9	4.75	1.37
0.07	2.10	2.2	1.0	5.28	1.45
0.10	2.59	2.8	1.5	7.92	1.79
0.14	2.99	3.2	2	10.56	2.07
0.21	3.69	3.9	3	15.84	2.55
0.28	4.26	4.5	4	21.12	2.94
0.35	4.77	5.1	5	26.40	3.29
0.42	5.23	5.6	6	31.68	3.61
0.50	5.65	6.0	7	36.96	3.91
0.57	6.04	6.4	8	42.24	4.18
0.64	6.41	6.8	9	47.52	4.43
0.70	6.75	7.2	10	52.80	4.66
0.85	7.39	7.9	12	63.36	5.10
0.99	7.98	8.5	14	73.92	5.51
1.1	8.54	9.1	16	84.48	5.90
1.3	9.06	9.7	18	95.04	6.26
1.4	9.54	10.2	20	105.60	6.59

SIXTEEN INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.01	0.66	0.9	0.10	0.53	0.60
0.01	0.74	1.0	0.12	0.64	0.67
0.01	0.82	1.2	0.15	0.79	0.74
0.01	0.98	1.4	0.2	1.06	0.88
0.02	1.23	1.7	0.3	1.58	1.11
0.03	1.44	2.0	0.4	2.11	1.30
0.04	1.63	2.3	0.5	2.64	1.47
0.05	1.79	2.5	0.6	3.17	1.61
0.06	1.93	2.7	0.7	3.70	1.74
0.07	2.06	2.9	0.8	4.22	1.86
0.07	2.18	3.1	0.9	4.75	1.97
0.08	2.30	3.2	1.0	5.28	2.07
0.13	2.84	4.0	1.5	7.92	2.56
0.17	3.27	4.6	2	10.56	2.95
0.25	4.05	5.7	3	15.84	3.65
0.34	4.69	6.5	4	21.12	4.23
0.43	5.26	7.3	5	26.40	4.74
0.52	5.77	8.0	6	31.68	5.20
0.60	6.23	8.7	7	36.96	5.62
0.69	6.65	9.3	8	42.24	6.00
0.77	7.05	9.8	9	47.52	6.36
0.86	7.44	10.4	10	52.80	6.71
1.0	8.15	11.4	12	63.36	7.35
1.2	8.81	12.3	14	73.92	7.95
1.4	9.42	13.1	16	84.48	8.50
1.6	9.99	13.9	18	95.04	9.01
1.7	10.5	14.7	20	105.60	9.49

EIGHTEEN INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet	Per Mile.	
0.01	0.72	1.3	0.10	0.53	0.83
0.01	0.81	1.4	0.12	0.64	0.92
0.01	0.90	1.6	0.15	0.79	1.03
0.02	1.06	1.9	0.2	1.06	1.21
0.03	1.33	2.4	0.3	1.58	1.52
0.04	1.56	2.8	0.4	2.11	1.78
0.05	1.76	3.1	0.5	2.64	2.01
0.06	1.93	3.4	0.6	3.17	2.20
0.07	2.09	3.7	0.7	3.70	2.39
0.08	2.23	3.9	0.8	4.22	2.55
0.09	2.36	4.2	0.9	4.75	2.70
0.10	2.49	4.4	1.0	5.28	2.84
0.15	3.07	5.4	1.5	7.92	3.51
0.20	3.55	6.3	2	10.56	4.05
0.30	4.39	7.8	3	15.84	5.01
0.41	5.11	9.0	4	21.12	5.84
0.51	5.71	10.1	5	26.40	6.52
0.61	6.26	11.1	6	31.68	7.15
0.71	6.76	11.9	7	36.96	7.72
0.81	7.23	12.7	8	42.24	8.26
0.91	7.67	13.5	9	47.52	8.76
1.0	8.08	14.3	10	52.80	9.23
1.2	8.85	15.6	12	63.36	10.1
1.4	9.56	16.9	14	73.92	10.9
1.6	10.2	18.0	16	84.48	11.7
1.8	10.8	19.1	18	95.04	12.4
2.0	11.4	20.2	20	105.60	13.0

TWENTY INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.01	0.77	1.7	0.10	0.53	1.09
0.01	0.87	1.9	0.12	0.64	1.23
0.01	0.98	2.1	0.15	0.79	1.38
0.02	1.16	2.5	0.2	1.06	1.64
0.03	1.45	3.2	0.3	1.58	2.05
0.04	1.70	3.7	0.4	2.11	2.40
0.06	1.91	4.1	0.5	2.64	2.69
0.07	2.09	4.6	0.6	3.17	2.95
0.08	2.26	4.9	0.7	3.70	3.19
0.09	2.41	5.2	0.8	4.22	3.40
0.10	2.56	5.6	0.9	4.75	3.61
0.11	2.70	5.9	1.0	5.28	3.81
0.17	3.32	7.2	1.5	7.92	4.68
0.23	3.84	8.4	2	10.56	5.41
0.35	4.74	10.3	3	15.84	6.68
0.47	5.51	12.0	4	21.12	7.77
0.59	6.17	13.4	5	26.40	8.70
0.71	6.76	14.7	6	31.68	9.53
0.83	7.30	15.9	7	36.96	10.3
0.94	7.80	17.0	8	42.24	11.0
1.1	8.27	18.0	9	47.52	11.7
1.2	8.72	19.0	10	52.80	12.3
1.4	9.55	20.8	12	63.36	13.5
1.7	10.3	22.5	14	73.92	14.5
1.9	11.0	24.1	16	84.48	15.5
2.1	11.7	25.5	18	95.04	16.5
2.4	12.3	26.9	20	105.60	17.4

TWENTY-TWO INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.01	0.83	2.2	0.10	0.53	1.42
0.01	0.94	2.5	0.12	0.64	1.60
0.02	1.05	2.8	0.15	0.79	1.79
0.02	1.24	3.3	0.2	1.06	2.12
0.04	1.56	4.1	0.3	1.58	2.66
0.05	1.83	4.8	0.4	2.11	3.12
0.07	2.05	5.4	0.5	2.64	3.50
0.08	2.24	5.9	0.6	3.17	3.82
0.09	2.42	6.4	0.7	3.70	4.13
0.10	2.59	6.9	0.8	4.22	4.42
0.12	2.74	7.3	0.9	4.75	4.67
0.13	2.89	7.6	1.0	5.28	4.93
0.20	3.56	9.4	1.5	7.92	6.07
0.26	4.11	10.8	2	10.56	7.01
0.40	5.05	13.3	3	15.84	8.62
0.53	5.86	15.5	4	21.12	10.0
0.67	6.56	17.3	5	26.40	11.2
0.80	7.19	18.9	6	31.68	12.3
0.94	7.76	20.5	7	36.96	13.2
1.1	8.29	21.9	8	42.24	14.1
1.2	8.79	23.2	9	47.52	15.0
1.3	9.27	24.5	10	52.80	15.8
1.6	10.2	26.8	12	63.36	17.3
1.9	11.0	29.0	14	73.92	18.7
2.1	11.7	31.1	16	84.48	20.0
2.4	12.4	32.8	18	95.04	21.2
2.7	13.1	34.6	20	105.60	22.4

TWENTY-FOUR INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD In Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.01	0.88	2.8	0.10	0.53	1.78
0.02	1.00	3.2	0.12	0.64	2.03
0.02	1.12	3.5	0.15	0.79	2.27
0.03	1.32	4.1	0.2	1.06	2.68
0.04	1.65	5.2	0.3	1.58	3.35
0.06	1.93	6.1	0.4	2.11	3.92
0.07	2.17	6.8	0.5	2.64	4.40
0.09	2.38	7.5	0.6	3.17	4.83
0.10	2.57	8.1	0.7	3.70	5.22
0.12	2.75	8.6	0.8	4.22	5.58
0.13	2.92	9.1	0.9	4.75	5.93
0.15	3.08	9.6	1.0	5.28	6.25
0.22	3.78	11.9	1.5	7.92	7.67
0.30	4.37	13.7	2	10.56	8.87
0.45	5.39	16.9	3	15.84	10.9
0.61	6.25	19.6	4	21.12	12.7
0.76	6.99	22.0	5	26.40	14.2
0.91	7.67	24.1	6	31.68	15.6
1.1	8.28	26.0	7	36.96	16.8
1.2	8.85	27.8	8	42.24	18.0
1.4	9.39	29.5	9	47.52	19.1
1.5	9.90	31.1	10	52.80	20.1
1.8	10.8	34.0	12	63.36	22.0
2.1	11.7	36.8	14	73.92	23.8
2.4	12.5	39.3	16	84.48	25.4
2.7	13.3	41.7	18	95.04	27.0
3.0	14.0	44.0	20	105.60	28.4

TWENTY-SIX INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.01	0.95	3.5	0.10	0.53	2.24
0.02	1.06	3.9	0.12	0.64	2.53
0.02	1.18	4.4	0.15	0.79	2.81
0.03	1.39	5.1	0.2	1.06	3.31
0.05	1.74	6.4	0.3	1.58	4.15
0.06	2.04	7.5	0.4	2.11	4.86
0.08	2.29	8.4	0.5	2.64	5.45
0.10	2.51	9.3	0.6	3.17	5.98
0.11	2.72	10.0	0.7	3.70	6.48
0.13	2.91	10.7	0.8	4.22	6.93
0.15	3.09	11.4	0.9	4.75	7.36
0.17	3.26	12.0	1.0	5.28	7.77
0.25	4.00	14.7	1.5	7.92	9.53
0.33	4.63	17.1	2	10.56	11.0
0.51	5.71	21.0	3	15.84	13.6
0.68	6.61	24.4	4	21.12	15.7
0.85	7.40	27.3	5	26.40	17.6
1.0	8.10	29.9	6	31.68	19.3
1.2	8.74	32.2	7	36.96	20.8
1.4	9.34	34.4	8	42.24	22.2
1.5	9.91	36.5	9	47.52	23.6
1.7	10.4	38.5	10	52.80	24.9
2.0	11.4	42.2	12	63.36	27.3
2.4	12.3	45.6	14	73.92	29.4
2.7	13.2	48.7	16	84.48	31.5
3.1	14.0	51.7	18	95.04	33.4
3.4	14.8	54.5	20	105.60	35.2

TWENTY-EIGHT INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.02	0.99	4.2	0.10	0.53	2.74
0.02	1.12	4.7	0.12	0.64	3.09
0.02	1.25	5.3	0.15	0.79	3.45
0.03	1.47	6.3	0.2	1.06	4.06
0.05	1.84	7.9	0.3	1.58	5.08
0.07	2.15	9.2	0.4	2.11	5.94
0.09	2.41	10.3	0.5	2.64	6.66
0.11	2.65	11.3	0.6	3.17	7.32
0.13	2.87	12.3	0.7	3.70	7.93
0.15	3.07	13.1	0.8	4.22	8.48
0.16	3.25	13.9	0.9	4.75	8.98
0.18	3.43	14.7	1.0	5.28	9.48
0.28	4.21	18.0	1.5	7.92	11.6
0.37	4.88	20.9	2	10.56	13.5
0.56	6.03	25.8	3	15.84	16.7
0.75	6.96	29.8	4	21.12	19.2
0.94	7.78	33.3	5	26.40	21.5
1.1	8.53	36.5	6	31.68	23.6
1.3	9.21	39.4	7	36.96	25.4
1.5	9.84	42.1	8	42.24	27.2
1.7	10.4	44.6	9	47.52	28.8
1.9	11.0	47.0	10	52.80	30.4
2.3	12.0	51.5	12	63.36	33.3
2.6	13.0	55.6	14	73.92	35.9
3.0	13.9	59.5	16	84.48	38.4
3.4	14.8	63.1	18	95.04	40.8
3.8	15.6	66.5	20	105.60	43.0

THIRTY INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.02	1.05	5.1	0.10	0.53	3.33
0.02	1.18	5.8	0.12	0.64	3.74
0.03	1.31	6.4	0.15	0.79	4.16
0.04	1.54	7.6	0.2	1.06	4.89
0.06	1.93	9.5	0.3	1.58	6.12
0.08	2.25	11.0	0.4	2.11	7.14
0.10	2.53	12.4	0.5	2.64	8.03
0.12	2.78	13.6	0.6	3.17	8.82
0.14	3.01	14.8	0.7	3.70	9.55
0.16	3.21	15.8	0.8	4.22	10.2
0.18	3.40	16.7	0.9	4.75	10.8
0.20	3.59	17.6	1.0	5.28	11.4
0.30	4.41	21.6	1.5	7.92	14.0
0.41	5.12	25.1	2	10.56	16.2
0.61	6.28	30.8	3	15.84	19.9
0.81	7.24	35.5	4	21.12	23.0
1.0	8.10	39.8	5	26.40	25.7
1.2	8.88	43.6	6	31.68	28.2
1.4	9.59	47.1	7	36.96	30.4
1.6	10.2	50.3	8	42.24	32.5
1.8	10.9	53.3	9	47.52	34.4
2.0	11.4	56.2	10	52.80	36.3
2.4	12.5	61.6	12	63.36	39.8
2.9	13.5	66.5	14	73.92	43.0
3.3	14.5	71.1	16	84.48	46.0
3.7	15.4	75.4	18	95.04	48.8
4.1	16.2	79.5	20	105.60	51.4

THIRTY-TWO INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.02	1.10	6.1	0.10	0.53	3.97
0.02	1.23	6.9	0.12	0.64	4.44
0.03	1.37	7.6	0.15	0.79	4.94
0.04	1.61	9.0	0.2	1.06	5.81
0.06	2.01	11.2	0.3	1.58	7.25
0.09	2.35	13.1	0.4	2.11	8.49
0.11	2.64	14.7	0.5	2.64	9.53
0.13	2.90	16.2	0.6	3.17	10.5
0.15	3.14	17.5	0.7	3.70	11.3
0.17	3.35	18.7	0.8	4.22	12.1
0.20	3.55	19.8	0.9	4.75	12.8
0.22	3.74	20.9	1.0	5.28	13.5
0.33	4.60	25.7	1.5	7.92	16.6
0.44	5.35	29.9	2	10.56	19.3
0.66	6.54	36.5	3	15.84	23.6
0.89	7.58	42.3	4	21.12	27.4
1.1	8.49	47.4	5	26.40	30.6
1.4	9.31	52.0	6	31.68	33.6
1.6	10.0	56.1	7	36.96	36.3
1.8	10.7	60.0	8	42.24	38.8
2.0	11.4	63.6	9	47.52	41.1
2.2	12.0	67.1	10	52.80	43.3
2.7	13.1	73.4	12	63.36	47.5
3.1	14.2	79.4	14	73.92	51.3
3.6	15.2	84.9	16	84.48	54.9
4.0	16.1	90.0	18	95.04	58.2
4.5	17.0	94.8	20	105.60	61.3

THIRTY-FOUR INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet	Per Mile.	
0.02	1.15	7.2	0.10	0.53	4.69
0.02	1.29	8.1	0.12	0.64	5.26
0.03	1.44	9.1	0.15	0.79	5.87
0.04	1.69	10.6	0.2	1.06	6.89
9.07	2.10	13.2	0.3	1.58	8.56
0.09	2.44	15.4	0.4	2.11	9.94
0.12	2.75	17.3	0.5	2.64	11.2
0.14	3.02	19.0	0.6	3.17	12.3
0.17	3.26	20.5	0.7	3.70	13.3
0.19	3.48	21.9	0.8	4.22	14.2
0.21	3.69	23.3	0.9	4.75	15.0
0.23	3.89	24.5	1.0	5.28	15.8
0.36	4.80	30.3	1.5	7.92	19.6
0.48	5.57	35.1	2	10.56	22.7
0.72	6.83	43.1	3	15.84	27.8
0.98	7.93	50.0	4	21.12	32.3
1.2	8.87	55.9	5	26.40	36.1
1.5	9.72	61.3	6	31.68	39.6
1.7	10.5	66.3	7	36.96	42.8
2.0	11.2	70.7	8	42.24	45.7
2.2	11.9	75.0	9	47.52	48.5
2.5	12.5	79.1	10	52.80	51.1
2.9	13.7	86.6	12	63.36	56.0
3.4	14.8	93.6	14	73.92	60.5
3.9	15.8	100	16	84.48	64.7
4.4	16.8	106	18	95.04	68.6
4.9	17.7	112	20	105.60	72.2

THIRTY-SIX INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.02	1.20	8.5	0.10	0.53	5.48
0.03	1.35	9.5	0.12	0.64	6.17
0.03	1.50	10.6	0.15	0.79	6.85
0.05	1.75	12.4	0.2	1.06	7.99
0.07	2.18	15.4	0.3	1.58	9.96
0.10	2.55	18.0	0.4	2.11	11.6
0.13	2.87	20.3	0.5	2.64	13.1
0.15	3.15	22.3	0.6	3.17	14.4
0.18	3.40	24.0	0.7	3.70	15.5
0.20	3.62	25.6	0.8	4.22	16.5
0.23	3.84	27.1	0.9	4.75	17.5
0.25	4.04	28.6	1.0	5.28	18.5
0.39	4.99	35.3	1.5	7.92	22.8
0.52	5.78	40.9	2	10.56	26.4
0.78	7.10	50.2	3	15.84	32.4
1.1	8.22	58.1	4	21.12	37.5
1.3	9.20	65.0	5	26.40	42.0
1.6	10.1	71.2	6	31.68	46.0
1.8	10.9	76.8	7	36.96	49.7
2.1	11.6	82.1	8	42.24	53.1
2.4	12.3	87.1	9	47.52	56.3
2.6	13.0	91.8	10	52.80	59.3
3.1	14.2	100	12	63.36	65.0
3.7	15.4	109	14	73.92	70.2
4.2	16.4	116	16	84.48	75.1
4.7	17.4	123	18	95.04	79.6
5.2	18.4	130	20	105.60	83.9

THIRTY-EIGHT INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.02	1.25	9.8	0.10	0.53	6.36
0.03	1.40	11.0	0.12	0.64	7.13
0.04	1.55	12.2	0.15	0.79	7.89
0.05	1.80	14.3	0.2	1.06	9.26
0.08	2.27	17.9	0.3	1.58	11.5
0.11	2.65	20.9	0.4	2.11	13.5
0.14	2.98	23.5	0.5	2.64	15.2
0.17	3.27	25.7	0.6	3.17	16.6
0.19	3.53	27.8	0.7	3.70	18.0
0.22	3.76	29.6	0.8	4.22	19.1
0.25	3.98	31.3	0.9	4.75	20.3
0.27	4.19	33.0	1.0	5.28	21.3
0.42	5.17	40.7	1.5	7.92	26.3
0.56	5.99	47.2	2	10.56	30.5
0.84	7.36	58.0	3	15.84	37.5
1.1	8.53	67.2	4	21.12	43.4
1.4	9.56	75.3	5	26.40	48.7
1.7	10.5	82.5	6	31.68	53.3
2.0	11.3	89.2	7	36.96	57.6
2.3	12.1	95.3	8	42.24	61.6
2.6	12.8	101	9	47.52	65.4
2.8	13.5	107	10	52.80	68.9
3.4	14.8	117	12	63.36	75.4
4.0	16.0	126	14	73.92	81.4
4.5	17.1	135	16	84.48	87.1
5.1	18.1	143	18	95.04	92.4
5.7	19.1	151	20	105.60	97.4

FORTY INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.03	1.30	11.3	0.10	0.53	7.33
0.03	1.45	12.6	0.12	0.64	8.18
0.04	1.60	13.9	0.15	0.79	9.02
0.06	1.89	16.5	0.2	1.06	10.7
0.09	2.35	20.5	0.3	1.58	13.2
0.12	2.73	23.8	0.4	2.11	15.4
0.15	3.07	26.8	0.5	2.64	17.3
0.18	3.37	29.4	0.6	3.17	19.0
0.21	3.65	31.8	0.7	3.70	20.6
0.24	3.90	34.0	0.8	4.22	22.0
0.26	4.12	35.9	0.9	4.75	23.2
0.29	4.34	37.9	1.0	5.28	24.5
0.45	5.36	46.8	1.5	7.92	30.2
0.60	6.20	54.1	2	10.56	35.0
0.90	7.60	66.3	3	15.84	42.9
1.2	8.82	77.0	4	21.12	49.7
1.5	9.88	86.2	5	26.40	55.7
1.8	10.8	94.5	6	31.68	61.1
2.1	11.7	102	7	36.96	65.9
2.4	12.5	109	8	42.40	70.4
2.7	13.3	116	9	47.52	74.8
3.0	14.0	122	10	52.80	78.8
3.6	15.3	133	12	63.36	86.2
4.3	16.5	144	14	73.92	93.2
4.9	17.7	154	16	84.48	99.6
5.5	18.7	163	18	95.04	106
6.1	19.7	172	20	105.60	111

FORTY-TWO INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.03	1.34	12.9	0.10	0.53	8.33
0.03	1.49	14.3	0.12	0.64	9.26
0.04	1.66	16.0	0.15	0.79	10.3
0.06	1.95	18.8	0.2	1.06	12.1
0.09	2.42	23.3	0.3	1.58	15.0
0.12	2.82	27.1	0.4	2.11	17.5
0.16	3.17	30.5	0.5	2.64	19.7
0.19	3.48	33.5	0.6	3.17	21.6
0.22	3.77	36.3	0.7	3.70	23.4
0.25	4.03	38.8	0.8	4.22	25.0
0.28	4.26	41.0	0.9	4.75	26.5
0.31	4.49	43.2	1.0	5.28	27.9
0.47	5.53	53.2	1.5	7.92	34.4
0.63	6.39	61.5	2	10.56	39.7
0.95	7.84	75.4	3	15.84	48.7
1.3	9.10	87.5	4	21.12	56.6
1.6	10.2	97.9	5	26.40	63.3
1.9	11.2	107	6	31.68	69.4
2.3	12.1	116	7	36.96	74.9
2.6	12.9	124	8	42.24	80.1
2.9	13.7	131	9	47.52	84.9
3.2	14.4	138	10	52.80	89.5
3.9	15.8	152	12	63.36	98.0
4.5	17.0	164	14	73.92	106
5.2	18.2	175	16	84.48	113
5.8	19.3	186	18	95.04	120
6.4	20.4	196	20	105.60	126

FORTY-FOUR INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.03	1.39	14.7	0.10	0.53	9.48
0.04	1.55	16.4	0.12	0.64	10.6
0.05	1.71	18.1	0.15	0.79	11.7
0.06	2.01	21.2	0.2	1.06	13.7
0.10	2.50	26.4	0.3	1.58	17.1
0.13	2.92	30.8	0.4	2.11	19.9
0.17	3.28	34.6	0.5	2.64	22.4
0.20	3.59	37.9	0.6	3.17	24.5
0.23	3.88	41.0	0.7	3.70	26.5
0.27	4.15	43.8	0.8	4.22	28.3
0.30	4.40	46.5	0.9	4.75	30.0
0.33	4.63	48.9	1.0	5.28	31.6
0.50	5.70	60.2	1.5	7.92	38.9
0.67	6.59	69.6	2	10.56	44.5
1.0	8.08	85.3	3	15.84	55.1
1.4	9.37	98.9	4	21.12	63.9
1.7	10.5	111	5	26.40	71.6
2.1	11.5	121	6	31.68	78.5
2.4	12.4	131	7	36.96	84.7
2.7	13.3	140	8	42.24	90.5
3.1	14.1	149	9	47.52	96.0
3.4	14.8	157	10	52.80	101
4.1	16.2	171	12	63.36	111
4.8	17.5	185	14	73.92	120
5.5	18.8	198	16	84.48	128
6.2	19.9	210	18	95.04	136
6.8	21.0	221	20	105.60	143

FORTY-SIX INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.03	1.43	16.5	0.10	0.53	10.7
0.04	1.60	18.5	0.12	0.64	11.9
0.05	1.78	20.5	0.15	0.79	13.3
0.07	2.08	24.0	0.2	1.06	15.5
0.10	2.59	29.9	0.3	1.58	19.3
0.14	3.01	34.7	0.4	2.11	22.5
0.18	3.37	38.9	0.5	2.64	25.1
0.21	3.69	42.6	0.6	3.17	27.5
0.25	3.99	46.0	0.7	3.70	29.8
0.28	4.27	49.2	0.8	4.22	31.8
0.32	4.52	52.2	0.9	4.75	33.7
0.35	4.76	54.9	1.0	5.28	35.5
0.53	5.87	67.7	1.5	7.92	43.8
0.71	6.78	78.2	2	10.56	50.6
1.1	8.31	95.9	3	15.84	62.0
1.4	9.65	111	4	21.12	72.0
1.8	10.8	125	5	26.40	80.5
2.2	11.8	137	6	31.68	88.3
2.5	12.8	147	7	36.96	95.3
2.9	13.6	157	8	42.24	102
3.3	14.5	167	9	47.52	108
3.6	15.3	176	10	52.80	114
4.3	16.7	193	12	63.36	125
5.1	18.1	208	14	73.92	135
5.8	19.3	223	16	84.48	144
6.5	20.5	236	18	95.04	153
7.2	21.6	249	20	105.60	161

FORTY-EIGHT INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.03	1.47	18.5	0.10	0.53	11.9
0.04	1.64	20.6	0.12	0.64	13.3
0.05	1.83	23.0	0.15	0.79	14.9
0.07	2.14	26.9	0.2	1.06	17.4
0.11	2.66	33.4	0.3	1.58	21.6
0.15	3.09	38.8	0.4	2.11	25.1
0.19	3.47	43.6	0.5	2.64	28.2
0.22	3.80	47.8	0.6	3.17	30.9
0.26	4.10	51.5	0.7	3.70	33.3
0.30	4.38	55.0	0.8	4.22	35.6
0.34	4.65	58.4	0.9	4.75	37.8
0.37	4.90	61.6	1.0	5.28	39.8
0.56	6.03	75.8	1.5	7.92	49.0
0.75	6.97	87.6	2	10.56	56.6
1.2	8.55	107	3	15.84	69.5
1.5	9.92	124	4	21.12	80.6
1.9	11.1	139	5	26.40	90.2
2.3	12.2	153	6	31.68	98.9
2.7	13.1	165	7	36.96	107
3.1	14.0	176	8	42.24	114
3.5	14.9	187	9	47.52	121
3.8	15.7	197	10	52.80	127
4.6	17.2	216	12	63.36	140
5.4	18.6	233	14	73.92	151
6.1	19.9	249	16	84.48	161
6.9	21.1	265	18	95.04	171
7.7	22.2	279	20	105.60	180

FIFTY-FOUR INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.04	1.60	25.5	0.10	0.53	16.4
0.05	1.79	28.5	0.12	0.64	18.4
0.06	1.99	31.6	0.15	0.79	20.4
0.08	2.32	36.9	0.2	1.06	23.8
0.13	2.88	45.8	0.3	1.58	29.6
0.17	3.33	52.9	0.4	2.11	34.2
0.22	3.75	59.6	0.5	2.64	38.5
0.26	4.11	65.3	0.6	3.17	42.2
0.31	4.44	70.6	0.7	3.70	45.6
0.35	4.74	75.4	0.8	4.22	48.7
0.40	5.03	80.0	0.9	4.75	51.7
0.44	5.30	84.3	1.0	5.28	54.5
0.66	6.50	103	1.5	7.92	66.8
0.88	7.51	119	2	10.56	77.2
1.3	9.25	147	3	15.84	95.0
1.8	10.7	170	4	21.12	110
2.2	12.0	190	5	26.40	123
2.7	13.1	208	6	31.68	135
3.1	14.1	225	7	36.96	145
3.5	15.1	240	8	42.24	155
4.0	16.0	255	9	47.52	165
4.5	16.9	269	10	52.80	174
5.3	18.5	294	12	63.36	190
6.2	20.0	317	14	73.92	205
7.1	21.3	339	16	84.48	219
8.0	22.6	360	18	95.04	222
8.8	23.8	378	20	105.60	245

SIXTY INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.05	1.72	33.8	0.10	0.53	21.8
0.06	1.92	37.7	0.12	0.64	24.4
0.07	2.13	41.8	0.15	0.79	27.0
0.10	2.49	48.9	0.2	1.06	31.6
0.15	3.07	60.3	0.3	1.58	38.9
0.20	3.58	70.3	0.4	2.11	45.4
0.25	4.03	79.1	0.5	2.64	50.9
0.30	4.41	86.6	0.6	3.17	55.9
0.35	4.76	93.4	0.7	3.70	60.4
0.40	5.09	99.9	0.8	4.22	64.6
0.45	5.40	106	0.9	4.75	68.5
0.50	5.69	112	1.0	5.28	72.2
0.75	6.96	137	1.5	7.92	88.3
1.0	8.04	158	2	10.56	102
1.5	9.93	195	3	15.84	126
2.0	11.4	225	4	21.12	145
2.6	12.8	251	5	26.40	162
3.1	14.0	276	6	31.68	178
3.6	15.2	298	7	36.96	192
4.1	16.2	318	8	42.24	206
4.6	17.2	337	9	47.54	218
5.1	18.1	355	10	52.80	230
6.1	19.8	389	12	63.36	251
7.1	21.4	420	14	73.92	272
8.2	22.9	450	16	84.48	291
9.2	24.3	477	18	95.04	308
10.2	25.6	503	20	105.60	325

SIXTY-SIX INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.06	1.84	43.7	0.10	0.53	28.2
0.07	2.05	48.7	0.12	0.64	31.5
0.08	2.28	54.1	0.15	0.79	35.0
0.11	2.62	62.2	0.2	1.06	40.2
0.17	3.27	77.7	0.3	1.58	50.2
0.23	3.81	90.5	0.4	2.11	58.5
0.28	4.26	101	0.5	2.64	65.4
0.34	4.69	111	0.6	3.17	72.0
0.40	5.07	120	0.7	3.70	77.8
0.45	5.42	129	0.8	4.22	83.2
0.51	5.75	137	0.9	4.75	88.3
0.57	6.05	144	1.0	5.28	92.9
0.84	7.39	175	1.5	7.92	113
1.1	8.59	204	2	10.56	132
1.7	10.5	250	3	15.84	161
2.3	12.2	288	4	21.12	187
2.9	13.6	323	5	26.40	209
3.4	14.9	354	6	31.68	229
4.0	16.1	382	7	36.96	247
4.6	17.2	409	8	42.24	264
5.2	18.3	435	9	47.52	280
5.7	19.2	457	10	52.80	295
6.9	21.1	501	12	63.36	324
8.0	22.7	539	14	73.92	349
9.2	24.3	577	16	84.48	373
10.3	25.8	613	18	95.04	396
11.5	27.2	646	20	105.60	418

SEVENTY-TWO INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.06	1.95	55.1	0.10	0.53	35.6
0.07	2.16	61.1	0.12	0.64	39.5
0.09	2.40	67.8	0.15	0.79	43.8
0.12	2.79	78.9	0.2	1.06	51.0
0.18	3.45	97.5	0.3	1.58	63.0
0.25	4.03	114	0.4	2.11	73.6
0.32	4.52	128	0.5	2.64	82.6
0.38	4.95	140	0.6	3.17	90.4
0.44	5.35	151	0.7	3.70	97.7
0.51	5.72	162	0.8	4.22	104
0.57	6.06	171	0.9	4.75	111
0.63	6.38	180	1.0	5.28	117
0.94	7.80	220	1.5	7.92	142
1.3	9.05	256	2	10.56	165
1.9	11.1	313	3	15.84	203
2.6	12.9	363	4	21.12	236
3.2	14.4	405	5	26.40	263
3.8	15.7	444	6	31.68	287
4.5	17.0	481	7	36.96	311
5.1	18.2	514	8	42.24	332
5.8	19.3	546	9	47.54	353
6.4	20.3	574	10	52.80	371
7.7	22.2	627	12	63.36	406
8.9	24.0	678	14	73.92	438
10.2	25.7	726	16	84.48	469
11.5	27.2	769	18	95.04	497
12.8	28.7	811	20	105.60	524

SEVENTY-EIGHT INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.07	2.05	68.0	0.10	0.53	44.0
0.08	2.28	75.6	0.12	0.64	48.9
0.10	2.53	83.9	0.15	0.79	54.2
0.14	2.95	97.9	0.2	1.06	63.3
0.21	3.63	120	0.3	1.58	77.8
0.28	4.24	141	0.4	2.11	90.9
0.35	4.76	158	0.5	2.64	102
0.42	5.21	173	0.6	3.17	112
0.49	5.63	187	0.7	3.70	121
0.56	6.01	200	0.8	4.22	130
0.63	6.37	211	0.9	4.75	137
0.69	6.70	222	1.0	5.28	144
1.0	8.20	273	1.5	7.92	176
1.4	9.50	315	2	10.56	204
2.1	11.7	388	3	15.84	251
2.8	13.5	448	4	21.12	289
3.5	15.1	501	5	26.40	324
4.2	16.5	547	6	31.68	354
4.9	17.8	591	7	36.96	382
5.7	19.1	631	8	42.24	409
6.4	20.2	670	9	47.54	433
7.1	21.3	707	10	52.80	457
8.5	23.3	773	12	63.36	500
9.9	25.2	836	14	73.92	540
11.3	27.0	896	16	84.48	579
12.7	28.6	949	18	95.04	613
14.0	30.1	999	20	105.60	645

EIGHTY-FOUR INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.07	2.16	83.1	0.10	0.53	53.7
0.09	2.39	92.0	0.12	0.64	59.4
0.11	2.66	102	0.15	0.79	66.1
0.15	3.10	119	0.2	1.06	77.1
0.23	3.81	147	0.3	1.58	94.7
0.31	4.44	171	0.4	2.11	110
0.38	4.97	191	0.5	2.64	124
0.46	5.46	210	0.6	3.17	136
0.54	5.90	227	0.7	3.70	147
0.61	6.29	242	0.8	4.22	157
0.69	6.67	256	0.9	4.75	166
0.77	7.02	270	1.0	5.28	175
1.1	8.60	331	1.5	7.92	214
1.5	9.94	382	2	10.56	247
2.3	12.2	469	3	15.84	303
3.1	14.1	542	4	21.12	351
3.9	15.8	608	5	26.40	393
4.6	17.3	666	6	31.68	430
5.4	18.7	719	7	36.96	465
6.2	20.0	770	8	42.24	497
7.0	21.2	816	9	47.54	527
7.7	22.3	858	10	52.80	555
9.2	24.4	939	12	63.36	607
10.8	26.4	1016	14	73.92	656
12.4	28.3	1089	16	84.48	703
14.0	30.0	1154	18	95.04	745
5.4	31.5	1212	20	105.60	783

NINETY INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.08	2.27	100	0.10	0.53	64.8
0.10	2.51	111	0.12	0.64	71.7
0.12	2.78	123	0.15	0.79	79.4
0.16	3.25	143	0.2	1.06	92.7
0.24	3.98	176	0.3	1.58	114
0.33	4.63	204	0.4	2.11	132
0.41	5.17	228	0.5	2.64	148
0.50	5.68	251	0.6	3.17	162
0.59	6.16	272	0.7	3.70	176
0.67	6.57	290	0.8	4.22	188
0.75	6.96	307	0.9	4.75	199
0.83	7.33	324	1.0	5.28	209
1.3	8.99	397	1.5	7.92	257
1.7	10.4	458	2	10.56	296
2.5	12.7	561	3	15.84	363
3.4	14.7	650	4	21.12	420
4.2	16.5	729	5	26.40	471
5.0	18.0	797	6	31.68	514
5.9	19.5	862	7	36.96	555
6.7	20.8	919	8	42.24	594
7.6	22.1	976	9	47.54	631
8.4	23.3	1029	10	52.80	665
10.1	25.5	1127	12	63.36	728
11.8	27.5	1218	14	73.92	787
13.5	29.5	1304	16	84.48	842
15.2	31.3	1382	18	95.04	893
16.8	32.9	1453	20	105.60	939

NINETY-SIX INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.09	2.37	119	0.10	0.53	77.0
0.11	2.61	131	0.12	0.64	84.8
0.13	2.90	145	0.15	0.79	94.2
0.18	3.40	171	0.2	1.06	110
0.27	4.15	208	0.3	1.58	135
0.36	4.81	242	0.4	2.11	156
0.45	5.40	272	0.5	2.64	175
0.54	5.91	296	0.6	3.17	192
0.63	6.41	322	0.7	3.70	208
0.72	6.84	344	0.8	4.22	222
0.81	7.25	364	0.9	4.75	235
0.91	7.64	384	1.0	5.28	248
1.4	9.37	471	1.5	7.92	304
1.8	10.8	548	2	10.56	354
2.7	13.2	664	3	15.84	429
3.6	15.3	769	4	21.12	497
4.5	17.1	860	5	26.40	555
5.4	18.7	940	6	31.68	607
6.3	20.2	1015	7	36.96	656
7.2	21.6	1085	8	42.24	702
8.1	22.9	1150	9	47.54	744
9.2	24.2	1216	10	52.80	786
10.9	26.5	1331	12	63.36	861
12.7	28.6	1437	14	73.92	929
14.5	30.6	1538	16	84.48	994
16.3	32.4	1632	18	95.04	1052
18.1	34.2	1719	20	105.60	1111

ONE HUNDRED AND EIGHT INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.10	2.56	163	0.10	0.53	103
0.12	2.82	179	0.12	0.64	116
0.15	3.15	200	0.15	0.79	129
0.21	3.68	234	0.2	1.06	151
0.31	4.48	285	0.3	1.58	184
0.42	5.18	330	0.4	2.11	213
0.52	5.79	368	0.5	2.64	238
0.62	6.35	404	0.6	3.17	261
0.73	6.87	437	0.7	3.70	282
0.84	7.34	467	0.8	4.22	302
0.94	7.78	495	0.9	4.75	320
1.1	8.20	522	1.0	5.28	337
1.6	10.1	640	1.5	7.92	413
2.1	11.6	737	2	10.56	486
3.2	14.2	905	3	15.84	584
4.2	16.4	1043	4	21.12	674
5.2	18.3	1164	5	26.40	752
6.3	20.1	1278	6	31.68	826
7.3	21.7	1380	7	36.96	892
8.4	23.2	1476	8	42.24	955
9.5	24.7	1570	9	47.54	1015
10.5	26.0	1654	10	52.80	1069
12.6	28.5	1813	12	63.36	1172
14.7	30.8	1960	14	73.92	1266
16.9	33.0	2100	16	84.48	1355
19.0	35.0	2227	18	95.04	1438
21.2	36.9	2346	20	105.60	1517

ONE HUNDRED AND TWENTY INCH PIPE.

Head in Feet required to pro- duce Velocity.	Velocity in Feet per Second.	Discharge in Cubic Feet per Second.	FRICTION HEAD in Feet.		Discharge in Million Gallons per twenty-four Hours.
			Per 1,000 Feet.	Per Mile.	
0.12	2.75	216	0.10	0.53	139
0.15	3.03	238	0.12	0.64	154
0.18	3.36	264	0.15	0.79	170
0.24	3.91	307	0.2	1.06	198
0.36	4.79	376	0.3	1.58	243
0.47	5.52	434	0.4	2.11	280
0.59	6.17	484	0.5	2.64	313
0.71	6.77	532	0.6	3.17	344
0.83	7.33	576	0.7	3.70	372
0.95	7.82	614	0.8	4.22	397
1.1	8.29	651	0.9	4.75	421
1.2	8.75	687	1.0	5.28	444
1.8	10.7	832	1.5	7.92	544
2.4	12.3	969	2	10.56	626
3.6	15.1	1188	3	15.84	768
4.8	17.5	1374	4	21.12	888
5.9	19.5	1531	5	26.40	990
7.1	21.4	1680	6	31.68	1085
8.3	23.1	1815	7	36.96	1173
9.5	24.7	1944	8	42.24	1257
10.8	26.3	2065	9	47.54	1336
12.0	27.7	2176	10	52.80	1406
14.3	30.3	2379	12	63.36	1538
16.6	32.7	2568	14	73.92	1660
19.0	35.0	2749	16	84.48	1776
21.4	37.1	2914	18	95.04	1880
23.8	39.1	3071	20	105.60	2030

Diameter of Pipe in Inches.	Area in Square Feet.	Hydraulic Radius R in Feet.	$\sqrt{R}$ in Feet.	Discharge in Million Gallons per Twenty-four Hours with Velocity of 1 Foot per Second.
12	0.7854	0.2500	0.500	0.508
14	1.069	0.2917	0.540	0.691
16	1.396	0.3333	0.577	0.902
18	1.767	0.3750	0.612	1.14
20	2.182	0.4167	0.646	1.41
22	2.640	0.4583	0.677	1.71
24	3.142	0.5000	0.707	2.03
26	3.637	0.5417	0.736	2.38
28	4.276	0.5833	0.764	2.76
30	4.909	0.6250	0.790	3.17
32	5.585	0.6667	0.817	3.61
34	6.305	0.7083	0.842	4.07
36	7.069	0.7500	0.866	4.57
38	7.876	0.7917	0.890	5.09
40	8.727	0.8333	0.913	5.64
42	9.621	0.8750	0.935	6.22
44	10.56	0.9167	0.957	6.82
46	11.54	0.9583	0.979	7.46
48	12.57	1.0000	1.000	8.12
54	15.90	1.1250	1.061	10.28
60	19.63	1.2500	1.118	12.69
66	23.76	1.3750	1.173	15.35
72	28.27	1.5000	1.225	18.27
78	33.18	1.6250	1.275	21.44
84	38.48	1.7500	1.323	24.87
90	44.18	1.8750	1.369	28.55
96	50.26	2.0000	1.414	32.48
108	63.62	2.2500	1.500	41.12
120	78.54	2.5000	1.581	50.76

VALUES OF C IN KUTTER'S FORMULA

with $n = 0.010$.

Fall in Feet per 1,000 Ft.	DIAMETER OF PIPE IN INCHES.									
	12	14	16	18	20	22	24	26	28	30
0.10	104	109	113	117	120	123	126	129	131	133
0.12	107	112	116	120	123	126	128	131	133	135
0.15	109	113	117	121	124	127	130	132	134	136
0.2	112	116	120	123	127	130	132	134	137	138
0.3	115	118	123	126	130	133	135	137	139	141
0.4	116	120	124	127	131	134	136	137	140	142
0.5	118	122	126	129	132	135	137	139	141	143
0.6	118	123	126	129	132	135	137	139	142	143
0.7	118	123	126	129	132	135	137	139	142	143
0.8	119	123	126	129	132	135	137	140	142	143
0.9	119	123	126	129	132	135	137	140	142	143
1.0	119	123	126	129	132	135	137	140	142	143
1.5	120	124	127	130	133	136	138	141	143	144
2	121	124	127	130	133	136	139	141	144	144
3	121	124	128	131	134	136	140	141	144	145
4	121	125	129	132	135	137	140	142	144	145
5	121	125	129	132	135	137	140	142	144	145
6	121	125	129	132	135	137	140	142	144	145
7	121	125	129	132	135	137	140	142	144	145
8	121	125	129	132	135	137	140	142	144	145
9	121	125	129	132	135	137	140	142	144	145
10	121	125	129	132	135	137	140	142	144	145
12	121	125	129	132	135	137	140	142	144	145
14	121	125	129	132	135	137	140	142	144	145
16	121	125	129	132	135	137	140	142	144	145
18	121	125	129	132	135	137	140	142	144	145
20	121	125	129	132	135	137	140	142	144	145

VALUES OF C IN KUTTER'S FORMULA

with $n = 0.010$.

Fall in Feet per 1,000 Ft.	DIAMETER OF PIPE IN INCHES.									
	32	34	36	38	40	42	44	46	48	54
0.10	135	137	139	140	142	143	145	146	147	151
0.12	137	139	141	143	144	145	147	148	149	153
0.15	138	140	142	143	144	146	147	149	150	154
0.2	140	142	143	145	147	148	149	151	152	155
0.3	142	144	146	148	149	150	152	153	154	157
0.4	143	145	146	148	149	151	152	154	154	157
0.5	145	146	148	149	150	152	153	154	155	158
0.6	145	146	148	149	151	152	153	154	155	158
0.7	145	146	148	149	151	152	153	154	155	158
0.8	145	146	148	149	151	152	153	154	155	158
0.9	145	146	148	149	151	152	153	154	155	158
1.0	145	146	148	149	151	152	153	154	155	158
1.5	146	147	149	150	152	153	154	155	156	159
2	146	147	149	150	152	153	154	155	156	159
3	147	148	149	151	152	153	154	155	156	159
4	147	149	150	152	153	154	155	156	157	159
5	147	149	150	152	153	154	155	156	157	159
6	147	149	150	152	153	154	155	156	157	159
7	147	149	150	152	153	154	155	156	157	159
8	147	149	150	152	153	154	155	156	157	159
9	147	149	150	152	153	154	155	156	157	159
10	147	149	150	152	153	154	155	156	157	159
12	147	149	150	152	153	154	155	156	157	159
14	147	149	150	152	153	154	155	156	157	159
16	147	149	150	152	153	154	155	156	157	159
18	147	149	150	152	153	154	155	156	157	159
20	147	149	150	152	153	154	155	156	157	159

VALUES OF C IN KUTTER'S FORMULA
with $n = 0.010$.

Fall in Feet per 1,000 Ft.	DIAMETER OF PIPE IN INCHES.							
	60	66	72	78	84	96	108	120
0.10	154	157	160	162	164	168	171	174
0.12	156	159	161	163	165	169	172	174
0.15	156	159	161	163	165	169	172	174
0.2	158	160	162	165	167	170	172	175
0.3	159	162	163	166	167	170	173	175
0.4	160	162	164	166	168	170	173	175
0.5	161	162	165	167	168	171	173	175
0.6	161	163	165	167	168	171	173	175
0.7	161	163	165	167	168	171	173	175
0.8	161	163	165	167	168	171	173	175
0.9	161	163	165	167	168	171	173	175
1.0	161	163	165	167	168	171	173	175
1.5	161	163	165	167	168	171	173	175
2	161	164	166	167	168	171	173	175
3	162	164	166	167	169	171	173	175
4	162	164	166	167	169	171	174	175
5	162	164	166	167	169	171	174	175
6	162	164	166	167	169	171	174	175
7	162	164	166	167	169	171	174	175
8	162	164	166	167	169	171	174	175
9	162	164	166	167	169	171	174	175
10	162	164	166	167	169	171	174	175
12	162	164	166	167	169	171	174	175
14	162	164	166	167	169	171	174	175
16	162	164	166	167	169	171	174	175
18	162	164	166	167	169	171	174	175
20	162	164	166	167	169	171	174	175

PRESSURE OF WATER.

Head in Feet.	Pressure in Lbs. per Sq. Inch.	Head in Feet.	Pressure in Lbs. per Sq. Inch.	Head in Feet.	Pressure in Lbs. per Sq. Inch.	Head in Feet.	Pressure in Lbs. per Sq. Inch.	Head in Feet.	Pressure in Lbs. per Sq. Inch.
1	0.4	51	22.1	101	43.7	151	65.4	201	87.1
2	0.9	52	22.5	102	44.2	152	65.8	202	87.5
3	1.3	53	22.9	103	44.6	153	66.3	203	87.9
4	1.7	54	23.4	104	45.0	154	66.7	204	88.4
5	2.2	55	23.8	105	45.5	155	67.1	205	88.8
6	2.6	56	24.3	106	45.9	156	67.6	206	89.2
7	3.0	57	24.7	107	46.3	157	68.0	207	89.7
8	3.5	58	25.1	108	46.8	158	68.4	208	90.1
9	3.9	59	25.5	109	47.2	159	68.9	209	90.5
10	4.3	60	26.0	110	47.6	160	69.3	210	91.0
11	4.8	61	26.4	111	48.1	161	69.7	211	91.4
12	5.2	62	26.8	112	48.5	162	70.2	212	91.8
13	5.6	63	27.3	113	48.9	163	70.6	213	92.3
14	6.1	64	27.7	114	49.4	164	71.0	214	92.7
15	6.5	65	28.1	115	49.8	165	71.5	215	93.1
16	6.9	66	28.6	116	50.2	166	71.9	216	93.6
17	7.4	67	29.0	117	50.7	167	72.3	217	94.0
18	7.8	68	29.4	118	51.1	168	72.8	218	94.4
19	8.2	69	29.9	119	51.5	169	73.2	219	94.9
20	8.7	70	30.3	120	52.0	170	73.6	220	95.3
21	9.1	71	30.7	121	52.4	171	74.1	221	95.7
22	9.5	72	31.2	122	52.8	172	74.5	222	96.2
23	10.0	73	31.6	123	53.3	173	74.9	223	96.6
24	10.4	74	32.0	124	53.7	174	75.4	224	97.0
25	10.8	75	32.5	125	54.1	175	75.8	225	97.5
26	11.3	76	32.9	126	54.6	176	76.2	226	97.9
27	11.7	77	33.3	127	55.0	177	76.7	227	98.3
28	12.1	78	33.8	128	55.4	178	77.1	228	98.8
29	12.5	79	34.2	129	55.9	179	77.5	229	99.2
30	13.0	80	34.6	130	56.3	180	78.0	230	99.6
31	13.4	81	35.1	131	56.7	181	78.4	231	100.1
32	13.9	82	35.5	132	57.2	182	78.8	232	100.5
33	14.3	83	35.9	133	57.6	183	79.3	233	100.9
34	14.7	84	36.4	134	58.0	184	79.7	234	101.4
35	15.2	85	36.8	135	58.5	185	80.1	235	101.8
36	15.6	86	37.2	136	58.9	186	80.6	236	102.2
37	16.0	87	37.7	137	59.3	187	81.0	237	102.7
38	16.5	88	38.1	138	59.8	188	81.4	238	103.1
39	16.9	89	38.5	139	60.2	189	81.9	239	103.5
40	17.3	90	39.0	140	60.6	190	82.3	240	104.0
41	17.7	91	39.4	141	61.1	191	82.7	241	104.4
42	18.2	92	39.8	142	61.5	192	83.2	242	104.8
43	18.6	93	40.3	143	61.9	193	83.6	243	105.3
44	19.0	94	40.7	144	62.4	194	84.0	244	105.7
45	19.5	95	41.1	145	62.8	195	84.5	245	106.1
46	19.9	96	41.6	146	63.2	196	84.9	246	106.6
47	20.3	97	42.0	147	63.7	197	85.3	247	107.0
48	20.8	98	42.4	148	64.1	198	85.8	248	107.4
49	21.2	99	42.9	149	64.5	199	86.2	249	107.9
50	21.6	100	43.3	150	65.0	200	86.6	250	108.3

