Wooden Stave Pipe

FOR

High Water Pressure.

WOODEN

STAVE PIPE

For High Water Pressure.

The Great Colorado Invention.

Some facts regarding its construction and its advantages over all other Pressure Pipes in use.

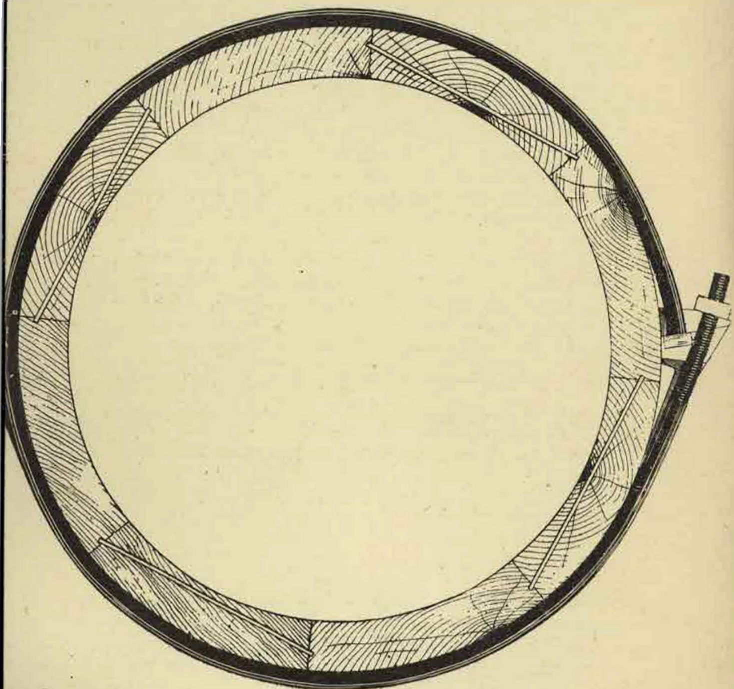
Patent No. 359,590. *Dated March 22, 1887.*

... BY...

CHAS. P. ALLEN,

DENVER, COLO.

Allens Wooden Pipe



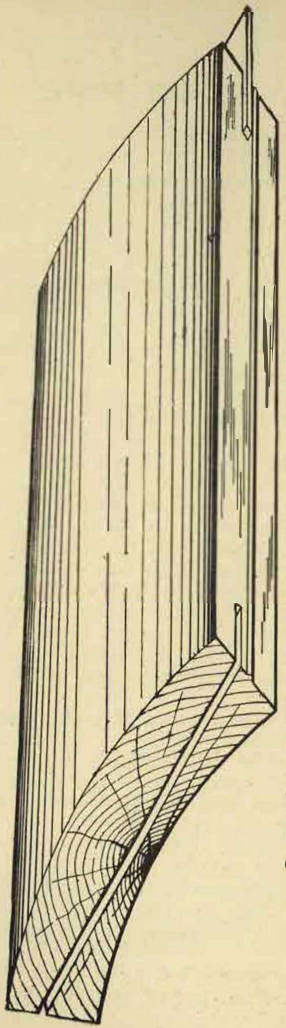
WOOD PIPE.

FEW INVENTIONS of modern times have attracted a more wide-spread interest than the successful demonstration by Mr. Charles P. Allen, of Denver, Colo., of the feasibility of making long lines of high-pressure water-pipe, of all sizes, out of wood—the cheapest and cleanest of all materials used for the carriage of water. Wooden pipe is not new; it has been used in one form or another for centuries, and the durable qualities of wood when continuously saturated with water have been demonstrated by innumerable examples. But previous attempts to utilize wood for this purpose have been chiefly confined to bored logs, made in sections of convenient lengths, bound around with wire or strap iron in various forms, and fitted together by driving the tapered end of one section into the enlarged end of the abutting section. This class of pipe has had a widely extended use, but is necessarily limited in size to twelve or fourteen inches diameter at the extreme. Wooden staves have also been used in a few instances for penstocks to water-wheels, but always heretofore with flat bands, with cumbrous and awkward couplings, and under very moderate pressure.

Allen's patent, No. 359,590, issued March 22, 1887, describes a novel form of making wooden-stave pipe, with round rods or bands instead of flat ones, a simple and inexpensive form of coupling or shoe, and an effective and cheap mode of making the end joints of the staves. Subsequent years of use have proven to the satisfaction of all who have examined the subject, that this patent covers the means of making the cheapest, simplest and most durable water-pipe ever invented, from a few inches up to ten, fifteen or twenty feet in diameter if desired. There is practically no limit to the size to which it can be built, and the larger the size the cheaper it becomes as compared with cast or wrought iron pipes of equal dimensions.

The special advantages of this patent are the following:

First—The staves, being cut to the true radius of the pipe inside and out, are of uniform thickness, and con-



Stave—Showing Butt End, Metallic Tongue and Lateral Calking Bead.

sequently, are uniformly saturated from the water inside to the outer shell, leaving no portion to rot from lack of saturation, experience having taught us the proper thickness to use with different woods, diameters and pressures to insure the necessary saturation.

Second—The bands being round, are of longer life than flat bands, as less surface is exposed to oxidation, and consequently they are more easily protected from rust.

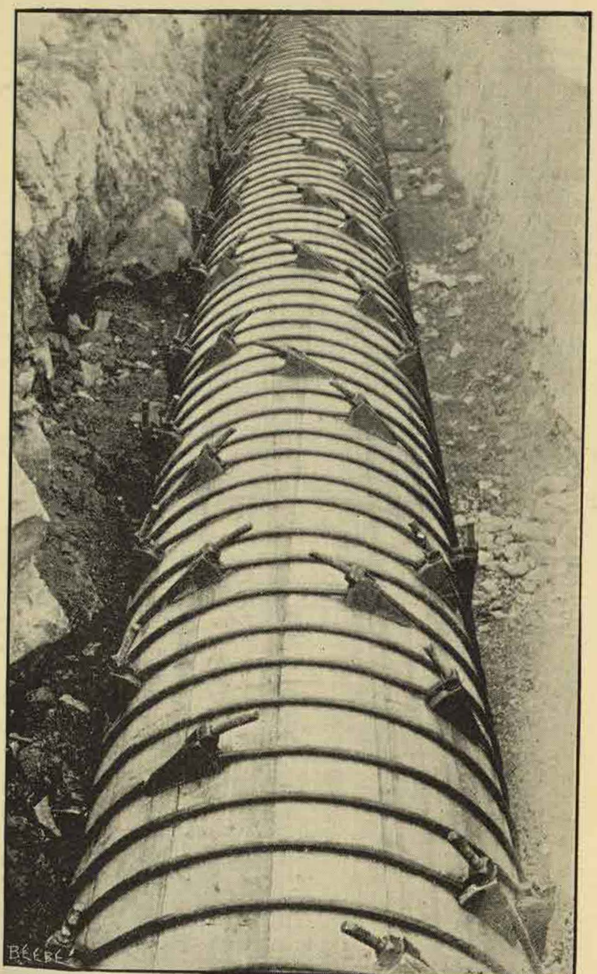
Third—The form of the bands enable them to imbed themselves slightly into the wood, and thus accommodate any excessive swelling of the wood without injury to the pipe.

Fourth—The round bands are stronger than flat bands of equal area, because all devices for coupling flat bands necessitate the punching of holes and riveting on the couplings, which weaken the band, consequently the round band attains equal strength with less weight and less machine work, and is therefore cheaper in addition to being more durable.

Fifth—The coupling shoes, being made of malleable iron, are stronger than the band and can never break, and are so simple in form that they are instantly placed in position when required. A recess near the bottom of the casting is made to receive the head on one end of the band, and the slot in the top receives the threaded end of the band directly over the head. Hence the pull on the band is in a direct line and all torsional strains on band and shoe are avoided. This gives it the directness of the ordinary "turn-buckle" with less cost. A more perfect coupling of the two ends of a rod was never devised.

Sixth—The metallic tongues inserted in the ends of the staves constitute a most perfect end joint, for the reason that they are cut longer than the width of the staves, and as the pipe is cinched up the ends are imbedded in the wood of the adjoining staves, thus cutting off all possible leakage around the ends.

Seventh—The minute bead on one side of each of the staves serves the purpose of calking the joint as it becomes imbedded in the adjoining stave—thus making a union superior to the ordinary tongue and groove, as it avoids the weakening of the bearings of the arch of the pipe, which must result from any form of tongue and groove.



24 INCH PIPE—ILLUSTRATING TAPER FROM 15 TO 16 STAVES.

The general advantages of the Allen pipe may be enumerated as follows :

Cheapness.

Durability.

It is cheaper than any other pressure pipe of equal durability.

It is more durable than any pressure pipe of equal cost.

Its probable life is far greater than sheet-iron, wrought-iron or steel pipe.

It has greater carrying capacity than either cast-iron or riveted pipe.

It has a smoother interior, and it retains its capacity.

Its diameter is never decreased by the formation of rust, incrustations or tubercles.

It is always clean and sweet.

It contains no calking yarn to decay and gather foul accretions.

It never bursts.

It will not break by settlement.

It is continuous.

It has no positive end-joints.

It can be laid at a hundred different points at once and the various sections coupled up without extra cost or delay.

It is easily tapped.

It can be easily repaired and new staves inserted or new bands put on with ease and safety.

It can be laid in easy and graceful curves, both vertically and horizontally.

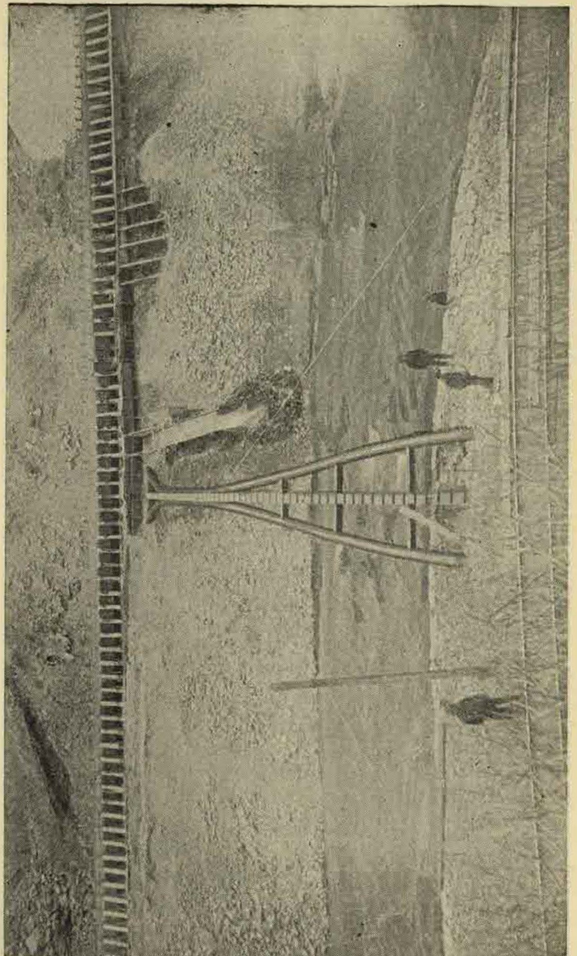
It can be laid with a foot of water in the trench.

It can easily be taken up and replaced without strain or injury to any of its parts.

It can be built anywhere of any size, over the most mountainous and inaccessible country, where the transportation of iron pipes would be next to impossible, as it is composed of pieces that are light and easily handled.

It is equally strong throughout, all the joints being broken and the bands spaced to the exact pressure at all points.

It is therefore built without excess of materials, and it is more scientific in the adjustment of strength to strain than any other pipe.

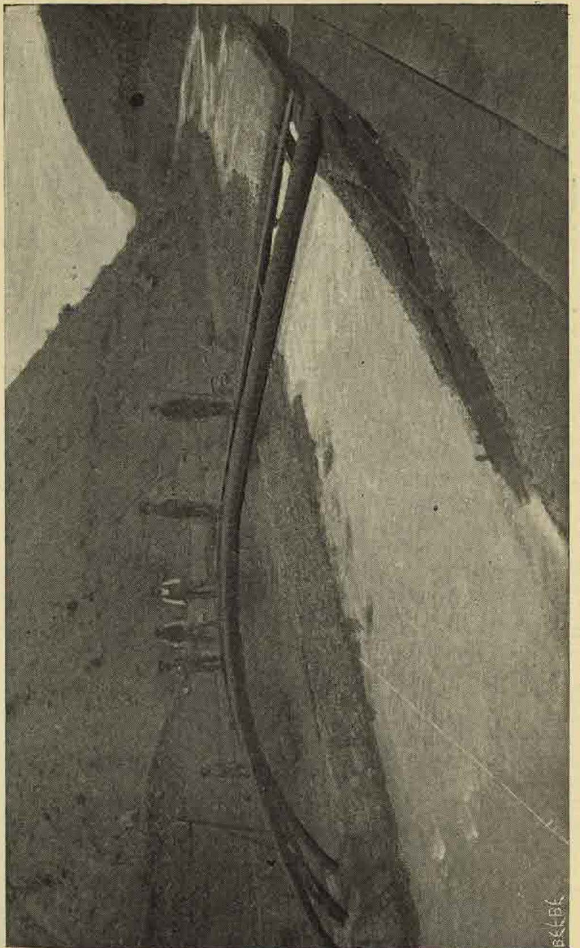


END VIEW OF PIPE ARCH IN PLATTE CANON, COLO.—SPAN 106 FEET.

GENERAL DESCRIPTION OF PIPE.

The pipe is composed of staves of wood banded with steel hoops. The staves are of any convenient width from two to eight inches, and of any length from twelve to twenty-four feet,—the thickness when dressed being from one to two-and-a-half inches, according to diameter and pressure. The flat sides are dressed to true circular lines, and the edges are made radial to those circles,—a certain number forming a circular ring composing the shell of the pipe. The staves are cut off squarely at the ends, and have a saw-kerf cut across the face of each end, three-quarter inch deep, for the insertion of a metallic tongue one and one-half inches wide and about one-quarter inch longer than the width of the stave. This slot is so made that the tongue will fit into it closely by tapping with a hammer. In construction all staves must break joints, and although all the joints of one section are generally brought within a space of two-and-a-half to three feet, (over which two to four extra bands are distributed); no two adjoining joints are placed nearer each other than six inches. This arrangement insures great strength of joint, and the overlapping of the metallic tongue into the staves on each side makes a perfect butt joint.

The bands are of round steel, with a head at one end and a thread from three to five inches long at the other end,—the two coming together in a malleable iron shoe of peculiar construction, fitted to the form of the pipe, and so arranged as to enable the staves to be drawn tightly together. When these 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. A bridge recently built of two twelve-inch wood pipes, arched and curved, has surprising stiffness and strength.

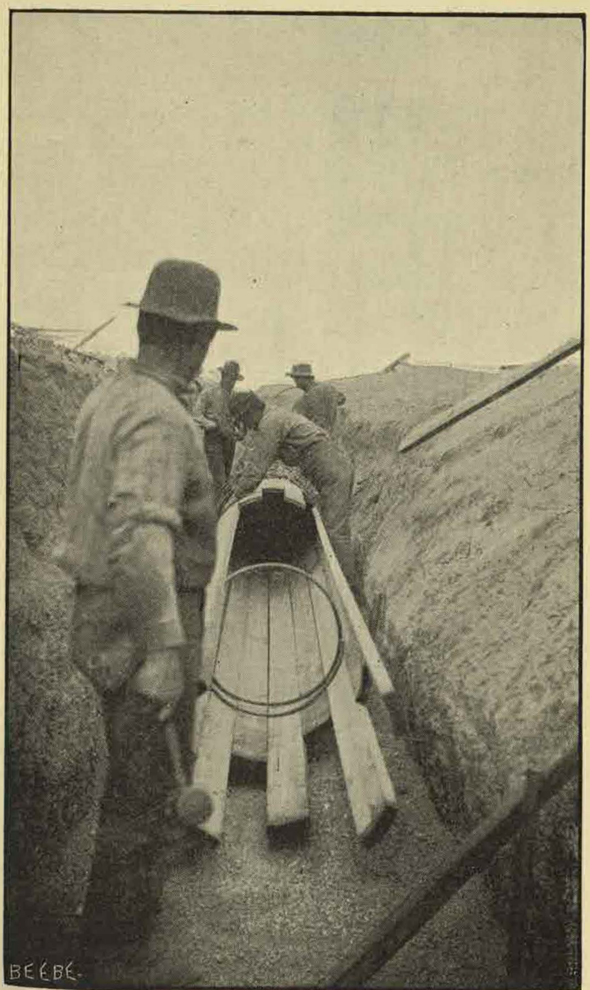


Side View of Pipe-arch in Platte Canon.

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 first placed in the bottom of the trench, ten to twelve feet apart, and the bottom staves with the tongues placed in the ends are placed loosely in position to form the bottom half of the pipe, inside which is then placed a ring of proper size, the remaining staves are added, the bands are put in position, spaced the proper distance apart, and the nuts are tightened up part way. The staves are then coopered out to complete the true circle, care being taken that no stave projects beyond its fellows. When the pipe is round and true and all the staves driven up tight at the butt joints, the bands are again cinched up tight and firm. Earth is tamped carefully all around the pipe and it is covered entirely over and the trench refilled. A pipe-laying gang consists of eight to sixteen men, according to the number of bands to be put on. Where the pressure is heavy and the bands are but two to three inches apart, a larger gang is required than on light-pressure pipe—at least one-half the gang being always engaged in the final cinching and finishing of the pipe, in the rear of those who set up the pipe and place the bands. It is customary on a long line of pipe to place gangs every fifteen hundred to two thousand feet, and where gangs working in opposite directions meet, the coupling of the ends is effected by cutting the staves about one-eighth inch longer than the space they are to occupy and springing them into position, the bands closing all tightly together, making the butt-joints at the coupling really tighter than ordinarily made elsewhere.

Years of experience in building this pipe have proven that there are a great many little niceties to be observed in construction which make all the difference between success and failure, and for this reason we prefer in all cases in granting licenses for the use of the pipe, to send



Erecting Pipe—Driving Staves Home to Position.

a man of experience to superintend the laying in order to insure success, which our patrons must desire as well as ourselves.

As soon after the pipe is laid as practicable, water should be slowly admitted and the pipe allowed to soak up gradually before the full pressure is applied. All minor leaks will gradually disappear and the serious ones may be located and stopped. This is usually a simple matter, accomplished with small pine wedges,—although, sometimes a broken or defective stave may have escaped inspection, and required to be replaced.

CONNECTIONS.

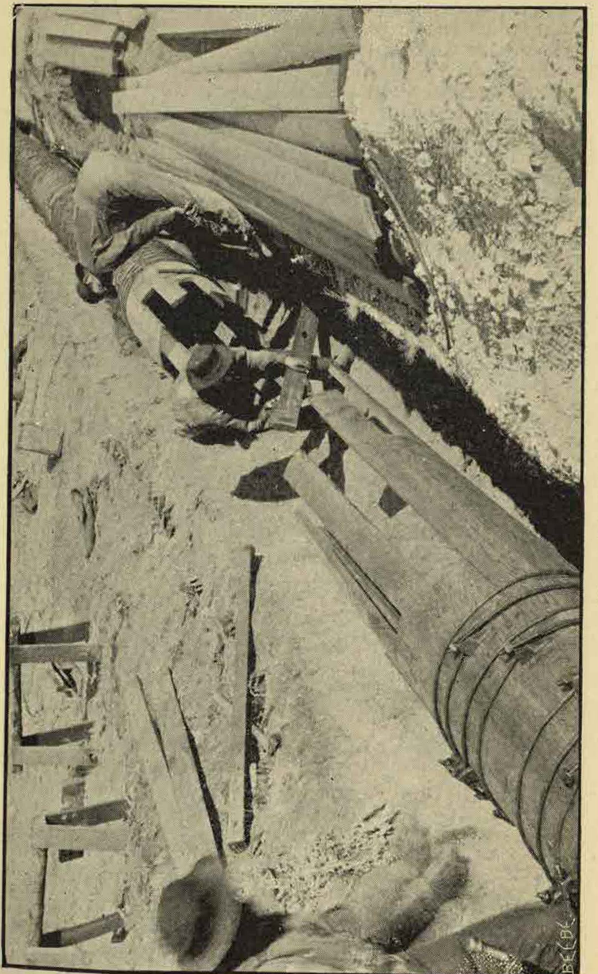
Where large branch lines are to be taken off the wood main, connection is made by means of a special casting or "T" of cast-iron, through which the wood pipe is built, a space being left at each end for oakum calking between the wood and iron. A hole is sawed through the pipe corresponding to the size of the outlet. 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.

The pipe can be tapered in any way desired, the inlet end being made wide and funnel-shaped to facilitate the freer admission of water, by inserting tapered staves,—one or more in number,—and changes in diameter can thus be made at will.

MATERIALS.

Lumber.—Any wood which is clear, well seasoned, free of knots, season checks, shakes, splits or other imperfections, may be used in this pipe, provided it is hard enough to resist crushing under a firm tensile



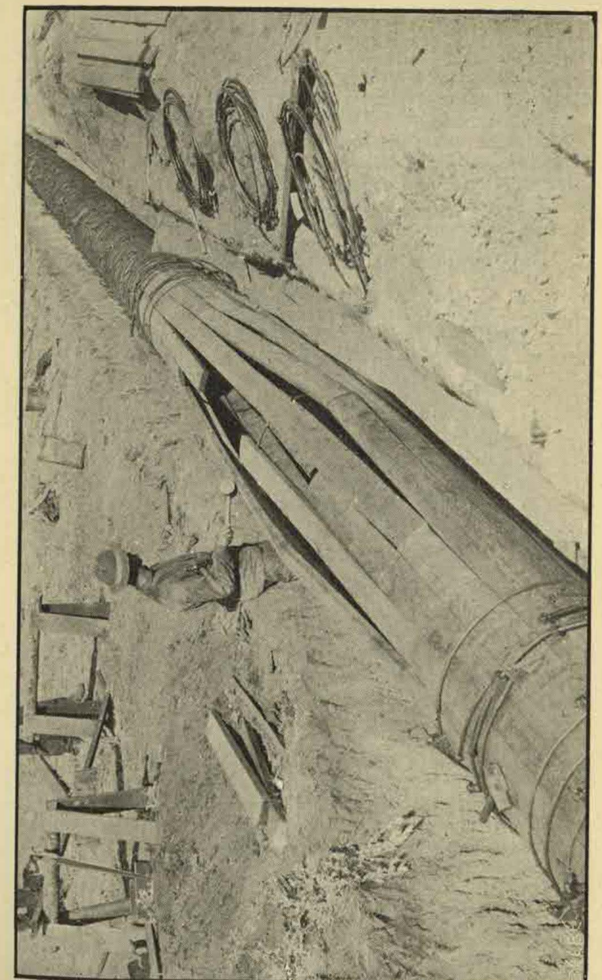
No. 1—Beginning Buckle.

strain on the bands, and provided it does not soften or become spongy when saturated. The two woods which have been most extensively used in Colorado are the yellow long-leaf pine of Texas, and the California redwood. The latter wood is highly regarded because it is an exceedingly durable wood when in contact with the ground,—under circumstances where many other woods decay,—hence, for a pipe line which may at times be left empty or partially empty for a considerable period, redwood has no superior. Where it is to be constantly in use, constantly filled and hence always saturated, any other firm wood will answer the purpose as well.

Bands.—The bands are made of a mild steel, of a quality that will bear a tensile strain of 60,000 to 70,000 pounds per square inch, and will elongate several times its diameter before breaking. At one end they have a square head of special form and at the other a thread is cut usually five inches in length, for which distance the rod is upset. The threads are cut of less depth than the standard thread, and the nuts are made thicker than the ordinary. The bands are shipped as straight rods in bundles and are bent on the ground by hand around wooden tables of proper size. They are dipped in a special preparation of asphaltum, heated to 300 degrees Fahrenheit, or painted with red oxide paint to preserve them from rust. After the bands are in place on the pipe the threaded ends are again carefully coated before the pipe is covered with earth.

Shoes.—The shoes are made of the best quality of malleable iron, having a tensile strength of at least 40,000 pounds per square inch. They are dipped in oil as soon as they come from the annealing furnace, and are afterward coated with asphalt or paint. This is done more as a protection to the threaded ends of the rods which lie in the shoes than as a protection to prolong the life of the shoes themselves, which are necessarily so much stronger than necessary to resist tensile strains, that no fear of their being weakened by rust need otherwise be entertained.

Tongues.—The strap-iron tongues that are used in the butt joints are cut to the proper length and shipped in boxes, or may be shipped in bundles as strap iron and cut on the work. Almost any quality of metal will answer for this important office, provided it is of uniform thickness and width.



No. 2—Buckle.

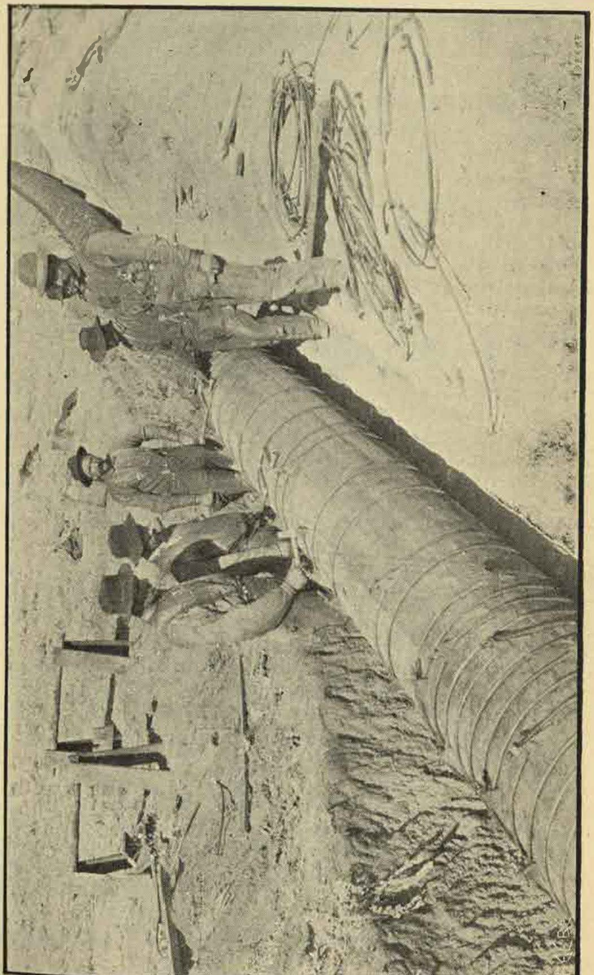
WHERE AND HOW THE PIPE HAS BEEN USED.

Denver, Colorado, a city of 150,000 inhabitants, being practically the birthplace of this wonderful pipe, displays its faith in its good qualities by the fact that every drop of water used in the city (30,000,000 to 35,000,000 gallons daily) is brought to the city through wooden pipes, built by the inventor, Mr. Allen. One of the lines is over twenty miles in length; another, sixteen and one-half miles long, bears a pressure due to a static head of 100 to 210 feet. The total mileage of wood pipe mains, twelve to forty-eight inches diameter, laid in connection with the Denver Water Works, is nearly sixty miles, the cost of which has not been far short of $500,000.00.

Other places where it is used for main water works conduits, or as syphons to replace flumes on irrigation canals, or as water power conduits, are the following:

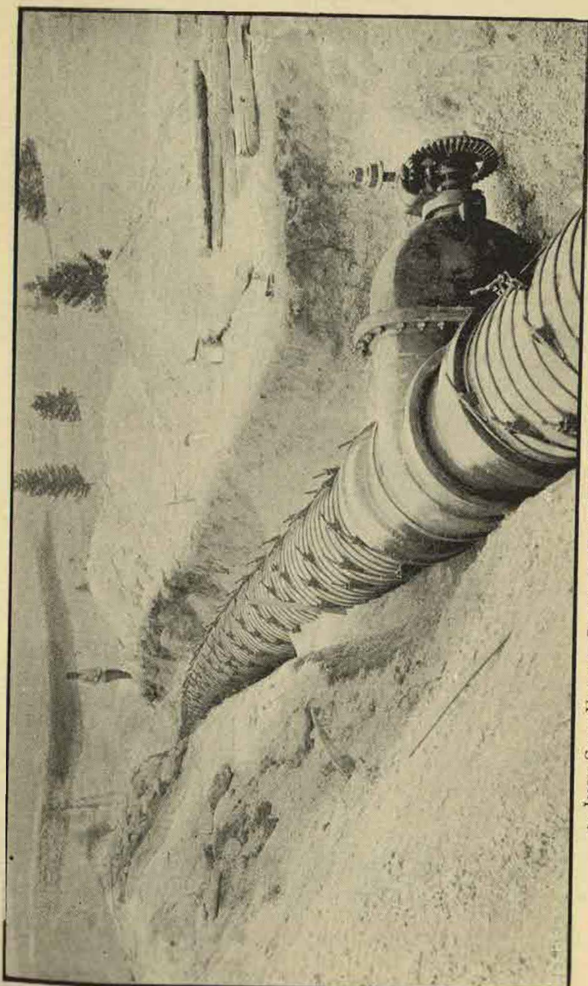
Butte City, Montana,	Cheyenne, Wyoming,
Provo, Utah,	Maxwell Grant, New Mexico,
Logan, Utah,	Rocky Ford, Colorado,
Ogden, Utah,	Ft. Garland, Colorado,
Pocatello, Idaho,	Pueblo, Colorado,
Gothenburg, Nebraska,	Yuma, Arizona.

The following table gives the detail of size, length, maximum pressures and date of construction of the main lines thus far in operation:



No. 3.—Buckle Completed.

NAME.	Diameter, Inches.	Length, Miles.	Maximum Head, Feet	Date of Construction.
Denver Water Company	48	3.20	10	1883
" " "	37	6.30	50	1885
" " "	30	1.00	90	1885
" " "	24	1.25	120	1885
" " "	25	2.00	45	1889
" " "	12	3.00	75	1886
Citizens' Water Company	30	16.50	210	1890
" " "	30	4.00	70	1892
" " "	34	14 00	140	1892
" " "	44	2.00	120	1892
Total in use in Denver Water-Works	------	53.25	------	------
Provo, Utah	14	4.00	165	1891
Butte City, Mont.	24	10.00	150	1892
Logan, Utah	18	1.00	75	1893
Pocatello, Idaho				
Yuma, Ariz. (pump main)	26	3.00	75	1893
City Ditch, Denver	48	0.50	5	1889
Cheyenne (Wyo.) Water Works	30	0.76	60	1889
Cheyenne (Wyo.) Water Works	24	1.78	40	1889
Berkley Lake, Denver	24	1.13	70	1889
Maxwell Grant, N. M. (Siphon)	72	290 ft.	25	1889
Rocky Ford, Col o. (Siphon)	------	0.06	30	1888
Maxwell Grant (Lake outlet)	72	------	15	1889
Fort Garland, Colo. (Siphon)	48	0.03	10	1889
Fort Garland, Colo. (Siphon)	37	0.03	4	1889
Bessemer Ditch, Pueblo (Siphon)	54	0.80	70	1890
Ogden, Utah, Water Works	24	5.00	60	1890
Gothenburg, Neb. (Pump plant)	72	0.20	38	1893
East Denver Water Works	12	6.00	------	1891

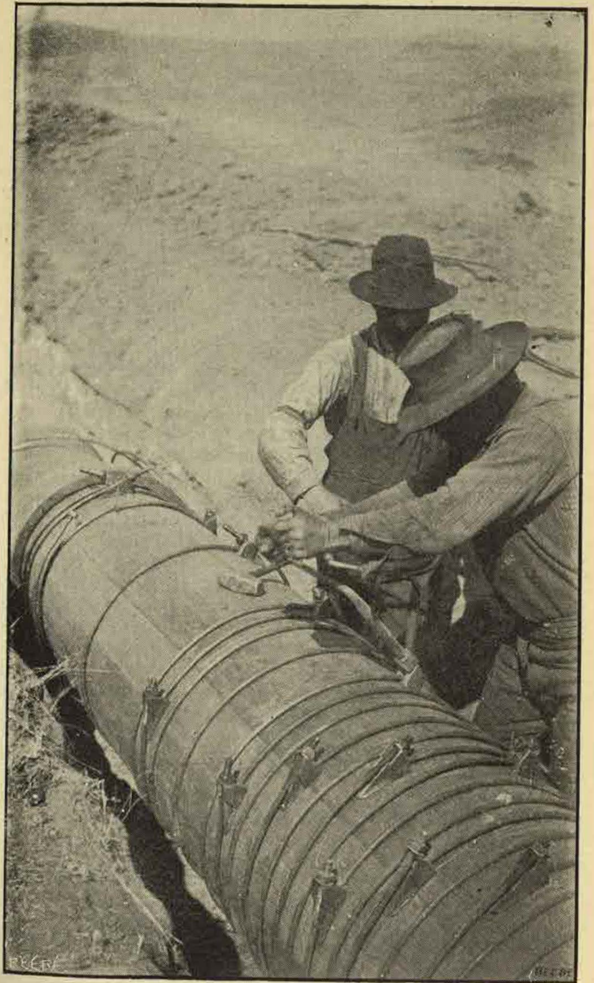


24-Inch Stop Valve—Showing Method of Connection with Wood Pipe.

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 being 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. 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



Illustrating Connection with Cast-Iron 24 to 20-Inch Reducer.

away with the troublesome growth of algæ in this kind of water, and with the annual expense of cleaning, and will admit of a continued flow during the winter season for 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.

On the Bessemer ditch there is a pipe line fifty-four inches in diameter, 4,200 feet long, built by J. S. Greene, the ex-State Engineer of Colorado, and on the Maxwell Grant in New Mexico there are two pipe lines seventy-two inches in diameter.

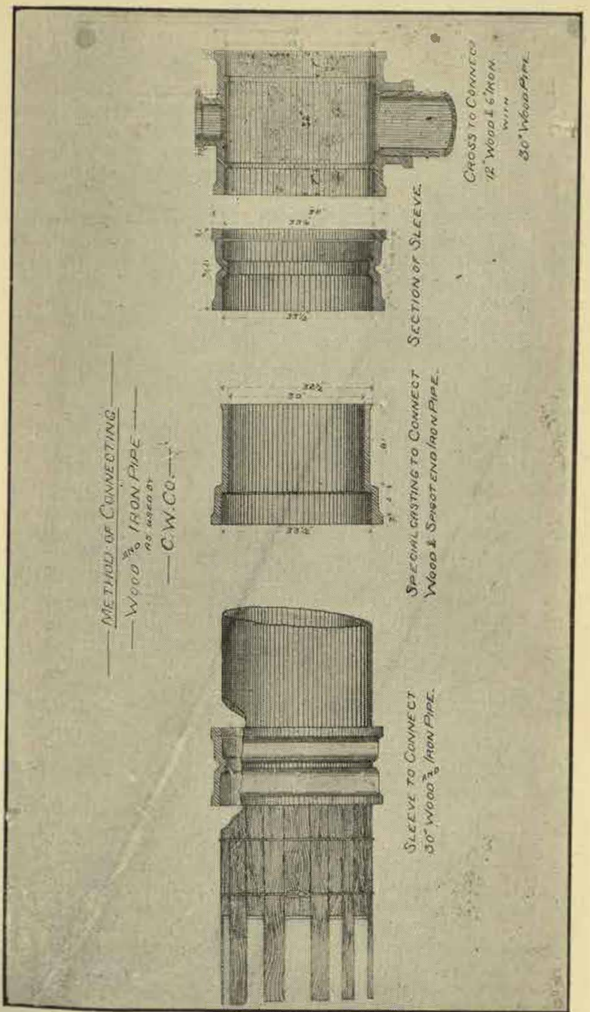
WATER POWER.

With the development of electric machinery water power is begining 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."

Mr. Hull of Connecticut, who has had an experience of over forty years with large wooden stave pipes, 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 around it, at from forty to fifty years, and that he considers its life indefinite when buried under ground.

The bands, being made of round steel, have a maximum area with a minimum surface, and being well coated they corrode slowly; and since they are from three to five times as strong as is called for by the bursting strain they have from two-thirds to four-fifths of their area to lose before their full strength is called upon.

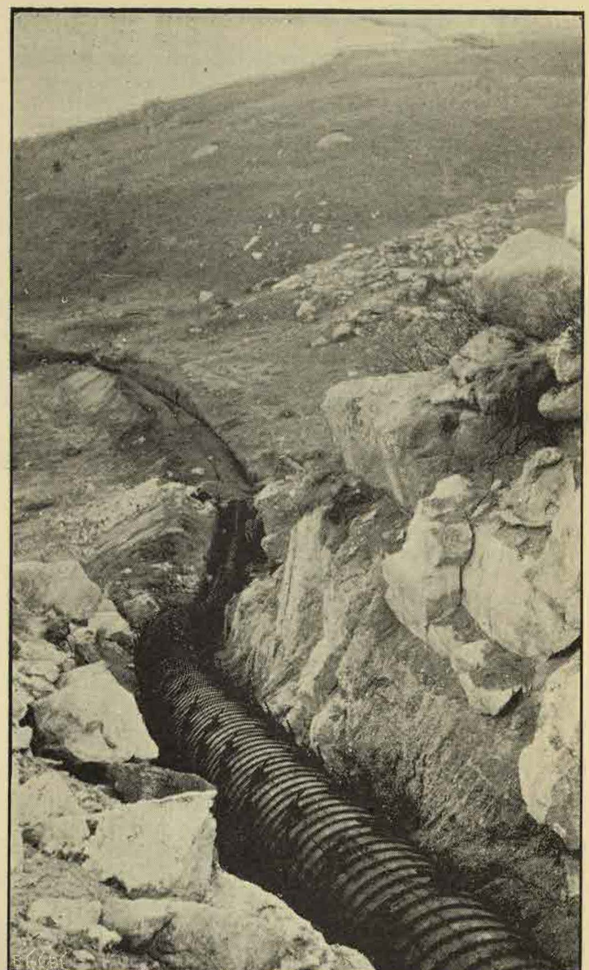
TESTIMONIALS.

JANUARY 12, 1893.

C. P. ALLEN, ESQ., *Chief Engineer Citizens' Water Company, Denver, Colo.*

DEAR SIR:—In response to your request for a testimonial as to the use of wooden stave water-pipe in the 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 in wooden



24-INCH PIPE AT BUTTE, MONT.—ILLUSTRATING A COMPOUND CURVE.

pipes constructed by you. The first line, three and one-half miles long, forty-eight inches in diameter, having been 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 Company, 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 Canon 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 is now constructing a second conduit, thirty-four inches in diameter, to be completed by March 1st. It has a maximum pressure of 150 feet. With the completion of this line there will be 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,

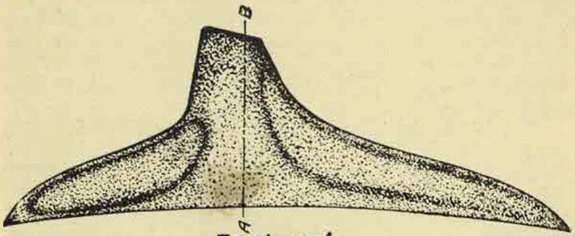
(Signed) J. B. HUNTER, *City Engineer.*

JANUARY 13, 1893.

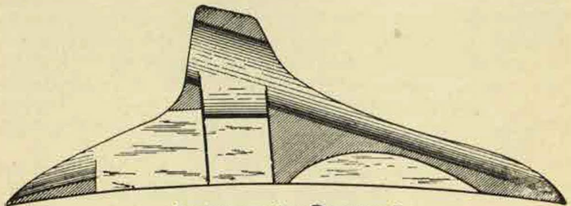
C. P. ALLEN, ESQ., *Chief Engineer Citizens' Water Company, Denver, Colo.*

DEAR SIR:—The use of wooden stave water-pipe, as constructed by you 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.

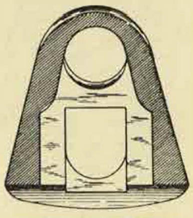
Knowing that you were the best authority on wooden pipe, I have always referred the parties seeking knowl-



ELEVATION



LONGITUDINAL SECTION



SECTION A-B

CAST-IRON COUPLING.

edge relating thereto to you for the desired information.

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 your style of construction. 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.

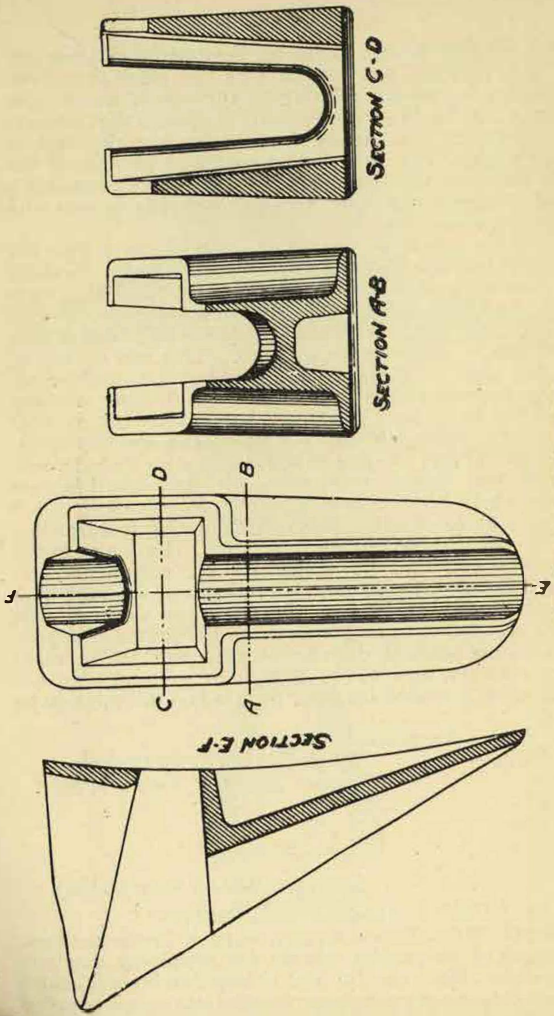
Respectfully,

(Signed) H. F. MERRYWEATHER,
Engineer Board of Public Works.

DENVER, COLO., May 31, 1893.

MR. CHARLES P. ALLEN, *Chief Engineer.*

DEAR SIR:—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 your patent wooden stave pipe, adopted



Malleable-Iron Coupling.

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 your 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.*

CAPACITY OF PIPE.

Careful experiments with the pipe in use show its capacity to be about as shown by the following tables:

12-INCH PIPE.

Grade or Fall in Feet per 1000 feet.	Discharge in Gallons per 24 hours.
0.10	260,000
0.15	300,000
0.30	500,000
0.50	670,000
0.80	850,000
1.0	950,000
3.0	1,680,000
5.0	2,170,000
8.0	2,750,000
10.0	3,070,000
16.0	3,880,000
20.0	4,340,000

16-INCH PIPE.

Grade or Fall in Feet per 1000 feet.	Discharge in Gallons per 24 hours.
0.10	600,000
0.15	740,000
0.30	1,110,000
0.50	1,470,000
0.80	1,860,000
1.0	2,070,000
3.0	3,650,000
5.0	4,740,000
8.0	6,000,000
10.0	6,710,000
16.0	8,500,000
20.0	9,490,000

20-INCH PIPE

Grade or Fall in Feet per 1000 feet.	Discharge in Gallons per 24 hours.
0.10	1,090,000
0.15	1,380,000
0.30	2,050,000
0.50	2,690,000
0.80	3,400,000
1.0	3,810,000
3.0	6,680,000
5.0	8,700,000
8.0	11,000,000
10.0	12,300,000
16.0	15,500,000
20.0	17,400,000

24-INCH PIPE

Grade or Fall in Feet per 1000 feet.	Discharge in Gallons per 24 hours.
0.10	1,780,000
0.15	2,270,000
0.30	3,350,000
0.50	4,400,000
0.80	5,580,000
1.0	6,250,000
3.0	10,900,000
5.0	14,200,000
8.0	18,000,000
10.0	20,100,000
16.0	25,400,000
20.0	28,400,000

30-INCH PIPE.

Grade or Fall in Feet per 1000 feet	Discharge in Gallons per 24 hours.
0.10	3,330,000
0.15	4,160,000
0.30	6,120,000
0.50	8,030,000
0.80	10,200,000
1.0	11,400,000
3.0	19,900,000
5.0	25,700,000
8.0	32,500,000
10.0	36,300,000
16.0	46,000,000
20.0	51,400,000

36-INCH PIPE.

Grade or Fall in Feet per 1000 feet.	Discharge in Gallons per 24 hours.
0.10	5,480,000
0.15	6,850,000
0.30	9,960,000
0.50	13,100,000
0.80	16,500,000
1.0	18,500,000
3.0	33,400,000
5.0	42,000,000
8.0	53,100,000
10.0	59,300,000
16.0	75,100,000
20.0	83,900,000

48-INCH PIPE.

Grade or Fall in Feet per 1000 feet.	Discharge in Gallons per 24 hours.
0.10	11,900,000
0.15	14,900,000
0.30	21,600,000
0.50	28,200,000
0.80	35,600,000
1.0	39,800,000
3.0	69,500,000
5.0	90,200,000
8.0	114,000,000
10.0	127,000,000
16.0	161,000,000
20.0	180,000,000

60-INCH PIPE.

Grade or Fall in Feet per 1000 feet.	Discharge in Gallons per 24 hours.
0.10	21,800,000
0.15	27,000,000
0.30	38,900,000
0.50	50,900,000
0.80	64,600,000
1.0	72,200,000
3.0	126,000,000
5.0	162,000,000
8.0	206,000,000
10.0	230,000,000
16.0	291,000,000
20.0	325,000,000

72-INCH PIPE		72-INCH PIPE.	
Grade or Fall in Feet per 1000 feet.	Discharge in Gallons per 24 hours.	Grade or Fall in Feet per 1000 feet.	Discharge in Gallons per 24 hours.
0.10	35,600,000	3.0	203,000,000
0.15	43,800,000	5.0	263.000,000
0.30	63,000,000	8.0	332,000,000
0.50	82.600,000	10.0	371,000,000
0.80	104,000,000	16.0	469,000,000
1.0	117,000,000	20.0	524,000,000

These tables were computed by Kutter's formula, using the coefficient N = .010, which experience has fully justified our using.

C. J. KELLY, PRINTER, DENVER