BYERS PIPE

GENUINE WROUGHT IRON
FULL WEIGHT GUARANTEED

Main Office and Plant:
PITTSBURGH, PA.

Sales Offices:
New York Philadelphia Boston Cleveland Chicago

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What is Wrought Iron?

MAKING good pipe starts with making good metal. To judge good metal, metallurgical science is necessary.

Modern steel, due to its alluring commercial possibilities, has occupied the attention of metallurgists almost to the exclusion of wrought iron, the older product. Such scientific understanding of wrought iron as exists today, we therefore owe in a large measure to a few metallurgists who have strayed from the beaten path of steel research.

In the absence of a more general knowledge of wrought iron, this product has been confused with soft steel, and has had to fight an unequal battle with cheaper, but inferior, products offered under the name of wrought iron or iron.

To avoid obtaining such inferior products purchasers have endeavored to protect themselves by prescribing the process by which the iron should be made, hand-puddling usually being considered the first essential to obtaining good wrought iron. While this condition still prevails, it is desirable to define, without regard to process employed, what does and does not constitute good wrought iron.

Such a definition is contained herein and should prove valuable; first, in making clear the physical and chemical differences between soft steel and wrought iron, and secondly, in determining whether the product of any process of making wrought iron measures up to the highest standards of this material, standards which have been consistently maintained by the Byers Company for over half a century.

Further, inasmuch as a large part of the wrought iron production of today enters into the manufacture of welded pipe, and is so used exclusively by the Byers Company, the special advantages of the material for this purpose will be explained herein.

Definition of Wrought Iron

Methods of Manufacture, Chemical and Physical Characteristics

The International Society for Testing Materials, in 1912, suggested the following definition of wrought iron:

> WROUGHT IRON—Malleable iron which is *aggregated from pasty particles without subsequent fusion,* and contains so little carbon that it does not harden usefully when cooled rapidly.
>
> REMARKS—Commercial wrought iron, though essentially made direct from the ore, is usually made from cast iron by such removal of its carbon and silicon as to convert it into pasty particles, and by squeezing these together in a bath of cinder or slag into a coherent mass, which *retains permanently an important quantity of that slag.*

The most important features of this definition, with its appended "Remarks," have been italicized in the above. The Byers guarantee quoted below, under which their pipe is sold, is an amplification of this definition, embodying additional provisions to safeguard against material not in keeping with the highest recognized quality of wrought iron. These additional provisions are italicized in the following:

> "All Byers pipe is guaranteed to be produced from genuine wrought iron, aggregated from *a solidifying mass* of pasty particles of *highly refined metal* with which, *without subsequent fusion,* is incorporated a *minutely and uniformly distributed quantity of silicate slag.*"

There is guaranteed by the above, a product which conforms to certain chemical and physical characteristics. The base metal must be refined to the requisite degree of purity, as indicated by the final amount of contained ingredients; and it must have incorporated in a proper manner, the desired proportion of slag of the quality essential for the production of good wrought iron. Finally, the process must be such as to *preclude the possibility of segregation of impurities, common to steel making.*

Smelting the Ore

All iron and steel is initially smelted from the ore. Among the ancients, the malleable, ductile product desired was produced in primitive furnaces, in a single operation. The output was relatively trivial, with a heavy requirement of time and labor, and the use of only the highest grade of ore was necessary. However, the nature of ores available in quantity, and consideration of operating economy and control, long ago resulted in duplex methods of refining, which are prevalent today.

A blast furnace first reduces the ore to a relatively crude pig or cast iron, which is non-malleable and non-ductile, and unsuited for general use in industry.

The pig iron is, in turn, refined by one of several methods into malleable and ductile wrought iron or steel, capable of being cast, rolled, or forged into plate, rails, pipe, structural shapes, or other forms, and possessing the physical characteristics needed for the employment of these products in construction.

Pig Iron Analysis

The composition of pig iron is approximately:

Carbon	3.50 to 4.00 per cent.
Manganese	0.50 to 1.50 "
Phosphorus	0.10 to 1.50 "
Sulphur	0.02 to 0.12 "
Silicon	0.75 to 2.00 "

The general composition of pig iron is the result of the process and condition of the smelting operation, and of the type of ore and fuel used. To some extent certain elements are controllable in the operation, and are varied to suit the subsequent refining method or product desired.

Refining the Pig Iron

The composition of refined iron and steel used in construction is about as follows:

Carbon	0.02 to 0.75 per cent.
Manganese	0.02 to 0.75 "
Phosphorus	0.02 to 0.15 "
Sulphur	0.01 to 0.08 "
Silicon	0.03 to 0.25 "

It will be seen that in the refined metal certain of the pig iron elements remain in varying amounts, which is due to the varying power of the several refining processes to remove these elements. Other elements, on the contrary, are purposely left in the product, or added, to confer specific and desired properties. Thus, aside from any question of operating advantages, economies and suitability to handle the available pig iron, the acid and basic Bessemer and Open Hearth, and the puddling processes, function in distinct and varying manners in effecting the refining, and in the extent to which it is accomplished.

Comparing wrought iron and steel, the former requires, and has in general, a higher purity of metal.

But the open hearth steel furnace can and does produce a metal of a standard of chemical purity equal to that of wrought iron. *To be classed as wrought iron, this pure open hearth steel would need, in addition, the incorporation, in a minute and even state of distribution, of a portion of the silicate slag.*

This incorporation, it should be noted, can only be accomplished while the metal is in a pasty, just solidified, or solidifying condition. Since all steel making operations cast the metal in molds while in a liquid condition, there is very complete separation of the slag and metal, and the product, whatever its purity of base may be, is slagless and therefore differs from wrought iron in this fundamental and essential characteristic.

Chemical Analysis of Wrought Iron

A typical analysis of good wrought iron follows:

Carbon	0.02 per cent.
Manganese	0.03 "
Phosphorus	0.14 "
Sulphur	0.02 "
Silicon	0.16 "

In comparing this analysis with that of soft steel, it must be borne in mind that this analysis is a composite of the base metal and included slag; in fact, almost all of the silicon and a large part of the phosphorus are ingredients of the slag. The base metal is therefore of higher purity than indicated by analysis, containing only a few hundredths of one per cent. of each of the metalloids. (The above analysis may be taken as representative of Byers pipe, having for many years been so used.)

Accepting the same analysis as representative of high grade wrought iron, let us consider each of the metalloids in detail, and the influence for good or evil of varying amounts of these metalloids, thus explaining the first characteristic of wrought iron—high purity of base metal.

Metalloids in Wrought Iron

CARBON—In steel making, this element is generally removed to the greatest possible extent in the refining operation, and is then added again in a quantity sufficient to give the metal the desired physical properties, carbon having the well-known virtue of increasing the tensile strength and hardness. Pipe steel never receives such additions of carbon, as carbon makes welding difficult. Soft steel for welded pipe contains from .05 to .15 per cent. carbon, while wrought iron contains only from .02 to .05 per cent.; this lower carbon content making for better welding. A higher quantity of carbon interferes with the welding quality.

Where analysis of wrought iron shows a carbon content over .05 per cent., it is an indication of imperfect refining, and awakens suspicion that steel scrap has been used in bushelling or in making up the customary "piles."

If some process could be developed for making wrought iron in large masses, eliminating the necessity of pile welding employed in connection with puddled and bushelled iron, wrought iron carrying carbon in amounts corresponding to steel, would be advantageous from the standpoint of tensile strength and hardness, making wrought iron suitable for many purposes for which only steel can now be used. But such carbon should be uniformly distributed and be accompanied by absence of segregation and proper slag distribution in order to retain all the present useful characteristics of wrought iron, plus the added advantages of high tensile strength and hardness, which are as desirable for many purposes as they are undesirable in making welded pipe.

Manganese

Manganese is an element quickly eliminated in the refining reactions of iron and steel making. Its presence in steel in relatively large amounts (0.30 to 0.75 per cent.) is the result of additions made necessary to counteract deleterious effects of the refining operation. In the puddling operation no such additions are feasible or desired; consequently well made wrought iron has a manganese content below 0.05 per cent. Manganese in wrought iron between 0.05 and 0.10 per cent. may mean imperfect refining of relatively high manganese pig iron in a puddling operation; or it may indicate adulteration by the use of steel in bushelling or piling.

Manganese above 0.10 per cent. in wrought iron is practically certain to indicate a mongrel product obtained by scrap bushelling or piling, with the quantity of manganese roughly proportional to the extent of adulteration, up to the 0.35 or 0.40 per cent. manganese normal to usual soft and medium steel.

The virtual absence of manganese in wrought iron produced by puddling, and its almost universal presence in steel, makes a fairly sure and simple means of differentiation. To this difference in manganese contents has been attributed the higher corrosion resistance of wrought iron over steel. In reality, however, the merit of this contention is somewhat doubtful, and the predominant factors, at least in the better corrosion resistance of wrought iron, are slag distribution and absence of segregated impurities.

If some process should be devised which would reproduce the product of the puddling furnace in all its chemical and physical attributes, and at the same time permit of moderate additions of manganese (say 0.15 to 0.25 per cent.) there would be improvement in the strength, ductility, and other physical properties, without loss of any of the recognized meritorious features of genuine wrought iron.

Phosphorus

Acid methods of refining will not eliminate any phosphorus from the pig iron charge. This is a characteristic of the Bessemer process as practiced in the United States. Basic methods, on the contrary, will eliminate the phosphorus in part or almost completely, depending upon operating conditions. The puddling process for producing wrought iron is in this latter class.

In steel making, a metal of 0.10 per cent. phosphorus or less is desired, since this element makes the product brittle under shock or vibration. This consideration is equally true with respect to the base metal of wrought iron, except that the effect is to some extent palliated by the influence of the incorporated slag, as explained in the following:

In dealing with wrought iron, as made according to the definition of the International Society for Testing Materials, it must be remembered that phosphorus, eliminated from the metal during refining, largely enters the slag, a portion of which is incorporated with the final product. Thus an analysis of wrought iron is of the composite substance, base metal and slag, and the phosphorus reported is the combined amount. From separate analyses made of slag it is estimated that from 40 to 60 per cent. of the phosphorus indicated in the ordinary analysis of wrought iron is combined with the slag.

The typical analysis of good wrought iron gives the amount of phosphorus as 0.14 per cent. This insures a base metal with phosphorus low enough to obtain the desired shock-resisting powers, while at the same time the slag and metal characteristics remain proper for rolling the light, thin sections required for skelp, and for obtaining a good welding quality.

For some purposes, low phosphorus contents (under 0.10 per cent.) in wrought iron is desired; this iron is chiefly used for chain and similar products of relatively heavy and easy rolling sections.

Among some manufacturers, relatively high phosphorus pig iron is used, so that the wrought iron carries 0.20 to 0.30 per cent. of this element. The danger in this case is that too much of the phosphorus may remain in association with the base metal, and in variable amounts. Such a product is treacherous and uncertain, and prone to be brittle under shock and vibration.

Sulphur

This element is detrimental in iron or steel, producing "red-shortness," and having a pronounced influence in promoting and accelerating corrosion. In the production of high grade wrought iron this element should not exceed 0.05 per cent., and is usually as low as 0.02 to 0.03 per cent. An amount exceeding 0.05 per cent. indicates imperfect refining of low grade raw material, high in sulphur. It should again be remembered that the greater part of the impurities shown in chemical analysis of wrought iron, is contained in the slag.

Silicon

In refining, silicon is removed easily and quickly under the oxidizing reactions prevailing. If present in steel, it is usually the result of after additions. While the amount noted in the typical analysis of wrought iron is 0.16 per cent., the proportion associated with the base metal is practically nil, and the presence of silicon in wrought iron is because of the silicate characteristic of the slag.

Very low silicon content (under 0.10) indicates either that there is not the normal amount of slag (desirable for pipe making purposes), or that the slag is not of the composition normally obtained by puddling or similar refining operations. On the other hand, silicon contents above 0.20 per cent. is a general indication of a super-normal quantity of slag, probably due to insufficient work in ejecting the surplus slag. Insofar as this is probably due to insufficient rolling, it points to a physically deficient grade of product. The confirmatory evidence rests in a metallographic examination to determine the quantity and state of distribution of the slag; big, isolated patches of slag being obviously detrimental from a physical standpoint.

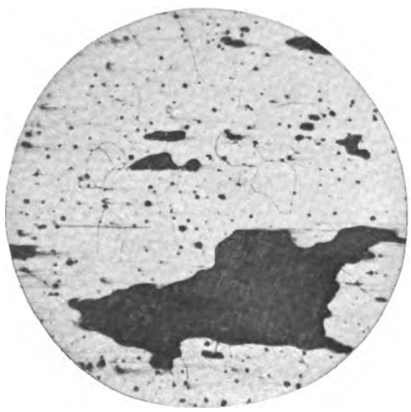


Photo-micrograph of wrought iron showing objectionable slag pocket

Absence of Segregation

A chain is no stronger than its weakest link. A string of pipe is no better than its poorest length, or than the weakest portion of this length. Uniformity in an average grade of product is better than a similar average obtained from a mixture of portions much above and below the average. (See Fig. A.) This applies with equal force to the chemical and physical characteristics of the product, all of which influence the quality of service rendered.

Control of refining reactions is an important factor. In steel making operations, the open hearth furnace, basic in particular, has more latitude and control than the Bessemer converter. In wrought iron manufacture, with proper initial grading and selection of the raw stock, the base metal is first brought to a state of uniformity comparable with the best product of a steel making operation. Subsequently, the re-working operations and quiet reactions between metal and included slag during reheatings, tend to efface small initial heterogeneity of wrought iron and bring the product to a final high degree of purity and uniformity.

Aside from that control of composition of metal which is a function of process, raw stock available, and skill in operation, steel makers are confronted with segregation of the associated metalloids. The associated elements dissolved in the base metal remain perfectly blended while the whole mass is liquid; but as solidification proceeds, most of them are rejected in large part from the solidified to the still liquid portion, resulting in their concentration in the last freezing portion of the mass; i. e., in the center and top of the ingot. This produces non-uniformity in the various sections of the mass, which is intensified in proportion to the amount and kind of ingredients to segregate, and to the time taken by the mass of metal undergoing solidification.

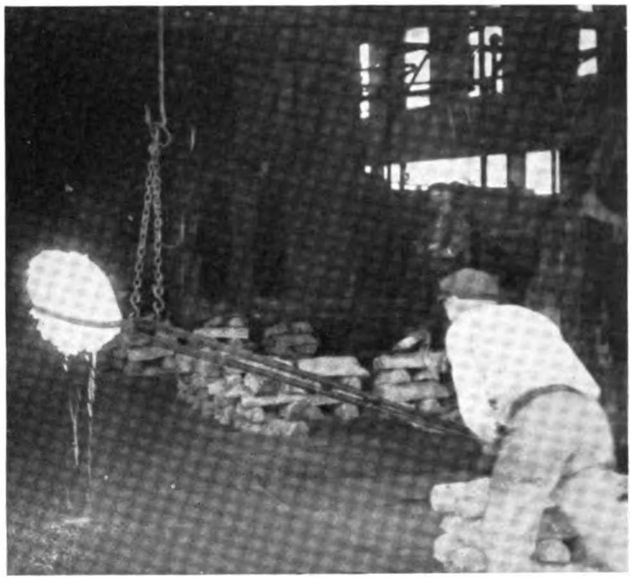


Fig. C
Ball of wrought iron in a pasty condition, as it is taken from the furnace. Being pasty (not fluid) before being taken from the furnace, segregation of impurities is precluded.

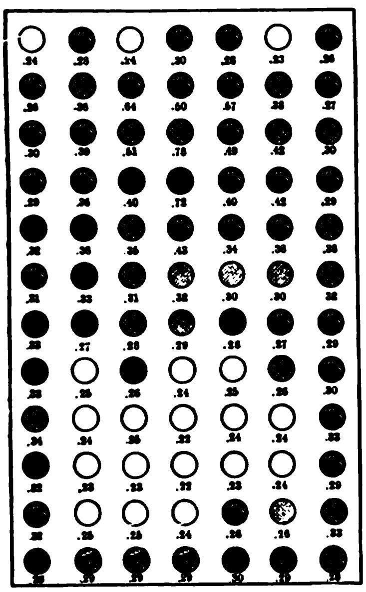
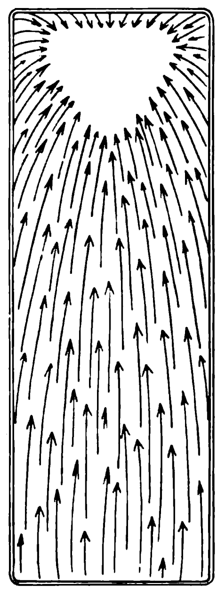


Fig. A
Figures indicate carbon percentage at different parts of a steel ingot.

Bradley Stoughton, Ph.B.,B.S., in his book, "The Metallurgy of Iron and Steel," presents this illustration of the different carbon percentages at different parts of a steel ingot. It will be seen that the percentage varies between .22% and .78% in the same ingot, the latter percentage being very close to the tool steel limit of carbon content, while the former percentage is near the average for dead-soft steel. Even if the top of the ingot is cut off and discarded, the range of carbon content is still very high. In the subsequent rolling of this metal, this condition can only be remedied to a small extent; hence the "hard spots" which are found in the softest steel, and which are responsible for so many failures in service.

The high-carbon spots, as stated, are hard and brittle. When such spots occur at or near a weld, the weld is invariably weak, as even a small amount of carbon greatly decreased the welding quality.

When similar concentration of manganese, sulphur, and phosphorus in the same zones, are taken into account, the detrimental effects on physical properties and rust-resistance are easily explained.



Arrows indicate travel of impurities in steel ingot, in direction from first "freezing" toward last "freezing" portions thereof.

While the top of the ingot is cut off and discarded in commercial practice, the amount thus cropped is entirely too small to remove the segregated zones. Well made wrought iron offers no opportunity for segregation because:

(1) The amount of the foreign elements is very small.

(2) The mass of metal refined in one heat is small.

(3) The grain-like solidification through a *pasty* stage does not permit the free flow of the elements to concentrate in a localized zone.

(4) All the subsequent operations on the metal tend to unify any slight initial heterogeneity which might exist therein.

The most important of these four factors is the finishing of the refining at a low temperature with the metal in a *pasty* or *solidifying* state; hence the requirement (in the Byers guarantee and in the definition of wrought iron), that the metal must be aggregated from *pasty particles*.

Slag Distribution

The most obvious feature which differentiates wrought iron from steel, is the incorporation within the former of a proportion of slag. The value of this feature varies with the slag composition, quantity, and state of distribution. In the puddling operation, the slag composition is the natural equilibrium between metal, refining fluxes, furnace lining, and operating conditions. This slag is essentially a silicate-phosphate of iron—a combination of iron, silicon, and phosphorus oxides, somewhat related to the glasses.

The incorporation of the slag with the metal is of a purely mechanical nature. It is accomplished by taking advantage of the higher fusion temperature of the refined base metal, as contrasted with the several hundred degrees lower fusion temperature of the slag.

Breaking up or granulating the base metal while in a semi-fused or pasty condition, while immersed in a bath of slag, results in the formation of a sponge, with a matrix of metal carrying throughout its voids or interstices the liquid slag. As the whole mass is at welding temperature, pressure at this time will eject pockets or surplus of slag, and squeeze the sponge into a sound coherent mass.

In puddling, the operation of slag incorporation is the natural result of breaking up the mass of refined metal, by use of the "rabble," while in the bath of slag; then balling it up and removing it from the furnace to a rotary type of squeezer, where a rough bloom is formed suitable for rolling. (See Fig. C.)

As a result of elongation and reduction during rolling, the slag incorporation in wrought iron takes the final form of a multitude of fine threads or ribbons, of microscopic dimensions. The microscope, therefore, furnishes the best means of examination of the structure.

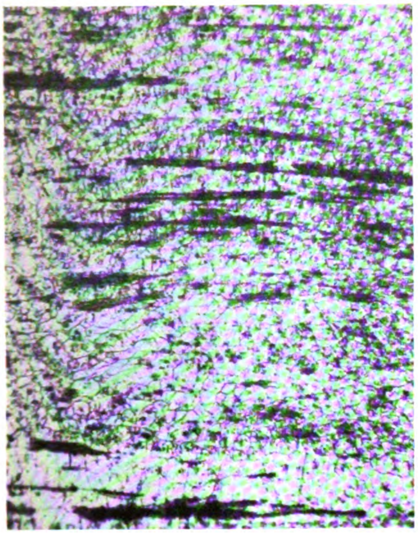
Well made wrought iron has several hundred thousand of these filaments per square inch of cross section. That is, the threads of slag are spaced from 1/400 to 1/1,000 inch apart in all directions, forming a network throughout the material.

The determining factors for well made wrought iron are: *quantity of slag; uniformity of distribution; and fineness of distribution.* Too high a proportion of slag leads to low strength and ductility, and is in general indicative of insufficient work in rolling. Each rolling operation, effecting a reduction of section, tends to eject some slag, especially that existing in pockets or larger aggregates, thus bringing about greater fineness and evenness in the distribution. The amount of slag in well made wrought iron is about 1 to 2 per cent. by weight, or 3 to 6% by volume.

Pockets of slag are undesirable, because forming zones of possible weakness; and especially for pipe, or other commodities requiring threading or fine machining, they are likely to result in faulty workmanship and physical failure.

The initial operations in refining well made wrought iron must effect uniform and relatively fine granulation of the metal. The merit of the product is lost in greater or less degree, *if portions of the mass metal at this stage are not properly disintegrated,* since these areas do not carry the necessary slag and the finished product has corresponding zones which do not have the benefit of this essential ingredient. Aside from the consideration of base metal quality, this poor character of slag distribution is a detrimental feature of so called wrought iron produced by the bushelling and piling of steel scrap. Non-uniform slag distribution, again, has been a weak point in numerous attempts to produce wrought iron by mechanical puddling methods.

Representative examples of high, medium and low slag contents, and of good, bad and indifferent distribution thereof, are found in the photo-micrographs on the following pages.



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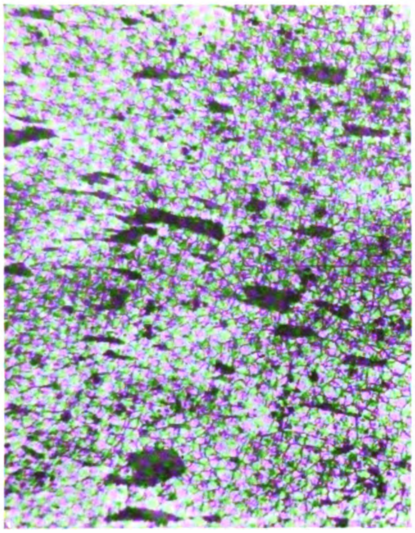

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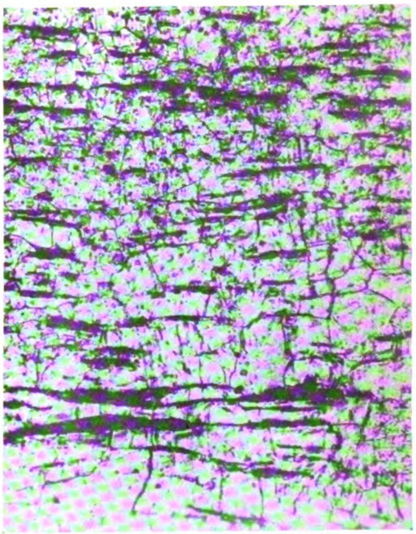

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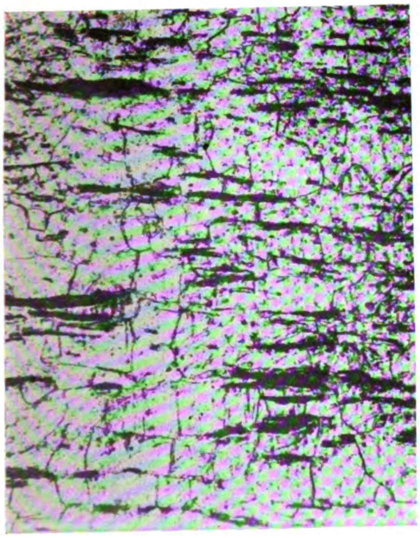


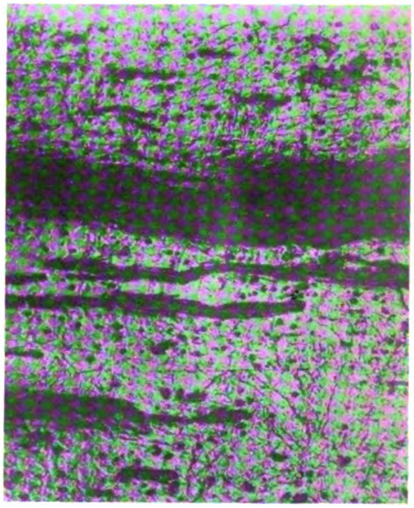
No. 4

Slag Distribution

1 and 2—Plate iron salvaged from old Panama Canal project, bearing date 1883, supposedly made in France. Longitudinal section, showing even slag distribution.

3 and 4—Longitudinal section of wrought iron plate, in use over 40 years. Slag distribution normal for good quality iron.

5 to 8—Wrought iron plate showing individual patches of slag which are too large in size for good quality iron.



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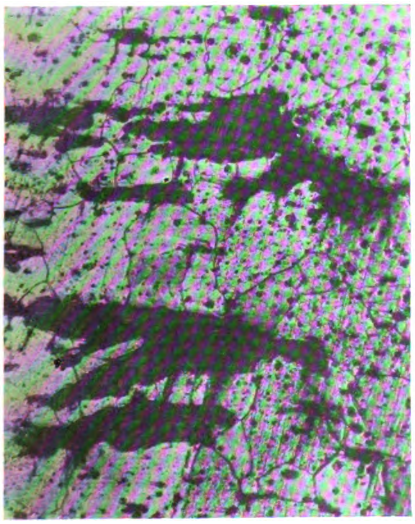

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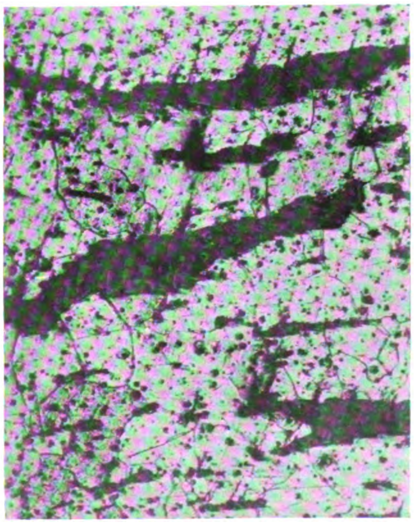

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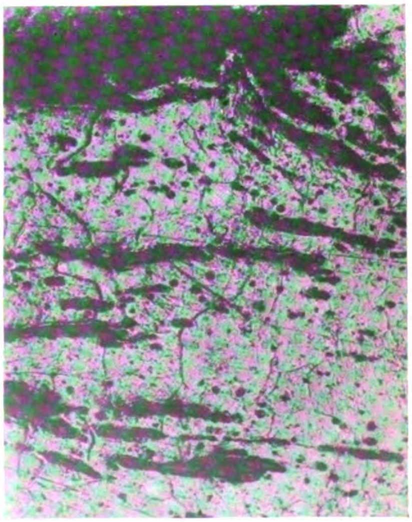

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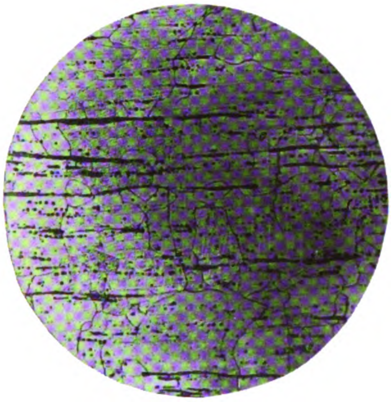

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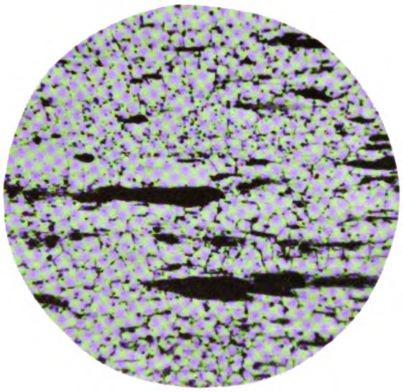

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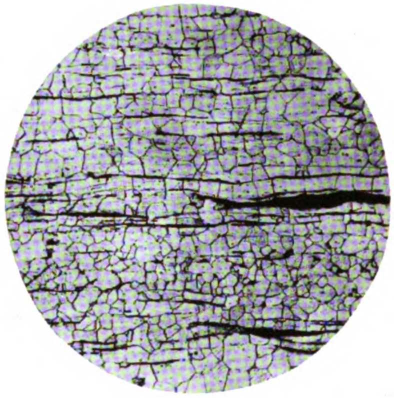

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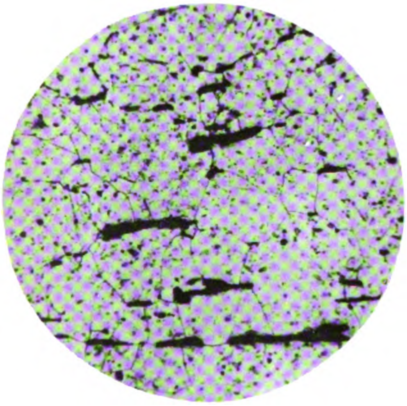

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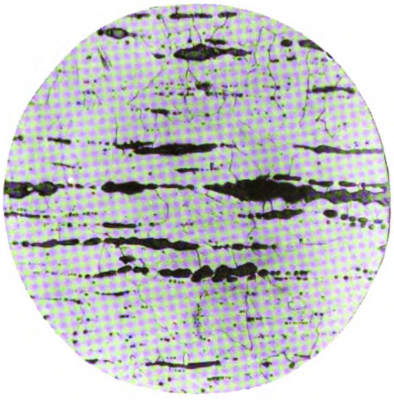

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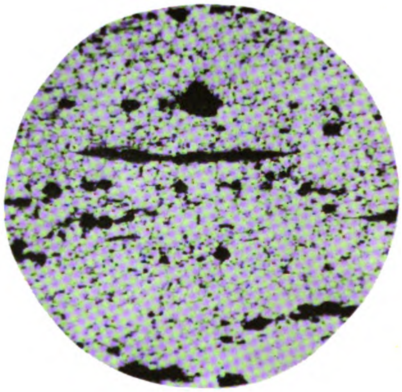

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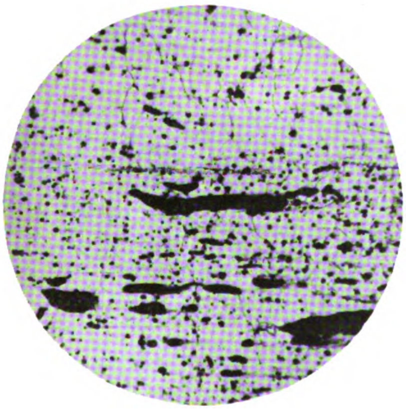

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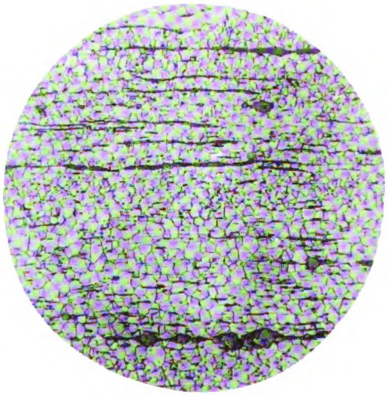

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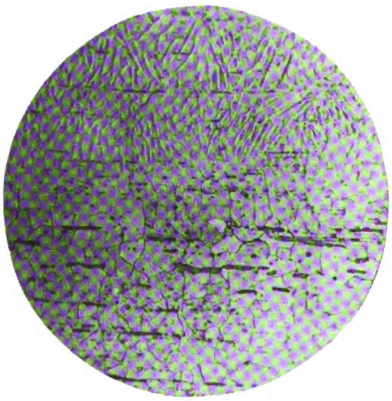
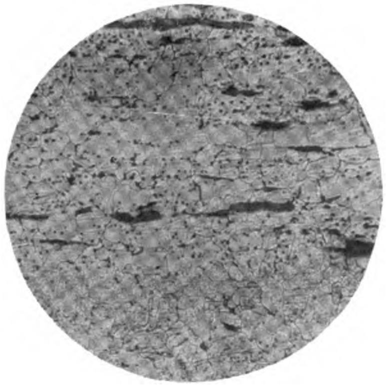


No. 19

Figs. 11 to 19 Inclusive

Sections of different samples of Byers wrought iron skelp and pipe. Magnified 67 dia. Showing slight variations in amounts and distribution of slag, but all well within the range of high grade wrought iron. Compare these with photo-micrographs on pages 9 and 10 of irons made 20 to 40 years ago, especially those of old Byers pipe.

No. 26-A



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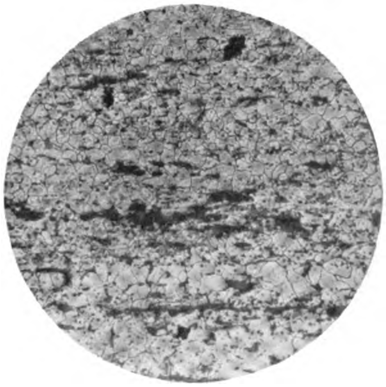
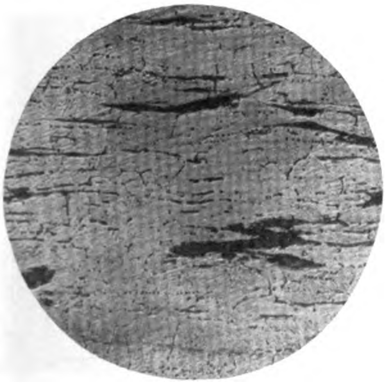


No. 26-C

No. 27-A

No. 27-B

No. 28-A



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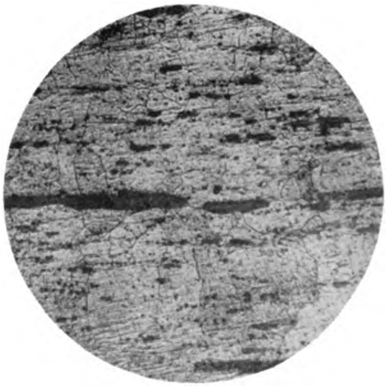


No. 29-A

No. 29-B

Pipe Samples of Different Age

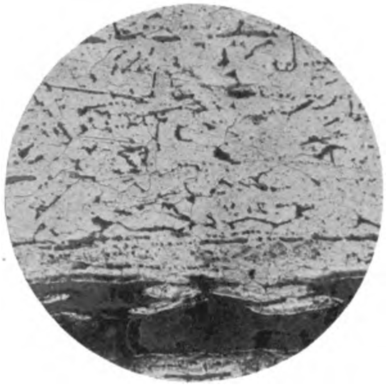
Nos. 26-A, B and C—Byers Pipe installed in water service in Weyman Building, Pittsburgh, Pa., in 1883. Removed in 1917, in very good condition. Rather banded structure, with good slag distribution in some zones, and deficient in others. Carbon traces. Heavy slag streak in No. 26-A objectionable.

Nos. 27-A and B—Byers pipe, installed in heating system in Eden Musee, New York City, 1885. Removed in 1918, in excellent condition. Good general structure, free from carbon.

Nos. 28-A and B—Byers pipe, laid underground for water service at Bridgeport, Pa., in 1891. Removed in 1921, in good condition. In general, good slag distribution; some zones slightly low in slag; traces of carbon.

Nos. 29-A and B—Morris Tasker & Co., pipe installed in 1872 in return line of steam heating system. Removed in 1907; corrosion very slight. Normal structure and slag quantity, entirely in keeping with present standards as maintained by Byers.

No. 30-A



No. 30-B

No. 30-C

No. 31

No. 32-A

No. 32-B

No. 33-A

Samples of Different Age, Removed After Many Years of Satisfactory Service.

No. 33-B

Nos. 30-A, B and C—Byers pipe, installed at Duquesne Garden, Pittsburgh, in 1900. Very good general structure, with some zones carrying small amount of carbon; also a few large slag streaks.

No. 31—Wrought iron bar from truss of old mill building of American Sheet and Tin Plate Co., 16th and Murial Sts., Pittsburgh, Pa. 50 to 60 years old. Good general structure. Some carbon areas.

Nos. 32-A and B—Wrought iron pipe from heating system, in service from 1876 to 1918, Sidebotham Co., Frankford, Pa. Good structure throughout; no carbon.

Nos. 33-A and B—Byers pipe in service for 40 years in plant of Morris & Co., Chicago. Good average structure, the photo-micrographs representing variations in slag contents and distribution.

Physical Properties of Wrought Iron

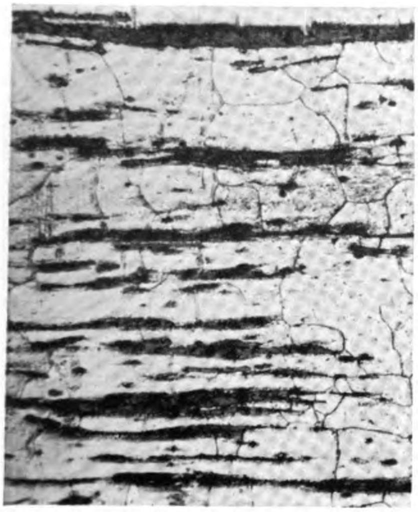
The physical properties of well made wrought iron conform largely to those of pure iron, since this purity is the predominant characteristic of the base metal. The strength, elasticity, and ductility, are affected to some degree by small variations in the metalloid contents of the wrought irons of different manufacturers, due to variations in kind of pig iron used, or to modifications of practice. Also, in even greater degree, the properties are influenced by the amount of incorporated slag and the character of its distribution.

A standard requirement for wrought iron pipe is:

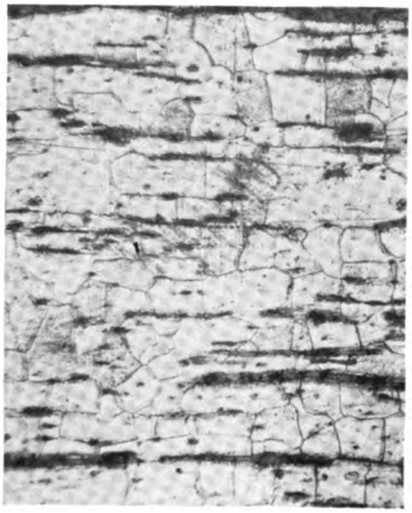
Tensile strength—not less than 40,000 lbs. per sq. in.
Yield point—not less than 24,000 lbs. per sq. in.
Elongation—not less than 12 per cent. in 8 inches.

The requirements for other standard products are:

	Engine Bolt Iron	Stay Bolt Iron	Refined Iron Bars	Plates Over 24" Wide
Tensile strength, lbs. per sq. in.	50,000–54,000	48,000–52,000	48,000 min.	48,000 min.
Yield point, lbs. per sq. in.	0.6 of tensile	0.6 of tensile	25,000 min.	26,000 min.
Elongation, per cent. in 8 in.	25 min.	30 min.	22 min.	12 min.
Reduction of area, per cent.	40 min.	48 min.		



No. 9-A



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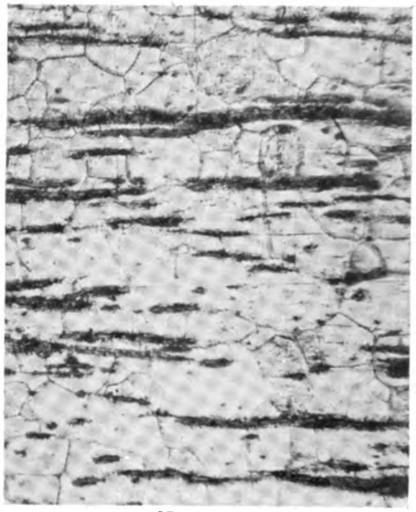
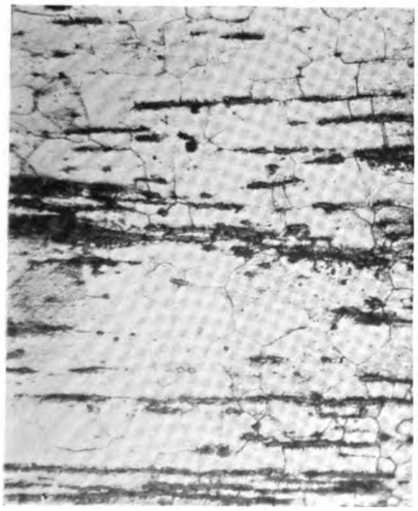
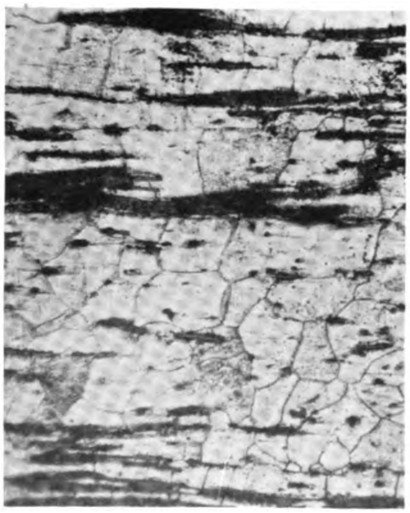


No. 9-C



No. 9-D



No. 9-E

No. 9-F

Figs. 9-A to 9-F

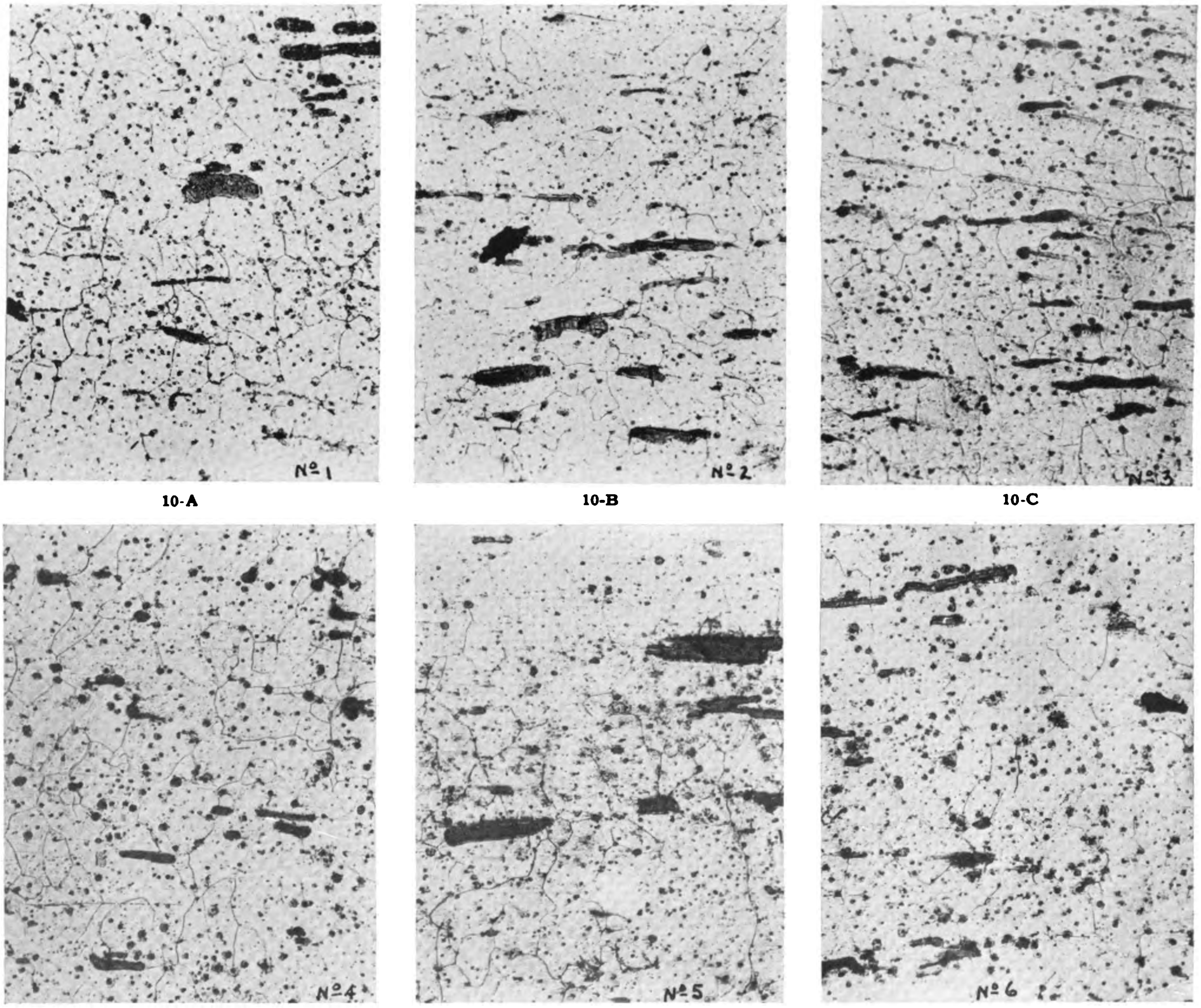
Longitudinal section of heavy plate iron, doing service since 1871 in 50 inch main at Brilliant Pump Station. Pittsburgh, Pa. The slag distribution is good, being not too coarse considering that the plate was over ½ inch thick. No. 6 is slightly irregular, but such areas are always to be expected, and are not beyond the limits of good iron, considering the thickness of the section. (Mag. 67 times.)

These various requirements reflect the effect of mill operations upon the physical properties of the product. With heavy reductions in section by rolling, and particularly where one or more repilings of bars is resorted to, the slag quantity is minimized and what remains is put into a very fine, thread-like condition. Consequently, the highest quality of bolt iron or similar material has strength and ductility above normal. On the contrary, in plate iron or pipe, the strength and ductility are below those of bars, since a heavier slag content is desired and obtained by the manner of refining and rolling. Further, in pipe, the high heat employed in welding has an influence in lowering the comparative strength and ductility.

For some products, minimum and maximum figures for tensile strength are specified. This is to check the use of steel scrap in the piles. Any considerable amount of steel, due to its higher strength than wrought iron, would raise the tensile strength of the product above the upper limits permissible by the specifications.

"Fatigue"

The physical properties of iron or steel as indicated by the customary tests giving tensile strength, elastic limit, and elongation, are indicative of the ability of

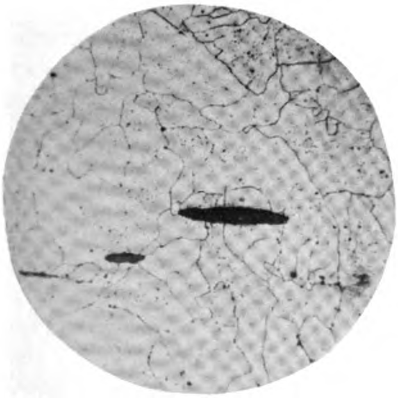


10-A 10-B 10-C

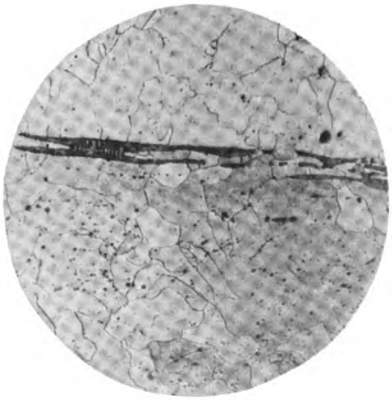
10-D 10-E 10-F

FIGS. 10-A TO 10-F

Contiguous sections, perpendicular to rolling, Byers Plate Iron, used for lap-welded pipe. Shows even slag distribution, coming well within the range of good wrought iron.



No. 20



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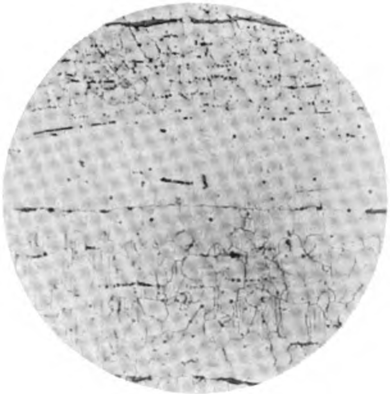

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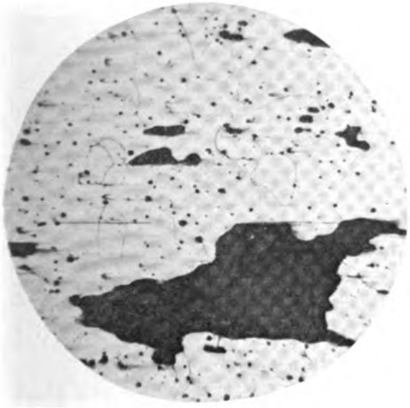

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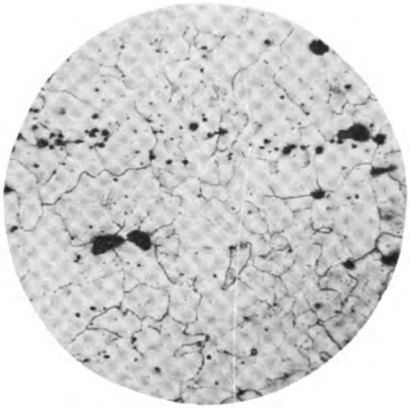
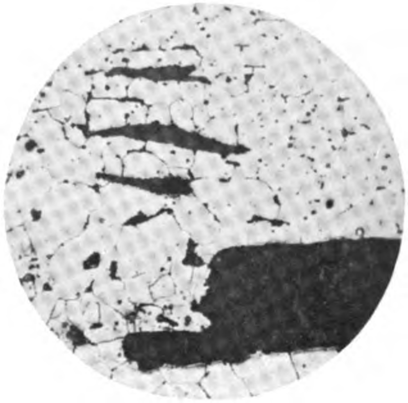


No. 24



No. 25

Figs. 20 to 25 Inclusive

Sections of different samples of wrought iron, of unsatisfactory slag content and distribution. Large patches, as in Nos. 23 and 25 are undesirable from a physical standpoint, especially in thin sections of metal. Deficiency in amount of slag, as in Nos. 20, 21, 22 and 24, is undesirable from standpoint of rust-resistance. It should be borne in mind, however, that the iron should not be condemned unless these deficiencies are fairly characteristic of the metal throughout.

the material to withstand static or steadily applied loads. These test data do not, however, denote the relative merits of the different materials in resisting the shocks of suddenly applied loads, or the vibration or alternation of stresses where the load is of a moving or repeating character.

It is a well known fact that if a stress is applied in a repeated manner, each repetition being made before the material has had time to recover from the preceding stress, the material will eventually fracture, even though the stress is below its elastic limit. The tensile strengths of the steel and iron are no indication of relative endurance in resisting failure because of this so-called "fatigue." Dr. Chas. B. Dudley, late Chief Chemist of the Pennsylvania Railroad, and an eminent authority on the properties of materials, said that:

"Iron and steel do not behave alike when subjected to bending stresses. We think it is perfectly safe to say that a well made car axle, the metal of which will show a tensile strength of from 48,000 to 52,000 pounds per square inch, will stand successfully the same fibre stress as steel of 80,000 pounds tensile strength. Just why this is so, I am unable to explain, but there is a very large amount of accumulated experience which seems to indicate that a metal like iron, which is believed to be a bundle of fibres, each surrounded by slag, and which has within itself the power of distribution of the strain, is a more reliable metal when subjected to bending stresses than a perfectly homogeneous metal like steel."

It was formerly thought that continual repetition or reversal of stress resulted in a progressive enlargement of the crystals making up the body metal, with the result that its cohesion was deteriorated and the material became "crystallized" or "fatigued." It is now generally recognized, however, that no enlargement of initial crystallization takes place, but that at the point of maximum stress there is a slippage of the crystals, one over the other, gradually developing into actual cracks, which finally cause fracture. Initial coarse crystallization of the metal, either local or as a whole, is conducive to more easy rupture due to the straighter path of slippage and subsequent fracture.

Wrought iron is less susceptible than steel to development of coarse crystallization at high temperatures. Naturally, therefore, it is in better condition after usual rolling mill and manufacturing operations, and especially the high heats of pipe welding, to withstand the effects of repeated stresses in service. Furthermore, the slag inclusions in wrought iron act as barriers to the progress of the incipient cracks. Figure 55 is interesting in illustrating this point. This photomicrograph shows a single grain of wrought iron, surrounded by portions of other grains. While straining of the metal has developed slip bands within the grains, shown by the parallel lines, the slag band crossing the grain has arrested the progress of the slip planes, preventing their continuation into the other portion of the grain. Thus the path of ultimate fracture has been checked.

Steel resembles glass in its characteristics, and any minute fracture develops with vibration, expansion, shocks and other stresses, until complete rupture occurs. A crack in a pane of glass may be arrested by boring a hole in its path to obstruct its progress; this method has been advocated by some authorities for certain steel shapes. The slag in wrought iron, giving it the characteristic fibrous nature, performs a similar function by arresting the development of fissures, which would continue in steel without obstruction.

Expressed in another way, the comparison between steel and wrought iron is analogous to a solid bar as contrasted with a stranded cable. Fracture in the solid bar may continue under repeated stresses until complete failure occurs; whereas, the cable may suffer rupture of a strand without materially affecting the cable as a whole. The strands of the cable are independent units. Wrought iron consists of a multitude of somewhat independent iron fibres by reason of the associated slag filaments.

Brake rods, brake levers, equalizers, hangers, air lines, frame members, engine bolts, and many other parts of locomotives and cars upon which safety of life and limb is vitally dependent, are specified of wrought iron according to standard practice upon the best railroads of the country. Wrought iron stay bolts for locomotive and marine boilers are required because they will best withstand the repeated stresses due to expansion and contraction. And this, in spite of the fact that no manufacturing difficulty prevents making and treating, for these purposes, steel which has a vastly greater tensile strength than any soft steel used for welding into pipe.

Advantages of Wrought Iron as a Pipe Material

As already explained herein, the physical and chemical characteristics of wrought iron make it a separate and distinct metal from soft steel. These different characteristics give rise to certain advantages which are especially important in considering pipe metal. These advantages are as follows:

Welding Quality

The efficiency of a weld depends on the thorough union of metal with metal. During the heating of the metal it becomes coated with scale, which is quite gummy at welding temperature and does not squeeze out from between the edges to be joined. The blacksmith in welding soft steel uses borax as a flux, but dispenses entirely with borax when welding wrought iron because the slag content of wrought iron makes it self-fluxing. In welding pipe in commercial practice, it is impracticable to apply a flux, due to the length of the weld, speed of operation, and quantity of material handled. The welds of steel pipe suffer from this lack of flux, while in wrought iron the flux is present, which explains the greater reliability of the wrought iron pipe welds, so universally observed by contractors, engineers and workmen responsible for cutting, threading, bending and fabricating pipe.

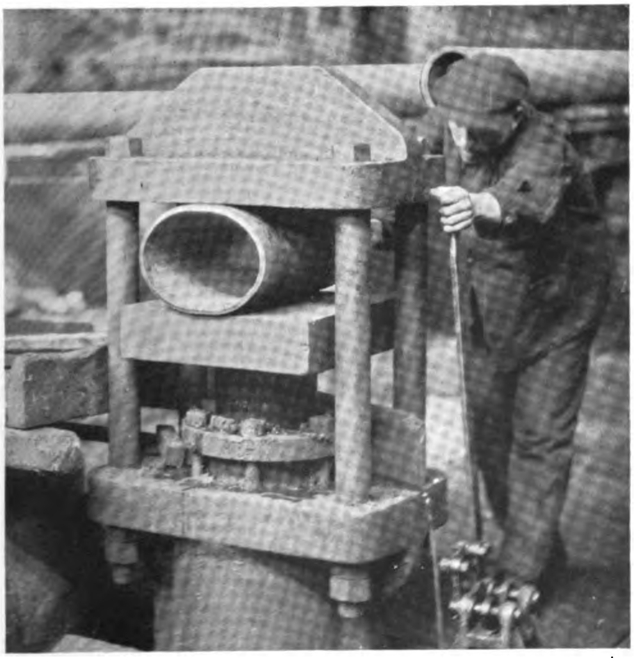


Fig. 50

Crushing each individual crop end of pipe in Byers mills to ascertain strength of weld. If the crop end shows fracture at weld, the pipe is scrapped, or laid aside for more thorough inspection.

Crushing tests made at the University of Pittsburgh in 1918, showed only eight weld failures out of 136 pieces of Byers lap-weld pipe of various sizes and weights. In 128 instances, therefore, the fracture, following crushing, occurred somewhere along the body metal, away from the weld. The pressure was applied at four different angles from the weld, which should have resulted in twenty-five per cent weld failures if the weld had been of equal strength to the body metal. The apparent extra strength at weld of all these pipes is accounted for by the slightly greater thickness of perfectly knitted metal at the lap. These results are, nevertheless, unattainable with any pipe metal except good wrought iron, and then only when made by the very best manufacturing practice.

The increasing use of electric and oxy-acetylene welding, has brought more forcefully to the attention of users the advantages of wrought iron pipe. So marked is the superiority of wrought iron over steel for electric welding, that on many competitive pipe contracts (where steel pipe is acceptable to the user) the pipe fabricator voluntarily furnishes wrought iron pipe, although receiving no extra compensation therefor. The reason is that the cost of manufacturing a good coil from steel pipe, due to costly weld failures in bending, is so high as to approximate the higher initial cost of wrought iron pipe.

Threading Quality

On the cutting of a clean, accurate thread, largely depends the strength and tightness of the pipe joint. Threading, in itself, is a shop operation requiring a considerable degree of skill and knowledge of dies. When these are lacking there results poor joints, pipe failures, shut-downs and costly repairs. With wrought iron pipe the obtaining of good threads becomes a comparatively easy matter, as long as dies with a "lip" angle not over 16° are used. The factors which contribute to the easy threading of wrought iron pipe are, briefly, as follows:

(1) Wrought iron is so uniform in texture and so free from segregation of carbon as to present no difficulties in the presence of "hard spots."

(2) Splitting, due to weak welds, is a rare occurrence.

(3) Most important is the fact that the metal is fibrous; the thread being cut at right angles to the direction of the fibre, causes the chip to crumble freely, and to fall out of the chip space without creating undue friction on the die, which results with steel pipe when an unbroken spiral chip continues to curl inside the small chip space.

An important point to be observed in threading wrought iron pipe, especially when power machines are used, is to have dies of proper "lip angle." (See Fig. 52.) For best results in threading both wrought

Fig 51
The wrought iron chips break up like wood turnings; the steel chips are long and curl up inside the chip space, increasing friction on the dies.

iron and steel pipe, an angle not over 16° should be used. If the lip angle is greater (from 20° to 25° is recommended by some manufacturers for threading steel pipe only) the dies will gouge and tear the metal instead of cutting it; such dies positively will not cut a good thread on wrought iron.

Resistance to Repeated Stresses

As already explained under the subject of "Fatigue," on pages 12-13, the use of wrought iron for many purposes is due entirely to its greater resistance to repeated stresses, shocks, and vibration.

In pipe service in buildings of every description, the pulsations of engines, pumps and compressors, the vibration caused by the operation of machinery in general, and by street traffic, combine to make the

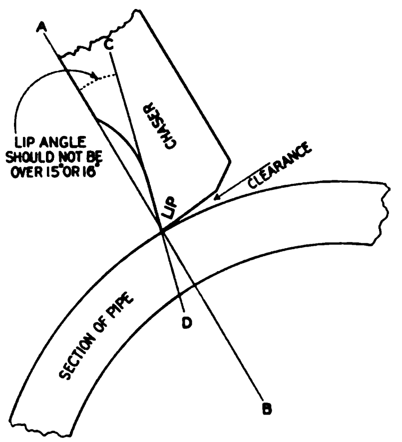


Fig. 52
The Lip Angle, as will be seen from above, lies between the lip line of chaser, C-D, and a line drawn from center of die past the cutting edge of chaser, A-B. This angle should not be over 16 degrees to obtain best results in threading *both iron and steel* pipe.

fatigue factor of the pipe material of equal importance with its tensile strength. Expansion and contraction accompanying temperature variations, can only partly be compensated for by expansion bends and joints and must, therefore, also be reckoned with.

In service on railroad cars and locomotives, on ship board, on steam shovels, in oil and gas well drilling, and elsewhere, the importance of the fatigue factor alone frequently governs the choice of pipe material, resulting in the choice of wrought iron.

The slightly higher tensile strength of steel pipe has sometimes been pointed to as making it the ideal material for high pressure steam, and for power plant installations in general, but this view obviously does not take into account the smaller "fatigue" of wrought iron, nor its higher welding quality.

Perhaps in no single instance are the physical advantages of wrought iron better demonstrated than under the extremely severe conditions of rotary oil well drilling, where Byers rotary drill pipe has established records impossible to explain merely from a consideration of its tensile strength and elasticity, so far excelling steel pipe used in the same service as to make an extra cost of 40% or more seem well worth while to the many large and experienced oil operators who use it.

Fig. 53
Wrought iron rod etched to bring out characteristic fibrous structure, resulting from the slag incorporation.

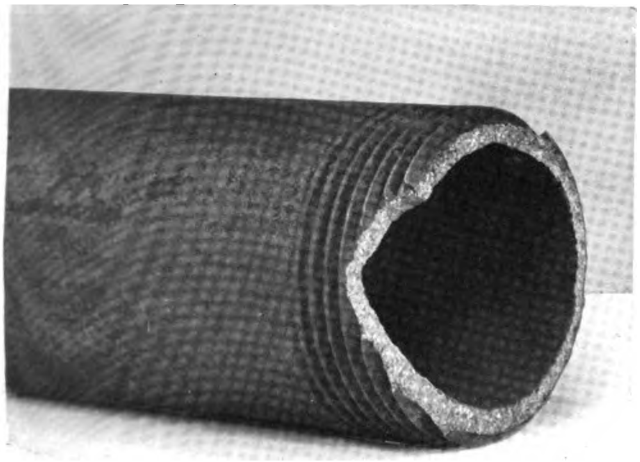


Fig. 54

Steel pipe crystallized as result of vibration. Byers pipe will outlast steel pipe from two to eight times in service where vibration is severe as in drill pipe and air lines on railroad cars.

Adhesion of Protective Coatings

It has been observed that protective coatings, such as paint and galvanizing, adhere more firmly to a wrought iron base than to a steel base. The reason is that wrought iron has a rougher surface, affording a good anchorage for such coatings. Especially in the case of galvanized pipe is this condition pronounced, for prior to applying the spelter, the black pipe is submerged in an acid bath (pickling), and while the acid attack on steel is uniform, it accentuates the rough surface of wrought iron by attacking the slag and iron unevenly.

The result is graphically illustrated in Figs. 60 and 61, which are micro-sections of wrought iron and steel pipe respectively, both galvanized, exhibiting the surface formation of both metals underneath the coating.

This difference in the adhesive quality of a galvanized coating on pipe is readily demonstrated by taking two rings or short pieces of pipe and flattening them in a vise or by hammering, as shown in Fig. 56. If the pipe is steel, the coating will flake off much more readily than when it is wrought iron. Incidentally, the wrought iron, due to its fiber, will fracture lengthwise under this test, while steel may be hammered flat on itself without fracture. This is, therefore, a good method of finding out, first, if a given piece of pipe is wrought iron or steel; second, for demonstrating the difference in the adhesion of the galvanized coating.

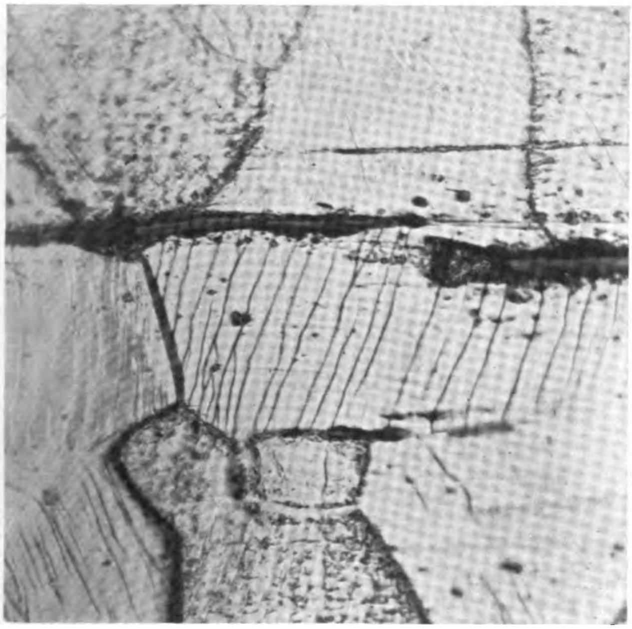


Fig. 55

Photomicrograph illustrating the influence of the slag in wrought iron in arresting the progress of slip bands through the grain of iron; thus checking a continuous path of ultimate fracture.

Note that the slip bands extending across the grain are confined by the slag bands at both ends.

Fig. 60

Fig. 61

Micro section of galvanized steel pipe. Note the characteristic smooth surface of the steel base, on which the zinc obtains but a poor anchorage, flaking off easily.

Fig. 56

Note how the galvanizing flakes off on the steel, and how it adheres to the wrought iron sample, demonstrating the better anchorage of the spelter on the rough iron surface.

(It should be noted that the fracturing of the wrought iron pipe in this test is of no practical importance in judging relative physical strength, for the bursting or collapsing strength of pipe is practically the same for wrought iron as for steel. Whatever advantage steel pipe may have in point of tensile strength is offset by its weaker weld. Besides, the longitudinal stresses exerted on pipe are of much greater importance than bursting or collapsing pressures.)

Resistance to Corrosion

This is the most important foundation stone upon which the wrought iron industry rests. No exposition of theory is needed; the facts and records of service are sufficient evidence of its superiority over unalloyed Bessemer or Open Hearth steels; and for pipe manufacture alloy steels are impracticable owing to welding and fabricating difficulties. The composition of the iron base, particularly its purity and freedom from segregated impurities, is an important factor in retarding corrosion and pitting. Moreover, once corrosion has begun its progress in forming pits, in wrought iron it is opposed by the myriads of corrosion-resisting slag barriers. A microscopic examination of wrought iron, in cross-section, discloses the fine, interlocking network of practically non-corrodible slag bands which everywhere obstruct the progress of corrosive attack.

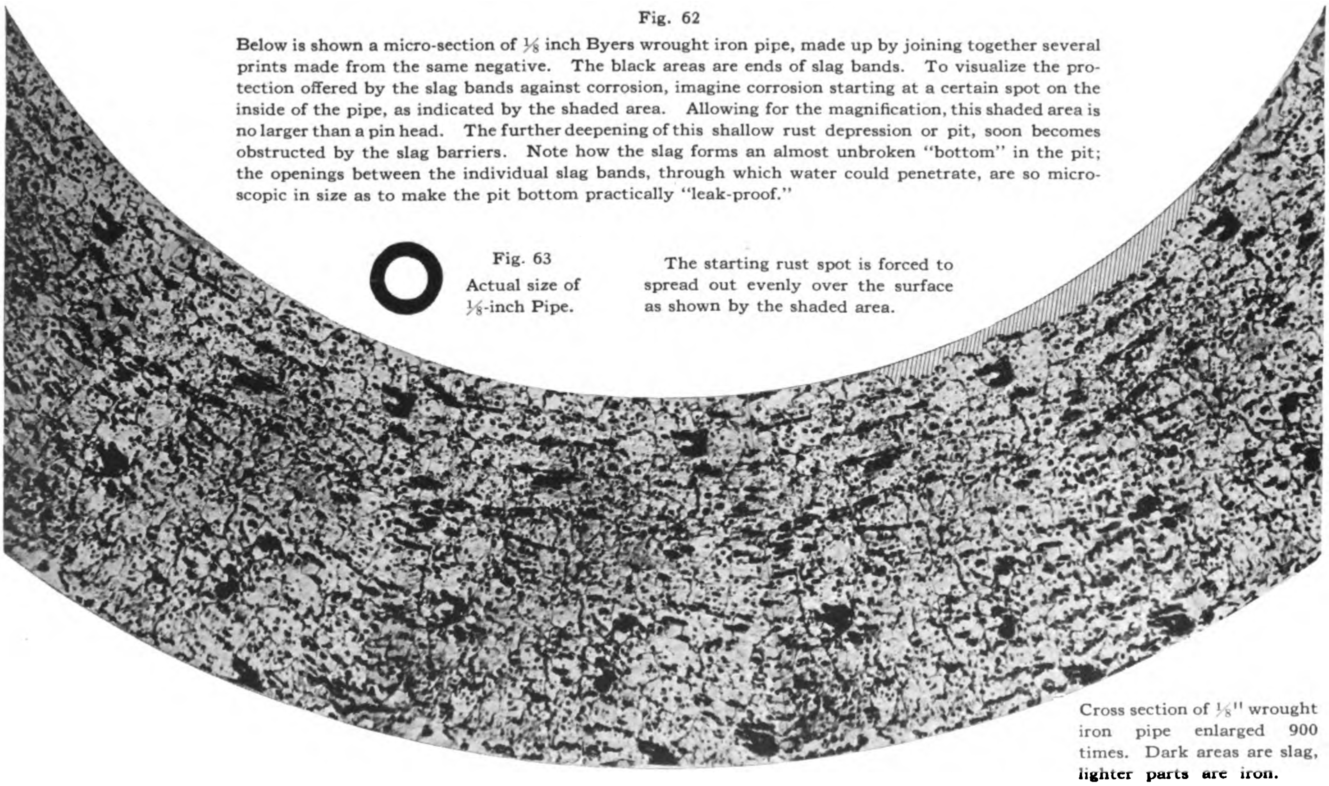
The evidence of service is so prolific as to make the citation of even a larger number of specific cases seem trifling and aimless. Confining ourselves, however, principally to such evidence as has been published by the Byers Company in regard to pipe, the following synopsis may be of interest.

Fig. 62

Below is shown a micro-section of ⅛ inch Byers wrought iron pipe, made up by joining together several prints made from the same negative. The black areas are ends of slag bands. To visualize the protection offered by the slag bands against corrosion, imagine corrosion starting at a certain spot on the inside of the pipe, as indicated by the shaded area. Allowing for the magnification, this shaded area is no larger than a pin head. The further deepening of this shallow rust depression or pit, soon becomes obstructed by the slag barriers. Note how the slag forms an almost unbroken "bottom" in the pit; the openings between the individual slag bands, through which water could penetrate, are so microscopic in size as to make the pit bottom practically "leak-proof."

Fig. 63
Actual size of ⅛-inch Pipe.

The starting rust spot is forced to spread out evenly over the surface as shown by the shaded area.



Cross section of ⅛" wrought iron pipe enlarged 900 times. Dark areas are slag, lighter parts are iron.

Synopsis of Evidence
ON THE
Corrosion Resistance of Wrought Iron Pipe

See Byers Bulletins Nos. 27, 30, 32, 34 and 36

Hot Water Service

In an investigation undertaken in 1917 by the Byers Company, all the exposed basement hot water lines in Pittsburgh Apartment buildings over five years old were inspected and tested, their present condition being noted, together with their past history, such as date of installation, whether of wrought iron, steel, or brass, amount of repairs done, etc. Out of a total of 124 Apartment buildings, 34 were found to be equipped with brass pipe, 25 with steel pipe, and 65 with wrought iron pipe.

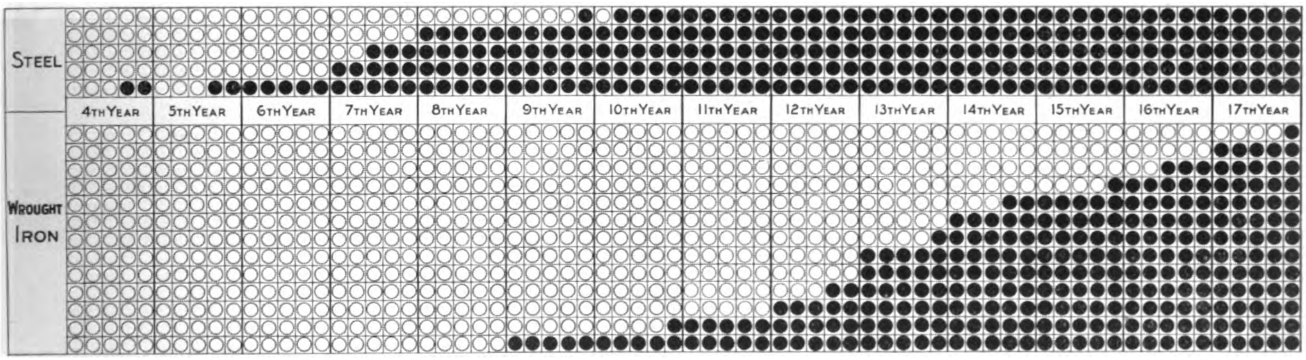
The detailed records showed the first two complete failures and replacements of steel pipe to have taken place in the fourth year after original installation. Three more occurred in the sixth year, and so on until in the *10th year after installation there was only one building in which the steel pipe had not been entirely replaced.*

The failures of wrought iron pipe started in the 9th year after installation, and in the 18th year there was one building left with the pipe still in service. The accompanying dot chart graphically illustrates the ratio of failures of the two respective materials; each dot represents one apartment building, the white dots being the original installations and the black dots indicate the year when failure occurred in each building, making replacement necessary.

It will be seen, if a comparison were made of the longest lived steel pipe installations with the shortest lived wrought iron pipe installations, the claim might be made that they have an equally long or short life; applying the law of averages, however, it is apparent that all the wrought iron pipe lasted twice as long as all the steel pipe.

In short, the 65 wrought iron pipe installations had an average life of 14 years, as against only 7 years for the 28 steel installations.

It should be noted, in this connection, that the corrosive conditions in this service (hot water, basement mains) in this locality (Pittsburgh), were so severe that even brass pipe was severely attacked. The brass piping in the 34 installations investigated, showed evidence of severe internal corrosion (dezincification) within 6 to 8 years, and replacements became necessary between the 10th and 15th years. The pipe would become very brittle, due to the separation of the zinc-copper alloy, and would fail from physical weakness. In comparison, extra heavy wrought iron pipe had a longer life.



EXPLANATION OF DOT CHART

The investigation comprised 90 buildings equipped with wrought iron or steel pipe. 65 of these proved to be of wrought iron and 25 of steel pipe. Each installation, in the chart is represented by a dot. Light dots are original installations, and the black dots indicate when the original installation rusted out and was replaced. Example: Among the 25 steel pipe installations, 2 failed in the 4th year, and 3 more failed in the 6th year, making a total of 5 failures out of 25 installations, in the 6th year after the pipe was first installed. The wrought iron failures started in the 9th year, with 5 failures out of 65 installations.

Vent and drainage piping usually compose the largest single part of a plumbing installation in respect to quantity of pipe used. In 1918, independent investigations were made in New York and Chicago of the relative life of cast iron, wrought iron, and steel pipe in house drainage systems, the older business buildings being selected for inspection. In this investigation, advantage was taken of the fact that waste and vent pipes extend through the roof where their interior is readily accessible for inspection. Accepting as indisputable evidence the visible condition of these roof terminals, the findings arrived at by independent investigators in Chicago and New York were in complete agreement as to the much longer life of wrought iron pipe. Figs. 64 and 65 are typical, though extreme, examples of the conditions of pipes after years of service in New York. In some buildings both wrought iron and steel pipe had been used without distinction. Figs. 66, 67 and 68 furnish eloquent illustrations of the relative corrosion of wrought iron and steel vent pipe in such buildings (Langson Building and Bowling Green Building, New York).

One of the investigators, Mr. Wm. P. Gerhard, Consulting Civil and Sanitary Engineer, concludes:

> "The investigation has furnished an almost overwhelming evidence in favor of genuine wrought iron pipe and against steel."

Fig. 69 shows a typical case of a mixed installation of wrought iron and steel, taken from the Marquette Building, Chicago. The tabulated records of 63 Chicago buildings in the Loop District, from 10 to 19 years old, served as the basis for the following relative rating of the different pipe materials:

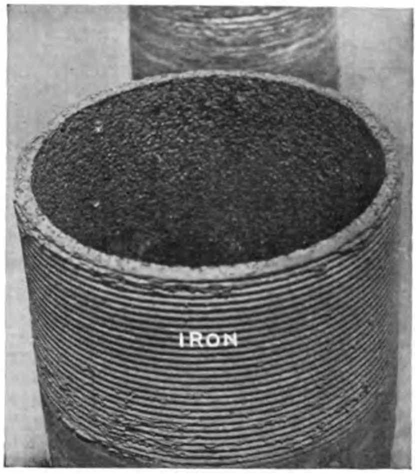


Fig. 64—Wrought Iron, Showing Typical Corrosion Resulting in Even Pock-marking or Shallow Pitting

Fig. 65—Steel, Showing Aggravated but Typical Corrosion Resulting in Flaking or Scaling

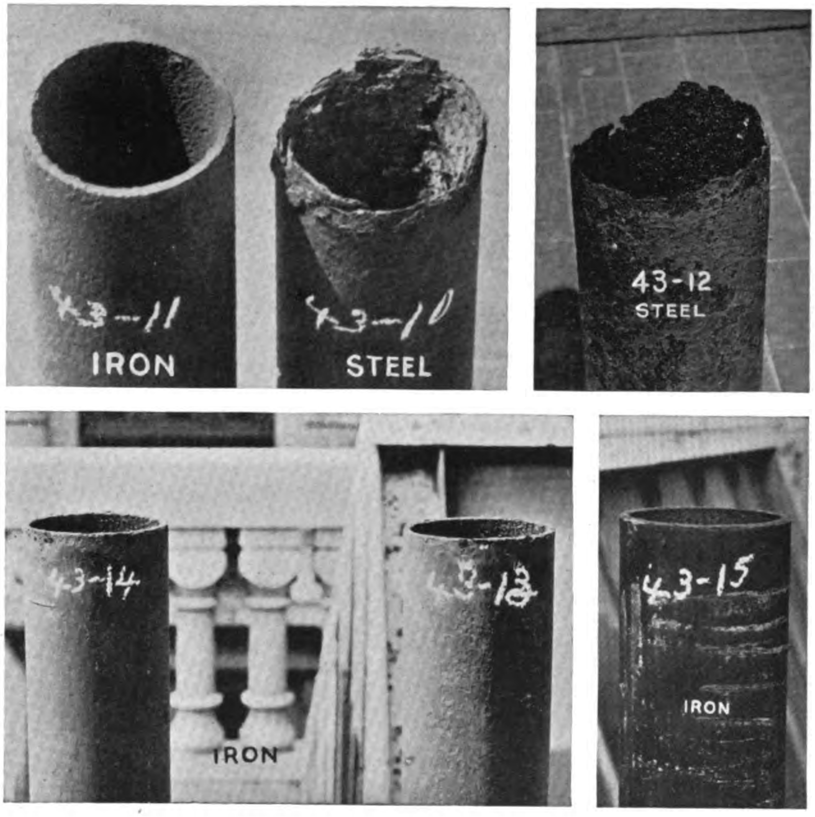


Fig. 66

WROUGHT IRON AND STEEL VENTS AFTER 24 YEARS' SERVICE IN THE LANGDON BUILDING

Note the striking difference in amount of corrosion of these pipes, which were installed at the same time (in 1896) in the same building (the Langdon Building, New York City) in the same service (Roof Vents). These six vents, together with the 9 vents shown opposite (in Fig. 67), are all the vents on the roof of this building. Evidence of this kind must convince the most ardent steel advocate.

Nos. 43-10 and 43-11 were photographed on the same negative, and standing so close together, are particularly striking. No. 43-12 has been reduced by corrosion to a shell of paper thickness.

Installations 10 to 19 years old

Pipe	Total Vents	Present Condition	Per Cent Depreciation
Steel	101 Galv.	Galvanizing 25% destroyed	
	144 Black	All scaling badly	75%
Wrought Iron	28	Both Black and galvanized good	10%
Cast Iron	13	All good	10%

Installations over 20 years old

Pipe	Total Vents	Present Condition	Per Cent Depreciation
Steel	33	All practically destroyed	90%
Wrought Iron	155	17 vents nearly destroyed	20%
Cast Iron	218	43 vents nearly destroyed	25%

This investigation was in charge of Mr. Thos. B. Claffy, Asst. Chief Sanitary Inspector, City of Chicago, who makes the following comment in regard to the above tabulation:

> "With reference to galvanized steel pipe, it appears that galvanizing is partly or wholly destroyed before the pipe is 15 years old, protecting it from destruction to this extent; the pipe as a result lasting from 15 to 25 years before complete destruction is observed. The relatively good condition of wrought iron, both black and galvanized, should again be noted. The 10 per cent. given in the table for both wrought iron and cast iron indicates a slight depreciation, but no actual failures."

MORE DETAILED INFORMATION IS CONTAINED IN
BYERS BULLETIN NO. 36

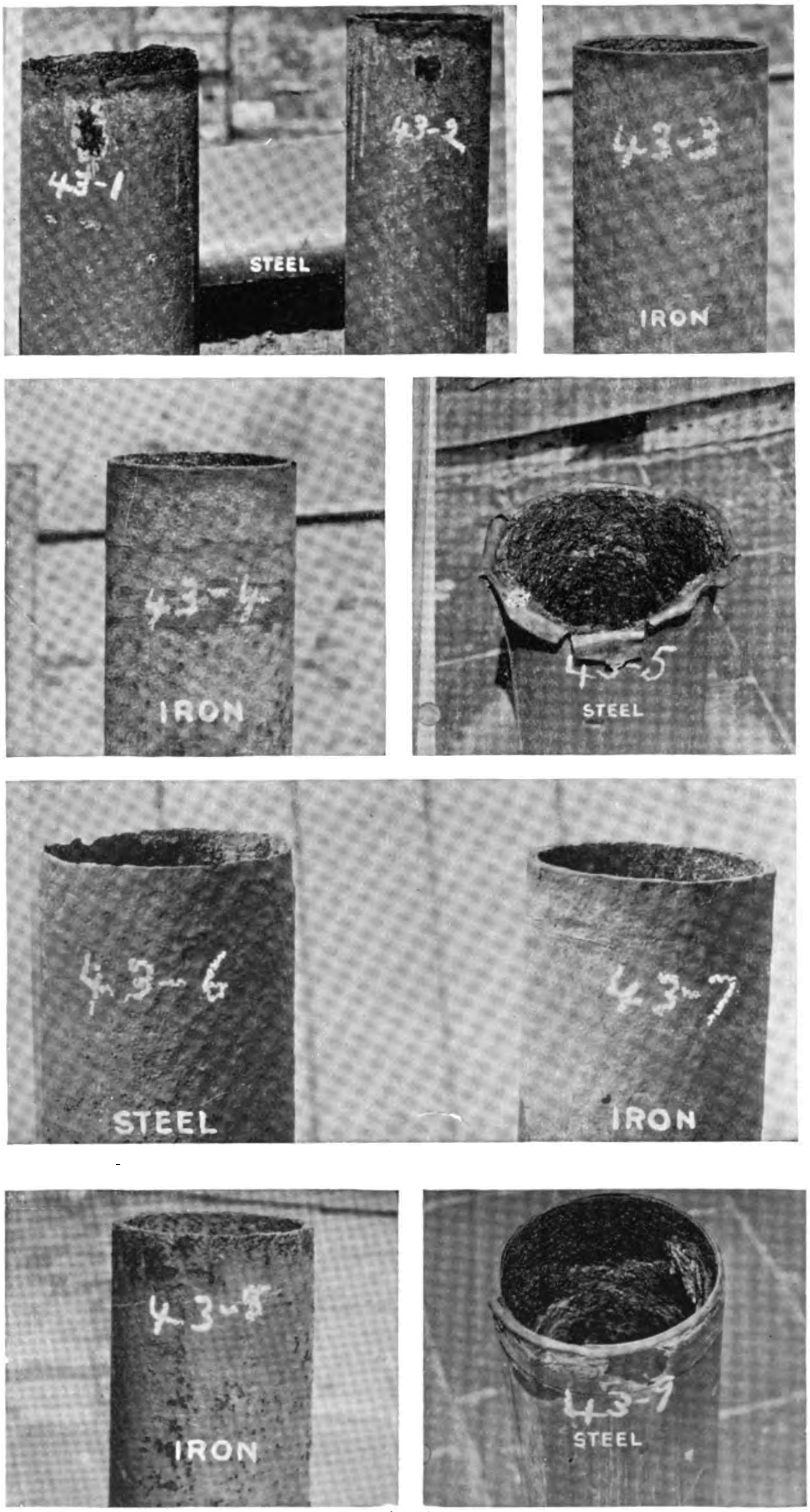


Fig. 67

MIXED INSTALLATION OF BLACK WROUGHT IRON AND STEEL VENTS AFTER 24 YEARS' SERVICE, IN LANGDON BUILDING

Again the consistently good condition of all the wrought iron pipe should be noted, contrasting sharply with the destruction, under identical conditions of service, of the different steel pipes.

Nos. 43-1 and 43-2 (steel) are rusted to mere shells.

Nos. 43-3 and 43-4 (wrought iron) have lost very little in thickness.

No. 43-5 (steel) broke off 6 ft. below the top. Their condition is shown at the fracture. The sleeve around this pipe is the lead flashing.

Nos. 43-6 and 43-7 show a steel and an iron vent, side by side, the steel pipe nearly gone; while the wrought iron pipe is almost as good as new.

Wrought Iron and Steel Vents From The Bowling Green Building After 21 Years' Service

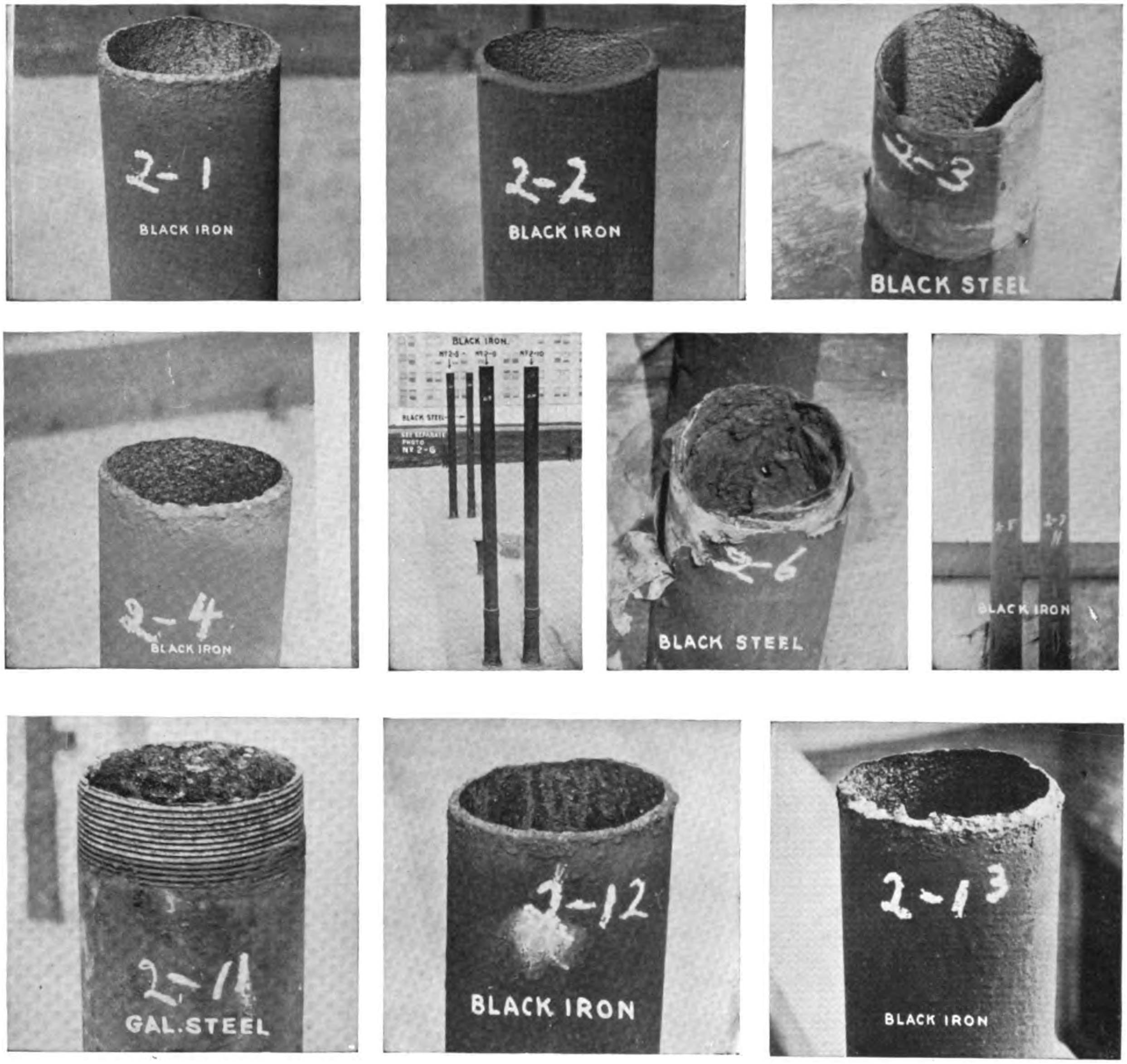


Fig. 68

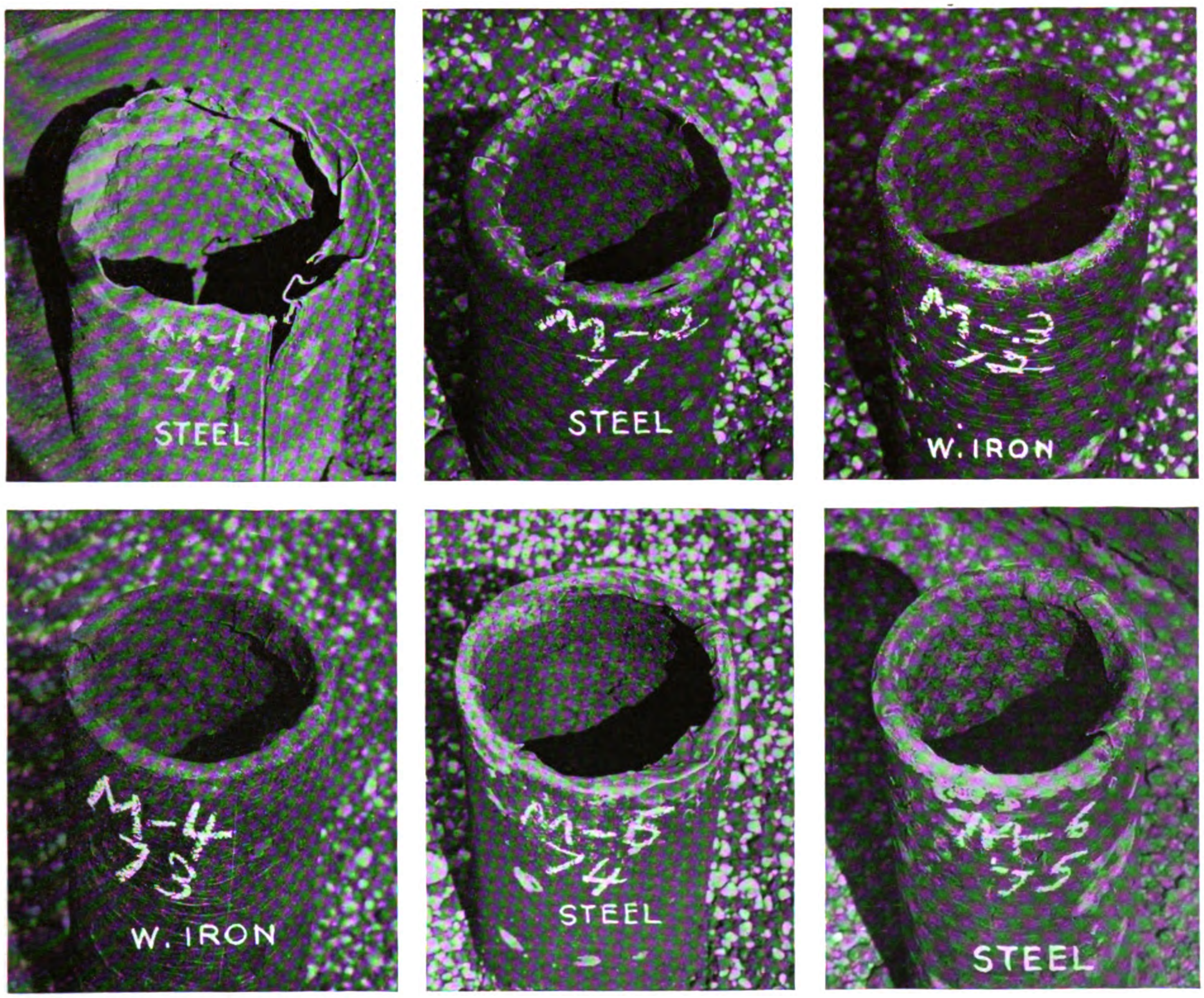
MIXED INSTALLATION

Fig. 68—Wrought Iron and Steel Vents on Roof After 21 Years' Service in the Bowling Green Building, New York City

Wrought iron vents have suffered very little loss in thickness. Nos. 2-3 and 2-6 show two steel vents which broke off 8 or 10 ft. below the top. There is practically nothing left of the walls except rust flakes, the sleeve around them being the lead flashing. Both vents were temporarily extended up to their original height by means of a sheet metal pipe, as shown to the left of No. 2-6. Observe the good condition of the wrought iron vents.

NOTE—These photographs are typical of hundreds of others taken in an investigation in New York and Chicago, of vent pipes. (See Byers Bulletin No. 32.)

HOUSE DRAINAGE INVESTIGATION
ROOF VENTS IN CHICAGO



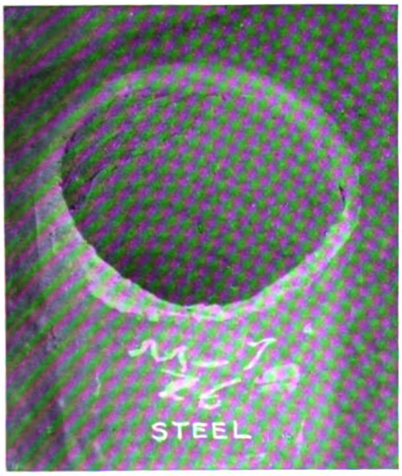


Fig. 69

WROUGHT IRON AND STEEL PIPE, INSTALLED 1894—MARQUETTE BUILDING, CHICAGO.

Nos. 1 and 2—Nearly destroyed (steel)
Nos. 3 and 4—Pitted but in good condition (wrought iron)
Nos. 5 and 7—Scaling badly, from 50 to 80 per cent destroyed (steel)
No. 6—Scaling badly (steel)

MIXED STEEL AND WROUGHT IRON INSTALLATION

Oil Refinery Piping

In an investigation made of piping in Western Pennsylvania Refineries in 1919-20, records were gathered wherever reliable information could be obtained, the results, indicating the life of pipe in different kinds of service, follow:

	Service	Estimated Average Life	
		Steel Pipe	Wrought Iron Pipe
1	Vapor Condensers	1½ to 3 years	4 to 12 years
2	Wax Lines	1½ to 5 years	4 to 10 years
3	Ammonia Condensers	1½ to 8 years	4 to 18 years

Throughout the country, there are thousands of old buildings of note, erected prior to the introduction of wrought steel pipe in the early nineties. One may take for granted that the original piping in these buildings is of genuine wrought iron, and it is but necessary to make inquiries with old engineers in charge of these buildings to ascertain the degree of satisfaction all this piping has given.

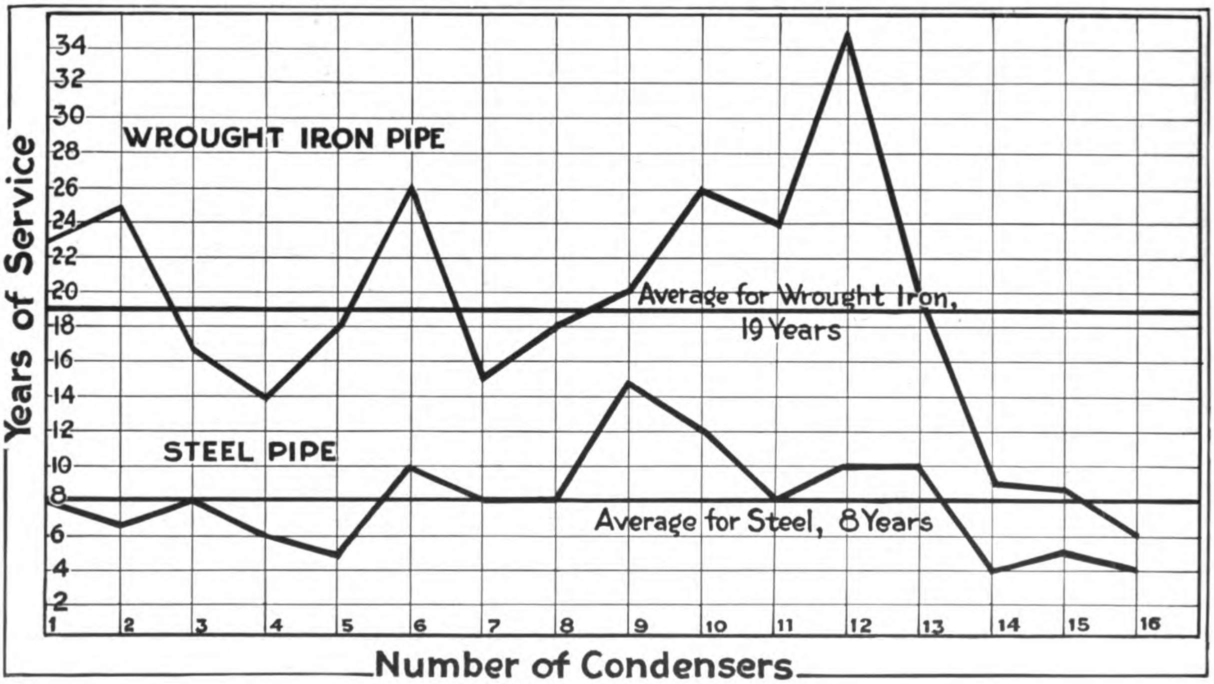
We know no proof of the great superiority of well made wrought iron pipe over modern wrought pipe, which could be more convincing than the contrast between the highly satisfactory service of such old piping, and the indifferent service of cheaper modern pipe, used under identical service conditions, in the same or nearby buildings of more recent construction.

Refrigeration Piping

In an investigation made by A. M. Byers Company in 1918, all the ice and refrigerating plants, of at least 100 tons daily capacity, were visited in New York, Boston, Washington, D. C., Pittsburgh, Cleveland, Cincinnati, Chicago and Milwaukee. From many of these plants were obtained some valuable records, especially in regard to the life of ammonia condensers. In many cases the information had to be supplemented or verified by chemical or metallurgical tests made on piping to establish whether it was of wrought iron or steel.

Comparing only the condensers which had actually rusted out and had been replaced, it was found that the average life of sixteen such condensers of wrought iron was nineteen years, against eight years for an equal number of steel pipe condensers. The life of each condenser has been indicated in the accompanying diagram. The variations in life between condensers made of the same kind of pipe are notable, these variations being due to the character of the water, and to other differences in service conditions.

The most significant fact is that the life curves of wrought iron and steel pipes run so closely parallel, both going up when conditions of service are light, and down when the corrosive effects are severe. Thus, while condensers Nos. 14, 15 and 16, due to the use of sea water for cooling purposes, all had a very short life, *wrought iron pipe still maintained its lead over steel pipe, lasting twice as long as the latter.*



The life of 32 condensers (16 of wrought iron and 16 of steel pipe) are charted in above diagram. Variations in service conditions account for the peaks and valleys in the life of the same material; significant is the fact that wrought iron steadily maintained its lead over steel in the ratio of two to one

Service Records

FROM

Old Buildings Equipped with Byers Pipe

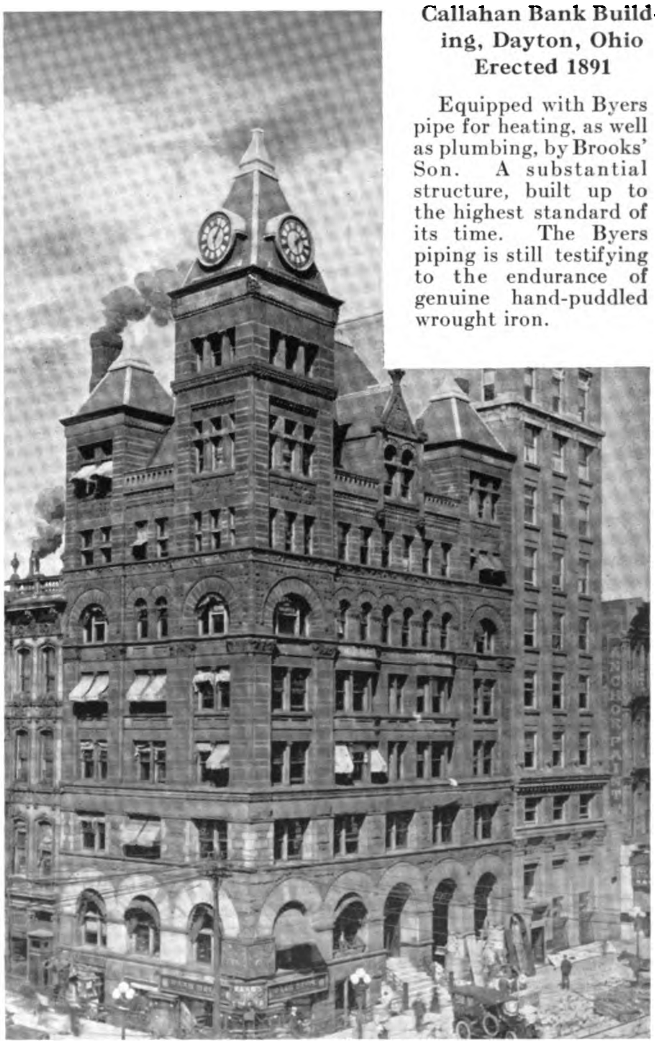
"As far as human testimony is capable of establishing a fact, there need be not the slightest question that modern steel does not serve the purpose as well as the older metal manufactured twenty or more years ago."

The above was one of the conclusions reached by investigation of the U. S. Department of Agriculture after investigating the corrosion of iron and steel fence wire. An interesting parallel to this is furnished by the service record of Byers genuine wrought iron pipe. For the Byers Company, alone, of pipe manufacturers, have continued to manufacture welded pipe from the same raw materials and by the same processes which yielded the extremely durable wire referred to by the government investigators as "the older metal manufactured twenty or more years ago."

The buildings illustrated on the following pages are but a few of thousands of buildings throughout the country, built prior to the introduction of steel pipe about 1890, and nearly all of these testify to the superior lasting qualities of wrought iron pipe. If steel pipe, installed in many buildings erected since that time, had perpetuated this record, the question of the relative rust-resistance of the two materials would never have been raised by pipe manufacturers, who 30 years ago gave this question no consideration whatever, never suspecting that steel pipe would prove unsatisfactory in this respect.

Garfield Building, Cleveland Erected 1890

In this huge old structure, the Byers pipe originally installed throughout in the heating system, may still be observed in a better condition **than in many buildings less than ten years old, equipped with cheaper pipe.**

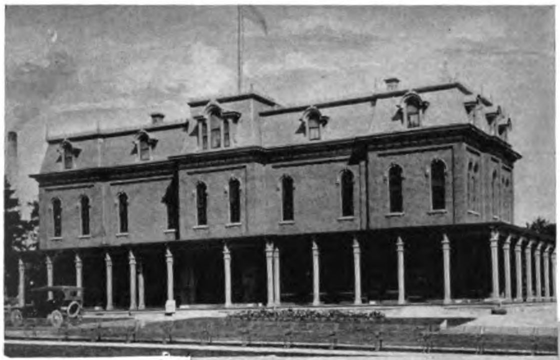


Callahan Bank Building, Dayton, Ohio Erected 1891

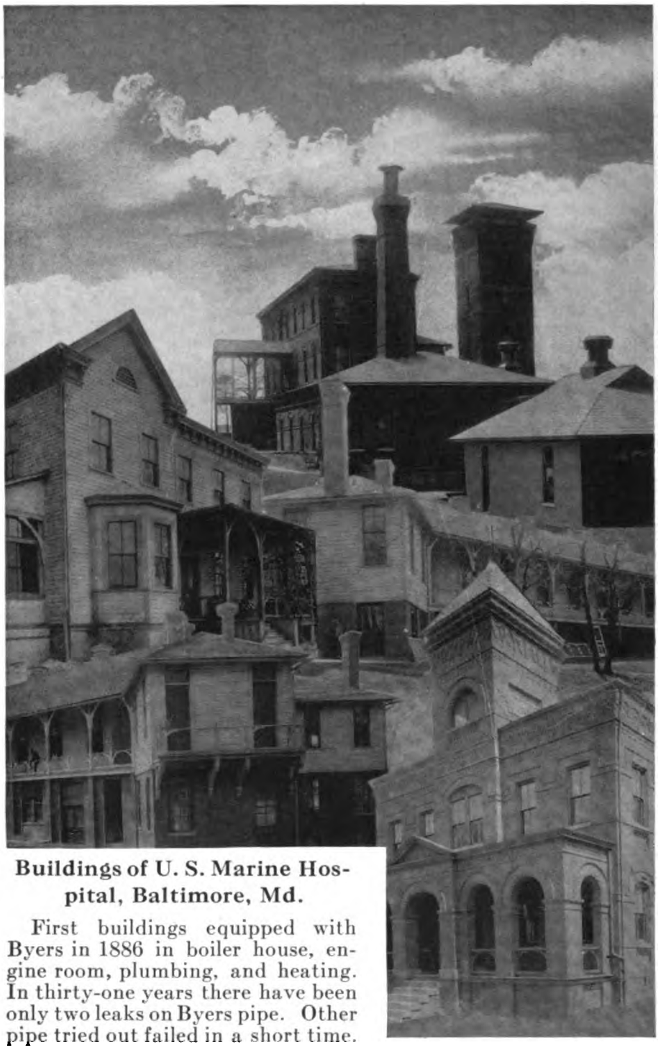
Equipped with Byers pipe for heating, as well as plumbing, by Brooks' Son. A substantial structure, built up to the highest standard of its time. The Byers piping is still testifying to the endurance of genuine hand-puddled wrought iron.

Below are illustrated three of the buildings at Military Home, Dayton, Ohio, which is one of the largest institutions in the country, having several thousand inhabitants. The record of Byers Pipe here goes back about forty years, and covers a network of pipe which is estimated as close to 100 miles in length, both above and underground, being used for every conceivable purpose for which pipe is suitable. The record has been one of unparalleled satisfaction; most of the lines laid underground thirty and forty years ago have never been touched, and are still serving satisfactorily.

It is a significant fact that Byers Pipe has its strongest supporters, not in the small, inconspicuous pipe users, who buy a length of pipe now and then without giving much thought to the matter, but among the experienced and practical men in every line of enterprise, who know pipe because they have used large quantities of it and have watched its performance in service.

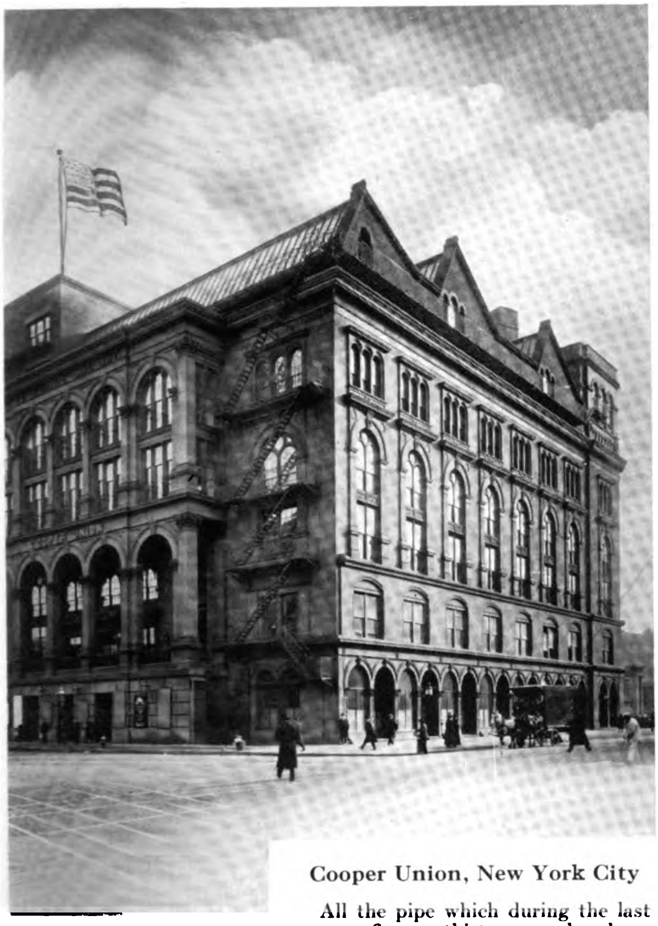


Military Home, Dayton, Ohio



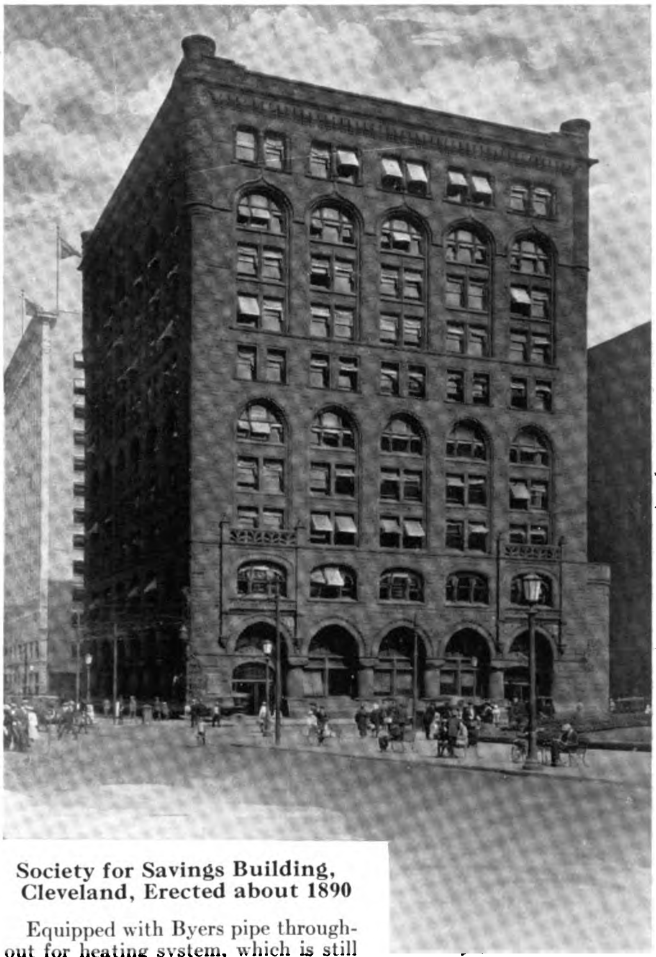
Buildings of U. S. Marine Hospital, Baltimore, Md.

First buildings equipped with Byers in 1886 in boiler house, engine room, plumbing, and heating. In thirty-one years there have been only two leaks on Byers pipe. Other pipe tried out failed in a short time.



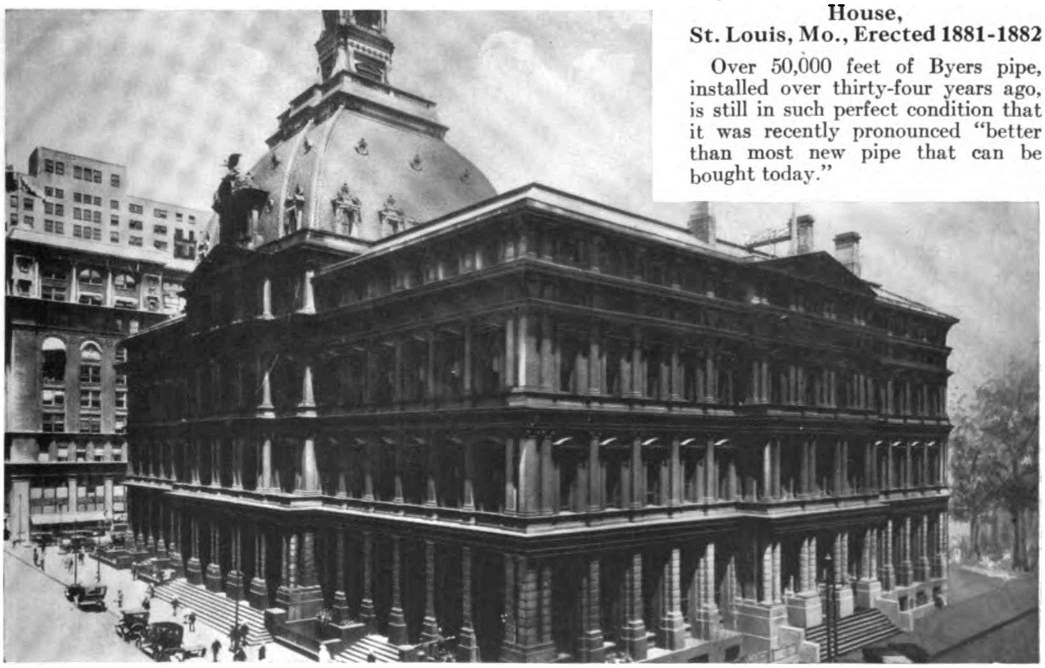
Cooper Union, New York City

All the pipe which during the last twenty-five or thirty years has been installed in this famous old edifice, including hot and cold water supply, has been Byers. There has been an entire absence of pipe troubles.



Society for Savings Building, Cleveland, Erected about 1890

Equipped with Byers pipe throughout for heating system, which is still in operation with a repair-free record for Byers pipe. Piping, including all condensation lines, is apparently unaffected by corrosion.

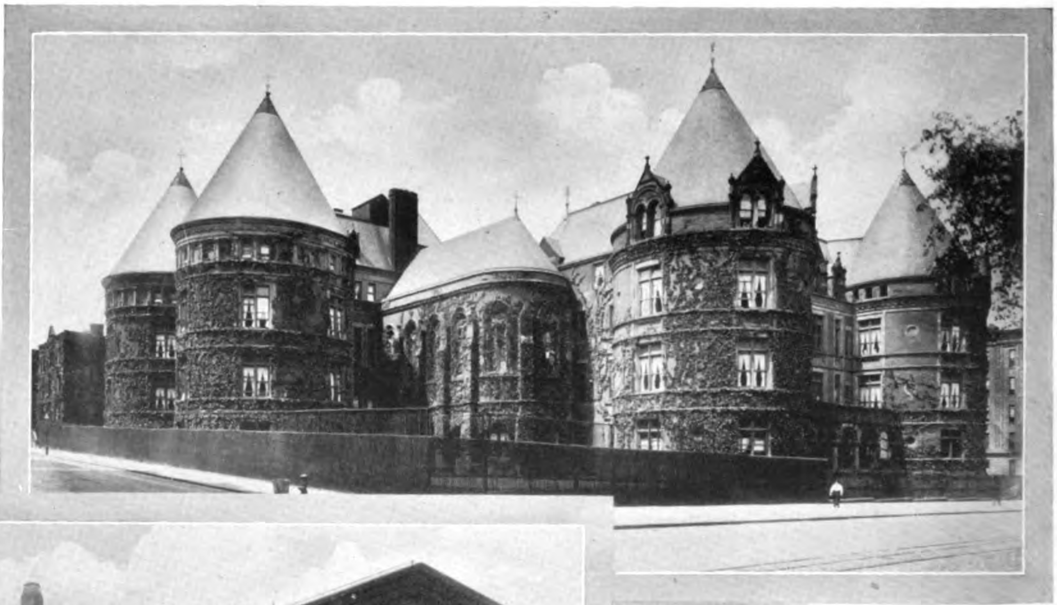


U. S. Postoffice and Custom House, St. Louis, Mo., Erected 1881-1882

Over 50,000 feet of Byers pipe, installed over thirty-four years ago, is still in such perfect condition that it was recently pronounced "better than most new pipe that can be bought today."

General Memorial Hospital New York City Erected 1885

Genuine wrought iron pipe in Durham drainage system has given no trouble in over thirty years, while cast iron pipe, used in the same service in the same building, has required repairs from time to time due to leaky joints.

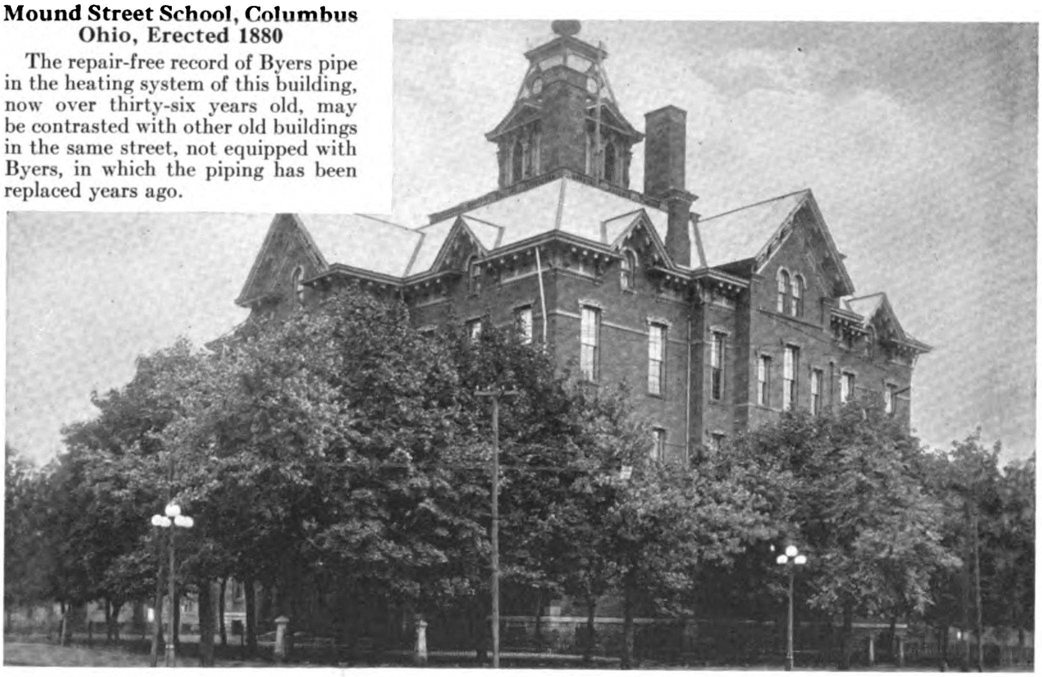


Presbyterian Hospital, New York City, Erected 1890

Byers pipe originally installed for power lines, heating and plumbing, still in good condition. Steel pipe, used occasionally for extensions and alterations, invariably rusted out within seven years or less.

Mound Street School, Columbus Ohio, Erected 1880

The repair-free record of Byers pipe in the heating system of this building, now over thirty-six years old, may be contrasted with other old buildings in the same street, not equipped with Byers, in which the piping has been replaced years ago.

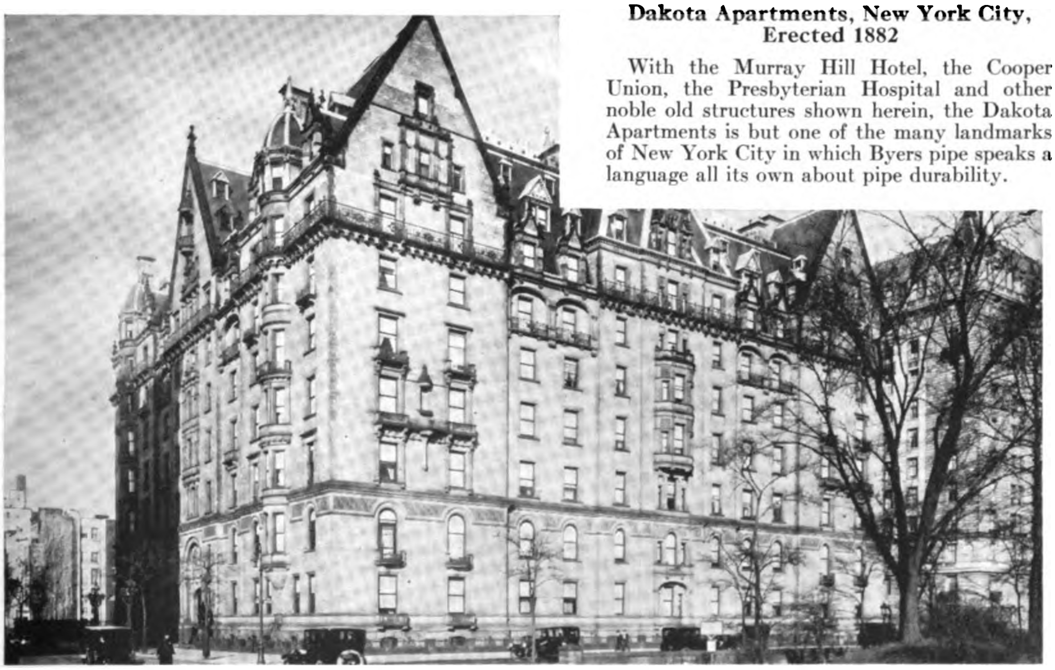


Cleveland Arcade, Erected 1889
Cleveland, Ohio

Boiler plant and steam heating and plumbing system installed by Sam'l I. Pope & Co., Chicago, Ill., involving over 60,000 feet of Byers pipe, which is still in good condition after twenty-eight years' service.

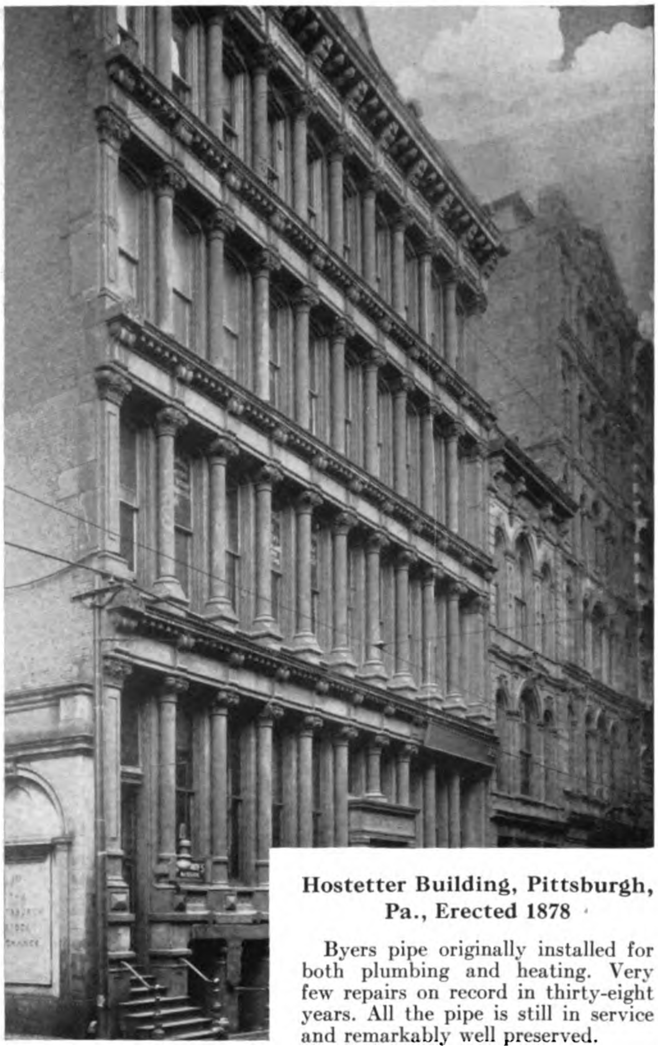
Eden Musee, New York City,
Erected 1883

When this old land-mark was torn down in 1916, the piping in the heating system—all Byers—was found to be as good as new, inside and outside, in spite of its thirty-three years' service.



Dakota Apartments, New York City,
Erected 1882

With the Murray Hill Hotel, the Cooper Union, the Presbyterian Hospital and other noble old structures shown herein, the Dakota Apartments is but one of the many landmarks of New York City in which Byers pipe speaks a language all its own about pipe durability.



Hostetter Building, Pittsburgh, Pa., Erected 1878

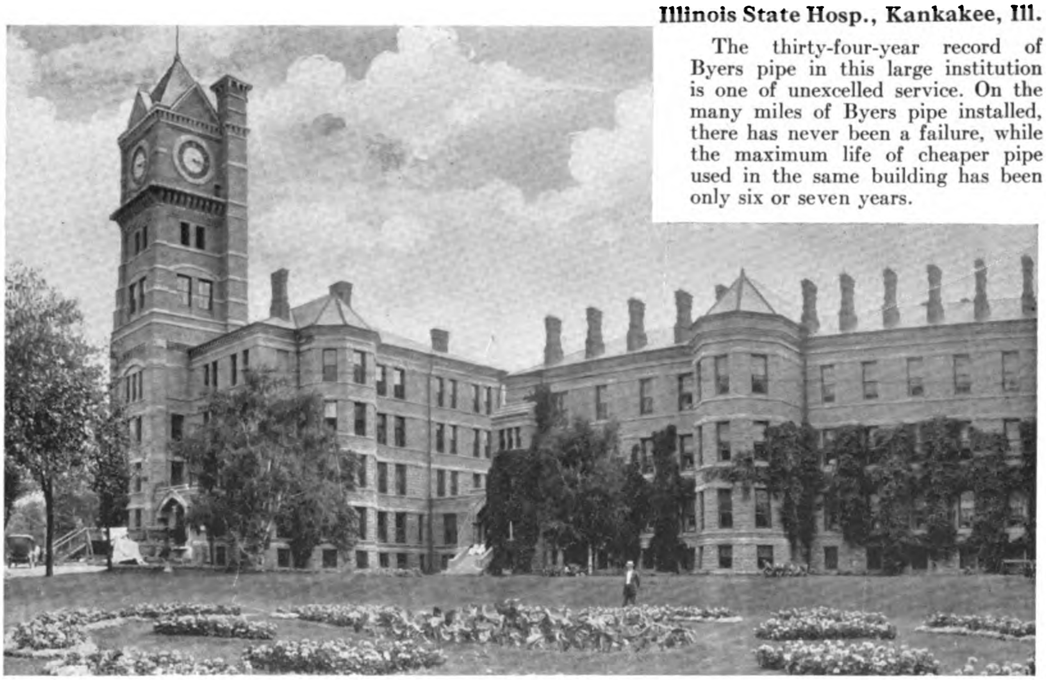
Byers pipe originally installed for both plumbing and heating. Very few repairs on record in thirty-eight years. All the pipe is still in service and remarkably well preserved.

Criminal Court Building, Chicago, Ill., Erected 1890

Byers used in steam, water, and refrigeration system of old part of building, with no repairs in last twenty years. Other pipe installed in new part of building has rusted out very fast.

Illinois State Hosp., Kankakee, Ill.

The thirty-four-year record of Byers pipe in this large institution is one of unexcelled service. On the many miles of Byers pipe installed, there has never been a failure, while the maximum life of cheaper pipe used in the same building has been only six or seven years.



Masonic Temple, Chicago, Erected 1889

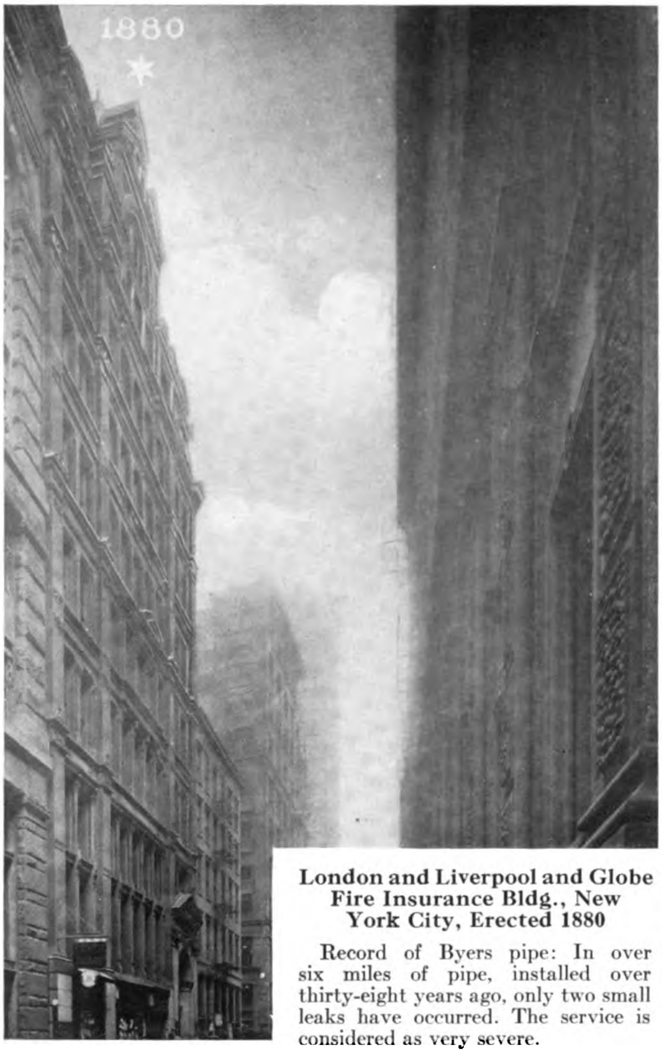
Byers used in the boiler plant in basement, and the steam and return lines throughout the heating system. All risers and mains and even smaller pipes throughout building are still apparently as good as when put in.

Tacoma Building, Chicago, Erected 1888

America's first skyscraper. Byers used throughout in boiler plant, engine room, and heating lines. First repairs made after sixteen years' service. Most of piping still in good condition. Steel in same service never lasted over five years.

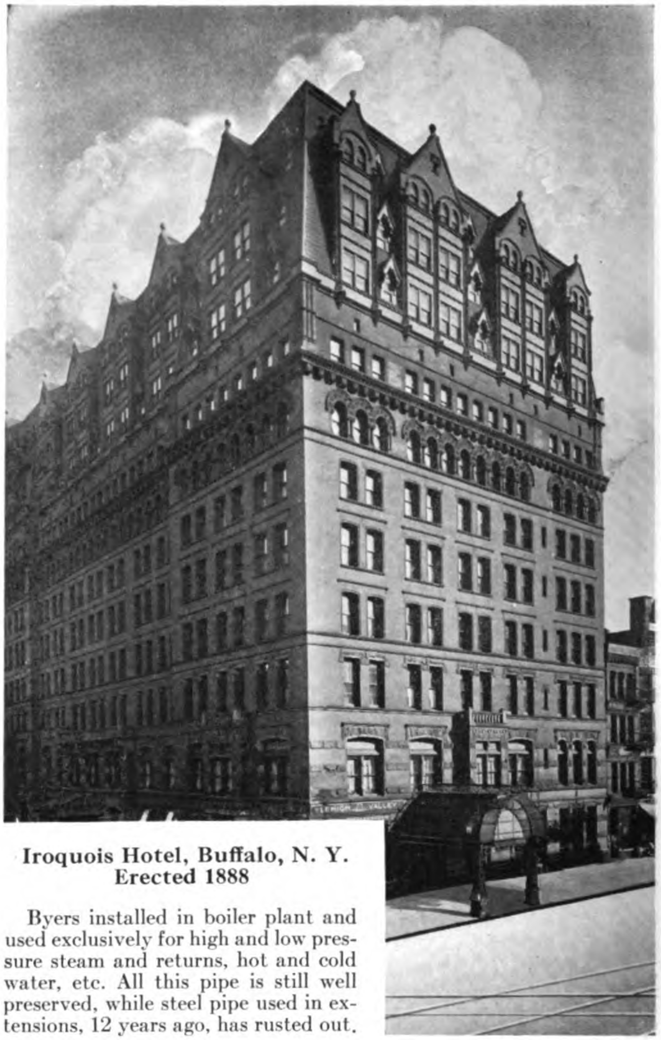
St. Lawrence State Hospital, Ogdensburg, N.Y.

Like many other large pipe users, this institution, at first equipped with Byers, tried out cheaper pipe for several years, and then came back to Byers because it proved to be the cheapest in service, if not in first cost. Only a few of the buildings are shown here.



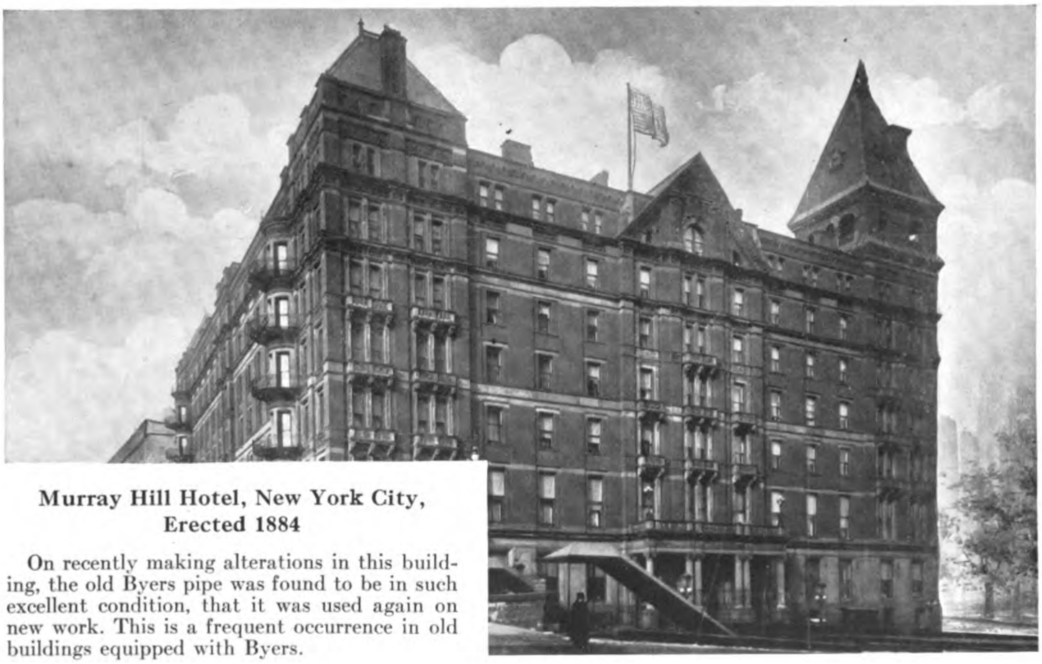
London and Liverpool and Globe Fire Insurance Bldg., New York City, Erected 1880

Record of Byers pipe: In over six miles of pipe, installed over thirty-eight years ago, only two small leaks have occurred. The service is considered as very severe.



Iroquois Hotel, Buffalo, N. Y. Erected 1888

Byers installed in boiler plant and used exclusively for high and low pressure steam and returns, hot and cold water, etc. All this pipe is still well preserved, while steel pipe used in extensions, 12 years ago, has rusted out.



Murray Hill Hotel, New York City, Erected 1884

On recently making alterations in this building, the old Byers pipe was found to be in such excellent condition, that it was used again on new work. This is a frequent occurrence in old buildings equipped with Byers.

Eaker Building, Erected 1874
Miami Valley Hosp., Erected 1894

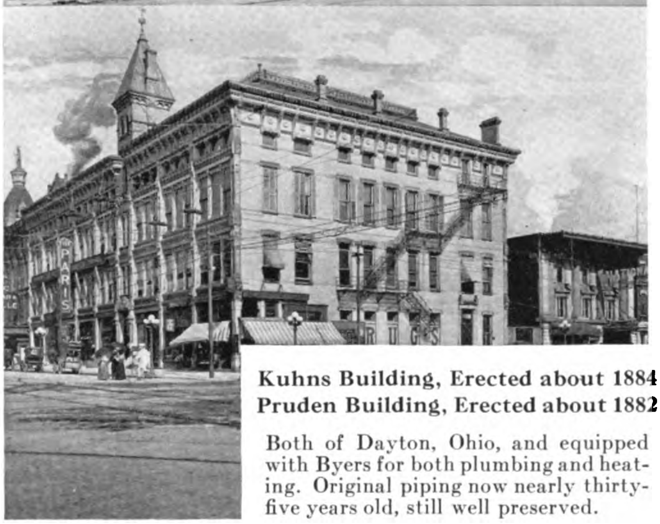
Both Dayton buildings, piped throughout with Byers for both plumbing and heating by Brooks' Son. Practically no repairs on record since first installed.

Plaza Hotel, Chicago, Erected 1889

The steam heating system of this hotel was installed by Kelly & Jones, Pittsburgh, Pa. In the twenty-seven years which have elapsed since all this piping was put in, practically no repairs have been required.

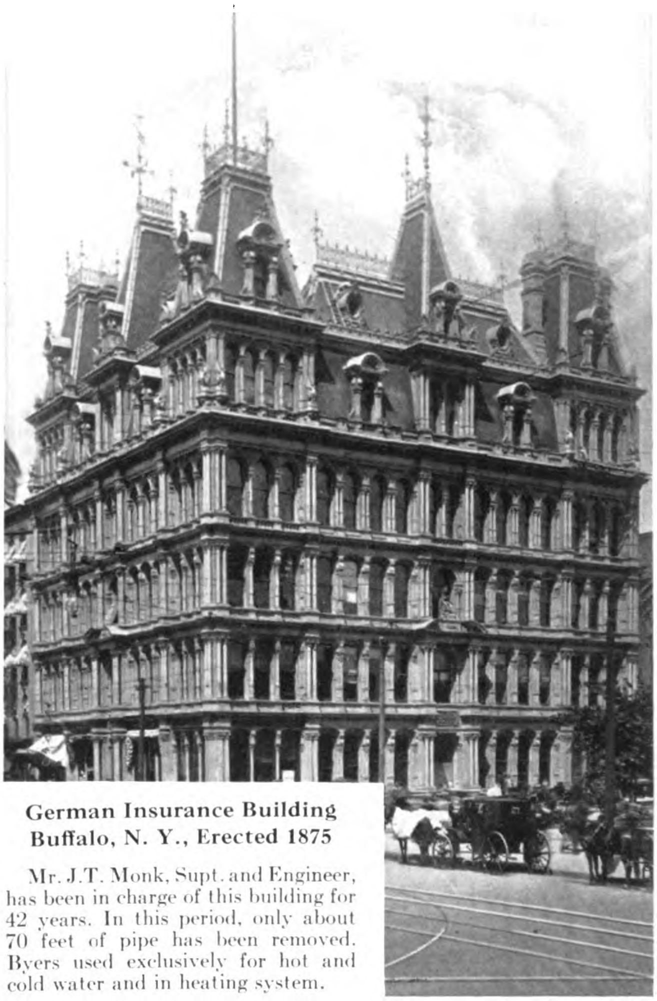
Cuyahoga Building, Cleveland, Erected about 1890

This is only one out of half a dozen of Cleveland's largest buildings erected over twenty-five years ago, and known to be equipped with Byers pipe. When you are in Cleveland, take a look at the piping—it tells its own story of resistance to rust and physical stresses of every kind.



Kuhns Building, Erected about 1884
Pruden Building, Erected about 1882

Both of Dayton, Ohio, and equipped with Byers for both plumbing and heating. Original piping now nearly thirty-five years old, still well preserved.



German Insurance Building Buffalo, N. Y., Erected 1875

Mr. J.T. Monk, Supt. and Engineer, has been in charge of this building for 42 years. In this period, only about 70 feet of pipe has been removed. Byers used exclusively for hot and cold water and in heating system.

Institute for Feebleminded, Columbus, Ohio, Erected 1881

Byers used in all the buildings and power plants, for steam, water supply, heating, and plumbing. The whole institution, containing over 40 miles of pipe, is a monument to the durability of Byers.

THREADS AND COUPLINGS

Black and Galvanized

(All Figures, Excepting Prices and Weights are Nominal)

REGULAR OR STANDARD WEIGHT

	THREADS ON PIPE						COUPLINGS									
							List Prices								Recess	
[illegible]	Weld	Number of Threads Per Inch	Length of Threads Inches	Number of Threads on Pipe	Number of Threads Socket Screws on by hand	Size	Black Each	Galv. Each	R. & L. Black Each	R. & L. Galv. Each	Outside Diam. Inches	Length Inches	Weight Lbs.	Taper	Length	Diam.
[illegible]	Butt	18	.562	10	3–4	¼	.07	.06	.07	.08	.750	1.000	.059	None	None	None
[illegible]	Butt	18	.580	10½	3–4	⅜	.06	.08	.08	.10	.968	1.343	.156	None	None	None
[illegible]	Butt	14	.650	9	3–4	½	.07	.10	.11	.14	1.078	1.343	.168	None	None	None
[illegible]	Butt	14	.812	11½	3–4	¾	.10	.13	.15	.18	1.312	1.531	.243	None	None	None
1	Butt	11½	.937	10¾	3–4	1	.13	.18	.20	.23	1.656	1.718	.425	None	None	None
1¼	Butt	11½	1.000	11½	3–4	1¼	.17	.25	.25	.33	1.984	2.062	.631	None	None	None
1½	Butt	11½	1.070	12¼	4–5	1½	.21	.32	.30	.41	2.281	2.312	.884	None	None	None
1¼	Lap	11½	1.000	11½	3–4	1¼	.17	.25	.25	.33	1.984	2.062	.631	None	None	None
1½	Lap	11½	1.070	12¼	4–5	1½	.21	.32	.30	.41	2.281	2.312	.884	None	None	None
2	Lap	11½	1.100	12½	4–5	2	.28	.40	.50	.62	2.781	2.500	1.300	None	None	None
2½	Lap	8	1.375	11	3½–4½	2½	.40	.55	.85	1.00	3.315	3.125	2.250	None	None	None
3	Lap	8	1.500	12	4–5	3	.60	.80	1.20	1.40	4.031	3.125	3.025	None	None	None
3½	Lap	8	1.560	12½	4½–5½	3½	.80	1.05	1.60	1.90	4.500	3.687	3.900	None	None	None
4	Lap	8	1.625	13	5–6	4	1.00	1.40	2.00	2.40	5.000	3.687	4.500	None	None	None
4½	Lap	8	1.625	13	5–6	4½	1.50	2.00	8.20	8.75	5.531	4.218	6.200	None	None	None
5	Lap	8	1.750	14	6–7	5	1.65	2.25	9.00	9.65	6.281	4.125	8.250	¾	None	None
6	Lap	8	1.750	14	6–7	6	2.40	3.25	12.50	13.35	7.375	4.125	9.750	¾	None	None
7	Lap	8	1.875	15	7–8	7	3.25	4.20	13.00	13.95	8.281	5.000	12.750	¾	½	7.687
8	Lap	8	2.000	16	7½–8½	8	4.25	5.50	17.00	18.25	9.281	5.000	14.850	¾	½	8.687
9	Lap	8	2.125	17	8½–9½	9	5.50	7.00	17.50	19.00	10.937	6.187	30.050	¾	9/16	9.687
10	Lap	8	2.375	19	10–11	10	7.50	9.75	23.00	25.25	11.925	6.750	40.500	¾	9/16	10.812
11	Lap	8	2.375	19	10–11	11	10.00	12.85	24.25	27.10	12.945	6.750	43.000	¾	9/16	11.812
12	Lap	8	2.500	20	11–12	12	10.00	13.65	28.00	31.65	13.945	6.750	47.000	¾	9/16	12.812

EXTRA HEAVY

¼	Butt	18	.600	10.8	3–4	¼	.10	.14	.15	.21	.843	1.250	.125	None	None	None
⅜	Butt	18	.620	11	3–4	⅜	.10	.14	.15	.21	.968	1.343	.156	None	None	None
½	Butt	14	.687	12¼	3–4	½	.10	.14	.15	.21	1.109	1.500	.200	None	None	None
¾	Butt	14	.937	13	3–4	¾	.12	.16	.18	.25	1.375	2.000	.443	None	None	None
1	Butt	11½	1.110	12½	3–4	1	.15	.21	.23	.31	1.687	2.562	.743	None	None	None
1¼	Butt	11½	1.110	12½	3–4	1¼	.25	.37	.38	.53	2.094	2.750	1.150	None	None	None
1½	Butt	11½	1.244	14	4–5	1½	.30	.46	.45	.63	2.375	2.750	1.300	None	None	None
1¼	Lap	11½	1.110	12½	3–4	1¼	.25	.37	.38	.53	2.094	2.750	1.150	None	None	None
1½	Lap	11½	1.244	14	4–5	1½	.30	.46	.45	.63	2.375	2.750	1.300	None	None	None
2	Lap	11½	1.315	14½	6–7	2	.40	.57	.70	.98	2.921	3.625	2.325	¾	⅜	2.437
2½	Lap	8	1.625	13	5–6	2½	.60	.85	1.20	1.70	3.625	4.125	4.550	¾	⅜	2.937
3	Lap	8	1.750	14	6–7	3	.80	1.15	1.60	2.25	4.156	4.125	4.870	¾	7/16	3.562
3½	Lap	8	1.810	14½	6–7	3½	1.30	1.90	2.60	3.65	4.703	4.375	6.350	¾	7/16	4.062
4	Lap	8	1.870	15	6–7	4	1.50	2.15	3.00	4.20	5.250	4.375	7.350	¾	7/16	4.562
4½	Lap	8	1.870	15	6–7	4½	2.00	2.85	7.75	9.15	5.671	4.375	7.700	¾	7/16	5.062
5	Lap	8	1.870	15	6–7	5	2.40	3.45	8.50	10.50	6.437	5.125	11.750	¾	7/16	5.625
6	Lap	8	2.000	16	7–8	6	2.80	4.00	9.75	12.00	7.500	5.375	14.250	¾	½	6.687
7	Lap	8	2.125	17	8–9	7	3.85	5.55	10.00	12.75	8.560	6.375	22.700	¾	½	7.687
8	Lap	8	2.250	18	8½–9½	8	4.00	5.80	11.50	15.75	9.625	6.187	27.450	¾	½	8.687
9	Lap	8	2.375	19	9–10	9	5.00	7.25	12.00	16.75	10.937	6.187	30.050	¾	9/16	9.687
10	Lap	8	2.625	21	10½–11½	10	6.00	8.75	14.75	20.25	11.925	6.750	40.500	¾	9/16	10.812
12	Lap	8	2.750	22	11–12	12	8.00	11.15	18.25	25.50	13.945	6.750	47.000	¾	9/16	12.812

DOUBLE EXTRA HEAVY—SAME AS EXTRA HEAVY

Ask for Catalogue No. 28 Listing Oil Country Tubular Goods.

LIST PRICES, WEIGHTS, DIMENSIONS AND AREAS OF BYERS PIPE

Black and Galvanized

(All Dimensions and Weights are Nominal)

STANDARD WEIGHT

Size	Weld	List Price Per Foot	Outside Diam. Inches	Thickness Inches	Inside Diam. Inches	Standard Weight Plain Ends Lbs. per Ft	Standard Weight Threaded with Coupling Lbs. per Ft.	Hydrostatic Test Lbs.	Internal Circumference Inches	External Circumference Inches	Area of Internal Diameter Sq. Inches	Area of External Diameter Sq. Inches
¼	Butt	.06	.540	.086	.367	.424	.425	750	1.153	1.696	.106	.229
⅜	Butt	.06	.675	.093	.489	.567	.568	750	1.536	2.120	.188	.358
½	Butt	.08½	.840	.111	.617	.850	.852	750	1.938	2.639	.299	.554
¾	Butt	.11½	1.050	.115	.819	1.130	1.134	750	2.573	3.299	.527	.866
1	Butt	.17	1.315	.136	1.043	1.678	1.684	750	3.277	4.131	.854	1.358
1¼	Butt	.23	1.660	.145	1.369	2.272	2.281	750	4.301	5.215	1.472	2.164
1½	Butt	.27½	1.900	.148	1.604	2.717	2.731	750	5.039	5.969	2.021	2.835
1¼	Lap	.23	1.660	.145	1.369	2.272	2.281	1000	4.301	5.215	1.472	2.164
1½	Lap	.27½	1.900	.148	1.604	2.717	2.731	1000	5.039	5.969	2.021	2.835
2	Lap	.37	2.375	.158	2.060	3.652	3.678	1000	6.472	7.461	3.333	4.430
2½	Lap	.58½	2.875	.208	2.460	5.793	5.819	1000	7.728	9.032	4.753	6.492
3	Lap	.76½	3.500	.221	3.059	7.575	7.616	1000	9.610	10.995	7.349	9.621
3½	Lap	.92	4.000	.231	3.538	9.109	9.202	1000	11.115	12.566	9.831	12.566
4	Lap	1.09	4.500	.242	4.016	10.790	10.889	1000	12.617	14.137	12.667	15.904
4½	Lap	1.27	5.000	.252	4.496	12.538	12.642	1000	14.125	15.708	15.873	19.635
5	Lap	1.48	5.563	.263	5.036	14.617	14.810	1000	15.821	17.477	19.919	24.306
6	Lap	1.92	6.625	.286	6.053	18.974	19.185	1000	19.016	20.813	28.776	24.472
7	Lap	2.38	7.625	.307	7.010	23.544	23.769	1000	22.023	23.955	38.594	45.663
8	Lap	2.50	8.625	.283	8.059	24.696	25.000	1000	25.318	27.096	51.010	58.426
8	Lap	2.88	8.625	.329	7.967	28.554	28.809	1000	25.029	27.096	49.860	58.426
9	Lap	3.45	9.625	.349	8.927	33.907	34.188	1000	28.045	30.238	62.589	72.760
10	Lap	3.20	10.750	.284	10.181	31.201	32.000	750	31.985	33.772	81.409	90.763
10	Lap	3.50	10.750	.313	10.124	34.240	35.000	750	31.805	33.772	80.500	90.763
10	Lap	4.12	10.750	.372	10.005	40.483	41.132	1000	31.432	33.772	78.619	90.763
11	Lap	4.63	11.750	.382	10.985	45.557	46.247	750	34.510	36.914	94.774	108.434
12	Lap	4.50	12.750	.336	12.077	43.773	45.000	750	37.941	40.055	114.554	127.677
12	Lap	5.07	12.750	.382	11.985	49.562	50.706	750	37.652	40.055	112.815	127.677
EXTRA HEAVY												
¼	Butt	.07½	.540	.122	.295	.535	Regularly furnished without threads and couplings	750	.927	1.696	.068	.229
⅜	Butt	.07½	.675	.129	.417	.738		750	1.310	2.120	.137	.358
½	Butt	.11	.840	.151	.539	1.087		750	1.693	2.639	.228	.554
¾	Butt	.15	1.050	.157	.735	1.473		750	2.309	3.299	.424	.866
1	Butt	.22	1.315	.183	.949	2.171		750	2.981	4.131	.707	1.358
1¼	Butt	.30	1.660	.195	1.269	2.996		1000	3.987	5.215	1.265	2.164
1½	Butt	.36½	1.900	.204	1.491	3.631		1000	4.684	5.969	1.746	2.835
1¼	Lap	.30	1.660	.195	1.269	2.996		1500	3.987	5.215	1.265	2.164
1½	Lap	.36½	1.900	.204	1.491	3.631		1500	4.684	5.969	1.746	2.835
2	Lap	.50½	2.375	.223	1.929	5.022		1500	6.060	7.461	2.924	4.430
2½	Lap	.77	2.875	.282	2.311	7.661		1500	7.260	9.032	4.194	6.492
3	Lap	1.03	3.500	.306	2.887	10.252		1500	9.070	10.995	6.546	9.621
3½	Lap	1.25	4.000	.325	3.350	12.505		1500	10.524	12.566	8.815	12.566
4	Lap	1.50	4.500	.344	3.811	14.983		1500	11.973	14.137	11.409	15.904
4½	Lap	1.80	5.000	.363	4.275	17.611		1500	13.430	15.708	14.352	19.635
5	Lap	2.08	5.563	.383	4.797	20.778		1500	15.070	17.477	18.073	24.306
6	Lap	2.86	6.625	.441	5.743	28.573		1500	18.042	20.813	25.901	34.472
7	Lap	3.81	7.625	.511	6.603	38.048		1500	20.744	23.955	34.250	45.663
8	Lap	4.34	8.625	.510	7.604	43.488		1500	23.888	27.096	45.411	58.426
9	Lap	4.90	9.625	.510	8.604	48.728		1500	27.030	30.238	58.143	72.760
10	Lap	5.48	10.750	.510	9.729	54.735		1000	30.565	33.772	74.344	90.763
11	Lap	6.10	11.750	.510	10.729	60.075			33.706	36.914	90.413	108.434
12	Lap	6.55	12.750	.510	11.729	65.415		1000	36.848	40.055	108.054	127.677

BYERS PIPE
LIST PRICES, WEIGHTS, DIMENSIONS AND AREAS
Black and Galvanized

(All Dimensions and Weights are Nominal)

DOUBLE EXTRA HEAVY

Size	Weld	List Price Per Foot	Outside Diam. Inches	Thickness Inches	Inside Diam. Inches	Standard Weight Plain Ends Lbs. per Ft		Hydro-static Test Lbs.	Internal Circum-ference Inches	External Circum-ference Inches	Area of Internal Diameter Sq. Inches	Area of External Diameter Sq. Inches
½	Butt	.32	.840	.307	.226	1.714	Regularly furnished without threads and couplings	According to customers' specifications	.710	2.639	.040	.554
¾	Butt	.35	1.050	.318	.413	2.440			1.297	3.299	.134	.866
1	Butt	.37	1.315	.369	.576	3.659			1.809	4.131	.260	1.358
1¼	Butt	.52½	1.660	.393	.874	5.214			2.746	5.215	.600	2.164
1½	Butt	.65	1.900	.411	1.078	6.408			3.387	5.969	.913	2.835
1½	Lap	.65	1.900	.411	1.078	6.408			3.387	5.969	.913	2.835
2	Lap	.91	2.375	.447	1.480	9.029			4.649	7.461	1.722	4.430
2½	Lap	1.37	2.875	.565	1.742	13.695			5.473	9.032	2.384	6.492
3	Lap	1.86	3.500	.615	2.270	18.583			7.131	10.995	4.047	9.621
3½	Lap	2.30	4.000	.651	2.697	22.850			8.473	12.566	5.712	12.904
4	Lap	2.76	4.500	.690	3.119	27.541			9.799	14.137	7.642	15.566
4½	Lap	3.26	5.000	.727	3.546	32.530			11.140	15.708	9.877	19.635
5	Lap	3.86	5.563	.768	4.028	38.552			12.654	17.477	12.741	24.306
6	Lap	5.32	6.625	.884	4.857	53.160			15.257	20.813	18.525	34.472

LINE PIPE

Size	Outside Diameter Inches	Thickness Inches	Inside Diameter Inches	Standard Weight Plain Ends Lbs. per Ft.	Standard Weight Threaded with Coupling Lbs. per Ft.	Hydro-static Test Lbs.	Internal Circum-ference Inches	External Circum-ference Inches	Couplings: External Diameter Inches	Couplings: Length Inches	Couplings: Weight Lbs.
⅜	.675	.093	.489	.567	.571	750	1.536	2.120	.968	1 11/32	.137
½	.840	.111	.617	.850	.856	750	1.938	2.639	1.109	1½	.187
¾	1.050	.116	.819	1.130	1.138	750	2.573	3.299	1.375	2	.425
1	1.315	.136	1.043	1.678	1.688	750	3.277	4.131	1.687	2 7/16	.612
1¼	1.660	.145	1.369	2.272	2.300	1000	4.301	5.215	2.094	2¾	1.000
1½	1.900	.148	1.604	2.717	2.748	1000	5.039	5.969	2.437	3⅛	1.580
2	2.375	.158	2.060	3.652	3.716	1000	6.472	7.461	2.921	3⅝	2.325
2½	2.875	.208	2.460	5.793	5.881	1500	7.728	9.032	3.625	4⅛	4.550
3	3.500	.221	3.059	7.575	7.675	1500	9.610	10.995	4.156	4⅛	4.870
3½	4.000	.231	3.538	9.109	9.261	1500	11.115	12.566	4.703	4⅜	6.350
4	4.500	.242	4.016	10.790	10.980	1500	12.617	14.137	5.250	4⅜	7.350
4½	5.000	.252	4.496	12.538	12.742	1500	14.125	15.708	5.671	4⅜	7.700
5	5.563	.263	5.036	14.617	14.966	1500	15.821	17.477	6.437	5⅛	11.750
6	6.625	.286	6.053	18.974	19.367	1500	19.016	20.813	7.500	5⅜	14.250
7	7.625	.307	7.010	23.544	23.975	1200	22.023	23.955	8.562	6⅜	22.700
8	8.625	.283	8.059	24.696	25.414	1000	25.318	27.096	9.625	6 3/16	27.450
8	8.625	.329	7.967	28.554	29.213	1200	25.029	27.096	9.625	6 3/16	27.450
9	9.625	.349	8.927	33.907	34.612	1200	28.045	30.238	10.937	6 3/16	30.050
10	10.750	.284	10.181	31.201	32.515	800	31.985	33.772	11.925	6¾	40.500
10	10.750	.313	10.124	34.240	35.504	900	31.805	33.772	11.925	6¾	40.500
10	10.750	.372	10.005	40.483	41.644	1000	31.432	33.772	11.925	6¾	40.500
11	11.750	.382	10.985	45.557	46.805	1000	34.510	36.914	12.945	6¾	43.000
12	12.750	.336	12.077	43.773	45.217	1000	37.941	40.055	13.945	6¾	47.000
12	12.750	.382	11.985	49.562	50.916	1000	37.652	40.055	13.945	6¾	47.000

Prices on Oil Well Tubing, Casing, Line Pipe and Drive Pipe will be furnished on application.
Ask for Catalogue No. 28 Listing Oil Country Tubular Goods.

BYERS GENUINE WROUGHT IRON NIPPLES

Regular or Standard Weight

BLACK. RIGHT HAND THREADS

Size	Length, Inches: Close and Short	Length, Inches: Long	Price, Each: Close and Short	Price, Each: Long	Price, Extra Long, Each: 4"	5"	6"	7"	8"	9"	10"	11"	12"
¼	⅞, 1½	2, 2½, 3, 3½	.04	.06	.07	.08	.10	.12	.14	.15	.17	.18	.19
⅜	1, 1½	2, 2½, 3, 3½	.04	.06	.07	.08	.10	.12	.14	.15	.17	.18	.19
½	1⅛, 1½	2, 2½, 3, 3½	.05	.07	.08	.10	.12	.14	16	.18	.20	.22	.23
¾	1⅜, 2	2½, 3, 3½, 4	.06	.09		.11	.13	.17	.18	.20	.22	.24	.26
1	1½, 2	2½, 3, 3½, 4	.08	.13		.15	.18	.23	.25	.28	.31	.34	.36
1¼	1⅝, 2½	3, 3½, 4, 4½	.11	.17		.20	.24	.29	.33	.36	.40	.44	.47
1½	1¾, 2½	3, 3½, 4, 4½	.13	.20		.25	.29	.36	.40	.45	.50	.54	.59
2	1¾, 2½	3, 3½, 4, 4½	.18	.27		.32	.38	.50	.54	.59	.65	.72	.77
2½	2½, 3	3½, 4, 4½, 5	.39	.59			.68	.90	.97	1.06	1.17	1.26	1.35
3	2½, 3	3½, 4, 4½, 5	.48	.72			.85	1.08	1.20	1.33	1.45	1.58	1.70
3½	2¾, 4	4½, 5, 5½, 6	.75	1.05				1.30	1.45	1.60	1.75	1.90	2.05
4	3, 4	4½, 5, 5½, 6	.85	1.20				1.52	1.69	1.87	2.05	2.22	2.40
4½	3, 4	4½, 5, 5½, 6	1.25	1.70				2.25	2.50	2.75	2.95	3.17	3.40
5	3¼, 4½	5, 5½, 6, 6½	1.55	2.45				2.58	2.83	3.10	3.35	3.60	3.85
6	3¼, 4½	5, 5½, 6, 6½	1.85	2.90				3.05	3.35	3.70	4.00	4.30	4.65
7	3½, 5	6	3.20	3.60				4.05	4.45	4.90	5.30	5.75	6.15
8	3½, 5	6	3.55	4.05				4.55	5.05	5.50	6.00	6.50	7.00
9	4, 5	8	5.25	6.50						7.10	7.75	8.40	9.00
10	4, 5	8	6.75	8.25						8.90	9.70	10.40	11.15
12	4, 5	8	8.00	10.00						10.80	11.75	12.70	13.65

GALVANIZED. RIGHT HAND THREADS

Size	Close and Short	Long	Close and Short	Long	4"	5"	6"	7"	8"	9"	10"	11"	12"
¼	⅞, 1½	2, 2½, 3, 3½	.06	.11	.12	.15	.17	.21	.24	.26	.29	.31	.34
⅜	1, 1½	2, 2½, 3, 3½	.06	.11	.12	.15	.17	.21	.24	.26	.29	.31	.34
½	1⅛, 1½	2, 2½, 3, 3½	.06	.11	.13	.16	.18	.23	.26	.28	.31	.33	.36
¾	1⅜, 2	2½, 3, 3½, 4	.08	.14		.18	.21	26	.29	.32	.35	.38	.41
1	1½, 2	2½, 3, 3½, 4	.11	.19	.....	.24	.28	.34	.38	.42	.47	.51	.55
1¼	1⅝, 2½	3, 3½, 4, 4½	.17	.29	.....	.32	.38	.45	.51	.57	.63	.69	.75
1½	1¾, 2½	3, 3½, 4, 4½	.21	.35	.....	.39	.46	.55	.63	.70	.77	.84	.91
2	1¾, 2½	3, 3½, 4, 4½	.27	.47	.....	.52	.61	.74	.83	.93	1.03	1.13	1.23
2½	2½, 3	3½, 4, 4½, 5	.56	.86	.....	.....	1.00	1.26	1.41	1.56	1.71	1.86	2.01
3	2½, 3	3½, 4, 4½, 5	.70	1.10	.....	.....	1.30	1.60	1.80	2.00	2.20	2.40	2.60
3½	2¾, 4	4½, 5, 5½, 6	1.20	1.70	.....	.....	.....	2.10	2.35	2.60	2.85	3.15	3.40
4	3, 4	4½, 5, 5½, 6	1.35	1.87	.....	.....	.....	2.30	2.60	2.90	3.20	3.50	3.80
4½	3, 4	4½, 5, 5½, 6	1.85	2.60	.....	.....	.....	3.30	3.65	4.05	4.45	4.85	5.25
5	3¼, 4½	5, 5½, 6, 6½	2.30	3.15	.....	.....	.....	3.75	4.20	4.60	5.00	5.40	5.85
6	3¼, 4½	5, 5½, 6, 6½	2.80	4.25	.....	.....	.....	4.50	5.00	5.55	6.05	6.60	7.15
7	3½, 5	6	4.25	4.95	.....	.....	.....	5.65	6.35	7.05	7.75	8.45	9.20
8	3½, 5	6	5.00	5.80	.....	.....	.....	6.65	7.50	8.35	9.25	10.10	10.95

BLACK. RIGHT AND LEFT THREADS

Size	Close and Short	Long	Close and Short	Long	4"	5"	6"	7"	8"	9"	10"	11"	12"
¼	⅞, 1½	2, 2½, 3, 3½	.05	.08	.09	.11	.13	.16	.18	.20	.23	.25	.27
⅜	1, 1½	2, 2½, 3, 3½	.05	.08	.09	.11	.13	.16	.18	.20	.23	.25	.27
½	1⅛, 1½	2, 2½, 3, 3½	.07	.10	.11	.13	.16	.18	.21	.24	.27	.29	.31
¾	1⅜, 2	2½, 3, 3½, 4	.08	.12	.....	.15	.17	.23	.25	.27	.29	.32	.35
1	1½, 2	2½, 3, 3½, 4	.11	.18	.....	.20	.24	.31	.33	.37	.41	.45	.48
1¼	1⅝, 2½	3, 3½, 4, 4½	.15	.23	.....	.27	.32	.39	.45	.50	.55	.60	.65
1½	1¾, 2½	3, 3½, 4, 4½	.18	.27	.....	.34	.39	.48	.52	.60	.67	.72	.80
2	1¾, 2½	3, 3½, 4, 4½	.24	.36	.....	.43	.51	.67	.72	.80	.87	.96	1.03
2½	2½, 3	3½, 4, 4½, 5	.52	.79	.....	.....	.91	1.20	1.30	1.40	1.55	1.68	1.80
3	2½, 3	3½, 4, 4½, 5	.65	.96	.....	.....	1.13	1.44	1.60	1.77	1.93	2.10	2.27
3½	2¾, 4	4½, 5, 5½, 6	1.00	1.40	.....	.....	.....	1.75	1.95	2.15	2.35	2.55	2.75
4	3, 4	4½, 5, 5½, 6	1.15	1.60	.....	.....	.....	2.00	2.25	2.50	2.75	3.00	3.25

"Close" and "Short" Nipples. Assorted "Close" and "Short" Nipples will always be shipped unless otherwise specified.

Black or Galv. Nipples, threaded one way, always furnished threaded right hand only unless otherwise specified.

Assorted R. & L. Nipples will be furnished "Long" unless otherwise specified.

2½" and 3" Nipples can be furnished with 11½ threads per inch, at special prices.

Galv. Nipples, threaded R. & L., are furnished at an advance of 60% beyond list prices on Black, R. & L.

BYERS GENUINE WROUGHT IRON NIPPLES

Extra Heavy

BLACK. RIGHT HAND THREADS

Size	Length, Inches: Close	Short	Long	Price, Each: Close and Short	Long	Price, Extra Long, Each: 4"	5"	6"	7"	8"	9"	10"	11"	12"
¼	⅞	1½	2, 2½, 3, 3½	.08	.12	.14	.16	.20	.24	.28	.30	.34	.36	.38
⅜	1	1½	2, 2½, 3, 3½	.08	.12	.14	.16	.20	.24	.28	.30	.34	.36	.38
½	1⅛	1½	2, 2½, 3, 3½	.10	.14	.16	.20	.24	.28	.32	.36	.40	.44	.46
¾	1⅜	2	2½, 3, 3½, 4	.12	.18	.....	.22	.26	.34	.36	.40	.44	.48	.52
1	1½	2	2½, 3, 3½, 4	.16	.26	.....	.30	.36	.46	.50	.56	.62	.68	.72
1¼	1⅝	2½	3, 3½, 4, 4½	.22	.34	.....	.40	.48	.58	.66	.72	.80	.88	.94
1½	1¾	2½	3, 3½, 4, 4½	.26	.40	.....	.50	.58	.72	.80	.90	1.00	1.08	1.18
2	1¾	2½	3, 3½, 4, 4½	.36	.54	.....	.64	.76	1.00	1.08	1.18	1.30	1.44	1.54
2½	2½	3	3½, 4, 4½, 5	.78	1.18	.....	.....	1.36	1.80	1.94	2.12	2.34	2.52	2.70
3	2½	3	3½, 4, 4½, 5	.96	1.44	.....	.....	1.70	2.16	2.40	2.66	2.90	3.16	3.40
3½	2¾	4	4½, 5, 5½, 6	1.50	2.10	.....	.....	.....	2.60	2.90	3.20	3.50	3.80	4.10
4	3	4	4½, 5, 5½, 6	1.70	2.40	.....	.....	.....	3.04	3.38	3.74	4.10	4.44	4.80
4½	3	4	4½, 5, 5½, 6	2.50	3.40	.....	.....	.....	4.50	5.00	5.50	5.90	6.34	6.80
5	3¼	4½	5, 5½, 6, 6½	3.10	4.90	.....	.....	.....	5.16	5.66	6.20	6.70	7.20	7.70
6	3¼	4½	5, 5½, 6, 6½	3.70	5.80	.....	.....	.....	6.10	6.70	7.40	8.00	8.60	9.30
7	3½	5	6	6.40	7.20	.....	.....	.....	8.10	8.90	9.80	10.60	11.50	12.30
8	3½	5	6	7.10	8.10	.....	.....	.....	9.10	10.10	11.00	12.00	13.00	14.00
9	4	5	8	10.50	13.00	.....	.....	.....	.....	.....	14.20	15.50	16.80	18.00
10	4	5	8	13.50	16.50	.....	.....	.....	.....	.....	17.80	19.40	20.80	22.30
12	4	5	8	16.00	20.00	.....	.....	.....	.....	.....	21.60	23.50	25.40	27.30

GALVANIZED. RIGHT HAND THREADS

Size	Close	Short	Long	Close and Short	Long	4"	5"	6"	7"	8"	9"	10"	11"	12"
¼	⅞	1½	2, 2½, 3, 3½	.10	.17	.19	.23	.27	.33	.38	.41	.46	.49	.53
⅜	1	1½	2, 2½, 3, 3½	.10	.17	.19	.23	.27	.33	.38	.41	.46	.49	.53
½	1⅛	1½	2, 2½, 3, 3½	.11	.18	.21	.26	.30	.37	.42	.46	.51	.55	.59
¾	1⅜	2	2½, 3, 3½, 4	.14	.23	.....	.29	.34	.43	.47	.52	.57	.62	.67
1	1½	2	2½, 3, 3½, 4	.19	.32	.....	.39	.46	.57	.63	.70	.78	.85	.91
1¼	1⅝	2½	3, 3½, 4, 4½	.28	.46	.....	.52	.62	.74	.84	.93	1.03	1.13	1.22
1½	1¾	2½	3, 3½, 4, 4½	.34	.55	.....	.64	.75	.91	1.03	1.15	1.27	1.38	1.50
2	1¾	2½	3, 3½, 4, 4½	.45	.74	.....	.84	.99	1.24	1.37	1.52	1.68	1.85	2.00
2½	2½	3	3½, 4, 4½, 5	.95	1.45	.....	.....	1.68	2.16	2.38	2.62	2.88	3.12	3.36
3	2½	3	3½, 4, 4½, 5	1.18	1.82	.....	.....	2.15	2.68	3.00	3.33	3.65	3.98	4.30
3½	2¾	4	4½, 5, 5½, 6	1.95	2.75	.....	.....	.....	3.40	3.80	4.20	4.60	5.05	5.45
4	3	4	4½, 5, 5½, 6	2.20	3.07	.....	.....	.....	3.82	4.29	4.77	5.25	5.72	6.20
4½	3	4	4½, 5, 5½, 6	3.10	4.30	.....	.....	.....	5.55	6.15	6.80	7.40	8.02	8.65
5	3¼	4½	5, 5½, 6, 6½	3.85	5.60	.....	.....	.....	6.33	7.03	7.70	8.35	9.00	9.70
6	3¼	4½	5, 5½, 6, 6½	4.65	7.15	.....	.....	.....	7.55	8.35	9.25	10.05	10.90	11.80
7	3½	5	6	7.45	8.55	.....	.....	.....	9.70	10.80	11.95	13.05	14.20	15.35
8	3½	5	6	8.55	9.85	.....	.....	.....	11.20	12.55	13.85	15.25	16.60	17.95

BLACK. RIGHT AND LEFT HAND THREADS

Size	Close	Short	Long	Close and Short	Long	4"	5"	6"	7"	8"	9"	10"	11"	12"
¼	⅞	1½	2, 2½, 3, 3½	.10	.16	.18	.22	.26	.32	.36	.40	.46	.50	.54
⅜	1	1½	2, 2½, 3, 3½	.10	.16	.18	.22	.26	.32	.36	.40	.46	.50	.54
½	1⅛	1½	2, 2½, 3, 3½	.14	.20	.22	.26	.32	.36	.42	.48	.54	.58	.62
¾	1⅜	2	2½, 3, 3½, 4	.16	.24	.....	.30	.34	.46	.50	.54	.58	.64	.70
1	1½	2	2½, 3, 3½, 4	.22	.36	.....	.40	.48	.62	.66	.74	.82	.90	.96
1¼	1⅝	2½	3, 3½, 4, 4½	.30	.46	.....	.54	.64	.78	.90	1.00	1.10	1.20	1.30
1½	1¾	2½	3, 3½, 4, 4½	.36	.54	.....	.68	.78	.96	1.04	1.20	1.34	1.44	1.60
2	1¾	2½	3, 3½, 4, 4½	.48	.72	.....	.86	1.02	1.34	1.44	1.60	1.74	1.92	2.06
2½	2½	3	3½, 4, 4½, 5	1.04	1.58	.....	.....	1.82	2.40	2.60	2.80	3.10	3.36	3.60
3	2½	3	3½, 4, 4½, 5	1.30	1.92	.....	.....	2.26	2.88	3.20	3.54	3.86	4.20	4.54
3½	2¾	4	4½, 5, 5½, 6	2.00	2.80	.....	.....	.....	3.50	3.90	4.30	4.70	5.10	5.50
4	3	4	4½, 5, 5½, 6	2.30	3.20	.....	.....	.....	4.00	4.50	5.00	5.50	6.00	6.50

"Close" and "Short" Nipples. Assorted "Close" and "Short" Nipples will always be shipped unless otherwise specified.

2½" and 3" Nipples can be furnished with 11½ threads per inch, at special prices.

Galv. Nipples, threaded R. & L., are furnished at an advance of 60% beyond list prices on Black R. & L.

Black or Galv. Nipples, threaded one way, always furnished threaded right hand only unless otherwise specified.

Assorted R. & L. Nipples will be furnished "Long" unless otherwise specified.

How to Tell the Difference Between Iron and Steel Pipe

There are about eight different ways to determine whether pipe is iron or steel. The four easiest ways are explained below. Tests 1, 2 and 3 can be applied to either new or old pipe. Identification by name rolled in the pipe is applicable only to pipe made within the last 15 or 16 years. More detailed information on this subject will be found in Bulletin No. 41, which will be sent on request.

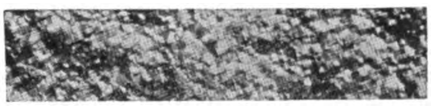
1. FRACTURE TEST

The fracture of genuine wrought iron pipe appears *ragged, dull gray* and *fibrous*. The fiber is particularly

Iron Fracture—Dull, Gray and Fibrous

distinct when compared with a steel fracture. A fracture is easily obtained by hammering a short piece of pipe, as shown in the illustration at the right under 'Galvanizing Test."

The fracture of steel is *even bright* and *crystalline*. which, when exposed to the air, soon loses its luster. Moreover, steel pipe shows a tendency to fracture at the



Steel Fracture—Even, Bright and Crystalline

weld, and here the metal presents a smooth, dull gray appearance, which should not be confused with the tough, fibrous fracture of wrought iron.

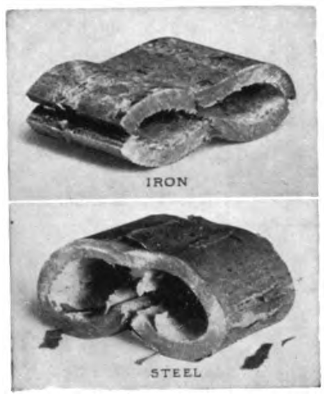
2. THREADING TEST

When wrought iron pipe is threaded, its fibrous structure causes the chip to *break and crumble* as when dressing the end of a piece of wood. (This prevents clogging of the die space and reduces friction. A clean, accurate thread results.)

With steel, owing to the absence of fiber, the chip tends to curl up, forming *a long, more or less perfect spiral*, beautiful to look at but an obstacle to easy threading, for it increases friction and causes clogging of the chip space.

3. GALVANIZING TEST

Hammer a piece of galvanized pipe repeatedly to flatten it. If the zinc coating adheres firmly to the pipe, showing little effect of the hammering or flattening, it is wrought iron pipe. If, on the other hand, the zinc begins to scale off at almost the first stroke of the hammer, the pipe is steel. Repeated blows will cause the galvanizing to come off in large flakes, leaving the steel almost bare in spots. This is virtually what happens during handling, cutting, bending and threading steel pipe and in the course of years of service.



Hammer a piece of Byers Pipe and note the tenacity of the coating on the iron. You may fracture the pipe, and the galvanizing will fracture with it, without cracking and scaling off at the edge of the fracture.

4. ROLL MARKS ON PIPE

All pipe bearing the Byers Name and Year of Manufacture rolled into the metal in raised letters, is genuine wrought iron. The Year of Manufacture rolled in the

Look for the NAME and YEAR on Every Length

metal is a Guarantee of the lasting qualities of Byers Pipe. It facilitates future observation as to the number of years the pipe has been in service. Watch and compare it with the service given by other welded pipe.

A. M. BYERS COMPANY, Pittsburgh, Pa.

ESTABLISHED 1864

New York Boston Philadelphia Cleveland Chicago Dallas

BYERS GENUINE WROUGHT IRON PIPE
FULL WEIGHT GUARANTEED

TUBING, CASING, LINE PIPE, DRILL PIPE AND DRIVE PIPE
BLACK AND GALVANIZED

A·M·BYERS COMPANY
ESTABLISHED 1864
PITTSBURGH, PA.

23 Sullivan Street NEW YORK CITY | 11 Sleeper Street BOSTON, MASS. | 401 McCormick Bldg. CHICAGO, ILL. | 1212 Carter Bldg. HOUSTON, TEX. | 706-7 Union Oil Bldg. LOS ANGELES, CALIF.

BULLETIN No. 27 Third Edition SEPTEMBER, 1918

THE EXPERIENCE OF PRACTICAL MEN

IN talking about the corrosion of iron and steel pipe, a noted Professor recently remarked that he placed the experience of practical men above that of science, especially of "commercialized science."

"The experience of practical men," he said, "indicates that genuine wrought iron resists corrosion to a much greater extent than steel, notwithstanding the fact that, from a strictly scientific standpoint, it may be difficult to explain why."

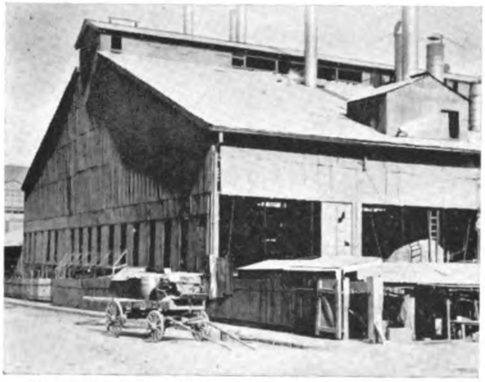
As a practical man, you wish above all to be sure that you are justified in paying the extra price for genuine wrought iron pipe.

If you have had sufficient experience with pipe, the enclosed letters from other practical men may be interesting merely as corroborating your own observations.

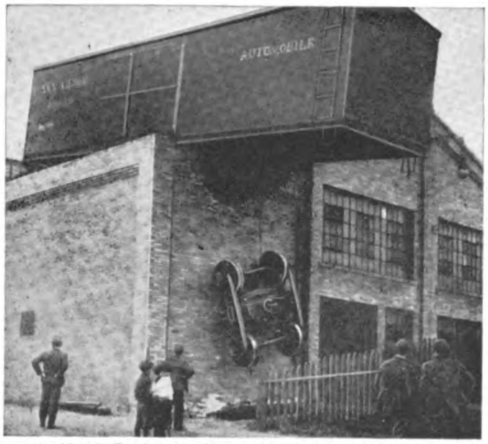
If, on the other hand, you are looking for reliable information on the subject, a reading of some of the enclosed quotations and letters will be profitable. The letters may be accepted merely as typical of a great mass of similar letters on file at the Byers' offices.

Whether or not you have time to look over these pages now, we wish you would kindly place this bulletin on file for future reference.

The opinion that steel corrodes more rapidly than iron does not rest on experimental evidence. (See statement of Richard H. Gaines on page 3.)



One of Byers' puddling mills, Pittsburgh, Pa., erected 1881. The roof and sides of this mill are covered with galvanized sheets made of Byers' genuine wrought iron, and still sheds water after 35 years exposure. The sheets have never been painted. (Compare with statement of Joseph Hartshorne on page 4.)



At North Rochester, Pa., a freight car recently ran off an elevated siding and lodged on factory roof as shown in picture. The front truck was torn loose but stopped in mid-air, suspended by the *genuine wrought iron* brake rod, only ¾ in. in diameter; a striking illustration of the toughness and strength of genuine wrought iron. (Compare with statement of Wallace G. Imhoff, Consulting Engineer, page 4.)

NOT until some ten or twenty years after steel pipe was introduced, did the subjects of corrosion and of the difference between the physical properties of iron and steel become acute. The discussion has since subsided to some extent, many people accepting as the inevitable the short life of steel pipe, wire, sheets, etc., exposed to corrosion, and to continued severe physical strains. It is of interest, however, to recall some of the original as well as more recent statements of practical men on the subject.

We recommend, in this connection, the reading of Bulletin No. 239 on the "Corrosion of Fence Wire," issued by the United States Department of Agriculture.

Probably the largest single user of wire in the world is the Western Union Telegraph Company. Their annual requirements amount to over 10,000 miles of wire. Mr. Robert C. Clowry, late President and General Manager of this company stated:

> "Bessemer or mild steel wire will rust or deteriorate much more rapidly than iron wire, in all probability three times as rapidly - - -

Mr. James P. Roe, Superintendent Glasgow Iron Company, Pottstown, Pa., in a paper presented before the Washington meeting of the Am. Institute of Mining Engineers, Washington, D. C., 1905, said:

> "That wrought iron resists oxidation better than steel is becoming the general opinion of those who have studied the question under actual working conditions. The difference is naturally more apparent in thin objects, but its influence is the same regardless of mass. The difference in the life of light sections is about as 5 to 1 in favor of puddled iron."

Dr. Raymond, Secretary of the Am. Institute of Mining Engineers, on above occasion said:

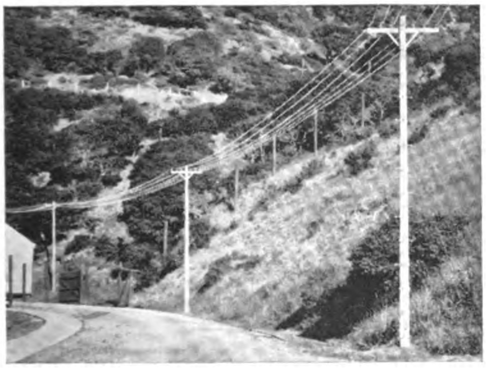
> "I approved the substitution of low-carbon steel for wrought iron for certain articles of manufacture. The immediate result was complaint from both consumers and selling agents that these articles rusted so soon as to look old, even upon delivery - - - - -

and further:

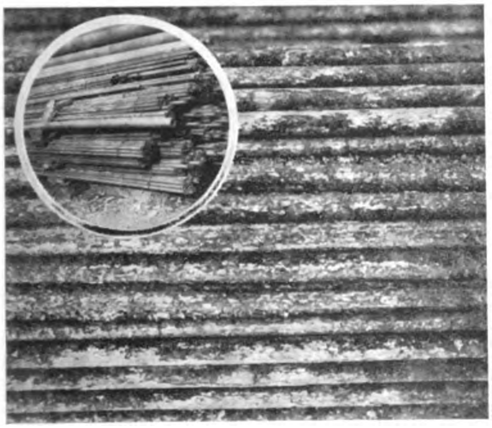
> "I have had recent occasion to realize with surprise and consternation the imperative necessity of repairs to roofs, pipes, etc., of tinned or galvanized "iron" (meaning steel, or iron mixed with steel scrap.)"

Henry M. Howe, well known metallurgist and author of books on iron and steel, on the same occasion remarked:

> "Under certain conditions—for instance in the case of boiler tubes—there appears to be little doubt that Bessemer steel of quality very similar to that which is rolled out for wire, apparently does rust more easily than wrought iron suitable for such wire."



"Bessemer or mild steel wire will rust or deteriorate much more rapidly than iron wire, in all probability three times as rapidly." (Statement of Mr. Robt. C. Clowry, late president of the Western Union Telegraph Co.)



Several carloads of steel pipe in pipe yards of a Youngstown, Ohio, jobber. After three months' exposure, this pipe was rusted so badly as to be entirely unsalable without scraping and cleaning.

Byers genuine wrought iron casing, after eight years' exposure to the elements, on property of Donaldson Bros., Langeloth, Pa. The pipe still looks like new and the threads are clean and perfect.

Dr. Charles B. Dudley of Altoona, Pa., late Chief Chemist of the P. R. R., said:

" - - - steel has been substituted for iron, and it may be said with all honesty that the belief and feelings of those who have guided this matter have been that the substitution was not only wise but clearly a step in the right direction. However, as we have obtained more experience (and I may say that it has apparently taken about twenty years to get this experience) we are finding that in certain constructions steel is not proving to be so satisfactory as we had hoped."

Joseph Hartshorne, Pottstown, Pa.

"My own investigations led me to believe that iron was the better material for many of the purposes for which steel is now applied, and it seemed to me that the decided trend of opinion, not only among tradesmen, but also among engineers and investigators, was in the same direction. If this opinion be warranted by facts, *as now, more than ever I think it is*, then the use of iron must largely increase in the near future.

N. B. Wittman, Metallurgical Engineer,
Philadelphia, Pa.

"I know of an important steel manufacturer, and therefore without prejudice in favor of iron, who will not have a steel tube in the boilers, nor a steel sheet on the roofs of the buildings."

Professor James Aston, University of Cincinnati, states: (Iron Trade Review, 1915.)

"Wrought iron offers such barriers (against corrosive attacks) in the form of slag - - - - such a product surely can claim logical reasons in the light of accepted theory to substantiate the more reliable service tests."

Richard H. Gaines:

"There is a prevalent and wide spread conviction among engineers that steel corrodes much more rapidly than wrought iron, and while the opinion may not rest on experimental evidence, the reasons for it are sound."

W. R. Fleming, Metallurgist, Andrews Steel Co.:

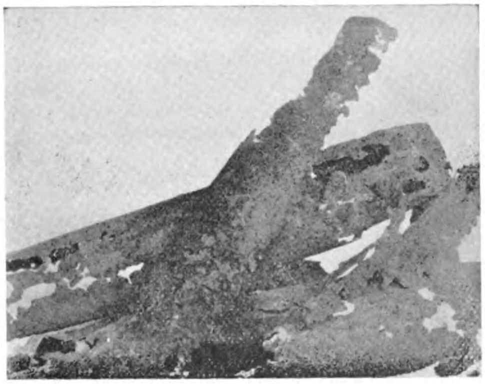
"Wrought iron in service resists corrosion better than steel. This is beyond dispute by overwhelming evidence." (Iron Age, March 14, 1912.)

Bradley Stoughton:

"There are other qualities of wrought iron which may tend to make it corrode less than steel, chief among which are the absence of blowholes and possibly the absence of manganese."

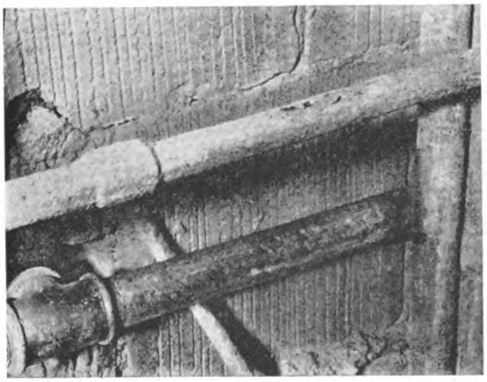
Thomas Turner, Professor in Metallurgy, University of Birmingham, England:

"Perhaps no other property of wrought iron has had greater influence in causing the puddling process to survive side by side with modern steel works, than that of its power to resist atmospheric influence better than steel."



Remains of steel railing on Congress Street Bridge, Boston, after 6 years' exposure. (Compare with statement of Mr. A. Sahlin and Prof. Thomas Turner on pages 3 and 4)

Home of D. E. Eakin, Allegheny County, Pa., erected 25 years ago. Part of an old galvanized iron rain leader, now from 50 to 75 years old, and taken from the old home when torn down, may still be seen in service at this place, while the new rain leader, seen at the corner of the house in above picture, has been renewed twice since the house was built, notwithstanding several paintings.



Pipe in Fulton Building, Pittsburgh, Pa, 7 years old. The upper pipe is steel conduit, the lower Byers wrought iron water line. The steel pipe is a mere shell, rusted away from the outside, while Byers pipe is still apparently as good as new.

A. Sahlin, (in Journal Iron & Steel Institute, 1884-1 P. 299) states:

"Iron fencing, wire, nails, tin plates, tubes, pipes, etc., are all found to resist corrosion under ordinary atmospheric conditions better than the average mild steel."

R. M. Starbuck, Sanitary Engineer and well known author of many books on plumbing and heating subjects, states in "Modern Plumbing," page 263:

"This material (steel pipe) is far shorter lived and is entirely unsuited to the plumbing system, which should be expected to render service almost as long as the house in which it is placed."

Wallace G. Imhoff, Consulting Engineer, Pittsburgh, Pa., (In Iron & Steel Plant, April, 1916):

"Briefly, - - - - wrought iron is tough, fibrous, ductile, having a tremendous resistance to shocks and vibration and a large factor of immunity from corrosion."

Alfred G. King, Heating and Ventilating Engineer, in his book "Practical Heating and Ventilating," states:

"There seems to be no doubt but that wrought iron pipe will last much longer than pipe made of steel, as it is less liable to corrode." (Page 66.)

Joseph Hartshorne, Metallurgical Engineer, Pottstown, Pa.:

"A Bessemer steel works was built under my supervision in 1885, the roof and sides of which were made of corrugated iron sheets of heavy gauge. They received two coats of paint on both sides before erection and one on the outside when in place. The sheets were put on in the latter part of 1885, blowing began in July, 1886, and ceased finally in August, 1893. Since that time most of the buildings have been entirely neglected. Extensions were erected at various times, generally after 1889, for which steel sheets of the same gauge were used and treated in the same way. Much of the first roof and a still larger proportion of the sides will still turn water after 20 years, although they have not been painted for 11 years and the wind has had free play with the sheets, which were never fastened if they got loose. None of the steel plates lasted over four years and a part which was re-roofed with steel sheets in May, 1901, now requires renewal."

Pipe removed from 6 inch line of Byers Black Pipe laid by the Philadelphia Company 28 years ago. Several hundred feet of this pipe was uncovered by the removal of Pittsburgh's "Hump" in 1913 and was found to have lost less than 3% of its original weight by corrosion.

The Philadelphia Company is one of the largest and best known gas companies. It has had a large experience with both steel and wrought iron and "is thoroughly convinced, after long experience and many experiments, that Byers genuine wrought iron pipe is worth considerably more than the extra cost."

THE L. S. STARRETT COMPANY

MAKERS OF FINE MECHANICAL TOOLS

ESTABLISHED 1880 — INCORPORATED 1900

NEW YORK
150 CHAMBERS ST
CHICAGO
NO. JEFFERSON ST.

L. S. STARRETT, PRESIDENT
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36 & 37 UPPER
THAMES ST. E.C.

ATHOL, MASS., U.S.A.

Oct. 10, 1913 To Messrs. A. M. Byers Company,

Mr. G. Frank Uhler, New England Agent,

No. 11 Sleeper St., Boston. Mass.

Gentlemen: We are pleased to inform you that we have always found Byers full weight genuine wrought iron pipe very satisfactory for our work. For a number of years we used standard or steel pipe. This pipe was hard on dies and much pipe was lost in working as some lengths split in threading. We find after about 10 years experience with Byers pipe that it is always uniform in weight and working qualities, We have a full equipment for piping, threading pipe up to 8" by power. For 8 years it has been our custom to install our heating and sprinkler systems, together with water lines, using Byers pipe exclusively and do not hesitate to recommend it to our friends.

Yours respectfully,

THE L. S. STARRETT CO.,

By F. A. Ball.
VICE-PRES. and PURCHASING AGENT.

MAKERS OF [illegible]

NEW YORK

[illegible]ton, Mass., U.S.A.

Oct. 30, 1913

Gentlemen: We are pleased to [illegible]

[illegible] full weight genuine wrought iron pipe [illegible]

our work. For a number of years we have [illegible] This

[illegible] bend condition [illegible] pipe [illegible]

[illegible] in threading. We find after about [illegible]

[illegible] pipe that it is always uniform [illegible]

[illegible] a full equipment for piping, [illegible]

[illegible] 6 years it has been our custom to install our heating and sprinkler

systems, together with water lines, [illegible] and do

[illegible] hesitate to recommend it to our friends.

Yours respectfully,

Won its Favor Through its Flavor.

KELLOGG TOASTED CORN FLAKE CO.

BATTLE CREEK, MICH. Jan. 3d-13

Kenneth Anderson Co.,
33 E. Atwater St.,
Detroit, Mich.

Gentlemen:

Referring to your recent inquiry in regard to the A. M. Byers Co. pipe. We have used Byers pipe for the last three years exclusively and our repair bills have been materially reduced. Before using Byers pipe we were in the habit of installing only the cheap steel pipe, but found that this was very unsatisfactory due to the fact that it often split on the seams and was very difficult to make a good thread on our threading machine. It often happened after a job was installed it was necessary to tear out many lengths of pipe on account of these defects. This trouble has been entirely eliminated since we started to use Byers and can assure you we will never use anything else as long as the quality of Byers pipe and the service given by your Company are maintained.

Yours very truly,

KELLOGG TOASTED CORN FLAKE CO.
Geo. L. Kellogg

JLK-CH

KELLOGG'S IS THE ONLY FLAKED CEREAL DISTRIBUTED THROUGH JOBBERS ONLY.

WORKS,
WORTH, McDOWELL COUNTY, W.VA.

ALL CONTRACTS ARE CONTINGENT UPON STRIKES ACCIDENTS OR DELAYS BEYOND OUR CONTROL

CHIEF

Indian Ridge Coal and Coke Co.,

MINERS AND MANUFACTURERS OF

Pocahontas Coal and Coke,

WORTH KILPATRICK, PRESIDENT.
KELL LONG, VICE PRESIDENT.
J.A. ARMSTRONG, SECY. & TREAS.
A. D. RICE, GEN. MANAGER.

FREIGHT,
EXPRESS AND TELEGRAPH OFFICE,
NORTH FORK, W.VA.

Connellsville, Pa.

Sept. 30, 1915.

A. M. Byers Company,

Pittsburgh, Penna.

Gentlemen:

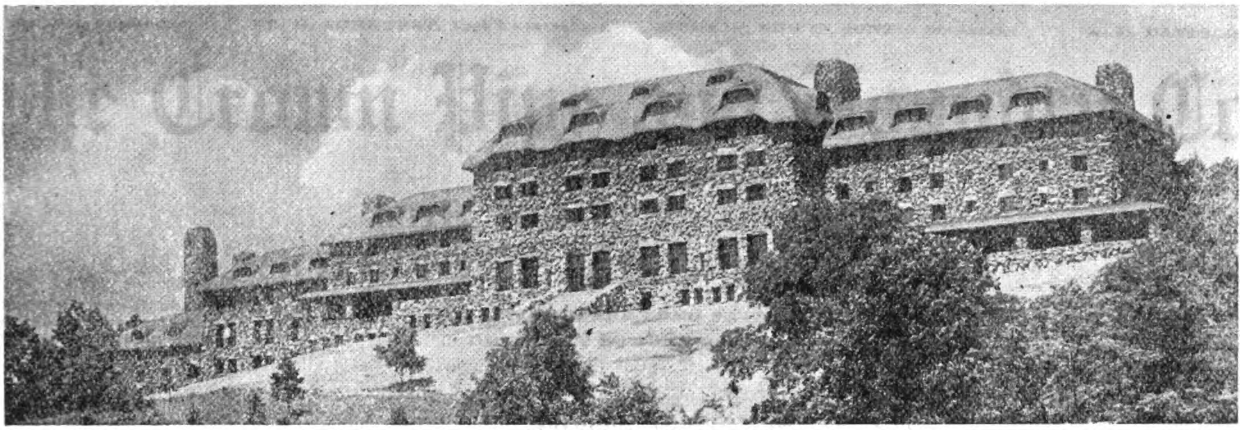
We have been in the Coal Mining business for about twenty two years and, of course, have been buying pipe more or less during that time. Our experience has been that it is almost a total waste of money to use steel pipe, especially where there is a considerable percentage of sulphur in the coal.

One experience we had made quite an impression upon me. It was at Fairmount, West Virginia, where the sulphur is high in the coal. We installed a pump line and used steel pipe, which gave out in one year. We then replaced the steel pipe with some of your pipe and it was still in good condition when, five years later, we abandoned that pipe line.

In the Pocahontas field, where the sulphur is very low, the life of all pipe would, of course, be longer.

Yours truly,

Worth Kilpatrick Prst.



Grove Park Inn, Asheville, N. C.

Absolutely Fireproof — Open All the Year

July 14, 1914.

The A. M. Byers Company,
Pittsburgh, Pa.

Gentlemen:-

In reference to your inquiry as to whether or not we are going to use Byers' pipe in the 100 room extension we are going to build on GROVE PARK INN, and as to whether or not we are fully satisfied with our present installation of your pipe, we can only say that we would not feel safe in even considering anything else.

It may be well to explain to you that all of the steam and cold water lines in the INN are carried in chases embedded in the granite boulder walls, placed there with a view to never having to get at them for repairs or adjustment. We felt therefore, that the only course to pursue was to use a product that had successfully been used through much more severe service than we expected to give it.

In fact, if it had not been possible to secure pipe in which we had as much confidence as yours, we would not have felt safe in placing the majority of our risers where we could not have gotten to them readily.

Of all the Byers' pipe used in GROVE PARK INN, I do not recall that there was a single instance of an imperfect thread, or that we had to throw out a single piece of pipe because of any imperfection.

I do not believe I can say more, except that I want to express our gratitude to you for having produced such a product, and thus relieved us of the anxiety that naturally comes from trouble caused by poor piping.

Yours very respectfully,

E. W. GROVE PARK, INC.

LS-FJB

F. L. Seely V.P.

Grove Park Inn, Asheville, N. C.

Absolutely Fireproof — Open All the Year

July 14, 1914.

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Pittsburgh, Pa.

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It may be well to explain to you that all of the steam and cold water lines in the INN are carried in channels embedded in the granite boulder walls, placed there with a view to never having to get at them for repairs or adjustment. We felt therefore, that the only course to pursue was to use a product that had successfully been through much more severe service than we expected to give it.

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LS-FJB

EDWIN JONES, President ED. H. ZURHORST, Vice President DONALD EDWIN JONES, Secretary A. M. DAVIS, Gen'l Supt

The Crown Pipe and Foundry Co.

MANUFACTURERS OF

THE "CROWN" BRAND

SOIL PIPE AND FITTINGS

ALL CONTRACTS SUBJECT TO UNAVOIDABLE CONDITIONS BEYOND OUR CONTROL. ALL PRICES SUBJECT TO CHANGE WITHOUT NOTICE.

ALL FITTINGS ARE LONG PATTERNS
CAPACITY 80 TONS DAILY

All our Products Made with Re-enforced Hub, from Best Northern Lake and High Silicon Iron, Full Weight, and Tested Fifty Pounds Water Pressure

Jackson, Ohio, May 3" '16.

A. M. Byers Company,

Pittsburgh, Pa.

Gentlemen:-

We sent you an order for some one inch Double extra strong Byers pipe and trust you can give early delivery.

No other pipe gives us the service, and it is so much more economical than steel. During the fifteen years that we have been in business, we have at all times used your product for our core arbors for making pipe. We find that the corrosive action is much less than on steel; it will stand much more repeated straightening without breaking and it will thread far more easily without pulling off the threads. Furthermore, it is much less expensive to drill or perforate the arbors than when they are made of steel and requires less sharpening of bits.

Yours truly,

The Crown Pipe and Foundry Co.

per Edwin Jones

President.

EJ/d

EDWIN JONES, President ED. H. ZUNHORST, Vice President DONALD EDWIN JONES, Secretary A. M. DAVIS, Gen'l Supt.

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per Edwin Jones

President.

EJ/d

P. F. APFEL
PRESIDENT

A. M. STEVENS
SECRETARY

"PAY A GOOD PRICE FOR SOMETHING GOOD"

ELECTRIC SALES CORPORATION

147-148 HENRY BLDG.

LICENSED SELLING AGENTS
UNDER LETTERS PATENT
APFEL'S SYSTEMS
OF
ELECTRIC HEATING

MAIN 7335

SEATTLE, March 29, 1918.

A. M. Byers Co.,
Pittsburgh, Pennsylvania.

Gentlemen:-

As a practical demonstration of the claims made in your advertisement in the Saturday Evening Post of March 30th, the following might be of interest.

For seven years past we have been manufacturing Apfel's "Electric Insert" water heaters. For all but two years of that time we have been using ordinary wrought steel pipe. We had so much difficulty due to the pipes rusting through and water entering the "Insert" and short-circuiting the coil that we were compelled in order to maintain our business to cast about for a better material.

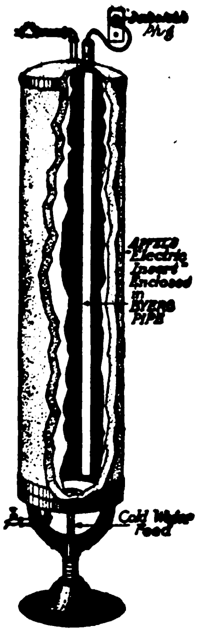
Two years ago we bought a car-load of Byers pipe, and have been using that exclusively since. The use of Byers pipe has eliminated over 93% of the former loss of business and prestige due to the use of ordinary wrought steel pipe. We believe our selling slogan applies to your product as well as to ours--"Pay a good price for something good"

P.F.A./S

Very truly,

P. F. Apfel

ELECTRIC SALES CORPORATION.



GOODS MUST NOT BE RETURNED, AND WILL NOT BE RECEIVED OR CREDITED, UNLESS WE ARE ADVISED PREVIOUSLY; THE REASON STATED AND OUR CONSENT GIVEN

A. M. STEVENS
SECRETARY

P. F. APFEL
PRESIDENT

"PAY A GOOD PRICE FOR SOMETHING GOOD"

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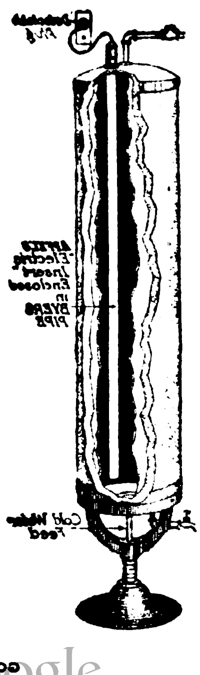

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ESTABLISHED 1864. ADDRESS ALL COMMUNICATIONS TO THE COMPANY BOX I, FROSTBURG, MD. CABLE ADDRESS. GORSUCH-FROSTBURG.

Savage Mountain Fire Brick Company

L. M. GORSUCH WORKS

[CH]ARLES C. GORSUCH, President.
[JO]HN A. CALDWELL, Treasurer.

Frostburg, Maryland U.S.A.

February 1st, 1916.

A. M. Byers Company,

Pittsburgh, Pa.

Gentlemen:-

Attention: Mr. J. E. Stauffer.

We have delayed sending you the sample of Byers pipe we spoke about in order to find out definitely how long your pipe had been in the ground.

The president of the Frostburg Water Company, tells us that this pipe was laid in the summer of 1883. One of our ex-foremen now retired says this date is right.

The pipe on one side had a hot brick yard,.on the other side a freezing street. The street was filled with ashes and the Water Company tells us that is very hard on pipe.

With kind regards, we are

Yours very truly,

SAVAGE MOUNTAIN FIRE BRICK CO.,

Charles C. Gorsuch

CCC/P President.

ESTABLISHED 1884. ADDRESS ALL COMMUNICATIONS TO THE COMPANY BOX I, FROSTBURG, MD. CABLE ADDRESS GORSUCH-FROSTBURG

Savage Mountain Fire Brick Company

L. M. GORSUCH WORKS

CHARLES C. GORSUCH, PRESIDENT.
JOHN A. CALDWELL, TREASURER.

Frostburg, Maryland, U.S.A.

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SAVAGE MOUNTAIN FIRE BRICK CO.,

Charles C. Gorsuch

President.

CCG/P

E.M. WILLOUGHBY. J. E. SWANSON J.A. AINSWORTH

WILLOUGHBY & COMPANY
REAL ESTATE

CENTRAL BUSINESS PROPERTY RENTED AND MANAGED.
7 W. MADISON STREET
S.W. COR. STATE ST.

AGENTS FOR
MASONIC TEMPLE,
COLUMBUS MEMORIAL BLD'G.
CHICAGO SAVINGS BANK BLD'
LYON & HEALY BUILDING
STEGER BUILDING,
WILLOUGHBY BUILDING,
MORTON BUILDING
CABLE BUILDING,
ATHENÆUM BUILDING,
FIRMENICH BUILDING,
WOLFF BUILDING,
JOSEPH E. OTIS ESTATE,
AND OTHER PROPERTIES.

TELEPHONE CENTRAL 418.
PRIVATE EXCHANGE.

CHICAGO,

April 18, 1917.

A. M. Byers Company,

401 McCormick Bldg., City.

Gentlemen:-

Replying to your letter of April 12th regarding some Byers pipe which we removed from Weeghman's Restaurant space in the Masonic Temple Building, would say that we will be very glad to turn this pipe over to you for the purpose you suggest, but in view of the fact that this pipe--in spite of its twenty-eight years of service - is practically as good as new, we shall have to ask you for its equivalent, either in new pipe or the market price of the same, as we consider the pipe fit to put back in service again and would not care to part with it unless it were replaced.

Please advise us if you wish to take it on these terms, and oblige

Yours very truly,

Dict.E.R.W.

Willoughby & Co

E M WILLOUGHBY   J E SWANSON   J.A. AINSWORTH

WILLOUGHBY & COMPANY
REAL ESTATE

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B. MILLER, PRESIDENT — A. S. DAVIS, SECY-TREAS. — ROY D. SCHOOLEY, DIRECTOR OF ICE AMUSEMENTS — JOSEPH N. MACKRELL, PUBLICITY

DUQUESNE GARDEN

LARGEST AND MOST BEAUTIFUL ICE SKATING PALACE IN THE WORLD

DUQUESNE GARDEN AMUSEMENT CO.

PITTSBURGH, PA.

January 27th, 1916.

A. M. Byers Company,

Pittsburgh, Pa.

Gentlemen:

In reply to your inquiry regarding the Byers pipe installed in the Duquesne Garden Ice Skating Rink, would say from our long experience that this is one of the most remarkable pipe installations we have ever known.

Seventeen years ago, 21 miles of Byers 1" pipe was installed on the skating area of the hall. This does not include the headers and brine mains - also Byers.

Ice skating was discontinued in 1908 when a roller skating floor was built, resting on the pipe lines. The physical strain and vibration to which the pipe has been subjected must have been very severe. During this entire period of seven years, the piping, being inaccessible, received absolutely no care or attention.

Before reopening recently as an ice skating rink, much apprehension was felt as to the condition of the piping after so many years of use and abuse. Predictions were freely made that we would not be able to open up this season and that a complete new pipe installation would be required.

We removed the floor, however, and tested the system out carefully with the result that NOT A SINGLE LEAK WAS FOUND AND WE ARE TODAY FREEZING A SKATING SURFACE AS SUCCESSFULLY AS WAS DONE SEVENTEEN YEARS AGO WITH THE SAME PIPING.

The condition of the piping, as revealed by a few lines removed on account of alterations, is very nearly perfect. The amount of corrosion, inside and outside, is negligible.

Yours very truly,

DUQUESNE GARDEN AMUSEMENT CO.

T. V. B. Miller

President.

J. B. MILLER, PRESIDENT
A. S. DAVIS, SECY-TREAS.
ROY D. SCHOOLEY, DIRECTOR OF ICE AMUSEMENTS
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Yours very truly,

DUQUESNE GARDEN AMUSEMENT CO.

President.

C. K. Hoffmeyer
FLORIST
R. Route No. 8, Crafton Branch
Box 56
PITTSBURGH, PA.

March 2nd, 1918.

A. M. Byers Company,

Pittsburgh, Pa.

Gentlemen:-

In answer to your letter of February 27th, 1918, with which you sent me Bulletin No. 30.

I have some A. M. Byers Company pipe which has been in service since 1884 in water and steam lines, and with few exceptions it is still good. Some time ago I got some 500 feet of steel pipe for water lines, which lasted only six years and then was so completely filled with holes as to be beyond repair. I also have several hundred feet of 2" pipe which I got at Reineman's on Troy Hill when they sold out their greenhouse outfit. This pipe was used by them for about ten years; I got it in 1886 and it is still O.K. This pipe, of which I am talking, is in my opinion a little heavier that the pipe of today. All the repairing I have done was to cut a few ends off and to put new couplings on lately.

A. M. Byers pipe can't be beat.

Very respectfully yours,

C K Hoffmeyer

JEREMIAH KIERSTED CADY
ARCHITECT.
170 W. WASHINGTON ST., CHICAGO, ILL.
TELEPHONE MAIN 8724

SUBJECT:

October 27, 1917.

A. M. Byers Company,

Pittsburgh, Pa.

Gentlemen:-

Will you kindly send me your Byers Bulletin No. 30.

I have been preaching for years against the use of steel in any of its attenuated forms - wire, pipe, tin plate, small structural sections, etc., and have never taken any stock in the rust-resisting qualities of steel as proved by accelerated tests. "The proof of the pudding is in the eating."

The iron pipe in this building (the Teutonic) of which I was architect, was installed just 25 years ago, and is still doing service: so far as I know, no repairs whatever have been made to it. Mr. Holt, the Engineer of the building, whom I have just interviewed, has been in charge of the Mechanical plant for 20 years: he stated that in all of that time he has made not to exceed half a dozen repairs to the piping, that all of them were minor, and that in some cases the repairs were to fittings, rather than to pipe.

Has steel any such record? I think not,

Cordially yours,

MILLER LINK-LUMBER COMPANY

MANUFACTURER OF

LONG LEAF YELLOW PINE LUMBER

ANNUAL CAPACITY FIFTY MILLION FEET

L. MILLER, PRESIDENT
OSCAR S. TAM, VICE-PRES. & GEN'L MANAGER
JOE MILLER, VICE PRES. & ASST. GEN'L MANAGER
MAURICE MILLER, SECRETARY-TREASURER

ORANGE, TEXAS December 12th, 1917.

Mr. N. Bowland,
c/o A. M. Byers Company,
Pittsburgh, Pa.

Dear Sir:-

Replying to your letter of the 6th addressed to Mr. L. Miller, wish to advise that we have been using Byers wrought iron pipe in our plant for the past two years. We find it superior to anything that we have ever used, especially in the boiler feed lines. We are troubled a great deal with salt water which is very hard on our steam and water lines.

Prior to our experience with Byers pipe, we were using ordinary steel pipe and the longest service we obtained from it was six months. We have had Byers pipe in some of the same lines for the past two years and it is still in seemingly good condition. While Byers pipe costs a little more than the steel pipe, we have found it to be cheaper in the long run.

Yours very truly,
Miller-Link Lumber Company,

O M Bowen

Superintendent.

MILLER LINK-LUMBER COMPANY

MANUFACTURER OF

LONG LEAF YELLOW PINE LUMBER

ANNUAL CAPACITY FIFTY MILLION FEET

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Yours very truly,

Miller-Link Lumber Company,

Superintendent.

GEORGE LITTLE, PRESIDENT JOHN A. NISBET, VICE PRESIDENT GEORGE F. COOPER, SEC'Y AND TREASURER

The Xenia Water Company

No. 26 East Market Street

Xenia, Ohio. Oct.18th.,1913

Mr. A. M. Byers & Co.

Pittsburgh, Pa.,

Gentlemen:- We have been useing your pipe for a good many years and in the future will never use any other kind. Twenty six years ago we laid your iron pipe on a street here in Xenia, and have never had a leak in it so far. Five years ago we laid some two inch steel pipe near this iron pipe and this summer we had three leaks on this line. For a number of years we always called for iron pipe but in the last few years some steel pipe was shipped to us in place of iron pipe. Steel pipe is entirely too hard and brittle and you cannot cut a good thread or make as good a joint. In the future we will use extra heavy Byers pipe for sizes up to, and including two inch.

Very truly yours,

H/D The Xenia Water Co.

George F. Cooper
Sec.

THE OSTERRIED COAL COMPANY.

PRODUCERS AND SHIPPERS OF

BITUMINOUS, STEAM AND DOMESTIC COAL

MINES
TIMORE & OHIO RAILWAY

MAIL ADDRESS LUCINDA, PENN'A. June 28th, 1915.

A. M. Byers Company,

Pittsburgh, Pa.

Gentlemen:

On account of illness of writer, your letter of April 24th lay unanswered.

In reply would state, as in my former letter, that I have used your pipe for extra hard service in mines where the percentage of sulphur runs very high, and my experience has proven that your wrought iron pipe gives more service, extra cost considered, than any steel pipe we could buy.

For my personal use I have taken up a gas line, lying on the surface of the ground, that had been in use fourteen (14) years; part of this line was of your wrought iron pipe, the balance steel pipe of one inch sise. The iron pipe was practically as good as new. I have used it in relaying a new line. The other pipe was corroded so badly that I was obliged to replace it with new pipe.

I would unreservedly recommend your wrought iron pipe for use in mines or anywhere else for hard service, also for tight joints possible with tapered threads.

Yours truly,

J. A. Schill

THE OS[illegible] COAL COMPANY.

PRODUCERS AND SHIPPERS OF

BITUMINOUS, STEAM AND DOMESTIC COAL

MINE [illegible]

[illegible]MORE & OHIO RAILWAY

[illegible], PENNA., [illegible], 1916.

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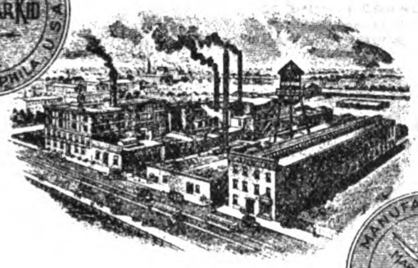
Yours truly,

CODES USED.
LIEBERS-A B C. 5TH EDITION

CABLE ADDRESS:
"CASTLEKID" Camden



CASTLE KID CO.

MANUFACTURERS OF
LEATHER
1516 BROADWAY
CAMDEN, N.J.

FACTORY AT CAMDEN, N.J.

PHILADELPHIA SALESROOM
56 No. FOURTH STREET

Aug. 14, 1913.

John Maneely, Inc.
309 Arch St., Phila.

Gentlemen:-

We desire to state that we consider Byers wrought iron pipe the best for tannery purposes of any of the different makes which we have tried. As you are no doubt aware, conditions in a tannery are such that it takes a good article to give even reasonable service. We have found that we get on an average at least twice the time service from Byers pipe that we do from any other which we have tried. We are now specifying this pipe in all construction and replacement work, and are glad to give this brand our unqualified endorsement.

Yours very truly,

CASTLE KID CO.
ASST. SEC.

MSC/CFS

John Maneely, Inc.

303 Arch St., Phila.

Gentlemen:-

We desire to state that we [illegible] pipe the best for tannery purposes of any of the [illegible] which we have tried. As you are no doubt aware, conditions in a tannery are such that it takes a good article to give [illegible] sonable service. We have found that we get on an average [illegible] twice the time service from Byers pipe that we do from any other which we have tried. We are now specifying this pipe for all construction and replacement work, and are glad to give this [illegible] our unqualified endorsement.

[illegible]

MSC/CIS

THE BROWNING COMPANY

LOCOMOTIVE CRANES
LIFTING MAGNETS
CLAM SHELL BUCKETS

BROWNING LOCOMOTIVE CRANES

REVOLVING SHOVELS
WRECKING CRANES
RAILROAD DITCHERS

CLEVELAND, OHIO

April 25, 1916

Standard Mfg. Company,

Cleveland, Ohio.

<u>ATTENTION MR. POPE</u>

Gentlemen:-

We have been using exclusively for the last four or five years, "Byers" Genuine full weight guaranteed wrought iron pipe, on our locomotive cranes.

This is most satisfactory, on account of our being compelled to furnish short lengths, which necessitates considerable cutting and threading. The pipe cuts freely and never opens up, which is very advantageous. This of course costs a trifle more than steel pipe, but effects a saving in the end.

Yours very truly,

THE BROWNING COMPANY,

G. T. Stalley

GTS/FHK

Gen. Works Manager.

THE BROWNING COMPANY

LOCOMOTIVE CRANES
LIFTING MAGNETS
CLAM SHELL BUCKETS

CLEVELAND, OHIO

April 25, 1913

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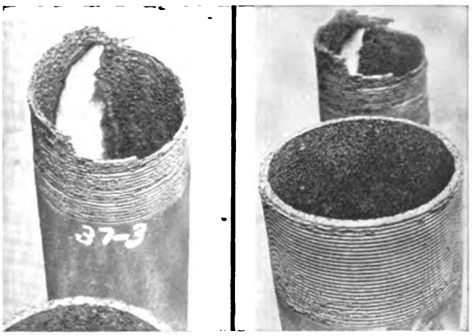
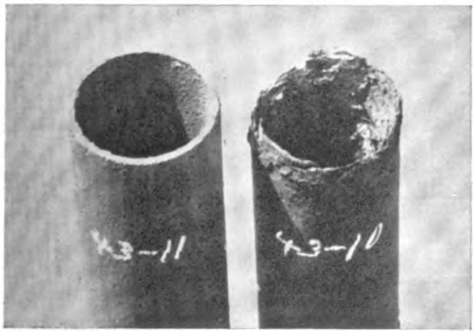
Gen. Works Manager.

GTS/FHK

Lafayette and Cambridge Apartments, McKee Place, Pittsburgh, Pa., erected 1902. Wrought iron pipe in hot water mains had a life of 14 years in these apartments—twice the average life of steel pipe in the same service. Byers Bulletin No 30, containing the results of an investigation conducted to determine the relative life of iron and steel pipe in hot and cold water lines in buildings, will be sent on request.



Two vent pipes side by side on roof of Home Life Bldg., New York City, installed 1905. The badly corroded pipe is galvanized steel. The good pipe is wrought iron. The bright spot on the steel pipe is all there was left of the galvanizing in 1918.



Left pipe wrought iron, right pipe steel, as seen side by side on roof of Langdon Bldg., New York City. Both installed 1893, in drainage system.

Hundreds of records similar to this one and the one above will be shown in Byers Bulletin No. 32, devoted to an investigation of drainage systems.

John Sharp, Wh. Sch., M. I. Mech. E., author of "Modern Foundry Practice" in a paper entitled "Some Considerations Regarding Cast Iron and Steel Pipes" says:

"The success of steel, however, has sometimes led to its introduction and departures from well established and successful practice, without a due regard to the particular working conditions under which it was employed. The result of this at times has been more or less unsatisfactory; in this respect the employment of steel in the construction of underground pipes and conduits has in some examples been equally disappointing."

"With the introduction of steel in the construction of ships, it was soon observed that the corrosive action of steel plates, etc., was a much more serious matter than formerly experienced when the constructural material was wrought iron throughout."

Albert A. Cary, Consulting Engineer, of New York City, Member of The American Society of Heating and Ventilating Engineers, in a paper read before the 1916 meeting of that Society made the following statements:

"In the late eighties I was called upon to remove an old wooden flooring in the large basement of a factory in this city in order to prepare it for the installation of some new machinery. About thirty years before, this factory had been used as a tannery and leather manufactory. I found the old tanks in this basement and a system of piping connecting them which had been buried in the floor for all these years. I was surprised to find the pipe in such excellent condition and after taking it out, I had it cleaned and after rethreading the ends of the pipe I used much of it again in another underground position. I found it to be genuine wrought iron pipe. Steel pipes, which had been in service for about five years, buried below the same floor, were found to be in such corroded condition that I threw them into the scrap. This was one of my early lessons as to the superiority of wrought iron pipe as compared with steel pipe.

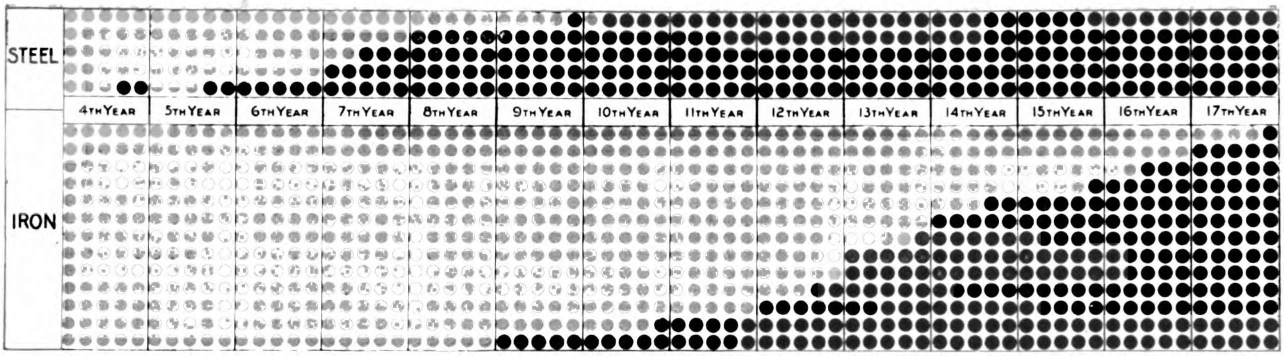
When in the boiler business a number of years ago, the concern with whom I was connected was called upon to furnish water tube boilers for a plant near this city. Charcoal iron tubes were specified and used in these boilers. After this plant had been in operation about two years, the company failed and the plant was shut down. The water used in these boilers deposited scale rapidly in the tubes and, in consequence, a number were burned out and removed. They were replaced by a local boiler maker with steel tubes bought in the open market. About two years after the plant stopped operation, the grates were removed. I was surprised to find so many tubes black and in good condition. The steel tubes which had been put in by the plant owner were all covered with rust and I had no difficulty in recognizing them.

The fibrous wrought iron of a desirable quality with a fraction of one per cent of contained carbon and with a small percentage of slag distributed well through its mass has proved itself, when formed into pipes, to resist corrosion when placed in the most trying damp positions for many years.

Those who for many years have been struggling with the crystalline, slag free steel have been trying to produce something "*just as good*" and they are apparently still at it."

W. W. Hanscom, Electrical and Mechanical Engineer, San Francisco, says:

"About ten years ago, having need of a short piece of pipe to complete connections to an instantaneous water heater, I used some iron pipe that had been in service for over twenty years in my old home, brought with me when I moved, and put away for emergency use. The old pipe is still in service while some steel pipe connected in the same run has been renewed twice and shows signs of needing renewal the third time."



Blue Dots, installations in *service*. Black Dots, installations *replaced* on account of failure. Years are figured from date of first or original pipe installation. The chart starts with the fourth year as no failures occurred during the first three years.

DOT CHART SHOWING RELATIVE LIFE OF IRON AND STEEL PIPE IN HOT WATER MAINS

The rapid rusting of water pipes, especially those carrying hot water, in the Pittsburgh district, has frequently been commented on in the daily press and the subject was, in the beginning of 1917, taken up for discussion and investigation by the Pittsburgh Board of Trade. So far, no systematic investigation had, however, been made by a house-to-house canvass of buildings to ascertain the difference in life between different kinds of pipe, and the A. M. Byers Company therefore arranged for such an investigation with a view to ascertaining all the pertinent facts which might aid property owners in meeting the rust question in the most efficient manner.

After several unsuccessful attempts to obtain accurate data from private residences and other buildings, it appeared for many reasons that apartment buildings offered the best field for investigation. First of all, the investigation could be made to cover the entire field and still be held within reasonable limits, as the number of apartment buildings in Pittsburgh is comparatively limited.

Only buildings erected within the last few years were omitted insofar as it was impossible to form any accurate estimate of the life of the piping in same; also, buildings where accurate data could not be obtained as to amount of repairs made in previous years, kind of pipe originally used, age of building, etc.

From the tabulated records compiled during this investigation and set forth in Bulletin No. 30, (which will be sent on request) the chart shown above has been worked up in order to show as graphically as possible exactly when each steel and each iron installation of hot water mains failed.

There are 65 dots in the wrought iron yearly division, and in the steel division 25 dots, each representing one installation. The discrepancy in these numbers is not accidental nor arbitrary, for the figures represent the total number of buildings investigated, (not including those equipped with brass pipe) showing that genuine wrought iron pipe is in much more general use than steel pipe in Pittsburgh buildings. This chart graphically illustrates the fate of each installation—it shows that out of 25 steel installations two failed in the fourth year, three more in the sixth year, eight more in the seventh year, and so on. Only one steel installation lasted as long as ten years, while the first five failures of wrought iron did not occur until the 9th year. Note also that 84% of the steel installations had been replaced when the first wrought iron failures occurred, and after 18 years one wrought iron installation still remained in service.

By comparing the longest lived steel installations with the shortest lived iron installations, it is easy to see the foundation for the claim that steel pipe lasts as long as iron pipe. Unfortunately, many of the claims made for steel pipe, accompanied by a great display of apparently scientific detail, rest on an even flimsier foundation, for there is no test as good as the test of time and actual service.

Using a similar line of reasoning, we might point to the fact that certain steel installations lasted only 4 years and certain iron installations from 16 to 18 years, outlasting steel from 4 to 5 times. Likewise we might even undertake to claim—and with considerable good evidence to back this claim—that extra heavy iron pipe lasts longer than brass pipe.

All of which argues for the advisability of discounting all corrosion evidence that does not rest on the law of averages, especially if it conflicts with common experience.

WHAT IS WROUGHT IRON?

Wrought iron is a composite material of almost pure iron mixed with about six per cent by volume of slag. This slag is silicate of iron, which is one of the products of the hand-puddling process employed in the refining of all Byers iron. During the rolling processes, the slag becomes elongated into long fine bands of fibres.

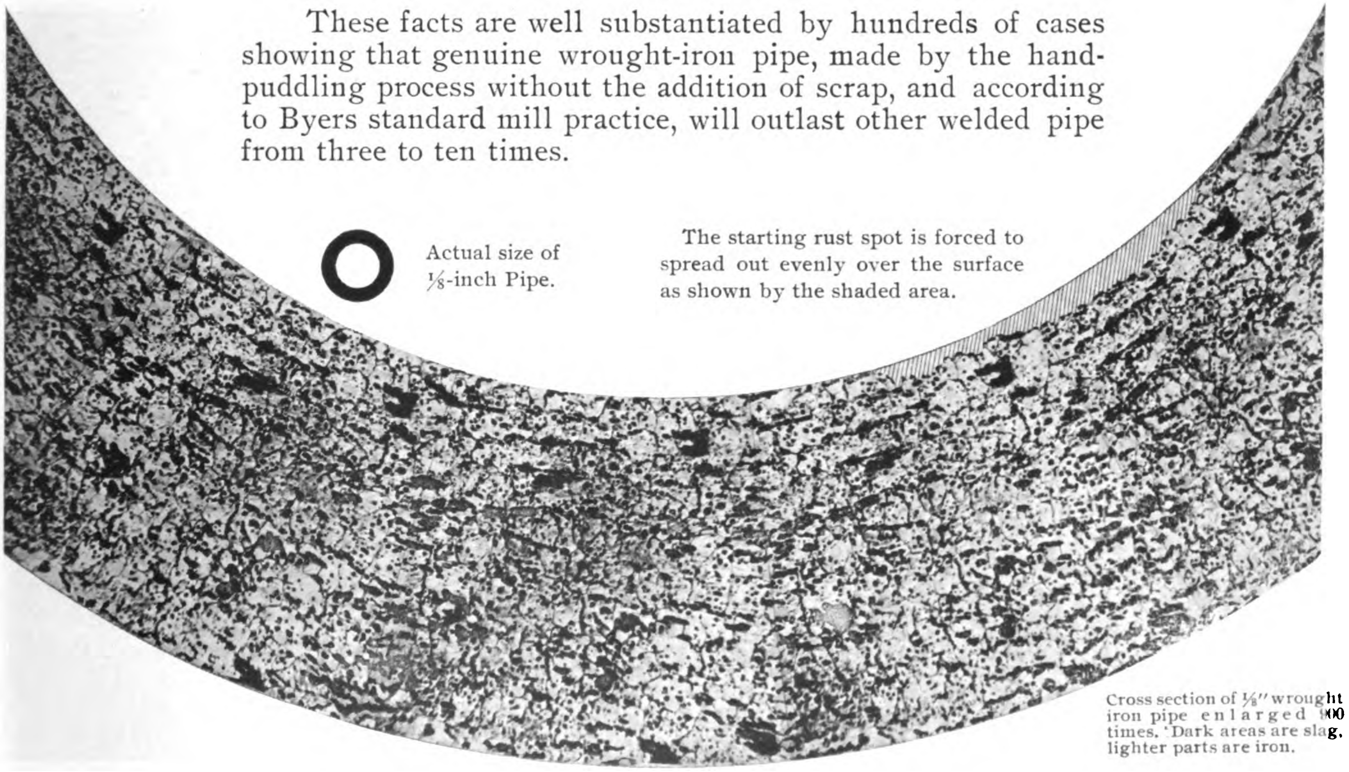
These slag fibres are finely distributed throughout the iron, and while each individual fibre is infinitesimal, the total exceeds 250,000 to the square inch, forming about 6% of the volume. These create an almost impenetrable barrier against attacks of corrosive agents.

This is the secret of the well-known durability of Byers wrought-iron pipe; when corrosion starts, its progress is obstructed by the non-corrodible slag. Instead of proceeding unhindered through the wall of metal, producing a pit, the starting rust spot is forced to spread out evenly over the surface, as shown by the shaded area in the illustration below. As corrosion advances, more and more slag is exposed to obstruct its progress, and the length of the path which it must follow is increased by the zig-zag character of the obstructed course.

In comparison, pig-iron, the most impure of the ferrous metals, possesses a somewhat similar protection in its graphite flakes, but at the same time they make the metal physically weak.

Soft steel, used in pipe manufacturing, possesses neither the slag of wrought-iron nor the graphite protection of pig-iron. On the other hand, pipe steel has a high manganese content, and much combined carbon in the form of pearlite, a combination furnishing all the necessary elements to assist the rapid progress of corrosion.

These facts are well substantiated by hundreds of cases showing that genuine wrought-iron pipe, made by the hand-puddling process without the addition of scrap, and according to Byers standard mill practice, will outlast other welded pipe from three to ten times.



Cross section of 1/8" wrought iron pipe enlarged 100 times. Dark areas are slag, lighter parts are iron.

HOW TO TELL THE DIFFERENCE BETWEEN IRON AND STEEL PIPE

There are about eight different ways to determine whether pipe is iron or steel. The four easiest ways are explained below. Tests 1, 2 and 3 can be applied to either new or old pipe. Identification by name rolled in the pipe is applicable only to pipe made within the last 15 or 16 years. More detailed information on this subject will be found in Bulletin No. 41 which will be sent on request.

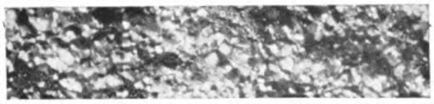
1. FRACTURE TEST

The fracture of genuine wrought iron pipe appears *ragged*, *dull gray* and *fibrous*. The fiber is

Iron Fracture—Dull, Gray and Fibrous.

particularly distinct when compared with a steel fracture. A fracture is easily obtained by hammering a short piece of pipe, as shown in the illustration at the right under "Galvanizing Test."

The fracture of steel is *even*, *bright* and *crystalline*, which, when exposed to the air, soon loses its luster. Moreover, steel pipe shows a tendency

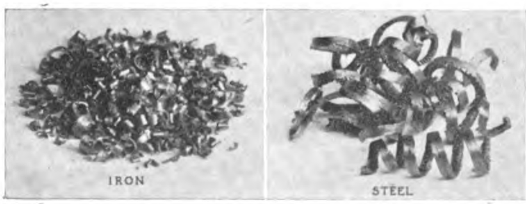


Steel Fracture—Even, Bright and Crystalline.

to fracture at the weld, and here the metal presents a smooth, dull gray appearance, which should not be confused with the rough, fibrous fracture of wrought iron.

2. THREADING TEST

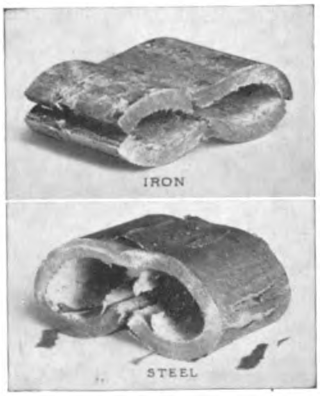
When wrought iron pipe is threaded, its fibrous structure causes the chip to *break and crumble* as when dressing the end of a piece of wood. (This prevents clogging of the die space and reduces friction. A clean accurate thread results.)



With steel, owing to the absence of fiber, the chip tends to curl up, forming *a long*, *more or less perfect spiral*, beautiful to look at but an obstacle to easy threading, for it increases friction and causes clogging of the chip space.

3. GALVANIZING TEST

Hammer a piece of galvanized pipe repeatedly to flatten it. If the zinc coating adheres firmly to the pipe, showing little effect of the hammering or flattening, it is wrought iron pipe. If, on the other hand, the zinc begins to scale off at almost the first stroke of the hammer, the pipe is steel. Repeated blows will cause the galvanizing to come off in large flakes, leaving the steel almost bare in spots. This is virtually what happens during handling, cutting, bending and threading steel pipe and in the course of years of service.



Hammer a piece of Byers pipe and note the tenacity of the coating on the iron. You may fracture the pipe, and the galvanizing will fracture with it, without cracking and scaling off at the edge of the fracture.

4. ROLL MARKS ON PIPE

All pipe bearing the Byers Name and Year of Manufacture rolled into the metal in raised letters is genuine wrought iron. The Year of Manufacture

Look for the NAME and YEAR on Every Length.

rolled in the metal is a guarantee of the lasting qualities of Byers pipe. It facilitates future observation as to the number of years the pipe has been in service. Watch and compare it with the service given by other welded pipe.

BYERS PIPE

GENUINE WROUGHT IRON
FULL WEIGHT GUARANTEED

Main Office and Plant :
PITTSBURGH, PA.

Sales Offices :
New York Boston Cleveland Chicago Dallas

BULLETIN No. 30

Third Edition, OCTOBER, 1919

An Investigation of Pipe Corrosion

Showing service records of iron, steel and brass pipe used for hot and cold water supply lines in 129 Pittsburgh Apartment Buildings

By THOMAS F. PAYNE

Sanitary Engineer, formerly Instructor in Plumbing, Carnegie Institute of Technology and Superintendent Specialty Department, Standard Sanitary Manufacturing Co.

FOREWORD

This report is published as being of general interest to architects, engineers and builders, not only in Pittsburgh where the investigation was conducted, but in many other important cities where the domestic water supply is of the same general character, being taken from nearby streams or lakes. This similarity exists in practically all the larger cities of the Atlantic Coast States, in the South, Southwest, Middle West and even in the Mountain and Pacific Coast States.

Analyses of tap water in Pittsburgh and a few other cities are given on page 19 for the guidance of those who wish to make a comparison with tap water in their own localities.

Since the publication of the first edition of this bulletin, we have been asked if there is any explanation of the fact that iron pipe does not give up its rust as easily as steel, as mentioned under heading "Rusty Water" on page 7. We frankly confess that we do not know, any more than we know why cast iron, zinc, brass and other metals form rust or oxides of a more or less adhesive, impervious character. As in these cases, the mere knowledge of the fact is of paramount value to the practical man.

It is possible that the network of infinitesimal, non-corrodible slag fibers contained in wrought iron (but not in steel) tend to enmesh the slowly forming rust, preventing it from being loosened from the iron by the flow of water.

A. M. BYERS COMPANY.

PITTSBURGH, OCTOBER, 1919.

PURPOSE OF THE INVESTIGATION

The rapid rusting of water pipes, especially those carrying hot water, in the Pittsburgh District, has frequently been commented on in the daily press and the subject was, in the beginning of 1917, taken up for discussion and investigation by the Pittsburgh Board of Trade. In this respect, Pittsburgh is no different from many other large cities in the United States, where similar complaints are common. So far, no systematic investigation had, however, been made by a house-to-house canvass of buildings to ascertain the difference in life between the different kinds of pipe. The A. M. Byers Company therefore arranged for such an investigation with the view to ascertain all the pertinent facts which might aid property owners in meeting and overcoming the rust difficulty in the most efficient manner.

(Whenever Iron or Steel Pipe is referred to in this Report, Galvanized Pipe is meant.)

BOARD OF TRADE INVESTIGATION

In the local agitation which preceded the Board of Trade investigation, it was charged that chemicals which destroyed the pipes were used at the filtration plants. A thorough investigation of the filtration system was therefore made by a "Committee on City Water," appointed by the Pittsburgh Board of Trade, and a report was rendered embodying a discussion prepared by Chas. A. Finley, Managing Engineer, Bureau of Water, which clearly showed that no chemicals were used in the filtration plants which could in any way be responsible for the trouble.

The following thought is expressed in the concluding paragraphs of the Report:

> **"The fact that there is more or less inferior pipe in service which does not meet requirements is to be deplored, but should not be charged to the character of the water, nor should the preservation of this piping be accomplished by means of costly, highly complicated and objectionable treatments at the public expense."**

DIFFERENCE IN RUST RESISTANCE OF IRON, STEEL AND BRASS

The corrosive effects of Pittsburgh water have always been recognized, even long before the filtration plant was completed. This is borne out by the fact that brass pipe has here, as elsewhere, been used to a considerable extent instead of lead or wrought iron, for both hot and cold water supply. This custom, to judge by the evidence collected, seems to have little in its favor, being in most cases decidedly expensive, as the excessively high cost of this material has proved out of all proportion to its life in service. The failure of brass pipe was, in fact, made the subject of special mention and comment in the Report of the "Committee on City Water."

Men interested in the Board of Trade inquiry were of the impression that galvanized hot water pipes of iron and steel only lasted from four to five years, and that there apparently was no difference between the two metals. They frankly admitted, however, that this was only an impression and that they would like to obtain more definite data on the subject.

Manufacturers of steel pipe energetically opposed the idea that there was any difference in the lasting quality of iron and steel pipe respectively, and put the whole blame on the service conditions, contending that where conditions were equal, one kind of pipe would last as long as another.

CLASS OF BUILDINGS INVESTIGATED

After several unsuccessful attempts to obtain accurate data from private residences and other buildings, it appeared for many reasons that apartment buildings offered the best field for investigation. First of all, the investigation could be made to cover the entire field and still be held within reasonable limits, as the number of apartment buildings in Pittsburgh is comparatively limited. Thus, while the 125 or more apartment buildings recorded herein do not include all the apartment buildings in Pittsburgh, they do represent the majority.

Buildings erected within the last few years have been omitted, as it was impossible to form any accurate estimate of the future life of the piping; also buildings where accurate data could not be obtained as to amount of repairs made in previous years, kind of pipe originally used, age of building, etc. Only in a few instances did the proprietor decline to give any information or to permit inspection of the piping. In a single case, that of a very large modern apartment building, erected in 1912 and equipped with steel pipe which was reported to be causing much trouble, the owner absolutely refused to give any information, evidently fearing the loss of prospective tenants who might be informed that the pipes in the apartments were giving out and causing inconvenience to occupants.

D'Arlington Apartments, erected 1909, equipped with brass pipe. The hot water lines are badly corroded and pitted after 8 years' service. Record No. 7, Brass Installations, page 13.

DIFFERENCE IN SERVICE CONDITIONS

It is true that conditions of service vary to a great extent, according to the size of pipe, its thickness, the quantity and temperature of water used, etc. There is even a difference in corrosive effects between piping in different parts of the same building, it being conclusively shown in hot water systems that—

1. The corrosion in hot water lines gradually decreases with the distance from the boiler.
2. The corrosion is more severe in mains or horizontal lines than in vertical lines conveying either hot or cold water.

Furthermore, there may be more corrosion in buildings in one locality than in another, due possibly to more air entering with the water into service pipes in buildings located near the filtration plants or pumping stations.

These differences, however, present no insurmountable obstacle to a fair comparison of the service given by different kinds of pipe in different buildings, and in this investigation careful note was made in every case of the various factors which might accelerate or retard corrosion, these factors all being taken into account in connection with the tabulated records.

Altogether, these records show a remarkable similarity of performance of each of the different kinds of pipe used in various buildings, so much so that the average life of iron, steel, or brass pipe respectively, in the first ten or twenty buildings investigated, coincides almost exactly with the average for the entire number of buildings investigated, leading to some exceedingly important conclusions regarding the choice of materials for plumbing pipes. *Under the most severe service conditions, in a total of over 125 buildings, genuine wrought iron pipe proved to have double the life of soft steel or "wrought pipe," and brass proved to be only slightly better than wrought iron and certainly not enough better to warrant the many times greater first cost.*

The service conditions in the apartment buildings investigated were found to be the same in the following respects:

1. City water used in all.
2. Closed system used in all.
3. Ordinary gas heater and hot water boiler or storage tank used in every case, except where otherwise mentioned.
4. The temperature of hot water supplied was generally about the same, and certainly averaged fairly well among the large number of buildings investigated.
5. The one-pipe system was in most cases used for hot water.
6. All iron and steel pipe was standard weight, galvanized, no exceptions being known.
7. All joints were of the standard screw type, Briggs American Standard.

The possible points of difference are as follows:

1. Proximity to Pumping Station

The piping in buildings close to some pumping station is probably subject to more severe corrosion on account of the larger amount of free oxygen in the water. (Note is made of cases of close proximity in the tabulations which follow.)

2. Location and Kind of Service

In making this investigation, a distinction was made between hot water mains in the basement and hot water risers. The corrosion of these parts of the system was recorded separately, so as to facilitate

Lafayette and Cambridge Apartments, McKee Place, erected 1902, equipped with wrought iron pipe. Most of the hot water mains were replaced in 1917, after 14 years' service. Record No. 42, Wrought Iron Installations, page 17.

The Howe and Kent Apartments, erected 1907. The hot water mains are of brass and already show pitting. See records on brass piping, page 14.

comparisons between the different buildings on an equal basis.

3. Size of Apartment House

The quantity of water flowing through pipes will, to a certain extent, influence corrosion, for the larger the quantity, the more abundant will be the amount of oxygen available for oxidation or corrosion. It might, therefore, be assumed that corrosion will vary to a great extent according to the size of the apartment building, and a record was therefore made of the number of apartments in each building. Some apartment buildings had two or three separate hot water systems, each system usually supplying a group of six individual apartments. Each of these groups was investigated and recorded separately as, for the purposes of this investigation, they must be regarded as separate and distinct buildings.

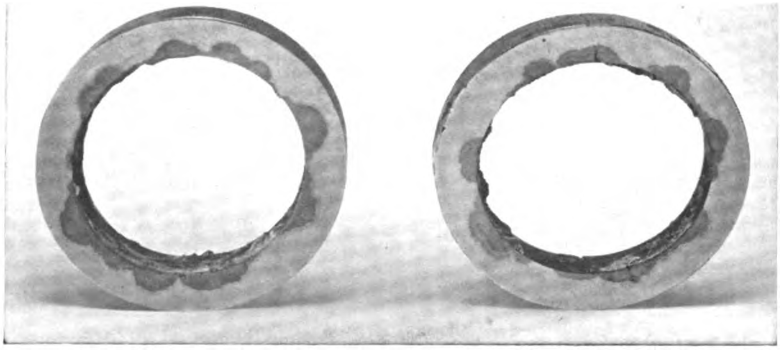
Contrary to expectation, however, it was found that the *life of the pipes was on an average no shorter in the larger buildings than in the smaller ones*, this being undoubtedly due to the fact that the sizes of the pipes are proportioned to the requirements, the largest buildings having the largest mains, which have heavier walls than smaller sizes of pipe and therefore afford a greater resistance to corrosion. In fact, the smaller sizes of pipe usually were found to be the first to give trouble in any part of a system where the conditions were otherwise equal. In addition, it should be noted that the range of sizes used was very small, between ¾" to 1¼".

St. Regis, Chesapeake, and Chamberlin Apartments, erected 1908. Equipped with steel pipe. Most of the hot water mains have already been replaced. See records Nos. 17, 18 and 19, page 15.

Negley Apartments, erected 1909. Hot water mains of steel, largely replaced between 1911 and 1914. Trouble with rusty water. See record No. 1, page 15.

Kennett Apartments, erected 1902, equipped with brass pipe. Record No. 4, page 13. Typical of most apartments equipped with brass pipe, the hot water mains being badly corroded after 10 to 15 years' service.

The Lexington, Argyle, and Drexel Apartments, erected 1909. Equipped with steel pipe. Life of hot water mains, 7 or 8 years. See records Nos. 13, 14 and 15, page 15.



Typical condition of pitted brass pipe after 10 years service in hot water mains.

SUMMARY OF DATA

Accurate information as to the maximum life of the pipe used for hot and cold water supply, was only obtainable for that part of the hot water system consisting of the basement mains, for these were in most cases found to be rusted out and replaced within twenty years or less. In many buildings only a part of the mains had been replaced; an estimate was then made of the life of those remaining, and the life was finally fixed as lying about midway between the shortest lived and the longest lived parts thereof. The estimates in no case cover more than a very limited range; therefore any error contained in the estimates, wherever made, cannot under any circumstances amount to more than one or two years. An examination of the column "Remarks", in the tabulations following, will make this clear. In the case of steel pipe, where any doubt existed, the estimate was purposely made high, so that no unfairness could be charged.

LIFE OF WROUGHT IRON AND STEEL PIPE

Hot Water Mains

The average life of galvanized wrought iron and steel hot water mains follows:

1. Wrought iron, 14 years
2. Steel, 7 years

These averages are based on the figures from 67 buildings equipped with wrought iron pipe and 28 buildings equipped with steel pipe.

That this ratio of 2 to 1 in favor of wrought iron is very conservative, is strongly indicated by the records of buildings Nos. 17, 18 and 52 in the table for wrought iron, pages 17-18. In these cases, iron pipe, after 16 and 11 years' service respectively, was replaced with steel which lasted only 2 and 4½ years respectively, giving a ratio of 4 to 1 in favor of wrought iron.

Hot Water Risers—Iron.

The life of the risers is more difficult to estimate, but judging from their general condition as far as it was possible to do so, and the very small amount of repairs that had been required after 10 to 18 years' service, it is reasonable to assume that they will in most cases last three times longer than the hot water mains. If pipe one size larger than that required in ordinary practice were used, the life would probably be 4 times longer.

Hot Water Risers—Steel.

The life of steel risers appears problematical, for none of the buildings equipped with steel pipe was over 12 years old, and most of them less than 10. It is safe to say, however, that the life of steel risers will bear about the same ratio to wrought iron risers as indicated by the life of the mains, namely, one to two in favor of wrought iron, which means that steel risers would have to be replaced some time during the useful life of the average building, probably within 20 years.

RUSTY WATER

A very important fact was unexpectedly developed during this investigation. Many complaints have been made on account of rusty water staining bath tubs, lavatories, sinks and other plumbing fixtures; also staining linen and apparel to such an extent that no amount of subsequent washing in rust-free water would restore the original color of the fabrics.

Not a single instance of rusty water was found where wrought iron pipe was installed, even where the pipe itself was rusted out and needed replacing.

On the other hand, in practically every building where steel pipe was used, the rusty water commenced to appear after three or four years' service. In several instances, filters had been installed in the belief that they would remedy the trouble. These filters were placed near the boiler in the basement, and only filtered the rust coming from the boiler and the short piece of pipe between the boiler and the filter and, therefore, only partly eliminated the trouble. The expense of installing and maintaining these filters would have been more than sufficient to pay for the extra cost of wrought iron pipe in the first place, obtaining for the owner pipe of double the life.

LIFE OF BRASS PIPE

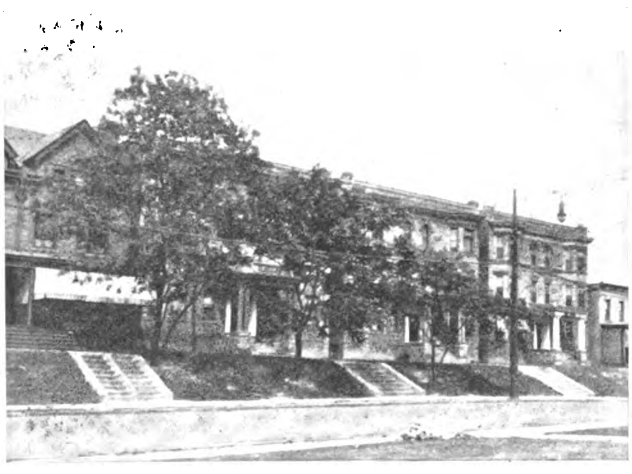
Hot Water Lines

The life of brass can only be estimated, as corrosion of brass does not, as a rule, result directly in leaks, but causes the pipe to become so fragile that it breaks when a wrench is applied or when it is subjected to shocks, expansion, or high water pressure. *The piping in most of the 34 apartments investigated which were piped with brass began to show signs of corrosion within 6 to 8 years and was very badly pitted after 10 to 15 years.* When repairs or alterations had to be made, the pipe would break at the threads when turned with a wrench, and keep on breaking, resulting in heavy replacement expense. The expansion of the pipe also caused it to break at the joints between the risers and the branch lines from fixtures located up through the building where the pipe is concealed in the wall, causing unusually costly repairs.

Cold Water Lines

No trouble was experienced with either iron or brass when used for cold water lines, and as the record of brass in this case, as well as for hot water lines, so closely coincides with that of wrought iron, it is difficult to see why the latter, in view of its first cost, which is from five to ten times lower than that of brass, should not be the more economical in service. In fact, there appears to be no good reason for the use of brass pipe even for hot water risers, and certainly much less for cold water lines.

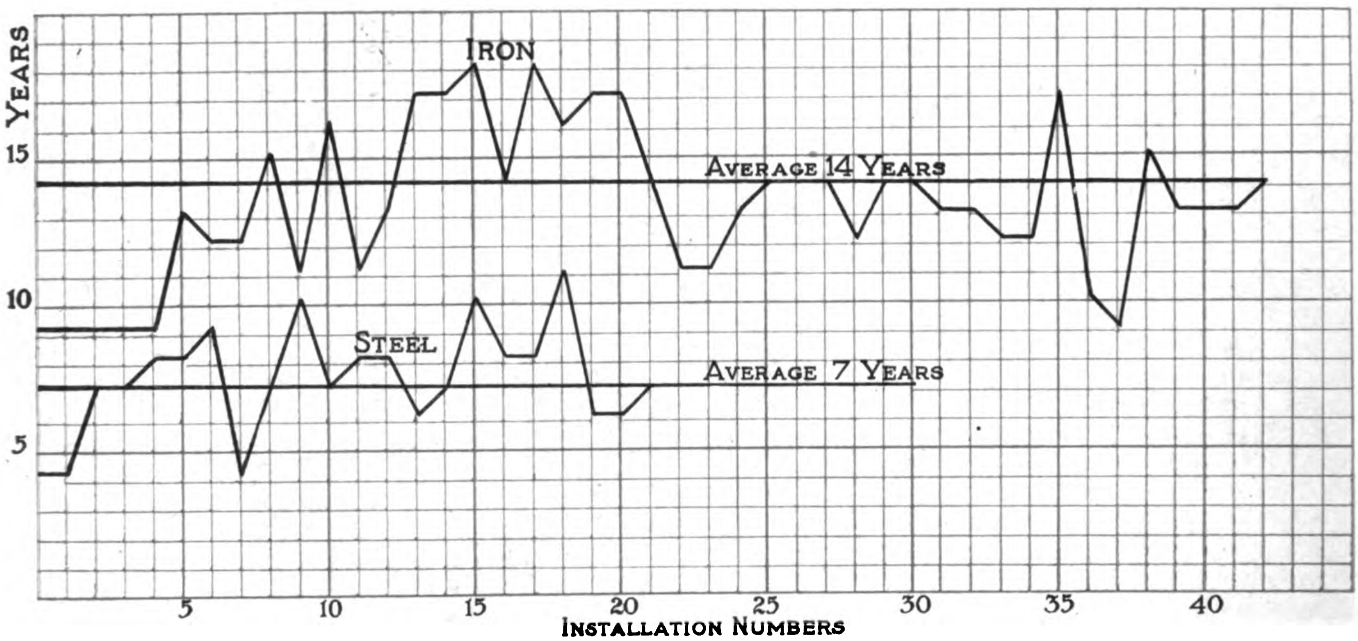
Oakland Apartments, Halket and Forbes Streets, erected in 1902, and equipped with wrought iron pipe, all of which is still in good condition, excepting the hot water mains which now need replacement after 15 years' service. See record No. 55, Wrought Iron Installations, page 18.



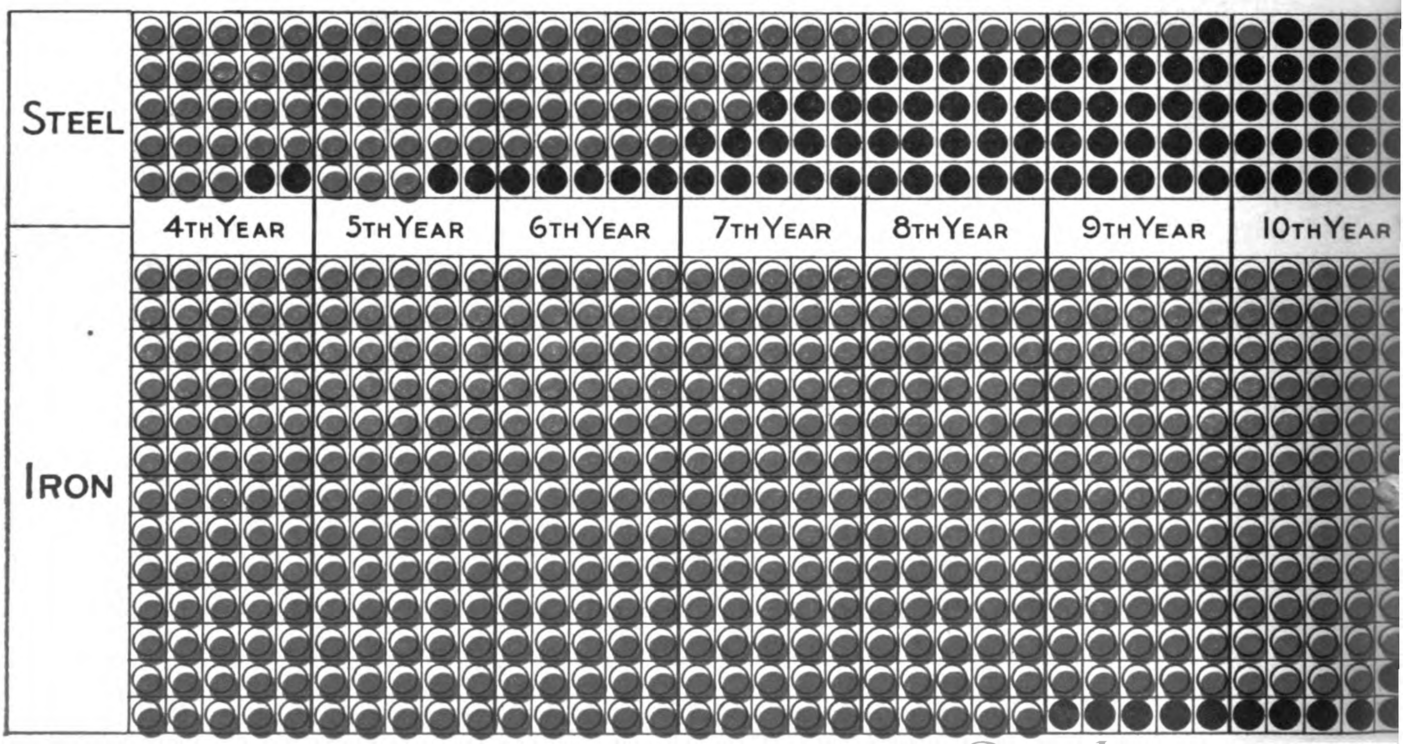
Yellow Brick Apartments, erected 1902. Equipped with wrought iron pipe. Hot water mains needing replacement after 14 years' service, See records Nos. 43 and 44, page 17.

That years ago brass pipe came into use at all for water supply undoubtedly was due to a belief that it was practically everlasting. Since this belief has not been substantiated by experience, and since genuine wrought iron pipe has been proved to last as long as the average building (except for hot water mains), the use of brass pipe is rapidly being abandoned by thoughtful architects and builders, for the difference in cost between the two materials is so great that wrought iron pipe could be replaced several times during the life of the building at a total cost not exceeding the first investment in the brass pipe installation, plus interest. No such replacement need, however, be looked for, except

CURVE SHOWING LIFE OF IRON AND STEEL PIPE



The curve above illustrates the life of hot water *mains* (exposed basement piping) in the 90 buildings which were equipped with iron and steel pipe. The "Installation Numbers" correspond with the individual record numbers shown in tabulations on pages 12 to 15 inclusive. The hot water *risers* are subject to much less corrosion, lasting so long that no definite idea can, for some years yet, be formed as to their average life. The significance of the data lies in the *ratio of life* established between iron and steel pipe,—namely, *2 to 1 in favor of genuine wrought iron.*



DOT CHART

LEGEND:—Green Dots—installations in *service*.
Black Dots—installations *replaced* on account of failure.
Years are figured from date of first or original pipe installation.
No failures occurred in the first 3 years after installation and the chart therefore starts with the 4th year.

DOT CHART

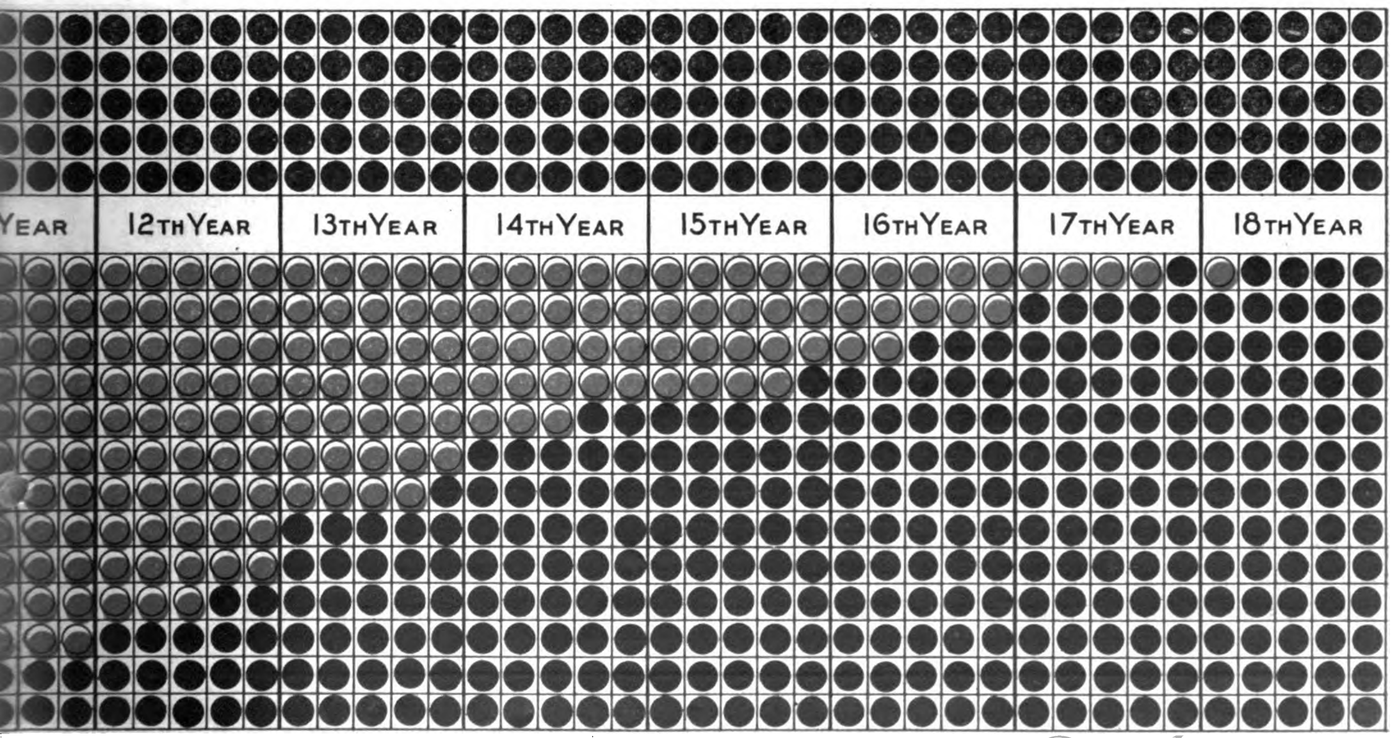
(Each dot represents one installation)

Explanatory: There are 65 dots in the wrought iron yearly division, and in the steel division 25 dots, each representing one installation. The discrepancy in these numbers is not accidental or arbitrary, for the figures represent the total number of buildings investigated, (not including those equipped with brass pipe) showing that genuine wrought iron pipe is in much more general use than steel pipe in Pittsburgh buildings. This chart graphically illustrates the fate of each installation—it shows that out of 25 *steel* installations two failed in the fourth year, three more in the sixth year, eight more in the seventh year, and so forth. Only one steel installation lasted as long as ten years, while the first five failures of wrought iron did not occur until the 9th year. Note also that 84% of the steel installations had been replaced when the first wrought iron failures occurred, and after 18 years one wrought iron installation still remained in service.

By comparing the longest lived steel installations with the shortest lived iron installations, it is easy to see that there is no reliable foundation for the claim that steel pipe lasts as long as iron pipe. Unfortunately, many of the claims made for steel pipe, accompanied by a great display of apparently scientific detail, rest on an even flimsier foundation, for there is no test as certain as the test of time and actual service.

Using a similar line of reasoning, we might point to the fact that certain steel installations lasted only 4 years and certain iron installations from 16 to 18 years, outlasting steel from 4 to 5 times. Likewise we might even undertake to claim—and with considerable good evidence to back this claim—that extra heavy iron pipe lasts longer than brass pipe.

All of which argues for the advisability of discounting all corrosion evidence that does not rest on the law of averages, especially if it conflicts with common experience.



in the hot water mains which are easily accessible, and where even brass has to be replaced if used. See in this connection suggestions made in the following section.

HOW TO LENGTHEN LIFE OF HOT WATER PIPING

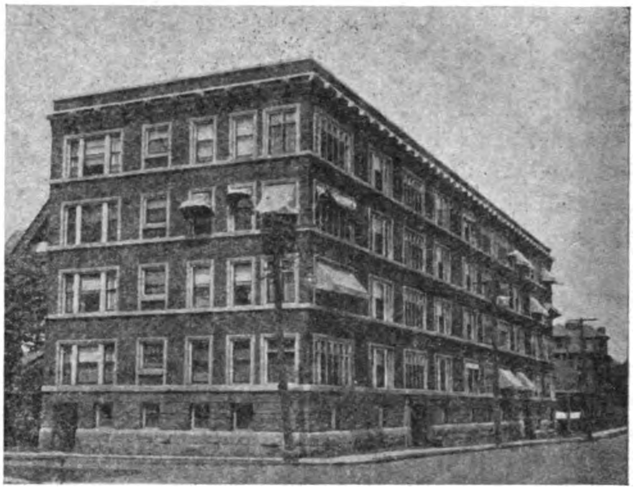
From the fact that nearly every community has trouble with corrosion of hot water lines and rusty water, the question arises how to minimize such trouble without investing, in special apparatus or materials, sums of money which are out of all proportion to the benefits derived therefrom. The life of hot water piping may, however, be lengthened by other inexpensive means.

Inasmuch as Byers genuine wrought iron pipe has an average life twice as long as that of the best steel pipe, (wrought pipe) the first precaution of a builder or architect should be to see that "genuine wrought iron pipe" is actually specified and installed where specified. Byers pipe can readily be identified by the shallow roll marks which appear every three or four feet on the pipe, reading "Byers '19," the latter figures indicating year of manufacture, being, of course, changed from year to year. The higher first cost of Byers pipe is relatively so small compared with its longer life in service as to make it short-sighted economy to allow cheaper pipe to be installed.

It appears that where automatic water heaters are used, the pipe stands up a little longer than in buildings equipped with an ordinary gas heater and tank.

This may be due to the maintenance of a lower temperature of the water where the automatic heater is used. It is certain that corrosion is not nearly as severe between 115° and 140° F. as between 140° and 170° F. Where, therefore, it is practicable to keep the temperature of the water down between the lower figures mentioned, which is an easy matter with a thermostatically controlled water heater, it is to be recommended.

If, in addition, pipe is installed which is larger than that which would be provided in standard practice, its life will be very materially lengthened. The advantages of the larger size pipe lie in its heavier wall and in its larger inside diameter. In view of the fact that wrought iron pipe in most cases clogs up before it is actually rusted through, the larger inside diameter should be an especially strong point.



The Netherlands Apartments, Summerlea and Elwood, erected 1911, equipped with steel pipe. The hot water soon became so rusty that filters were installed in 1916. These filters, however, have not eliminated the rust from the water. See record No. 20 on page 15 and also paragraph on "Rusty Water" on page 7.

The question as to whether or not an open type of heater is practicable or preferable to a closed one, can only be solved by practical service tests. The Byers Company at the present time are not in a position to make any definite recommendations on this subject, pending the outcome of an investigation which they are now conducting.

Theoretically, it would seem that in an open system, allowing escape of the oxygen liberated in heating the water, the corrosion would be less than in the ordinary closed system, which does not permit of such escape. In this, however, as in all other matters pertaining to corrosion, the Byers Company feel that the only safe ground is the path of experience, which as yet has remained largely unexplored in this direction. Such meager data as the Byers Company has so far been able to collect does not show up favorably for the open type heater, but this may be due to faulty design of apparatus rather than to wrong principle.

TABULATED SERVICE RECORDS

The tables following have been subdivided into three groups, the first for brass, the second for steel, and the third for iron pipe installations.

Inasmuch as it was not practicable to remove samples of the piping from a large number of buildings, the identity of iron and steel pipe was determined by obtaining filings from the pipe for the purpose of making a manganese test. Manganese, in the process of steel manufacture, has to be added to the molten metal in order to make it possible to roll and weld it into pipe, while wrought iron requires no manganese addition and therefore usually contains only a trace of this metal. In a few cases, the pipe seemed to contain too much manganese to be classified as wrought iron, and not enough to be classified as steel, and in order to be entirely fair, these cases have been left out of consideration. Where it was possible to obtain samples, the manganese test was supplemented by the crushing test, revealing the bright crystalline fracture of steel or the dull grey, fibrous fracture of wrought iron. The procedure followed in the manganese test is described on pages 18 and 19.

Explanatory Notes to Tables.

Number of Apartments: In this column is indicated the number of apartments in each building which are served by a separate hot water system. It will be seen that some buildings have several hot water systems, each serving its own group of apartments.

Hot Water Mains: Under this column is indicated the number of years of service given by the hot water mains. Where an "s" precedes this figure, it indicates that it represents an average between the longest lived and shortest lived parts of the mains.

"Still Good:" Piping which is indicated as "still good," is not included in arriving at the average life, which is revealed to be 14 years for iron and 7 years for steel pipe in the hot water mains. Where it was impossible to obtain any idea of the condition of the risers, it is indicated by an interrogation mark in the column for risers.

"s" The prefix "s" before figure denoting life of pipe, indicates that it has been estimated in accordance with the rules explained under "Summary of Data", on page 7.

BRASS PIPE INSTALLATIONS

Name and Location	No. of Apts.	Year Erected	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
1. Iroquois Apts. 3600 Forbes St.	74	1903	Hot water lines badly pitted throughout, including mains, risers and returns.	Pitted.	Pitted.	Still good.
2. Elsinore Apts. Craft Ave.	6	1902	Hot water mains badly pitted throughout.	Pitted.	Pitted.	Still good.
3. 306 Craft Ave.	6	1902	Hot water mains badly pitted throughout.	Pitted.	?	Still good.
4. Kennett Apts. Kennett Square	6	1902	Hot water pipe badly pitted in basement.	Pitted.	?	Still good.
5. Craft Apts. Elsinore Square	6	1902	Hot water pipe badly pitted in basement.	Pitted.	?	Still good.
6. Colonial Apts. Craft Ave.	6	1902	Hot water pipe badly pitted in basement.	Pitted.	?	Still good.
7. D'Arlington Apts. Cor. Bayard and Neville Sts.	24	1909	Hot water lines show much corrosion at joints; also pitting.	Pitted.	?	Still good.

BRASS PIPE INSTALLATIONS (Continued)

Name and Location	No. of Apts.	Year Erected	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
8. Holland Apts. Louisa and McKee Place.	12	1904	Hot water mains badly pitted.	Pitted.	?	Still good.
9. Wiltshire Apts. 219 Millvale Ave.	6	1900	Hot water mains in basement somewhat pitted.	Pitted.	?	Still good
10. Apartments 5810 Kentucky Ave.	6	1910	Slight pitting of hot water main.	Slightly Pitted.	?	Still good.
11. Kretzschmar Apt. 912 Maryland Ave	6	1906	Both hot and cold water lines pitted throughout building. Pitting started when building was 3 years old.	Pitted.	Pitted.	Pitted.
12–14. Pennwood Apts. 5736–48 Kentucky Ave. (3 units.)	6	1910	Pipe slightly pitted in basement.	Slightly Pitted.	?	Still good.
15. Seneca Apts. 2041 Forbes St.	12	1906	Steel pipe originally installed, rusted out and replaced with brass in 1915	Pitted.	?	Still good.
16–17. Howe and Kent Apts. Howe and Maryland	6	1907	Hot water mains show some pitting.	Pitted.	?	Still good.
18–19. Bellefonte Apts., Elm and Bellefonte (2 units).	6	1900	Instantaneous heater; pipe somewhat pitted.	Pitted.	?	Still good.
20. Walnut Apts. Cor. S. Negley and Elwood.		1911	Instantaneous heater; pipe in good condition.	Good.	Good.	Good.
21. Fairview Apts. 22. Maryland Apts. 632–34 Maryland	6 3	1906 1906	Hot water pipes only slightly pitted. Hot water pipes only slightly pitted.	Slightly Pitted.	?	Good.
23–26. Wallace Apts. 512–26 Wallace St. (4 units.)	6	1906	Temperature of hot water is kept rather low. Pipe in good condition.	Good.	Good.	Good.
27. Lorain Hotel Highland Avenue	Abt. 6	1902	Hot water mains all pitted.	Pitted.	?	Iron, good.
28. Montana Apts. Penn Ave.	8	1899	Hot water mains all pitted.	Pitted.	?	Iron, good.
29. Idaho Apts. Penn Ave.	8	1899	Hot water mains all pitted.	Pitted.	?	Iron, good.
30. Hugus Apts. 5500 Penn Ave.	9	1909	Hot water mains pitted.	Pitted.	?	Good.
31. Rosemont Apts. Penn and Fairmont.	4	1903	Hot water mains pitted.	Pitted.	?	Good.
32. Elberon Apts. Friendship and Winebiddle.	6	1901	Hot water lines all pitted.	Pitted.	?	Good.
33. Wellington Apts. Sycamore St. and Maple Terrace.	18	1906	Hot water mains all pitted.	Pitted.	?	Good.
34. Horst Apts. California Ave.	6	1900	Hot water mains pitted.	Pitted.	?	Good.

STEEL PIPE INSTALLATIONS

Name and Location	No. of Apts.	Year Erected	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
1. Negley Apts. S. Negley and Elmer	18	1909	Hot water mains, largely replaced 1911–14. Rusty water.	4 yrs.	?	8 yrs. Still good.
2. Berwin Apts. 3. Elmont Apts. 4. Delwood Apts. Holden Ave.	6 6 6	1907 1907 1907	Gradual replacement of hot water mains since 1912. Rusty water.	s–7 yrs.	10 yrs. Still good.	10 yrs. Still good.
5. Brayton Apts. 6. Crescent Apts. Negley Ave.	6 6	1907 1907	Gradual replacement of hot water mains since 1912. Some steel pipe used for replacement pitted through in one year.	s–7 yrs.	10 yrs. Still good.	10 yrs. Still good.
7. Darlton Apts. 8. Kingston Apts. Maryland and Elwood.	6 6	1907 1907	Instantaneous hot water heater. Entire system replaced 1915.	8 yrs.	8 yrs.	Still good.
9. Ellsworth Apts. 5806 Ellsworth Ave.	12	1908	Hot water mains in basement need replacement. Counted about 36 leaks	9 yrs.	9 yrs. Still good.	9 yrs. Still good.
10. Belvedere Apts. 5523 Ellsworth Ave.	18	1910	Very large amount of trouble with rusty water. Replaced basement mains in 1914 and hot water tank in 1916 with brass and copper respectively. Still have trouble with rusty water. Replacing steel risers with iron risers.	4 yrs.	7 yrs.	7 yrs. Still good.
11. Fellabaum Apts. 218–22 Beatty St.	8	1910	Basement hot water mains need replacement. Badly pitted. Rusty water.	7 yrs.	7 yrs. Still good.	7 yrs. Still good.
12. Darlington Apts. McKee Place.	6	1907	Mixed installation of iron and steel, iron appears to be in good condition, steel rusted out.	10 yrs.	10 yrs. Still good.	10 yrs. Still good.
13. Drexel Apts. Penn near Homewood.	6	1909	Hot water mains and 1 riser replaced winter 1916–17.	7 yrs.	Small repair after 7 yrs.	8 yrs. Still good.
14. Argyle Apts. Penn near Homewood.	6	1909	Part of hot water mains in basement replaced 1915.	s–8 yrs.	8 yrs Still good.	8 yrs. Still good.
15. Lexington Apts. Penn and Lexington.	6	1909	Part of hot water mains replaced in basement 1916.	s–8 yrs.	8 yrs. Still good.	8 yrs. Still good.
16. Wm. Pitt Apts. S. Negley and Elmer.	12	1911	Hot water mains badly corroded. Installed filter 1915 to eliminate rust, but did not accomplish purpose.	Filters 6 yrs. Still good.	6 yrs. Still good.	6 yrs. Still good.
17. St. Regis Apts. Maryland and Howe.	18	1908	Cold water pipes too small and replaced in 1915. Hot water mains replaced 1915, account rust.	7 yrs.	7 yrs. Still good.	See Remarks.
18-19. Chesapeake and Chamberlin Apts. Maryland and Howe.	12	1908	Gradually replacing hot water mains in basement	s–10 yrs.	10 yrs. Still good.	10 yrs. Still good.
20. Netherlands Apts. Summerlea and Elwood.	20	1911	Filters installed 1916 to eliminate rusty water, but did not do so. Hot water mains partly replaced, and 1 riser entirely replaced.	s–8 yrs.	See Remarks.	6 yrs. Still good.

STEEL PIPE INSTALLATIONS, Continued.

Name and Location	No. of Apts.	Year Erected	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
21. Gerber Apts. 724 S. Negley	6	1912	Rusty water. Some repairs made in 1916. Mains entirely replaced 1918.	6 yrs.	6 yrs. Still good.	6 yrs. Still good.
22. Everett Apts. Ellsworth and Bellefonte.	12	1906	Hot water mains showing some corrosion at joints. Water kept not higher than 130° which is much below average.	11 yrs. Still good.	11 yrs. Still good.	11 yrs. Still good.
23. Ruberta Apts. Termon Ave.	6	1911	Hot water mains badly corroded and leaking.	6 yrs.	6 yrs. Still good.	6 yrs. Still good.
24. Henrietta Apts. Termon Ave.	6	1911	Mixed installation of iron and steel. Iron pipe next to boiler in good condition. Steel pipe rusted out.	6 yrs.		
25. 706 Summerlea St.	6	1910	Hot water mains pitted through and in bad condition. Need replacement.	7 yrs.	7 yrs. Still good.	7 yrs. Still good.
26-28. Pennwood Apts 5736–48 Kentucky Ave. (13 units)	6	1910	Hot water mains rusted out and replaced 1915.	5 yrs.	7 yrs. Still good.	7 yrs. Still good.

WROUGHT IRON INSTALLATIONS

Name and Location	Year Erected	No. of Apts.	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
1. Englewood Apts. Forbes St.	1909	6	A few small repairs required on hot water mains in basement since 1915.	s–9 yrs.	8 yrs. Still good.	Good after 8 yrs.
2. Lynwood Apts. Forbes St.	1909	6	A few small repairs required to hot water mains since 1915.	s–9 yrs.	8 yrs. Still good.	8 yrs. Still good.
3. Hollywood Apts. Forbes St.	1909	6	A few small repairs after 6-8 years.	s–9 yrs.	8 yrs. Still good.	8 yrs. Still good.
4. Maplewood Apts. Forbes St.	1909	6	A few small repairs after 6-8 years.	s–9 yrs.	8 yrs. Still good.	8 yrs. Still good.
5. Summerlea and Elwood Apts. Cor. Summerlea and Elwood	1902	18	Hot water main replaced 1915.	13 yrs.	15 yrs. Still good.	15 yrs. Still good,
6–7. Luela and Earle Apts. (2 units) 5433 Elmer	1905	6	Hot water main about ⅜ part replaced 1916–17.	12 yrs.	12 yrs. Still good.	12 yrs. Still good.
8–9. Elmer Apts. No. 1 and 2. (2) Cor. Elmer and Bellefonte.	1905	6	Over half of hot water main replaced 1916–17.	12 yrs.	12 yrs. Still good.	12 yrs. Still good.
10–12. Lennox Apts. (3 units) 223–31 Mathilda	1902	6	Some of basement mains and 1 riser up to 2nd floor replaced 1915. There is a total of 12 risers in buildings.	s–15 yrs.	One small repair after 15 yrs.	15 yrs. Still good.
13. Lockhart Apts. 201 Millvale Ave.	1906	6	No repairs to hot or cold water.	11 yrs. Still good.	11 yrs. Still good,.	11 yrs. Still good.
14. Bovard Apts. 200 Millvale Ave.	1902	6	Practically no repairs to hot water, but beginning to rust out.	s–16 yrs.	15 yrs. Still good.	15 yrs. Still good.
15. Albion Apts. 205 Millvale Ave.	1902	6	Hot water mains replaced in 1913.	11 yrs.	11 yrs. Still good.	11 yrs. Still good.
16. Clarendon Apts. 211 Millvale Ave.	1902	6	Some of hot water mains replaced 1914–15.	s–13 yrs.	15 yrs. Still good.	15 yrs. Still good.

WROUGHT IRON INSTALLATIONS (Continued)

Name and Location	Year Erected	No. of Apts.	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
17–18. McLean Apts. 256 Mathilda (2 units).	1899	6	Most of hot water mains replaced 1915 with steel; the latter already pitted through in four places and tied up with rags.	s–17 yrs.	18 yrs. Still good.	18 yrs. Still good.
19. Colonial Apts. Hays St., Wilkinsburg.	1899	47	Hot water mains required minor repairs since 1912. Now needs replacing.	17 yrs.	18 yrs. Still good.	18 yrs. Still good.
20–21. Colonial Annex No. 1 and 2. (2). Franklin Street	1902	24	Hot water mains still in fair condition. Very few repairs.	s–18 yrs.	15 yrs. Still good.	15 yrs. Still good.
22–25. 503, 511 and 515 and 539 Rosedale St. (4 units.) Wilkinsburg.	1901	6	Wrought iron mains and lead risers for hot water; both replaced in 1915. 160 lbs. water pressure, Wilkinsburg water, same as Pittsburgh.	14 yrs.	Lead 14 yrs. (Replaced)	16 yrs. Still good.
26. 519 Rosedale St.	1901	6	Instantaneous hot water heater. Both iron mains and lead risers still in fair condition.	s–18 yrs.	Lead s–18 yrs.	16 yrs. Still good.
27–32. 523, 527, 531, 535, 543 and 547 Rosedale St. (6).	1901	6	Hot water lines have had some repairs, but are still in fair condition. Iron and lead plugging, and have had to be cleaned out.	s–16 yrs.	Lead. 16 yrs.	16 yrs. Still good.
33. Seeley Block Penn and Beatty	1897	6	Pipe around hot water heater gradually replaced since 1912.	s–17 yrs.	20 yrs. Still good.	20 yrs. Still good.
34–36. Norfolk Apts. Delaware Apts. Howard Apts. (3) Cor. Bryant and Hiland.	1898	6	Hot water basement mains largely replaced 1912 to 1917. Risers now leaking.	s–17 yrs.	19 yrs.	19 yrs. Still good.
37. Verner Apts. 3801 California.	1900	6	Basement mains replaced in 1914.	14 yrs.	17 yrs. Still good.	17 yrs. Still good.
38. Hiawatha Apts. 3803 Hiawatha St.	1906	6	Still good. No trouble.	11 yrs. Still good.	11 yrs. Still good.	11 yrs. Still good.
39. Minnehaha Apts. 3805 Hiawatha St.	1906	6	Still good. No trouble. Showing slight corrosion at joints in basement.	11 yrs. Still good.	11 yrs. Still good.	11 yrs. Still good.
40. Tacoma Apts. 3805 California Avenue.	1911	6	Still good; no trouble.	Still good.	6 yrs. Still good.	6 yrs. Still good.
41. Denslow Apts. 3624 California Avenue.	1904	12	Equipped with wrought iron pipe of doubtful quality, being high in manganese. Needs replacement in basement.	13 yrs.	13 yrs. Still good.	13 yrs. Still good.
42. Lafayette and Cambridge Apts. McKee Place.	1902	12	Most of hot water mains in basement replaced 1917.	14 yrs.	14 yrs. Still good.	14 yrs. Still good.
43. Yellow Brick Apt. McKee Place.	1902	12	Repairs started in 1915. Entire basement hot water piping now needs replacement.	14 yrs.	14 yrs. Still good.	14 yrs. Still good.
44. Yellow Brick Apts. No. 2. McKee Place.	1902	6	Some of hot water mains replaced, all now need replacement.	14 yrs.	14 yrs. Still good.	14 yrs. Still good.
45. Hanover Apts. McKee Place.	1903	12	Hot water mains in basement replaced in 1915; stopping up and corroding at joints.	12 years	13 yrs. Still good.	13 yrs. Still good.

WROUGHT IRON INSTALLATIONS (Continued)

Name and Location	Year Erected	No. of Apts.	Remarks	Hot Water Mains	Hot Water Risers	Cold Water Lines
46. Cheswick Apts. McKee Place.	1903	6	Small repairs made 2 yrs ago near boiler in basement. Entire hot water piping in basement will need replacement in a year or two.	s-14 yrs.	14 yrs. Still good.	14 yrs. Still good.
47. Olympia Apts. McKee Place.	1903	12	Some repairs made 1915 to hot water mains in basement. Same will have to be replaced soon.	14 yrs.	14 yrs. Still good.	14 yrs. Still good.
48. Dundee Apts. McKee Place.	1902	12	Hot water pipe in basement replaced in 1915.	13 yrs.	15 yrs. Still good.	15 yrs. Still good.
49. Wabash Apts. McKee Place.	1902	12	Hot water mains replaced 1915–1916.	13 yrs.	15 yrs. Still good.	15 yrs. Still good.
50. Jarvis Apts. McKee Place.	1902	12	Hot water mains replaced 1914, account plugging and rusting.	12 yrs.	15 yrs. Still good.	15 yrs. Still good.
51. Lancaster Apts. McKee Place.	1903	12	Hot water mains in basement replaced 1915, account leaking and plugging.	12 yrs.	14 yrs. Still good.	14 yrs. Still good.
52. Saybrook Apts. Craft Ave.	1901	95	One length of pipe replaced 1912 with steel; the latter is rusted through and leaking after 4½ years. All hot water lines in basement now needing replacement within a few years. Lower ends of risers also corroded.	s-17 yrs.	16 yrs. lower ends corroded	16 yrs. Still good.
53. Imelda Apts. Melwood and Baum.	1907	6	Entire hot water system now being replaced (1917). Risers plugged up, being too small. (Near pumping station.)	10 yrs.	10 yrs.	10 yrs. Still good.
54. Margarita Apts. Melwood Ave.	1907	6	Entire hot water system replaced 1916. (Near pumping station.)	9 yrs.	9 yrs.	10 yrs. Still good.
55. Oakland Apts. Halket and Forbes	1902	12	Hot water mains need replacement.	15 yrs.	15 yrs. Still good.	15 yrs. Still good.
56–58. Shadyside Apt. 5121-25 Centre Ave. (3 bldgs.)	1902	6	Instantaneous hot water heater (3). Basement mains replaced 1915.	13 yrs.		
59–61. Shadyside Apt. 5115–19 Centre Ave. (3 bldgs.)	1902	6	Hot water mains replaced in 1915.	13 yrs.	Brass. Still good	Good after 15 yrs.
62. Geneva Apts. 63. Virginia Apts. 64. Lincoln Apts. 65. Columbia Apts. 66. Emerson Apts. (All Mathilda St.)	1902 1902 1902 1902 1902	6 6 6 6 6	Hot water mains replaced in basement in 1915.	13 yrs.	Lead.	Lead
67. Burlington Apts. McKee Place	1903	12	Hot water mains rusted out and need replacement.	14 yrs.	14 yrs. Still good.	14 yrs. Still good.

MANGANESE TEST

Place a small chip about the size of a large pinhead, or filings to equal this quantity, in a small, clean test tube. Add twenty drops of chemically pure nitric acid, specific gravity 1.2, and heat with a match until the metal is completely dissolved. Let the solution cool until the tube can be held in the hand without discomfort, and add as much sodium bismuthate as will lie on the point of a small penknife blade, or as much more as may be required to produce a small amount of brown residue. Bubbles of oxygen gas will be given off by the solution when the bismuthate is added, after which the development of a pink or red color may appear in the solution, indicating the presence of maganese which shows that the material is steel. If no reddish tint appears, or only a very slight pinkish discoloration is visible, the material is iron.

If wrought iron contains more than a trace of manganese, which occasionally happens, this test is misleading. A fracture test or chemical analysis is, therefore, preferable whenever possible. It should also be noted that "Ingot Iron" and other soft steels of very high purity, contain only a trace of manganese, but so little pipe is as yet made from these materials that the possibility may be practically ignored.

ANALYSES OF WATER

The Pittsburgh water supply is obtained by slow filtration of river water, coupled with very slight additions of chlorine to destroy bacteria. The water is moderately hard and of good quality for domestic consumption.

The records obtained of the comparative life of wrought iron, steel and brass pipe in Pittsburgh apartment buildings, are applicable to similar service in most of the large cities of this country. The water supplies of such cities are in general obtained from lakes or rivers, and do not differ sufficiently from the Pittsburgh supply in contained salts to be materially different in corrosive effect.

The only place where the use of the data may result in error is in certain smaller cities where the water supply is obtained from artesian wells or similar sources. These may differ sufficiently in composition and hardness from the Pittsburgh supply, to make comparisons somewhat misleading. However, it may be said in general that if the salt content of domestic water supply is not sufficient to affect its potable quality, the *difference in the corrosive effects of the various waters is quantitative only, and only in exceptional cases will there be a disturbance of the relative effect upon wrought iron, steel and brass. The comparative data secured in Pittsburgh, therefore, has almost universal application.* Following is a representative analysis of Pittsburgh water compared with analyses from a few other large cities:

Analysis of Domestic Water Supply in Large Cities.

City	Source of Supply and Treatment	PARTS PER MILLION						
		Sodium and Potassium	Calcium	Magnesium	Silica	Sulphate	Chlorine	Carbonate
Pittsburgh	Allegheny River. Settling, sand filter, chlorine sterilization.	6.8	28.6	7.3	2.6	93.8	21.0	....
Cincinnati.	Ohio River. Settling, coagulation, sand filter, chlorine sterilization.	...	30.5	4.8	...	47.3	17.0	26.9
Philadelphia Schuylkill. Delaware.	River. Sand filter.	(Analysis not complete as to bases)				45.6 13.2	5.3 5.1	....
Washington, D. C.	Potomac River. Sand filter, settling.	2.9	43.6	6.8	8.8	11.4	3.9	114.8
Minneapolis	Mississippi River. Settling, coagulation, sand filter, chlorine sterilization	7.3	39.9	12.7	8.9	26.7	2.2	161.0
St. Louis.	Mississippi River. Settling, coagulation, sand filter, chlorine sterilization	28.8	21.0	11.7	9.6	84.2	13.4	55.0
New Orleans.	Mississippi River. Settling, coagulation, sand filter, chlorine sterilization.	13.0	15.0	3.0	10.0	31.5	9.6	....
Atlanta, Ga.	Chattahoochee River. Coagulation, mechanical filter.	2.6	Trace.	Trace.	2.0	2.6	....	1.6
New York. Catskill. Croton.	Impounding of river water in reservoirs.	0.8 2.0	5.2 9.6	0.8 3.4	1.0 9.0	3.2 8.0	1.2 3.0	17.4 38.4
Chicago.	Lake Michigan. Chlorine sterilization.	1.1	29.2	11.8	3.9	10.0	6.3	65.4
Los Angeles.	Aqueduct. Los Angeles River. Settling.	52.0 39.3	45.0 68.6	16.0 23.8	....	109.0 98.9	30.0 29.0	15.6 22.6
Indianapolis, Ind.	River. Coagulation, sand filter, chlorine sterilization.	13.0	72.0	27.0	....	58.0	20.0	136.5
Houston, Texas	Artesian Wells.	71.4	29.5	3.5	....	13.6	49.4	147.9
Memphis, Tenn.	Artesian Wells.	35.6	13.8	13.0	....	4.2	53.8	53.0
Milwaukee, Wis.	Lake Michigan. Not filtered. Chlorine sterilization	4.9	39.2	9.8	12.5	8.2	3.8	130.0
Ocean Water		**11100.0**	**420 0**	**1300.0**	....	**2700.0**	**19350.0**	**70.0**

NOTE: It will be observed that all of the analyses given show only negligible amounts of impurities which have any effect on corrosion. This is be illustrated by comparison with the analysis of ocean water.

THE CORROSION OF HOT WATER PIPING IN BATH HOUSES

A few comments on the interpretation of Mr. Ira H. Woolson's Report, published in the Engineering News, December 3rd, 1910, page 630.

The Byers Company has recently devoted much time and effort to the collection of exact data on the life given by iron and steel pipe in actual service. Besides this Bulletin, No. 30, during the past three years the following publications, containing a large number of service records, have been issued:

Bulletin No. 26—21 pages, 8½ x 11", containing 70 different records of service.

Bulletin No. 27—"The Experience of Practical Men," containing the testimony of practical men in every part of the country, as to the life of iron or steel pipe for a wide variety of uses.

Bulletin No. 32—"The Relative Corrosion of Wrought Iron, Cast Iron and Steel Pipe in House Drainage Systems." Data obtained through investigations conducted in New York by Dr. Wm. Paul Gerhard, C. E., Consulting Sanitary Engineer, and in Chicago by Thomas J. Claffy, Asst. Chief Sanitary Inspector, City of Chicago.

Book: "On the Trail of Byers Pipe" 40 pages of illustrations of old buildings from 25 to 45 years old, describing the service given by the pipe in each.

In addition, subsequent bulletins, containing the results of systematic investigations made in a number of large cities, will be published.

Against this exact data, manufacturers of steel pipe appear to rest their case on the one single piece of evidence that could possibly be interpreted in favor of the contention that steel pipe lasts as long as iron. This refers to Professor Ira H. Woolson's report on the "Corrosion of Hot Water Pipes in New York Bath Houses." This report has been published and republished, one edition following another, for the last seven years, and has been quoted by exponents of steel pipe on every possible occasion, remaining throughout all these years the mainstay of their propaganda. One is therefore tempted to ask this question: If steel pipe really lasts as long as wrought iron pipe, why not produce some definite evidence of **life in actual service of pipe tested to destruction?** This question is not answered by the report of Professor Woolson who beyond question, never intended his report to be used for this purpose, for in the very beginning he clearly states:

> "This paper represents the *progress* of the work up to May, 1910, when I severed my connection with that institution (Columbia University). The original plan was to *collect further evidence* * * * but as that is now impossible * * *.

And further:

> "I visited all the public bath houses * * * collecting all the samples of corroded pipe I could secure. In some places it was difficult to get satisfactory samples, because the old piping was sold for junk as rapidly as possible".

It is difficult, therefore, to understand how anyone could have utilized Mr. Woolson's Report for the purpose of showing that steel pipe will last as long as iron pipe when tested to destruction, for although all the pipe was actually removed because it had rusted out, nowhere in Mr. Woolson's Report is any mention made of the *length of time each sample had been in service.*

This vital point of time was not touched on at all by Mr. Woolson, no doubt due to the fact that it was impossible for him to obtain this information about samples collected largely from the scrap pile from a number of buildings which were not of the same age. The 23rd Street bath house, at the time of the investigation, was about one year old, the 76th Street bath three or four years, the 11th Street and Allen Street baths four years, the 109th Street bath four or five years, the 41st Street bath five years and the Rivington Street bath eight years.

In lieu of a comparison of life, Mr. Woolson thought that a comparison of the iron and steel samples might reveal a difference in their condition, but any such expectation naturally was foredoomed to disappointment, **as one piece of pipe which has failed in service, from a practical standpoint, can be no worse nor better than another pipe which has also failed in service due to the same cause—corrosion.** Unless a correct answer can be given to the question, "How long was each sample in service?" the other comparison is valueless.

In New York bath houses there are at least five different kinds of "hot water" pipes, in which the service conditions vary greatly, as follows:

1. "Steam Drips" carrying hot water condensed from the steam lines which is returned to the boiler. (This is usually black pipe.)
2. Boiler feed lines, also hot water (usually black pipe.)
3. Hot water supply lines between the heater and the shower lines (galvanized.)
4. The "shower lines" proper, which are the overhead lines in the bath rooms, to which the shower heads are attached (galvanized.)
5. The hot water return lines from the shower lines (galvanized.)

The samples collected were both black and galvanized, varying sizes from ¾ to 4", showing that they must have been installed under *greatly varying conditions of service.* For a boiler feed line invariably has a life several times shorter than a hot water supply line, and a drip or return line will usually last much longer than the supply line. This is another important point on which Mr. Woolson was prevented from throwing any light, owing to collecting the samples so largely from the junk pile. But the first and last question that must be asked of those who are quoting Mr. Woolson is: Where is the time record of service?

In the extensive remodeling done to the various baths in 1911, (after Woolson's investigation), *genuine* wrought iron was specified for all hot water lines in the plumbing system of the baths and special care was taken to prevent the substitution of steel pipe. It is of interest to note that this piping has so far required very few repairs. In the Rivington Street bath, erected 1914, Byers pipe apparently was installed throughout, and up to March, 1917, (the date of our last visit to this bath) no repairs had been required on account of rusting.

BYERS PIPE

GENUINE WROUGHT IRON
FULL WEIGHT GUARANTEED

BULLETIN No. 32 — Second Edition — JUNE, 1921

Corrosion of
Wrought Iron, Cast Iron and Steel Pipe
in House Drainage Systems

1.—Reprint of Paper presented at Annual Meeting of the American Society of Mechanical Engineers, New York, Dec. 6, 1918, by Dr. Wm. Paul Gerhard, C. E., Consulting Sanitary Engineer, Member A. S. M. E., Honorary Corr. Mem. Amer. Inst. of Architects.........................Pages 2-16

2.—Reprint of Paper read by Mr. Thomas J. Claffy, Assistant Chief Sanitary Inspector, City of Chicago, at Annual Convention of American Society of Sanitary Engineering, held at Congress Hotel, Chicago, October 14 and 15, 1918..Pages 17-32

The Relative Corrosion of CAST IRON, WROUGHT IRON and STEEL PIPE in House Drainage Systems

—BY—

DR. WM. PAUL GERHARD, C. E.

Member Amer. Soc. Mech. Eng.—Honorary Corr. Mem. Amer. Inst of Archts.

DURING the months of June and July, 1918, the writer was engaged in a special investigation, intended to bring out facts as to the life (or deterioration by corrosion) and other relative characteristics of cast iron, wrought iron and steel pipe, as used in the drainage of buildings.

He considers the results of this investigation and the facts elicited to be of such far-reaching importance and of such general interest to the engineering profession that he decided to bring them to its attention through this paper.

DEFINITION OF HOUSE DRAINAGE

Omitting from consideration the plumbing fixtures and the traps attached to them, the plumbing of every building may be said to be composed of two equally essential but distinct pipe systems, namely,

First: the hot and cold *water supply system;*

Second, the ***drainage system***, comprising the sewer, drain, soil, waste, leader and vent lines or stacks, the function of which is to remove promptly and thoroughly from the building all waste water from lavatories, sinks, bathroom, kitchen, and laundry plumbing fixtures; all storm water from roofs, yards, areas and courts; as well as any noxious gases, commonly termed "sewer gas," originating in such pipe systems.

This special investigation was restricted to the drainage and vent system, and the hot and cold water supply pipes were excluded from consideration.

SCOPE OF INVESTIGATION

The investigation was made in New York City and took in the buildings along the line of Broadway, beginning at Bowling Green and ending at 42d Street, a total distance of approximately four miles. Buildings less than six stories in height and less than five years old were omitted, because they were not of sufficient size and age to give much information as to the corrosion of the pipes. Accordingly, such well-known tall buildings as the Woolworth, the Equitable Life, the Adams Express, the American Express, and a few others recently erected, do not appear in the tabulation.

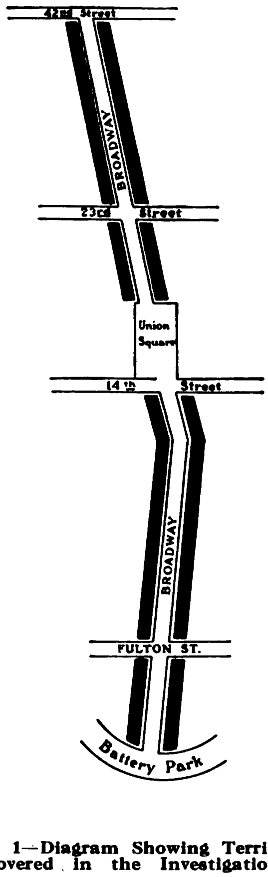


Fig. 1—Diagram Showing Territory Covered in the Investigation.

The total number of buildings coming within the scope outlined was 81, and permission was obtained to inspect 78 of these.

DIAGRAMS AND TABULATED RESULTS

The tables on pages 13-15 give a complete statement of all buildings examined; the age of the building; the number of stories; the kind of pipe material used for drainage and so forth.

Examination of the table brings out clearly the fact that since the introduction of the screw-jointed system preference has been, and is still, given by architects and engineers to the use of welded pipe with screw joints; it confirms the fact that the latter system has so many advantages as to render it superior to the cast iron system.

The total number of vent pipes counted on the roofs of these buildings was 1676, about one-third being cast iron and two-thirds screw-jointed pipes, and the condition of all but those which were quite inaccessible was looked into.

The total number of pipe samples (both roof vent pipes and cellar drains) taken for chemical tests to determine the character of the material, viz., whether of steel or of wrought iron, was more than 500. The roof vent pipes were taken as the principal objects of the inspection and the tests, because they were almost the only parts of the house-drainage systems, the interior condition of which could be freely ascertained. After noting the age of the buildings, or the number of years these vents had been in actual service exposed to the sewer air and the atmosphere, their condition and degree of corrosion gave important information regarding the life of the different pipe materials, whether cast iron or black or galvanized wrought iron or steel. Such actual service records are, undoubtedly, superior to the more or less accelerated corrosion tests on small quantities of pipe which have been offered from time to time as evidence on the subject.

Photographs showing the typical condition of the older roof vent pipes were taken under the writer's directions and have been reproduced in Figs. 2 to 16, inclusive.

Fig. 2—Cast Iron, Showing Typical Corrosion Resulting in Even Pock-marking or Shallow Pitting.

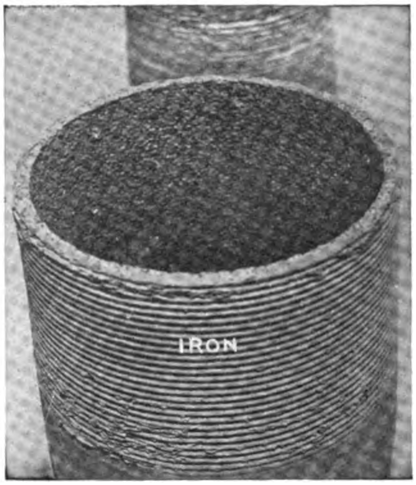


Fig. 3—Wrought Iron, Showing Typical Corrosion Resulting in Even Pock-marking or Shallow Pitting.

Fig. 4—Steel, Showing Aggravated but Typical Corrosion Resulting in Flaking or Scaling.

EXPLANATORY NOTE ON TERMS DESCRIBING CHARACTER OF RUSTING

In this investigation two distinct forms of rusting or corrosion were observed, namely:

1. Pitting, or pock-marking
2. Scaling, or flaking.

A great many wrought iron and cast iron pipes were found evenly pitted or pock-marked, to a comparatively shallow depth, reducing the wall section only slightly. Where the term "pitting" is used on the diagrams or elsewhere in this paper, it should be understood that it does not indicate irregular, deep pits, such as are so frequently found in hot water pipes, and which in a comparatively short time may result in complete perforation of the metal. (See Figs. 2 and 3.)

A large proportion of the older steel pipes showed a characteristic and generally aggravated form of flaking or scaling, the flakes often covering large parts of the surfaces. These flakes, of course, are simply the product of corrosion, and, when removed, frequently leave only a thin outer shell of the original material. The scale could easily be removed by hand, and also had a tendency to drop off by its own weight and to choke the pipes at angles, offsets or bends.

Just how surprisingly bad this condition was, is but poorly indicated by the photographs which accompany this paper, for a pipe which might look fairly good with a thin crust of flaky material, would, when the flakes were removed, frequently turn out to be so thin as to be incapable of supporting its own weight. (See Fig. 4.)

PHOTOGRAPHS OF VENT PIPES

CONDITIONS WHICH THE INVESTIGATION REVEALED

PHOTOGRAPHS OF VENT PIPES

Supplementing the detailed records given in the tables, a number of photographs showing the typical condition of wrought iron and steel vent pipes, from 20 to 30 years old, are herewith presented. These illustrations, undoubtedly, will give a better idea of the conditions found than lengthy descriptions could accomplish, though it should again be mentioned that, so far as illustrating the extent of the flaking is concerned, even these photographs give but an inadequate conception of the degree in which these pipes have suffered from corrosion.

Mail and Express Building

Figs. 5 and 6 show the condition of all the 20 black wrought iron vent lines found on the roof of the Mail and Express Building, 203 Broadway, after 27 years' service. It will be seen that they are all in an excellent state of preservation, with possibly only one exception, namely No. 12-7 (Fig. 5), which has suffered some reduction in wall thickness, due to pitting. It is interesting to contrast these vents with the steel vents on the Townsend Building, the Bowling Green, the Langdon and other buildings, photographs of which are shown elsewhere herein.

Townsend Building

Fig. 12 is from the Townsend Building, erected in 1896. On this roof ten vents were tested. Five of them proved to be black steel and five galvanized steel. All of these vents have been in service 22 years. One of the five black steel pipes, No. 63-7 (Fig. 12) has just a thin shell of the original metal left and the remainder are about half rusted away. The galvanizing on the other five has to a large extent disappeared and the pipes show considerable flaking similar to that found on the black vents, only to a slighter degree, owing to the protection afforded by the galvanizing during the first 10 or 15 years after installation.

Langdon Building

Figs. 15 and 16 show a mixed installation of eight black wrought iron and seven black steel vents on the roof of the Langdon Building, erected in 1894. Some of these photographs are very characteristic. No. 43-6 and No. 43-7 (Fig. 15) are 4-in. black pipes, the former steel, the latter wrought iron, side by side. These illustrate very aptly the difference in the corrosion of iron and steel under identical conditions of service. The same applies to vents No. 43-10 and No. 43-11 (Fig. 16), the former steel, the latter wrought iron. The evidence is unmistakable. No. 43-5 (Fig. 15) shows what remains of a steel vent which, due to complete rusting out, broke off 6 ft. below the top. The outer shell seen in the photograph is the lead roof flashing, which is all that is holding the remainder of the pipe together. This particular pipe, as well as others which had broken off at some distance below the top, were convincing evidence that the condition of all the vents as seen by inspection of the top is indicative of the condition of at least a considerable proportion of the pipes down through the building. These, as well as the other vents shown, are 24 years old and form a most striking exhibit.

Bowling Green Building

Fig. 14 is from the Bowling Green Building, erected in 1897, and all vents were installed at that time, 21 years ago. Ten were black wrought iron, all showing the typical even pitting of wrought iron, which results in very little reduction in the thickness of the pipe. No. 2-3 (Fig. 14) shows what remains of a 4-in. black steel vent, which broke off near the roof at a distance of about 10 ft. below the top, again indicating that the degree of rusting shown on the top of the vents in general extends down through the building. No. 2-6 (Fig. 14) is almost an exact duplicate of No. 2-3, also being broken off near the roof, due to rusting out. Both vents were temporarily extended up to regular height by means of sheet-metal tubes.

The photographs from the four buildings just described include every vent tested, none being omitted. A few other photographs, picked at random from other buildings, may also be of interest. These are as follows:

Home Life Building

Fig. 13 shows a galvanized steel and a galvanized wrought iron pipe side by side in the Home Life Building. While this building was erected in 1893, the present vent pipes were installed in 1905, after a fire. This photograph again illustrates the striking difference in the corrosion of the two metals under iden-

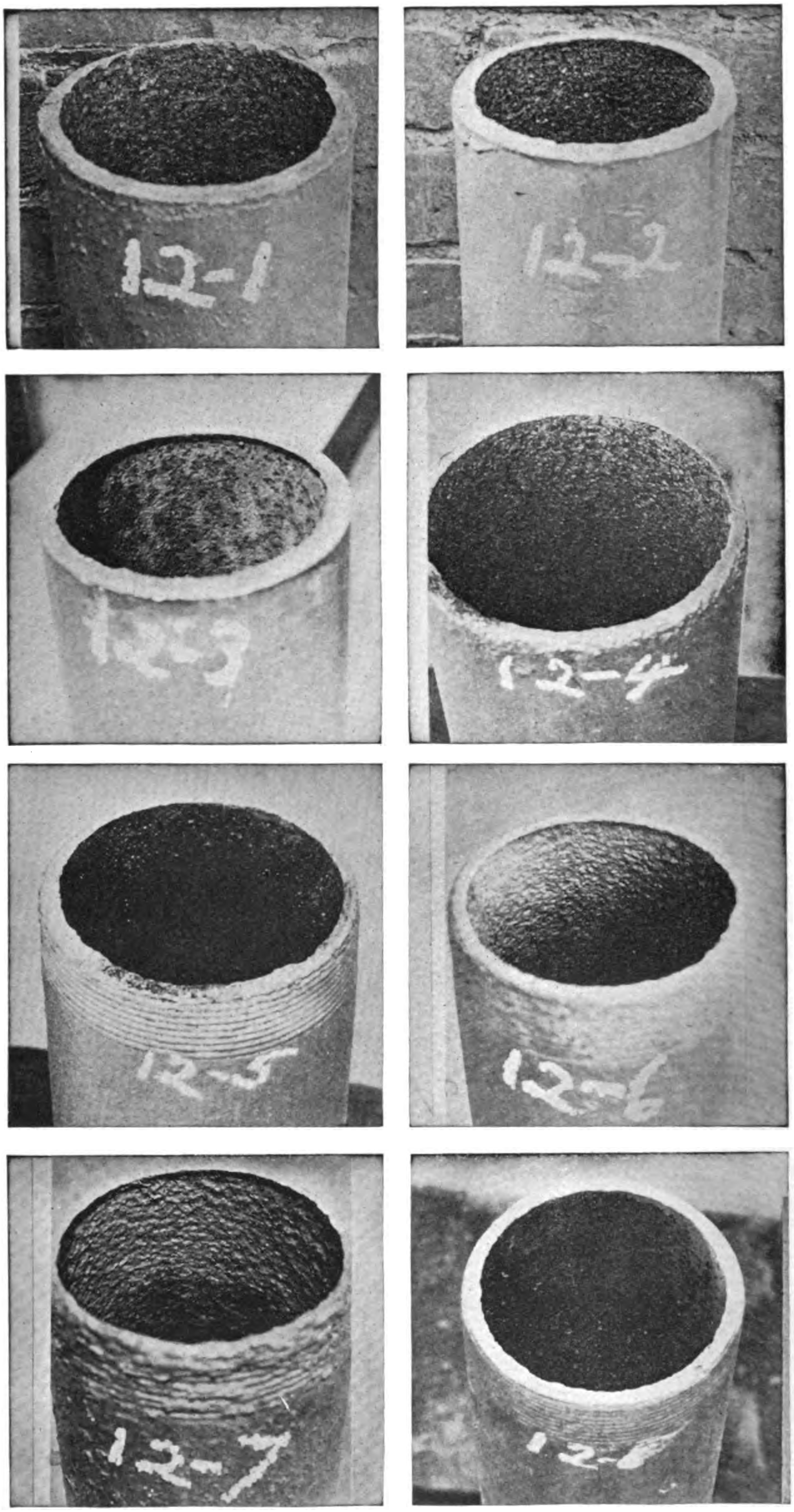


Fig. 5—Black Wrought Iron Vents, After 27 Years' Service in the Mail and Express Building.

The twenty vents illustrated, Nos. 12-1 to 12-20 include all the vents on the Mail and Express Bldg., all genuine wrought iron, 27 years old.

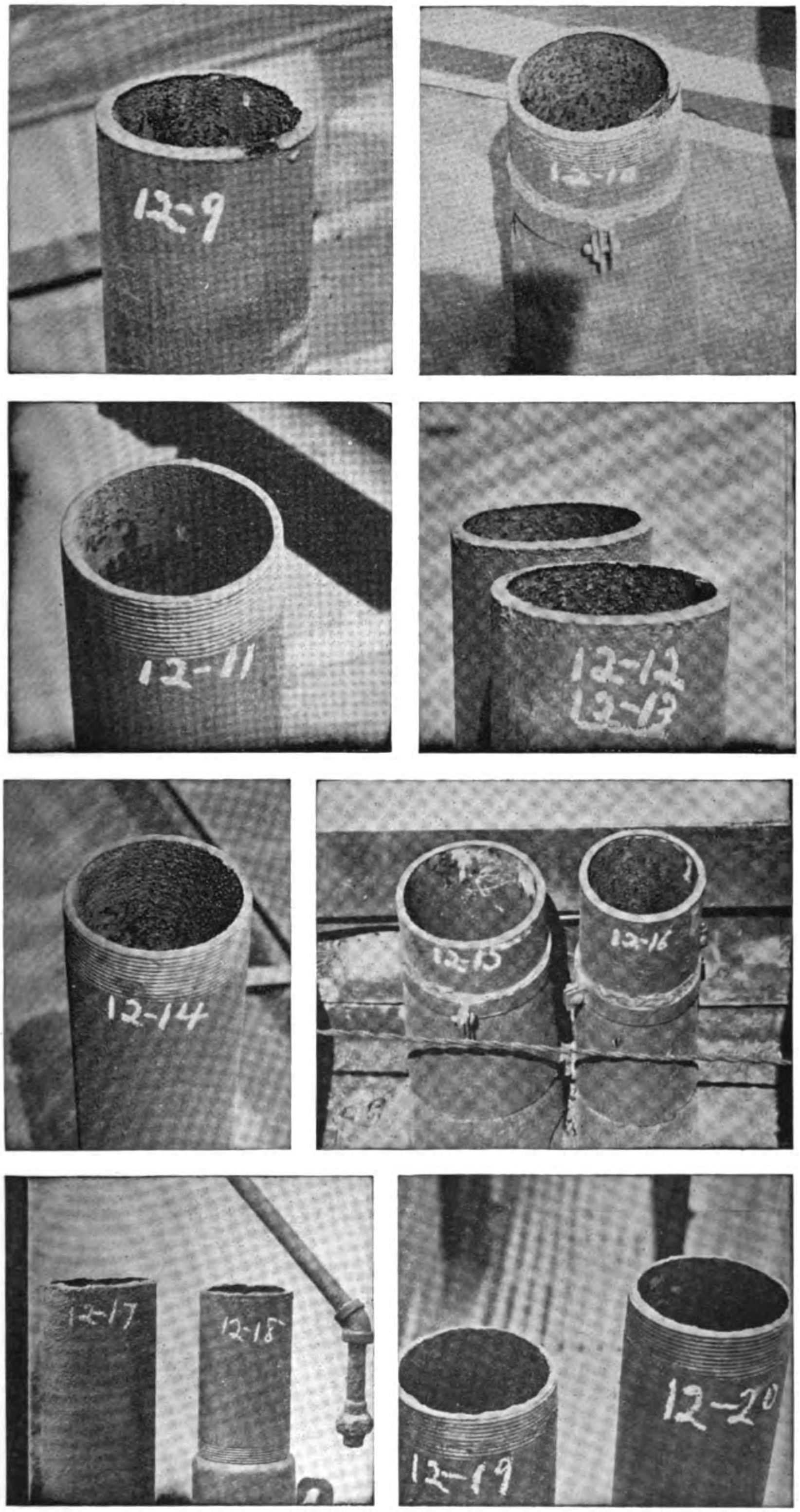


Fig. 6—Black Wrought Iron Vents, After 27 Years' Service in the Mail and Express Building.

They are representative of the condition of wrought iron vents after 20 years' or longer service in all buildings investigated.

tical conditions, and is a further reminder that galvanizing protects the base metal from attack for only a comparatively few years.

Broadway-Chambers Building

No. 40-3, No. 40-4 and No. 40-5 (Figs. 9 to 11) represent galvanized steel vents on the roof of the Broadway-Chambers Building which are 19 years old; the galvanizing has nearly disappeared in this time, leaving the base metal open to attack. These three vents are typical illustrations of the *best* galvanized steel vents to be found in buildings of the same character and age.

SUMMARY OF VENTS

Summarizing: inasmuch as these photographs are typical of the conditions found, one cannot fail to notice the ***excellent showing made by genuine wrought iron pipe*** as contrasted with the ***nearly universally bad***, or at least inferior, condition of the ***steel vent pipes*** after 20 years' service. These examples might have been extended to include a very much larger number of buildings, but inasmuch as the records for all of them are briefly enumerated in the tables, it would seem unnecessary to particularize further by photographs and descriptions.

CONDITION OF THE DRAINS

An attempt was made to ascertain the condition of the main drains and branches in the cellars. Inasmuch as it was not practicable to inspect the interiors of the pipes, the tabulated notes are based largely on information given by the engineers in charge of the buildings. Only a few cases were found where the drain pipes had corroded through and actually been replaced by new pipes.

Bowling Green Building

In the Bowling Green Building, parts of the main drain lines gave out by corrosion and were replaced three years ago, after 18 years' service, with galvanized welded pipe. Only one of the removed pipes was available for test, viz., a 2-in. waste pipe, which was found to be steel; its condition is illustrated in Fig. 7.

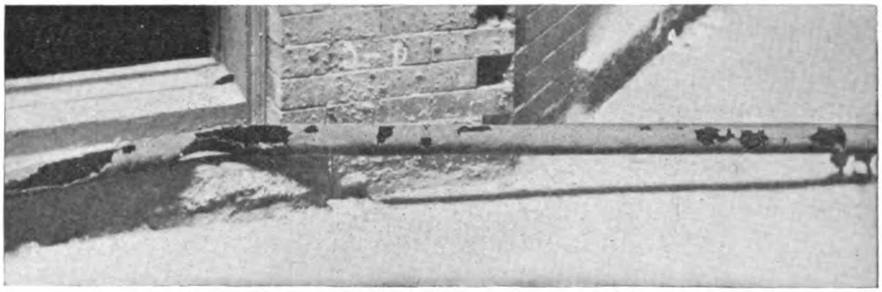


Fig. 7—Steel Waste Pipe Removed After 18 Years' Service From Drainage System (Bowling Green Building).

Title Guarantee and Trust Building

In the Title Guarantee and Trust Building, a drainage line gave out a year ago, after 22 years' service, the pipe having "rusted completely through." As all the pipes in this building are of steel it may be assumed that the drain was also of steel.

Home Life Building

In the Home Life Building, two main drainage lines had to be removed, after 25 years' service, because they corroded away at the top. These pipes probably were of steel because other lines in the cellar were tested and found to be steel; but the pipes removed were not available for test.

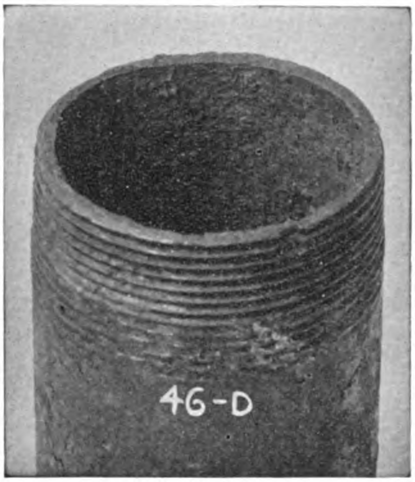


Fig. 8—2-in. Black Wrought Iron Drain Pipe, After 19 Years' Service, Serving a Urinal. Pipe removed because fixture had become unnecessary (St. Paul Building).

Broadway-Chambers Building

In the Broadway-Chambers Building, one 8-in. line was replaced three years ago, after 15 years' service, on account of its being eaten away by corrosion; the pipe "leaked very badly." As all the other lines tested in this building were galvanized steel, it may be assumed that the drain pipe which gave way was also of steel.

St. Paul Building

In the St. Paul Building, a 4-in. black drain pipe was removed a year ago, after 19 years' of service, because it gave way at the top and leaked; the pipe was located over the steam boilers. A sample of this corroded pipe was obtained and

Fig. 9

Fig. 10

Fig. 11

Three Galvanized Steel Vents, 19 Years Old in the Broadway-Chambers Building.

Galvanizing has nearly disappeared, leaving the base metal exposed to attack. These photographs are typical of the best galvanized steel vents found in buildings of similar age and character.

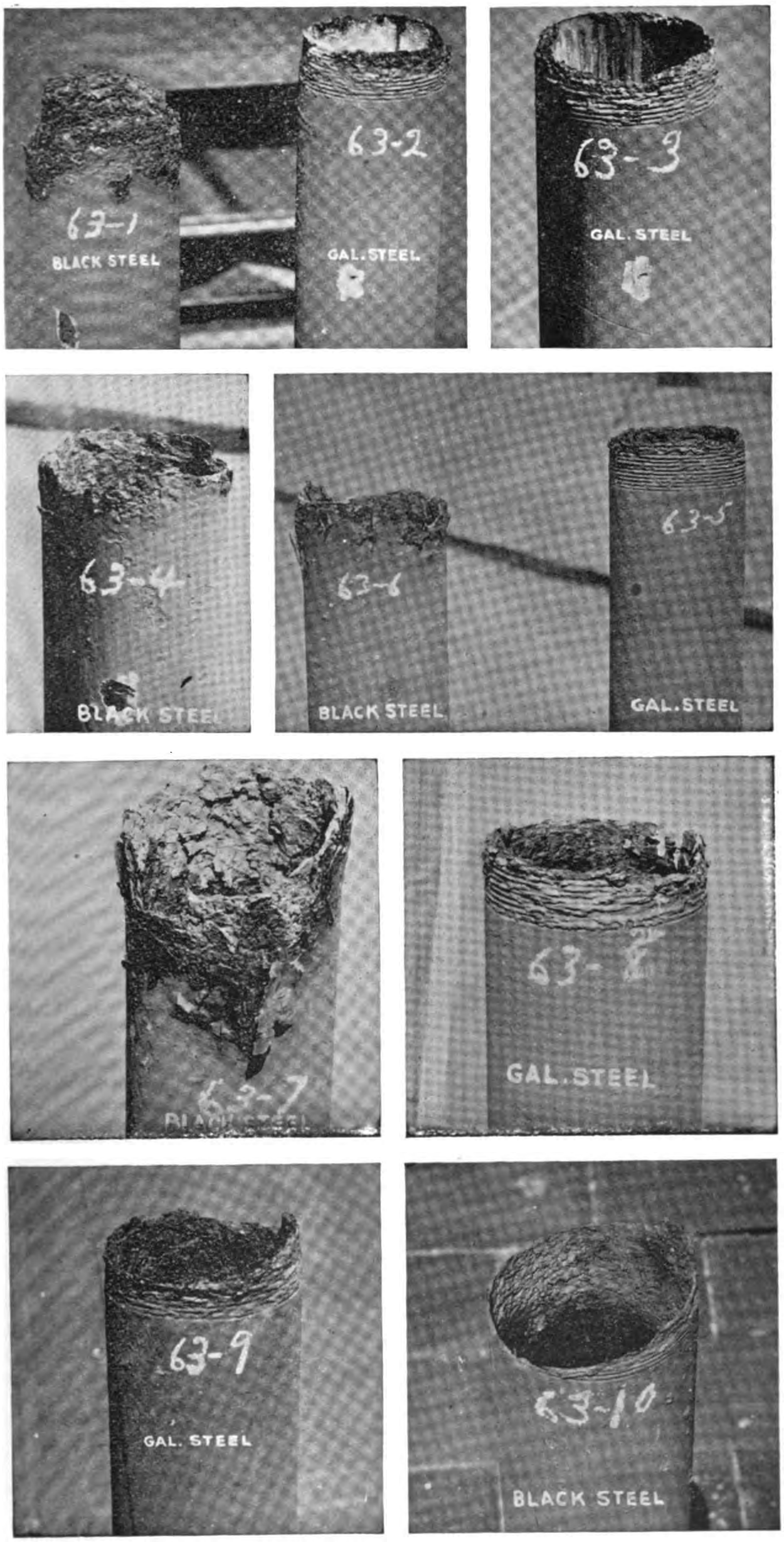


Plate No. 12

Steel Vents, Townsend Building, 22 Years Old.
Contrast with wrought iron pipes on pages 4 and 5.

proved on test to be steel. In the same building a sample was obtained of a 2-in. waste pipe, taken out after 19 years' service because the fixture, a urinal, had become unnecessary and was removed. This sample pipe was of ***black wrought iron***, and but slightly pitted on the inside, its general condition being surprisingly good, considering the severity of this service. (See Fig. 8.)

Townsend Building

In the Townsend Building, where all the black and galvanized steel vents are in very bad condition, some of the drainage lines in the cellar, of black steel, are starting to go at the top, after 22 years' service.

St. James Building

In the St. James Building some of the drain lines have recently been removed after 20 years' service, because they gave out. One leader line also gave out and had to be removed from the 12th to the 16th floor. None of the removed pipes could be obtained for testing.

SUMMARY REGARDING DRAINS

As will be seen from the foregoing, the information as to corrosion of drain lines is not as comprehensive and direct as in the case of roof vents. Assuming however, that the corrosive conditions in the cellar drains are no more severe than observed in the roof vents, we may reasonably expect the drains to last somewhat longer, owing to their greater wall thickness, for ordinarily these pipes are of larger diameter than those seen on the roof.

Lessons Derived From The Investigation

(1) *Cast Iron Pipe and the Calked Joint.* Some of the oldest buildings inspected, such as the Produce Exchange, the Broadway Central Hotel, and a few others, were found to have a standard or light weight cast iron soil pipe installation, but as this material for pipes met with universal condemnation over 25 years ago and is not approved by any city or state plumbing regulations, it does not seem necessary to give it even the slightest consideration in this paper.

Extra heavy cast iron soil pipe, on the other hand, was found in a number of buildings, and in nearly all cases the cast iron vents were found to be evenly pitted on the inside, similar to wrought iron vents, and still good for many years' service. (See Fig. 2.) In one building, two cast iron roof pipes were found with large holes; these were, undoubtedly, pipes with sand or blow holes, which were originally defective, and the other cast iron vents on the same roof were found to be in good condition, although pitted. In one or two instances cast iron vent pipes were found to be as good as new, though they were the original pipes put in when the building was erected, in one case 36 years ago; in another case over 35 years; in another 29 years ago. In the case of one building with a cast iron system, erected 30 years ago, the roof vents were in good condition, but showed the characteristic pitting and were partly choked up at the bends with rust and dirt.

As regards the extra heavy cast iron house drains and branch wastes, it was found that the lead-calked joints had opened up, more or less, in numerous buildings. In some cases they had been repeatedly recalked, when leaks started; in other cases could be seen the calking lead forced out of the joint. This is a well known defect of the cast iron pipe system, and one which is particularly noticeable wherever large quantities of hot waste water, as from dish washing in restaurants, pass through the pipes, and also where steam exhaust or drip pipes, or boiler blow-offs, are tapped into the house sewer. Such practice has been forbidden for many years by plumbing rules and regulations, but it is nevertheless done, and usually after the building has passed official plumbing inspection. A number of such instances were encountered. In one case the main house sewer was found to be highly heated, due to the steam backing up into the house drain from the street sewer.

While it is freely admitted that cast iron pipe, from the standpoint of corrosion, is a satisfactory material for house drainage purposes, and that many of the cast iron roof vents inspected showed a much better condition as regards corrosion than anticipated, the objections to a cast iron system, well known heretofore and corroborated by this investigation, are the unsafety and unreliability of the calked joint. A calked joint can never be considered a permanent one as long as expansion and contraction cannot be eliminated.

Then, again, the further objection should be considered that cast iron pipes for plumbing purposes are cast in lengths of 5 ft., which involves the making of a much larger number of joints than in a screw-jointed pipe system, and that any of these joints, no matter how well made at first and how carefully tested, may become leaky after only a short use. Besides, it is a fact that a much greater amount of labor is involved in the erection and supporting of cast iron pipe stacks in high buildings.

(2) *Welded Steel Pipe.* The investigation showed conclusively that ***steel pipe is much inferior*** to both ***cast iron*** and ***wrought iron pipe*** when exposed to corrosive action. In many cases the black steel vents showed scaling to a considerable depth after only ten years' use. Generally speaking, galvanizing was observed to be somewhat less of a protection against corrosion on steel pipes than on wrought iron pipes. It appears that the galvanized coating does not adhere so firmly to the smooth surface of steel pipes as to the comparatively rougher surface of wrought iron pipes. The galvanizing on steel pipes showed signs of disappearing within 10 to 20 years, after which time the life of such pipe may be assumed to be merely equal to that of ordinary black steel pipe.

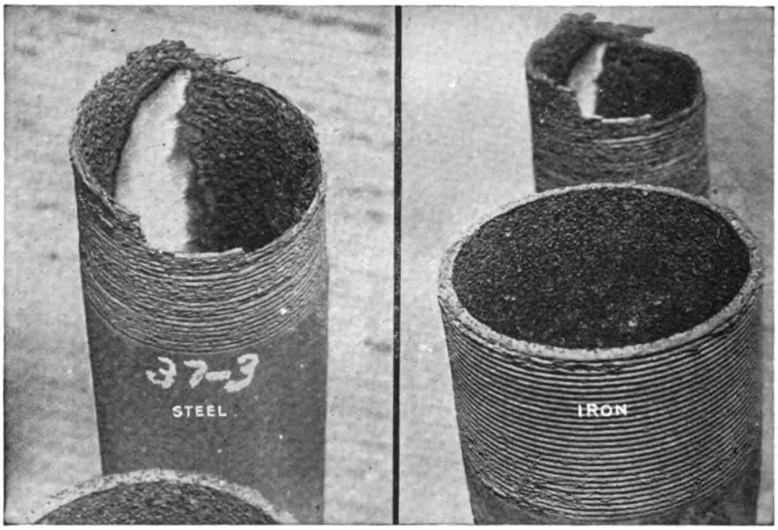
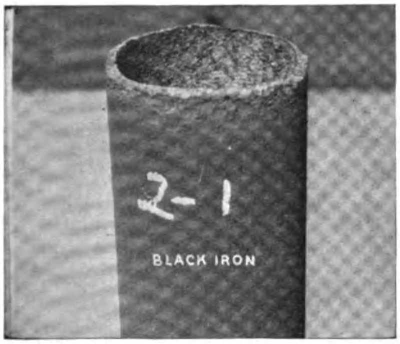
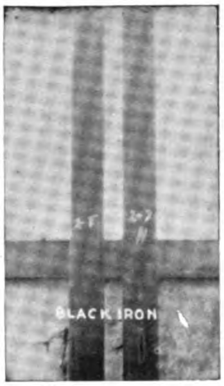


Fig. 13—Steel and Wrought Iron Vents, Both Galvanized, Side by Side on Roof, After 12 Years' Service (Home Life Building).

It should be mentioned that during the course of this examination it soon became possible to discriminate between wrought iron and steel pipes from the general appearance of the vents, and in many cases a correct guess could be made before making the manganese test or the

Wrought Iron and Steel Vents From The Bowling Green Building After 21 Years' Service





MIXED INSTALLATION

Fig. 14—Wrought Iron and Steel Vents on Roof After 21 Years' Service in the Bowling Green Building.

Wrought iron vents have suffered very little loss in thickness. No. 2-3 and No. 2-6 show two steel vents which broke off 8 or 10 ft. below the top. There is practically nothing left of the walls except rust flakes, the sleeve around them being the lead flashing. Both vents were temporarily extended up to their original height by means of a sheet metal pipe, as shown to the left of No. 2-6.

fracture test as to whether the pipe was steel or wrought iron; in only a few cases were there errors in this prognostication.

(3) *Welded Genuine Wrought Iron Pipe.* The investigation has furnished an almost overwhelming evidence ***in favor of genuine wrought iron pipe*** and ***against steel.*** To mention only one example, contrast the black wrought iron vent pipes in the Langdon Building, installed 24 years ago, with the black steel vents in the same building, as shown in Figs. 15 and 16. It was also found that the galvanized coating lasts a little longer on the wrought iron than on the steel pipes, but that ultimately the rust resistance of the base metal is of far greater importance than that of the coating.

INDISCRIMINATE USE OF WROUGHT IRON AND STEEL PIPE

The mixed steel and wrought iron installations not only afforded an excellent comparison of the life of wrought iron and steel pipe under equal conditions of service, but also emphasized the widespread substitution of the cheaper steel pipe where wrought iron is specified. The presence of steel pipe in buildings supposed to be piped with wrought iron may possibly account for the erroneous belief on the part of some engineers and architects that there is practically very little, if any, difference in the corrosion of iron and steel pipe, and hence in their respective duration of life.

The fact should also be mentioned that many architects' and engineers' specifications do not attempt to make a distinction between genuine wrought iron and steel pipe. Take, as an instance, the recent specifications for the Mechanical Equipment of Government Buildings for the Treasury, War and Navy Departments, which I was privileged to inspect. I find upon examination that these call indiscriminately for either ***wrought iron*** or ***mild steel pipes.*** They do not, apparently, give any consideration whatever to two facts of much importance, viz.—*first,* that genuine wrought iron pipe, being manufactured by the costly hand puddling process, must necessarily be more expensive than steel pipe turned out in larger bulk by the Bessemer converter process; *secondly,*

INDISCRIMINATE USE OF WROUGHT IRON AND STEEL PIPE

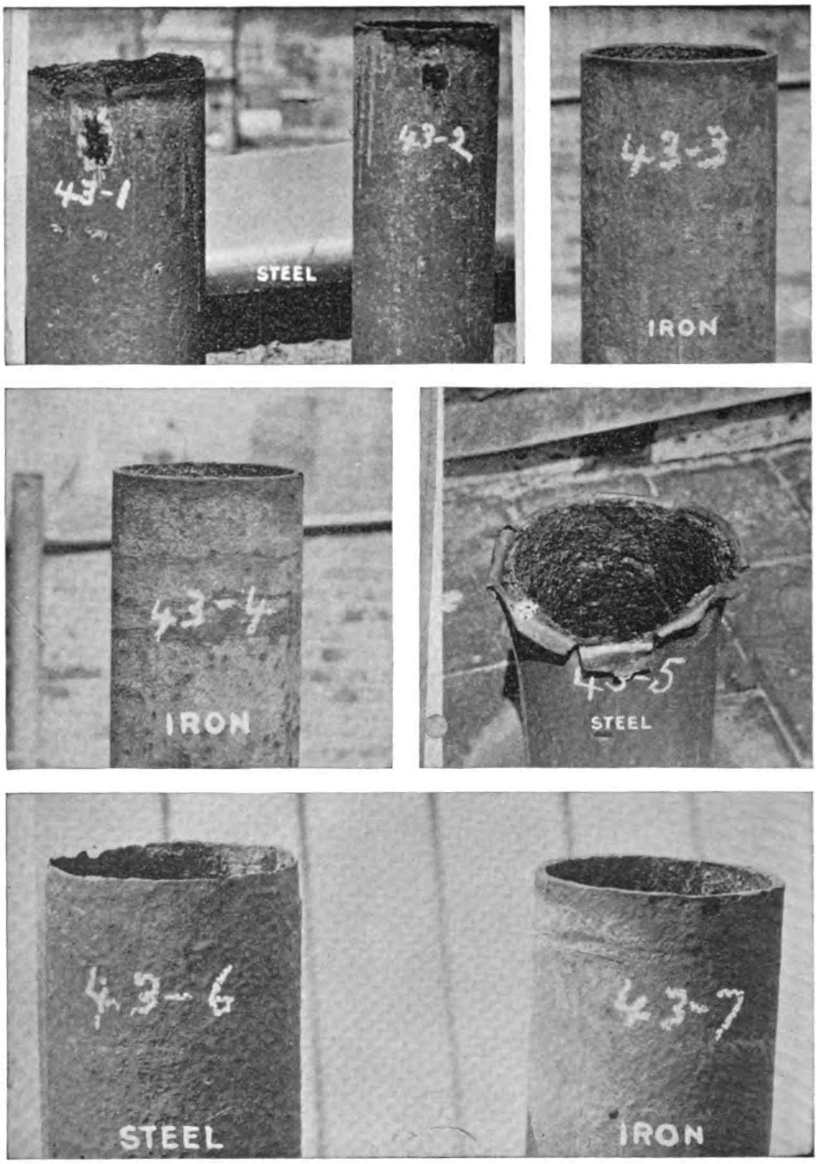


Fig. 15—Mixed Installation of Black Wrought Iron and Steel Vents After 24 Years' Service. Langdon Building.

Nos. 43-1 and 43-2 are rusted to a mere shell. Nos. 43-3 and 43-4 (wrought iron) have lost very little in thickness. No. 43-5 (steel) broke off 6 ft. below the top. Condition is shown at the fracture. The sleeve around this pipe is the lead flashing. No. 43-6 and No. 43-7 show a steel and an iron vent side by side, both 4-in. black. Steel nearly gone; wrought iron almost as good as new.

INDISCRIMINATE USE OF WROUGHT IRON AND STEEL PIPE

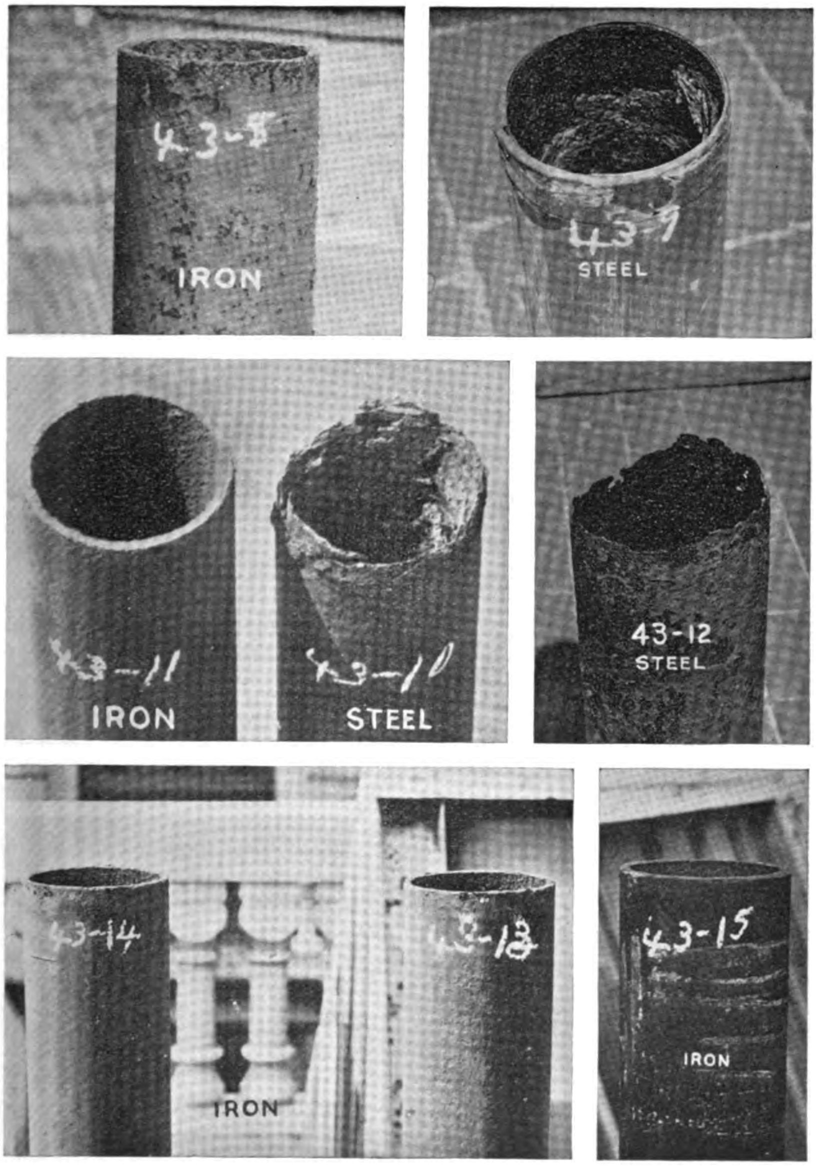


Fig. 16—Wrought Iron and Steel Vents After 24 Years' Service in the Langdon Building.

No. 43-9 shows severe flaking inside steel vent. No. 43-10 and No. 43-11 again show iron and steel pipe side by side under identical service conditions. No. 43-12 shows steel vent reduced by 24 years' service to a mere shell and completely perforated near the top. Iron vents in every case almost as good as new.

that genuine wrought iron pipe, of standard weight, has shown itself in actual service and under variety of conditions, such as hot and cold water installations, refrigeration machinery installations, house drainage systems, oil well piping, etc., to be much more resistant to corrosion than steel pipe.

Important buildings, such as those erected for the Government and also the costly skyscrapers erected by private enterprises, are expected to show a duration of life of from 50 to 100 years. Hence it follows that all important materials, particularly if inaccessible after being installed, should, as far as possible, have a corresponding life, and no material which has not, in actual practice, shown such qualities of durability can be considered as satisfactory. For this reason the writer has slowly come to the conclusion that the pipes of permanent buildings of the character mentioned should be of genuine wrought iron, either standard weight or extra heavy pipe, according to the expected life. While averse to speculating on anything covering a period of 100 years, the writer, if asked to make a conservative estimate of the life of the black wrought iron vents on the roof of the Mail and Express Building, basing it on the deterioration which they have suffered in the past 27 years, would conclude that they would last 100 years or possibly even longer. It is apparent that it makes less difference whether the pipe be black or galvanized than whether it is wrought iron or steel, even though plumbing regulations draw an arbitrary line between black and galvanized pipe, but not between wrought iron and steel pipe. Careful consideration should be given to these important facts in drawing specifications.

One fact which may also have contributed to the confusion between wrought iron and steel pipe is the practice followed by manufacturers of steel pipe, and dealers marketing it, of using the term "wrought" pipe. There is no *good* reason why steel pipe should not be called by its proper name, for is it not a fact that this use of the word "wrought" is incorrect and is intended to give a wrong impression as to the nature and character of the pipe?

SUMMARY AND RECOMMENDATIONS

a *Cast iron extra heavy soil pipe*, while satisfactory as a material from the corrosion point of view, is objectionable because of the calked joints, which cannot be depended upon to remain tight under all conditions of use.

b The *screw joint* is far superior to the calked joint. Care should be taken to cut the threads, and to have drainage fittings so tapped that the pipe can be screwed well into the shoulder of the fitting. Any portion of the thread remaining exposed can readily be protected against external corrosion by careful painting. Any fears that may have been felt as to the strength of the weld and the rust resistance of the pipe thread have not been confirmed, for such failures as were observed were due in general to extensive corrosion rather than to weld failure or localized corrosion at threads.

c It must be conceded, after the evidence furnished by this investigation, that *genuine wrought iron pipe* is a *far more durable* material for house drainage purposes *than steel pipe.*

Test Made to Determine Whether Pipe Samples Were Wrought Iron or Steel

In order to determine whether a pipe was of steel or of genuine wrought iron, the following methods of testing the pipe material were adopted.

As it was impracticable in the majority of cases to obtain larger samples of the piping, small chips from the pipe were cut off by hammer and chisel, after paint, galvanizing, rust or dust had been removed with a file. Each pipe so tested was numbered and the corresponding number put on the envelope containing the sample and marked with the name of the building. Two sample chips were placed in each envelope. The size and condition of the pipe were also noted previous to making the chemical test to determine whether the sample was steel or wrought iron. All samples obtained from a building were tested by so-called "manganese test," a very simple qualitative chemical analysis which can be readily performed by any one having the necessary testing outfit. (See Fig. 17.)

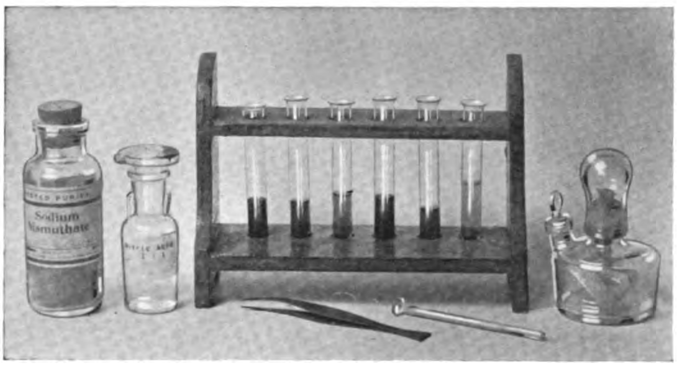


Fig. 17—Manganese Testing Outfit.

Briefly stated, the manganese test is based upon the well known fact that the manufacturers of steel pipe add to the fluid metal in the Bessemer retort or converter a certain amount of ferro-manganese in order to make it possible to roll and weld the over-oxidized metal. There is no such addition of manganese in the manufacture of genuine wrought iron pipe, which therefore contains only an insignificant amount of manganese. In making this test, each sample chip is placed in a glass test tube, and 10 to 12 drops of nitric acid, diluted with an equal amount of water, are added. The solution is then heated for a few seconds over a candle flame, or preferably an alcohol lamp. After the test tube has cooled off, a small amount of sodium bismuthate is added to the solution. If the sample is steel, a decided pink color will show in the test tube, whereas if it be wrought iron, the solution will show a light brown color, which gradually fades away, leaving a brownish residue in the bottom of the tube.

In many cases the chemical tests were supplemented by "fracture" tests, which furnished a conclusive check on the former, wrought iron showing a *fibrous* character and steel a bright *crystalline* one. In doubtful cases, larger samples of the pipe were obtained and referred to Prof. W. Campbell, of the Department of Metallurgy, Columbia University, for a microscopical examination to determine the physical characteristics of the pipe. In a few cases samples were also submitted to Dr. Fales, of the Department of Chemistry, Columbia University, for a complete quantitative manganese analysis.

The writer personally superintended the taking of the pipe samples and also personally witnessed all the chemical or manganese tests made at his office.

ACKNOWLEDGMENTS

This investigation was conducted at the request of the A. M. Byers Company, of Pittsburgh, Pa., manufacturers of wrought iron pipe and it is proper to state that the express desire of the officials of this company was to have the facts as to the life of pipe in house drainage service impartially stated, just as they were found to be, with no omissions, even if detrimental to wrought iron pipe. The writer desires to express his appreciation regarding their open and fair attitude on all questions connected with the investigation.

Acknowledgement should be made to the engineers and superintendents of the buildings visited, for the permission and assistance so freely given in inspecting the pipe systems, and for other information of value obtained from them.

Table 1—Soil and Vent Record

All Lines are Black Unless Otherwise Indicated

Investigation No.	Building and Broadway Number	Age of Installation Years	No. of Stories	Total No. of Vents	Vents Tested	Pipe Material	Condition of Vents: Cast Iron	Condition of Vents: Wrought Iron	Condition of Vents: Steel	House Drains
1	Washington 1 Broadway	29	11	4	......	C. I.	Inaccessible	....	....	Drains apparently in good condition
2	Bowling Green 11 Broadway	21	16	36	14	12 w. i. 2 steel	....	Nearly all good	Badly pitted	6 drains steel; 2 w. i. some replacements
3	Columbia 29 Broadway	28	15	40	......	C. I.	Good	....	....	1 bad joint on cast-iron drain pipe
4	Old Hamburg-American 45 Broadway	32	9	10	......	C. I.	Slightly pitting	....	....	Cellar drains could not be inspected
5	Empire 71 Broadway	20	20	30	9	Steel galv.	....	....	2 good 7 bad	House drain 2 galv. w. i. and 1 steel; c. i. at cellar wall, joint leaking
6	Trinity 111 Broadway	13	21	42	6	Galv. w. i.	....	Good	....	1 galv. w. i.; 1 galv. steel; apparently good
7	U. S. Realty 115 Broadway	10	21	38	8	Galv. w. i.	....	Good	....	1 galv. w. i.; 1 galv. steel; apparently good
8	Title Insurance 135 Broadway	16	15	12	6	5 galv. w. i. 1 Steel	....	Good	Scaling	Inaccessible
9	Washington Life 141 Broadway	21	19	7	7	6 steel 1 w. i.	....	Good	Badly gone at top	7 in. w. i. and 5 in. steel; some cast iron with leaky joints
10	Singer 149 Broadway	20 and 11	13 and tower	43	9	8 steel 1 w. i.	....	1 Bad at top	2 bad at top 6 very good	Inaccessible
11	City Investing 165 Broadway	11	26 and 33	48	12	Galv. w. i.	....	Good	....	2 w. i. good, also c. i.; good
12	Mail and Express 203 Broadway	27	10	20	20	W. I.	....	Some slightly pitted, but all lines good	....	2 w. i. good; c. i; good
13	Produce Exchange 2 Broadway	34	7	70	......	C. I. (light)	Not visible	....	....	Inaccessible
14	New York Produce Exchange Bank. 12 B'way	15	12	11	8	Galv. w. i.	....	Good as new	....	Some leaky joints on c. i.
15	Welles 18 Broadway	36	10	24	......	C. I.	Good	....	....	Some lead joints on c. i. blown out
16	Standard Oil 26 Broadway	33 and 20	15	33	25	19 galv. steel; 6. galv w. i.	....	Good	Scaling badly	2 black steel and some c. i. with leaky joints
17	Hudson 32 Broadway	20	16	15	6	4 steel 2 w. i.	....	Pitted, but good	Scaling badly	1 w. i. apparently good
18	42 Broadway	14	21	37	8	6 w. i. 2 steel	....	Very good	Badly pitted	Trouble with calked c. i. joints
19	Exchange Court 52 Broadway	21	12	44	12	2 galv. w. i. 10-in. steel	....	Good	Bad at top	2 galv. steel apparently good
20	Columbia Trust 60 Broadway	9 and 7	22	12	5	Galv. steel	....	....	Good; some scaling	8-in. galv. steel apparently good
21	Manhattan Life 66 Broadway	24	18 and tower	22	10	5 steel 5 w. i.	....	Pitted, but good	1 very good: 4 very bad	C. I., 4 joints leaking
22	Century. 74 B'way	18	19	12	6	Galv. w. i.	....	Very good	....	W. I. good
23	Union Trust Company 80 Broadway	28	12	12	4	4 galv. w. i. 8 c. i.	Good	Good	....	4 joints leaking
24	1 Wall St. 84 B'way	11	18	2	2	W. I.	....	Good	....	Inaccessible
25	1st Nat. Bk. 94 B'way	......	......	......	......	....	....	....	....	Could not inspect
26	Schermerhorn 96 Broadway	36	9	6	......	C. I.	Good but caps rusted away	....	....	Cast iron apparently good
27	American Surety 100 Broadway	25	21	15	8	7 w. i. 1 steel	....	Good, 1 pitted	Scaling badly	No sample obtainable for test: screw pipe
28	American Exch. Nat. Bank. 128 B'way	18	17	12	12	9 w. i. 3 steel	....	Good	1 bad 1 bad at top	6-in. galv. steel apparently good
29	Lawyers Title and Trust Co. 160 Broadway	10	18	11	6	6 w. i.	....	Good	....	Screw-jointed pipe, could not be tested
30	Broadway-Maiden Lane 170 Broadway	16	18	22	10	10 w. i.	....	Good	....	....

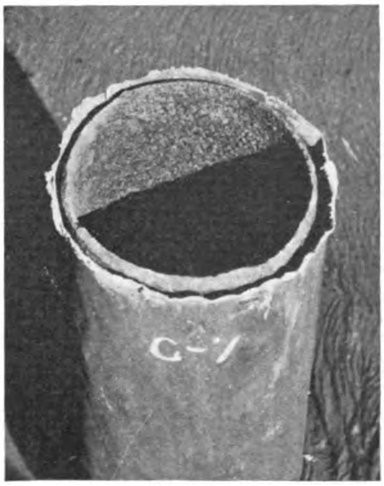
TABLE 1—SOIL AND VENT RECORD—Continued

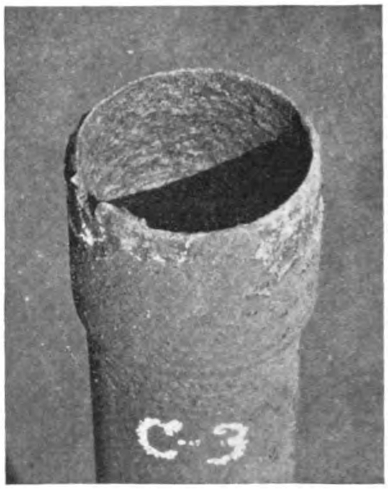
Investigation No.	Building and Broadway Number	Age of Installation Years	No. of Stories	Total No. of Vents	Vents Tested	Pipe Material	Condition of Vents: Cast Iron	Condition of Vents: Wrought Iron	Condition of Vents: Steel	House Drains
31	Title Guarantee and Trust 176 Broadway	13	9	8	4	Galv. steel	....	....	Good	One steel drain rusted through, others good condition
32	180 Broadway	16	12	4	4	3 galv. w. i. 1 steel	....	Good	Bad	Could not inspect
33	Chatham National Bank. 192 B'way	30	8	16	......	C. I.	Some pitting —mostly good	....	....	Saw 3 leaks on c. i. sewer
34	Girard 198 Broadway	16	12	11	......	C. I.	Some cracked and broken	....	....	C. I. apparently good
35	Hegeman 200 Broadway	15	6	11	......	C. I.	Some pitted; mostly good	....	....	1 c. i. joint completely forced out
36	Postal Telegraph 253 Broadway	26	14	37	3	34 c. i. 2 w. i. 1 steel	Badly pitted; 2 have holes	Good	Good	C. I. apparently good
37	Home Life Insurance 257 Broadway	25	18	13	8	7 w. i. 1 steel	....	4 pitted 3 good	1 bad at top	Mixed w. i. and steel; has failed in spots and been replaced
38	City Hall Building 261 Broadway	14	12	18	8	Steel	....	....	Scaling and pitting	W. I. and steel apparently good
39	Shoe and Leather Bank 271 Broadway	26	11	......	......	Could not inspect				
40	Broadway-Chambers 277 Broadway	18	18	8	7	Black and galv. steel	....	....	Scaling and pitting	Steel; 1 line replaced
41	East River Savings Inst. 295 Broadway	7	20	12	6	Galv. w. i.	....	Good	....	Inaccessible
42	Barclay 299 Broadway	13	18	35	11	Galv. steel	....	....	Starting to scale	1 w. i. and 1 galv. steel apparently good
43	Langdon 309 Broadway	24	14	23	15	8 w. i. 7 steel	....	Good	Scaling badly	Tested one 6-in. w. i; apparently good
44	377-379 Broadway	22	11	10	......	C. I.	Badly pitted	....	....	C. I. apparently good
45	395 Broadway	17	15	4	......	C. I.	Badly pitted	....	....	C. I. apparently good
46	St. Paul 220 Broadway	20	25	22	11	2 steel 9 w. i.	....	Slight pitting but good	Almost destroyed	One w. i. good; one 4-in. steel line failed; replaced
47	Federal Court House and Post Office	51	7	11	......	C. I. tarred	Good, some pitted	....	....	C. I. one joint leaking
48	Old A. T. Stewart 280 Broadway	34	7	13	......	W. I.	....	Good	....	Inspected inside of one c. i. drain; deeply pitted but good
49	R. G. Dun 290 Broadway	20	15	26	12	3 w. i. 9 steel	....	Good	Bad at top	Screw pipe; inaccessible
50	Vincent 302 Broadway	19	15	9	2	Galv. steel	....	....	Scaling badly	C. I. sewer has two leaky joints; screw pipe c. llar drain good
51	Citizens National Bank. 320 B'way	22	16	......	......	Could not inspect		....	....	....
52	New York Life 346 Broadway	21 and 26	13	64	33	13 black steel 18 galv. steel 1 w. i. black 1 w. i. galv.	....	Good; galvanizing lost	Most scaling badly; galvanizing lost	Galv. w. i. apparently good
53	Broadway-Leonard 350 Broadway	15	9	27	......	C. I.	Good, some pitting	....	....	C. I. apparently good
54	Royal Typewriter 366 Broadway	10	12	16	......	C. I.	Good, some pitting	....	....	C. I., 1 leak in coal cellar
55	Commercial 396 Broadway	20	10	12	......	C. I.	Good, some pitting	....	....	C. I. apparently good
56	520 Broadway	18	11	3	......	C. I.	pitted, but good	....	....	C. I. good
57	Broadway Central Hotel. 673 B'way	over 50	8	over 50	......	C. I.	Pitted, but good	....	....	Bad; counted 11 repair patches
58	New Wanamaker Broadway at 8th St.	13	14	21	10	W. I.	....	Good	....	W. I.; could not inspect; no trouble
59	McIntyre 874 Broadway	over 20	10	4	......	C. I.	Apparently good	....	....	C. I.; apparently good

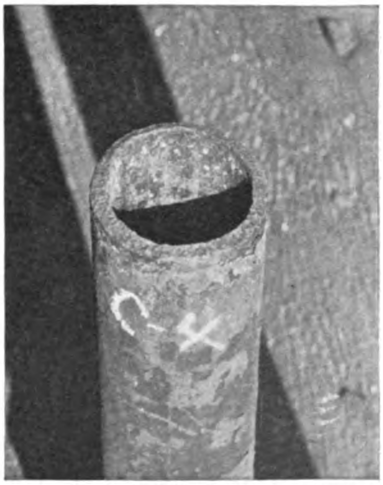
TABLE 1—SOIL AND VENT RECORD—Continued

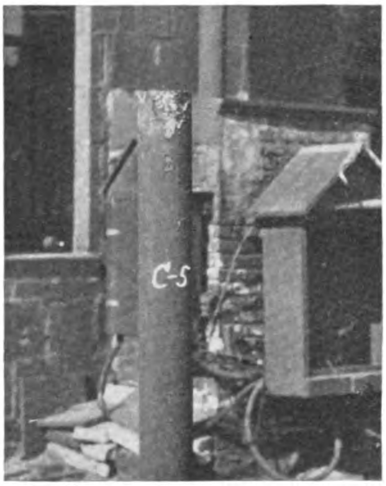
Investigation No.	Building and Broadway Number	Age of Installation Years	No. of Stories	Total No. of Vents	Vents Tested	Pipe Material	Condition of Vents: Cast Iron	Condition of Vents: Wrought Iron	Condition of Vents: Steel	House Drains
60	Reis 889 Broadway	25	8	2	......	C. I.	Pitted, but good	....	....	C. I.; apparently good
61	Flatiron 949 Broadway	16	23	20	10	W. I. galv.	....	3 slightly scaling; 7 good	....	Apparently good
62	Fifth Avenue 200 Fifth Avenue	9	14	42	......	Steel, galv.	....	....	Apparently good	Apparently good
63	Townsend 1123 Broadway	22	12	24	10	Steel, black and galv.	....	....	Black vents nearly destroyed; galvanized bad	W. I.; some lines starting to corrode at top
64	St. James 1133 Broadway	20	16	31	14	7 steel 7 w. i.	....	All good	Pitting and scaling badly	1 length tested; w. i. some replacements of screw pipe
65	Johnston 1170 Broadway	15	12	22	10	Steel galv.	....	....	Scaling at top and inside	1 test; w. i.; apparently good
66	Centurian 1182 Broadway	8	16	14	......	W. I., galv. "Byers"	....	Good as new	....	Inaccessible; screw pipe no trouble
67	Hotel Breslin 1194 Broadway	14	13	62	6	W. I. galv.	....	Good as new	....	1 test; w. i.; apparently good; galv. screw pipes and c. i., good condition
68	Hotel Imperial	29	9	......	......	....	Pitted, but good	....		....
69	" " 1252 Broadway	new part 18	17	21	8	Steel galv.	....	....	2 good; 6 scaling badly	
70	Martine 1261 Broadway	9	11	4	2	Steel galv.	....	....	Good as new	C. I. and screw pipe, apparently good
71	Martinique Hotel 1266 Broadway	21	16	23	10	5 galv. steel and 5 w. i. galv.	....	4 good 1 scaling	2 bad; 3 good	Galv. steel, apparently good
72	Martinque Hotel 1266 Broadway	addition 9	16	29	11	Steel galv.	....	....	4 good; 7 bad	....
73	R. H. Macy Co. 1317-29 Broadway	16	10	21	4	3 steel and 1 W. I. galv.	Good condition	Good	2 bad; 1 galv. lost	6-in. galv. steel; apparently good
74	Hotel Marlborough 1361 Broadway	about 35	6	31	......	C. I.	Pitting, but good	....	....	C. I. Standard and extra heavy; many leaky joints
75	Hotel Normandie 1388 Broadway	about 35	8	27	......	C. I.	Deeply pitted	....	....	C. I. apparently good
76	Knickerbocker Theater 1400 Broadway	25	5	13 old	......	C. I.	Pitted	....	....	C. I., good
77	Knickerbocker Theater 1400 Broadway	new part 13	13	new 17	12	W. I. galv. 11 Steel galv. 1	Deeply pitted	Good as new	Scaling badly	Screw drain in coal cellar replaced 1915
78	Metropolitan Opera House. 1425 B'way	36	7	14	......	C. I.	Evenly pitted	....	....	C. I., some trouble with leaky joints
79	Hotel Continental 1450 Broadway	about 35	10	26	......	C. I.	Slightly pitted	....	....	C. I., apparently good
80	Hotel Calvert 1454 Broadway	25	6	18	4	8 C. I.; 3 galv. w. i.; galv. steel	Slightly pitted	Slightly pitted	Slightly pitted	Inaccessible
81	Knickerbocker Hotel 1470 Broadway	12	15	20 main roof 15 pent house	10 10	9 galv. steel 1 w. i. galv. 5 steel 5 W. I.	....	Galv. lost Pitted, but good	Some scaling Scaling badly	Inaccessible

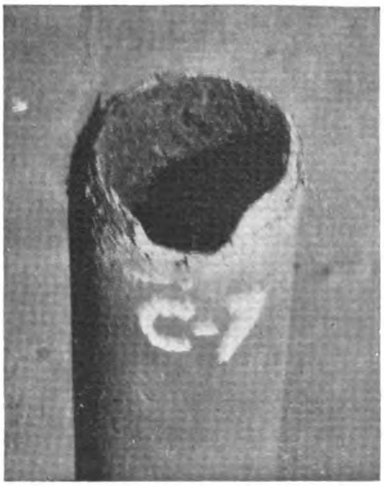
35 YEARS' SERVICE











BLACK WROUGHT IRON VENTS IN THE COUNSELMAN BUILDING

Erected 1883.

The vents on this building—8 in all—are black wrought iron, in an excellent state of preservation, in spite of 35 years' service. As the lead coping is absent, the condition of each vent is clearly shown. Nos. 7 and 8 are corroded at the top but good inside.

PLATE No. 1
BLACK WROUGHT IRON VENTS IN THE COUNSELMAN BUILDING
CHICAGO, ILL.

Investigation of Corrosion in House Drainage Piping in Chicago

Paper Presented at Eleventh Annual Meeting
of the
American Society of Sanitary Engineering
Congress Hotel, Chicago, Oct. 14 and 15, 1918

by
THOMAS J. CLAFFY
Ass't Chief Sanitary Inspector, City of Chicago
and President A. S. S. E. 1900-1918

It has been observed for some time by those in close touch with plumbing installations in Chicago and elsewhere that under certain conditions, iron pipe is affected seriously by rust. The corrosive element, whatever it may be, seems to have more effect on one kind of pipe than on another, and also to be worse in some buildings than in others.

In previous investigations conducted by the Research Committee of this Society, special attention was given to the house drains and sewers. It was suggested to the author some months ago that some attention should be given the pipe in the system above the basement or cellar floor. An investigation of this kind appeared to be not only practical but of great value if successful. About May 1st an inspector was, therefore, assigned to make a canvass of that portion of the down-town section of Chicago covering La Salle, Clark and Dearborn Streets, between Randolph and Van Buren Streets. In this section we find nearly all of the large office buildings, several banks, and the Municipal and County Buildings. Also, the U. S. Government Building, which contains the Post Office and Federal Courts. On account of war conditions, the investigation did not include this building. We aimed to confine our attention to buildings 6 stories and upwards, and over 5 years old. One or two less than five years were included because of the conditions noted in buildings very close to that age.

THE INTRODUCTION OF SCREW PIPE

Cast iron pipe has been recognized for many years as a very durable material for soil, vent or drainage purposes and, consequently, has been much used in building construction and, no doubt, its use will continue. When construction of buildings over six stories high began, a new epoch was introduced in building construction and we very shortly had buildings twice that height and higher. About 30 years ago began the common use of screw pipe in plumbing systems in such buildings. With the introduction of special recessed drainage fittings such pipe soon became exclusively used, and the entire system became known as the Durham System of House Drainage, Mr. Durham being the inventor of the fittings used. Because of the fact, noted in recent years, that there is a great deal of corrosion in drainage pipe systems, it was deemed expedient to find out, if possible, the relative life and merits of cast iron, wrought iron and steel pipe in such systems.

METHOD OF INVESTIGATION

In making this investigation, the inspector was required to report on the height and age of each building separately; the number of vents at the roof line; size; and whether pipe was cast iron or screw joint; to obtain a sample where possible for test purposes; and under the head of "Remarks," to describe such conditions as were found. Photographs were obtained of sufficient vents on the roofs to show an existing average of their condition. The inspector also was required to state whom he interviewed, whether the owner, superintendent, engineer or other person. In order to distinguish between wrought iron and steel pipe, it was necessary to take samples for test, filings being obtained for chemical tests and pieces of the pipe for fracture tests. In obtaining filings, the outside skin, which was generally either a heavy coat of paint or a coat of rust, was filed away and filings of the clean metal procured. These samples were sealed in individual envelopes and numbered, the numbers on the envelope corresponding with the numbers on the investigation reports describing the condition of each waste, vent, drain or soil pipe, together with the name of the building.

Wrought Iron and Cast Iron in Same Service

No. 6
35 Years Old.
Cast Iron Pipe.
Gaff Building.

No. 8
35 Years Old.
Wrought Iron Pipe.
Gaff Building.

No. 9
35 Years Old
Cast Iron Covered by
Lead Coping.
Gaff Building.

PLATE No. 2

Wrought Iron and Steel in Same Service

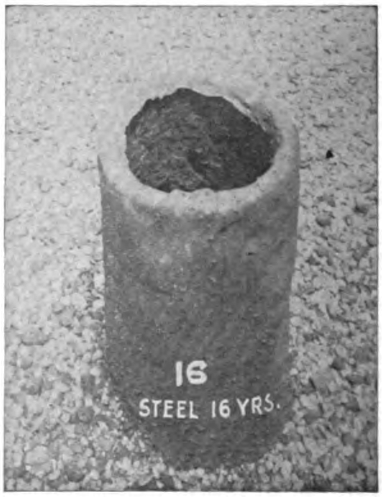


Plate No. 3—NATIONAL LIFE BUILDING, ERECTED 1902, CHICAGO.

Nos. 14 and 16 are typical of the steel vents on this building, which are from 50 to 75 per cent destroyed. No. 15 shows iron vent on same roof, corroded, but only to a small extent.

CHEMICAL TEST OF PIPE

All samples were tested by the so-called manganese test, a very simple qualitative chemical analysis which may readily be performed by anyone having the necessary inexpensive outfit. (See photograph on page 12.)

In the manufacture of steel pipe, it is well known that to the molten metal in the Bessemer converter a certain amount of Ferro-manganese is added in order to make it possible to roll and weld the over-oxidized metal. There is no such addition of manganese in the manufacture of wrought iron. The latter metal contains only a very insignificant amount of manganese, such as may have been contained in the original ore. In making this manganese test, each sample of filings is placed in a glass test tube. The amount need only be a few grains. To this is added 10 drops of nitric acid diluted with an equal part of water. The solution is then heated for a few seconds over a flame and allowed to cool off. When cooled, a small amount of sodium bismuthate is added. If the sample is steel, a decided pink color will show. If it be wrought iron, the solution will show a light brown color, which gradually fades away, leaving a brownish residue in the bottom of the tube. In several cases, these tests were supplanted by fracture tests, which furnish a conclusive check on the manganese test. Wrought iron fractures show a fibrous character of metal, and steel a brilliant crystalline one. For the purpose of these investigations, the tests outlined answered the purpose.

LIFE OF BUILDINGS

A notable feature of the Chicago skyline (which it evidently shares with all our large cities) is the fact that skyscrapers are as yet largely in the minority as compared with buildings only 6 or 8 stories high, making the skyline of each street very uneven and jagged. A very large proportion of these smaller buildings are upwards of 30 and 40 years old.

At the same time we find steel frame structures or skyscrapers from 20 to 30 years old which stand out as landmarks almost as strongly as they did at the time they were built. In spite of the tremendous growth of the city, it is noteworthy that the question of obsolescence of large buildings has not been and will not have to be reckoned with within any period we can foresee. This leads to the conclusion that the prospective life of representative buildings may be very great, probably upwards of 75 or 100 years. It can readily be seen that this has a vital bearing on the selection of pipe which has to be buried in the walls and partitions.

DATA COLLECTED

The table herein contains a brief summary of the data collected, showing the name and location of each building, the age of pipe installations, the total number of roof terminal vents, number of screw pipes tested to determine whether of wrought iron or steel, and the condition of all pipes with respect to corrosion at time of investigation.

Altogether, 63 buildings were investigated, in all but two of which more or less complete data was obtained. In age, these buildings range as follows:

30 years up	13 buildings
25 to 29 years	18 "
20 to 24 years	6 "
15 to 19 years	3 "
10 to 14 years	12 "
8 years or less	11 "
	63

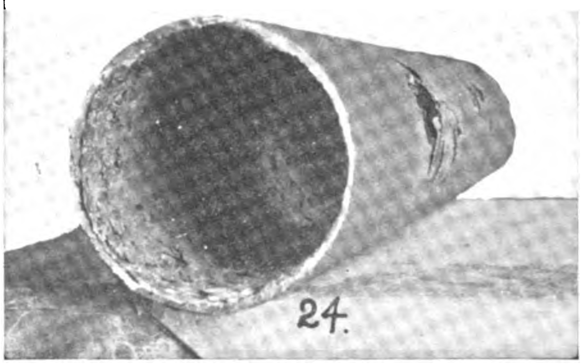
Dividing these buildings, according to the kind of pipe used in their drainage systems, we find—

1.	Cast iron in	15 buildings
2.	Wrought Iron in	8 "
3.	Steel in	19 "
4.	Mixed W. I. and Steel in	11 "
5.	C. I. mixed with W. I. or Steel in	10 "
		63

PLATE No. 4

Wrought Iron Vent
28 Years
Monon Building

Piece of black wrought iron vent rusted through and removed after 28 years' service. One of the exceptional cases of destruction of wrought iron found in the investigation.



PHOTOGRAPHS

A number of photographs were obtained in an effort to show the average condition of terminal vents. Unfortunately, many of these photographs leave much to be desired in clearness, something which is principally due to the lead coping entirely covering the exterior and top of the pipe above the roof. It is, therefore, difficult to depict the interior corrosion, as this is usually best revealed by the thinness or thickness of the pipe around the edge at the top. Only to a smaller degree is the degree of corrosion indicated by the flaking or pitting of the interior surface, as a thin crust of rust flakes in a photograph does not look very different from a heavy crust of rust flakes. Hence it is necessary to note the description under most photographs of pipes in order to obtain a better idea of their true condition.

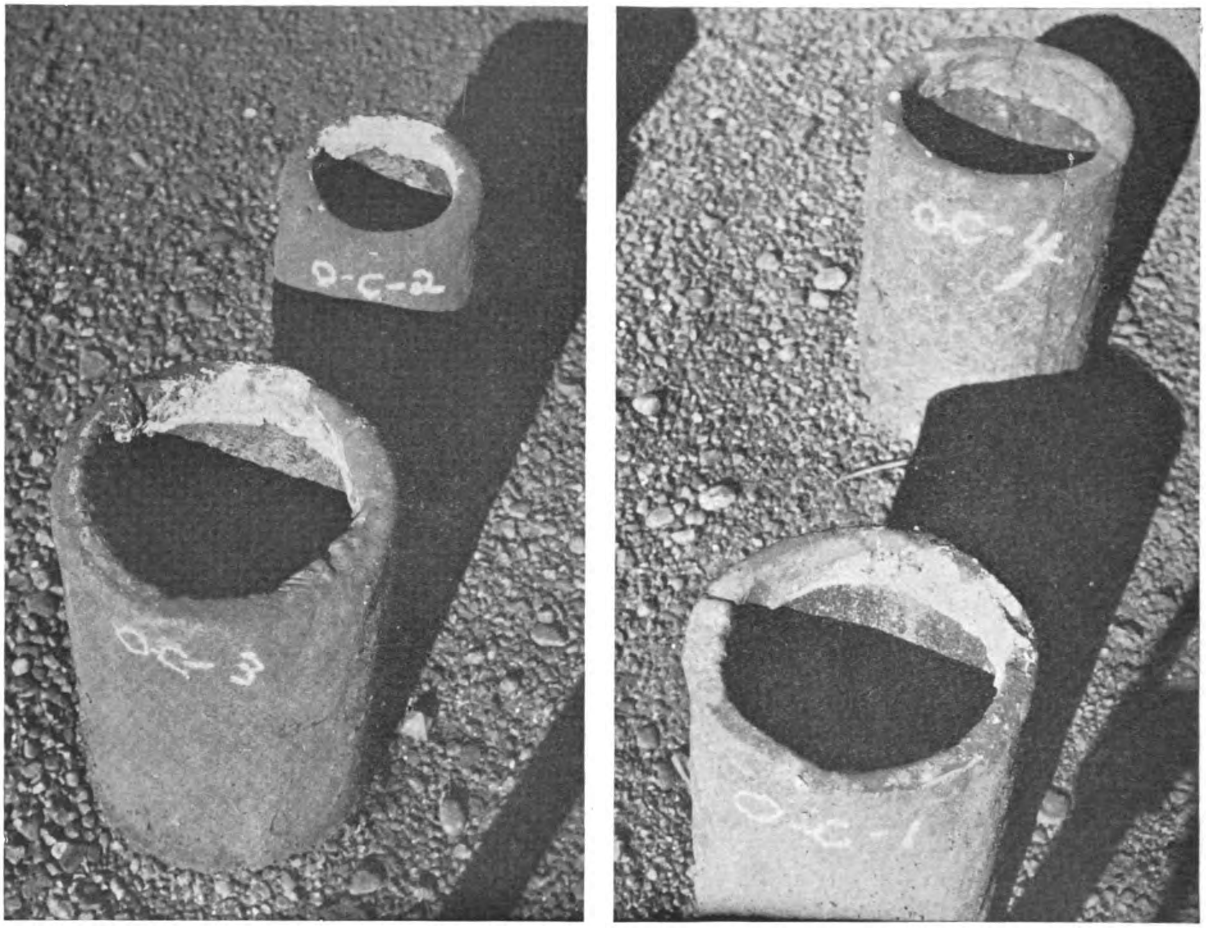


Plate No. 5—WROUGHT IRON, 28 YEARS OLD.

Old Colony Building, Chicago. The black wrought iron vents—19 in all—are in good condition.

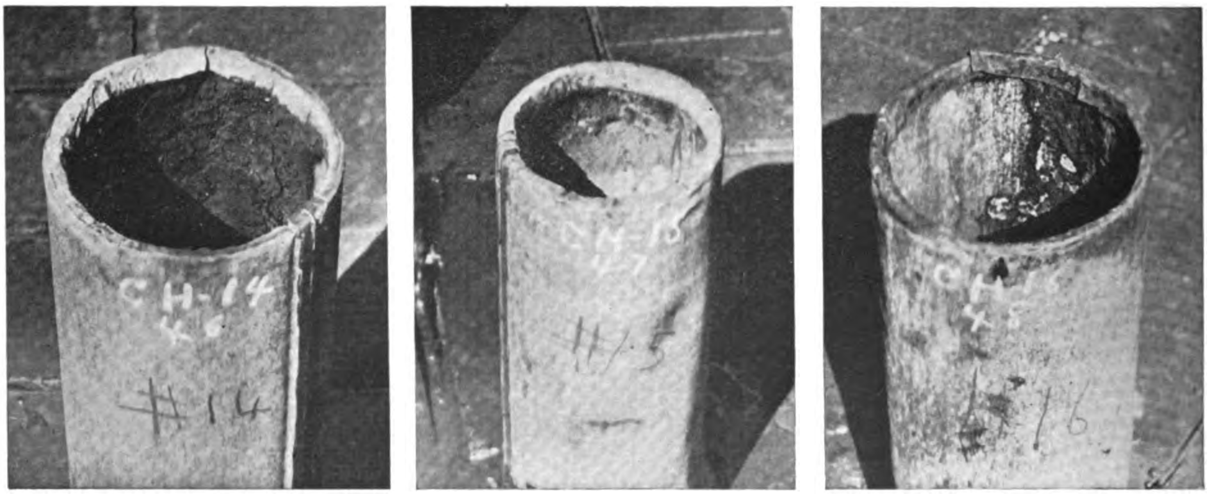


Plate No. 6—STEEL PIPE, 7 YEARS OLD.

CITY HALL, CHICAGO, ILL. ERECTED 1911.

42 galvanized steel vents already scaling badly after 7 years' service.

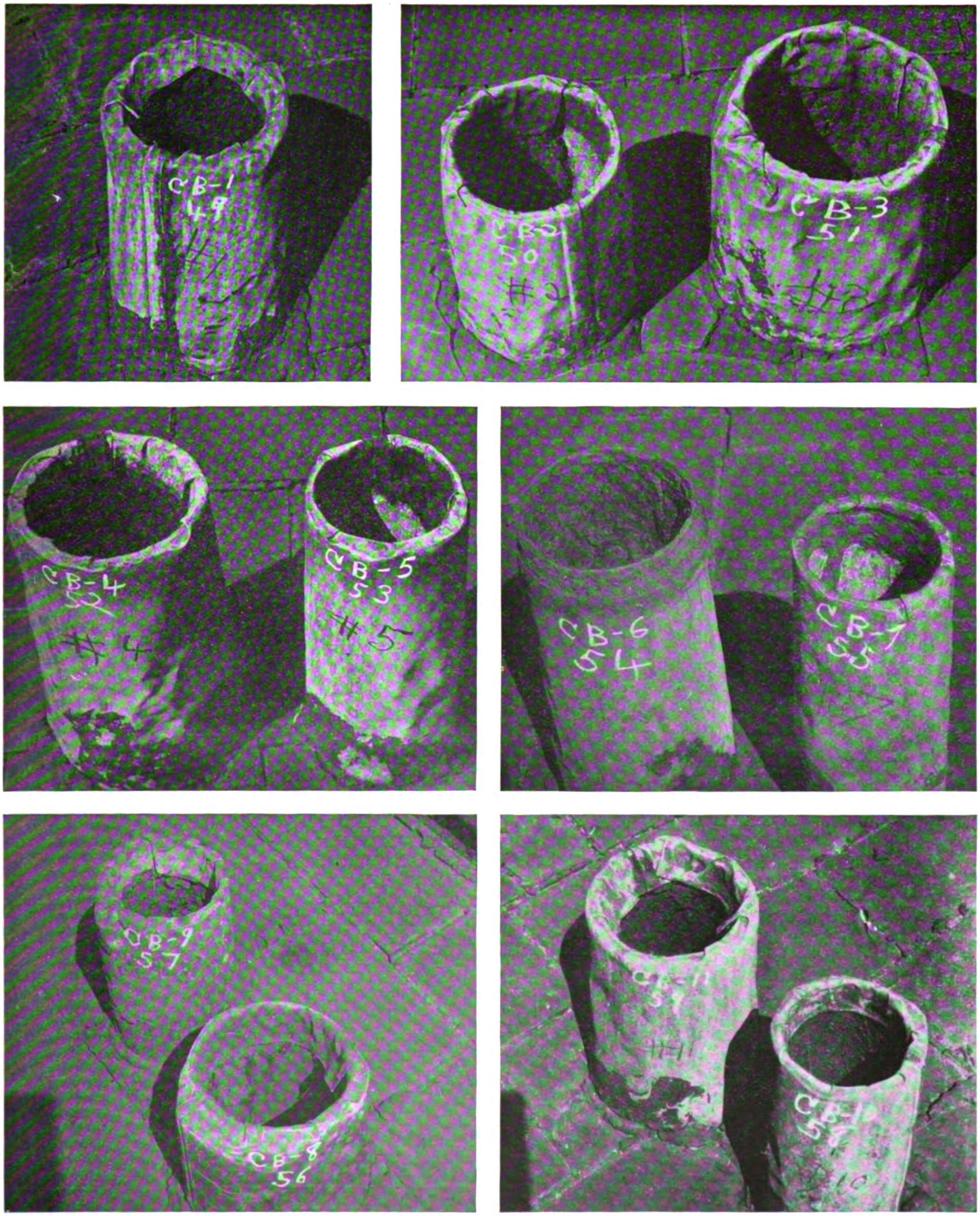
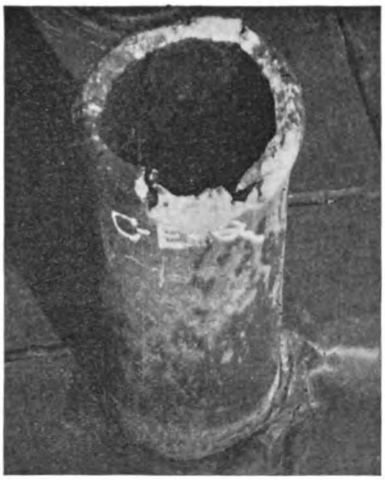


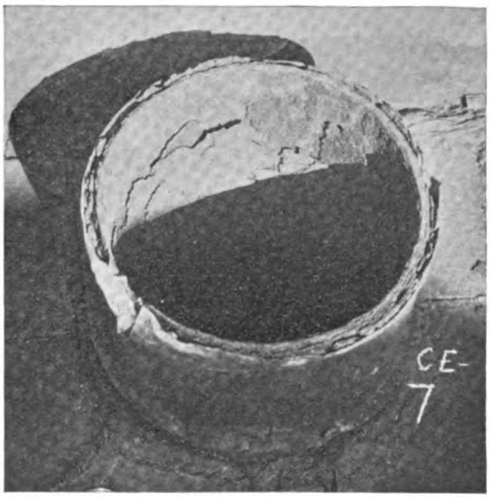
Plate No. 7

STEEL PIPE, 10 YEARS OLD, COOK COUNTY BLDG., CHICAGO.

All the black steel vents on this building are from 50 to 75 per cent destroyed by corrosion.
17 galvanized steel vents on same roof are already scaling badly.
All installed in 1908.

PLATE No. 8





STEEL PIPE, INSTALLED 1908 IN THE CORN EXCHANGE BANK BUILDING, CHICAGO, ILLINOIS.

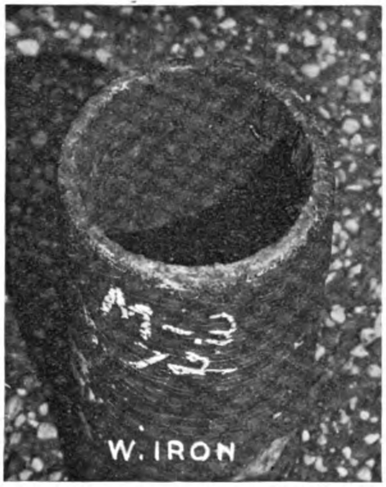
No. 1—Scaling badly.
No. 2—Almost destroyed, only thin shell remaining.
No. 3—About 25% destroyed.
No. 4—Almost destroyed, only thin shell remaining.
Nos. 5 and 7—About 25% destroyed.
No. 6—About 50% destroyed.

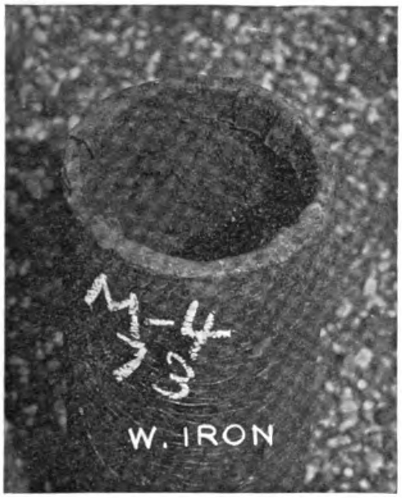
NOTE:—Although vent No. 7 is in better condition than most of the others, the photograph shows the severe corrosion more clearly due to the removal of the coping at the top. All of these vents are only 10 years old, and of black steel.

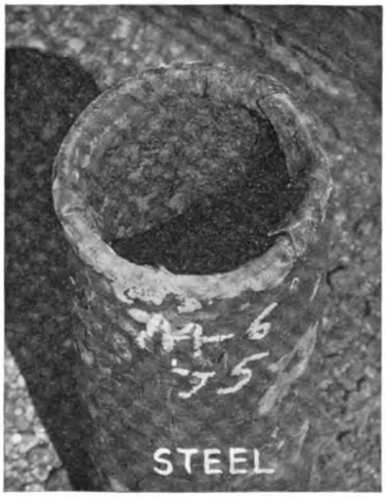
All steel,—10 years old.

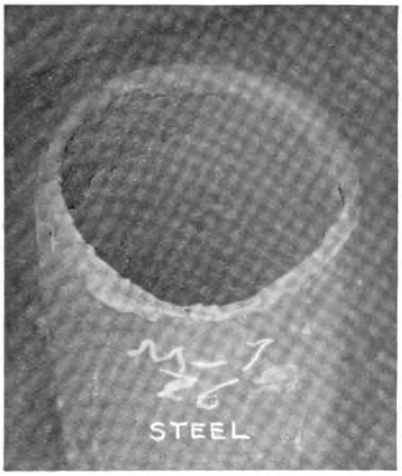
ALL STEEL, 10 YEARS OLD

PLATE No. 9









WROUGHT IRON AND STEEL PIPE, INSTALLED 1894—MARQUETTE BUILDING, CHICAGO.

Nos. 1 and 2—Nearly destroyed (steel b.)
Nos. 3 and 4—Pitted but in good condition (wrought iron b.)
Nos. 5 and 7—Scaling badly, from 50 to 80 per cent destroyed (steel b.)
No. 6—Scaling badly (steel b.)

MIXED STEEL AND WROUGHT IRON INSTALLATION

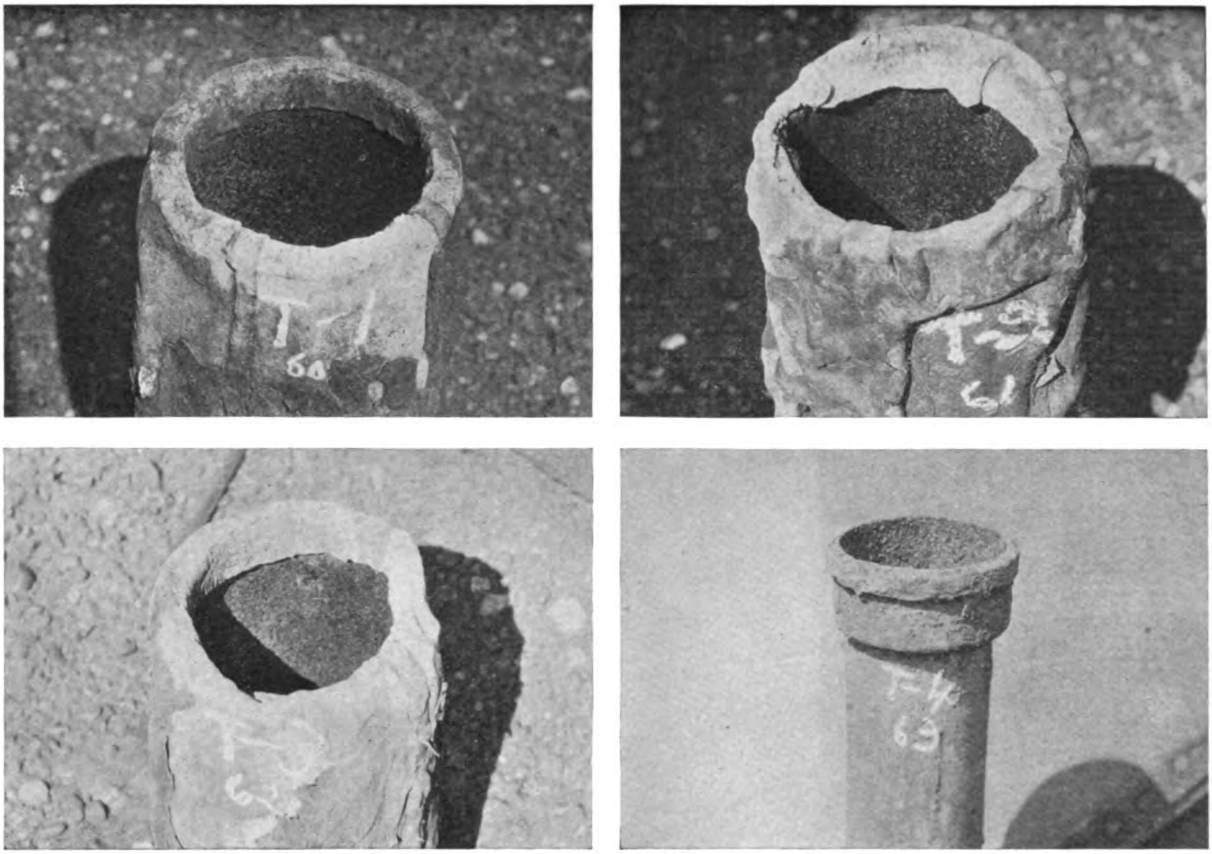


Plate No. 10

WROUGHT IRON AFTER 30 YEARS' SERVICE,
TACOMA BUILDING, CHICAGO.
ERECTED 1888

All the black wrought iron (as well as the cast iron) vents on this building are in an excellent condition. Slightly pitted, but very little loss in thickness.

Tabulated Records of Pipe Corrosion in Buildings Investigated

NOTE: Letter (g) after the words "iron" or "steel" means galvanized. Letter (b) means black. Where no letter is appended, it is understood the pipe is black.

TABLE 1—SOIL AND VENT RECORD

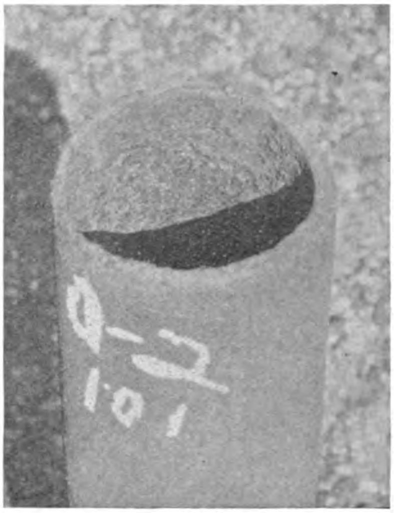
Inv. No.	Name and Location of Building	Age of Instal-lation	No. of Stories	Total No. of Vents	Vents Tested	Pipe Material	CONDITION OF VENTS			Remarks
							Cast Iron	Wrought Iron	Steel	
1	Cunard Building, 140 No. Dearborn	2 yrs.	14	8	8	Steel g.	....	....	6 good as new; 2 started to scale	
2	Lumber Exchange, 3-11 So. LaSalle	3 "	16	16	......	Steel b and g.	....	....	Good	
3	Westminister Building, 110 South Dearborn	5 "	17	11	8	8 steel g.	....	....	1 scaling; 2 galvanizing slightly attacked; 5 good as new	
4	City Hall Sq., 139 No. Clark Street	6 "	21	13	......	13 C. I.	Pockmarked, but good	....	....	

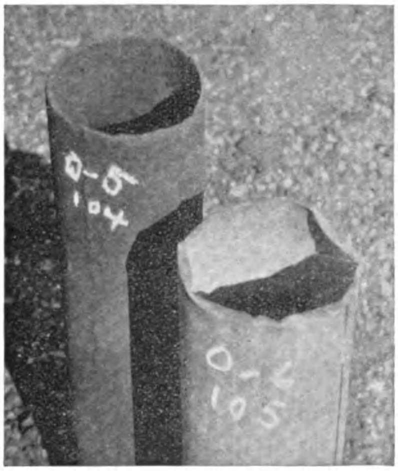
TABLE 1—SOIL AND VENT RECORD—Continued

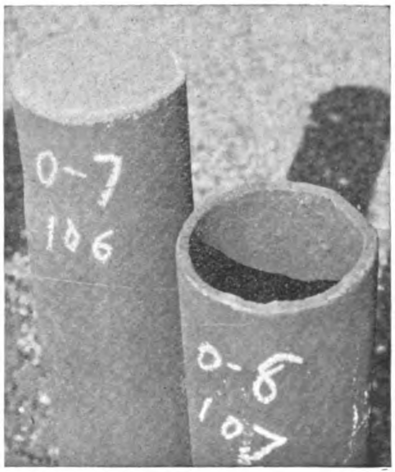
All Lines are Black Unless Otherwise Indicated. Letter (g) means galvanized.

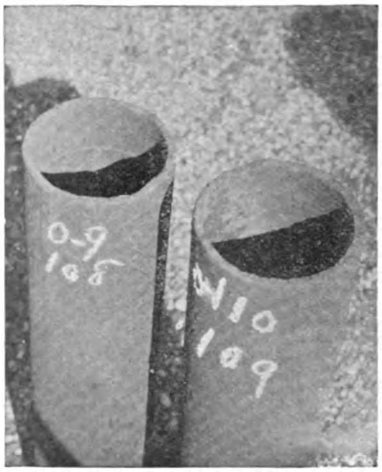
Inv. No.	Name and Location of Building	Age of Instal-lation	No. of Stories	Total No. of Vents	Vents Tested	Pipe Material	Condition of Vents: Cast Iron	Condition of Vents: Wrought Iron	Condition of Vents: Steel	Remarks
5	Y. M. C. A. 19 So. LaSalle	6 yrs.	16	17	17	Steel g.	....	....	One scaling; 15 pitted; 1 O. K.	Four top floors steel, built 6 years. W. I. soil pipe branch 25 years old—rusted through at top
6	Com. Nat'l Bk., 208 So. LaSalle	6 "	21	......	......	Steel b. and g.	....	....	One scaling slightly—some pitting	....
7	Hotel Planters, 19 No. Clark Street	7 "	9	22	12	12 steel g.	....	....	9 scaling at top; 3 good as new	....
8	Otis Building 10 So. LaSalle	7 "	16	32	10	10 steel g.	....	....	Scaling at top; galvanizing partly destroyed	....
9	City Hall	7 "	11	42	16	Steel g.	....	....	Scaling badly	....
10	Hotel Sherman 156 No. Clark	8 "	15	33	18	18 steel g.	....	....	12 scaling slightly; 3 scaling badly; 3 galvanizing attacked	....
11	Hotel LaSalle	9 "	18	33	14	2 W. I. g. 10 steel g.	....	Galvanizing destroyed but otherwise good	Nearly all scaling badly at top	Two steel vents were added 1914 and are still good as new
12	Cook County Building	10 "	11	34	15	17steel g. 17 steel b.	....	....	8—75% destroyed; 9 50% destroyed, 17 galvanizing scaling badly	One 5" line clogged up with rust below roof
13	The Daniel Hayes, 109 No. Dearborn	10 "	13	8	5	Steel g.	....	....	3 good as new; 2 scaling	....
14	Corn Exchange 134 So. LaSalle	10 "	17	36	7	Steel b.	....	....	All scaling badly; ¼ to ¾ gone	....
15	Great Northern Hotel, Jackson and South Dearborn	10 "	14	39	8	1 W. I. b. 7 steel b.	....	Scaling 25%	Most lines over 75% destroyed	Tested 2 cellar drains, black W. I., installed 1892; pitted, but no leaks
16	Edison Building 125 So. Clark	11 "	19	66	15	9 steel g. 6 steel b. 6 C. I.	Good	....	Galvanizing scaling at top. Black lines about 75% destroyed	....
17	Tribune Building, 7 So. Dearborn	12 "	18	16	6	1 W. I. g. 5 steel g.	....	Good as new	About 50% destroyed by scaling	One drain tested—black steel—apparently good
18	Fisher Building 343 So. Dearborn	12 "	20	13	6	6 steel g.	....	....	Starting to scale	....
19	Borland, 105 So. LaSalle Street	13 "	19	......	......	Steel b. and g.	....	....	2 lines destroyed in 10 years	....
20	Standard Trust and Savings Bank, Monroe and Clark	13 "	16	23	4	4 W. I.	....	All vents pockmarked but good	....	....
21	Fort Dearborn Bank, 74 West Monroe	13 "	18	32	5	4 steel b. 1 steel g. 3 C. I.	Good as new	....	All 32 lines scaling badly. Most over 50% destroyed	1 vent (4" g. steel) installed as relief vent 1910; still good
22	First National Bank, Monroe Street	14 "	18	86	4	4 steel b.	....	....	about 50% destroyed by scaling	32 lines (not tested) in same condition as those tested
23	Rector Building, Monroe and Clark	14 "	14	20	7	7 steel b.	....	....	All but one line nearly destroyed by scaling	....
24	Republic Building, 209 State Street	16 "	19	22	6	6 steel g.	....	....	Galvanizing nearly gone; some scaling	Two cellar drains rusted out and replaced. Another line is rusted through in two places. All these are steel

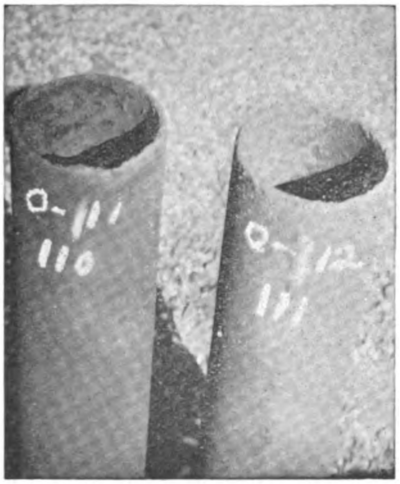
PLATE No. 11











CAST IRON, INSTALLED IN 1892
OXFORD BUILDING, CHICAGO.

The photos give a good idea of the destruction of the cast iron vents after 26 years' service.

No. 1—Rusted to a thin shell and broken.
No. 2—In fairly good condition, but scaling considerably inside.
No. 3—Completely destroyed above roof, due to rusting extending down inside.
Nos. 4 and 6—Same as No. 3 and replaced by galvanized sheet metal.
No. 5—Rusted to a thin shell.
No. 7—Rusted badly and abandoned.
Nos. 8 to 12—Fairly good at top but pitting and scaling badly down inside.

TABLE 1—SOIL AND VENT RECORD—Continued

All Lines are Black Unless Otherwise Indicated. Letter (g) means galvanized.

Inv. No.	Name and Location of Building	Age of Instal-lation	No. of Stories	Total No. of Vents	Vents Tested	Pipe Material	Condition of Vents			Remarks
							Cast Iron	Wrought Iron	Steel	
25	National Life Building, 29 So. LaSalle	"	13	20	7	6 steel b. 1 W. I. b.	....	1 scaling slightly	4 vents 50% destroyed; 2 vents only thin shell left	....
26	Merchant Loan and Trust, 140 So. Clark	18 "	12	41	9	7 steel b. 2 W. I. b. 4 C. I.	Good	Scaling slightly	Scaling badly; nearly destroyed over 50%	....
27	Ashland Block, 201 No. Clark (New addition)	20 "	16	3	3	3 steel	....	....	Gone to a shell	....
28	Straus Building 6 No. Clark	21 "	10	10	5	Steel b.	....	....	Scaling badly; ¼ to ¾ gone	Black steel 6" drain in cellar (suspended). Hole rusted through on top
29	Portland Building, 35 No. Dearborn	21 "	6	15	2	2 W. I. 13 C. I.	3 good; 8 pitted; 2 scaling badly (50% to 90%)	about 25% destroyed	....	6 cast iron vents clogged with rust at increaser below roof
30	Fisher Building 343 So. Dearborn	22 "	20	19	10	10 W. I.	....	Scaling badly		....
31	Marquette Building 140 So. Dearborn	24 "	17	34	7	5 steel b. 2 W. I. b.	....	Pockmarked, but good	Scaling badly. Only a thin shell remaining of 3 vents	....
32	New York Life, 39 So. LaSalle	24 "	14	40	6	4 W. I. b. 2 steel b. 2 C. I.	Scaling down inside	3 scaling slightly; 1-25% destroyed	1 nearly destroyed; 1 painted at top—good	Have had to recalk several leaky joints on C. I. drain. Two joints now require repairing
33	Western Union, 300 So. Clark	25 "	11	6	1	6 C. I.	Good	....	A 5" steel vent was installed 1909; scaling slightly	....
34	Chicago Stock Exchange, 30 No. LaSalle	25 "	13	19	11	9 steel b.	....	....	Practically destroyed; some replaced	Galvanized steel used for vents replaced
35	Teutonic Building 79 W. Washington Street	26 "	10	11	6	3 W. I. 3 steel	....	Scaling badly	Scaling badly; nearly gone at roof	....
36	Boyce Building 30 No. Dearborn	26 "	12	13	......	13 C. I.	Nearly all pockmarked and scaling	....	....	....
37	Oxford Building, 118 So. LaSalle	26 "	8	29	......	29 C. I.	Over 50% destroyed. Some completely gone	....	....	....
38	Monadnock Block, 53 E. Jackson	27 "	17	39	10	W. I. b.	....	Pitted, but in good condition	....	General condition good. Pitting deep in some lines
39	Ashland Block, 201 N. Clark (Original building)	26 "	16	20	20	20 W. I.	....	Scaling slightly	....	....
40	Unity Building 127 No. Dearborn	27 "	16	23	6	5 W. I. b. 1 steel b.	....	3 good (painted); 2 about 25% loss	Completely corroded and broken off	Length of 6" cellar drain of steel replaced 1918, due to rusting through
41	Tacoma Building 5 No. LaSalle	30 "	12	6	3	1 C. I. 5 W. I.	Pitted slightly	Pitted over inner surface	....	Pipe generally in good condition
42	Chicago Title & Trust, 69 W. Washington	27 "	16	21	......	21 C. I.	19 pockmarked and scaling; 2 good as new	....	....	....
43	W. C. T. U. 108 So. LaSalle	28 "	12	......	2	W. I.	....	Pitted, but good	....	....
44	Old Colony, 37 W. Van Buren	28 "	16	19	2	W. I. b.	....	Evenly pitted on inner surface	....	....
45	Masonic Temple, 159 N. State	28 "	21	......	4	W. I.	....	All in good condition	....	Could not get on roof

TABLE 1—SOIL AND VENT RECORD—Continued

All Lines are Black Unless Otherwise Indicated. Letter (g) means galvanized.

Inv. No.	Name and Location of Building	Age of Instal-lation	No. of Stories	Total No. of Vents	Vents Tested	Pipe Material	CONDITION OF VENTS			Remarks
							Cast Iron	Wrought Iron	Steel	
46	Caxton Building, 508 So. Dearborn	28 yrs.	12	6	......	C. I. X. H.	Slightly pitting	....	....	Vents visible and in good condition
47	Chamber of Commerce Building, 133 W. Washington	28 "	14	17	10	W. I.	....	Good. 3 about 50% destroyed at top	....	....
48	Monon Building, 440 So. Dearborn Street	28 "	13	13	7	6 C. I. 1 steel b. 6 W. I. b.	4 good; 2 pockmarked	1 good; 5 from 50% to 75% destroyed	1-75% destroyed	....
49	Chemical Building 117 No. Dearborn St.	29 "	7	10	10	9 W. I. b. 1 steel b.	....	All in good condition	1 gone to a shell	....
50	Bedford Building, 203 So. Dearborn St.	29 "	13	3	2	2 W. I. 1 C. I.	Good	1 good; 1 50% rusted	....	Cast iron drain leaked and was replaced about 1906
51	Grace Hotel 301 So. Clark	30 "	9	28	......	C. I.	15 vents clogged up with rust; all lines pitted	....	....	C. I. drain stopped up and cleaned out
52	McCormick Building, 143 No. Dearborn St.	30 "	10	4	......	C. I.	4 pitted: stopped with rust	....	....	Clogged up with rust
53	The Rookery, 209 So. LaSalle	30 "	12	12	......	C. I. X. H.	Pitted, but in good condition	....	....	Drain in cellar W. I. apparently good
54	Provident Building, 226 LaSalle	34 "	12	4	2	C. I. 2 W. I.	Pitted and scaling badly	1 scaling 1 pitted	....	1 gal. line appears relatively new
55	301-11 No. Michigan Avenue	35 "	7	......	......	C. I.	....	....	....	Front half of building wrecked; pipe samples in good condition
56	Watson Building 17 No. LaSalle	35 "	8	6	......	C. I. X. H.	Pitted	....	....	....
57	Home Insurance Building, 137 So. LaSalle	35 "	12	12	......	Ex. Hvy. C. I.	Pitted but in good condition	....	....	....
58	Counselman Bldg., 234 So. LaSalle	35 "	9	8	8	8 W. I.	....	5 good as new; 3 pockmarked	....	....
59	Gaff Building, 320 So. LaSalle	35 "	9	8	1	7 C. I. 1 W. I.	3 pockmarked; 4 painted—(good)	1 pockmarked	....	Joints on C. I. drain forced out
60	3501 S. State	40 "	3	......	......	C. I.	Badly pitted	....	....	Large hole in 4" soil vent over "T"
61	Hoyne & Co. Bldg., 112 No. LaSalle	about 30 years	4	......	2	C. I. and W. I.	2 rusted through and scaling	3 good condition	....	Building erected 1873 but pipe supposed to have been installed about 30 years ago
62	Union Bank, 35 No. Dearborn	45 "	8	20	20	5 C. I. 7 W. I. b. 3 W. I. g.	Pockmarked, but good	14 pockmarked; but good; 2 scaling	....	C. I. drain in boiler room has leaky joint
63	Merchants Building, 106 No. LaSalle	46 "	6	8	......	8 C. I.	Pitted and scaling	....	....	....

Rating of Cast Iron, Wrought Iron and Steel

BUILDINGS OVER 20 YEARS OLD

If we analyze the record for all systems over 20 years old, as recorded in the table, and also in the individual reports which are too voluminous to be embodied in this report, we find that a total of 33 roof terminal vents were steel, 155 wrought iron, and 218 cast iron. If we now attempt to summarize as far as possible the condition of all these vents, we find the interesting facts as per table following:

INSTALLATIONS OVER 20 YEARS OLD

PIPE	TOTAL NUMBER	No. of Vents Entirely or Nearly Destroyed	Estimated Percent Depreciation
Steel	33 vents	All practically destroyed	90%
Wrought Iron	155 vents	17 vents nearly destroyed	20%
Cast Iron	218 vents	43 vents nearly destroyed	25%

The poor rating for cast iron in comparison with wrought iron, as shown in this table, is to some extent due to the probable higher average age of the cast iron installations. The comparison refers only to destruction or depreciation by corrosion, and does not take into account several dozen cast iron vents which had clogged up with rust at the increaser below the roof and thus become temporarily useless. Neither does it take into account the condition of the joints, which would further improve the rating of wrought iron over cast iron. Steel pipe, it will be noted, is so completely destroyed by corrosion after 20 years, as to exclude all consideration of joints or clogging which might otherwise be figured in its favor.

BUILDINGS FROM 10 TO 19 YEARS OLD

Turning now to the buildings from 10 to 19 years old, the table exhibits a large number of steel installations, indicating how completely steel pipe, on account of its slightly lower first cost, has come into use in Chicago. A rating table, compiled along the lines just described, but distinguishing between black and galvanized pipe, follows:

INSTALLATIONS 10 TO 19 YEARS OLD

PIPE	TOTAL VENTS	PRESENT CONDITION	Percent Depreciation, Black Pipe
Steel	101 g. 144 b.	Galvanizing 25% destroyed. 144 black—all scaling badly.	75%
Wrought Iron	28	Both black and galvanized good.	10%
Cast Iron	13	All good.	10%

With reference to galvanized steel pipe, it appears that galvanizing is partly or wholly destroyed before the pipe is 15 years old, protecting it from destruction to this extent, the pipe as a result lasting from 15 to 25 years before complete destruction is observed. The relatively good condition of wrought iron, both black and galvanized, should again be noted. The 10% given in the table for both wrought iron and cast iron indicate a slight depreciation, but no actual failures.

BUILDINGS LESS THAN 10 YEARS OLD

In perusing the tabulation, one is struck by the fact that the severe corrosion of steel pipe becomes evident even before the building has passed its first decade of existence. Notable examples are the Cook County Building (Plate No. 7), 10 years old, with 34 steel vents, about half of them galvanized. Further, the City Hall (Plate No. 6), 7 years old, with 42 steel vents, all galvanized but in spite of this, all scaling severely. This does not lend substance to the oft-repeated claims concerning the marvelous improvement of steel pipe in recent years. If anything, these new installations seem to be relatively worse than the older ones.

CORROSION INTERNAL

If the destruction of the different kinds of pipe mentioned was confined to the roof line or the space immediately below it, there might be some grounds for believing that sulphuric acid gas from burning coal would be the destructive element. This, however, is not the case as the corrosion is mainly from the inside of the pipes. In the Borland Building the soil, waste and vent pipes at the third and fourth floor levels were entirely rusted away while the same lines of pipe near the roof were practically as good as when installed. In the Unity Building a wrought iron waste line from urinals was rusted out entirely from the third floor up. In the Great Northern Hotel Building it was found during the process of reconstruction of bath rooms about ten years ago that the old pipe system of waste and vent pipes was entirely destroyed at the threads and over practically the entire length of the pipe in many places. In other instances drains hanging on the basement ceiling had rusted through and had to be replaced and branch soil and waste pipes on intermediate floors were subject to the same deterioration from internal corrosion. So it is clear that the agency causing corrosion is not from the atmosphere above the roof, but is due to the gases developed within the plumbing system itself and from the sewer in the street.

DESIGN OF DRAINAGE SYSTEMS IN CHICAGO

It is recognized that in downtown Chicago the main street sewers are too small, a condition which is made worse by the fact that they are elevated but a few feet above the lake and river outlets, giving a very sluggish flow. The street sewers have been found full of water well beyond midnight, when repairs are usually made without difficulty in other cities. Further, the pipe sizes used in vents and wastes in large buildings generally are too small and skimpy, resulting in blowing out of trap seals and in syphonage of fixtures. The conditions noted with respect to sewers long since caused the main house trap to be abandoned, the sewers and house drains being ventilated through the plumbing system. The sewers are also ventilated by means of manholes in the street. Altogether, there can be no question but what these conditions combine to aggravate the corrosion in pipes in this city, for although corrosion of drainage piping is severe everywhere, it appears to be about 50% worse in Chicago than in New York and other cities. We discovered in the course of the investigation considerable evidence indicating how to improve the service obtained from the pipe system, both in respect to proper functioning of fixtures and pipes, and lessening of corrosive attack.

HEIGHT OF VENTS ABOVE ROOF

The general practice in Chicago is to extend the vents about one foot above the roof, while in New York City, vents on large buildings are usually from 7 to 12 feet above the roof. Very few people can furnish a satisfactory explanation of this difference in practice. I think the case of the Standard Trust & Savings Bank Building in Chicago explains the reason. In this building trouble was experienced with syphoning of fixtures. It was thought to be caused by the suction of winds over the roof, preventing the free influx of air to the vent to relieve the vacuum in the wake of water rushing down the pipes. Galvanized sheet steel extensions about 5 feet high were therefore fitted to the top of the vents, with the result that the trouble was completely eliminated. The extension also is to be

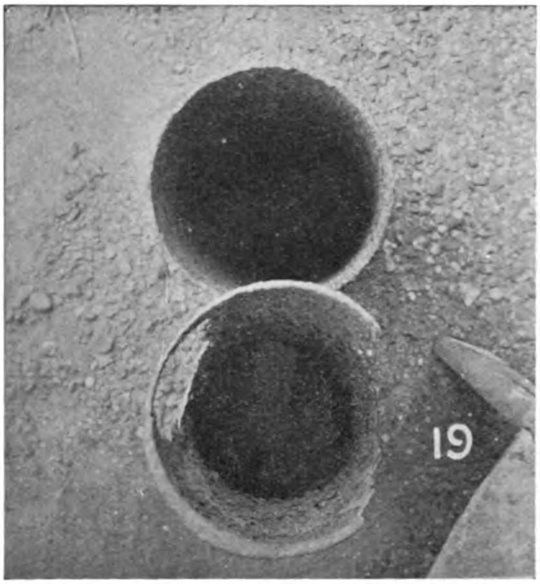


Plate No. 12

CAST IRON VENTS

HOYNE BUILDING, ERECTED 1873.
112 N. LA SALLE ST., CHICAGO.

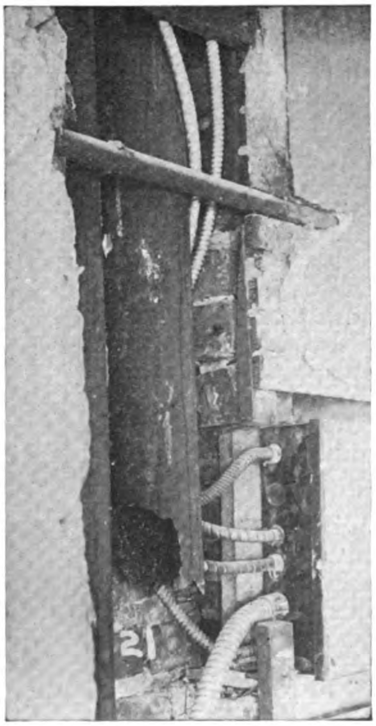
Cast iron rusted, broken and filled up with rust. Three wrought iron pipes on same roof are in good condition. (Some doubt as to age of installation. It is supposed to be about 30 years old.)

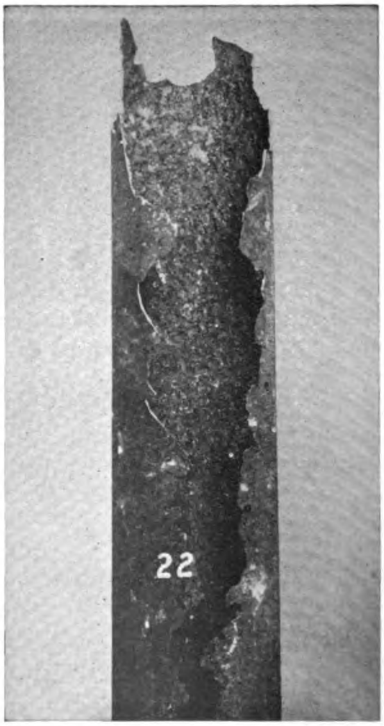
Plate No. 13

3501 S. STATE STREET, CHICAGO.

4-in. standard cast iron, just above the top tee in bath room. Supposed to have been installed in 1875. Completely destroyed by corrosion.

NOTE:—These installations illustrate that cast iron is far from being immune to corrosion, even though it usually gives very satisfactory service from a corrosion standpoint.





recommended because it serves to keep the exceedingly strong fumes from being inhaled by workers or occupants of the roofs and pent houses.

VENT INCREASER AT ROOF

City ordinances in Chicago demand that the size of vents and soil stacks be increased from a point directly below the roof to the top of the pipe, to prevent hoar frost from closing up the pipe in cold weather. Unfortunately, this causes rust and dirt falling down the pipe to find lodgment at the increaser, clogging up the pipe and defeating the purpose of the ordinance. This tendency to clogging is noticeable everywhere, even in cast and wrought iron pipe installations. The type of fitting now used as an increaser has a more gradual taper than that formerly in vogue, but the tendency to clogging can hardly be eliminated. The remedy would seem to be in the adoption of larger sizes of pipes, all the way down through the building, and if increasers are used, they should never be over 1-in. taper. It would seem far preferable to have the hoar frost closing up the pipes for a few days in extremely cold weather than to have the pipes permanently clogged up with rust and dirt.

PROPORTIONING PIPES TO SUIT NUMBER AND SIZE OF FIXTURES

In a certain building there were over 40 closets on the 17th floor, besides lavatories and urinals. All these fixtures discharged into a 6-in. stack. During rainy weather the rain water emptying into the main house sewer, added to the discharge from the 17th floor toilet rooms, would cause trap seals to be blown out and waste water overflowing from fixtures on lower floors and in basements. This trouble was overcome by the installation of an extra relief vent but it would be far cheaper in all buildings to prevent costly and annoying occurrences of this kind by employing in the first installation pipe of larger sizes for both soil stack and regulation vent.

LEAKY CAST IRON JOINTS

From the standpoint of sanitation, one leaky pipe is as bad as another, regardless of what causes the leak, be it corrosion or merely the giving way of a joint from expansion and contraction.

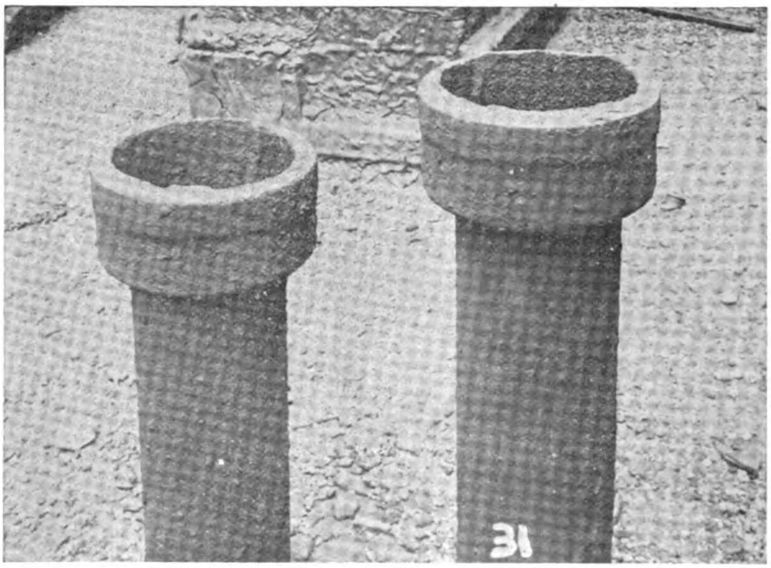


Plate No. 14

EXTRA HEAVY CAST IRON, 30 YEARS OLD

Old McCormick Building, Chicago.

Showing typically good condition of cast iron after 30 years' service.

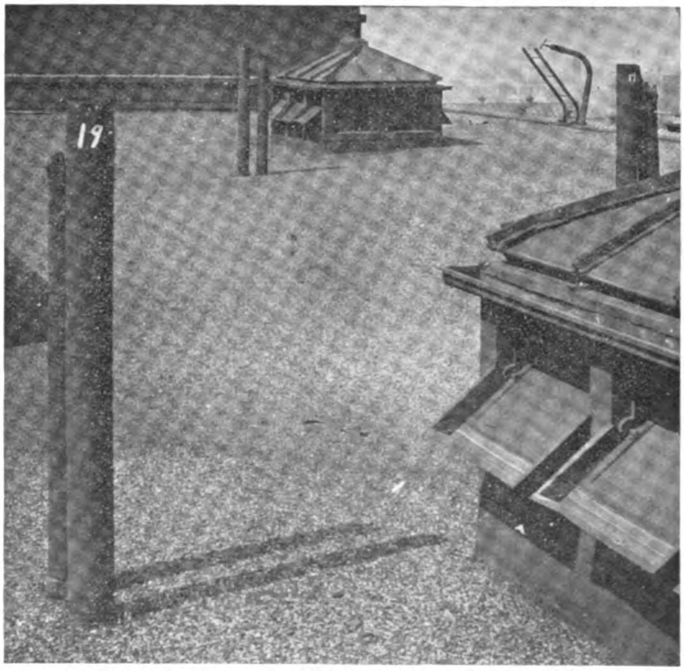


Plate No. 15

Roof of Standard Trust and Savings Bank.

To overcome siphoning of fixtures, the vents were extended about 5 feet above roof by means of temporary galvanized sheet tubes. This remedied the trouble. (See paragraph "Height of vents above roof,"—page 29.)

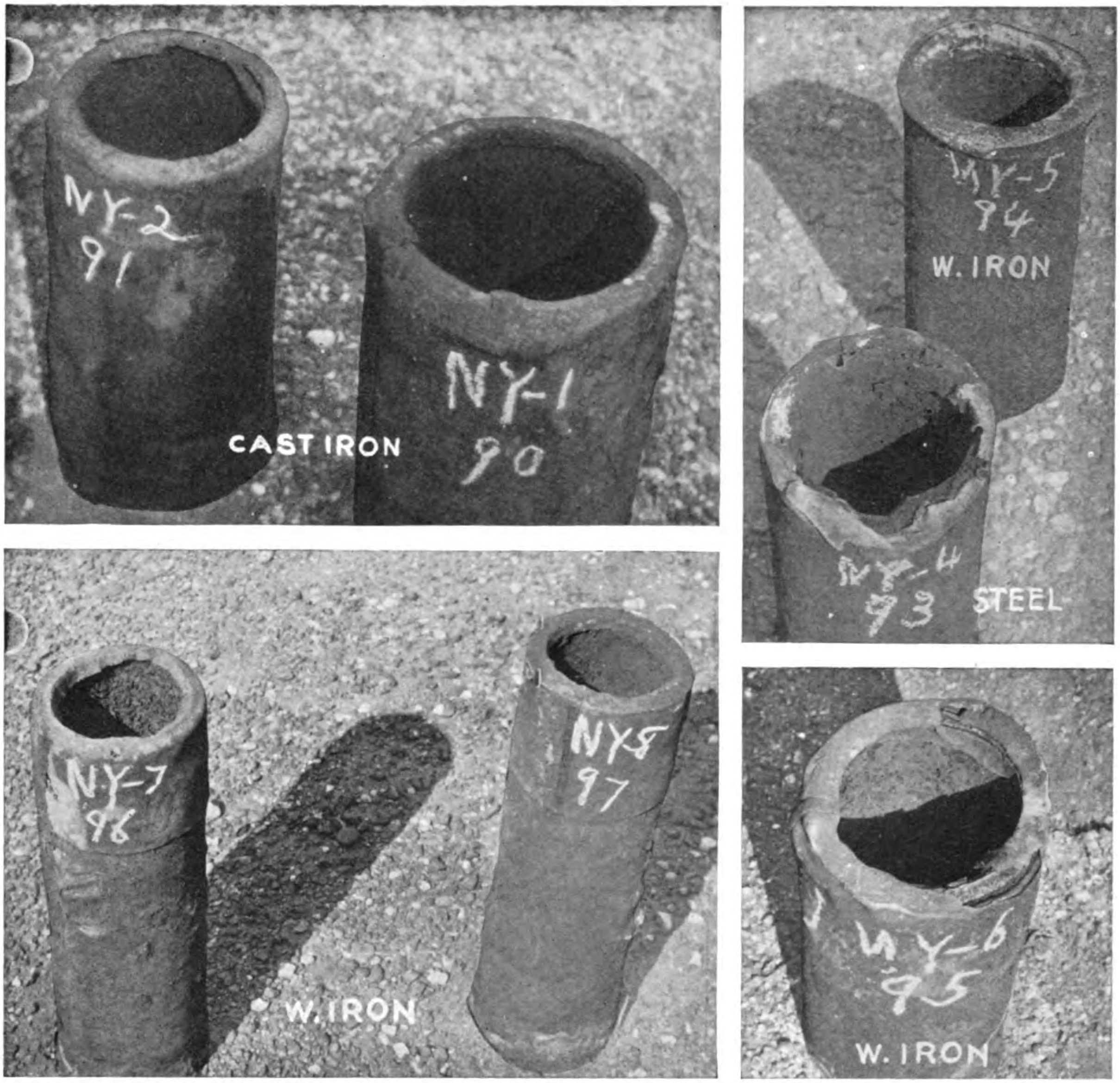


Plate No. 16—MIXED INSTALLATION OF CAST IRON, WROUGHT IRON AND STEEL.
NEW YORK LIFE BUILDING, Erected 1894.
2 cast iron scaling down inside; 3 wrought iron scaling slightly; 1 wrought iron 25% destroyed. 1 steel (No. 93) nearly destroyed.

Although the tabulation embodied in the report does not make specific mention of the fact, many instances of leaky calked joints were observed and unquestionably many also escaped our attention, being more or less inaccessible. Many joints also had been re-calked but it is nevertheless a regrettable fact that leaky calked joints are not always readily discovered and even less frequently repaired with promptness, in the meantime permitting the escape of gases of a noxious, if not dangerous, character. Unquestionably, the screw joint is to be preferred from this standpoint, as long as it can be obtained without sacrifice of the necessary rust resistance of the pipe material.

STEEL PIPE

If satisfactory service from black and galvanized steel pipe is only obtained for a relatively brief period of five to fifteen years, and our ordinances do not differentiate between such pipe and wrought iron, I believe we are not playing fair with the public who pays the bill. The evidence against steel pipe is so indisputable as to admit of no contention. I am firmly convinced from what has been demonstrated in this investigation, that there is a most decided difference between steel and wrought iron for such purposes as are necessary in a sanitary plumbing system and that we should recognize that fact, and in the writing of ordinances, laws or specifications we should provide that steel pipe be not used in any buildings except those of a temporary character.

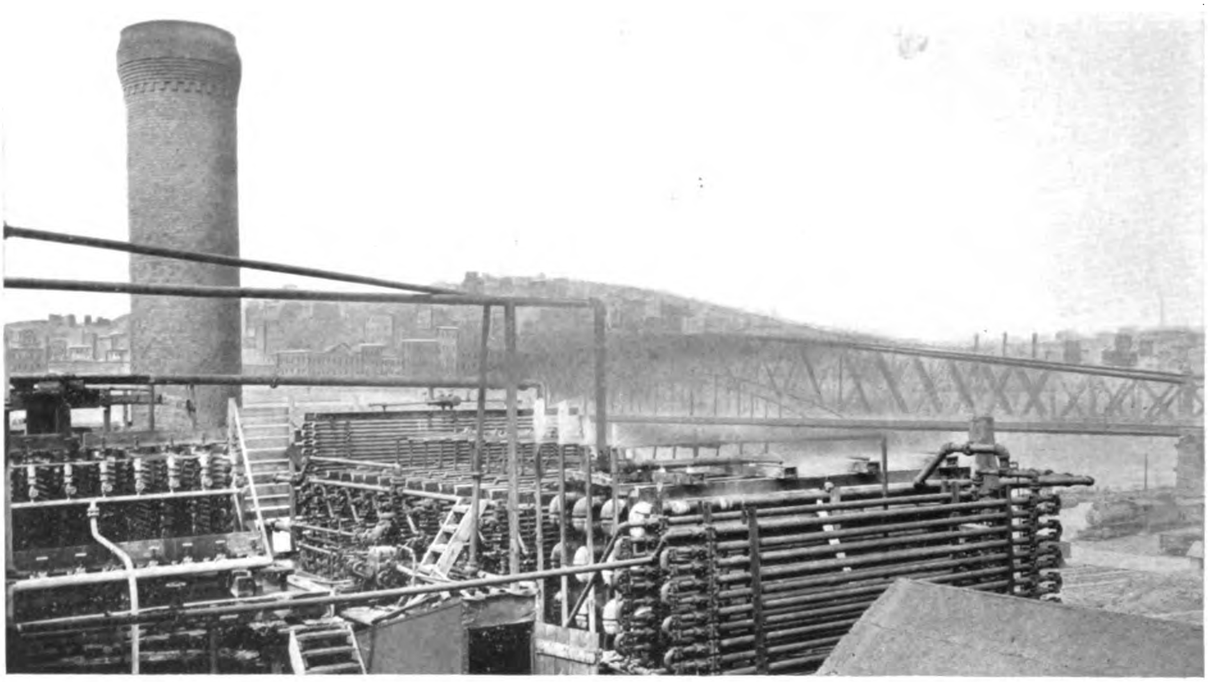
BYERS PIPE

GENUINE WROUGHT IRON
FULL WEIGHT GUARANTEED

BULLETIN No. 34

Second Edition—July, 1921

The Life of Pipe in Refrigeration Service



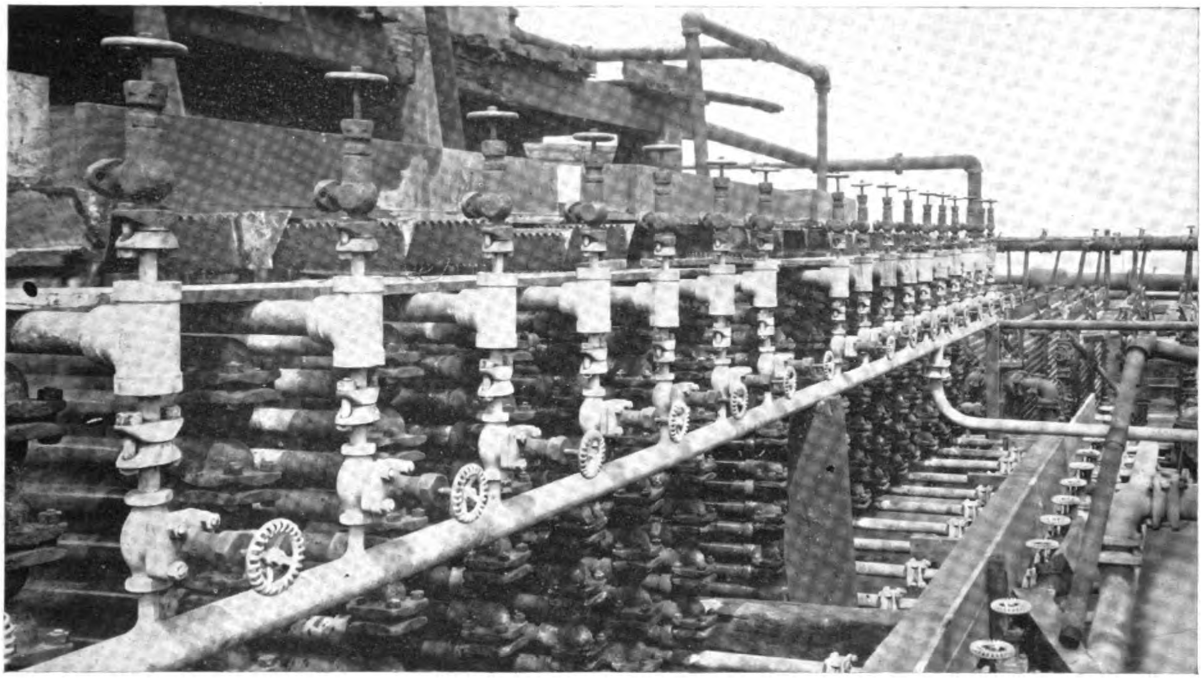
Installing Refrigerating Equipment

As the piping is a large and important part of any refrigerating plant, this Bulletin is prepared principally as an aid to present and prospective investors in equipment of this character. It is recommended, where outside engineering assistance is required, to employ consulting engineers who have had extended experience in this special line of work.

In obtaining bids for piping and equipment, attention should be paid to the manner of designating the pipe it is proposed to install. Such nondescript names as "wrought pipe", "special-tested ammonia pipe", etc., mean only one thing, viz: steel pipe. Those contractors who are figuring on furnishing *genuine wrought iron pipe* always say so, and sometimes go a step further by mentioning the pipe manufacturer's name.

Through a lack of knowledge of pipe on the part of the investor, engineers and contractors are frequently prevented from protecting the best interests of their clients who ultimately, often without realizing it, pay dearly for their failure to see the economy of buying the best pipe at first, in order to protect their whole investment from early corrosion and excessive maintenance cost.

The fact that wrought iron and steel pipe are as similar in outward appearance as silver plate and sterling silver, makes it all the more necessary for the pipe user to exercise vigilance in this matter.



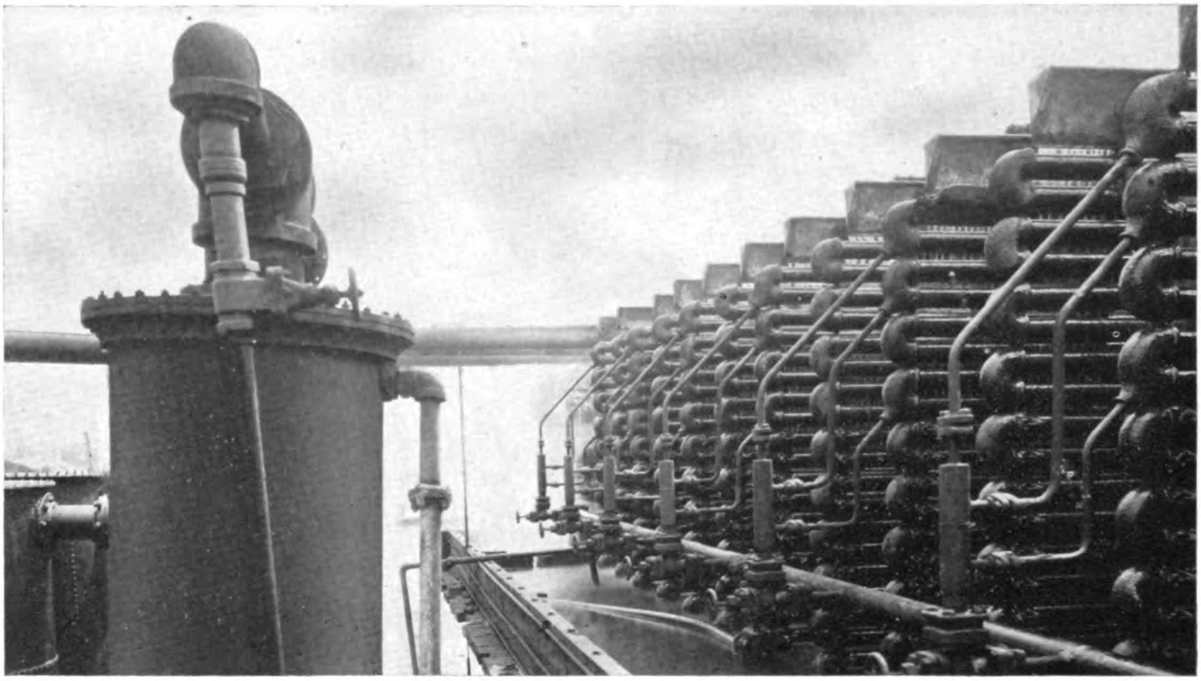
Misleading Trade Names for Steel Pipe

The corrosion of piping in refrigerating plants threatens to become increasingly serious with the advent of pipe cheaper and less durable than that made of genuine wrought iron, which has heretofore been used almost exclusively, on account of its special advantages for this service.

A condition which especially deserves the attention of those who are investing their money in ice and refrigerating equipment, large and small, is the marketing of numerous makes of steel pipe under names concealing the identity of this material. Thus, steel pipe is advertised, quoted, sold and shipped as "wrought pipe", "special-tested ammonia pipe", and even as "wrought iron pipe". It is supposed to be a "trade custom" among certain dealers that if the purchaser really desires wrought iron pipe he should specify "*genuine* wrought iron pipe", otherwise the dealer will furnish steel pipe.

Although so-called "trade customs" of this kind have never been approved by the engineering profession, many specifications for "wrought iron pipe" are being filled with steel pipe. The unsuspecting purchaser in all cases is the ultimate sufferer, paying heavily in repair and replacement expense after a few years of service.

To avoid all possibility of pipe specifications being misunderstood or circumvented, many large pipe users simply use the specification, "Byers Pipe", which is synonymous with genuine wrought iron of the highest grade.



Definition of Wrought Iron

Making good pipe starts with making good metal. The manufacturer may use the cheapest metal, steel, or the more expensive metal, wrought iron. In outward appearance these metals are almost identical, making deception easy. Differences may also exist in the quality of wrought iron, arising from the employment of cheapening processes. In each case the purchaser gets no more than he pays for; and the less he pays, the sooner he will face a heavy replacement expense; and this, at best, is many times greater than any initial saving made in buying the pipe.

In 1912, a committee of the International Society for Testing Materials formulated the following definition for wrought iron:

> "Wrought Iron: Malleable iron which is *aggregated from pasty particles* without subsequent fusion and contains so little carbon that it does not harden usefully when cooled rapidly.
>
> Remarks: Commercial wrought iron, though occasionally made direct from the ore, is usually made from cast iron by such removal of its carbon and silicon as to convert it into pasty particles and by squeezing these together in a bath of cinder or slag into a coherent mass, which *retains permanently an important quantity of that slag*".

This definition briefly touches on the fundamental features common to all good wrought iron, as distinguished from steel, cast iron, or other ferrous materials. All Byers pipe is made in conformity with this definition. (See Byers Guarantee on page 15.) The significance of the definition is briefly explained in the following:

"Aggregated from Pasty Particles"

The meaning of this wording deserves special attention, because it holds the most important point of difference between genuine wrought iron and soft steel. In steel making, final temperatures of operation are such that the finished metal and slag are taken from the furnace in a *liquid condition.* The slag is first poured off, then the metal is poured into ingot molds, effecting complete separation of metal and slag. On the contrary, in the puddling operation, and other methods employed in making good wrought iron, the metal becomes pasty when refining approaches completion, while the slag remains in a liquid condition throughout. The resulting product–wrought iron–differs from steel in having a portion of the slag thoroughly and uniformly intermingled with iron.

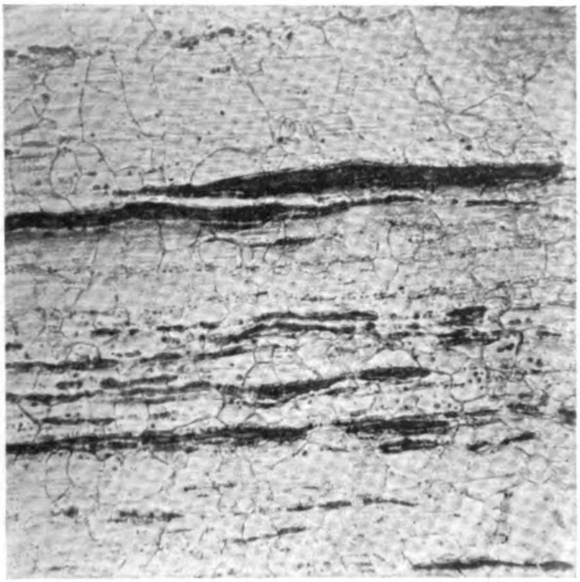


Photo-micrograph of longitudinal section of Byers Pipe, showing slag fibers (black) separating the grains of pure iron, and protecting the iron against corrosive attack.

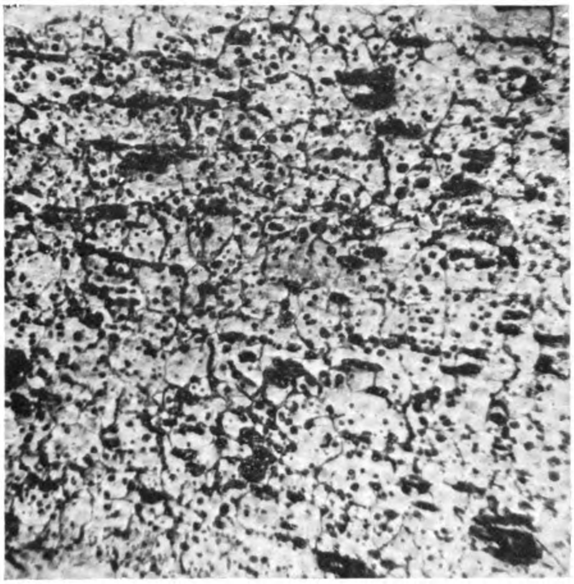


Photo-micrograph of cross section of Byers Pipe, showing ends of slag fibers. There are nearly 250,000 such slag fibers in a square inch of metal cross-section.

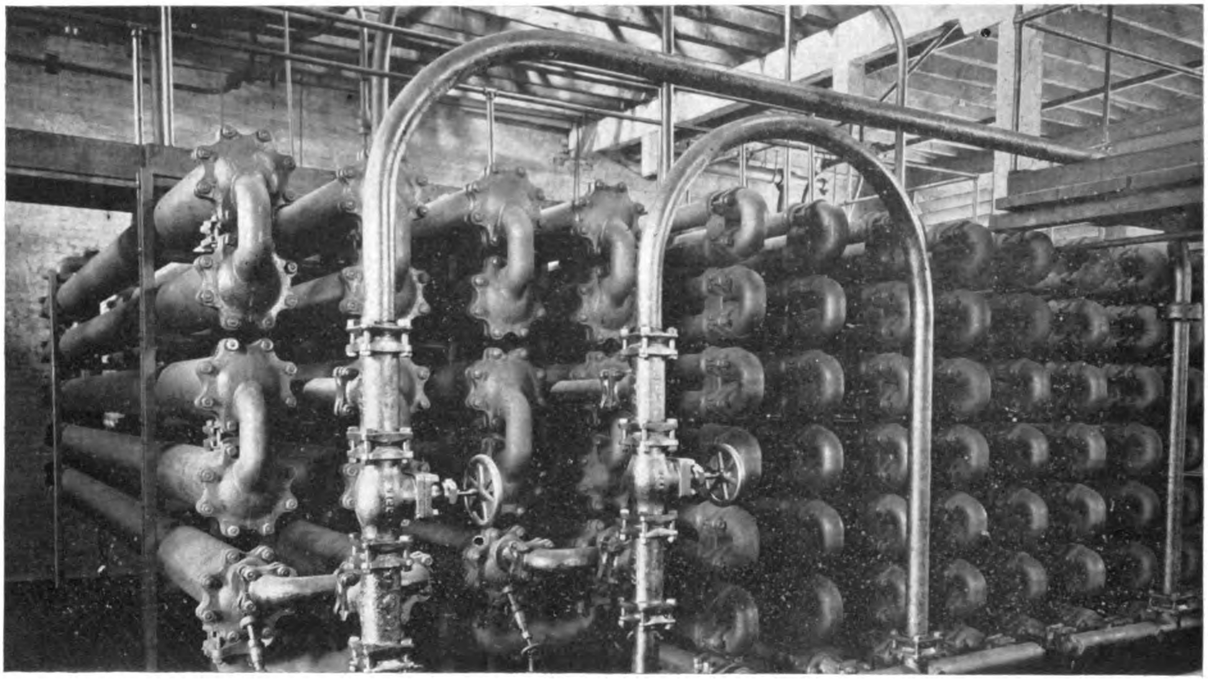
An important result of this difference in iron and steel making is the presence in steel of segregated impurities and blowholes, and the total absence thereof in wrought iron. The segregation of impurities and the formation of blowholes in steel occur *after* the refined metal is poured into the ingot mold; for the mass of molten metal cools *from the outside towards the center and top* of the ingot, and the impurities being more fusible than the pure steel, tend to concentrate in the direction of cooling, forming a pathway of "piping" and blowholes, and leaving, in the upper and central portion of the ingot, sections high in impurities. This action is known as segregation. The segregated impurities form zones of rapid corrosion, and account for the early rusting in spots so characteristic of steel; these zones or spots in the metal are high in carbon, and are therefore hard and difficult to weld or thread, which are very objectionable features in pipe material.

To avoid completely all these harmful effects, inseparable from steel making, the provision is made in the wrought iron specification that the metal must be "aggregated from pasty particles" (as opposed to a liquid mass); where this is done there is no opportunity for segregation of impurities, nor for the complete elimination of the beneficial slag.

Significance of Slag Inclusion

It is on account of slag inclusion that we are still dependent upon the iron maker for something which cannot be produced by steel making operations. This slag is mechanically incorporated in the form of a multitude of minute threads or ribbon-like particles which may be likened to a fine screen. There are several hundred thousands of these filaments uniformly distributed throughout each square inch of section of wrought iron.

Wrought iron, therefore, is a composite material of almost pure iron, mixed with about six per cent by volume of slag. During the rolling processes the particles of slag become elongated into fine bands or fibres, and these create an almost impenetrable barrier against attacks of corrosive agents. The slag also improves the welding and threading qualities of the pipe, as explained later herein.



Corrosion of Ammonia Condensers

The opportunity for making direct comparisons of a large number of ammonia condensers in service is a very easy matter as far as wrought iron pipe installations are concerned; as for steel pipe condensers, this is more difficult, owing to the relatively small number of these that have been in service long enough to afford facts of value.

Data so far collected on this subject indicates an average life of about *nineteen years for a wrought iron condenser, and about eight years for a steel pipe condenser.* This ratio of two to one and better, in favor of wrought iron pipe, is in close agreement with data collected in regard to hot water supply pipes (Byers Bulletin No. 30), house drainage piping (Byers Bulletin No. 32), and other services.

The Byers Company, in a desire to obtain the most reliable data possible on the subject, has made a systematic investigation of a number of the most important ice and refrigerating plants in the country. During this investigation, comparative life records were obtained on sixteen condensers of wrought iron and sixteen condensers of steel, all of which had either actually rusted out or were in such a bad condition as to need immediate replacement. While not in a position to publish the names of the owners of these condensers, the diagram on page 9 shows the facts at a glance.

Cases of Special Interest

In the Iron City Brewery, Pittsburgh, wrought iron and steel pipe condensers were used under identical conditions of service as to character of water supply, period of operation, etc. The iron condenser lasted twenty-five years and the steel pipe condenser lasted seven years.

In the Phoenix Brewery, Pittsburgh, the wrought-iron condenser lasted seventeen years, and the steel pipe condenser lasted eight years.

Ultimate destruction of the condensers in the above cases was due to pipe corrosion; the fittings were identical in type, as were the size and design of condensers; the same water was used; and other factors affecting the life of the condensers were identical.

In the Fort Pitt Brewery, Pittsburgh, a steel pipe condenser was first installed in 1907, lasting for five years, when it was replaced by one of wrought iron pipe, the latter being reported still in good condition in 1918, after six years of continuous service. Its service shortly thereafter was interrupted

TELEGRAPHIC ADDRESS: "SWEEHO, BANGKOK."
CODES: A.B.C. 4TH & 5TH EDITIONS.

Bangkok, October 17th. 1919.

FROM **H. SWEE HO,** *Importers & Exporters,* "Crystal Ice Factory"
CHAROEN KRUNG ROAD, PHITSTIEN BRIDGE, BANGKOK.

*To M*essrs. A. M. Byers Co., Pittsburgh, Pa, U.S.A.

Dear Sirs;

Being one of the users of your pipe in our ice plant, we shall be glad to have a copy each of your Bulletin #26 and Booklet "On the Trail of Byers Pipe", for which we thank you. We find that a section of our ammonia condensers made up of your pipes could stand well against the corrosion owing to bad water being used over them, than pipes of other make, which formed unfortunately a large part of our condensers.

Yours faithfully,
H. S W E E H O.

Thus even distant Siam voluntarily testifies to the economic loss sustained by unsuspecting purchasers of cheap pipe.

by prohibition, and further record is not available.

Closely parallel to the above record is that of a steel pipe condenser installed in 1905 by the Cleveland Home Brewing Company, which rusted out by 1915, while a wrought iron condenser installed in the same plant in 1907 was in such excellent condition eleven years later that it was expected to last five or ten years longer.

The experience of Louis Phaelzer & Sons, Chicago, is of more than ordinary interest. A condenser of wrought iron pipe was installed by them in 1901, and in 1910 was removed to their new plant. Having by this time become too small for their growing requirements, an addition was built of steel pipe. This addition was leaking so badly in 1918 that replacement was imperative, while the wrought iron pipe which had been in service twice as long, was in fairly good condition and without any leaks. Here there can be no question whatever of the identical nature of the service conditions; the water, temperature, time in operation per year, amount of water flowing, etc., being exactly the same.

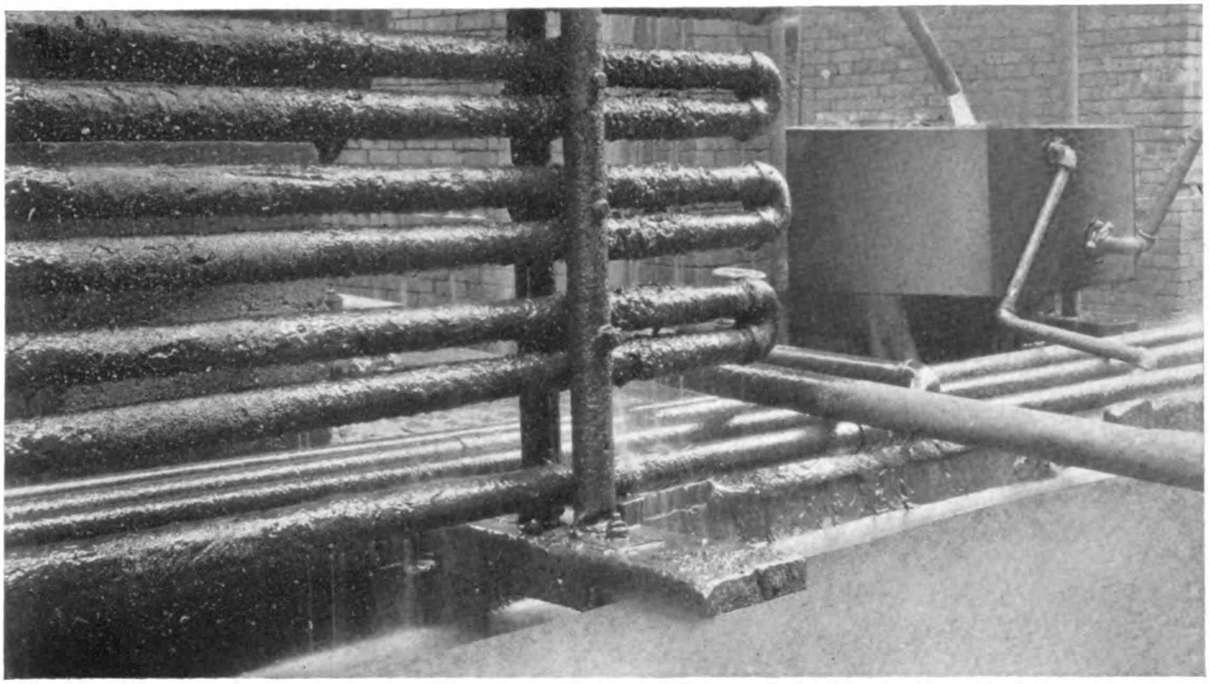
The Carry Manufacturing Company, Washington, D. C., in 1918, reported they had in service an old condenser, installed in 1888, made of genuine wrought iron, and still in good condition. To their great disappointment, a steel pipe condenser installed as late as the year 1910, in 1918 was already so badly pitted as to make it doubtful that it would last two years longer. Here the respective life of the two condensers would be thirty years or more for wrought iron and only eight years for steel pipe. It is possible that service conditions may have become more severe in recent years, but this would affect the wrought iron condenser equally with the steel condenser.

The Bronx Consumers' Ice Company, New York City, installed a wrought iron condenser in 1901, and in 1910 built an addition thereto, using steel pipe. In 1918 the wrought iron part of the condenser, seventeen years old, was in a better state of preservation than the steel part, eight years old.

From every source where the owners have been willing and able to furnish information as to their experience with wrought iron and steel pipe in condenser service, the records are in striking agreement. Oil refiners notably have observed the life of wrought iron pipe condensers to be from twelve to fifteen years, and of steel to be from seven to eight years.

Wrought Iron Pipe Condemned on the Record of Steel Pipe

About the year 1910 a certain packing house, in conformity with their usual prac-



tice, specified Byers Pipe for a new plant to be built for them in Texas. Before the pipe was installed, however, a sales representative succeeded in inducing their local manager to install steel pipe instead. About five or six years later, this piping began to fail; some large condenser units had, in fact, completely rusted out.

Not having had the substitution of steel pipe called to their attention, headquarters, subsequent to this conspicuous pipe failure, discontinued the use of wrought iron pipe altogether, believing they had here positive evidence of the claims made by steel pipe advocates, namely, that wrought iron pipe is no better than steel and that such wrought iron pipe as is made today is not as good as it was years ago, and is not worth the extra price.

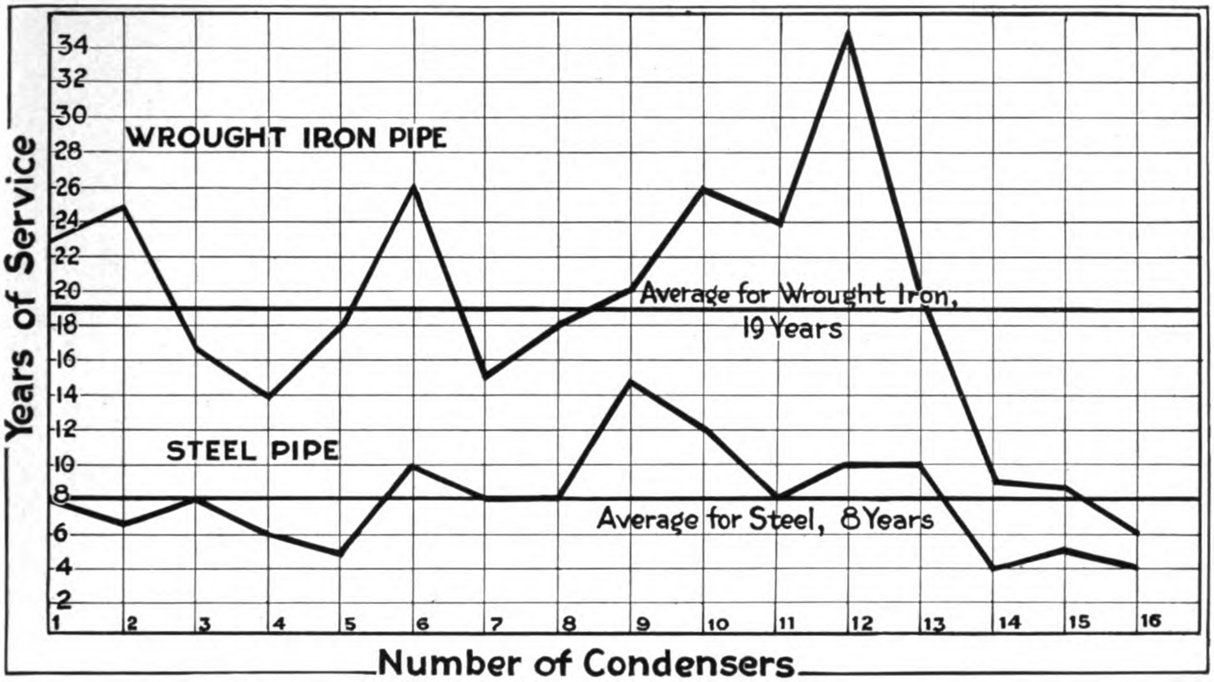
After using steel pipe for several years, the real facts about the above case, on which the Engineering Department of this packing house had based their action, were brought quite accidentally to their attention. They then investigated the whole case thoroughly and found indeed, that the condensers which had failed were made of steel pipe and *not* of wrought iron. Also, that in none of their plants had wrought iron condensers ever shown signs of failure in so short a time, and that the life of wrought iron in this service appeared to be three times longer than steel. Needless to say, they now more than ever became confirmed users of wrought iron pipe.

No doubt many other pipe users have had similar experiences, in that they have been laboring under the misunderstanding that they have obtained wrought iron pipe, and have blamed this material for the untimely failure of the steel pipe which they really obtained.

Double Life of Wrought Iron Pipe Conceded

Instances showing the great rust resistance of wrought iron pipe are so numerous as to have come to the attention of every man who has extended experience with pipe, not only in ammonia condensers but in steam condensers, hot water supply, steam drips and drains, boiler feed and blow-off lines, and so forth. Even the most conservative observers, excepting only those affiliated with steel pipe interests, are now willing to concede to wrought iron pipe a life from fifty to one hundred per cent longer than steel pipe; and it is also a fact that the life of wrought iron (as in house drainage) sometimes appears to be more like five hundred per cent longer than that of steel.

Many who recognize these facts, however, make the mistake of underestimating the cost of pipe failures. (See estimates on pages 9 and 10.)



Service Records of 32 Condensers

The above diagram exhibits the results of an investigation made by the Byers Company to ascertain the actual life of atmospheric ammonia condensers in service. The records were obtained from large ice and refrigerating plants in New York, Boston, Chicago, Pittsburgh, Cleveland, and other cities, where the condensers had been in operation for many years. Thirty-two different condensers are included in these records, equally divided between wrought iron and steel pipe, and while the life differs to some extent between condensers made of the same material, according to service conditions, the notable fact brought out is the average of nineteen years for all the wrought iron condensers against only eight years for steel condensers.

Corrosive Effect of Salt Water

It will be noted that Condensers Nos. 14, 15, and 16, of both kinds, had a much shorter life than the others. These condensers were located in New York and Boston, and the use of salt water from the harbor as a cooling agent accounts for their relatively rapid corrosion. For all the other condensers, the water was obtained from the municipal water systems or from private wells. Where salt water is used, extra-heavy pipe may prove a better investment than pipe of standard weight.

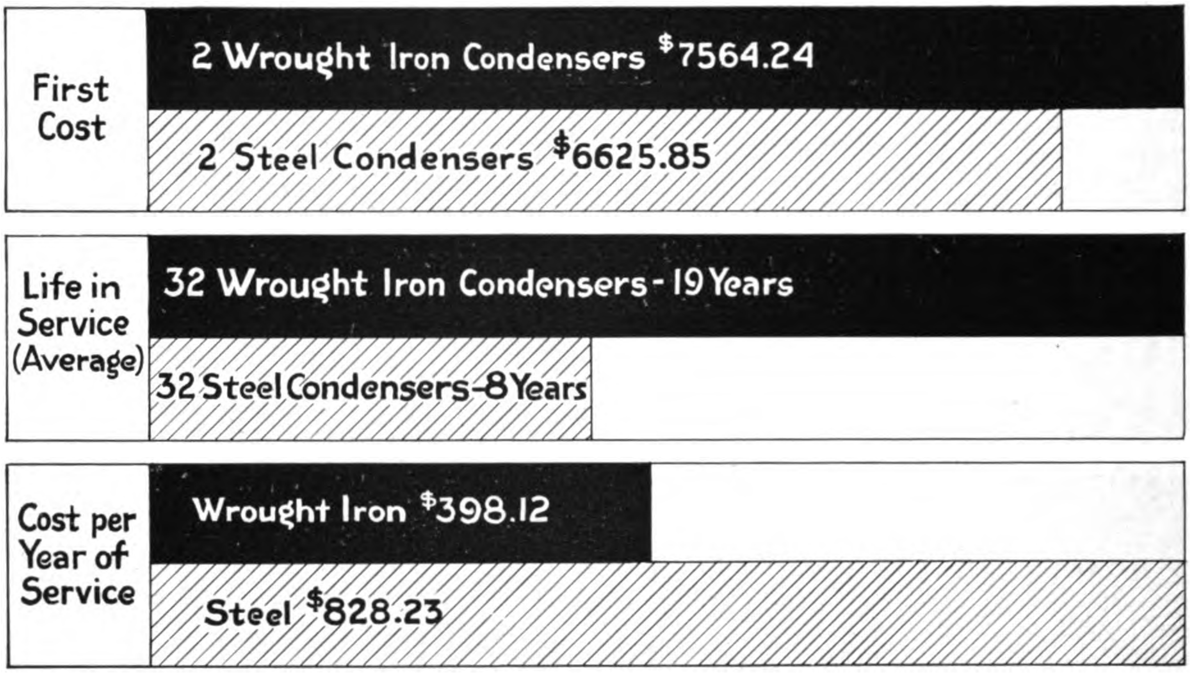
Double-Pipe Condensers

The life of double-pipe condensers appears to be somewhat longer than that of an atmospheric condenser; as the former type is of comparatively recent origin, sufficient actual service records are difficult to obtain.

Installation Cost of Pipe

One might ask the question: If, in refrigerating outfits, wrought iron pipe lasted fifty per cent longer and cost fifty per cent more than steel pipe, what would be the advantage to the user?

The first answer is, that the average life of wrought iron is at least one hundred per cent longer than steel pipe; the second, *and more important*, is that even if it did last only fifty per cent longer, when the replacement cost is taken into account, the extra cost of the pipe alone becomes a very small consideration. Usually the pipe cost amounts to no more than fifteen to twenty per cent of the installation, and if the pipe fails, the total investment, and more, may be lost, for the salvage of items other than the pipe is negligible.



Cost Per Year of Service

Examining first the items of cost in an ammonia condenser, the following figures represent an analysis of a condenser unit which was installed in 1919, replacing an old condenser which had rusted out.

Atmospheric Condenser Extra Heavy Pipe

	Byers W. I.	Steel Pipe
Pipe (7,326 feet) 2-inch Extra Heavy	$2,502.40	$1,905.00
Ammonia Flange Unions and Gaskets	221.00	221.00
Channels and Bolts for Supports	100.00	100.00
Supervision, Overhead and Profit	828.63	828.63
Red Lead and Painting	180.00	180.00
Gas for Welding	250.00	250.00
Hauling	200.00	200.00
Labor, Cutting, Threading, Welding	709.75	709.75
	$4,991.78	$4,394.38

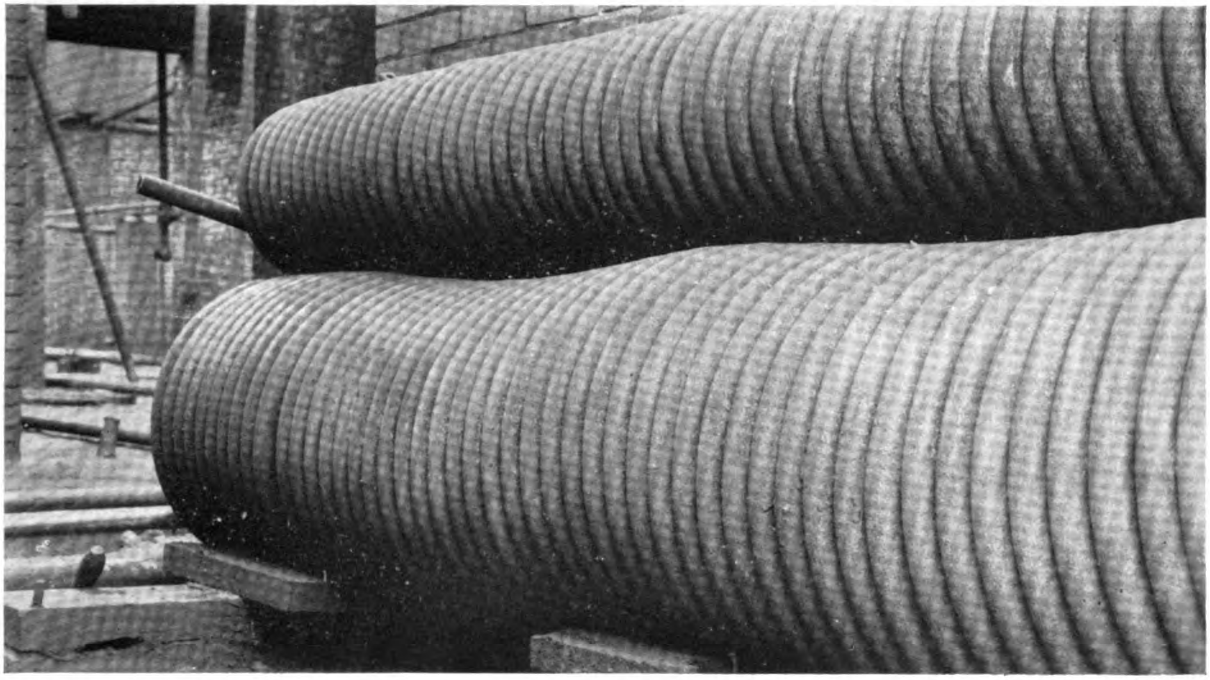
A more common type of atmospheric condenser unit would be one made of standard weight pipe, having 100 tons daily capacity, to be used where the temperature of the water is about the average, and where no unusual atmospheric conditions exist. Such a condenser would ordinarily contain about eight coils of twenty-four pipes each. The price of this condenser, based on the cost of labor and materials prevailing between 1918 and 1920, would be about as follows:

Standard Weight Pipe Atmospheric Ammonia Condenser

	Wrought Iron	Steel Pipe
Fittings, Valves, Headers, Stands and Erection (not including pipe)	$1,484.82	$1,484.82
Freight and Hauling, 50c per cwt. on 20,000 lbs.	100.00	100.00
PIPE:		
2" Byers' black wrought iron, standard weight, lap-weld	987.64	
2" Black steel, standard weight, butt-welded		646.65
	$2,572.46	$2,231.47

Averaging the figures for the above two condensers, we arrive at the following figures:

	Byers Wrought Iron	Steel
First Condenser	$4,991.78	$4,394.38
Second Condenser	2,572.42	2,231.47
	$7,564.20	$6,625.85
Average life as per diagram on page 9	**19 years**	**8 years**
Cost per year of service	**$398.12**	**$828.23**



Pipe Bends and Coils

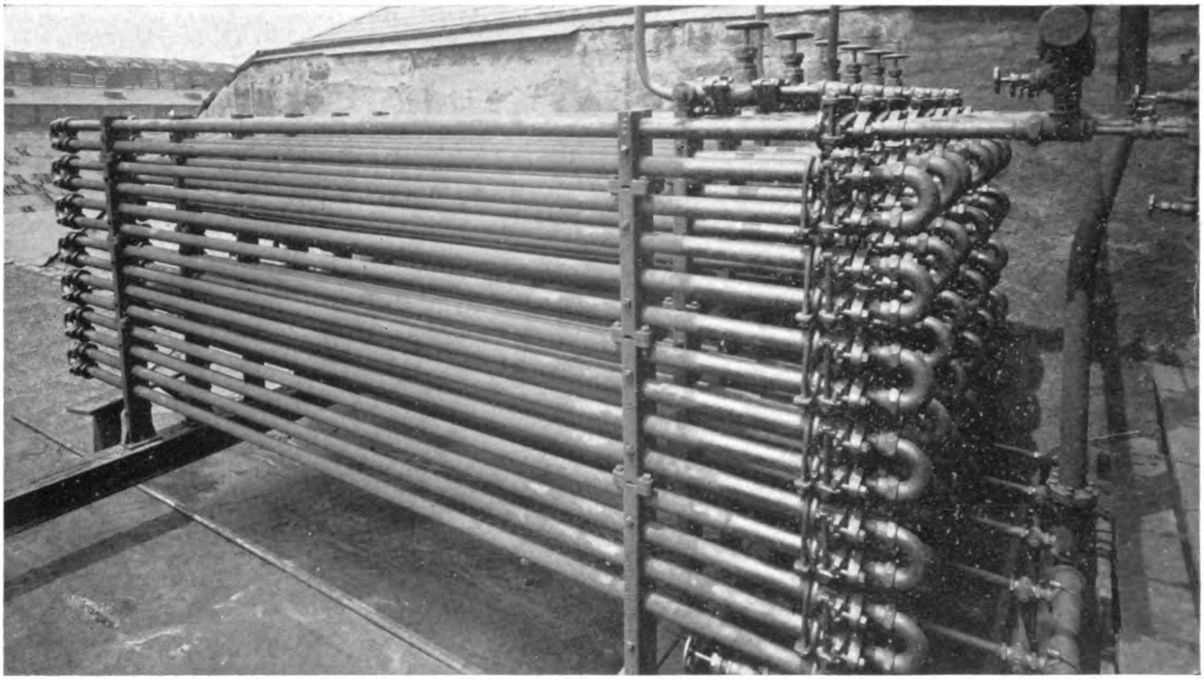
In making coils for refrigeration purposes, the first problem is to obtain a strong union of metal to metal where the pipe ends are welded together in order to make a continuous length of pipe, free from couplings and unions. Due to the severe test to which these end-to-end welds are subjected in coiling or bending the pipe, soundness of the weld itself, and of the pipe metal next to the weld, is an indispensable requirement.

Electric welding is the common method employed. The universal experience in welding steel pipe by this method has been that the metal will become burned and brittle from the heat applied at the ends of the pipe, causing frequent breaks, either in the weld or directly back of it. This breakage is difficult to repair after the bending of the pipe has commenced; if it occurs after a coil has been finished and installed, the damage and repair cost are still greater.

Such failures are so numerous and unavoidable in making coils from steel pipe as to offset the higher initial cost of wrought iron pipe. Many fabricators, therefore, will not tolerate the use of steel pipe for coils when end-to-end electric welding is necessary, for the finished steel coil has little or no advantage to the maker in point of low manufacturing cost; and a wrought iron coil is sure to stand up far better in service than the steel pipe coil. The corrosive action may in both cases be relatively slow; the strength of the weld is thus the important factor in determining the first cost as well as the satisfaction the coil will give in years of service under varying stresses.

Concentrations of sodium chloride or magnesium chloride, such as are customarily used in brine systems, have no serious corrosive effects on ferrous pipe unless air is admitted to the system. This may frequently happen, especially during shut-downs in plants operated intermittently. If wrought iron pipe is used, no serious consequences may be looked for, while with cheaper pipe entire installations have been destroyed within one or two years after being installed.

A certain amount of exterior corrosion will also be observed on pipe systems operated intermittently. Considering the possibilities of both interior and exterior corrosion combining to shorten the life of the pipe, wrought iron pipe would ordinarily be a good investment even if it did not possess the physical advantages already described above.



Other Characteristics of Wrought Iron Pipe

In addition to the high rust-resistance of genuine wrought iron pipe, referred to in the foregoing, other characteristics, which distinguish it from steel or "wrought pipe", result largely from the presence of the slag in the iron, absence of segregation, high chemical purity and notably freedom from carbon and sulphur. The characteristics are as follows:

Better Welding

The efficiency of a weld depends on the thorough union of metal with metal. During the heating of the metal it becomes coated with scale, which is quite gummy at welding temperature and does not squeeze out from between the edges to be joined. The blacksmith in welding soft steel uses borax as a flux, but dispenses entirely with borax when welding wrought iron because the slag content of wrought iron makes it self-fluxing. In welding pipe in commercial practice, it is impracticable to apply a flux, due to the length of the weld, speed of operation, and quantity of material handled. The welds of steel pipe suffer from this lack of flux, while in wrought iron the flux is present, which explains the greater reliability of the wrought iron pipe welds, so universally observed by contractors, engineers and workmen responsible for cutting, threading, bending, and fabricating pipe.

Crushing tests made at the University of Pittsburgh in 1918, showed only eight weld failures out of 136 pieces of Byers lap-weld pipe of various sizes and weights. In 128 instances, therefore, the fracture, following crushing, occurred somewhere along the body metal, away from the weld. The pressure was applied at four different angles from the weld, which should have resulted in twenty-five per cent weld failures if the weld had been of equal strength to the body metal. The apparent extra strength at weld of all these pipes is accounted for by the slightly greater thickness of perfectly knitted metal at the lap. These results are, nevertheless, unattainable with any pipe metal except good wrought iron, and then only when made by the very best manufacturing practice.

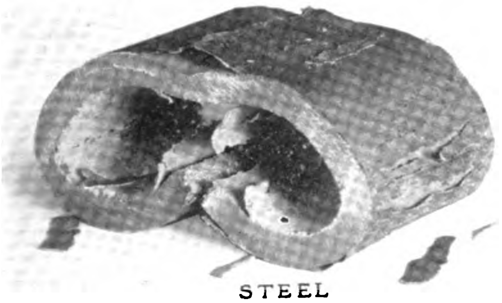


FIG. 3. GALVANIZED STEEL PIPE
Flatten a piece of steel pipe and the galvanizing will crumble and come off in large scales and flakes. This is due to the relatively smooth surface of steel, affording poor anchorage for the coating of zinc.

FIG. 4. GALVANIZED IRON PIPE
Take a short piece of pipe and flatten it out. If it is iron, the galvanizing will stick like glue—it may break, but it will rarely scale off. The rough surface of genuine wrought iron affords excellent anchorage for zinc and other protective coatings.

The increasing use of electric and oxy-acetylene welding, has brought more forcefully to the attention of users the advantages of wrought iron pipe. So marked is the superiority of wrought iron over steel for electric welding, that on many competitive pipe contracts (where steel pipe is acceptable to the user) the pipe fabricator voluntarily furnishes wrought iron pipe, although receiving no extra compensation therefor. The reason is that the cost of manufacturing a good coil from steel pipe, due to costly weld failures in bending, is so high as to approximate the higher initial cost of wrought iron pipe.

Threading Qualities

On the cutting of a clean, accurate thread, largely depends the strength and tightness of the pipe joint. Threading, in itself, is a shop operation requiring a considerable degree of skill and knowledge of dies. When these are lacking there results poor joints, pipe failures, shut-downs and costly repairs. With wrought iron pipe the obtaining of good threads becomes a comparatively easy matter, as long as dies with a "lip" angle not over 16° are used. The factors which contribute to the easy threading of wrought iron pipe are, briefly, as follows:

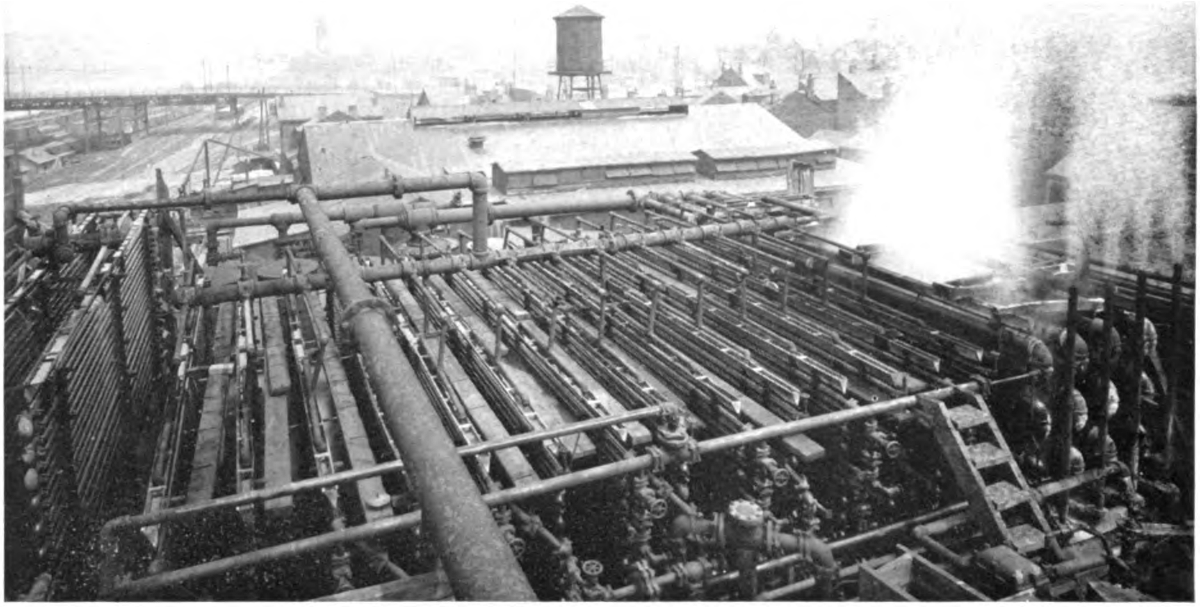
(1) Wrought iron is so uniform in texture and so free from segregation of carbon as to present no difficulties in the presence of "hard spots".

(2) Splitting, due to weak welds, is a rare occurrence.

(3) Most important is the fact that the metal is fibrous; the thread being cut at right angles to the direction of the fibre, causes the chip to crumble freely, and to fall out of the chip space without creating undue friction on the die, which results with steel pipe when an unbroken spiral chip continues to curl inside the small chip space.

Adhesion of Protective Coatings

It has been observed that protective coatings, such as paint and galvanizing, adhere more firmly to a wrought iron base than to a steel base. The reason is that wrought iron has a rougher surface, affording a good anchorage for such coatings. Especially in the case of galvanized pipe is this condition pronounced, for prior to applying the spelter, the black pipe is submerged in an acid bath (pickling), and while the acid attack on steel is uniform, it accentuates the rough surface of wrought iron by attacking the slag and iron unevenly.



This difference in the adhesive quality of a galvanized coating on pipe is readily demonstrated by taking two rings or short pieces of pipe and flattening them in a vise or by hammering, as shown in Figs. 3 and 4. If the pipe is steel, the coating will flake off much more readily than when it is wrought iron. Incidentally, the wrought iron, due to its fiber, will fracture lengthwise under this test, as shown in Fig. 5, while steel may be hammered flat on itself without fracture. This is, therefore, a good method of finding out, first, if a given piece of pipe is wrought iron or steel; second, for demonstrating the difference in the adhesion of the galvanized coating.

(It should be noted that the fracturing of the wrought iron pipe in this test is of no practical importance in judging relative physical strength, for the bursting or collapsing strength of pipe is practically the same for wrought iron as for steel. Whatever advantage steel pipe may have in point of tensile strength is offset by its weaker weld. Besides, the longitudinal stresses exerted on pipe are of much greater importance than bursting or collapsing pressures).

Byers' Guarantee

As the genuineness of wrought iron pipe is always open to question, due to the extensive deception practiced on unsuspecting consumers, the Byers Company not only adheres strictly to the definition of wrought iron formulated by the International Society for Testing Materials, but goes a step further in safeguarding their customers against material not up to the very highest standard of wrought iron pipe manufacture, as will be seen in the following Byers Guarantee:

> "All Byers Pipe is guaranteed to be produced from genuine wrought iron, aggregated from a solidifying mass of pasty particles of highly refined metal which, without subsequent fusion, are incorporated with a minutely and uniformly distributed quantity of silicate slag".

(A full explanaton of this guarantee is contained in Byers Bulletin No. 26.)

Nominal Sizes and Specifications of Byers Pipe
Black and Galvanized

STANDARD WEIGHT

Size	Weld	List Price Per Foot	Outside Diam. Inches	Thick-ness Inches	Inside Diam. Inches	Standard Weight Plain Ends Lbs. per Ft.	Standard Weight Threaded with Coupling Lbs. per Ft.	Hydro-static Test Lbs.	Number of Threads Per Inch	Length of Threads Inches	COUPLINGS Outside Diam. Inches	COUPLINGS Length Inches	COUPLINGS Weight Lbs.
¼	Butt	$0.06	.540	.086	.367	.424	.425	750	18	.562	.750	1.000	.059
⅜	Butt	.06	.675	.093	.489	.567	.568	750	18	.580	.968	1.343	.156
½	Butt	.08½	.840	.111	.617	.850	.852	750	14	.650	1.078	1.343	.168
¾	Butt	.11½	1.050	.115	.819	1.130	1.134	750	14	.812	1.312	1.531	.243
1	Butt	.17	1.315	.136	1.043	1.678	1.684	750	11½	.937	1.656	1.718	.425
1¼	Butt	.23	1.660	.145	1.369	2.272	2.281	750	11½	1.000	1.984	2.062	.631
1½	Butt	.27½	1.900	.148	1.604	2.717	2.731	750	11½	1.070	2.281	2.312	.884
1¼	Lap	.23	1.660	.145	1.369	2.272	2.281	1000	11½	1.000	1.984	2.062	.631
1½	Lap	.27½	1.900	.148	1.604	2.717	2.731	1000	11½	1.070	2.281	2.312	.884
2	Lap	.37	2.375	.158	2.060	3.652	3.678	1000	11½	1.100	2.781	2.500	1.300
2½	Lap	.58½	2.875	.208	2.460	5.793	5.819	1000	8	1.375	3.315	3.125	2.250
3	Lap	.76½	3.500	.221	3.059	7.575	7.616	1000	8	1.500	4.031	3.125	3.025
3½	Lap	.92	4.000	.231	3.538	9.109	9.202	1000	8	1.560	4.500	3.687	3.900
4	Lap	1.09	4.500	.242	4.016	10.790	10.889	1000	8	1.625	5.000	3.687	4.500
4½	Lap	1.27	5.000	.252	4.496	12.538	12.642	1000	8	1.625	5.531	4.218	6.200
5	Lap	1.48	5.563	.263	5.036	14.617	14.810	1000	8	1.750	6.281	4.125	8.250
6	Lap	1.92	6.625	.286	6.053	18.974	19.185	1000	8	1.750	7.375	4.125	9.750
7	Lap	2.38	7.625	.307	7.010	23.544	23.769	1000	8	1.875	8.281	5.000	12.750
8	Lap	2.50	8.625	.283	8.059	24.696	25.000	1000	8	2.000	9.281	5.000	14.850
8	Lap	2.88	8.625	.329	7.967	28.554	28.809	1000	8	2.000	9.281	5.000	14.850
9	Lap	3.45	9.625	.349	8.927	33.907	34.188	1000	8	2.125	10.937	6.187	30.050
10	Lap	3.20	10.750	.284	10.181	31.201	32.000	750	8	2.375	11.925	6.750	40.500
10	Lap	3.50	10.750	.313	10.124	34.240	35.000	750	8	2.375	11.925	6.750	40.500
10	Lap	4.12	10.750	.372	10.005	40.483	41.132	1000	8	2.375	11.925	6.750	40.500
11	Lap	4.63	11.750	.382	10.985	45.557	46.247	750	8	2.375	12.945	6.750	43.000
12	Lap	4.50	12.750	.336	12.077	43.773	45.000	750	8	2.500	12.945	6.750	47.000
12	Lap	5.07	12.750	.382	11.985	49.562	50.706	750	8	2.500	12.945	6.750	47.000
						EXTRA HEAVY							
¼	Butt	.07½	.540	.122	.295	.535	Regularly furnished without threads and couplings	750	18	.600	.843	1.250	.125
⅜	Butt	.07½	.675	.129	.417	.738		750	18	.620	.968	1.343	.156
½	Butt	.11	.840	.151	.539	1.087		750	14	.687	1.109	1.500	.200
¾	Butt	.15	1.050	.157	.735	1.473		750	14	.937	1.375	2.000	.443
1	Butt	.22	1.315	.183	.949	2.171		750	11½	1.110	1.687	2.562	.743
1¼	Butt	.30	1.660	.195	1.269	2.996		1000	11½	1.110	2.094	2.750	1.150
1½	Butt	.36½	1.900	.204	1.491	3.631		1000	11½	1.244	2.375	2.750	1.300
1¼	Lap	.30	1.660	.195	1.269	2.996		1500	11½	1.110	2.094	2.750	1.150
1½	Lap	.36½	1.900	.204	1.491	3.631		1500	11½	1.244	2.375	2.750	1.300
2	Lap	.50½	2.375	.223	1.929	5.022		1500	11½	1.315	2.921	3.625	2.325
2½	Lap	.77	2.875	.282	2.311	7.661		1500	8	1.625	3.625	4.125	4.550
3	Lap	1.03	3.500	.306	2.887	10.252		1500	8	1.750	4.156	4.125	4.870
3½	Lap	1.25	4.000	.325	3.350	12.505		1500	8	1.810	4.703	4.375	6.350
4	Lap	1.50	4.500	.344	3.811	14.982		1500	8	1.870	5.250	4.375	7.350
4½	Lap	1.80	5.000	.363	4.275	17.611		1500	8	1.870	5.671	4.375	7.700
5	Lap	2.08	5.563	.383	4.797	20.778		1500	8	1.870	6.437	5.125	11.750
6	Lap	2.86	6.625	.441	5.743	28.573		1500	8	2.000	7.500	5.375	14.250
7	Lap	3.81	7.625	.511	6.603	38.048		1500	8	2.125	8.560	6.375	22.700
8	Lap	4.34	8.625	.510	7.604	43.488		1500	8	2.250	9.625	6.187	27.450
9	Lap	4.90	9.625	.510	8.604	48.728		1500	8	2.375	10.937	6.187	30.050
10	Lap	5.48	10.750	.510	9.729	54.735		1000	8	2.625	11.925	6.750	40.500
11	Lap	6.10	11.750	.510	10.729	60.075							
12	Lap	6.55	12.750	.510	11.729	65.415		1000	8	2.750	13.945	6.750	47.000

For Pipe Bending

When pipe is required for bending, order should indicate radius of bend and any special conditions that must be fulfilled.

How to Tell the Difference Between Iron and Steel Pipe

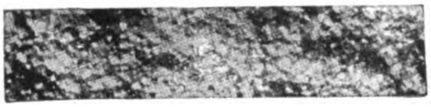
There are about eight different ways to determine whether pipe is iron or steel. The four easiest ways are explained below. Tests 1, 2 and 3 can be applied to either new or old pipe. Identification by name rolled in the pipe is applicable only to pipe made within the last 15 or 16 years. More detailed information on this subject will be found in Bulletin No. 41, which will be sent on request.

1. FRACTURE TEST

The fracture of genuine wrought iron pipe appears *ragged, dull gray* and *fibrous*. The fiber is particularly distinct when compared with a steel fracture. A fracture is easily obtained by hammering a short piece of pipe, as shown in the illustration at the right under "Galvanizing Test."

Iron Fracture—Dull, Gray and Fibrous

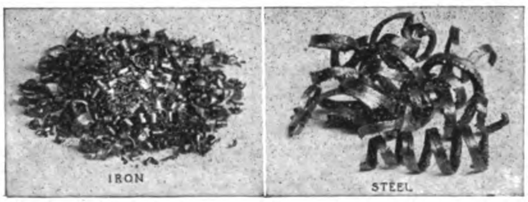
The fracture of steel is *even, bright* and *crystalline*, which, when exposed to the air, soon loses its luster. Moreover, steel pipe shows a tendency to fracture at the weld, and here the metal presents a smooth, dull gray appearance, which should not be confused with the tough, fibrous fracture of wrought iron.



Steel Fracture—Even, Bright and Crystalline

2. THREADING TEST

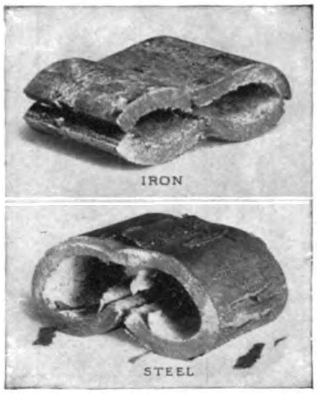
When wrought iron pipe is threaded, its fibrous structure causes the chip to *break and crumble* as when dressing the end of a piece of wood. (This prevents clogging of the die space and reduces friction. A clean, accurate thread results.)



With steel, owing to the absence of fiber, the chip tends to curl up, forming *a long, more or less perfect spiral*, beautiful to look at but an obstacle to easy threading, for it increases friction and causes clogging of the chip space.

3. GALVANIZING TEST

Hammer a piece of galvanized pipe repeatedly to flatten it. If the zinc coating adheres firmly to the pipe, showing little effect of the hammering or flattening, it is wrought iron pipe. If, on the other hand, the zinc begins to scale off at almost the first stroke of the hammer, the pipe is steel. Repeated blows will cause the galvanizing to come off in large flakes, leaving the steel almost bare in spots. This is virtually what happens during handling, cutting, bending and threading steel pipe and in the course of years of service.



Hammer a piece of Byers Pipe and note the tenacity of the coating on the iron. You may fracture the pipe, and the galvanizing will fracture with it, without cracking and scaling off at the edge of the fracture.

4. ROLL MARKS ON PIPE

All pipe bearing the Byers Name and Year of Manufacture rolled into the metal in raised letters, is genuine wrought iron. The Year of Manufacture rolled in the metal is a Guarantee of the lasting qualities of Byers Pipe. It facilitates future observation as to the number of years the pipe has been in service. Watch and compare it with the service given by other welded pipe.

Look for the NAME and YEAR on Every Length

A. M. BYERS COMPANY, Pittsburgh, Pa.

ESTABLISHED 1864

New York Boston Philadelphia Cleveland Chicago Dallas

BYERS PIPE

GENUINE WROUGHT IRON
FULL WEIGHT GUARANTEED

Main Office and Plant:
PITTSBURGH, PA.

Sales Offices:
New York Philadelphia Boston Cleveland Chicago Dallas

BULLETIN No. 38

Second Edition, June, 1921

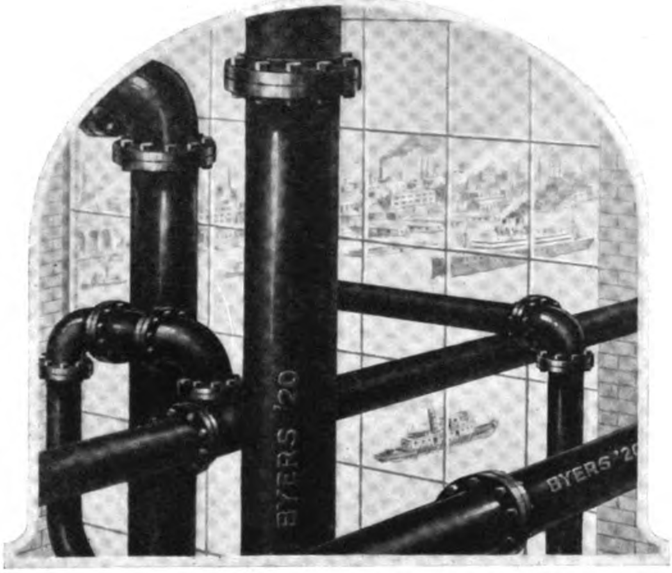
The Installation Cost of Pipe

IT is apparent that where the cost of any given material used in construction is but a fraction of the incidental cost of installation or replacement, the question of durability is of the greatest consequence. In a large proportion of power, hydraulic, plumbing, heating, and other installations, it is conceded that the life of the whole system is limited largely by the ability of the pipe material to resist corrosive attack. In such installations the superior lasting quality of well-made, genuine wrought iron as a pipe material is generally recognized, leaving the question of the extra cost of such pipe to be considered *in its relation to the installation and replacement cost of the whole system*, rather than by a mere comparison of the first cost of one kind of pipe with that of another.

The series of cost analyses of pipe systems contained herein, are dedicated to engineers, architects, and builders, in the hope that they will aid in defining and clarifying the premises upon which so many important decisions depend.

Relation of Installation Cost to Pipe Cost and Life in Service of 20 iron and steel pipe installations

THE above eccentric circle diagram illustrates the relative proportions obtained by averaging and reducing to a percentage basis, the figures for replacement cost of pipe systems, as shown in cost analyses of 20 different pipe systems, on Pages 8 to 28 herein. The area of crescent No. 4, represents the average extra life of the whole pipe system which results from adding to the installation cost (area 1 and area 2) the small extra cost of Byers pipe represented by area 3.



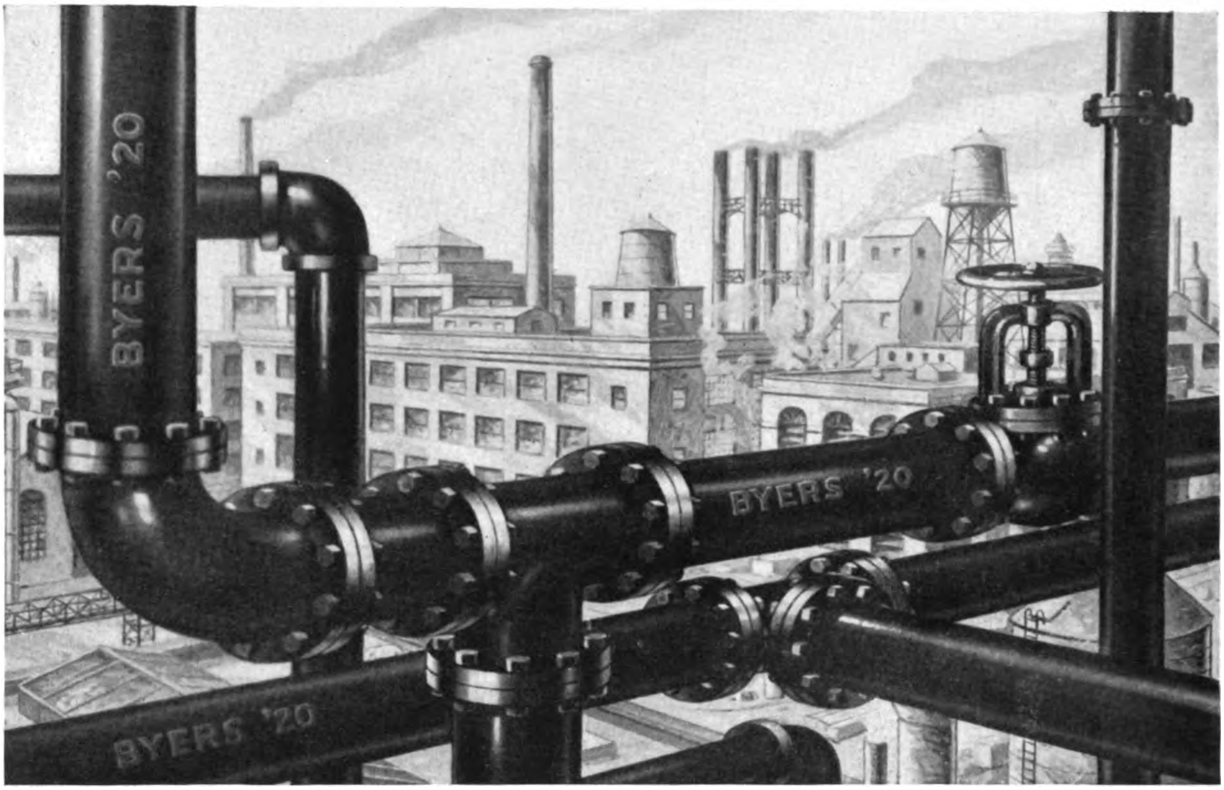
The Extra Cost of Byers Pipe

Dialogue between a General Manager and his Chief Engineer

"THE extra cost of Byers pipe on this job is $208.00," said the general manager in looking over the estimate for a drinking water system. "That's 40% more than for the other pipe." "Let's see," retorted the chief engineer. "This pipe system, not including the fountains, will cost $8200.00. Ninety percent of this cost is for fittings, valves, shop labor, covering, freight, overhead, supervision, and contractor's profit. Using Byers pipe adds only 2½% to this bid, making it $8408.00. If Byers pipe gives double life in service, this additional $208.00 purchases as much value as the first $8200."

"How do you make that out?", asked the general manager.

"It's like this", said the chief engineer. "When the pipe rusts out, as it gradually will, you have to replace the whole system, piecemeal or all at once, for you cannot remove the pipe without dismantling the whole system. Now, there is little or no salvage on such an item as pipe covering, and as for valves and fittings, you could not afford to put them into a new system even if most of them did not have damaged threads. The items of freight, shop labor, installation, overhead, and supervision and



contractor's profit are entirely lost. In fact, the shop and labor cost in making replacements is doubled or trebled, for the replacements usually have to be made gradually, with the least possible interference with mill operation. It's a pretty well established fact that Byers genuine wrought iron pipe lasts two or three times longer than cheaper pipe, so, you see, the $208.00 extra is well worth while.

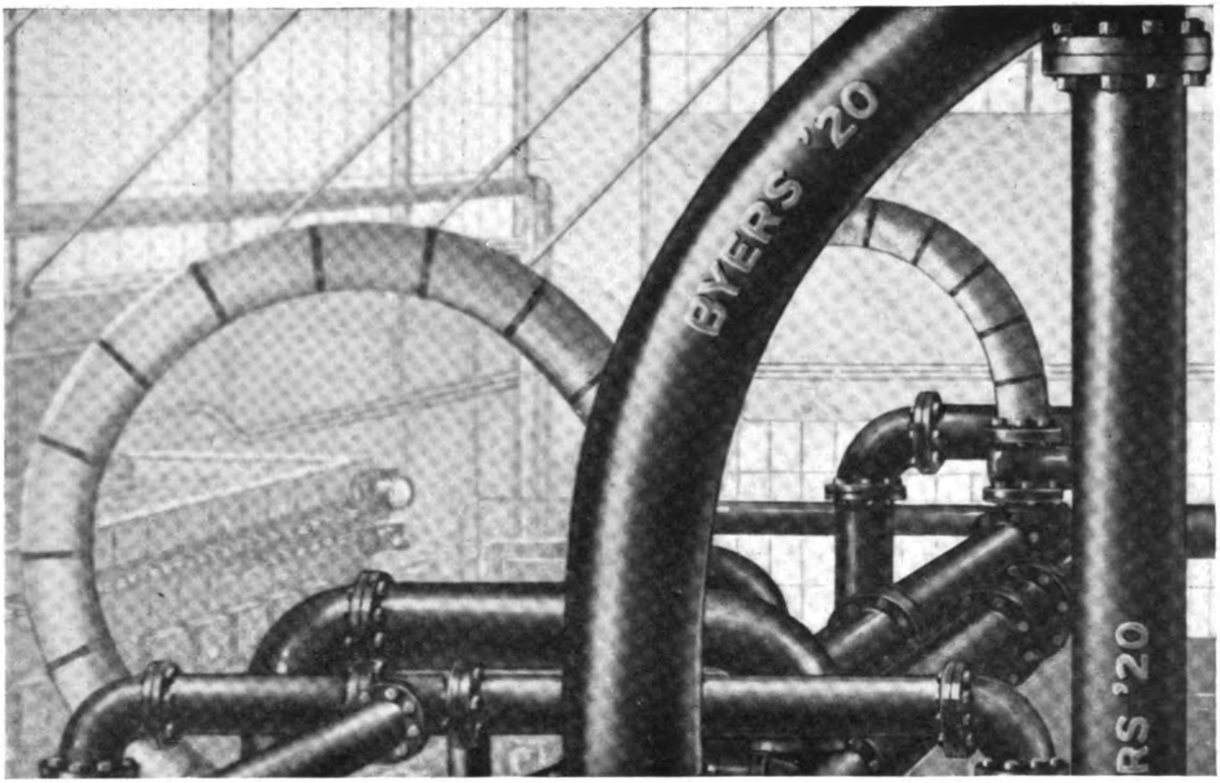
The general manager, after a moment's thought, came back at his very capable looking engineer with the most obvious rejoinder.

"But suppose the pipe lasts longer than the fittings, valves and covering?"

"The covering can easily be replaced without disturbing the system. Valves and fittings have two or three times the thickness of the pipe, so naturally the pipe is shorter lived, as far as corrosion is concerned, and you only have to figure with an occasional replacement of a worn out or leaky valve or fitting.

"But, this must be an exceptional case in that the pipe item is very insignificant and the other items in the installation very high," said the general manager.

"You would naturally think so," was the reply, "but I have had a lot of experience in this line while with the Halden & Banks Piping Company,

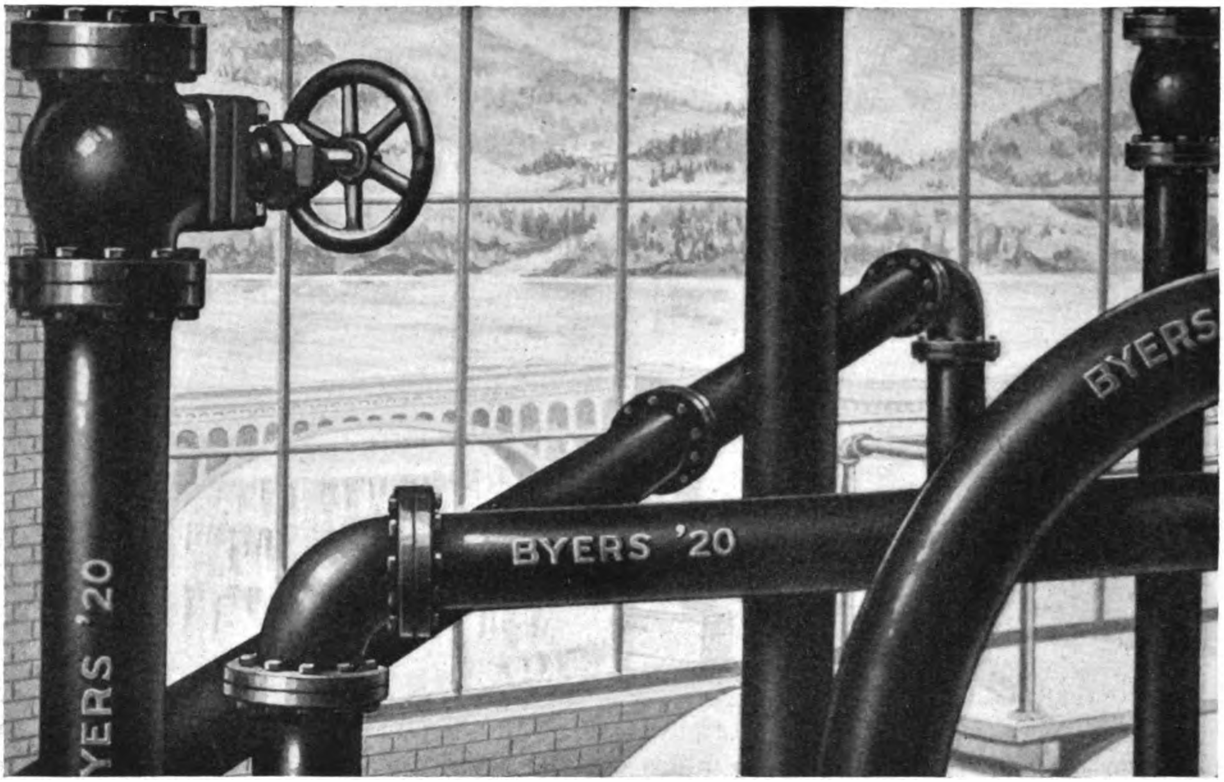


you know. From my experience with them I know I am not far wrong in saying that the main items of cost in the average pipe system are about in the same proportion as in this case."

"What do you mean by an 'average pipe system'?", interrupted the general manager.

"I mean almost any kind of plumbing, heating, power or industrial pipe systems. Take, for instance, the piping system for our new soot blowers, or for our new water treating plant, or the complete power piping for the new city water works which was installed by Halden & Banks, or the hydraulic piping they installed for the Burbank Mills, or any of the dozens of heating or water supply systems they have installed in various places. In any of these systems, I am sure the pipe item alone could not have amounted to more than 10%, and the difference between so-called "wrought pipe" and genuine wrought iron pipe would then be about 3% of the total installation cost."

"What do you mean by the total installation cost? Do you include therein engines, boilers, pumps, fans, compressors, and other mechanical equipment used in the system?"

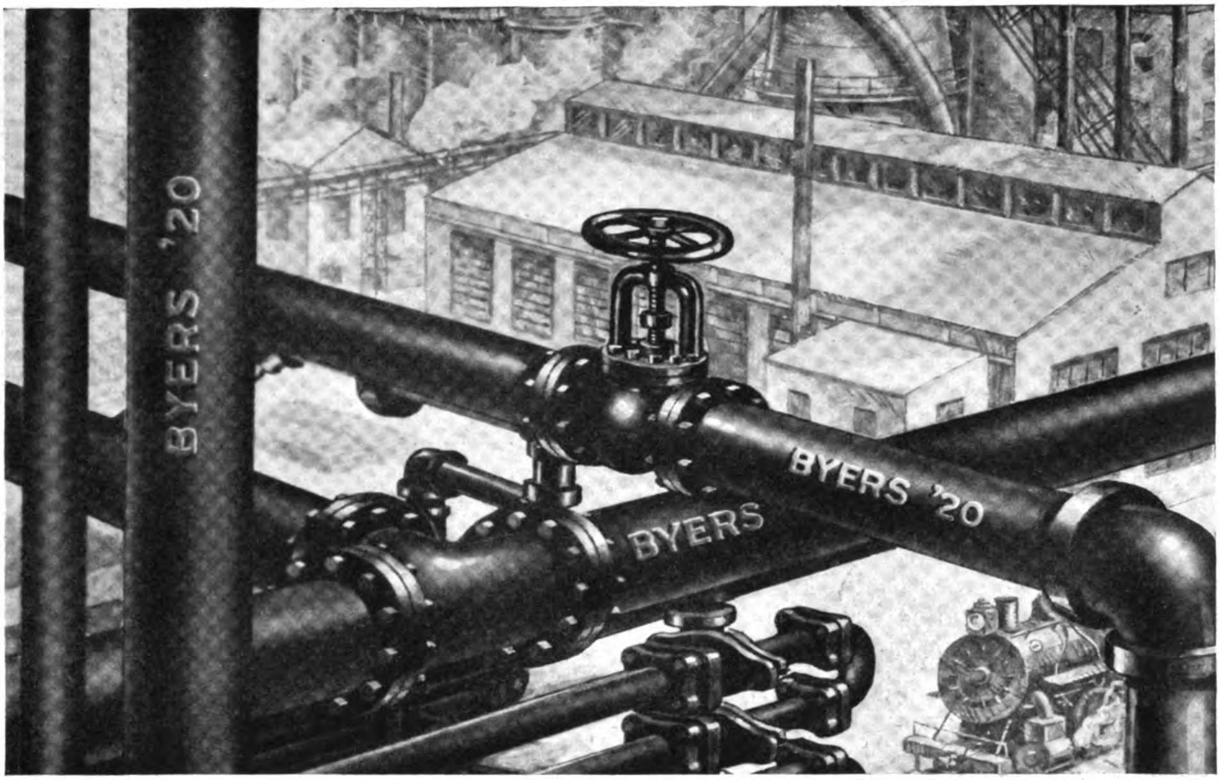


"Not at all, sir. I am speaking only of the pipe system in itself, stripped of everything except its integral parts, such as valves, fittings, hangers, supports, covering, and the like."

"That is rather surprising. I always imagined the pipe was at least half the cost," said the general manager. "I certainly would like to see the figures; for if you are quite right (which I do not doubt), it puts this whole matter of pipe in an entirely different light. You know the Byers man has been after us to standardize on Byers pipe."

"Yes, I do," retorted the chief, "and I feel he is right, but before recommending any action, I will speak to the master mechanic and I will also have my assistant analyze the old cost sheets we have here and some estimates I will get from Halden & Banks, making recapitulations of each estimate, showing the main items of cost. And, while I am at it, I will also have him prepare replacement cost estimates for the same jobs, showing salvage on each item of cost in the original job."

"How about the incidental cost of interrupted operations?", asked the general manager.



"That, of course, is too big and too variable a factor to be estimated, except in specific cases," responded the chief.

"All right," said the general manager, "how soon will you have these estimates?"

"In a couple of weeks; you know there are thousands of items in a piping estimate, and we have to analyze and classify each item carefully in order to arrive at the correct totals, leaving out all items which are not affected by a failure of the pipe."

P. S. The estimates as they finally were laid before the general manager a couple of weeks later, are reproduced, with comments and explanations, on the following pages.

These estimates cover actual jobs done, and are taken at random from the files with a view to obtaining a variety of different pipe systems, thus representing a fair average for piping jobs generally.

Power House Piping Complete

Installed in 1918 for Water Works Company

Pipe (Steel)	$ 1,515.48
Bending and Shop Work	908.80
Flanges, Valves, Hangers, Bolts, Fittings	14,527.32
Freight (100,000 pounds at $.24)	240.00
Labor (including Supervision)	3,600.00
Overhead and Profit	1,708.40
Covering	2,500.00
	$25,000.00

Extra Cost of Byers Pipe

Difference between cost of wrought iron and steel pipe (plus 10 percent overhead	$665.50
Percent difference, based on total installation cost of pipe system	2.7%

Estimated Replacement Cost

First Cost	$25,000.00
100 percent extra labor for dismantling and installing	3,600.00
	$28,600.00
Less salvage on pipe, fittings and covering	$ 2,000.00
	$26,600.00

The cost of mechanical equipment has been left out of this and all following estimates. The shop work and cost of valves and fittings in this installation is very heavy, but this is always to be expected in power piping installations.

The corrosive conditions in water works and power plants generally vary considerably according to the character of the water and the service in which the pipe is used. Steam returns and other lines carrying more or less condensation, as well as hot and cold water, are subject to considerable corrosion.

In the above installation, costing $25,000.00, steel pipe was used at an initial saving of only 2.7 percent. It may easily be seen how quickly this little saving will be wiped out and replaced by a deficit after five or ten years' service, when pipe failures become more and more frequent, with the attendant heavy repair cost, including shop labor, fittings, covering and incidentals, as well as interruption of plant operation. Any replacement due to failure of the pipe, whether small or large, will usually cost twenty or thirty times more than the initial saving made by using pipe cheaper and less durable than Byers.

Drinking Water System

40 Fountains on a 7,000-foot Circuit in Iron and Steel Plant
Installed 1917

Pipe (Genuine Wrought Iron)	$ 830.00
Fountains and Fittings	659.10
Shopwork and Installation Labor	2,405.88
Cork Covering	3,105.02
Overhead and Supervision	700.00
Contractors' Profit—10%	770.00
	$8,470.00

Extra Cost of Byers Pipe

Difference between cost of Byers genuine wrought iron pipe and steel pipe ($208.00 plus 10 percent overhead)	$ 228.80v
Percent difference, based on total installation cost	2.7%v

Estimated Replacement Cost

First Cost	$ 8,470.00
100 per cent extra for labor (wrecking the old, and installing the new system)	2,405.88
	$ 9,375.88
Less salvage on pipe, fittings and covering	300.00
	$ 9,075.88

In the above estimate, the cost of refrigeration and electrical equipment, which amounted to $3,601.92, is not included. In other words, the $8,470.00 represents the cost of drinking water *pipe system* only.

By using Byers pipe, at an extra cost of $228.80 as compared with steel pipe, the entire prospective life of the whole investment was doubled, and repair-free service insured for many years to come.

The important point to remember is that, if any part of the pipe fails, the salvage is very small and the replacement involves the use of new fittings and covering, and a considerable extra expense for labor of installing, shop labor, etc., all of which amount to twenty or thirty times more than any initial saving made by using less durable pipe in the first installation. This holds good whether replacements are made "piece-meal" or the whole system is replaced at one time.

Due to the purity of the water, corrosion is a factor to be seriously reckoned with in almost any drinking water system, as has been amply demonstrated by past experience with such installations.

Hydraulic Pipe System

For 8-inch, 10-inch and 12-inch Presses in Three Buildings

Pipe (2,862 feet) Extra Heavy Genuine Wrought Iron	$ 1,211.65
Unions, Valves, Nipples, Tees, Ells	8,320.45
Flanges, Gaskets, Bolts, Couplings	905.02
Supports and Hangers	161.50
Shop Work (Cutting, Threading, Bending)	4,596.00
Erection—Labor	4,051.50
Overhead, Profit and Supervision	1,750.00
Pipe Covering	1,675.00
	$22,669.12

Extra Cost of Byers Pipe

Difference between cost of genuine wrought iron and steel pipe (plus 10 percent overhead)	$ 368.55
Percent difference as compared with installation cost	1.7%

Estimated Replacement Cost

First Cost, as per estimate above		$22,669.00
100 percent extra for labor in wrecking and replacement		4,051.50
100 percent extra for shop work (cutting, threading and bending)		4,596.00
Repairs to foundation, floors, partitions, etc.		1,000.00
		$32,316.50
Salvage:		
10 percent of pipe	$ 121.17	
20 percent fittings, $8,320.45	1,664.00	
20 percent flanges, gaskets, etc.	181.00	
50 percent supports and hangers	80.75	
20 percent pipe covering	335.00	2,981.92
		$29,334.58

In this, as in all other pipe systems, the bare extra cost of Byers pipe (which may be from 30 percent to 50 percent higher than steel pipe) is not the thing to be looked at, but rather the *relation* which this extra cost bears to the cost of making replacements when in years to come pipe failures become more and more frequent. Looked at in this light, one is again struck by the small cost of the pipe itself and the many times greater incidental cost of shop work and labor, as well as fittings, flanges, gaskets, bolts, covering and other materials on which there is very little salvage when the pipe fails.

In hydraulic pipe systems, water hammer and other shocks are factors to be reckoned with. Tight joints are also essential in a hydraulic pipe system. For some of the largest installations in the world, Byers pipe has been installed solely by reason of its safety of weld, tightness of joint and ability indefinitely to withstand vibration, shocks and other physical stresses, without crystallization of the pipe metal.

Complete Pipe Installation
for Argon Gas Plant

Pipe (9,737 feet) Genuine Wrought Iron	$ 5,897.50
Unions, Valves, Nipples, Tees, Ells	17,540.41
Flanges, Gaskets and Bolts	8,014.25
Supports and Hangers	1,877.22
Shop Work (Cutting, Welding, Threading)	2,095.86
Labor	1,234.50
Overhead, Profit and Supervision	8,856.00
Freight	1,382.00
Crating and Hauling	500.00
Erection	17,745.00
Pipe Covering	8,200.00
	$73,342.94

Extra Cost of Byers Pipe

Difference between cost of genuine wrought iron and steel pipe (plus 10 per cent overhead)	$ 1,677.83
Percent difference as compared with installation cost	2.3%

Estimated Replacement Cost

First Cost as per estimate		$73,342.94
100 per cent extra for labor in wrecking and replacement		21,075.36
Repairs to floors, partitions, sidings		2,200.00
		$96,618.30
Salvage:		
10 percent on pipe	$ 589.75	
20 percent on unions, valves, nipples, tees, ells	3,183.00	
30 percent on flanges, gaskets, bolts	2,420.00	
60 percent on supports and hangers	1,125.00	
10 percent on pipe covering	820.00	8,137.75
		$88,480.55

This installation included gas piping only, which involved a great amount of complicated fitting work. This is one of the many cases in which Byers genuine wrought iron pipe is used chiefly because of its better quality of welds and threads and lower shop cost.

Where the greatest strength and tightness of joints and welds are essential, as in gas and hydraulic installations, no pipe will give as permanently satisfactory results as Byers. This is due partly to the safer, stronger welds characteristic of genuine wrought iron and partly to its better threading qualities, resulting in a tighter, safer and more permanent joint.

The extra cost of Byers pipe, $1,677.83, appears large when compared with the bare cost of steel pipe, but looked at in the light of a one-time premium paid to insure better service for years to come, from the whole system costing $73,342.94, the 2.3 percent extra paid for Byers pipe is, indeed, a slight consideration.

Complete Pipe Equipment
for Toluol Nitration Plant
Toluol, Mixed Acid, Water, Steam and T. N. T. Piping

Pipe (8,486 feet) Genuine Wrought Iron (different sizes)		$ 3,681.20
Valves and Cocks		3,766.80
Fittings	Nipples, Ells, Tees, etc.	2,612.85
	Unions, Flanges, Bolts, Gaskets	2,439.87
Hangers and Supports		1,285.80
Shop Work (Cutting, Threading, Bending, etc.)		3,186.65
Erection		5,074.40
Freight		687.00
Overhead, Profit and Supervision		2,165.43
		$24,900.00

Extra Cost of Byers Pipe

Difference between cost of genuine wrought iron and steel pipe (plus 10 percent for overhead)	$1,165.57v
Percent difference as compared with installation cost	4.7%v

Estimated Replacement Cost

First Cost as per estimate		$24,900.00
100 percent extra for labor in dismantling and replacement		4,261.05
Repairs to brickwork, floors, tanks		1,500.00
		$30,661.05
Salvage:		
10 percent on pipe	$ 368.12	
50 percent on valves and cocks	1,883.40	
20 percent on fittings	1,010.54	
75 percent on hangers and support	964.35	4,226.41
		$26,434.64

If every pipe user at the time of writing specifications or of purchasing pipe could have before him a condensed cost analysis such as the above, there would be little question in his mind as to what kind of pipe to use. Under the contract system, however, all he ordinarilysees is the total cost of the pipe system (which is frequently higher than he expected) and which quite naturally leads him to consider methods of reducing the outlay. One of the first and most apparent items which comes to his mind is the pipe itself.

In the above case, $1,165.57 could have been clipped from the investment of $24,900.00 and, if this was not done, it was undoubtedly due to proper consideration being given to the much heavier repair cost of cheaper pipe (always in evidence after a few years' service where such pipe is installed) which soon wipes out any small percentage of saving which it effects in the first installation. The corrosive conditions are also generally so uncertain and severe as to make the use of the best pipe most desirable, regardless of cost.

Water Piping in Chemical Plant

All Lines Above Ground—Does Not Include Intake to Pumps

Pipe (1,899 feet) Genuine Wrought Iron (different sizes)	$ 500.93
Valves, Unions, Nipples, Tees, Ells	723.46
Flanges, Bolts and Gaskets	169.37
Supports and Hangers	248.81
Overhead, Profit and Supervision	410.00
Freight	141.71
Erection	890.40
Pipe Covering	750.25
Shop Work and Labor	144.19
	$3,979.12

Extra Cost of Byers Pipe

Difference between cost of Byers genuine wrought iron pipe and steel pipe (plus 10 percent for overhead)	$ 143.47v
Percent difference figured on basis of installation cost of pipe system	3.6%v

Estimated Replacement Cost

First Cost	$ 3,979.12
100 percent extra for wrecking old system and erection and shop work on new system	1,034.59
	$ 5,013.71
Deduct salvage of 10 percent on pipe and 33½ percent on fittings and covering	680.72
	$ 4,332.99

This water supply installation includes mostly small sizes of pipe, such as one-inch and two-inch, with standard couplings, involving a comparatively small outlay for cutting, threading, flanging, bending and other shop work. Even so, it will be seen that the extra cost of Byers pipe as compared with steel pipe, was only 3.6 percent of the total installation cost.

Even among practical engineers and mechanical men, there are few who realize the consistently small extra cost of Byers pipe in any pipe system, and the comparatively heavy penalty paid for pipe failures.

Pipe replacements, indeed, are so costly as to warrant an initial expenditure many times greater than the one shown, in order to obtain the longer life and greater freedom from repairs insured by the use of Byers genuine wrought iron pipe. Even if the cost of Byers pipe were double of what it actually is, it would in most cases be a good investment.

Ammonia Condensers

Actual Replacement Cost in 1919

Pipe (7,326 feet) 2-inch Byers Extra Heavy Lapweld	$2,502.40
Ammonia Flange Unions and Gaskets	221.00
Channels and Bolts for Supports	100.00
Supervision, Overhead and Profit	828.63
Red Lead and Painting	180.00
Gas for Welding	250.00
Hauling	200.00
Labor, Cutting, Threading, Welding	709.75
	$4,991.78

Extra Cost of Byers Pipe

Difference between cost of wrought iron lapweld pipe and buttweld steel pipe	$597.40v
Percent difference as compared with replacement cost	12%v
Extra life of genuine wrought iron	112%

Cost Per Year of Service or Actual Depreciation

	Per Year
Steel Condenser, cost $4,394.38, average life 8 years, depreciation	$549.29
Byers Wrought Iron Condenser, cost $4,991.78, average life 18 years, depreciation	277.38

Explanatory Note

The average life of steel pipe ammonia condensers, by careful investigation of service records in hundreds of the largest ice and refrigeration plants in New York, Boston, Washington, D. C., Pittsburgh, Cleveland, Cincinnati, Chicago and Milwaukee, has been found to be 8 years, as against 18 years for genuine wrought iron. The "cost per year of service" as per above, has been figured on this basis, and is equivalent to depreciation per year.

It will be seen that even though the initial cost of a condenser made of genuine wrought iron pipe, is from 10 to 20 percent more than one made of steel pipe, the depreciation of the former is so much smaller that its cost per year of service is only one-half that of a steel pipe condenser.

Two-Pipe Steam Heating System

In 8-Story Warehouse in Chicago

(Note: The pipe items in this estimate by the contractor were figured at 23 cents per square foot radiation for wrought iron and 20 cents per square foot for steel. This includes shop labor, erection, fittings, cartage, etc., and it is, therefore, impossible to show these items separately in this case. The total bid was $8,333.69 including radiators, boilers and other material not included in the following statement of pipe cost.)

	Genuine Wrought Iron	Steel
Permits and Inspection	$ 13.00	$ 13.00
Pipe Coils, 1½-inch W. I., 3,882 feet in place	2,290.38	2,057.46
Painting Pipe Coils	79.01	79.01
Pipe and Fittings, W. I.	1,180.13	1,026.20
Pipe Sleeves	15.00	15.00
Pipe Covering	513.10	513.10
Radiator Valves	242.32	242.32
Labor	625.00	625.00
	$4,957.94	$4,571.09
Superintendence and Overhead (10 percent)	495.79	457.11
Plan Fee	75.01	75.01
	$5,528.74	$5,103.21
Profit, 10 percent	552.87	410.32
	$6,081.61	$5,613.53

Extra Cost of Byers Pipe

Difference, or extra cost of wrought iron pipe	$ 468.08v
Percent difference as between wrought iron and steel	8.3%v

Estimated Replacement Cost

First Cost, as per estimate		$ 5,613.53
50 percent extra labor in dismantling and replacement		312.50
100 percent extra superintendence and overhead		457.11
Repairs to floors, partitions, sidings		525.00
		$6,908.14
Salvage:		
15 percent on pipe coils	$308.00	
20 percent on pipe and fittings	202.50	
30 percent on radiator valves	72.60	
10 percent on pipe covering	51.31	634.41
		$6,273.73

Installation of Soot Blowers

In Power Plant, erected in 1919

Pipe (700 feet) 2-inch Extra Heavy Genuine Wrought Iron	$ 274.00
Valves and Fittings	*750.00
Cement, Lumber, Miscellaneous	23.08
Labor (Erection)	405.20
Shop Labor (Cutting, Threading, etc.)	302.48
Freight and Express	66.82
Overhead, Profit and Supervision	195.00
	$2,016.58

*This item does not include the cost of the soot blowers with nozzles, $4,296.00

Extra Cost of Byers Pipe

Difference between cost of genuine wrought iron and steel pipe (plus 10 percent for overhead)	$	66.00✓
Percent difference as compared with installation cost		3.3%✓

Estimated Replacement Cost

First Cost, per estimate		$2,016.58
100 percent extra labor in dismantling and replacement		707.68
Repairs to boiler walls and foundations		800.00
		$3,524.26
Salvage:		
15 percent on pipe	$ 45.00	
25 percent on valves and fittings.......	187.50	232.50
		$ 3,191.76

In a soot blower system, considerable corrosion must be anticipated, for in the numerous intermissions between the operation of the system, condensation collects in the lines, especially at joints and in tiny depressions in the interior pipe surface, attacking the pipe vigorously. Water of condensation, as is well known, is one of the worst enemies of all ferrous metals used in power plants, causing severe rusting, often in the form of pitting.

When it is considered that the first replacement expense is likely to be very much greater than the first installation cost, the extra cost of Byers pipe will almost disappear in the cost of this system, yet insuring double life of the whole investment. This installation, not including nozzles and other mechanical equipment, costs $2,016.58. To replace it, in the case of extensive pipe failures, would cost approximately $3,191.76. On this basis, the extra cost of Byers pipe may be considered as a small premium of 2 per cent paid only once to insure double life of the whole system.

Power Piping

Steam Header, Mains and Branches, installed in 1918

Pipe (2,730 feet) ½-inch to 16-inch Steel	$ 3,338.49
Shop Work (Cutting, Bending, Threading)	1,488.17
Unions, Valves, Ells, Tees, Nipples	5,385.40
Flanges, Bolts, Gaskets	4,261.25
Hangers and Supports	1,575.79
Profit, Supervision, Miscellaneous	1,257.40
Erection	6,100.00
Hauling	150.00
Covering	3,325.00
	$26,881.50

Extra Cost of Byers Pipe

Difference between cost of genuine wrought iron pipe and steel pipe (plus 10 percent overhead)	$ 1,464.10
Percent difference as compared with installation cost	5.5%

Estimated Replacement Cost

First Cost		$26,881.50
100 percent extra labor in erection and dismantling		7,588.17
Damage to machinery, walls, floors, etc		1,500.00
		$35,969.67
Salvage:		
10 percent on pipe	$ 333.85	
20 percent on valves, fittings, etc	1,077.08	
30 percent on flanges, bolts, gaskets	1,278.38	
50 percent on hangers and supports	787.89	2,477.20
		$33,492.47

The above is a fairly typical power plant installation, involving a very high expenditure for Van Stone pipe joints, flanges, unions, valves, fittings, hangers, covering and labor, practically all of which represents a dead loss when the pipe fails. The replacement cost, in fact, is estimated at $33,492.47. Especially for the smaller sizes of pipe, in which there is more or less condensation of steam, the danger of rapid corrosion is to be taken into account.

With the high standardization reached in power plant equipment, it seems reasonable to assume that obsolesence is ever becoming a smaller factor, and it is well to remember that even of installations made twenty or thirty years ago, there are still a great many in service. The character of the building or enterprise should be a factor—if they are of a permanent nature certainly the small extra cost of Byers pipe is fully warranted, to insure the lowest possible repair and replacement cost in years to come.

Compressed Air Piping

Pipe, (2,682 feet) Steel	$ 319.22
Valves, Cocks and Regulators	498.75
Nipples, Ells, Tees, Crosses	42.08
Unions, Flanges, Bolts, Gaskets	142.74
Hangers and Supports	143.63
Cutting and Threading	114.80
Erection	875.20
Overhead, Profit, Miscellaneous	400.00
Freight	85.00
	$2,621.42

Extra Cost of Byers Pipe

Difference between cost of Byers genuine wrought iron pipe and steel pipe (plus 10 percent for overhead)	$ 144.90v
Percentage difference figured on basis of installation cost of pipe system	5.6%v

Estimated Replacement Cost

First Cost	$2,621.42
100 percent extra for labor in wrecking old system and shop work on new system	990.00
	$3,611.42
Deduct for salvage, 10 percent on pipe and 15 percent on fittings and supports	156.02
	$3,455.40

Pipe service conditions for transmission of compressed air very closely parallel those in steam return lines; the latter are universally recognized as presenting abnormally severe corrosive influences. Atmospheric air carries very appreciable amounts of moisture, varying with locality, season, and weather conditions. This moisture, being the result of evaporation, has a purity upon condensation similar to that of the condensate in return lines. The air also has in association carbon dioxide, sulphur dioxide, and other harmful gaseous ingredients.

This mixture is forced by the compressor into the transmission pipe system, at temperatures considerably above normal.

Condensation of moisture will take place throughout the line, with temperatures in a portion of the system extremely favorable to promote accelerated corrosion. The combination of high temperature, high purity water of condensation and general association of carbonic and sulphurous gases, account for the aggravated corrosion which is observed in such lines after a period of operation, this period being relatively long or short, depending upon the kind of pipe material used.

Shocks from water hammer and tightness of joints are incidental factors of importance, which make the choice of genuine wrought iron pipe all the more desirable.

Underground Gas Distribution Lines In Small Town

Laid Between the Years 1914 and 1917

Pipe—	3,475 feet	2-inch Black Wrought Iron	
	14,279 feet	3-inch Black Wrought Iron	
	36,090 feet	4-inch Black Wrought Iron	
	14,851 feet	6-inch Black Wrought Iron	
	9,566 feet	8-inch Black Wrought Iron	
	79 feet	14-inch Black Wrought Iron	
			$30,400.97
	35,640 feet	1¼-inch Black Wrought Iron Service Lines	2,850.12
			$33,251.09

Labor of Unloading, Stringing, Ditching, Laying, Filling, Teaming and Miscellaneous, Street Mains	$16,758.24
Labor of Laying, Ditching, Filling, etc. of 1282 Service Lines	15,655.00
Fittings, 2-inch and over	1,261.00
	$66,925.33

Extra Cost of Byers Pipe

Difference between price of Byers pipe and steel pipe	
Mains	$ 8,786.00
Service lines	865.12
	$ 9,651.12
Percent on Installation Cost of entire system	14.4%
Percent extra cost of Byers pipe for service lines only	5.5%

Estimated Replacement Cost

First Cost	$66,925.33
100 percent extra for labor in repairing or relaying leaky pipes	32,413.24
	$99,338.57

These lines were laid by the gas company, and the above cost therefore includes no charges for planning, overhead and supervision.

The loss of gas and damage to streets and lawns, incidental to leaks which might develop, are also items difficult to estimate, and therefore not included. It seems reasonable to assume, therefore, that the extra cost of Byers pipe as compared with steel pipe is a very small extra premium, paid but once, to insure against future trouble from rust, leaky joints, and poor welds. This is especially true of the smaller pipes, which are thinner and therefore more liable to failure; also because these smaller pipes cost so little in themselves, yet are nearly as expensive to lay as the larger pipes.

Plumbing Contract

11-Story Office Building, Chicago, 1908

The fixtures, pumps, tanks, etc., cost $31,870.00 installed. Leaving these out of consideration and figuring only the pipe system (rough work) proper, the cost was as follows:

Pipe System Only

Pipe only, (steel)	$ 6,506.00
Valves and Fittings	8,400.00
Labor	8,000.00
Miscellaneous, including Overhead and Profit	11,000.00
	$33,906.00

Estimated Replacement Cost

First Cost		$33,906.00
100 percent extra labor		8,400.00
Damage to floors, walls and ceilings		7,500.00
		$49,806.00
Less Salvage:		
10 percent of pipe	$ 650.00	
20 percent of valves and fittings	1,680.00	
10 percent of miscellaneous	1,100.00	3,430.00
		$46,376.00

Extra Cost of Byers Pipe

Estimated difference between wrought iron and steel pipe	$ 2,300.00
Percent on replacement cost	5%

The above installation includes Durham System of Drainage, and hot and cold water supply.

When it is borne in mind that the amount of pipes installed in large city buildings for power, water, gas, vacuum cleaning, drainage, heating, etc., frequently has an aggregate length in excess of ten, twenty, or thirty miles, and that this network of pipes is installed in the most inaccessible places, exposed to heat, cold and moisture, from within and without, one can clearly see the importance of using the best pipe possible.

Those who have had considerable experience with pipe have learned to discount claims for corrosion resistance based on nothing but laboratory tests. Laboratory tests, and short-time service tests, valuable as they may be when properly conducted, have unfortunately too frequently been proven so entirely at variance with practical experience as to make a word of caution seem most appropriate.

Direct and specific evidence of the relative corrosion of genuine wrought iron and steel pipe in plumbing systems in New York, Chicago and Pittsburgh, is contained in Byers Bulletins Nos. 30 and 32.

Steam Heating Contract

Department Store, Pittsburgh, Erected 1913

Leaving out of consideration boilers, radiators, pumps and other easily installed parts, the cost of the pipe system proper (rough work) was as follows:

Pipe System Alone

Byers Pipe	$ 4,340.00
Valves and Fittings	6,900.00
Labor	6,000.00
Cartage and Incidentals	540.00
Miscellaneous, including Supervision and Profits	5,334.00
	$23,114.00

Estimated Replacement Cost

Pipe job as above		$23,114.00
100 percent extra labor		6,000.00
Repairs to walls, ceilings, floors, etc.		5,000.00
		$34,114.00
Less Salvage:		
10 percent of pipe	$ 434.00	
20 percent of valves and fittings	1,380.00	
10 percent of miscellaneous	533.40	2,347.40
		$31,766.60

Extra Cost of Byers Pipe

Difference between cost of Byers pipe and steel pipe	$ 1,302.00
Percent on replacement cost	4.1%

The heating system is frequently the cause of considerable expense in buildings after five or ten years' occupancy. The hot water or water of condensation, causes aggravated corrosion, and a large number of leaks frequently occur at the beginning of each winter season.

It is sometimes argued that corrosion should be very small in a heating system, due to the small amount of fresh water added to the system from time to time permitting the oxygen in the water in the intervals to be gradually eliminated, even though the elimination can take place only by combining with pipe metal to form rust. It should be remembered, however, that carbonic acid is another cause of corrosion, and that small quantities of acids, salts, etc., contained in the water may be heavy contributing factors in the ultimate destruction of the pipes.

The corrosion will vary considerably with the installation and practice; but, as experience has amply demonstrated, there is ample access of oxygen and other gases in the make-up water and in seasonal refilling, to result in rapid deterioration in many parts of the system.

Plumbing Contract

24-Story Hotel, New York City, Erected 1918

The plumbing fixtures, tanks, pumps, etc., cost $1,250,000.00, leaving a cost of $550,000.00 for the piping system proper, as follows:

Piping System Alone

Pipe only	$126,500.00
Valves and Fittings	122,500.00
Labor	190,000.00
Miscellaneous, including Overhead and Profit	$111,000.00
	$550,000.00

Estimated Replacement Cost

Cost of original installation		$550,000.00
100 percent extra labor		190,000.00
Repairs to walls, floors, ceilings, etc.		250,000.00
		$990,000.00
Less Salvage:		
10 percent of pipe	$12,650.00	
20 percent of valves and fittings	24,500.00	
10 percent of miscellaneous	11,100.00	48,250.00
		$941,750.00

Extra Cost of Byers Pipe

Estimated difference between wrought iron and steel pipe	$ 38,000.00
Percent on replacement cost	4%

The above installation includes Durham System of Drainage, hot and cold water supply, and all other parts of the plumbing system.

More detailed information in regard to corrosive conditions in plumbing systems is contained in Byers Bulletin No. 30, presenting the results of an investigation of pipe corrosion in 129 apartment buildings, and in Bulletin No. 32 containing the reports on two separate investigations of the corrosion of iron and steel pipe in house drainage systems. These investigations were made in New York, Chicago and Pittsburgh. Copies will be mailed on request.

In the case of hot water supply mains of steel, in 90 buildings investigated in Pittsburgh, these were found to have an average life of about 7 years, as against 14 years for genuine wrought iron pipe. The service in this case was so severe that even brass pipe showed considerable oxidation after 10 years' service, necessitating extensive replacements after 10 to 20 years' service. In the house drainage investigations, steel pipe showed up even less favorably in comparison with wrought iron.

Heating System

6-Story Office Building, Cleveland, 1915

Leaving out of consideration the boilers, radiators, air washers, fans and other mechanical equipment, the installation cost of which is relatively small, the cost of the pipe system itself was as follows:

Pipe System Alone

Pipe only	$ 1,400.00
Fittings, Valves, etc.	1,150.00
Labor	5,000.00
Miscellaneous, including Overhead and Profit	3,000.00
	$10,550.00

Estimated Replacement Cost

First installation cost		$10,550.00
100 percent extra labor		5,000.00
Damage to floors, walls, ceilings		5,000.00
		$20,550.00
Less Salvage:		
10 percent of pipe	$140.00	
20 percent of fittings, valves, etc.	230.00	
10 percent of miscellaneous	300.00	670.00
		$19,880.00

Extra Cost of Byers Pipe

Difference in cost between wrought iron pipe and steel pipe	$ 400.00v
Percent on replacement cost	2%v

The heating system is frequently the cause of considerable expense in buildings after five or ten years' occupancy. The hot water or water of condensation, causes aggravated corrosion, and a large number of leaks frequently occur at the beginning of each winter season.

It is sometimes argued that corrosion should be very small in a heating system, due to the small amount of fresh water added to the system from time to time permitting the oxygen in the water in the intervals to be gradually eliminated, even though the elimination can take place only by combining with pipe metal to form rust. It should be remembered, however, that carbonic acid is another cause of corrosion, and that small quantities of acids, salts, etc., contained in the water may be heavy contributing factors in the ultimate destruction of the pipes.

The corrosion will vary considerably with the installation and practice; but, as experience has amply demonstrated, there is ample access of oxygen and other gases in the make-up water and in seasonal refilling, to result in rapid deterioration in many parts of the system.

Plumbing Contract

Hotel in Chicago, Erected, 1909

The total cost of the complete plumbing system was $178,000.00. Leaving out of consideration lavatories, toilets, and other fixtures, pumps and other mechanical equipment, the cost of the pipe system alone (rough work) was as follows:

Pipe System Alone

Pipe only (Steel)	$ 9,397.00
Valves, Traps and Fittings	10,500.00
Labor	11,000.00
Miscellaneous, including Supervision, Overhead and Profit	8,500.00
	$39,397.00

Estimated Replacement Cost

First Cost		$39,397.00
100 percent extra labor		11,000.00
Repairs to walls, floors, ceilings		20,000.00
		$70,397.00
Less Salvage:		
10 percent of pipe	$ 939.70	
20 percent of valves, traps, fittings	2,950.00	3,889.70
		$66,507.30

Extra Cost of Byers Pipe

Difference between cost of wrought iron pipe and steel pipe	$ 3,758.00v
Percent difference as compared with replacement cost	5.7%v

The above installation includes Durham System of Drainage and hot and cold water supply.

Report on Corrosion of Pipes in the Same Hotel After 10 Years' Service

"They have had so much trouble with their steam and hot water lines that the chief engineer would recommend that any new building erected by the company be equipped with anything but steel pipe, which would mean either brass or genuine wrought iron pipe, or both.

"In one instance, as a result of their horizontal hot water lines giving out, leaks developed in the ceiling of the main lobby and, because of its inaccessibility, these lines had to be cut off and abandoned. Part of the new piping was laid by a circuitous route in order to make it accessible in case of future trouble.

"The horizontal lines, where they contain the slightest depressions or low spots, rust through quickly. The return lines are now commencing to give out. The plumbing in the kitchen and laundry has been replaced several times at some points."

Hot Water Heating System

Large Residence at Grosse Point, Michigan, 1915

The boilers, radiators and other easily installed parts cost $11,115.00 installed. The piping system proper cost $11,712.00 as follows:

Piping System Alone

Byers Pipe	$ 3,000.00
Fittings and Valves	2,547.00
Labor	3,000.00
Freight and Cartage	465.00
Miscellaneous, including Overhead and Profit	2,700.00
	$11,712.00

Estimated Replacement Cost

System as above		$11,712.00
100 percent extra labor		3,000.00
Damage to walls, floors, ceilings, etc.		4.000.00
		$18,712.00
Less Salvage:		
10 percent of pipe	$300.00	
20 percent of fittings, valves and 10 percent of miscellaneous	805.00	1,105.00
		$17,607.00

Extra Cost of Byers Pipe

Estimated difference between cost of Byers pipe versus steel pipe	$ 950.00v
Percent on replacement cost	5.1%v

In office buildings, hotels, stores, apartments, residences, etc., extensive pipe replacements carry with them a very high incidental cost of repairing damage to floors, walls and partitions, and a very high labor cost due to necessity of making repairs with the least possible damage to decorations and furnishings, and inconvenience and interference with the work of occupants. Due to the importance of these items, the extra cost of Byers pipe should be measured against the estimated *replacement* cost rather than against the *first installation cost.*

Not infrequently, a single failure, involving the replacement of a pipe worth only a few dollars, will involve re-decorating and other expense running into hundreds of dollars.

Inasmuch as no guarantee or assurance given with any pipe will insure the owner against such damage, much annoyance and expense is saved by obtaining the best kind of pipe for the first installation. Only too frequently, the realization of this fact is not brought home to the owner until after the damage is done.

Plumbing Contract

14-Story Detroit Hotel, 1916—(Drainage, Hot and Cold Water, Fire Lines)

Pipe System Alone

Pipe, (15,688 feet) Steel	$ 3,175.89
Bends, Y's, Traps, Plugs, Reducers, Nipples, Unions	2,653.84
Valves, Hangers, Ells, Tees	3,453.20
Pig Lead and Oakum	77.68
Cutting Threads and Flashings	111.65
Hose, Couplings, Nozzles	1,454.83
Pipe Covering (Steam Lines only)	376.00
Carting, Insurance, Incidentals	538.96
Labor	4,652.50
Overhead and Profit	2,755.45
	$19,250.00

Estimated Replacement Cost

First Cost		$19,250.00
100 percent extra labor		4,652.50
Repairs to walls, floors, ceilings		15,000.00
		$38,902.50
Deductions for Salvage:		
10 percent of pipe	$ 317.59	
20 percent of traps, fittings, nozzles, hangers, valves and covering	7,937.87	8,255.46
		$30,647.04

Extra Cost of Byers Pipe

Difference between cost of wrought iron and steel pipes (plus 10 percent contractors' profit)	$ 1,219.90
Percent difference as compared with replacement cost	4%

One cannot study the above and the various other cost analyses presented herein, without the thought constantly recurring that the items of cost, other than the pipe itself, are exceptionally high. Again it should be pointed out, however, that the estimates are not selected with a view to showing anything but *average* proportions of cost in the different pipe systems, and the greatest care has been taken, in the preparation of each analysis, to avoid errors one way or the other.

The main purpose of presenting these analyses, is to induce executives to cause similar analyses to be prepared whenever they may be in doubt as to the advisability of paying the extra price for genuine wrought iron pipe, deciding the question with due regard to the degree of permanence desired, corrosive conditions, and the percent extra cost of the pipe system when using wrought iron pipe, and the relation of bare pipe cost to replacement cost.

One may conservatively expect Byers pipe to give 100 percent longer life than the best steel pipe.

Plumbing Contract

Hotel in Chicago, Erected 1916

The total cost of the complete plumbing system was $270,000.00. Deducting from this the cost of fixtures, pumps, and other easily installed parts, the sum of $109,390.00 remains, covering the cost of the pipe system (rough work) as follows:

Pipe System Only

Cost of Pipe only	$ 23,624.68
Labor installing Pipe	42,500.00
Fittings and Miscellaneous, including Supervision and Profit	43,265.32
	$109,390.00

Estimated Replacement Cost

First Cost		$109,390.00
100 percent extra labor		42,500.00
Repairs to damaged floors, walls, and ceilings		40,000.00
		$191,890.00
Less Salvage:		
10 percent of pipe	$2,362.47	
20 percent of fittings, valves, traps and other materials	4,400.00	6,762.47
		$185,127.53

Extra Cost of Byers Pipe

Difference between wrought iron pipe and steel pipe.	$ 7,800.00v
Percent of replacement cost	4.2%v

The above estimate covers all plumbing pipes, including Durham System of Drainage.

When the plumbing pipes in a system begin to fail, the owner either faces continuous emergency repairs with attendant heavy gradual depreciation of the property value, or complete remodeling of the piping, involving a very heavy repair expense to the building. The latter alternative, although more drastic, is probably the least expensive, for few things make a building suffer more in appearance and reputation than frequent and ever-increasing pipe failures.

What has just been said is particularly true about hotels and large office buildings, occupied by a large number of people with whom the appearance of toilets, lavatories, and bathrooms, count heavily for or against paying the price asked for rooms or offices. With such issues at stake, the extra few thousand dollars paid to obtain the best kind of pipe, are like the proverbial stitch in time.

Heating System

2-Story Apartment House, Pittsburgh, 1912

Leaving out of consideration the easily installed parts, such as boilers, radiators, etc., and figuring only the pipe system proper, the cost was as follows:

Pipe System Alone

Pipe only	$ 175.00
Valves and Fittings	165.00
Labor and Incidentals	560.00
Cartage, Supervision and Profit	475.00
	$1,375.00

Estimated Replacement Cost

Original Cost		$1,375.00
100 percent extra labor		560.00
Damage to walls, floors, ceilings, etc		500.00
		$2,435.00
Less Salvage:		
10 percent of pipe	$17.50	
20 percent of valves and fittings	33.00	
10 percent of miscellaneous	47.50	98.00
		$2,337.00

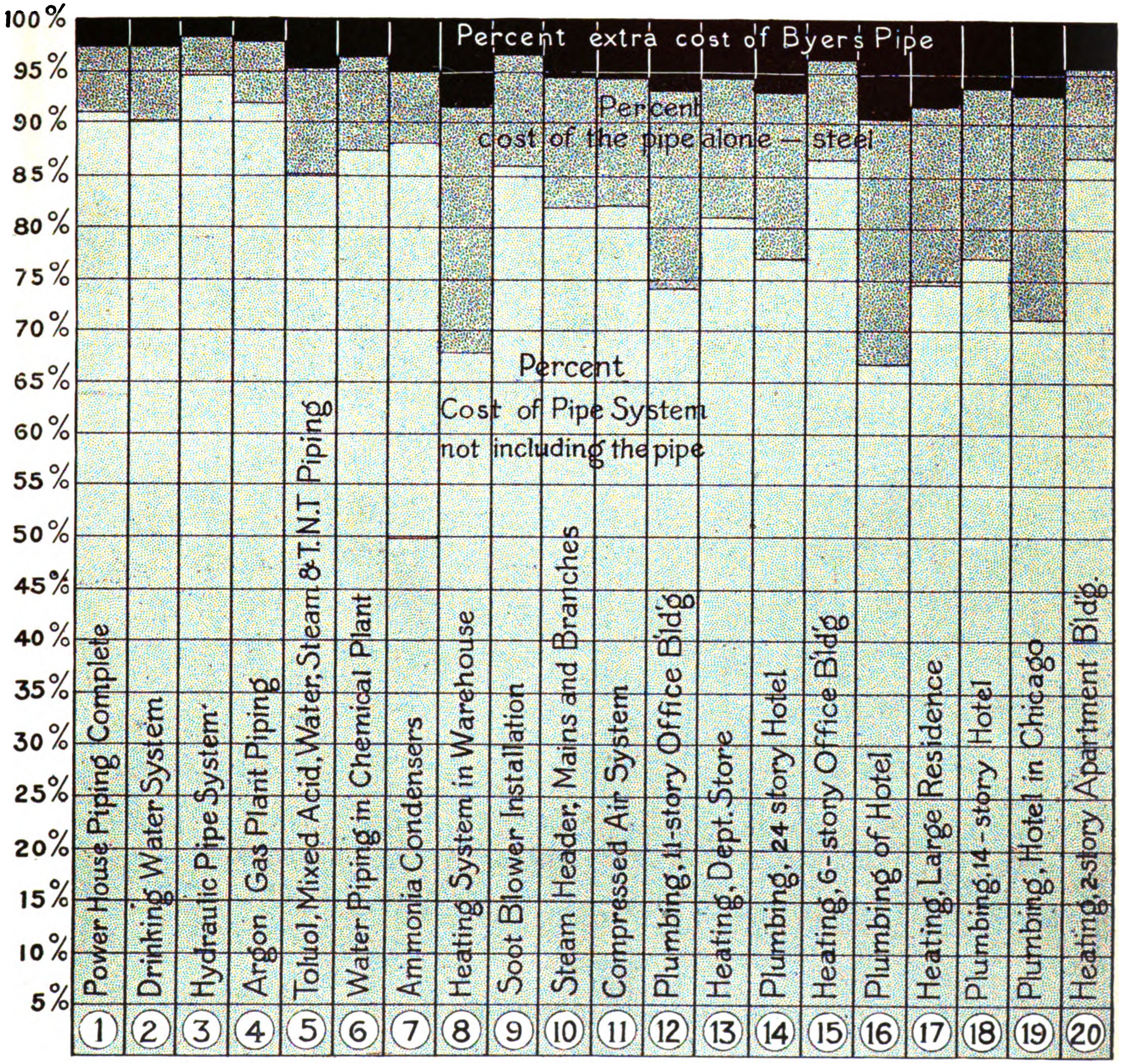
Extra Cost of Byers Pipe

Difference in cost between Byers pipe and steel pipe	$60.00
Percent on replacement cost	2.5%

In office buildings, hotels, stores, apartments, etc., extensive pipe replacements carry with them a very high incidental cost of repairing damage to floors, walls, and partitions, and a very high labor cost due to necessity of making repairs with the least possible inconvenience to occupants and interference with their work. Due to the importance of these items, the extra cost of Byers pipe should be measured against the estimated *replacement* cost rather than against the *first installation cost.*

In the above installation, the estimated replacement cost, less salvage, is $2,337.00, and the extra cost of Byers pipe only $60.00. This ratio of pipe cost to replacement cost is rather low, but even if the difference were two or three times greater, it would still be a case of buying 100 percent extra life for *the whole pipe system,* at a cost of less than 10 percent of its cost. It is significant that in the largest institutions, railroads, factories, mills and other buildings, planned by the best engineers and architects, genuine wrought iron pipe is found most extensively installed.

Percent Diagram showing Extra Cost of Byers Pipe and Relation of Pipe Cost to Installation Cost in 20 Pipe Systems



THE figures contained in the cost analyses of the 20 different pipe systems, (pages 8 to 28) in the above diagram have been reduced to a percentage basis, for the purpose of illustrating how large the cost of *installing* pipe usually is, and how *small* the extra cost of Byers pipe, yet insuring on an average double the life in service from the *whole pipe system.*

Byers Publications

Copies Sent On Request

Service records showing the relative life of genuine wrought iron versus steel pipe under different corrosive conditions, are contained in several bulletins issued by the Byers Company. These and other publications are furnished free, on request. When writing, please refer to these publications by number or title, as follows:

Bulletin No. 26—General Information for Pipe Users.

Contains description of materials and processes employed in the manufacture of Byers genuine wrought iron pipe; discusses the factors influencing corrosion; gives tables of pipe sizes, weights, dimensions, tests, etc.; shows form of pipe specification and contains tabulated records of the life of iron and steel pipe in various kinds of service.

Bulletin No. 27—"The Experience of Practical Men."

Quotations by well known men of wide practical experience who have found that genuine wrought iron pipe in actual service is far more resistant than steel to the action of corrosive influences. Letters from large companies throughout the United States whose experience has proved the use of wrought iron pipe, despite its higher price, to be much more economical than steel in industrial buildings, greenhouses, mines, underground water, gas and steam mains, etc. The last part of this bulletin is given over to a description of the physical structure of wrought iron, illustrating the distribution of the protective silicate slag in iron which affords protection from corrosion. Also describes four easy ways to distinguish between iron and steel pipe.

Bulletin No. 30—An Investigation of Pipe Corrosion.

Showing service records of iron, steel and brass pipe used for hot and cold water supply lines in 125 Pittsburgh apartment buildings. A report of general interest to architects, engineers and builders, not only in Pittsburgh where the investigation took place, but in most other cities where the domestic water supply is of the same general character. Analyses of tap water in Pittsburgh and a number of other cities are given for the guidance of those who wish to make a comparison with the water in their own localities.

Bulletin No. 32—Corrosion of Wrought Iron, Cast Iron and Steel Pipe in House Drainage Systems.

Data obtained through investigations conducted in New York and Chicago by Dr. Wm. Paul Gerhard, C. E., Consulting Sanitary Engineer, and Thomas J. Claffy, Assistant Chief Sanitary Inspector, City of Chicago.

Bulletin No. 38—"The Installation Cost of Pipe".

Size 8½ x 11, 32 pages. Showing cost analyses of 20 different pipe installations, in power and industrial plants, office buildings, hotels, residences, etc. The different items of cost are separated into main groups, such as, pipe, valves,

Byers Publications

Copies Sent On Request

fittings, coverings, hangers, supports, shopwork, labor of installing; excavating, supervision, etc.; also estimated salvage and replacement cost, when pipe failures occur. This bulletin is a practical aid to any one who has to decide whether or not he is justified in paying the initial extra cost of genuine wrought iron pipe over steel, this question depending on various factors, such as:

(a) How large is the extra cost of a pipe system in which Byers pipe is used?
(b) In case of pipe failure, how large is the replacement cost?
(c) How much longer life may be expected from a pipe system when Byers pipe is used?
(d) What degree of permanency is desired?
(e) What are the corrosive conditions?

Bulletin No. 41—Some Facts About Galvanized and Other Coated Pipe.

Explains why galvanized pipe is usuallycheaper in the long run than black pipe; shows the advantages of black iron overgalvanized steel pipe; discusses the factors that influence the thickness of the coating, its penetration and its adhesion to the base metal. Gives tabular records of test made to determine the difference in thickness of the coating on iron and on steel pipe. The averages of a number of such tests are shown graphically in a chart. Also contains descriptions of eight ways to distinguish between wrought iron and steel pipe.

"The Selection of Pipe for Modern Buildings".

Explains the difference between iron and steel pipe and contains in general a résumé of the material in Bulletin No. 26, including a short form of specification for genuine wrought iron pipe. Tables are omitted. Contains illustrations of buildings in which Byers pipe has been installed for over 25 years.

"On the Trail of Byers Pipe".

An illustrated record of the service given by Byers pipe in plumbing, heating, and power systems in the largest and best known buildings in America erected from 25 to 40 years ago. A brief record of the service given by the pipe in each building is given in connection with the photographs thereof.

Byers Guarantee

1. Material

All Byers pipe is guaranteed to be produced from genuine wrought iron aggregated from a solidifying mass of pasty particles of highly refined metal, which, without subsequent fusion, are incorporated with a minutely and uniformly distributed quantity of silicate slag.

2. Full Weight

Every individual length of Byers pipe is guaranteed to have passed rigid inspection and testing, and to be full weight with a variation of not more than 2½ percent below card weight.

How to Tell the Difference Between Iron and Steel Pipe

There are about eight different ways to determine whether pipe is iron or steel. The four easiest ways are explained below. Tests 1, 2 and 3 can be applied to either new or old pipe. Identification by name rolled in the pipe is applicable only to pipe made within the last 15 or 16 years. More detailed information on this subject will be found in Bulletin No. 41, which will be sent on request.

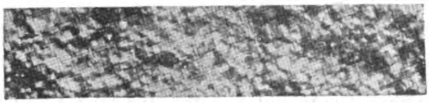
1. FRACTURE TEST

The fracture of genuine wrought iron pipe appears *ragged, dull gray* and *fibrous.* The fiber

Iron Fracture—Dull, Gray and Fibrous

is particularly distinct when compared with a steel fracture. A fracture is easily obtained by hammering a short piece of pipe, as shown in the illustration at the right under "Galvanizing Test."

The fracture of steel is *even, bright* and *crystalline,* which, when exposed to the air, soon loses its luster. Moreover, steel pipe shows a tendency

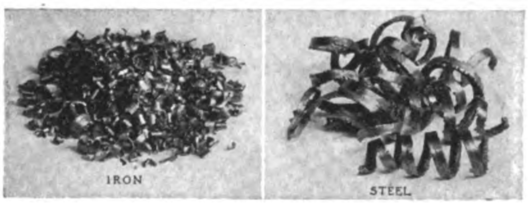


Steel Fracture—Even, Bright and Crystalline

to fracture at the weld, and here the metal presents a smooth, dull gray appearance, which should not be confused with the tough, fibrous fracture of wrought iron.

2. THREADING TEST

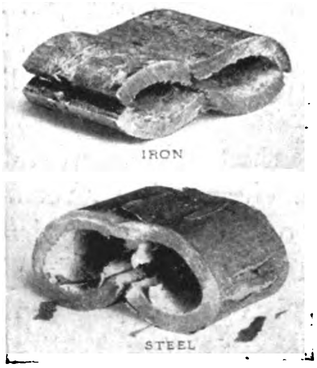
When wrought iron pipe is threaded, its fibrous structure causes the chip to *break and crumble* as when dressing the end of a piece of wood. (This prevents clogging of the die space and reduces friction. A clean accurate thread results.)



With steel, owing to the absence of fiber, the chip tends to curl up, forming *a long, more or less perfect spiral,* beautiful to look at but an obstacle to easy threading, for it increases friction and causes clogging of the chip space.

3. GALVANIZING TEST

Hammer a piece of galvanized pipe repeatedly to flatten it. If the zinc coating adheres firmly to the pipe, showing little effect of the hammering or flattening, it is wrought iron pipe. If, on the other hand, the zinc begins to scale off at almost the first stroke of the hammer, the pipe is steel. Repeated blows will cause the galvanizing to come off in large flakes, leaving the steel almost bare in spots. This is virtually what happens during handling, cutting, bending and threading steel pipe and in the course of years of service.



Hammer a piece of Byers pipe and note the tenacity of the coating on the iron. You may fracture the pipe, and the galvanizing will fracture with it, without cracking and scaling off at the edge of the fracture.

4. ROLL MARKS ON PIPE

All pipe bearing the Byers Name and Year of Manufacture rolled into the metal in raised letters is genuine wrought iron. The Year of Manufacture rolled in the metal is a guarantee of the

Look for the NAME and YEAR on Every Length

lasting qualities of Byers pipe. It facilitates future observation as to the number of years the pipe has been in service. Watch and compare it with the service given by other welded pipe.

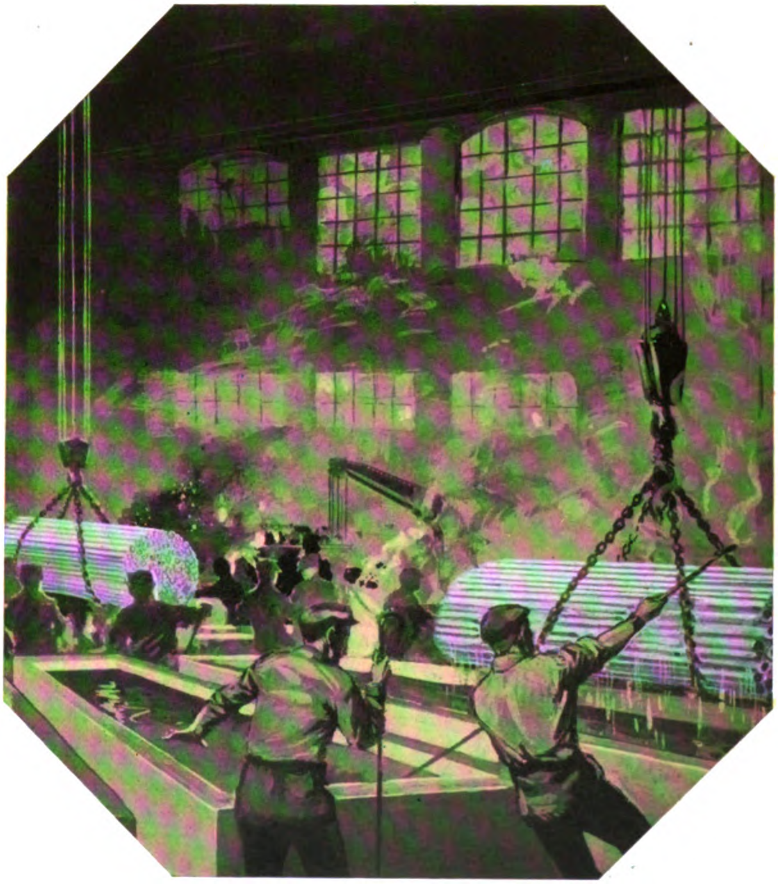
BYERS GENUINE WROUGHT IRON PIPE
FULL WEIGHT GUARANTEED

TUBING, CASING, LINE PIPE, DRILL PIPE AND DRIVE PIPE
BLACK AND GALVANIZED

A·M·BYERS COMPANY
ESTABLISHED 1864
PITTSBURGH, PA.

23 Sullivan Street NEW YORK CITY	11 Sleeper Street BOSTON, MASS.	401 McCormick Bldg. CHICAGO, ILL.	1212 Carter Bldg. HOUSTON, TEX.	706-7 Union Oil Bldg. LOS ANGELES, CALIF.

BULLETIN No. 41 First Edition MAY, 1918



Some Facts about Galvanized and other Coated Pipe

IS GALVANIZED PIPE WORTH THE EXTRA PRICE?

The difference in price between black and galvanized pipe is relatively small—about 20%. Generally speaking, the extra life given to the pipe by the galvanizing is more than sufficient to offset the higher cost of the pipe itself, especially when the pipe is laid underground or installed in other inaccessible places where the labor and incidental expense of installing or replacing it often amounts to much more than the cost of the pipe itself. This is especially true of the smaller sizes of pipe used for plumbing installations. As these sizes also have thinner walls, they are in greater need of a protective coating than larger sizes.

Galvanized pipe is especially recommended for hot water lines and for other service where corrosive conditions are very severe, and wherever the best uncoated pipe is none too good.

BLACK IRON vs. GALVANIZED STEEL

Galvanizing probably adds from 20 to 30 per cent. to the life of black iron and steel pipe. Thus, in service where the life of black steel pipe is, say, 10 years, galvanized steel pipe will probably not last over 13 years, while, by comparison, wrought iron pipe (which has an average life twice as long as steel pipe) would last 20 years black and 26 years galvanized.

It will be seen that black Byers pipe (which costs about the same as galvanized steel) would give 20 years service against only 13 years for galvanized steel. The life of both metals may be longer or shorter according to the severity of service conditions, but the ratio will be about the same, i. e., black Byers pipe lasts about 50 per cent. longer than galvanized steel pipe.

The importance of the base metal so far eclipses that of the coating that, where limited funds are available, it is better to sacrifice the coating than the base metal, using black wrought iron in preference to galvanized steel pipe.

THE COATING STICKS TO IRON

Figure 2 shows a piece of Byers galvanized wrought iron pipe hammered flat to the point of fracture. Yet there is no sign of scaling or chipping of the galvanizing. Figure 3 shows what happens to steel pipe under similar treatment—the galvanizing begins to crack and peel off in large flakes at the first strokes of the hammer. This test can be made by anyone, and it may even be used for determining whether the pipe is iron or steel.

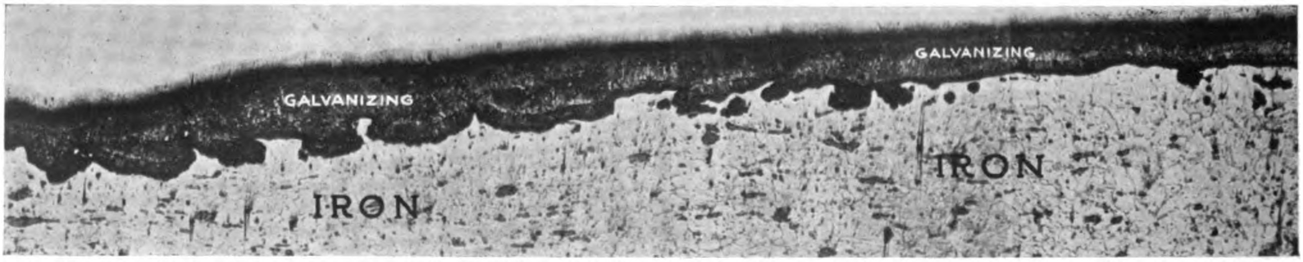


Figure 1

Micro section of galvanized *iron* pipe. Note the deep anchorage of the zinc on the iron base. The line of fusion between the iron and zinc is as furrowed and dented as the coast of Alaska, with bays and islands, deep fjords and peninsulas.

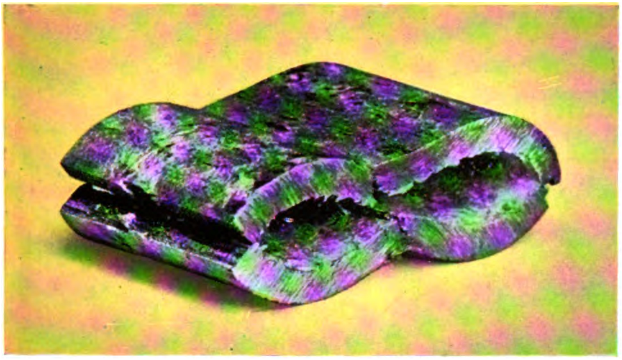


Figure 2. Galvanized Iron Pipe

Take a short piece of pipe and flatten it out. If it is iron, the galvanizing will stick like glue—it will break, but it will not scale off. See explanation in Figures 1 and 5.

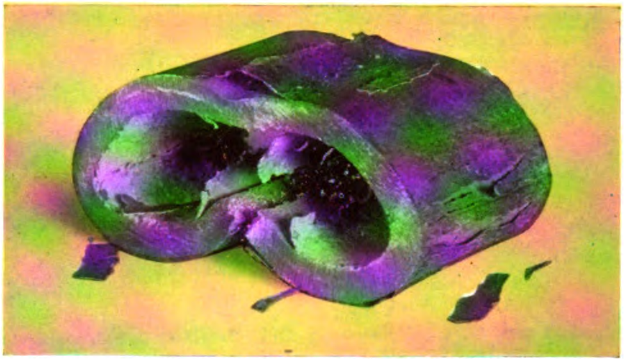


Figure 3. Galvanized Steel Pipe

Flatten a piece of steel pipe and the galvanizing will crumble and come off in large scales and flakes. See explanation in Figures 4 and 6.

Figures 1, 4, 5 and 6 demonstrate, by photo-micrographs, the difference in the surface of iron and steel pipe, and graphically explain why protective coatings on iron obtain a much better anchorage.

PAINTING THE PIPE

In plants or buildings where black pipe is used, it is good economy to paint the exterior of pipes which are subject to corrosion from condensation and from water trickling over the pipes. A coat of paint on iron pipe will stick like glue, while it takes but a poor hold on the smooth surface of steel pipe.

THICKNESS OF COATING

Byers pipe is galvanized by the hot metal process, and nothing but prime Western spelter is used in the galvanizing kettle. The Byers Company has been approached with many schemes for cheapening this coating by means of different processes and the use of cheaper materials, claimed to give as good or better results. For general purposes, however, none of these processes has produced a coating giving as good results in actual service. The Byers practice includes a short period of immersion and a relatively low temperature of the spelter bath. Lengthening the period of immersion would tend to increase the alloy area to an undesirable degree, while the low temperature of the spelter bath tends to increase the thickness of the surface layer of pure zinc to the most desirable extent. More information on this subject is contained in the explanation on page 5 of "How the Coating on Byers pipe compares with Electro-galvanizing and Sherardizing."

In a series of tests, made to ascertain the relative thickness of coating on Byers pipe and the best steel pipe, the following results were shown:

TEST No. 1

METHOD: Stripping off coating from galvanized pipe with solution of antimony chloride in hydrochloric acid—(known as the Aupperle Method).	
BYERS Pipe—12 pieces 1¼ in. pipe, each 2 in. long, spelter average per square foot **outside** surface	3.41 oz.
STEEL Pipe—12 pieces, same as above	2.48 oz.
DIFFERENCE in favor of Byers Pipe	37.8 %

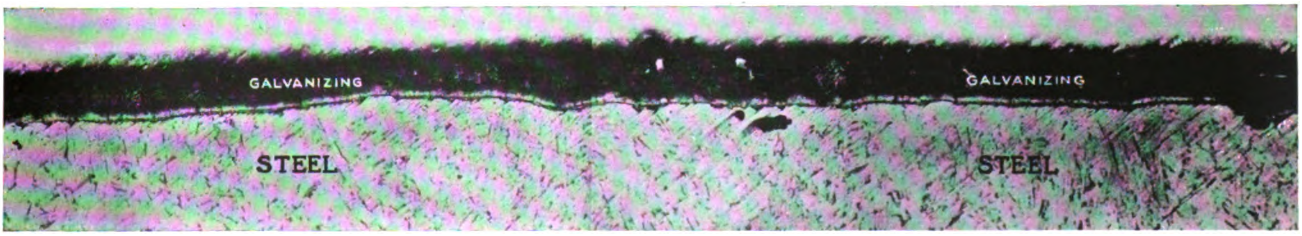


Figure 4

Micro section of galvanized steel pipe. Note the characteristic smooth surface of the steel base, on which the zinc obtains but a poor anchorage, flaking off easily as shown in Figure 3.

TEST No. 2

METHOD: Chemical analytical.

BYERS Pipe—2 pieces 1¼ in., each 2 in. x 2 in. **outside** surface, average spelter per square foot outside surface 3.31 oz.

STEEL Pipe—Same as above 2.37 oz.

DIFFERENCE in favor of Byers Pipe 39.6 %

TEST No. 3

METHOD: Aupperle.

BYERS Pipe—5 pieces 1¼ in., each 2 in. long, spelter per square foot **outside** surface 4.19 oz.

STEEL Pipe—5 pieces, same as above 2.95 oz.

DIFFERENCE in favor of Byers Pipe 42.1 %

TEST No. 4

METHOD: Stripping of coating with lead acetate solution (Walker Method).

BYERS Pipe—6 pieces 1¼ in. pipe, 2 in. x 2 in. **outside** surface, average spelter per square foot of surface 3.90 oz.

STEEL Pipe—Same as above 2.59 oz.

DIFFERENCE in favor of Byers 50.3 %

TEST No. 5

METHOD: Aupperle.

BYERS Pipe—6 pieces 1¼ in. with 2 x 1¼ in. surface, inside dimensions, average spelter per square foot **inside** surface 5.63 oz.

STEEL Pipe—Same as above, average spelter inside surface 3.78 oz.

BYERS coating on inside surface thus is heavier than inside coating on steel pipe by 48.9 %

TEST No. 6

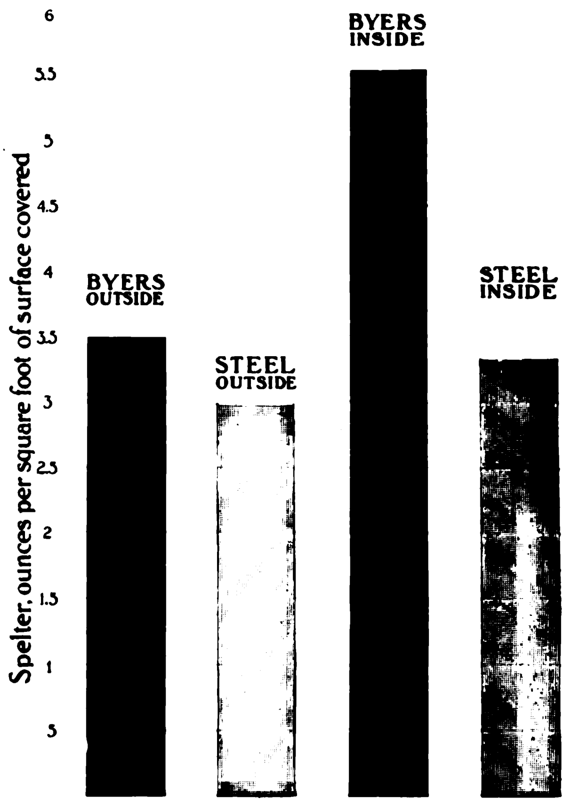
METHOD: Aupperle.

BYERS Pipe—10 pieces 2 in. with 2 in. x 2 in. inside surface; average spelter per square foot surface 5.37 oz.

STEEL Pipe—10 pieces, same as above 2.56 oz.

DIFFERENCE in favor of Byers 109.8 %

THICKNESS OF GALVANIZED COATING BYERS *vs.* STEEL PIPE



RESUME OF TESTS

For tests 1 to 4 inclusive, the average weight of coating on Byers pipe per square foot covered was 42.45% heavier than on steel pipe, all samples being stock pipe, taken at random. The *inside* coating on Byers pipe by tests Nos. 5 and 6 was shown to be nearly

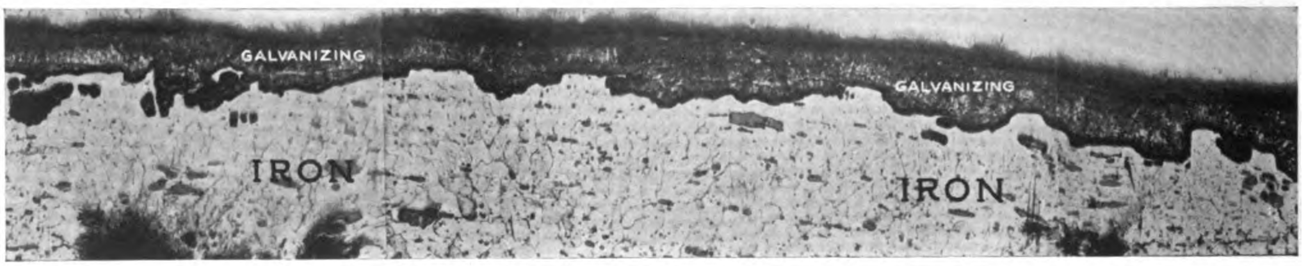


Figure 5. Iron Pipe Galvanized

Another view showing characteristic rough surface of iron pipe on which the zinc coating secures a tenacious anchorage. See also Figure 1.

twice as heavy as the *outside* coating. As the extra price of Byers galvanized pipe over Byers black pipe is no greater than the difference between galvanized steel and black steel pipe, the extra thickness of coating on Byers pipe represents an extra value of which the purchaser is given the entire benefit.

HOW THE COATING ON BYERS PIPE COMPARES WITH ELECTRO-GALVANIZING AND SHERARDIZING

Many schemes have been broached to the Byers Company for coating pipe by processes and materials for which certain advantages are claimed. The number of such processes brought out has increased from year to year and very extravagant claims are made for many of them. Closer acquaintance with most of these processes and observation of the results obtained in service have, however, so far proven that the hot galvanizing process, as employed on Byers pipe, has every advantage of *thickness of coating, adhesion, penetration and rust resistance,* while the strongest argument in favor of other processes, when all the evidence is sifted, is usually low price. The best known of these processes are sherardizing and electro-galvanizing.

DIFFERENCE IN THICKNESS

The anchorage or adhesion of the coating on Byers galvanized pipe has already been clearly demonstrated in Figures 1 to 6, and the thickness as compared with steel pipe, by tests already described. In addition, Figures 7, 8 and 9 illustrate the difference in thickness between (a) the inside coating in Byers pipe, (b) the sherardized coating on sheet metal, (c) the electro-galvanized coating on sheet metal. These micro-photographs are interesting not only in graphically illustrating the difference in thickness, but in showing the "penetration" or alloying action between the zinc and the base metal as explained in the following.

PENETRATION OR ALLOYING ACTION

Thorough "penetration" or absorption of the coating is the one great advantage claimed for the sherardizing process. As will be seen from Figure 7, the entire sherardized coating is alloyed with the steel base, while in Figure 8 (electro-galvanizing) there is practically no such alloying action, the division or fusion line in this case between the steel and the zinc being quite distinct, and shows a coating of pure zinc adhering to the steel surface. In Figure 9 (hot galvanizing) it will be seen there is an alloy or penetration area slightly greater than in the case of sherardizing (Figure 7) and, *in addition, a heavy coating of pure zinc, the entire coating*

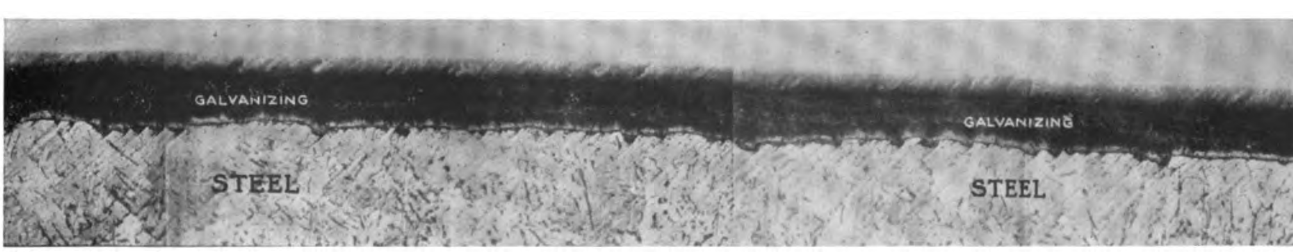


Figure 6. Steel Pipe Galvanized

Another view showing the smooth surface of steel pipe, which explains the tendency, always present in galvanized steel pipe, to flaking of the zinc coating.

Figure 7. Sherardized Coating on Steel.

Figure 8. Electro-Galvanizing on Steel

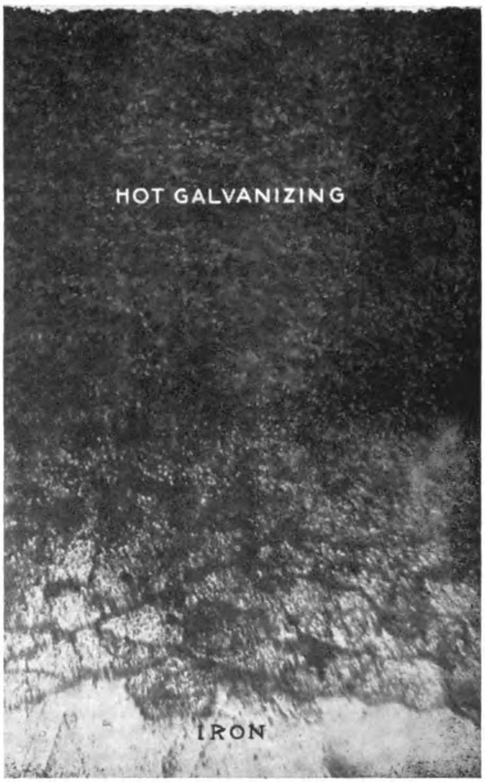


Figure 9. Hot Galvanized Coating on Byers Pipe.

being over five times heavier than the average sherardized and electro-galvanized coating on sheets.

Between these two elements, viz., the alloy coating ($FeZn_{10}$) and the pure zinc coating, by far the most valuable part is the layer of pure zinc where it is present. By comparison, the underlying alloy ($FeZn_7$ or $FeZn_{10}$), where it exists, has much less rust resistance and is very brittle and crumbly, a condition which makes it unpracticable to use a heavier coating by the sherardizing process as it would flake off too easily. The alloy, ($FeZn_{10}$), chemically and physically, closely resembles dross and is even more crumbly, a characteristic which applies in the case of sherardizing as much as in hot galvanizing. It is just because of this tendency of the alloy to crumble, and the impossibility of obtaining a pure zinc surface, that a successful sherardized coating cannot be made nearly as heavy as the hot galvanized coating on Byers pipe.

SPECIFICATIONS FOR GALVANIZED PIPE

The pipe shall be genuine wrought iron, guaranteed free from steel and foreign scrap of any kind, being hand-puddled from pure pig iron. On this base the coating shall be applied by the hot metal process, nothing but prime Western Spelter, containing not over 1% of lead, being used. The coating on the *outside* of the pipe shall have an average weight not less than 3.25 oz. per square foot of surface covered, and on the *inside* not less than 5.25 oz. per square foot of surface covered.

Note. The customary 2 oz. per square foot of sheet metal means the *combined* thickness of the coating on two sides, or only 1 oz. per square foot of surface covered. The thickness of the inside and outside coating on Byers pipe, expressed in the same manner, would therefore be 8.5 oz.

HOW TO TELL THE DIFFERENCE BETWEEN IRON AND STEEL PIPE

Any one of the following six or seven methods described may be employed to ascertain of which material pipe is made, iron or steel. If a sample of the pipe is available, the crushing or fracture test (No. 2) is the easiest and surest, and if the pipe is installed and cannot be removed, a few filings may be obtained for manganest test (No. 4). These two tests, being easily and quickly made, are always to be preferred. If any doubt still remains as to the identity of the material, the microscopic test (No. 6) is the court of final decision; fortunately, this cumbersome test, which can only be made in a laboratory, is rarely necessary, as one or two of the other and easier tests are invarably sufficient to determine the question.

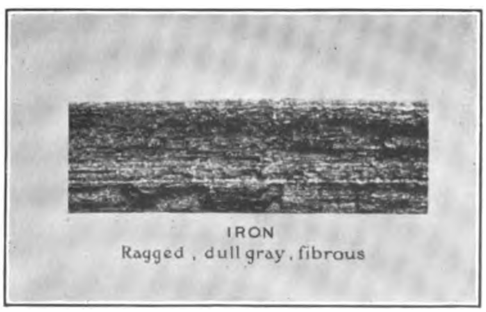
1. GALVANIZING TEST

Hammer a piece of galvanized pipe repeatedly to flatten it. If the zinc coating adheres firmly to the pipe, showing little effect of the hammering or flattening, it is iron pipe. If, on the other hand, the zinc begins to scale off at almost the first stroke of the hammer, the pipe is steel. Repeated blows will cause it to come off in large flakes, leaving the steel almost bare in spots. This is virtually what happens during handling, cutting, bending and threading steel pipe and in the course of years of service

Hammer a piece of Byers pipe and note the tenacity of the coating on the iron. You may fracture the pipe, and the galvanizing will fracture with it, without cracking and scaling off at the edge of the fracture. (See illustration, Figures 2 and 3, page 3.)

2. FRACTURE TEST

The fracture of genuine wrought iron pipe appears *ragged, dull gray* and *fibrous.* The fiber is particularly distinct when compared with a steel fracture. A fracture is easily obtained by hammering a short piece of pipe, as shown at top of page 3.


IRON
Ragged, dull gray, fibrous


STEEL
Even, bright, crystalline

The fracture of steel is *even, bright* and *crystalline,* which, when exposed to the air, soon loses its luster. Moreover, steel pipe shows a tendency to fracture at the weld; the metal here presents a smooth, dull gray appearance, which should not be confused with the rough, fibrous fracture of wrought iron.

3. THREADING TEST

When wrought iron pipe is threaded its fibrous structure causes the chip to *break and crumble* as when dressing the end of a piece of wood. (This prevents clogging of the die space and reduces friction. A clean accurate thread results.)

With steel, owing to the absence of fiber, the chip tends to curl up, forming *a long, more or less perfect spiral,* beautiful to look at but an obstacle to easy threading, for it increases friction and causes clogging of the chip space.

4. MANGANESE TEST

Place a small chip about the size of a large pin-head, or filings to equal this quantity, in a small, clean test tube. Add twenty drops of chemically pure nitric acid, specific gravity 1.2, and heat with a match until the metal is completely dissolved. Let the solution cool until the tube can be held in the hand without discomfort, and add as much sodium bismuthate as will lie on the point of a small pen-knife blade, or as much more as may be required to produce a small amount of brown residue. Bubbles of oxygen gas will be given off by the solution when the bismuthate is added, after which the development of a pink or red color may appear in the solution, indicating the presence of manganese, which shows that the material is steel. If no reddish tint appears, or only a very slight pinkish discoloration is visible, the material is iron.

If wrought iron contains more than a trace of manganese, which occasionally happens, this test is misleading. A fracture test or chemical analysis is, therefore, preferable whenever possible. It should also be noted that "Ingot Iron" and other soft steels of very high purity, contain only a trace of manganese, but so little pipe is as yet made from these materials that the possibility may be practically ignored.

5. "CINDER RING" TEST

This is an old, well-known test, made by the aid of a solution consisting of 25% sulphuric acid, 25% nitric acid and 50% water. Take a short piece of pipe, finished straight and fairly smooth at one end, submerging this end in the solution. After half an hour or more the pipe, if iron, will show rough concentric rings at the end, while the steel pipe will appear perfectly smooth. Occasionally steel pipe, if the material is piled from scrap, will also show rough ring structure, and this test is therefore not always reliable.

6. MICROSCOPIC TEST

Polish pipe to be tested, as customary in the preparation of metallographic samples, and etch with picric acid. The metal, if genuine wrought iron, will show the characteristic silicate slag fibers in the longitudinal section (parallel to rolling) and ends of slag fibers in a cross section of metal. If steel, no such slag fibers will be present, but an even distribution of pearlite, consisting of one part of combined carbon and six parts of iron. See Figures 12, 13 and 14.

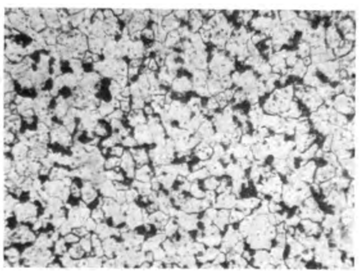


Figure 12—Micro section of soft steel. The black spots are Pearlite, consisting of 1 part of combined carbon and 6 parts of iron, a mixture which is not only corrodible, but induces electrolysis.

Figure 13—Micro section of wrought iron taken parallel to rolling. The black streaks are non-corrosive slag.

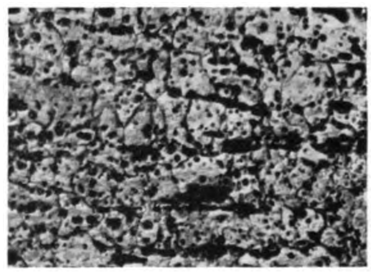


Figure 14—Micro section of wrought iron transverse to rolling (end section.) The black areas represent the ends of the fine slag bands.

7. ROLL MARKS ON PIPE

In the case of new pipe, the easiest way to eliminate all doubt as to whether the pipe is genuine wrought iron is to see that it is marked as shown in the illustration on this page. The Byers Name and the Year of Manufacture are rolled, in raised letters, into the metal of all sizes of Byers pipe with the exception of 1/8 inch Standard and Extra Heavy and 1/4 inch Extra Heavy, which are bundled and bear a metal tag marked Byers. The roll marks showing the Name and Year are necessarily shallow to avoid damaging the pipe or making threading difficult but, if you look for them, you can easily find them. The Year of Manufacture rolled in the metal is a guarantee of the lasting qualities of Byers pipe. It facilitates future observation as to the number of years the pipe has been in service. Watch and compare it with the service given by other welded pipe.

OTHER LITERATURE ON BYERS PIPE	The subject of corrosion of pipe is covered in various publications issued by the Byers Company; also the physical properties of pipe, specifications for genuine wrought iron pipe, tables of dimensions and sizes, etc. Tell us in what you are interested and the proper publication will be sent you free of charge.
