April 17, 1934. N. F. S. RUSSELL ET AL 1,954,892

CENTRIFUGALLY CAST CAST IRON PIPE

Filed Jan. 17, 1933

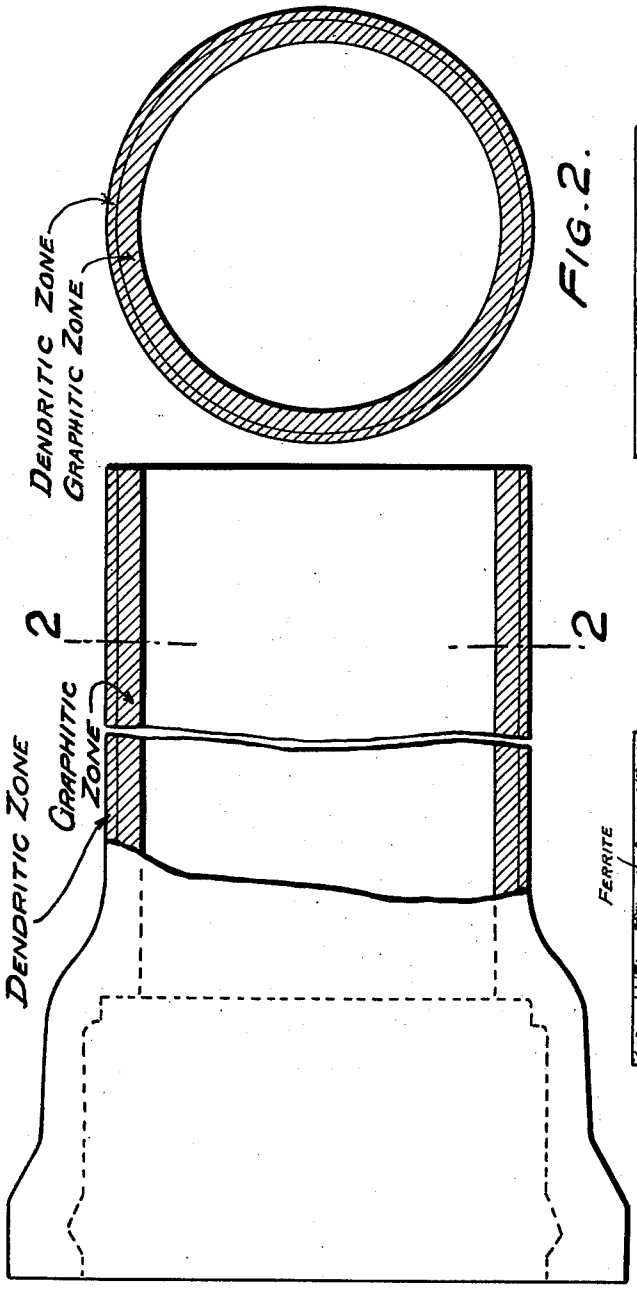


FIG. 1.

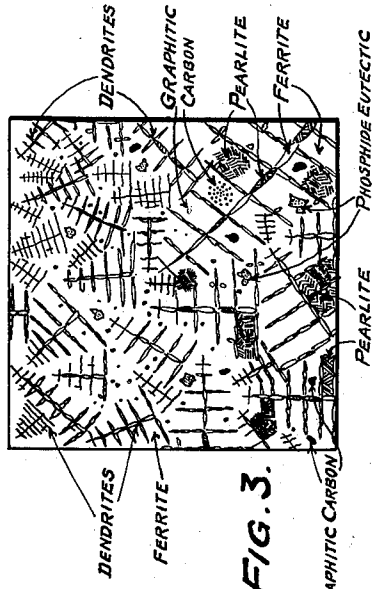


FIG. 2.

FIG. 3.

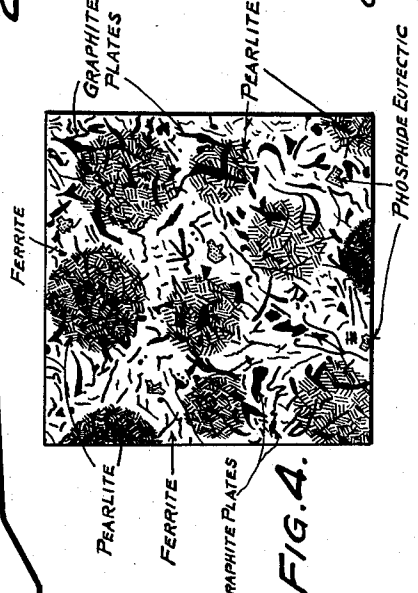


FIG. 4.

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Patented Apr. 17, 1934 1,954,892

UNITED STATES PATENT OFFICE

1,954,892

CENTRIFUGALLY CAST CAST IRON PIPE

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Application January 17, 1933, Serial No. 652,160

4 Claims. (Cl. 29—180)

Our invention relates to centrifugally cast cast iron pipe and has for its object to provide a pipe which will be freely machinable and highly resistant to impact shock throughout its cylindrical portion and in which a crack, when formed, will be much less liable to occur in straight lines or planes than is the case with cast iron pipes as previously manufactured, said cracks in our new pipe having a marked tendency to occur with irregular outlines. Our new pipes are also characterized in that they have a distinctly novel and advantageous structure. Another and practically important object which we have in view is the manufacture of pipe having our novel constructive features, from iron compounds or mixtures which, by reason of their commercial availability, are usually employed in the manufacture of cast iron pipes. The essential qualities of iron compounds, available for use in the manufacture of our pipes, are that, when cast in dry sand molds, they will form a machinable gray iron casting and, when cast against a cold metallic surface, they will form for some distance inward from the surface in contact with the mold, a chill. Such irons can be and, for our purposes, preferably are prepared from such commercially available irons or iron mixtures of comparatively low cost as are ordinarily used in the manufacture of cast iron pipe and come within the following specification:

C.	Si.	S.	Mn.	P.
3.00-3.85	1.20-3.00	.05-.15	.20-.80	.20-2.00

It will be understood that irons coming within the specification may and frequently do contain varying amounts of alloying elements, such as copper, nickel, chromium, molybdenum, titanium and vanadium, the presence of which elements does not in any material degree affect the general character and quality of the product.

As examples of such iron compounds as we have very successfully used in the manufacture of our pipes, we would instance the following:

Si.	S.	Mn.	P.	T.C.
2.02	.065	.56	.49	3.70
1.72	.074	.43	.81	3.64
2.20	.147	.42	.77	3.47

Further objects of our invention are to provide a structure having the qualities above mentioned and which will be capable of being manufactured rapidly and cheaply.

The essential characteristic features of our new pipe consist, first, in that its cylindrical portion is made up substantially of two concentric annular zones, of which the outer zone extends from the outer surface of the pipe inward for a distance of not less than one-quarter the thickness of the wall casting of the pipe and consists preponderantly of compacted, interlacing, dendritic, crystalline formations of ferrite and/or pearlite, without unidirectional tendency, said dendritic formations being symmetrically distributed both longitudinally and radially of the zone, without intervening areas of that eutectic of cementite with austenite in various stages of decomposition, commonly referred to as a chill. In speaking of the dendrites as symmetrically distributed throughout the zone, we mean that in all cross-sections of the dendritic zone the dendrites will be found to be, in number, fineness and distribution, approximately the same, although it may also be true that the dendrites will show a tendency to become less fine and less numerous in the inner than in the outer portion of the dendritic zone. Another distinctive feature of the outer dendritic zone of our pipe lies in the fact that the carbon eliminated from combination occurs in this zone in the form of dots or nests as distinguished from such graphitic plates as characterize the inner zone of the pipe and not in the form of such graphitic plates; still another distinctive feature of our pipe lies in the fact that, as cast, the combined carbon present in the outer dendritic zone is present in markedly smaller percentage per unit of mass than is the case as to the combined carbon in the inner or graphitic zone of our pipe.

The graphitic structure of the inner zone of our pipe consists of a matrix of ferrite and/or pearlite, through which is distributed small plates of graphitic carbon and in which substantially no dendritic crystalline structures occur, said inner or graphitic zone being further characterized in that per unit of mass it contains a higher percentage of combined carbon than is the case with the outer or dendritic zone.

It will be understood that the actual percentage of combined carbon to be found in the cylindrical portion of pipes embodying our invention will vary with the composition of the metal and with the thickness of the wall casting of the pipe and these conditions will also affect the relative percentages of combined carbon per unit of mass in the inner and outer zones of our pipes, though, in all cases, it will be found that the percentage of combined carbon is less in the outer or dendritic zone than in the inner or graphitic zone.

A notable and, we believe, valuable characteristic of our cast pipe lies in the fact that the combined carbon in the dendritic zone is notably less per unit of mass than is the case in the graphitic zone. The difference will vary somewhat with the thickness of the casting and the composition of the iron but will exist in all pipes

having the otherwise characteristic features which distinguish our improved pipes; for example, in a pipe having a wall thickness of .38 inches, cast from an iron of the following composition:

C.	Si.	S.	P.	Mn.
3.70	2.03	.074	.55	.56

we find that the combined carbon in the dendritic zone is .16% while, in the graphitic inner zone, the combined carbon is .44%. Again, in the case of a pipe having a wall thickness of .64 inches, we find that combined carbon in the dendritic zone is .11% while, in the graphitic zone, it is .29%. We believe, from tests and experiments which we have made, that the comparatively low percentage of combined carbon in the dendritic, as compared with the graphitic zone, of our pipes, is not only a distinguishing feature but is a feature contributing in no inconsiderable degree, to the excellence of our pipe.

It will be noticed that in the examples which we have given showing the percentages of combined carbon in the inner and outer zones of our pipe that the total combined carbon in the casting is less than .5% and this would be characteristic of most of the pipes embodying our invention and prepared to meet the ordinary requirements of the trade. In some cases, however, and to meet specific requirements for pipes to be used for certain purposes, it will be desirable that the total percentage of combined carbon should be greater and this, it will be recognized, can be readily provided for by familiar expedients.

We have referred to the outer or dendritic structure as having a depth of not less than one-quarter the thickness of the wall of the pipe. Such a proportionate depth of this annular zone is sufficient to impart to pipes embodying our invention, and to a marked degree, the notably increased capacity to resist impact shocks, together with the quality of being freely machinable, though we believe that with increased proportionate depth of the dendritic zone the capacity of resisting impact shock is materially increased and it is true that with pipes having thinner wall sections the proportionate depth of the dendritic zone will be greater than with pipes having thicker walls and, with comparatively thin walled pipes, the dendritic zone will, in many cases, extend inward for approximately one-half the thickness of the pipe. The proportionate depth of the dendritic zone will decrease with increased wall thickness but will not be less than one-quarter of the thickness of the pipe with pipes having the wall thickness of centrifugally cast pipe.

A fuller description of the structure of our pipe as it appears on careful microscopic examination, is as follows:

The outer dendritic zone consists preponderantly of a continuous structure of compacted, interlacing, dendritic, crystalline formations of ferrite and/or pearlite without unidirectional tendency, through which formations are dispersed dots and nests of carbon, as distinguished from graphitic plates such as characterize the inner graphitic zone of the casting and small areas of iron phosphide and/or iron phosphide eutectic. The dendrites in this zone are relatively fine at or near the outer surface of the zone and have a tendency to become somewhat coarser and less numerous as the inner limit of the zone is approached. The inner or graphitic zone of our casting is made up of a matrix which is composed of pearlite and/or ferrite containing areas of phosphide eutectic and having a structure which tends to become coarser toward the inner wall of the zone. Throughout this matrix, the graphite is distributed in small dots and, more particularly, in distinct small plates of graphite.

As an aid to the understanding of our new pipe structure, we would refer to the drawing forming a part of this specification, in which

Figure 1 is an elevation of a cast iron pipe embodying our improved structure and composition, with the cylindrical portion of the pipe shown in longitudinal central section and with said cylindrical portion shown as partly broken away between the bell and spigot ends of the pipe.

Figure 2 is a cross-section through the cylindrical portion of the pipe shown in Fig. 1, taken, for example, on the section line indicated at 2—2 of Fig. 1.

Figure 3 is a somewhat diagrammatic showing of the structure and make-up of the outer dendritic zone of our improved pipe, as it appears in a micro-photographic enlargement of approximately 100 diameters, and

Figure 4 is, again, a somewhat diagrammatic showing of the structure and make-up of the inner zone of our improved pipe, as it appears in a micro-photographic enlargement of approximately 100 diameters.

In Figs. 1 and 2, the outer and inner zones are indicated by appropriate labels. In Fig. 3, the dendrites forming the preponderating mass of the outer dendritic zone of our pipe are, it will be understood, owing to their interlacing and nondirectional disposition, sectioned in every conceivable way in any surface prepared from microscopic examination and photography.

In the drawing, dendritic forms lying approximately in the section prepared for microscopic examination, are indicated by lead lines leading to appropriate labels. While the dendrites in the dendritic zone are preponderantly made up of ferrite, areas of pearlite will occur and these are indicated in the drawing by lead lines leading to appropriate labels. The occurrence in the dendritic zone of carbon dots and small areas of phosphide eutectic are also indicated by lead lines leading to appropriate labels. As indicated in Fig. 4, the mass of the inner graphitic zone is made up of a matrix of ferrite and pearlite, as indicated by lead lines leading to appropriate labels, through which matrix are distributed small plates of graphite, as indicated by lead lines and labels and in which also occur areas of phosphide eutectic, as indicated by lead lines to appropriate labels.

Our new pipe structure can be produced successfully and economically by casting an iron of the character described by the method invented by us and forming the subject matter of our application for Letters Patent filed October 19, 1932, Serial Number 638,480. By this method the molten iron is progressively delivered to a rotating externally cooled steel mold through a relatively retractable runner so that the metal is delivered to the mold in the form of a helical coil and the inner surface of the mold is progressively coated with a finely divided, dry coating material, such as ferro-silicon, in advance of the contact of the molten metal with the coated portion of the mold by means of a jet of carrier gas loaded with distributed particles of the coating material,

which jet is relatively retracted with regard to the rotating mold so as to deposit upon the surface of the mold a helical band of the coating material in immediate advance of the contact of the molten metal with the coated surface and, as we have pointed out in our said former application, it is important that the coating of the mold should be of uniform thickness, that the thickness, for the best results, should not materially exceed that minimum thickness which is found to prevent the formation of areas of chill in the casting, a thickness which in the case of the use of ferro-silicon as a coating material, should not materially exceed that formed by the delivery by the jet of carrier gas of a quantity of finely divided ferro-silicon which, if it all remained in contact with the mold wall and was compactly deposited thereon, would form a coating of approximately .0003 of an inch in thickness. We have also pointed out in our former application that the coating, for reliable results, should not exceed that formed by the uniform delivery of the powdered material in quantity which, if it all remained in contact with the wall of the mold and was compacted thereon, would form a coating not to exceed .001 of an inch and we have also pointed out the great importance of laying down the coating upon the surface of the mold as short a time as possible before that surface is contacted by the molten metal and have pointed out that it is exceedingly undesirable that the coating should be deposited upon the surface of the mold more than six seconds before the coated surface is contacted by the molten metal. We have also in our former application pointed out the reasons which lead us to believe that the efficiency of the very thin layer of coating material in preventing chill and bringing about a desirable structure in the casting is largely due to the fact that, as the coating is deposited, the fine particles of coating material projected against the surface of the mold by the carrier gas are individually coated with thin films of adsorbed gas, which films form a part of the coating as it is first formed and play an important part in the formation of the desirable iron structure and it is, we believe, the tendency of these gaseous films to disappear under the conditions existing in the mold, which makes it important that the coating should be laid down on the mold as nearly as possible immediately before the molten metal contacts with the coated surface and accounts for the loss of efficiency of the coating which is observable where the coating is applied by the jet to portions of the mold which are not contacted by the molten metal for some appreciable time after the coating is applied.

We have also pointed out in our former application that a mold coating of finely divided, dry coating material is liable, under certain conditions, to lose its continuity so as to leave areas of the mold surface uncoated and with the result that the casting in contact with these uncoated portions will present areas of chill. These fractures, so to speak, of the coating occur from two causes. One, the slipping of a portion of the coating on the mold surface, due to the rotation of the coated surface, and the other is the tendency of the molten metal, in its impact against the coated surface of the mold, to push a portion of the coating before it so as to break the continuity of the coating and bring about areas of chill in the casting. Both of these forces tending to bring about fractures in the coating, are more injuriously effective the thicker the mold coating is and this makes it important to use as little coating material as is found effective to prevent chill, say in the case of finely divided ferro-silicon, a coating built up by the introduction into the mold of ferro-silicon in quantity which, if it all remained in contact with the mold and was compacted thereon, would form a coating of approximately .0003 of an inch in thickness and this is also the reason why we have found it very undesirable to use the coating material in quantity which, under the conditions mentioned, would form a coating in excess of .001 of an inch in thickness.

In the formation of our improved cast pipe, it is essential that throughout the cylindrical portion of the pipe there should be no areas of chill and very important that the coating should be as thin as possible because the thickness of the coating also affects to an important degree the depth of the dendritic zone of the casting, that is to say, the thicker the coating the less will be the depth of the dendritic zone and the greater will be the depth of the inner graphitic zone, characterized by a substantial absence of dendrites and the occurrence of plates as distinguished from dots and unformed patches of graphite.

By manufacturing our pipe by the process which we have described above, it is practical, on a manufacturing scale to produce pipes having dendritic zones of the character which we have described extending through not less than one-quarter of the thickness of the cylindrical wall of the pipe and this process, as applied to the casting of pipes having the characteristics of our new pipe, has the additional advantage that the tensile strength of the dendritic area is high even when the metal is very hot, thus enabling the casting to resist the longitudinal strains occurring during solidification and liable to result in the formation of checks in the outer surface of the pipe and, again, the nondirectional disposition of the interlacing dendrites has a marked tendency to prevent the formation of what are called pin holes in the wall of the casting, brought about by the escape of occluded gases, which gases, where the crystalline structure is more or less normal to the surface, have a tendency to follow the surface of the crystals and escape through the outer surface of the casting.

It should, perhaps, be noted that our improved pipe as cast by the process which we have described, is characterized by having a fairly smooth and even outer surface which may be taken as fairly indicative of the symmetrical distribution of the dendrites in the outer zone of the wall of the pipe.

Having now described our invention, what we claim as new and desire to secure by Letters Patent, is:

1. A centrifugally cast, cast iron pipe having the compactness of structure characteristic of centrifugally cast pipe, the cylindrical portion of which as cast is freely machinable throughout its length and highly resistant to impact shocks, said cylindrical portion as cast being structurally made up of two annular zones, of which the outer zone extends from the outer surface of the pipe to a distance of not less than one-fourth the thickness of the pipe and is characterized in that its iron constituent is preponderantly present in said zone as a mass of compacted interlacing dendrites of ferrite and/or pearlite substantially without unified directional tendency, said dendrites being symmetrically dis-

tributed both longitudinally and radially of the zone so as to form a compact and continuous structure, without intervening areas of that eutectic of iron carbide with austenite in various stages of decomposition commonly known as a chill, said outer zone being further characterized in that the uncombined carbon therein is present in the form of dots and nests of carbon as distinguished from the graphitic plates characteristic of the inner zone and in that such graphitic plates do not occur therein, said outer dendritic zone being further characterized in that as cast the combined carbon therein is present in smaller percentage per unit of mass than is the case in the inner graphitic zone, said cylindrical portion of the pipe being further characterized in that its inner, annular zone consists essentially of a matrix of ferrite and/or pearlite, substantially free from dendritic formations and through which matrix are distributed small plates of graphitic carbon, said inner graphitic zone being further characterized in that as cast it contains a higher percentage of combined carbon per unit of mass than is the case with the outer dendritic zone.

2. A cast iron pipe as called for in claim 1, having a composition coming within the following specification:

C.	Si.	S.	Mn.	P.
3.00-3.85	1.20-3.00	.05-.15	.20-.80	.20-2.00

3. A centrifugally cast cast iron pipe having the compactness of structure characteristic of centrifugally cast pipe, the cylindrical portion of which is freely machinable throughout its length and highly resistant to impact shocks, said cylindrical portion being structurally made up of two annular zones, of which the outer zone extends from the outer surface of the pipe to a distance of not less than one-quarter the thickness of the pipe and is characterized in that its iron constituent is preponderantly present in said zone as a mass of compacted interlacing dendrites of ferrite and/or pearlite substantially without unified directional tendency, said dendrites being symmetrically distributed both longitudinally and radially of the zone so as to form a compact and continuous structure, said outer zone being further characterized in that the uncombined carbon therein is present in the form of dots and nests of carbon as distinguished from the graphitic plates characteristic of the inner zone and in that such graphitic plates do not occur therein, said cylindrical portion of the pipe being further characterized in that its inner, annular zone consists essentially of a matrix of ferrite and/or pearlite, substantially free from dendritic formations and through which matrix are distributed small plates of graphitic carbon.

4. A cast iron pipe as called for in claim 3, having a composition coming within the following specification:

C.	Si.	S.	Mn.	P.
3.00-3.85	1.20-3.00	.05-.15	.20-.80	.20-2.00

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