Aug. 28, 1934. N. F. S. RUSSELL ET AL 1,971,385

CAST IRON PIPE

Filed May 4, 1933

Fig. 1.

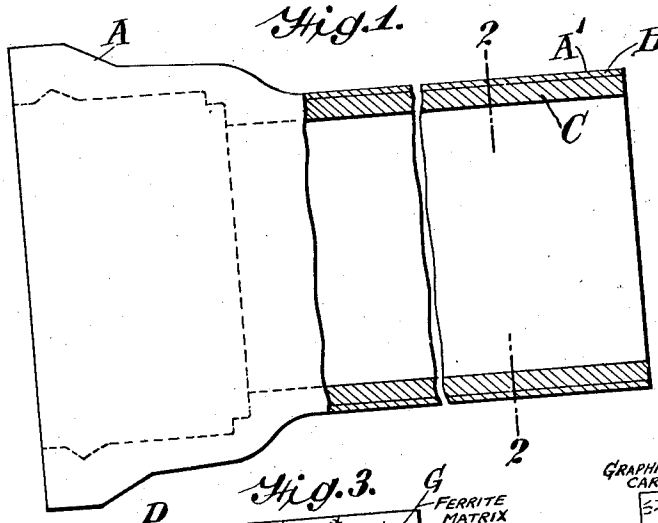


Fig. 2.

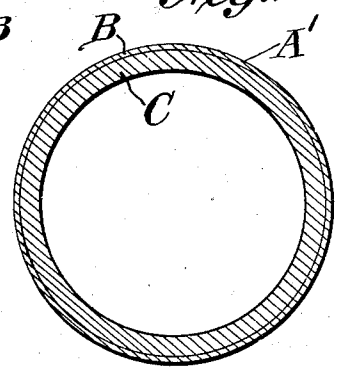


Fig. 3.

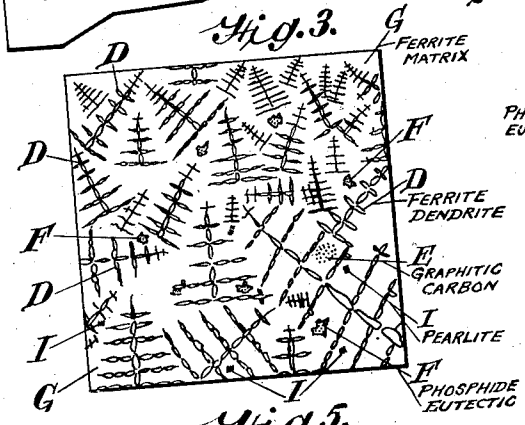


Fig. 4.



Fig. 5.

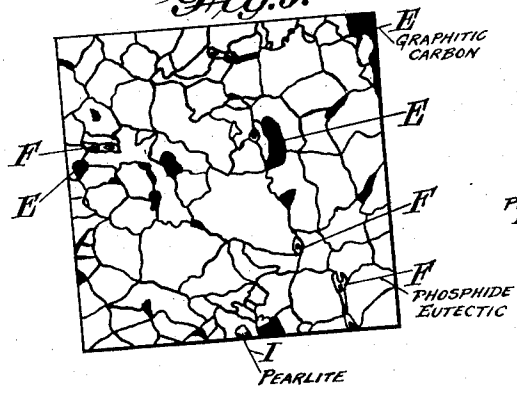
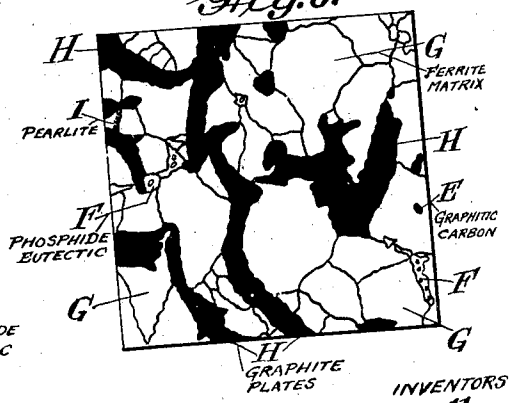


Fig. 6.



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UNITED STATES PATENT OFFICE

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CAST IRON PIPE

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Application May 4, 1933, Serial No. 669,356

2 Claims. (Cl. 148—31)

Our invention relates to centrifugally cast cast iron pipe having the density of structure characteristic of centrifugal castings and cast from iron compounds of such a character that they will, when cast against a chilled metal mold, have what is known as a chill formed upon their outer surface while, when cast in a sand mold, they will have throughout a graphitic gray iron structure, such iron compounds are those which by reason of cost are considered available for the manufacture of cast iron pipe and which have 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 balance substantially iron.

As examples of iron compounds which we have successfully employed in the manufacture of our new pipes, we will give the following:

	C	Si	S	Mn	P
Example 1	3.70	2.02	.065	.56	.49 balance substantially iron.
Example 2	3.64	1.72	.074	.43	.81 balance substantially iron.
Example 3	3.47	2.20	.147	.42	.77 balance substantially iron.

The object of our invention is to provide a centrifugally cast pipe of an iron composition coming within the above specification having a marked superiority over centrifugally cast pipes as heretofore manufactured from such iron compounds, particularly in the quality of ductility and consequent capacity to successfully resist impact shocks and characterized in that our pipes have a distinctive novel structure.

In our co-pending application for Letters Patent, filed January 17, 1933, Serial Number 652,160, we have described and claimed as a new article of manufacture a centrifugally cast cast iron pipe made from irons coming within the above specification and characterized in that the cylindrical portion of the pipe is essentially made up of an outer annular zone of not less than one-fourth the thickness of the wall of the pipe and which zone is preponderantly made up of compacted, interlaced and substantially nondirectional dendritic crystals of ferrite and/or pearlite without intervening areas of that columnar structure normal to the outer surface of the pipe which is characteristic of the formation of what is known as a chill, said interlacing dendrites being symmetrically disposed both longitudinally and radially in the zone though radially the dendrites have a tendency to become somewhat coarser and less numerous toward the inner limit of the dendritic zone. Said dendritic zone is further characterized in that it embodies no areas made up of those refractory forms of combined carbon constituting what is commonly known as a chill. A further distinctive feature of the outer zone is that the graphitic carbon therein is dispersed among the dendrites in the form of dots and patches of graphite as distinguished from plates or flakes such as occur in the inner zone of the pipe. In the said pipes of our former application, the inner zone is preponderantly made up of grains of ferrite and/or pearlite substantially without the occurrence of dendritic crystals and having distributed throughout the matrix of ferrite and/or pearlite flakes or plates of graphite such as are characteristic of ordinary gray iron castings as well as what we may call unformed dots and patches of graphitic carbon such as characterize the outer dendritic zone of the pipe. It will be understood that areas of iron phosphide and/or iron phosphide eutectic will occur in both zones of the pipe, such areas being somewhat more extensive in the inner than in the outer zone. It is a further characteristic of the pipes forming the subject matter of our said former application that, as cast, the percentage of combined carbon in the outer dendritic zone is notably less than that in the inner or graphitic zone.

The pipes described and claimed in our said former application are, as they come from the mold freely machinable and highly resistant to impact shocks and have in other respects distinct advantages over centrifugally cast cast iron pipe as previously manufactured.

The improved cast iron pipe which forms the subject matter of our present application retains and embodies the distinctive zonal structure of the pipes described in our former application in that our new pipe has an outer dendritic zone free from areas of chill and preponderantly made up of compacted interlacing and substantially nondirectional dendrites without intervening areas of that columnar structure normal to the outer surface of the pipe which is characteristic of the formation of a chill and the inner zone is preponderantly made up of a matrix of iron grains through which is distributed formed plates or flakes of graphite and in that the outer dendritic zone is free from formed graphite plates or flakes and the inner zone substantially free from dendritic crystals. The essential differences be-

tween the old and new structures are, that, whereas in the pipes of our former application both the dendrites of the outer zone and the iron grains of the inner zone were, to a considerable extent, pearlitic in character; in our new pipe substantially all of the dendrites and grains in both zones are distinctly ferritic in character with only occasional occurrence of minute specks of pearlite. Another, and we believe even more distinctive, feature of our new pipe lies in the fact that whereas in the pipe of our former application the grain structure of the iron, both in the inner and outer zones, is markedly irregular in form and ill defined in outline, whereas in our new pipe the grain structure is made up of polyhedral crystals of quite regular form and size and well defined outline. A further and notable distinction between the pipe of our older application and that which forms the subject matter of this application is that while retaining the good qualities of our earlier pipe, our new pipe is markedly superior in ductility and capacity for resisting shocks.

A further distinctive feature of our new pipe as compared with the pipe of our former application, lies in the fact that whereas, as we have stated, the pipe of our former application, as cast, had a distinctly smaller percentage of combined carbon in its outer dendritic zone than in its inner graphitic zone; in our new pipe the combined carbon, materially less in the casting as a whole, is practically in the same proportion in both inner and outer zones and constitutes not more than .15% of the mass of the casting.

In manufacturing our new pipe we preferably cast the iron into the form of a pipe in an externally cooled centrifugal metal mold by the process forming in part the subject matter of our copending application, filed October 19, 1932, Serial Number 638,480. By this process a coating of finely divided dry coating material is, preparatory to the pouring of the metal into the mold, deposited upon the inner cylindrical face of the rotating mold by means of a jet of carrier gas charged with particles of finely divided dry coating material directed against the inner face of the rotating mold and the molten metal is then poured into the rotating mold so as to contact with the so coated cylindrical portion of the mold in the formation of the cylindrical portion of the pipe. As pointed out in our said method application, it is, for the best results with regard to the structure of the casting produced, important that the molten metal should be poured upon the coated surface of the mold very promptly after the application of the coating for the reason, we believe, that the coating as applied is made up not only of the particles of finely divided dry coating material but also in part of adsorbed films of the carrier gas, the presence of which, as a component part of the coating is of importance as influencing the character of the casting and which films of gas have a tendency to escape if the coating is not promptly covered by the molten metal. We have also in our method application pointed out that the efficiency of the coating applied as described is materially affected by the thickness of the coating and that we have found it undesirable in the application of the coating material to the mold to use a quantity of the dry finely divided coating material in excess of that which, evenly distributed over the cylindrical portion of the mold and compacted thereon, would form a coating of more than .001" in thickness for the reason that coatings of greater thickness are more liable to scale off and also because they are more liable to be broken and displaced by the impact of the molten metal upon the coating, thereby leaving portions of the metal mold unprotected and bringing about areas of chill in the casting. We have also pointed out that it is desirable in all cases to use as little of the coating material in forming a coating for the cylindrical portion of the mold as is consistent with the formation of a coating which will effectually prevent the occurrence of chill in the casting and that, with finely divided ferro-silicon as a coating material, and this is among the best of the coating materials we have employed to make an efficient coating, is one made up of finely distributed ferro-silicon applied in quantity which, if evenly and compactly distributed over the cylindrical surface of the mold, would form a coating of approximately .0003" in thickness.

Cast under the conditions described in our said method application and briefly summarized above, an iron of the composition which we have above specified will produce a pipe having the characteristic features of that described in our application, Serial Number 652,160, but for the production of our new pipe it is necessary that the casting so produced should be subjected to a heat treatment somewhat above the critical point at which the crystalline structure of the iron employed will change from the alpha to the gamma structure and then, to avoid the development of injurious strains in the casting, gradually cooled to a temperature of 1200° F. after which cooling of the casting may be carried on at any convenient speed. The effect of this heat treatment which involves, first, the change of the alpha structure to that of the gamma structure and then the reformation of the alpha structure on cooling below the critical point, is to effect a very marked change in the grain structure of the casting in that the grains which in the casting as it comes from the mold, are ill defined and of markedly distorted and irregular form are, after the heat treatment, found to be in the form of well defined polyhedral crystals of marked regularity in size and shape. The heat treatment of the casting necessarily and no doubt advantageously reduces the combined carbon in the casting to a point not in excess of .15% and in practice considerably lower. The graphitic carbon thus thrown out of combination is found in the treated casting in the form of dots and patches as distinguished from formed plates of graphitic carbon and the low percentage of combined carbon existing in the dendritic zone naturally results in the graphitic carbon so formed being notably smaller in quantity in the outer zone than in the inner zone, a fact which we believe is highly advantageous in preserving the increased ductility of the dendritic zone, due to the heat treatment and the reformation of the grains.

The notable effect of the heat treatment upon the casting is not only to bring about the structural changes which we have above noted but also to impart to the cast pipe a very marked increase in shock resisting capacity as compared with the improved pipe forming the subject matter of our former application and this marked increase in ductility and shock resisting capacity is secured without impairment of any of the good qualities of the pipe as cast: for example, an approved method for testing the shock resist-

ing capacity of cast iron pipes has been to support a 24'' span of the pipe upon suitable supports, and then, beginning with a height of 1 foot, increased by increments of 2'' to a height of 5 feet, to drop a 50 pound weight upon the so supported portion of the pipe. Noting the first occurrence of a crack in the pipe, then the first occurrence of a perceptible leak and finally the occurrence through the crack of the escape of such a sheet of water as would amount to a total failure. Tested in this way, the unannealed pipe generally failed before the delivery of a blow from the 5 feet elevation while the annealed pipe very generally showed no failure even after the delivery of fine blows from a height of 5 feet and, computing the energy in foot pounds of the blows delivered to produce failure or, in the case of the annealed pipe, to produce either failure or on the assumption that failure had occurred after the delivery of five blows from the upper height of 5 feet, the test showed that the changes effected in the unannealed casting by the heat treatment, which changes constitute the novel features of our new pipe, had increased the impact resisting quality of the pipe, over that of the pipe as cast, by more than 300%. To obtain a pipe having the distinguishing structural features characteristic of our new pipe and its notably increased capacity to resist shock, it is necessary that the pipe should be heated to temperatures above the critical point at which the change from the alpha to the gamma structure occurs and this critical point will vary somewhat with the composition of the iron but, so far as our observations have extended, will occur between 1400° and 1500° F. and with irons which we have used on an extensive scale, we have found the critical point to be in the neighborhood of 1480° F. For practical reasons, we have found it convenient to raise the temperature of the pipes to approximately 1700° F. but care should be taken that the temperature does not materially exceed this point and while excellent pipes have been produced by this heat treatment, our experiments have led us to the conclusion that even better pipes will be produced if the maximum temperature to which the pipes are raised is lessened so long as care be taken that the casting shall be heated above the critical point.

In view of the fact that the cast pipe as it comes from the mold embodies in its cylindrical portion no areas of that refractory form of combined carbon which constitutes a chill. It will, of course, be obvious to those skilled in the art that it is not necessary, in order to reduce the percentage of combined carbon to .15% or less, to heat the cast pipe to as high a temperature as that of the critical point but to obtain the distinctive structure and distinctive qualities of our new pipe it is absolutely necessary that the cast pipe should be heated to temperatures in excess of the critical point.

While we believe that the structure and composition of our new pipe will be entirely clear to those skilled in the art, from the foregoing description, a clearer understanding of the structural peculiarities of our pipe may be aided by reference to the drawing in which

Figure 1 is an elevation of our pipe shown, so far as the cylindrical portion thereof is concerned, in central section and partly broken away in the middle.

Figure 2 is a cross-sectional view taken, for example, on the line 2—2 of Fig. 1.

Figure 3 is a somewhat diagrammatic microphotographic view of a typical area of the dendritic zone of the pipe taken on a scale of enlargement which will best display the dendritic structure of this portion of the pipe. A scale of enlargement of 100 diameters we have found to be effective for this purpose but it will be understood that this scale is not applicable to the drawing as it will appear on the reduced scale of the printed drawing forming a part of the patent specification.

Figure 4 is a microphotographic view of a typical area of the graphitic zone of our new pipe taken on a similar scale of enlargement to that of Fig. 3.

Figure 5 is again a microphotographic view of an area of the dendritic zone on a scale of enlargement which will better exhibit the grain structure of the ferrite constituent of this zone, the enlargement being on a ratio of 700 diameters as compared with the 100 diameter enlargement of Fig. 3, and

Figure 6 is a view of a typical area of the graphitic zone shown on a similar scale of enlargement to that of Fig. 5, to show the grain structure of the ferrite occurring in this zone of the pipe.

It will be understood, with reference to Fig. 3, that any surface of the dendritic zone prepared from microscopic examination and photography will intersect the interlacing dendrites at every conceivable angle and this is also true as to the intersection of the plane with the grain crystals which we have attempted to illustrate in Fig. 5. This must be borne in mind also in considering Fig. 6 and, to a certain extent in considering Fig. 4, particularly with regard to the intersection of the plane under observation with the formed plates or flakes of graphite. With these facts in mind, our diagrammatic drawing is, we believe, helpfully illustrative as to the structures which they are intended to make clear.

In the drawing,

A indicates the bell end and A^1 the cylindrical body of our pipe. B indicates the outer dendritic zone of our pipe shown as extending from the outer surface for about one-third the thickness of the pipe. C indicates the inner graphitic zone of the pipe. In Fig. 3, D indicates certain of the dendritic crystals of ferrite which appear in the view in a manner which makes clear their dendritic formation. E indicates the presence in the section under examination of the unformed dots and patches of graphitic carbon and at F we indicate the occurrence in the section depicted of areas of phosphide eutectic. Referring to Fig. 4, G indicates the granular ferrite matrix making up the preponderant mass of the graphitic zone of the pipe. H, H, etc., the distributed formed plates or flakes of graphite characteristic of this inner zone of the pipe. E, E, indicates the occurrence in this zone of unformed dots and patches of graphitic carbon similar to those which occur in the dendritic zone and at F, F, we have indicated the occurrence of areas of phosphide eutectic occurring in this graphitic zone of the pipe. In Figs. 5 and 6, we have indicated the structure of the ferrite grains. At I, I, etc., we have indicated the occasional occurrence in these grains of very minute specks of pearlite.

We have also in the drawing indicated the various structural components of the illustrated structure by labels.

To sum up the characteristic features of our new pipe, it has the density and compactness of

structure peculiar to centrifugally cast pipe. It is cast from an iron coming within the specification above given. It is made up, so far as its cylindrical portion is concerned, of an outer dendritic zone, of not less than one-fourth the thickness of the pipe, and an inner graphitic zone. Its dendritic zone embodies, distributed among its dendrites, graphitic carbon in the form of dots and patches as distinguished from plates or flakes of graphite. The dendrites which make up the preponderating mass of the outer zone are interlacing and without unified directional tendency and are symmetrically distributed throughout the structure of the outer zone without intervening areas of that columnar crystalline structure normal to the outer surface of the pipe which characterizes what is commonly known as a chill. Its inner zone is characterized in having distributed formed plates or flakes of graphite throughout a matrix of ferrite and by the nonoccurrence in this zone of dendritic formations. The combined carbon in both zones of the pipe does not exceed .15% and does not materially differ in the inner and outer zones. The dendrites of the outer zone and the grains of the iron in both zones are distinctly ferritic in character with only occasional inclusions of fine specks of pearlite. The grains of the ferrite both in the outer and inner zones are in the form of well defined polyhedral crystals of regular form and size and, finally, our new pipe has a greatly increased capacity to resist impact shocks as compared with the cast pipe as it comes from the mold or with centrifugally cast cast iron pipe as heretofore produced.

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

1. An annealed centrifugally cast cast iron pipe, the cylindrical portion of which is freely machinable and highly resistant to impact shocks and has 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

balance substantially iron, said pipe having as cast an outer annular zone of substantial depth preponderantly made up of compacted interlaced dendrites of ferrite and/or pearlite without unified directional tendency and symmetrically distributed throughout the length and depth of said zone, said outer dendritic zone being further characterized in that it is free from distributed formed plates of graphite and from areas of chill, said cylindrical portion of the pipe being further made up as cast of an inner annular zone in which formed plates of graphite are distributed throughout a matrix of ferrite and/or pearlite grains substantially free from dendritic formations, said cast pipe being heat treated after casting by raising its temperature to a point above that critical point at which a change from the alpha to the gamma structure occurs in the crystalline grains of the iron component of the casting and then permitted to cool and characterized after such heat treatment in that the dendrites of the outer zone and the iron matrix of the inner zone are made up of grains of ferrite substantially free from pearlite and in that said grains are preponderantly made up of clearly defined and symmetrical polyhedral crystals and further in that the shock resisting capacity of the pipe is materially increased as compared with the pipe as cast.

2. An annealed centrifugally cast cast iron pipe having the characteristics called for in claim 1, and in which the outer dendritic zone comprises not less than one-fourth of the thickness of the pipe.

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