March 6, 1934. N. F. S. RUSSELL ET AL 1,949,433

METHOD AND APPARATUS FOR CASTING PIPES CENTRIFUGALLY

Filed Oct. 19, 1932 3 Sheets-Sheet 1

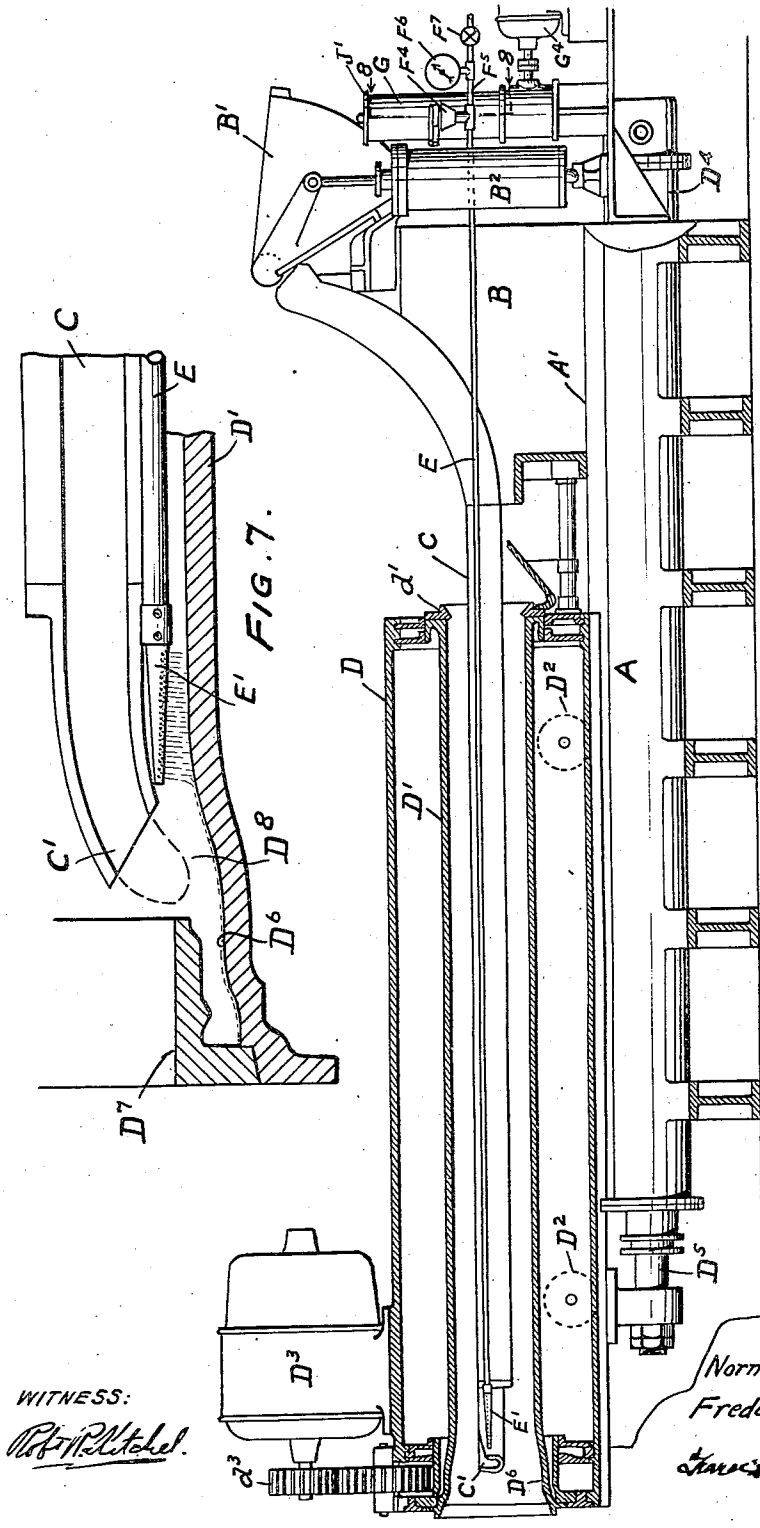


FIG. 7.

FIG. 1.

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METHOD AND APPARATUS FOR CASTING PIPES CENTRIFUGALLY

Filed Oct. 19, 1932 3 Sheets-Sheet 2

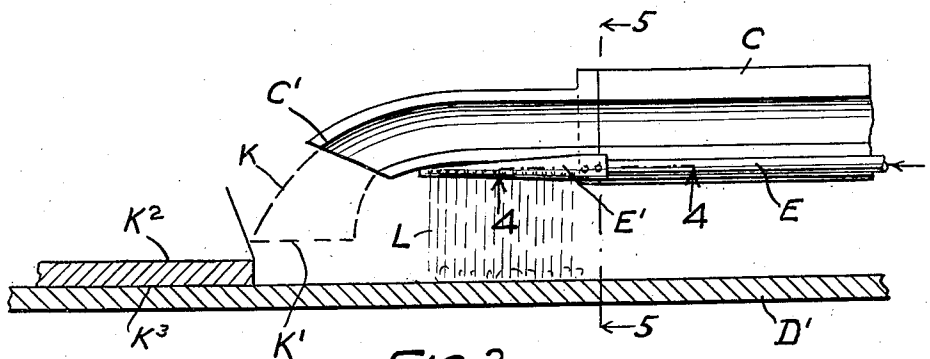


FIG. 2.

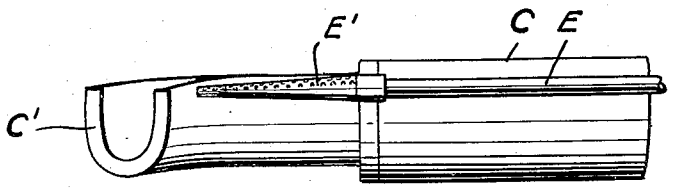


FIG. 3.

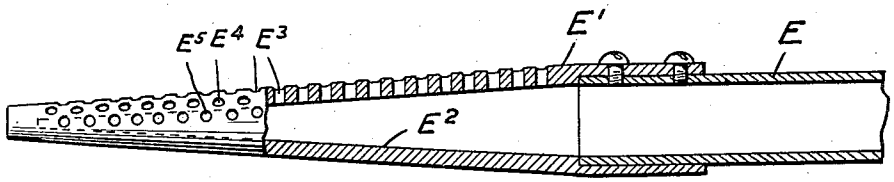


FIG. 4.

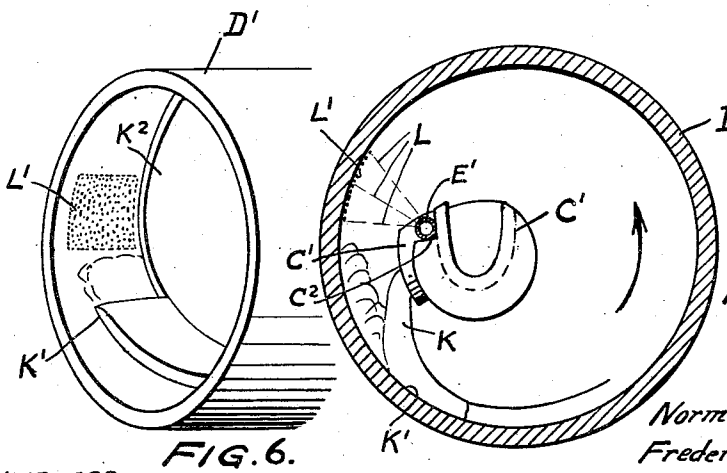


FIG. 6.

FIG. 5.

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METHOD AND APPARATUS FOR CASTING PIPES CENTRIFUGALLY

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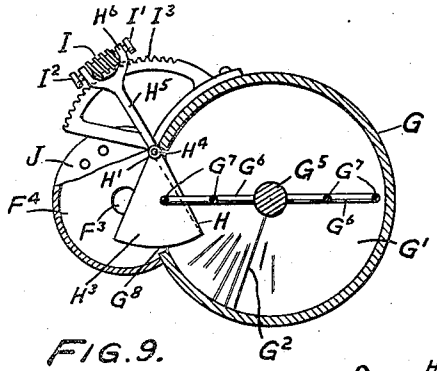


FIG. 9.

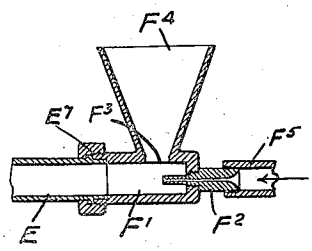


FIG. 10.

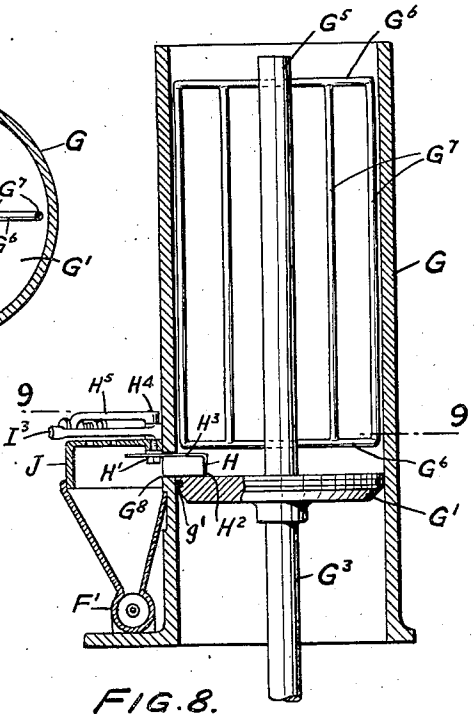


FIG. 8.

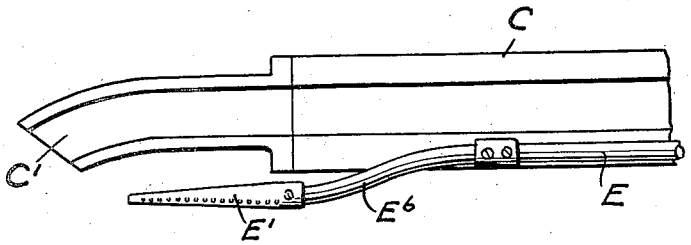


FIG. 11.

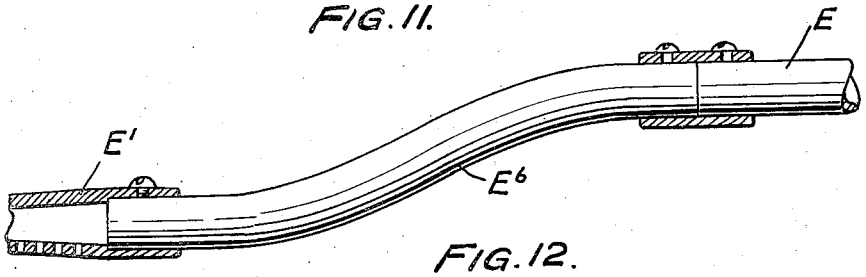


FIG. 12.

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UNITED STATES PATENT OFFICE

1,949,433

METHOD AND APPARATUS FOR CASTING PIPES CENTRIFUGALLY

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Application October 19, 1932, Serial No. 638,480

11 Claims. (Cl. 22—200)

Our invention relates to that method of casting pipes in which the molten metal is progressively delivered to a rotating mold through a relatively retractable runner so that the metal is delivered to the mold in helical coils with over-lapping edges which fuse together to form a continuous casting and, more especially, our invention is adapted for use with externally cooled metal molds although it can be usefully applied in connection with other kinds of pipe molds. The object of our invention is to provide a practical and efficient method and apparatus whereby a thin coating of a powdered coating material can be progressively applied to the inner surface of the mold in over-lapping helical coils in immediate advance of the contact of the molten metal with the mold and in such manner as to build up a coating of the powdered material of substantially uniform thickness and remarkable efficiency in the production of a casting having uniform and desirable qualities.

We are aware that it has heretofore been proposed to apply a coating to the inner surface of metal molds used in casting pipe but, so far as we are aware, no method heretofore proposed, used, or experimented with, has been effective in use to bring about a coating of the mold with a loose, dry, powdered material which will maintain its coherence and continuity as a coating during the casting operation and result in the production of a casting of uniform and desirable structure. Our studies and experiments in developing our invention have developed that the failure of methods heretofore proposed is due to many causes, among which may be mentioned the difficulty met with in effecting an even distribution of the coating material over the surface of the mold. Again, we have found that a coating of dry, powdered material is liable to become fractured or displaced in parts so as to leave bare, uncovered spots of mold surface if the coating is left too long in contact with the mold surface before it is covered by the molten iron and this is the more liable to occur as the thickness of the coating is increased. Again, we have found that the impact of the metal with the coated surface of the mold has a tendency to fracture the coating, pushing portions of the coating over the mold surface so as to leave unprotected areas which bring about areas of chill in the casting and also bring about very undesirable roughening of the outer surface of the casting and we have found that this liability to displacement of the coating material notably increases with increase in the thickness of the coating layer.

Broadly speaking, our invention has for its leading feature the progressive building up of a coating of powdered material upon the inside of the mold and in immediate advance of the contact of the molten metal with the coated surface of the mold by means of a jet of carrier gas carrying distributed particles of a powdered coating material and progressively directed toward those portions of the mold which are to be shortly thereafter contacted by the molten metal. The energy of the jet of carrier gas should be such as to impart sufficient velocity to the particles of coating material to carry them into contact with the surface of the mold without the jet of gas itself having such velocity as to impinge on the mold surface with any substantial velocity and the powdered coating material should be fed to the gas jet at a uniform rate of speed so as to result in the production of a coating layer of a substantially uniform thickness and we have found that a coating produced in this way has certain distinguishing and valuable qualities in that the coating has good resistance to disruptive forces, can be applied to the mold with great uniformity even when the coating is very thin and has, even when the coating is very thin indeed, an effect in preventing the formation of chilled areas in the casting which would seem to be explainable only on the assumption that the particles of coating material impelled by the carrier gas against the mold are surrounded by an adsorbed film of the gas, which films, for an appreciable time after the coating is deposited, form an effective part of the coating and perform an important function in bringing about the absence of chill and a desirable structure in the casting.

Another important feature of our invention has to do with the interval of time which may be permitted to elapse between the time when the coating is applied to the mold and the time when the so applied coating is contacted by the molten metal issuing from the spout of the runner and as to this the maximum time during which the coating should be permitted to remain uncovered by the melted metal should not exceed six seconds and, for the best results, should be as short as possible. By preference, we direct the jet of carrier gas so that it will deposit its particles of coating material upon that portion of the mold which, at the time of deposit, lies immediately above and close to that portion of the mold upon which the molten metal is being poured so that the coating is contacted by the molten metal almost instantly. It must be understood that the jet of carrier gas must be so directed as to de-

posit its particles of coating material upon the uncovered mold surface without bringing any appreciable amount of the coating material into direct contact with the metal issuing from the spout of the runner or with the molten metal which has already been deposited in the mold and that, with due observance of this condition, the closer the coating is applied to the metal issuing from the runner and to the previously poured coil of metal, the better, and we strongly recommend that the gas jet should be directed with these conditions in view, against the upper surface of the mold. Reasons which influence us in directing and recommending the progressive direction of the gas jet against those portions of the mold which are to be contacted by the metal issuing from the runner in a very brief interval of time, are, that we have found that the longer the coating remains on the surface of the mold before it is contacted by the metal, the more liability there is for portions of the coating material to slip or become displaced, leaving uncovered areas, the existence of which brings about undesirable qualities in the casting and, besides this, our experience with the process has convinced us that the longer the interval intervening between the laying of the coating and its contact with the melted metal, the less efficient is the coating even when its continuity is not impaired and this we believe to be explainable only on the assumption that the adsorbed films of gas adhering to the particles of coating material when they are deposited upon the surface of the mold form an important but short-lived element of the coating layer.

Another and important feature of our invention has to do with the thickness of the coating layer which will bring about the best results. This is determined by the amount of coating material fed to and delivered by the carrier gas jet during the casting of the pipe and as there is a draft of air through the mold during the casting operation which undoubtedly carries away a part of the powdered coating material delivered to the mold by the gas jet, it is impossible to state definitely what the actual thickness of the coating effected by any specific rate of feed is. We have found, however, that with all the coating materials with which we have worked or experimented it is distinctly detrimental to the efficiency of the coating produced to feed to the mold, during the casting process, powdered coating material in greater quantity than would, if it all remained in contact with the mold, form a coating of a thickness exceeding .001 of an inch and we have found that in all cases the powdered coating material should not be fed to the mold in greater quantity than that minimum quantity less than the amount which would produce a coating of .001 of an inch in thickness which will result in the production of a casting without areas of chill. This will vary somewhat with different powdered coating materials but can be readily ascertained and, when once ascertained, can be applied with uniformity and assurance as to good results. Working with powdered ferro-silicon which will pass a sieve of thirty meshes to the inch, we have found that the feed of ferro-silicon to the gas jet should, for the best results, be in such amount as would produce, if all the coating material remained in position in the mold, a coating of approximately .0003 of an inch in thickness.

Working with other coating materials we have found that the feed will vary. Thus, with kaolin, we have found that the feed should be at a rate which would produce a coating, if it all remained in contact with the mold, of .0009 of an inch; with talc, the feed should be at the rate of .0009 of an inch; with magnetite, the feed should be at the rate of .0005 of an inch; with ferro-manganese, the feed should be at the rate of .0007 of an inch; with zirconium manganese silicon, the feed should be at the rate of .0003 of an inch; with mica, the feed should be at the rate of .0008 of an inch; and with seacoal, the feed should be at the rate of .001 of an inch. It will be understood from what we have said above that coating materials such as ferro silicon, which will form an efficient coating of minimum thickness, are decidedly the best materials for use and that coating materials which require to be fed in larger quantity than would produce a coating of .001 of an inch are distinctly inferior for use in our process. Aside from the fact that the thicker the coating deposited upon the mold the more liable it is to fracture and loss in continuity, it would seem clear from our work with this process that the thinner coatings result in the production of castings of the most desirable structure.

In the casting of bell ended pipe in which the mold is formed with a bell into which is inserted a core, it is not, of course, practicable to lay down upon the bell portion of the mold such a uniform coating as can, by our process, be applied to the cylindrical portion of the mold. In view of the fact that the casting is heavier in the bell portion, it is not so important that the bell should be coated as it is with regard to the cylindrical portion of the mold but by directing the gas jet with distributed particles of coating material into the portion of the bell which lies between the end of the core and the beginning of the cylindrical portion of the mold for a short interval before the pouring of the metal begins, we have found it practicable to bring about at least a reasonably satisfactory coating of the bell portion of the mold.

Our invention further relates to the provision of a suitable and efficient apparatus for carrying into effect the improved process which we have described above and our improved apparatus is, in its general construction, the same as that commonly used in the casting of pipes by the method in which the molten metal is fed to a rotating mold through a relatively retractable runner, the runner in the standard construction being stationary and the rotating mold supported on a longitudinally movable carriage and, generally speaking, our invention consists in supporting upon the runner a pipe or conduit suitable for the conveyance of a carrier gas and having at its end adjacent to the free end of the runner, a nozzle adapted to deliver a jet of the carrier gas, of suitable form and dimensions, toward such portions of the inner surface of the mold as should, at the time, have a coating applied to them. This involves that the gas nozzle should occupy a fixed position with reference to the delivery spout of the runner and, for the best results, the nozzle should be so located and directed that the jet issuing from it should be directed at that portion of the mold which lies immediately above the portion upon which, at the time, metal is being delivered from the spout of the runner and, again, the relative locations of the spout of the runner and of the carrier gas nozzle should be such that when the runner is fully inserted in the mold so that the runner spout registers with the end of the bell, at least a portion of the jet issuing from the gas nozzle should also register with the end of the bell in the mold. Our invention also involves

the provision, at the end of the gas conduit opposite to that to which the nozzle is applied, of means for injecting a jet of the carrier gas into the conduit and of feeding into this jet a regulated quantity of the powdered coating material.

The above and other features of our improved apparatus will be best understood as described in connection with the drawings which illustrate a pipe casting machine provided with our improvements in what we believe to be their best form and in which

Figure 1 is a side elevation of a pipe casting machine provided with our improvements, with the mold and surrounding water chamber shown in vertical longitudinal section and with the supporting frame and tracks upon which the mold carriage moves, broken away at the left hand end of the view and somewhat diagrammatically indicated, as is also the case with the details of construction of those parts of the apparatus which in themselves form no part of our invention and are of well known and familiar construction.

Figure 2 is a plan view of the delivery end of the runner through which molten metal is delivered to the mold, showing the carrier gas conduit and nozzle which are supported upon the runner. One side of the mold is shown in section and the position of impact with the mold of the metal issuing from the spout of the runner with reference to the edge of the previously deposited helical coil of metal, is also roughly indicated. It will be understood that the position of the runner and parts supported thereon, with reference to the mold, is, as shown in this figure, somewhat retracted from the position shown in Fig. 1.

Figure 3 is a side elevation of the parts of the runner and carrier gas conduit with their spout and nozzle as shown in Fig. 2.

Figure 4 is an elevation of the delivery nozzle and the carrier gas conduit shown, for the most part, on the section line 4—4 of Fig. 2, and showing the union of the nozzle with the conduit pipe.

Figure 5 is a cross sectional view on the line 5—5 of Fig. 2, with the surrounding portion of the mold also shown in section and the areas of contact with the mold of the metal issuing from the spout of the runner and the dust issuing from the nozzle of the gas conduit also indicated.

Figure 6 is a perspective view showing that portion of the mold upon which the molten metal and the coating of pulverized material are being simultaneously deposited.

Figure 7 is a plan view of the end of the runner and the parts supported thereon, shown in connection, with one side of the mold shown in horizontal, central section and provided with the core which is inserted in the bell end of the mold. This is a scale drawing of the illustrated parts in the proportions in which they exist in an apparatus adapted for the casting of a six inch pipe, involving the use of a mold having the proportion of a cylindrical portion of 7 inches internal diameter, the parts being shown in the relative positions they occupy at the beginning of the casting operation.

Fig. 8 is a vertical section taken on the line 8—8 of Fig. 1, showing the mechanism provided for feeding the pulverized coating material to the carrier gas conduit.

Figure 9 is a cross sectional view of the container for the powdered coating material and connected devices, taken on the section line 9—9 of Fig. 8, with the mechanism for adjusting the feed of powdered material shown in plan.

Figure 10 is a sectional elevation of the rear portion of the carrier gas conduit and of the hopper through which the powdered coating material is fed to the conduit.

Figure 11 is a plan view of the delivery end of the runner for molten metal, showing a modification in the disposition of the carrier gas nozzle, and Figure 12 is a view similar to Fig. 11, with the joints between the air conduit and between the off-set portion and the gas nozzle shown in section.

A indicates the frame supporting the casting machine and its appliances. B indicates a supporting structure erected on the frame to support the ladle B^1, from which metal is fed to the runner. B^2 indicates a hydraulic cylinder coupled to actuate the ladle. C indicates the runner which is secured to the structure B and is of usual construction, provided at its end with a spout C^1 inclined to one side. The runner, as we have said, is of usual construction except that it has formed along the side toward which the spout C^1 extends, a recessed seat C^2 adapted to receive the carrier gas conduit. D indicates the water box carriage through which extends the rotatable mold D^1, d^1 indicating the annular ring provided at the spigot end of the mold and projecting inwardly to the depth of the projected wall thickness of the casting. The carriage, as is usual, is supported on wheels indicated at D^2, resting upon the tracks A^1 on the top of the framing A. The framing and tracks are partly cut away in Fig. 1, but it will be understood that the construction is, as usual, such as to permit the longitudinal travel of the mold carriage with respect to the stationary runner. D^3 indicates a motor supported on the mold carriage and connected as by gearing indicated at d^3 to drive the mold D^1. Longitudinal motion is given to the mold carriage by the hydraulic cylinder D^4. The piston, not shown, working in the cylinder is coupled through its piston rod D^5 to the mold carriage. D^6 indicates the bell end of the mold and D^7, Fig. 7, indicates the core which is inserted in the bell end of the mold before metal is poured into it, D^8, Fig. 7, indicating the space intervening between the end of the core and the beginning of the cylindrical portion of the mold.

In all of the above features of general construction, the apparatus is of the familiar type of construction used in the method of progressively casting pipe in a centrifugal mold which, during the casting operation, is retracted relatively to the stationary runner through which the metal is flowing into the mold.

E indicates a conduit for a carrier gas, such as air, which, as shown, is supported on the runner C, preferably as shown, in the recessed portion C^2. To the end of this gas conduit, which lies near the end of the runner, is secured a nozzle E^1 which is directed in such manner that it will deliver the carrier gas fed to it by the gas conduit outwardly toward the side of the mold toward which the runner spout C^1 also extends. The essential constructive features of this nozzle are that it will deliver the carrier gas and the powdered coating material which it conveys, in a direction which will deposit the coating material on the side of the mold in advance of the contact of the metal issuing from the spout of the runner with the so coated portion of the mold and also deliver the powdered coating material upon the surface of the mold at a point at a distance, so to speak, in front of the freshly laid coil of still fluid metal, these conditions being necessary to prevent the impact of the powdered coating ma-

terial with the fluid metal already deposited in the mold and that issuing from the spout of the runner. For the best results, the carrier gas nozzle should be so located and directed as to deliver the coating material upon the surface of the mold in immediate advance of the contact of the melted metal issuing from the runner so that the deposited coating will be contacted by the metal issuing from the spout of the runner almost immediately after its deposition on the mold. While we have experimented with varying degrees of success with many forms of nozzles, we have found the nozzle construction indicated in the drawings to be especially well adapted for our purposes. This nozzle, as shown, is of gradually contracting cross sectional area from its union with the gas conduit, preferably conical as shown at E^2, and is provided with three parallel rows of holes, as indicated at E^3, E^4, E^5, the aggregate area of the holes being about three times the cross sectional area of the gas conduit. This special construction of the nozzle was not invented by us but is shown simply as the one which we have found best adapted for the practice of our invention. It is desirable that the nozzle should be so located as to lie quite close to that portion of the mold to which it is directed. The actual distance which will exist between the nozzle and the mold when the runner to which the nozzle is attached is inserted in the mold is determined, to a certain extent, by the radial thickness, so to speak, of the ring d^1 at the spigot end of the mold because the nozzle must be so placed as to pass this ring without contacting with it when the runner is withdrawn from the mold. In molds of the larger diameters we connect the carrier gas conduit to the nozzle by means of an off-set section indicated in Figs. 11 and 12, at E^6, this off-set portion being so curved, as indicated, as to bring the nozzle to the desired proximity to the side of the mold. The other end of the carrier gas conduit is connected with what we may call the gun, the union being indicated at E^7. This gun is formed with a cylindrical passage F^1 of the same diameter as that of the gas conduit with which it communicates and at its outer end a nozzle F^2 enters the end of this passage, this nozzle being, as shown, connected with an air hose which in turn is connected with any source, not shown, of compressed air or other available gas. Opening into the cylindrical passage F^1 is a passage F^3, leading from a funnel F^4 which is erected to receive a measured feed of pulverized coating material from any suitable feeding apparatus. We have indicated the air conduit leading to the nozzle F^2 at F^5, F^6 indicating a pressure gauge connected with this air conduit and F^7 a regulating valve.

It is very important for the most successful application of our invention that the powdered coating material should be fed to the gun and through the carrier gas conduit to the delivery nozzle with great regularity so as to effect the coating of the mold with a uniform depth of coating material and for this purpose we have found the feeding apparatus indicated in the drawings to be especially well adapted though it is not in itself our own invention. This feeding apparatus consists of an upright cylinder G in the lower portion of which is secured a rotatable disc G^1, the upper surface of which should be grooved or otherwise roughened, as indicated at G^2, so as to take a better hold upon the powdered coating material which is charged into the cylinder and rests upon this disc. g^1 indicates packing employed to make a reasonably close joint between the disc and the cylinder. The disc is supported on a rotating spindle G^3 which by any convenient gearing, not shown, is driven by a motor, as indicated at G^4, and from the upper surface of the disc projects a spindle G^5 from which extend at different levels lateral arms G^6 connected by vertical rods G^7, the framing thus formed being intended to facilitate the rotation of the charge of powdered coating material with the disc. Through the wall of the cylinder G is formed a slot-like opening G^8 located, as shown, just above the disc. To one side edge of this opening G^8 is hinged, as indicated at H^1, a knife blade H which extends across the opening with its sharp edge H^2 projecting into the cylinder through the opening G^8 and to the top of this knife blade is secured a flanged extension H^3 which is provided to prevent the escape of the powdered coating material over the upper edge of the knife. From the hinged side of the knife extends a shaft H^4, to the upper end of which is secured a lever H^5 having a forked end H^6 in which is journalled a worm I which is turned by means of a button I^1 and secured in any desired position by means of a clamping screw I^2. This worm is in engagement with a sector I^3 and it will readily be seen that by turning the worm any desired adjustment of the knife blade can be effected. J indicates a cover for the hopper F^4. This cover is provided to protect the hopper from the intrusions of undesirable material but it is provided with openings to permit the inflow of air. A similar cover J^1 is indicated for the cylinder G.

K, Figs. 2 and 5, indicates the stream of molten metal issuing from the runner spout C^1 and the area of impact of this stream of molten metal with the side of the mold is indicated at K^1 in Figs. 2, 5, and 6. K^2, Fig. 6, indicates the last previously poured coil of metal and K^3, Fig. 2, indicates in section the cast metal in contact with the wall of the mold. L, Figs. 2 and 5, indicate the lines on which the dust issuing from the nozzle travels on its way to contact with the side of the mold. L^1 indicates the location on the side of the mold of the pad of dust directly applied to it by the nozzle.

It will be understood that the parts of our apparatus are shown in Figs. 1 and 7, in the relative positions they occupy at the beginning of the pouring of molten metal to form a bell ended cast iron pipe. After the molten metal is fed from the ladle into the runner and begins to issue into the mold from the nozzle of the runner the parts remain relatively stationary, except that the mold is in full revolution, until sufficient metal has flowed into the mold to fill the space between the bell and the core. Where it is desired to at least partially coat the bell end of the mold with the powdered coating material, we turn on the jet of carrier gas with its load of powdered coating material so that the powder will be delivered into the open end of the bell slightly in advance of the flow of metal from the spout of the runner. This is made practicable by having at least a portion of the carrier gas jet so located as to deliver the powder into the open end of the bell at the same time that the nozzle of the runner registers with the open end of the bell. After the bell end of the casting is poured, the mold is retracted with the result that the metal issuing from the nozzle of the runner is deposited on the cylindrical portion of the rotating mold in helical coils which fuse together at their contacting edges to form a continuous

casting. At the same time that the metal is being delivered to the retracting mold a jet of air is delivered through the nozzle F^2 into the tubular portion F^1 of the gun F and at the same time the feeding apparatus delivers a nicely regulated feed of powdered coating material into the funnel F^4 and through it into the tubular portion of the gun so that it is carried through the carrier gas conduit with the air and into the nozzle E^1 from which it issues together with the carrier gas and by the kinetic energy imparted to the particles of coating material in its passage through the conduit E, these particles are impelled into contact with the side of the mold where they form a layer or coating, the depth of which depends, of course, upon the quantity of powdered material fed to the carrier gas and the percentage of this powdered material which actually remains in contact with the sides of the mold. This coating layer will be deposited upon the mold in helical coils as is the case with the metal issuing from the runner and the breadth of the coils and the pitch of the helix will be such that the coils of coating material will somewhat overlap, thus insuring that the entire surface of the mold is coated. The location of the dust nozzle E^1 with reference to the metal delivery nozzle C^1 must be such that it will direct the powdered coating material issuing from it toward that portion of the mold which is not contacted at the time that powder is deposited by the stream of metal issuing from the runner or by the previously poured helical coil of molten metal and with this requirement in view, the closer the point of application of the coating material to the mold to the point of impact upon the mold of the molten metal issuing from the runner, the better. We have indicated in the drawings the point of deposit of the coating material as in the upper quadrant of the mold immediately above that lower quadrant upon which the metal from the runner is deposited so that the coated surface of the mold is contacted by the metal issuing from the spout of the runner by the rotative movement of the mold through less than 90° or, in view of the speed with which the mold is rotated, almost instantly after its deposit upon the mold and it will be seen that the application of the pad of coating material at the point indicated is greatly facilitated by the construction shown in the drawings in which the carrier gas conduit and nozzle are supported on that upper side of the runner which lies to the same side of the runner as that from which the spout C^1 extends. It will also be seen that by providing the runner with a recessed seat, such as indicated at C^2, and locating the carrier gas conduit in this recessed portion of the runner, this part of the apparatus is greatly compacted, which is desirable in all constructions and important in the construction of apparatus for the manufacture of small diameter pipes.

While, obviously, our invention can be availed of in modified forms of the apparatus shown and described, we would point out that the location of the gas nozzle on the upper side of the runner and its direction toward the upper side of the mold, are highly preferable features, both from the point of view of compactness in the structure of the apparatus and because this location of the nozzle enables the carrier gas and the dust to be most conveniently directed so as to deposit the coating on the upper side of the mold and as close as practicable to the point of contact of the metal issuing from the spout of the runner.

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

1. In the casting of pipes from molten metal in externally cooled centrifugal metal molds having a cylindrical section, the method steps which consist in building up upon the cylindrical portion of the mold a coating of finely divided dry coating material by progressively directing a jet of carrier gas charged with finely divided dry coating material against successive portions of the surface of the mold to be so coated and then centrifugally casting molten metal in the so coated mold to form a pipe.

2. In the casting of pipes from molten metal in externally cooled centrifugal metal molds having a cylindrical section, the method steps which consist in setting the mold in rotation, then building up upon the cylindrical portion of the rotating mold a coating of finely divided dry coating material by directing against said cylindrical portion of the rotating mold a jet of carrier gas charged with particles of finely divided dry coating material and then pouring molten metal into the so coated cylindrical portion of the rotating mold to form the cylindrical portion of the pipe.

3. In the method of casting pipes in which the molten metal is progressively delivered to an externally cooled rotating metal mold having a cylindrical section through a relatively retracting runner in such manner that the metal is delivered to the cylindrical portion of the surface of the rotating mold in the form of a helix, the method steps which consist in setting the mold in rotation prior to the delivery of molten metal thereto, progressively building up upon the cylindrical surface of the rotating mold a coating of finely divided dry coating material made up of a helical band, so applied to the surface of the mold that adjacent coils of the helix will overlap, by directing first against the end of the cylindrical portion of the mold a jet of a carrier gas charged with finely divided dry coating material and then progressively relatively retracting said charged jet throughout the length of the cylindrical portion of the rotating mold at a rate of speed substantially equal to that at which the runner delivering molten metal to the mold is relatively retracted and during the progressive application of the coating to the rotating mold progressively feeding molten metal to the cylindrical portion of the mold through the relatively retracting runner in such manner that the progressively coated portions of the mold are contacted by molten metal shortly after the deposit of the coating thereupon.

4. In the method of claim 3, the further step which consists in so coordinating the progressive deposit of the coating upon the mold and the progressive deposit of molten metal upon the coated surface that freshly coated areas of the rotating mold surface will be contacted by the molten metal within six seconds of the time that the coating is applied thereto.

5. In the method of claim 3, the further step which consists in so coordinating the progressive deposit of the coating upon the mold and the progressive deposit of molten metal upon the coated surface that freshly coated areas of the rotating mold surface will be contacted by the molten metal within the period of time in which

the rotating mold is making one complete revolution.

6. In the method of claim 3, the further step which consists in so coordinating the progressive deposit of the coating upon the mold and the progressive deposit of molten metal upon the coated surface that the coating will be applied to areas of the rotating mold surface lying above the point of impact of the molten metal upon the surface of the mold and to be contacted by the molten metal before the mold has completed one revolution.

7. In the method of claim 3, the further step which consists in so regulating the charge of dry finely divided coating material with which the carrier gas jet is charged that the total amount of coating material progressively delivered by the carrier gas jet to the inside of the cylindrical portion of the mold will not exceed a quantity which, if evenly and compactly distributed over the cylindrical portion of the mold, would form a coating of .001" in thickness.

8. In the method of claim 3, the further steps which consist in so coordinating the progressive deposit of the coating upon the mold and the progressive deposit of molten metal upon the coated surface that freshly coated areas of the rotating mold surface will be contacted by the molten metal within six seconds of the time that the coating is applied thereto and in so regulating the quantity of finely divided dry coating material delivered by the jet of carrier gas that the total quantity of such finely divided dry coating material delivered by the jet during the progressive formation of the coating shall not exceed that quantity which, if evenly and compactly distributed over the cylindrical portion of the mold, would form a coating of .001" in thickness.

9. In the method of claim 3, the further steps which consist in so coordinating the progressive deposit of the coating upon the mold and the progressive deposit of molten metal upon the coated surface that freshly coated areas of the rotating mold surface will be contacted by the molten metal within the period of time in which the rotating mold is making one complete revolution and in so regulating the quantity of finely divided dry coating material delivered by the jet of carrier gas that the total quantity of such finely divided dry coating material delivered by the jet during the progressive formation of the coating shall not exceed that quantity which, if evenly and compactly distributed over the cylindrical portion of the mold, would form a coating of .001" in thickness.

10. In the casting of pipes from molten metal in externally cooled centrifugal metal molds having a cylindrical section, the method steps which consist in setting the mold in rotation, then, prior to the delivery of molten metal to coated portions of the rotating mold, building up upon the cylindrical portion of the rotating mold a coating of finely divided dry coating material permeated with adsorbed films of the carrier gas by directing against said cylindrical portion of the rotating mold a jet of carrier gas charged with particles of finely divided dry coating material and pouring molten metal into the so coated cylindrical portion of the rotating mold before a material portion of the entrained gas films are eliminated from the composition of the coating and within a period of six seconds after the deposit of the coating upon the surface of the mold to form the cylindrical portion of the pipe.

11. In a pipe casting machine comprising a rotatable mold and a relatively reciprocable runner adapted to deliver molten metal progressively to the rotating mold, the combination therewith of a conduit for a carrier gas secured to and supported by the runner so as to be relatively longitudinally movable with respect to the mold to the same extent as is the runner, a delivery nozzle for a carrier gas charged with finely divided dry coating material supported by and movable with the runner and so located with respect to the delivery end of the runner and the inner surface of the mold as to direct a jet of the carrier gas progressively towards those portions of the mold which by the rotating movement of the mold and the simultaneous relative retraction of the runner are, shortly after the application of the coating material, contacted by the molten metal issuing from the runner, a carrier gas conduit connected to the nozzle, means for delivering a jet of carrier gas to the outer end of the gas conduit and means for feeding a pulverized mold coating material into the carrier gas conduit.

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