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APPARATUS FOR MAKING CENTRIFUGAL CASTINGS

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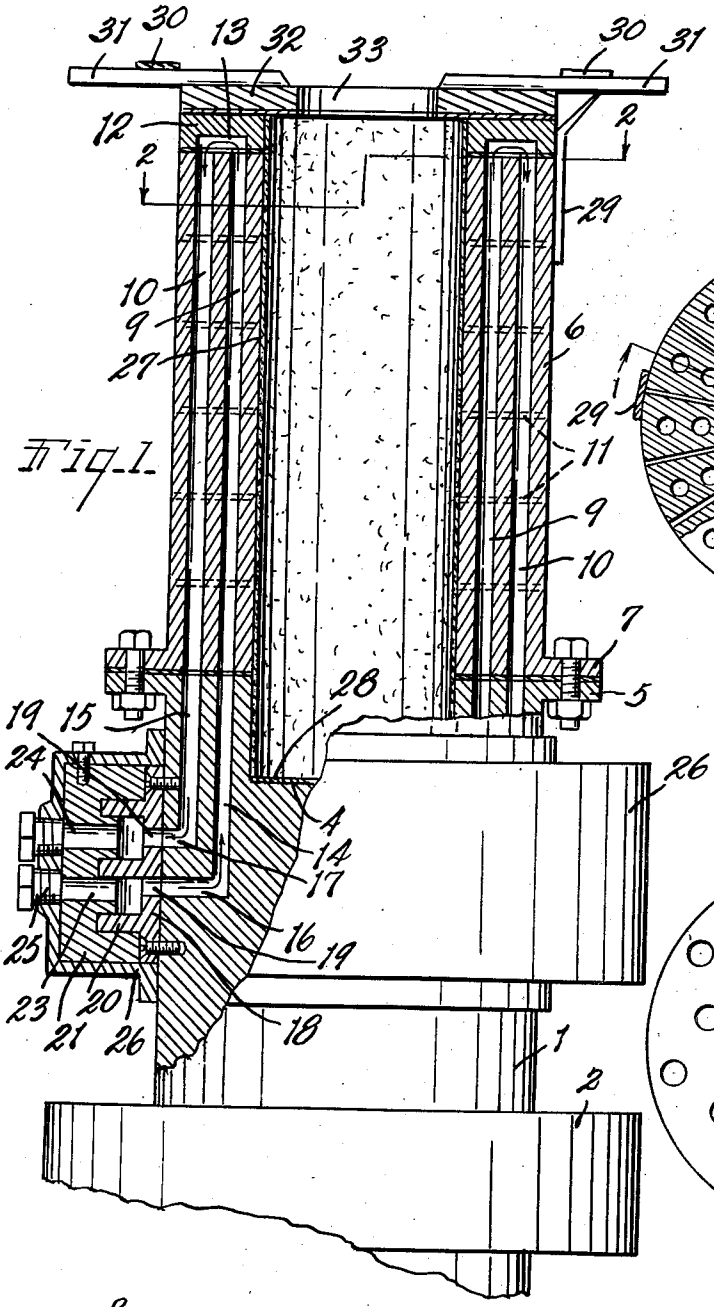


Fig. 1.

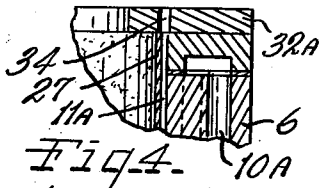


Fig. 4.

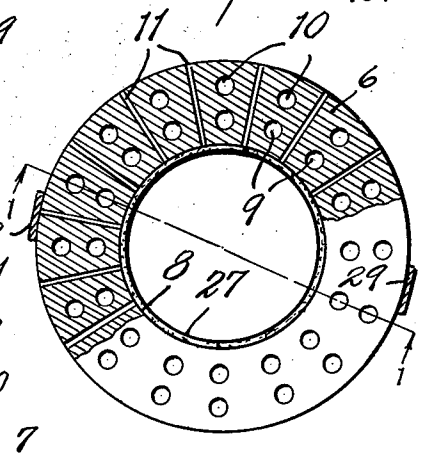


Fig. 2.

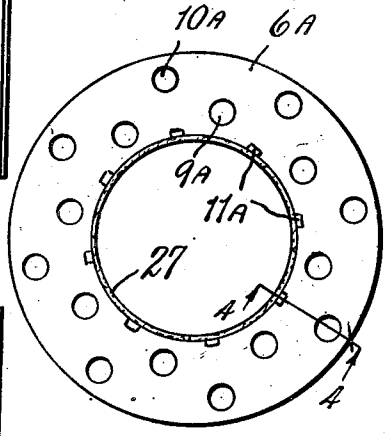


Fig. 3.

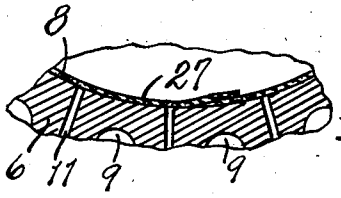


Fig. 5.

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APPARATUS FOR MAKING CENTRIFUGAL CASTINGS

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5 Claims. (Cl. 22—113.5)

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This invention relates to improvements in the apparatus for making centrifugal castings. More particularly the invention relates to apparatus for centrifugally casting relatively thin walled tubular castings which may be slightly out-of-round and which are designed to be cut into piston rings. The apparatus also may be used in the forming of tubular castings for cylinder wall sleeves and the like.

The principal objects of this invention are:

First, to provide a casting for the manufacture of piston rings having improved strength and micro-structure characteristics due to the thickness of the casting and the cooling rate thereof obtained by our method.

Second, to reduce the cost of producing piston ring castings by reducing the amount of metal cast and reducing the amount of machining necessary on the casting by eliminating taper or draw in the casting and reducing the irregularities and chaff on the casting which must be removed.

Third, to reduce the cost of centrifugal tubular castings by eliminating the necessity of heat treating the casting to obtain proper machinability.

Fourth, to reduce the cost of producing centrifugal tubular castings by eliminating the expense of replacing and repairing the mold and by increasing the rate of production of the molding machine.

Fifth, to improve the grain structure of centrifugal tubular castings by eliminating the chilling effect of the mold on the molten metal and thereafter accurately controlling the cooling rate of the casting.

Other objects and advantages relating to details and economies of the invention will appear from the description to follow. The invention is defined and pointed out in the claims.

In the art of casting ferrous metals it has been appreciated for some time that the strength, hardness or machinability and lubricating properties of the final product were interrelated with the carbon content of the metal and the cooling rate of the casting. Generally speaking, a high carbon content iron slowly cooled produce a mixture of large graphite flakes intermixed with a coarse grain pearlitic matrix. This grain structure produced a relatively soft, weak metal without particularly satisfactory wear properties due to the fact that the large graphite flakes formed parting planes in the metal permitting early disintegration or wear thereof.

If a metal of the same chemical composition as

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that described above were rapidly cooled as by casting the metal in a thin wall against a cooled metal mold, the carbon was largely retained in chemical combination with the iron forming an iron carbide composition, known as cementite which is extremely hard and unmachinable. The desirable medium between these two extremes, particularly for piston rings and the like, is to cast a relatively high carbon metal so that the iron carbide or cementite is allowed to break down into free graphite in combination with a matrix of fine pearlite and to check growth of the graphite flakes and pearlite grain structure before they have reached the objectionable size described above. In this form the evenly dispersed graphite flakes provide excellent lubricating properties to the metal without sufficiently interrupting the grain structure of the pearlite to adversely affect its wear and strength properties.

To accomplish this preferred form of casting and obtain tubular castings for the manufacture of piston rings having excellent wear properties and high tensile strength as well as for other tubular castings we have devised apparatus and method for casting in which the molten metal of the desired chemical composition is centrifugally cast against a sheet of asbestos or other heat resistant material which is not consumed by the heat of the molten metal and which retains its shape and form so as to be readily withdrawn from the mold with the finished casting. The asbestos surface is backed up or supported by a water-cooled metal mold having a casting cavity of the desired contour of the finished casting. The metal mold cavity is vented as will be more particularly described hereafter, to prevent buckling and distintegration of the asbestos liner. The insulating properties of the asbestos serve to prevent the formation of a chilled surface on the casting while the forced cooling character of the mold functions to cool the casting rapidly enough to prevent the formation of undesirable large flake graphite. The asbestos liner has the additional functions of protecting the mold surface and making the casting easily removable therefrom and also forming a smooth accurate surface on the casting which may be closely duplicated in a series of castings produced in the same mold cavity.

The sum effect of the combined use of the sheet asbestos liner in the ventilated water-cooled mold is to permit the economic casting of thin tubes having a minimum of surplus stock which must be machined away and having highly favorable

cooling rates and consequent favorable microstructure. The structure and methods hereinafter described substantially fulfill all of the objects of the invention set out above.

With this general description of our invention in mind, attention is now directed to the drawings of which there is one sheet illustrating a specific preferred embodiment of apparatus for performing our method of casting and one modified form of casting apparatus. The invention is further pointed out in the claims.

Fig. 1 is a plan view partially broken away and shown in cross-section along the line 1—1 in Fig. 2, of a centrifugal casting device.

Fig. 2 is an end view partially broken away along the line 2—2 in Fig. 1 of the mold with the end cap removed.

Fig. 3 is an end view of a modified form of a mold with the end cap removed.

Fig. 4 is a fragmentary cross-sectional view on the plane 4—4 in Fig. 3 showing the end cap in place on the modified form of mold.

Fig. 5 is a fragmentary sectional view showing an embodiment in which the edges of the liner are overlapped.

In the drawings reference character 1 indicates a hub provided with a flange section 2 arranged to be attached to a suitable spindle generally indicated at 3 which will rotate the hub at high speed about a generally horizontal axis. At its forward end the hub is provided with a central recess 4 and annular flange 5.

A cylindrical mold member 6 is provided with a flange 7 arranged to mate with and be secured to the flange 5 on the hub. The interior of the mold 6 is shaped with the desired contour of the object to be cast and is shown in the drawings as forming a slightly out-of-round cylindrical surface 8 for the casting of tubular stock from which the piston rings may be cut. The cavity formed in the mold is of uniform cross-section throughout its length and is not tapered to provide draft in the mold. The walls of the mold 6 are drilled axially in a series of inner passages 9 peripherally spaced around the center cylindrical surface 8 and a series of outer passages 10 which are spaced radially outwardly from the inner passages. Radial bores 11 extend through the walls of the mold between the passages 9 and 10 from the inner cylindrical surface 8 to the outside of the mold. A cap 12 secured to the front of the mold cylinder by suitable screws, not shown, is formed with an annular groove 13 forming a header between the ends of the inner bores 9 and the outer bores 10.

The rear or flanged end of the mold 6 is clamped tightly to the hub 1 and the passages 9 and 10 communicate respectively with inlet ducts 14 and outlet ducts 15 drilled axially in the hub. The inlet ducts 14 are connected to the surface of the hub by a series of radial bores 16 while the outlet ducts 15 are connected to the surface of the hub by the radial bores 17. A rotating seal member 18 is secured around the hub 1 and provided with ports 19 communicating with the radial bores 16 and 17. The annular flanges 20 formed on the rotating seal separate the inlet and outlet passages. A stationary seal member 21 is provided with internal annular grooves which receive the annular flanges 20 of the rotating seal and form a sliding gland or seal therewith. A water inlet passage 23 and a water outlet passage 24 formed in the stationary seal member communicate with suitable couplings 25 by means of which the water supply and outlet pipes

may be attached to the mold. A retaining ring 26 having a generally U-shaped cross-section supports the couplings 25 and retains the fixed seal tightly against the rotating seal 18.

Positioned inside of the mold and against the surface 8 is a mold wall liner 27 which is of preformed bendable sheet material, desirably a sheet of single ply asbestos or a similar heat resistant material. The sheet asbestos is highly desirable because it has sufficient strength for manipulation and resists the molten metal; that is, it is not destroyed by the molten metal although the binder may be destroyed. The sheet, however, retains its sheet form so that it adheres to and may be removed with the casting. If other material than sheet asbestos is used the sheet should contain a heat resisting constituent that is not destroyed by the heat of the molten metal. The binder for the fibres of the sheet should be either completely volatilized or consumed by the heat of the molten metal or be substantially unaffected by it. The sheet preferably is arranged in the mold with its longitudinal edges adjacent but unconnected and in non-overlapping relation. The width of the sheet is thus equal to or slightly less than the circumference of the mold cavity. Overlapping of the edges of the sheet is permissible so long as the inside lap trails the direction of rotation of the mold. The unconnected character of the edges of the liner permits it to expand firmly against the wall of the mold, the mold wall being ventilated or having ventilating passages opening thereto as at 11 so that air or gas pockets are not formed behind the sheet liner either when the liner is inserted or during the molding operation. The centrifugal action of the molten metal forces the liner firmly against the wall of the mold and conforms it to the contour of the mold cavity.

An annular ring 28 of sheet asbestos is positioned at the bottom of the recess 4 in the hub and together with the sleeve 27 forms a casting surface which prevents the surface of the casting from becoming too rapidly chilled by contact with the walls of the mold.

Metal strips 29 secured as by welding to the sides of the mold have their outer ends twisted and folded into retaining arms 30 for engaging the handles 31 carried on the cover plate 32. The cover can thus be secured to the mold by placing it against the mold and rotating the handles under the arms 30. The cover defines a pouring hole 33 through which the molten metal is introduced into the mold but overhangs the edges of the mold cavity to retain the molten metal in the mold.

In operation it is contemplated that a new sleeve 27 will be installed in the mold prior to each casting operation. The sleeve is conveniently seated by rolling it into a small enough roll to be easily thrust into the mold. It is then allowed to unroll and is expanded into shape by running a smooth plug into the cavity. The cover 32 will then be installed and the hub 1 and the mold carried thereby will then be rotated at high speed and molten metal will be poured into the mold to form a tubular casting of desired thickness. Cooling water may be admitted through the inlet passages 23, 16 and 9, from where it will flow to the header at the front end of the mold member and be returned through the outlet passages 10, 17 and 24. The rate of cooling of the casting may be controlled by regulating the volume and temperature of the cooling water passing through the mold. Gases formed in the mold by the ac-

tion of the hot metal on the binder of the liner 27 escape out of the bores 11 and do not tend to deform the liner. We have found some form of ventilation to be essential to the use of the asbestos liner since otherwise the gases bulge the liner permitting molten metal to get behind it and foul both the mold and the casting. It is believed that the close proximity of the asbestos to the mold wall prevents the asbestos from being consumed as it would otherwise be at the temperature of molten iron.

After the casting has reached the desired temperature, the cover 32 is removed and the casting is removed from the mold, which operation is facilitated by the asbestos sleeve 27 which is drawn out of the mold with the casting. Since the liner substantially covers all of the mold wall there is no necessity for cleaning the mold other than to blow out dust with an air blast, and another asbestos sleeve 27 may be immediately installed for another casting operation.

Figs. 3 and 4 illustrate a modified form of the mold 6A in which the inner cooling passages 9A are more widely spaced than the corresponding passages in Figs. 1 and 2 and in which the outer passages 10A are spaced around the circumferences of the mold between the inlet passages 9A and radially outwardly therefrom. Longitudinally extending grooves 11A formed in the walls of the mold extend between the ends of the mold and take place of the radial bores 11 in the preferred form of the invention to permit the escape of air and gases from behind the liner 27 to the open end of the mold. Coacting with the grooves 11A are holes 34 formed in the cover 32A to complete the vent passages. The cover 32A is retained on the mold in the same manner as the cover 32. In other respects the modified form of the mold and its operation is the same as the preferred form.

Using either form of our invention, the casting with the liner thereon is withdrawn from the mold as a unit. The liner serves as an insulating medium protecting the molten metal from the wall of the mold so that the casting does not have a chilled surface which requires heat treatment to render the casting machinable. The inner surface of the liner also gives the casting a smooth, even surface and further protects the surface from oxidation when the casting is removed hot from the mold. It will be understood that this results in a very great saving of time and labor and cost of heat treating furnace operation. Also, the liner being removed from the casting leaves the mold cavity surface of the mold clean so that it is not necessary to clean the cavity, although in practice it is desirable to direct an air blast into the mold cavity before the liner is inserted in order to free it from dust or particles which might collect therein in foundry operation. The employment of the cooled mold increases production as it increases the number of castings which may be made in a single mold during a given time as well as improving the microstructure of the casting. In practice, substantially as soon as one casting is removed from the mold, the mold is immediately prepared for another casting operation by inserting a new liner sheet and repeating the molding steps.

Operation of the mold in the manner just described provides tubular castings having a smooth and clean dense machinable outer surface quickly and inexpensively without requiring extensive cooling periods or repair periods to change molds which have become cracked and dirty due to contact with the molten metal. Control of the temperature and volume of the cooling fluid accurately determines the grain structure of the casting so that very few faulty castings are produced. Further, the spinning time of the mold is reduced and the lighter impurities of the metal are concentrated at the inner surface of the casting where they are easily machined away with a minimum depth of cut permitting the use of less metal and obtaining better cooling characteristics as explained above.

A particular advantage of the mold is that the mold cavity may be of uniform cross-section, either cylindrical or out-of-round or other desired shape, from end to end. This produces a casting requiring less machining on the outer surface than older type molds which had to be tapered to permit the casting to be removed. Of course, if a tapered casting is desired the mold cavity and liner may be so formed. Sheet liners of the type described may be easily obtained in uniform size, thickness and smoothness.

While there are advantages in positioning the liner with its longitudinal edges in non-overlapping relation, the edges may be overlapped as shown in Fig. 5. The overlapping edge should be positioned in regard to the direction of rotation of the mold so that the metal will not tend to flow under the liner.

The invention has been herein described and illustrated in a highly satisfactory commercial embodiment. No attempt has been made to show other adaptations, as it is believed that this disclosure will enable those skilled in the art to embody or adapt the invention as may be desired.

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

1. Centrifugal casting apparatus comprising, a hub adapted to be rotated at high speed about a horizontal axis, a permanent mold member secured to the end of said hub with its longitudinal axis coincident with said horizontal axis and having a generally cylindrical tubular casting cavity formed in the center thereof and having a plurality of radial ventilating bores formed through its walls from said cavity to the outside of said mold, said hub and mold having a plurality of aligned axially extending inlet passages formed within the walls thereof and angularly spaced around said cavity and having a plurality of aligned axially extending outlet passages formed in the walls thereof and spaced radially outwardly from said inlet passages, said passages being located in portions of said mold wall between said bores, means forming a header connecting the outer ends of said inlet and outlet passages, a rotating seal member secured around said hub and having a pair of outwardly opening annular grooves, one communicating with all of said inlet passages, the other of said grooves communicating with all of said outlet passages, a stationary seal member engaging the walls of said grooves to form an annular inlet and an annular outlet passage around said hub and having inlet and outlet ports opening to said annular inlet and outlet passages respectively, a retainer around said stationary seal member, connecting members on said retainer for attaching cooling fluid lines to communicate with said ports, and a liner of preformed sheet material having the heat resisting and insulating properties of sheet asbestos positioned within said cavity in unattached substantially covering facing relationship with the surface of said cavity and having its

axially extending edges adjacent to each other but unattached.

2. Centrifugal casting apparatus for ferrous metals comprising, a rotatable mold having a casting cavity with circulatory cooling fluid passages located within the wall of said mold and positioned around said cavity, a running seal for connecting fluid circulating pipes to said passages in said mold, and a preformed liner of sheet heat resistant material covering the wall of said cavity, the wall of said mold having ventilating passages formed therein and opening from between said sheet and the surface of said cavity to the space around said mold, said sheet having its adjacent edges unattached and being unconnected to said mold.

3. In combination, a tubular centrifugal mold member having an approximately cylindrical mold cavity wall surface and having cooling fluid circulating passages formed in the wall of said mold member and located around said cavity, such wall surface having ventilating grooves formed therein and opening to the open end of the mold cavity, and a preformed bendable sheet asbestos liner disposed within the mold cavity in radially supported relationship to the wall thereof and constituting a mold cavity wall facing bridging said grooves, the longitudinal edges of the liner being positioned adjacent to each other but unconnected, the liner being free to expand into close supported contact with the mold cavity wall surface of the mold member.

4. In combination, a centrifugal mold member forming an approximately cylindrical mold cavity open at one end, the surface of said cavity having ventilating grooves formed therein and extending to the open end of said cavity, means rotatable with said mold member for directing a circulatory flow of cooling fluid around and in contact with the wall forming said mold cavity, and a preformed bendable sheet asbestos liner disposed within said mold cavity in rolled, radially supported, conforming relation to the wall thereof and bridging said grooves to form ventilating passages opening to the end of said mold and constituting a facing for said cavity wall surface, the liner being free to unroll and maintain close supported contact with the mold cavity wall upon expansion of the latter but being unconnected to said cavity wall.

5. Centrifugal casting apparatus comprising a rotatable member, a mold member having an elongated casting cavity formed therein and secured to said rotatable member with the axis of the cavity coincident with the axis of rotation of said rotatable member, the surface of said cavity having grooves formed therein and extending to the open end thereof, the walls of said mold member having circulatory cooling fluid passages formed therein, a liner of preformed bendable sheet material of heat resistant composition positioned against the surface of said cavity in unattached, substantially covering non-overlapping relationship, said liner and said grooves cooperating to form ventilating passages therebetween opening to the end of said mold, a cover removably secured to said mold and having a central pouring opening to said cavity formed therein, said pouring opening being smaller than the cross sectional area of said cavity whereby said cover overlies the end of said cavity, said cover also having holes formed therethrough registering with the ends of said ventilating passages, and means carried on said rotatable member for attaching cooling fluid conduits to said cooling fluid passages.

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