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STOPPER FOR METALLURGICAL LADLES

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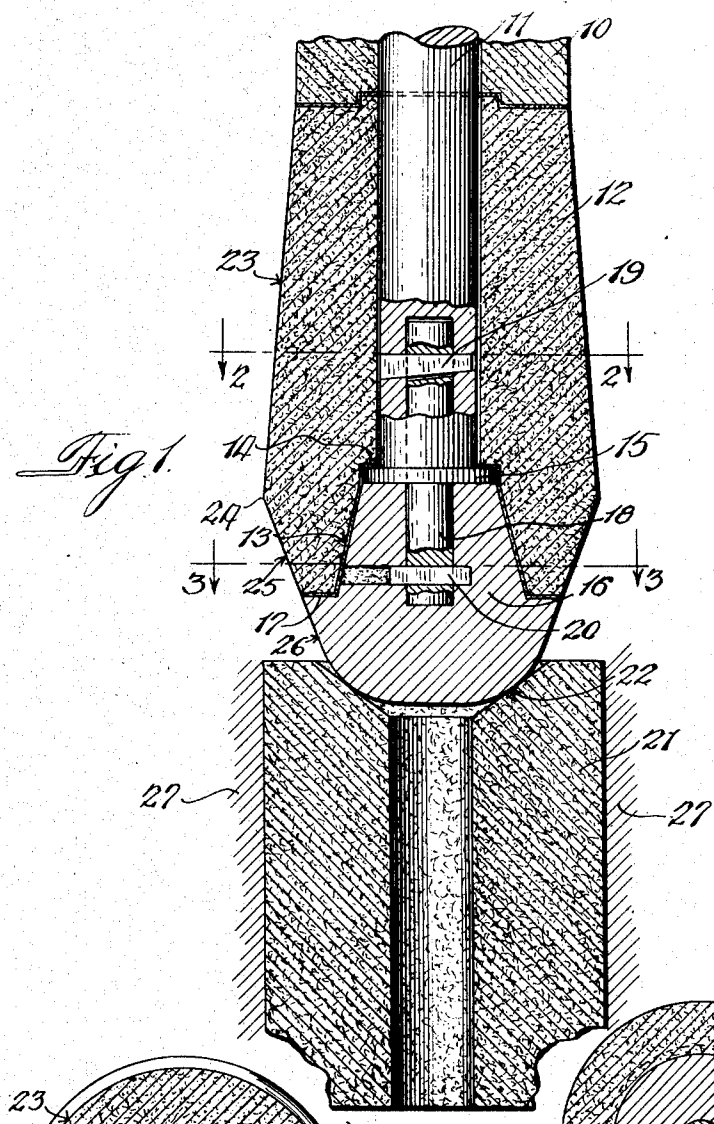

Fig. 1.

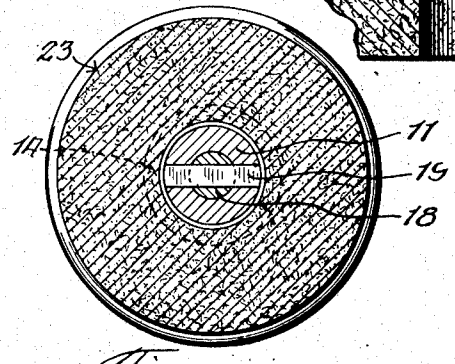

Fig. 2.

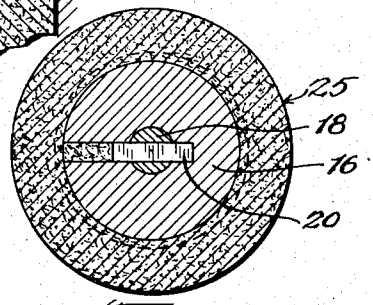

Fig. 3.

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STOPPER FOR METALLURGICAL LADLES

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8 Claims. (Cl. 22—85)

This invention relates to improvements in stoppers for ladles used for conveying molten metal, such as steel, from converters, melting furnaces, etc., and pouring it into molds. Such stoppers work from the inside of the ladles to open and close the passage through the pouring nozzle which extends vertically through the bottom of the ladle, and to control the flow of the molten metal therethrough.

As usually constructed the stopper comprises a long central 2-inch iron rod closely surrounded by tubular sleeves of refractory material, such as fire clay, extending up through the molten steel in the ladle. The lower end of the stopper is provided with a head of a graphite and fire-clay mixture, which is adapted to rest upon the depressed annular seat in the upper end of the pouring nozzle in the bottom of the ladle to close the passage therethrough, like a valve, and when raised from the seat to open the passage. Suitable mechanical connections at the upper end of the stopper and extending down over the outside of the ladle enable the stopper to be raised and lowered manually as desired.

These stoppers are subjected to the high heat, 2600° to 3100° F., of the steel bath, and as usually constructed are more or less rapidly destroyed, particularly at their lower ends where the heads are secured to the iron rod. It not infrequently happens that the heads "burn off," as it is called, from the remainder of the stopper and drop into the ladle, with consequent trouble and expense. The longer time for which the lower end and head of the stopper are necessarily subjected to the high heat of the bath, the relatively high heat-conductivity of the head, and the mechanical and erosive action of the flowing metal contribute to the increase of these difficulties at this point.

It is found in practice, also, that when the ordinary stopper is raised to open the nozzle the flowing metal tends to swirl about the lower end of the stopper, something like the water in a wash-bowl when the stopper is removed, which cuts the nozzle and interferes with the proper flow into and out of the nozzle and causes spraying or fanning of the metal as it issues from the nozzle, all of which is objectionable.

An object of the present invention is to improve the construction of the lower end of the stopper, whereby the essential connections and parts are better protected from the destructive effects of the highly heated liquid metal and the danger of their destruction or the breaking off and dropping of the head during a pour is avoided.

Another object is to provide a construction having the effect to break up or prevent the swirl of the hot metal which tends to develop in the ladle around the stopper and nozzle in pouring, and to do this in a way which also permits pouring with the cooler molten metals. This is commonly referred to as "cold pouring."

Other objects are to provide an improved construction universal in its application to the various conditions of such pouring, which may be standardized in its own and associated parts, such as the nozzle, for the industry, which may result in a shortened nozzle—a most desirable end—and in which the head may be made of less expensive and more readily obtainable grades of material and a less percentage of the more expensive ingredient.

Further objects and advantages will appear from the detailed description and claims to follow, in connection with the drawing which illustrates an embodiment of the invention, and in which—

Figure 1 is a vertical section through the lower end of a stopper of the usual construction and proportions, with an embodiment of the present invention attached;

Figure 2 is a cross-section of the improved stopper on the line 2—2 of Figure 1; and

Figure 3 is a cross-section of the stopper on the line 3—3 of Figure 1.

It will be understood that the ladles here involved are of comparatively large size, usually 15 to 20 feet in height and 10 feet or more in diameter, and take in one filling the charge output of a furnace, commonly 150 tons of molten metal. The ladle after being so filled is conveyed to the pouring location by an overhead crane and the contents thereof poured usually into vertical ingot molds, of which there may be 40 or 50, spaced a few feet apart, to be poured successively from a single filling of the ladle. The ladle is of the bottom pouring type, a vertical pouring nozzle being secured in the bottom wall of the ladle, which is brought over each mold for the pouring. The nozzle is opened and closed for the filling and pouring by an inside stopper, that is, a stopper located and working inside of the ladle, and therefore subjected to the high temperature of the molten metal.

Such stoppers ordinarily comprise a central supporting 2-inch iron rod extending from the bottom to the top of the ladle and which is covered with refractory tubular sleeves of fire

clay, or the like. These sleeves ordinarily are all alike, usually slightly less than a foot in length, with their meeting ends flat or grooved and ribbed for engagement, and, of course, with a thin layer of refractory cement or material therebetween to prevent seepage to the rod of the hot liquid metal. The sleeves closely surround the rod, with only a small clearance therebetween for ease of assembling and providing a thin layer of air around the rod for heat-insulation purposes. These sleeves are thick-walled, to obstruct as much as possible the passage of the heat to the rod.

Figure 1 of the drawing shows, at the top, the lower end of such a sleeve 10 and the rod 11 of the usual dimensions and proportions. These sleeves ordinarily extend down to the head of the stopper and are of the same diameter throughout. The head, as it is called, located immediately beneath the lowermost or bottom sleeve, is that part which contacts the pouring nozzle to close the opening therethrough. The material is usually graphite bonded with fire clay, the graphite content running from 18 to 30 per cent, and both ingredients being of the imported variety and therefore difficult and expensive to obtain.

Graphite is used because it does not melt in contact with the fire-clay nozzle and weld and stick thereto, like other materials which have been tried. But the graphite and graphitic mixture is of relatively high heat conductivity, and as heretofore constructed and attached to the supporting rod the latter was not sufficiently protected from the high heat and frequently burned off and dropped the head.

In the present invention, the bottom sleeve 12 of the stopper, which is of refractory material, such as fire clay, like the sleeves above it, is of the usual size and construction at its upper end suitably to conform and co-operate with the bottom of the ordinary sleeve above. As shown, this bottom sleeve 12 is enlarged toward the lower end to provide room therein for an enlarged recess 13 in the lower end and still maintain a thick wall of refractory material thereabout. An internal shoulder or ledge 14 is formed at the upper end of this recess between the central bore of the sleeve and the walls of the recess. The central iron supporting rod 11, which extends down through the usual central bore or passage of the sleeve to this point, is provided with a lateral projection which may be in the form of a collar 15 secured thereto or formed thereon in any desired way, or other forms of lateral projection or projections may be provided on which the shoulder or ledge 14 of the bottom sleeve may rest.

The head 16 is of a size and shape to fit into and fill the enlarged recess 13 in the bottom sleeve. This is preferably in the form of a truncated cone. A peripheral ledge 17 at its midsection underlies or underlaps the edge of the bottom sleeve 12 and its generally rounded, substantially hemispherical bottom forms the end of the stopper, the lower face of which engages the nozzle seat with a line contact to stop the flow of metal therethrough and to permit its flow when raised. This head is secured to the supporting rod 11 through the medium of an extension of the rod, preferably in the form of a smaller rod 18, the upper end of which is inserted in a hole in the lower end of the rod 11 and is securely keyed therein by key 19 driven into the transverse openings therethrough. The lower end of this rod 18 projects into a corresponding hole in the upper part of the head and the latter is secured thereto by a cross-pin 20, preferably square or rectangular, in cross-section, with the flat side up for better bearing surface. This pin projects at its ends from the rod 18 sufficiently to sustain the load, if need be, of the head, the bottom sleeve and the sleeves above it, though the shoulder 14 may share the load.

In assembling the stopper, the extension 18 is placed in the rod and keyed therein. The head is next secured tightly in position and the hole at the end of the pin filled with refractory cement or plug. The sleeves are then slipped over the rod 11 from the other end, the bottom sleeve being brought down into position over the head as shown. All meeting faces of the head and sleeve, and of the sleeves themselves, are, of course, coated or provided with a layer of refractory cement or equivalent material, as is intended to be indicated by the double lines in the drawing. This tends to make a more rigid construction and prevents the liquid iron from seeping through the joints and reaching the metal rod and connections.

By this construction an imperforate, solid bottomed head is provided, while the upper truncated half is surrounded and protected by the refractory material of the walls of the sleeve, and the part so encompassed is sufficient in size and strength to receive the metallic supporting connections with the rod, thereby enabling the lower exposed portion of the head to be a relatively thick, solid, unbroken block of material. This increases the strength of the head, which must bear the weight of the entire stopper when closed and the shocks and jars due to normal closing, and its violent closing to shut off any end trickles of the hot metal, and affords greater heat protection for the embedded metallic supports. The greater protection to the metallic parts thus afforded by this construction from the high heat of the bath and its rugged strength enable a less expensive grade of graphite and fire clay, such as the domestic varieties, to be employed for the head and a less percentage of graphite may be used in the mixture and more of the fire clay, which still further reduces the expense and simultaneously decreases the heat conductivity of the mixture, thereby further protecting the metallic parts. Engineering specifications for such material for these new heads now call for as low as an 8% graphite content of the domestic type and may well be reduced with safety to 4%.

The pouring nozzle 21 is of the usual construction and material, to wit, fire clay, except that it may be shorter than heretofore, due to the true stream flow obtained therethrough as later explained. A slightly depressed seat 22 is formed in the upper end in which the head of the stopper engages by line contact, as shown in Fig. 1. Such nozzles extend vertically through the bottom wall of the ladle, indicated at 27, and are suitably secured therein. The upper end is frequently in a shallow well or sloping depression in the upper face of the bottom of the ladle or it may be flush with the flat face.

The difficulty in bottom pouring with stoppers having substantially straight sides, that is, of substantially the same diameter throughout, is the tendency of the metal to swirl when pouring. The erosive action on the nozzle tends to cut it, the desired free, full flow through the nozzle is interrupted, and the hot metal tends to spray and fan out as it emits from the nozzle. The nozzles

have been lengthened, in an effort to overcome some of this, until now they are usually 13 or 14 inches in length. Long nozzles, however, are objectionable, for various reasons, and if too long tend to produce a swirl within themselves.

In this invention, the swirl is prevented by the outward flare of the outside of the bottom sleeve toward the bottom thereof, preferably, as shown in the drawing, by a straight, uniform slope 23 from the top of the sleeve to near the bottom; and at a point 24 near the bottom of the sleeve by the inward slope at a comparatively sharp angle and steeper slope, as shown in the drawing and indicated at 25. The outer surface 26 of the head beneath the shoulder 17 is made to form a continuation of this inward slope of the bottom of the sleeve and which ends in the rounded solid imperforate bottom of the head.

By this contour of the sleeve the descending hot metal about the stopper is caused to change its direction of flow, to break up and prevent the tendency to swirl, and the sharp inward slope at the end admits also a full and free flow into the nozzle regardless of whether the metal is in a highly heated and fluid condition or cooler, so as to constitute what is termed a "cold" pour. The result, too, is that a shorter nozzle may be used, since there is no spraying or fanning of the metal as it issues from the nozzle. A nozzle of 9 inches in length may be satisfactorily used. The design and proportions shown in the drawing are preferred for average conditions and temperature of metal to be poured and average characteristics of the metal such as are met with in the average plant doing general work of this nature. For special conditions and characteristics slight variations may be desired, as will be understood by those skilled in the art.

It is intended, of course, that the invention should not be limited to the specific embodiment (or embodiments) disclosed herein, since modifications may be made, and it is contemplated, therefore, by the appended claims, to cover any such modifications as fall within the true spirit and scope of this invention.

Having thus described this invention, what is claimed and desired to be secured by Letters Patent is:

1. In an inside bottom pouring ladle stopper having the usual central metal supporting and operating rod surrounded by the usual refractory tubular sleeves, a refractory bottom sleeve cooperating at the upper end with the sleeve above it and having an exterior in the form of a truncated cone throughout its greater length, the remainder of its length being inwardly sloped exteriorly at a sharp angle with the surface above and at a steeper slope, to prevent swirl of the molten metal and permit free flow thereof to the nozzle, said sleeve having in its expanded lower end an enlarged and deep recess for the reception of a correspondingly shaped head with its metallic connections to the rod above and a rounded projecting bottom for engagement by line contact with the nozzle seat.

2. In an inside bottom pouring ladle stopper having the usual central metal supporting and operating rod surrounded by the usual refractory tubular sleeves, a refractory bottom sleeve cooperating at the upper end with the sleeve above it and having an exterior in the form of a truncated cone throughout its greater length, the remainder of its length being inwardly sloped exteriorly at a sharp angle with the surface above and at a steeper slope, to prevent swirl of the molten metal and permit free flow thereof to the nozzle, said sleeve having in its expanded lower end an enlarged and deep recess, a head extending and fitting into said recess and having a rounded solid imperforate bottom for engagement by line contact with the nozzle seat, and metallic securing and supporting connections of said rod with said head embedded in the upper part of said head.

3. In an inside bottom pouring ladle stopper having the usual central metal supporting and operating rod surrounded by the usual refractory tubular sleeves, a refractory bottom sleeve cooperating at the upper end with the sleeve above it and having an exterior in the form of a truncated cone throughout its greater length, the remainder of its length being inwardly sloped exteriorly at a sharp angle with the surface above and at a steeper slope, to prevent swirl of the molten metal and permit free flow thereof to the nozzle, said sleeve having in its expanded lower end an enlarged and deep recess, a head having its upper half extending and fitting into said recess and having a mid-sectional, circumferential ledge or shoulder underlying the end of the sleeve and a rounded lower solid and imperforate lower half for engagement by line contact with the nozzle seat, and metallic connections of the said rod with the head embedded in the said upper half of the head within said recess.

4. In an inside bottom pouring ladle stopper having the usual central metal supporting and operating rod surrounded by the usual refractory tubular sleeves, a refractory bottom sleeve cooperating at the upper end with the sleeve above it and having an exterior in the form of a truncated cone throughout its greater length, the remainder of its length being inwardly sloped exteriorly at a sharp angle with the surface above and at a steeper slope, to prevent swirl of the molten metal and permit free flow thereof to the nozzle, said sleeve having in its expanded lower end an enlarged and deep recess, a head having its upper half extending and fitting into said recess and having a mid-sectional, circumferential ledge or shoulder underlying the end of the sleeve and a rounded lower solid and imperforate half for engagement by line contact with the nozzle seat, said lower half having a surface contour forming a continuance of the inward slope of the lower part of the sleeve, and metallic connections of the said rod with the head embedded in the said upper half of the head within said recess.

5. In an inside bottom pouring ladle stopper having the usual central metal supporting and operating rod surrounded by the usual refractory tubular sleeves, a refractory bottom sleeve circular in cross-section throughout and corresponding at the upper end to the sleeve above and having an outwardly sloping exterior throughout its greater length, the remainder of the exterior being inwardly sloped at a sharp angle with that above and at a steeper slope and having an enlarged recess in the bottom, a head having its upper half extending into and fitting within said recess, an extension of the supporting rod entering a central bore in the said upper half of the head, and a cross-pin inserted through aligning apertures in said upper half of the head and the rod extension and connecting said head to said rod, said head having a solid imperforate bottom half extending beneath the said sleeve and rounded to form a bottom to

engage by line contact with the ladle nozzle seat.

6. An inside bottom pouring ladle stopper having a central metal supporting rod surrounded by refractory tubular sleeves and a head at the lower end for engagement with the nozzle seat, the lower end of said rod having a central hole, an extension of the rod secured at its upper end in said hole, said head having a hole in its upper end into which said extension projects, and a cross-pin inserted after assembly of the head on the rod extension through aligning apertures therein to secure the head to the extension and rod and to provide bearing surfaces therefor.

7. A stopper of the class described having a metal supporting rod surrounded by refractory sleeves and a head at the end, said rod having a central bore at its lower end, an extension of the rod having its upper end fitting into said bore, a transverse locking key through the rod and extension to secure the latter to the rod, the lower end of the extension projecting and fitting into an aperture in the upper part of the head, a cross-pin inserted after assembly of the head on the rod extension through aligning apertures in the head and extension to secure the head to the extension, and said head having an imperforate solid depending lower end to engage the nozzle seat of the ladle.

8. In an inside bottom pouring ladle stopper having a central metal supporting rod surrounded by refractory tubular sleeves, a head for use at the lower end of the stopper for valve engagement with the nozzle seat, said head having its upper half in the form of a truncated cone to fit within a corresponding recess in the bottom sleeve and having a mid-sectional outwardly extending ledge to receive the lower end of the bottom sleeve and a substantially hemispherical lower half forming from the periphery of said ledge an inwardly sloping surface and a rounded bottom for engagement by line contact with the nozzle seat, said upper half being of sufficient size to accommodate the metal connections from the central rod to the head and its anchoring means thereto and said lower half being solid and imperforate.

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