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STOPPER ROD ASSEMBLY AND PARTS

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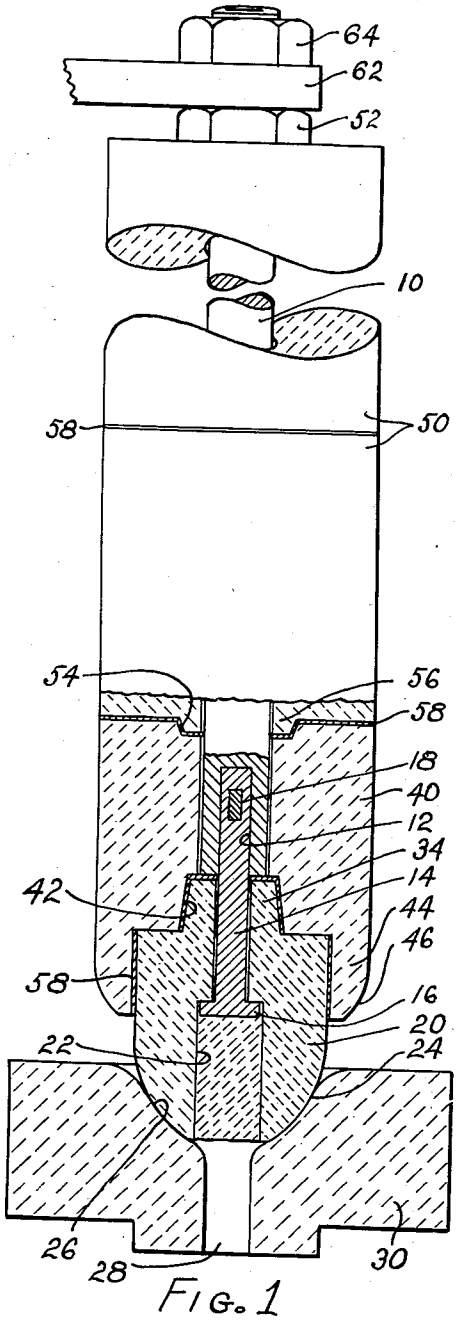


FIG. 1

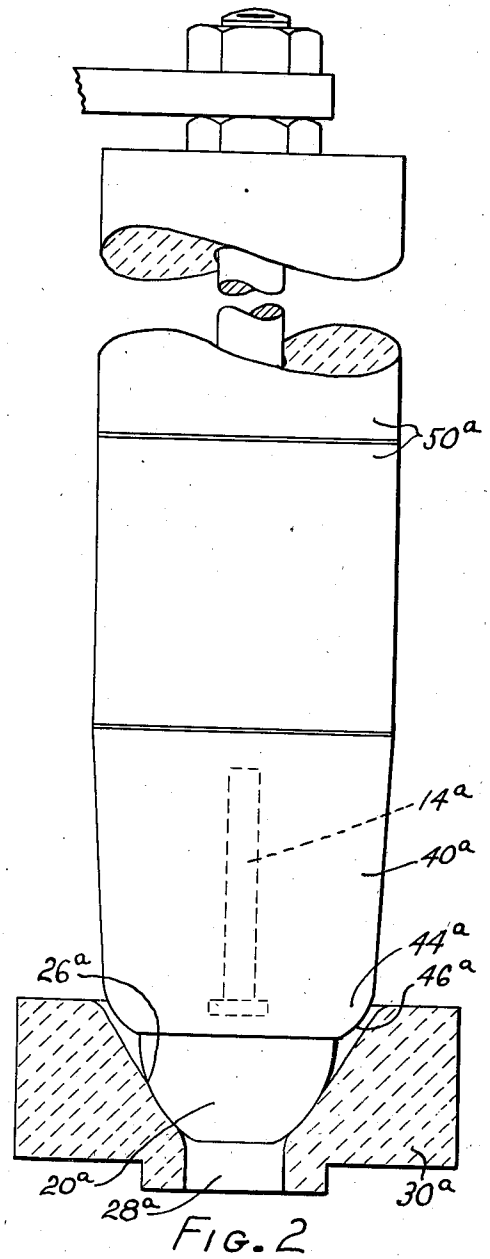


FIG. 2

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STOPPER ROD ASSEMBLY AND PARTS

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13 Claims. (Cl. 22—85)

This invention relates to stopper rod assemblies for removably plugging a discharge orifice in the bottom of a ladle carrying molten metal, or similar material, and with the stopper rod assembly being of the type adapted to extend through the molten material and operated by mechanism positioned outside of the ladle, and the invention is concerned with the parts for such stopper rod assemblies.

Ladles for carrying molten metal and including a bottom discharge orifice removably closed by a stopper rod assembly carried in the molten metal and operated from outside the ladle are old and well known in the art, one typical use being to receive the molten metal from an open hearth furnace followed by pouring of a plurality of ingot molds from the ladle. Usually, the stopper rod assemblies are made up with a metal base rod upon which are threaded a plurality of refractory sleeves made of fire clay, and with the rod being tipped or carrying at its bottom end a plug of graphite which engages with the discharge orifice to effect the sealing operation. The plug is held on the bottom end of the rod by a bolt and the refractory sleeves are clamped end to end and down against the plug by suitable fastening means, such as nuts, carried by the upper end of the rod.

Heretofore, the steel industry has experienced considerable difficulty in the successful operation and maintenance of stopper rod assemblies. It is a relatively common occurrence for the plug to become disengaged from the stopper rod assembly during pouring, with the plug falling down into the orifice and sealing off the flow of metal. This is very obnoxious because a "pricker rod" must be forced up through the bottom of the orifice to disengage the plug, and when the plug is disengaged it will rise to the surface of the ladle, and the ladle cannot be shut off thereafter so that it is necessary to move the ladle from one ingot mold to the next with the metal splashing down to the floor between the ingot molds much to the danger and discomfort of the workmen, to say nothing of the loss of material. Furthermore, in free running ladles of the type just described, it is impossible to control the character of the flow of metal from the ladle to the ingot mold, which is well understood to be advisable, and the result is that the best type of fissureless ingot is not obtained. Even with the stopper rod assembly complete there is a definite tendency to avoid complete control of the pouring from the ladle because of the danger of overtaxing the capabilities of the stopper rod assembly.

When it is realized that the steel industry is going to bigger and bigger ladle sizes, for example, capable of handling up to as much as one hundred and fifty tons of molten metal at one time, or even more, the strains and stresses to which a stopper rod assembly is subjected in service will become apparent. Also, certain alloy steel, and particularly low carbon steel, being manufactured in large quantities today, tend to cut or wear away the stopper rod assembly and the discharge orifice during pouring in a more rapid manner than characterizes the action of ordinary steel. It is not uncommon to form the discharge orifice with a starting hole size of approximately one and three-eighths inches, and to have this hole cut to a diameter of three or even more inches during pouring. The difficulties of obtaining proper shut-off of the orifice during any moment of pour will be apparent.

Because of the reasons only partially listed above the steel industry has resorted to the use of a plurality of stopper rod assemblies and discharge orifices in a single ladle, but in spite of this practice the usual pouring floor of a steel plant has a relatively large supply of stopper rod assemblies and the various parts thereof. For example, relatively large quantities of the metal rods for the stopper rod assemblies are constantly being brought in from the blacksmith shop to the pouring floor. These rods are relatively expensive and are most always ruined when the stopper rod assembly comes apart in service.

It has been proposed heretofore to form the bottom refractory sleeve on the stopper rod assembly with a flange which extends part way down over and in snug relation around the upper periphery of the plug so as to prevent the flow of molten metal up between the plug and the bottom refractory sleeve. However, because of the formation of a skull, which is a layer of solidified metal, in the ladle it is very often impossible to raise the stopper rod assembly because the skull has solidified around the depending flange formed on the bottom refractory sleeve. Hence, stopper rod assemblies of the type just mentioned have never met with commercial success, and it will be evident that the formation of a skull in a ladle complicates stopper rod assembly construction and operation. Also, it should be noted that the use of a depending flange of the type described has been thought to be unsuitable because the flange may strike

the refractory block forming the discharge orifice of the ladle which is highly undesirable because the flange attempts to perform the sealing operation instead of leaving this to the plug proper and allowing the plug to seal against the discharge orifice.

It is the general object of our invention to avoid and overcome the foregoing and other difficulties of and objections to known stopper rod assemblies, and parts thereof, by the provision of an improved stopper rod assembly, and parts, characterized by low cost, simplicity of construction, and greatly prolonged life without failure, with the attending production of better ingots and reduction of waste.

Another object of our invention is the provision of a stopper rod assembly for use in metal pouring ladles and wherein the metal parts of the assembly are adequately protected against failure due to heat.

Another object of our invention is to provide a stopper rod assembly having a longer plug and a bottom refractory sleeve formed with a skirt portion closely surrounding the plug and extending down at least to a point to surround the metal bolt holding the plug to the assembly, and with all of the diameters of the bottom refractory sleeve being at least equal to the outside diameter of the skirt.

Another object of our invention is the provision of a bottom refractory sleeve for a stopper rod assembly characterized by a skirt portion adapted to surround and protect the plug of the stopper rod assembly with the bottom periphery of the skirt being chamfered or beveled so as not to engage with the discharge orifice refractory block, and with all portions of the body of the sleeve having a diameter equal to or greater than the external diameter of the skirt portion.

The foregoing and other objects of our invention are achieved by provision of a stopper rod assembly for metal pouring ladles, and the like, comprising a metal rod, a graphite plug, the graphite plug having an axial bore, a bolt for securing the plug to the lower end of the rod, said plug having a counter-bore receiving the head of the bolt, a filling of graphite in the counterbore covering the bolt head, said plug having a rounded lower end and an integral, truncated-conical, axially-positioned extension of reduced diameter on its upper end, a refractory sleeve on the rod having a complementary recess receiving the plug extension, a skirt on the refractory sleeve extending down around the plug in protective fashion and terminating at a point substantially to completely surround the bolt head, the outer periphery of the lower end of the skirt being formed with a chamfer so that the skirt does not strike the ladle discharge nozzle and interfere with the sealing action of the plug, said sleeve having a diameter at least equal to the skirt, a plurality of additional refractory sleeves mounted on the rod above said first named sleeve, and means for securing the sleeves tightly together on the rod and against the plug.

In one embodiment of our invention, the skirt terminates substantially flush with the lowermost portion of the bolt holding the plug to the metal rod of the assembly, and in another form, the skirt extends to a point considerably below the lowermost portion of the bolt. Also, in one embodiment of our invention the outer periphery of the bottom refractory sleeve and the outer periphery of the skirt are formed as a continuous cylindrical surface, while in another form of our invention, the same peripheries are formed as an inverted, truncated-conical surface terminating at its uppermost and larger diameter in a diameter equal to the diameter of the remaining refractory sleeves of the assembly.

Our invention is predicated upon our discovery that while the graphite of the plug is better adapted to resist the action of the heat from the molten metal and any change of shape from heat or metal flow, nevertheless, it possesses the physical characteristics of transmitting the heat by conduction in a much higher degree than does refractory clay. On the other hand, we have found that although refractory fire clay softens at temperatures considerably below those required to soften graphite, none the less, the refractory clay of the sleeves of an ordinary stopper rod assembly does not transmit the heat by conduction in anywhere near the degree transmitted by the graphite. In other words, the refractory clay possesses much greater insulating characteristics.

For a better understanding of our invention, reference should be had to the accompanying drawing wherein Fig. 1 is a side elevation, partly in section, of a stopper rod assembly comprising one embodiment of our invention, and shown in combination with a refractory block forming a discharge orifice; and Fig. 2 is a view similar to Fig. 1 but showing a modified form of our invention.

Referring to the drawing, the numeral 10 indicates a relatively long steel or alloy rod adapted to extend from a position adjacent the discharge orifice of the ladle to a point adjacent or above the top of the ladle. The rod 10 is formed at its lower end with a socket 12 which is adapted to snugly receive the upper end of a steel, or alloy bolt 14 formed with a suitable head 16. The bolt 14 is adapted to be removably secured in the socket of the rod 10 in any suitable manner, and one convenient way of doing this is to provide a locking or wedge pin 18 which is adapted to extend through suitable complementary openings formed in the bolt and the sides of the socket 12.

The bolt 14 holds a plug 20, usually made of graphite, on the lower end of the rod 10. The graphite plug 20 is adapted to substantially retain its form and shape without softening under the action of intense heat, and even during the flow of molten metal thereover. The plug 20 is formed with an axial bore to receive the bolt 14 and is provided with a counterbore 22 to receive the bolt head. After the bolt is inserted in the plug 20 the counterbore 22 is filled with a graphite paste or cement, as will be understood. The bottom of the plug 20 is formed with a curved surface 24 which is complementary to the curved surface of seat 26 of a discharge orifice 28 formed in any known type of refractory block, such as that shown at 30, and adapted to be positioned and secured in the bottom of the ladle by the usual or suitable means. The top of the plug 20 is formed with an axially-positioned, truncated-conical, integral extension 34 in order to effect an improved connection and joint between the plug and the rest of the stopper rod assembly. It should be understood, however, that the exact shape of the extension 34 may be varied, or that the extension may even be eliminated, so long as the mechanical connection and the fluid tightness of the connection between the plug and the rest of the assembly is satisfactory.

The numeral 40 indicates the bottom refractory

sleeve of the stopper rod assembly, and the shape and construction of this sleeve comprises an important part of our invention. Particularly, the refractory sleeve **40** is provided with a recess **42** which is complementary to the extension **34** of the plug **20**, and is formed with an axial bore to receive the rod **10**. The diameter of the refractory sleeve **40** is somewhat greater than the diameter of the plug **20**, and this permits an integral skirt **44** to be formed on the bottom of the refractory sleeve which extends down in snug relation around the upper periphery of the plug **20**. The skirt **44** extends down to a point substantially equal to or slightly greater than the lowermost portion of the bolt **14** and the head **16** so that the skirt **44** substantially completely incloses or surrounds the bolt **14**.

This is important because the skirt **44** has characteristics of very low heat conductivity, and, therefore, serves to insulate the bolt **14** from the heat of the molten metal in the ladle. The protection of the bolt **14** is a very necessary thing to long stopper assembly life, and we believe that the failure to adequately protect the metal parts, and, particularly, the bolt of a stopper rod assembly has been one of the chief things causing stopper rod failures in use. The outer periphery of the lower end of the skirit **44** is formed with a chamfer or bevel **46** so that, in spite of the length of the skirt **44**, the skirt will not strike the seat **26** of the discharge orifice **28** during the full use of the stopper rod assembly, and even though the seat **26** and discharge orifice **28** change considerably in size during a complete pouring operation.

It will be noted that the outer periphery of the skirt **44** is a continuation of the outer cylindrical periphery of the sleeve **40** so that all diameters of the sleeve **40** are at least equal to the outer diameter of the skirt **44**. This is important for the reason that if the diameter of the sleeve is less than that of the skirt considerable difficulty may be experienced in the operation of the stopper rod due to the formation of a skull on the bottom of the ladle which would prevent the proper functioning of the stopper rod assembly.

The stopper rod assembly is completed by threading a plurality of additional sleeves **50** onto the rod **10**, and holding these sleeves together and against the bottom sleeve **40** and the plug **20**, for example, by means of a nut **52** adjustably carried upon the threaded upper end of the rod **10**. The ends of the sleeves **40** and **50** may be formed with annular recesses **54** which receive truncated-conical bosses **56** to improve the joint between the ends of the sleeves so that stopper assembly will have mechanical strength and improved resistance to the flow of molten metal between the ends of the sleeves. Usually, the stopper rod assembly is put together with thin layers of refractory cement or paste between the engaging surfaces of the sleeves and plug so as to improve the solidity and integralness of the assembly. Such thin layers of cement are indicated by the numeral **58**.

An important part of our invention is to make the plug **20** longer than the standard plug in a vertical direction so that the head **16** of the bolt **14** is further removed from the sealing surface **24** of the plug. This not only protects the bolt from failure in use but also allows the skirt **44** of the bottom sleeve **40** to project down around the outer periphery of the plug to further protect the bolt, all without the skirt **44** striking the seat **26** of the refractory block **30** forming the discharge orifice. Also, making the body of the plug **20** longer in a vertical direction facilitates proper sealing action between the surface **24** of the plug and the seat **26** of the discharge orifice during the entire pouring operation even though the seat **26** and the discharge orifice **28** change considerably in size and shape during the complete pour.

It will be understood that the complete stopper rod assembly is adapted to be operated by any of the standard or conventional stopper operating mechanisms now associated with bottom pouring ladles. Thus, we have illustrated merely an operating bar or member **62** which is secured to the upper end of the rod **10** by a nut **64**.

The embodiment of our invention illustrated in Fig. 2 is quite similar to the form of our invention shown in Fig. 1, with several exceptions. First, the bottom refractory sleeve, marked **40*a***, is formed with an upward taper. In other words, it has an inverted, truncated-conical periphery with its largest diameter at its upper end and of a dimension substantially equal to the diameter of the remaining refractory sleeves **50*a*** of the stopper rod assembly. The skirt portion **44*a*** of the lower refractory sleeve **40*a*** is formed with an outer periphery which is a continuation of the outer periphery of the body proper of the sleeve **40*a***. The outer periphery of the lower end of the skirt **44*a*** is formed with a bevel or chamber **46*a*** in a manner similar to the bevel **46** on the sleeve **44** of Fig. 1.

Second, the skirt **44*a*** of the embodiment of our invention illustrated in Fig. 2, extends to a position considerably below the lowermost point of the bolt **14*a***. This may be achieved by making the skirt **44*a*** longer, or by sinking the bolt **14*a*** somewhat farther into the plug **30*a*** or by a combination of both of these alternatives. In all events, the result is that the heat insulating skirt **44*a*** very adequately protects the bolt **14*a*** from deterioration and failure due to the heat of the molten metal in the ladle.

The stopper rod of Fig. 2 differs from that of Fig. 1 in one other regard, namely, that the refractory block **30*a*** forming the discharge orifice is illustrated to show how it has been worn away during the pouring operation. Specifically, the discharge orifice **28*a*** has been shown as having worn away to a diameter almost double that of the discharge orifice **28**, and in a like manner, the seat **26*a*** of the discharge orifice **28*a*** has been materially increased in size, and its shape altered, all due to the flow of molten metal thereover during the pouring operation. However, it will be noted that the skirt **44*a*** of the lower refractory sleeve **40*a*** does not engage with any portion of the refractory block **30*a*** and that the sealing function of the stopper rod assembly is not impaired because of the change of shape of the seat **26*a*** and the discharge orifice **28*a***.

The slight upward taper of the outer periphery of the lower refractory sleeve **40*a*** insures that the stopper rod assembly will never become anchored with respect to a skull formed on the bottom of the ladle during the pouring operation or the ordinary handling of the ladle. In this connection, it should be noted that we may reduce the diameter of the refractory sleeves **50*a***, and also the diameter of the refractory sleeves **50**, from the top of the rod assembly down to a point sufficiently above the top of any possible skull formation that there is no chance for the rod assembly to become anchored in the skull. In most instances, the use of a bottom sleeve **40** or **40*a*** and one additional sleeve **50** or **50*a*** which

provide vertical or outwardly inclined peripheries without shoulders which might lock with the skull are satisfactory, and the remaining sleeves may be of a reduced diameter to reduce the cost of the assembly.

From the foregoing it will be recognized that the objects of our invention have been achieved by the provision of a relatively inexpensive, but materially improved stopper rod assembly, and parts thereof, for controlling the flow of molten metal, and the like, from a bottom pouring ladle. We have found from actual experience that stopper rod failures are substantially eliminated, as are frozen stoppers and running ladles. Pouring can be very accurately controlled to obtain the best type of ingots or other poured articles, and metal waste and injuries to workmen are almost completely alleviated. Further, losses of the metal rods upon which the stopper rod assemblies are constructed is almost completely mitigated as the rods can be used over and over again without failure or repair.

While in accordance with the patent statutes we have specifically illustrated and described certain embodiments of our invention it will be understood that we are not to be limited thereto or thereby, but that the scope of our invention is defined in the appended claims.

We claim:

1. A stopper rod assembly for metal pouring ladles, and the like, comprising a metal rod, a graphite plug having an axial bore, a bolt for securing the plug to the lower end of the rod, said plug having a counterbore receiving the head of the bolt, a filling of graphite in the counterbore covering the bolt head, said plug having a rounded lower end and an integral, truncated-conical axially-positioned extension of reduced diameter on its upper end, a refractory sleeve on the rod having a complementary recess receiving the plug extension, a skirt on the refractory sleeve extending down around the plug in protective fashion and terminating at a point to completely surround the bolt head, the outer periphery of the lower end of the skirt being formed with a chamfer so that the skirt does not strike the discharge orifice block and interfere with the sealing action of the plug, said sleeve having a diameter at least equal to the skirt, a plurality of additional refractory sleeves mounted on the rod above said first-named sleeve, at least the lowermost of said additional sleeves having a diameter equal to the diameter of the skirted sleeve, and means for securing the sleeves tightly together on the rod and against the plug.

2. A stopper rod for metal pouring ladles, and the like, comprising a metal rod, a heat-resisting plug having an axial bore, means for securing the plug to the lower end of the rod, said plug having a rounded lower end, a refractory clay sleeve on the rod, a skirt on the refractory sleeve extending down around the plug in protective fashion and terminating at a point substantially to completely surround the plug securing means, the outer periphery of the lower end of the skirt being formed with a chamfer so that the skirt does not strike the orifice block and interfere with the sealing action of the plug, said sleeve having a diameter at least equal to the skirt, a plurality of additional refractory sleeves mounted on the rod above said first-named sleeve, at least the lowermost of said additional sleeves having a diameter equal to the diameter of the skirted sleeve, and means for securing the sleeves tightly together on the rod and against the plug.

3. A stopper rod assembly comprising a metal rod, a graphite plug, metal means releasably securing the plug to the lower end of the rod, a plurality of refractory clay sleeves threaded over the rod and held end to end against each other and down against the plug, and a skirt associated with the lowermost sleeve and extending down and closely around the outer periphery of the plug, said skirt extending down at least as far as the lowermost portion of the metal means, the diameter of all portions of the lowermost sleeve being at least equal to the diameter of the skirt, said skirt having a chamfer formed on its lowermost outer periphery.

4. A stopper rod assembly comprising a metal rod, a plug characterized by high refractoriness, means releasably securing the plug to the lower end of the rod, a plurality of refractory sleeves threaded over the rod and held end to end against each other and down against the plug, and a skirt associated with the lowermost sleeve and extending down and closely around the outer periphery of the plug, the diameter of all portions of the lowermost sleeve being at least equal to the diameter of the skirt, said skirt having a chamfer formed on its lowermost outer periphery.

5. A stopper rod assembly for bottom-pouring ladles comprising a metal rod, a plug characterized by extra high refractoriness, means releasably securing the plug to the lower end of the rod, a plurality of refractory sleeves threaded over the rod and held end to end against each other and down against each other and down against the plug, and a skirt associated with the lowermost sleeve and extending down and closely around the outer periphery of the plug, said skirt extending down at least as far as the lowermost portion of the plug securing means.

6. A stopper rod assembly for bottom-pouring ladles comprising a metal rod, a plug characterized by extra high refractoriness, means releasably securing the plug to the lower end of the rod, a plurality of refractory sleeves threaded over the rod and held end to end against each other and down against the plug, and a skirt associated with the lowermost sleeve, said skirt extending down and closely around the outer periphery of the plug and to a position below the lowermost portion of the plug securing means, the outer peripheries of the lowermost sleeve and the skirt being substantially in line and formed with an upward and outward taper.

7. A stopper rod assembly for bottom-pouring ladles comprising a metal rod, a plug characterized by extra high refractoriness, means releasably securing the plug to the lower end of the rod, a plurality of refractory sleeves threaded over the rod and held end to end against each other and down against the plug, and a skirt associated with the lowermost sleeve, said skirt extending down and closely around the outer periphery of the plug, the outer peripheries of the lowermost sleeve and the skirt being substantially in line and formed with an upward and outward taper.

8. A stopper rod assembly for bottom-pouring ladles comprising a metal rod, a plug characterized by extra high refractoriness, means releasably securing the plug to the lower end of the rod, a plurality of refractory sleeves threaded over the rod and held end to end against each other and down against the plug, and a skirt associated with the lowermost sleeve, said skirt extending down and closely around the outer periphery of the plug and to a position below

the lowermost portion of the plug securing means.

9. A bottom sleeve for a ladle stopper rod comprising a refractory clay body portion having an axial bore and a truncated-conical counterbore in the lower end of the body portion, an integral skirt formed on the lower end and outer periphery of the body portion, said skirt depending downwardly at least to the point of substantially completely surrounding any metal parts adapted to extend through the sleeve, said skirt having a chamfer on its lower and outer end, said body portion of the sleeve having all of its diameters at least equal to the diameter of the skirt.

10. A bottom sleeve for a ladle stopper rod comprising a refractory body portion having an axial bore, an integral skirt formed on the lower end and outer periphery of the body portion, said skirt having a chamfer on its lower and outer end, and said body portion of the sleeve having all of its diameters at least equal to the diameter of the skirt.

11. A bottom sleeve for a ladle stopper rod comprising a refractory body portion having an axial bore, an integral skirt formed on the lower end and outer periphery of the body portion, the outer periphery of the sleeve and the skirt being substantially coincident and formed of an inverted truncated-conical shape.

12. The combination in a stopper rod assembly for bottom pouring ladles of a metal rod, a plug mounted at the lower end of the rod and having the characteristic of withstanding very high temperatures without change of shape but possessing relatively low heat insulating characteristics, refractory spool means mounted above the plug on the rod and possessing relatively high heat insulating characteristics, and high heat insulating means associated with the plug and substantially preventing the flow of heat through the plug to the metal rod.

13. The combination in a stopper rod assembly for bottom pouring ladles of a metal rod, a plug adapted to be mounted at the lower end of the rod and having the characteristic of withstanding very high temperatures without change of shape but possessing relatively low heat insulating characteristics, metal means securing the plug to the lower end of the rod, refractory spool means mounted above the plug on the rod and possessing relatively high heat insulating characteristics, and relatively high heat insulating means associated with the plug and substantially surrounding the metal means and substantially preventing the flow of heat in metal damaging quantities of the metal means.

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