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[54] **STOPPER ROD HAVING FIBROUS PROTECTIVE SLEEVE**

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[58] **Field of Search** 266/38, 39, 40; 164/335, 164/337, 281; 222/1, 559, 566; 251/366, 356, 368, 318

[56] **References Cited**

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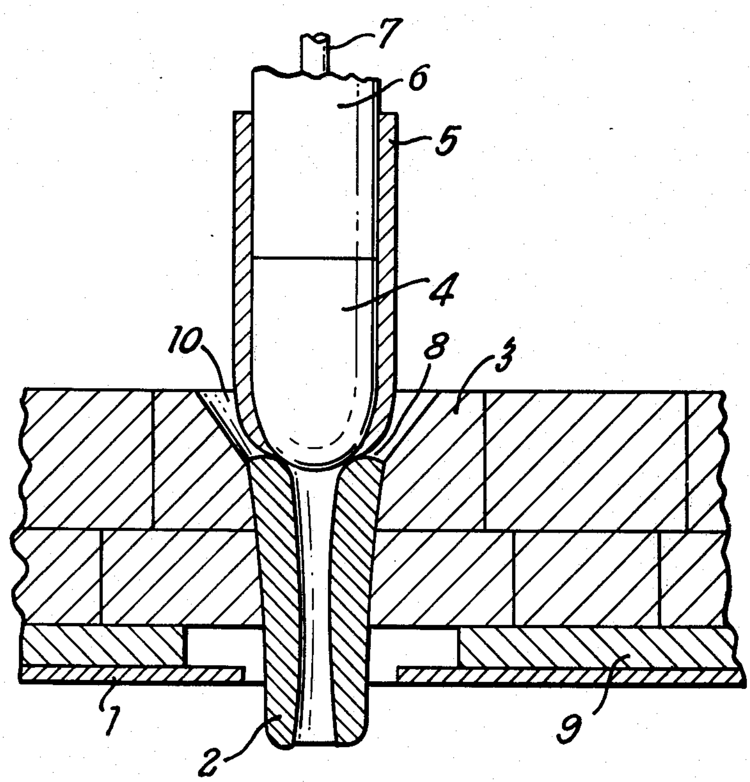
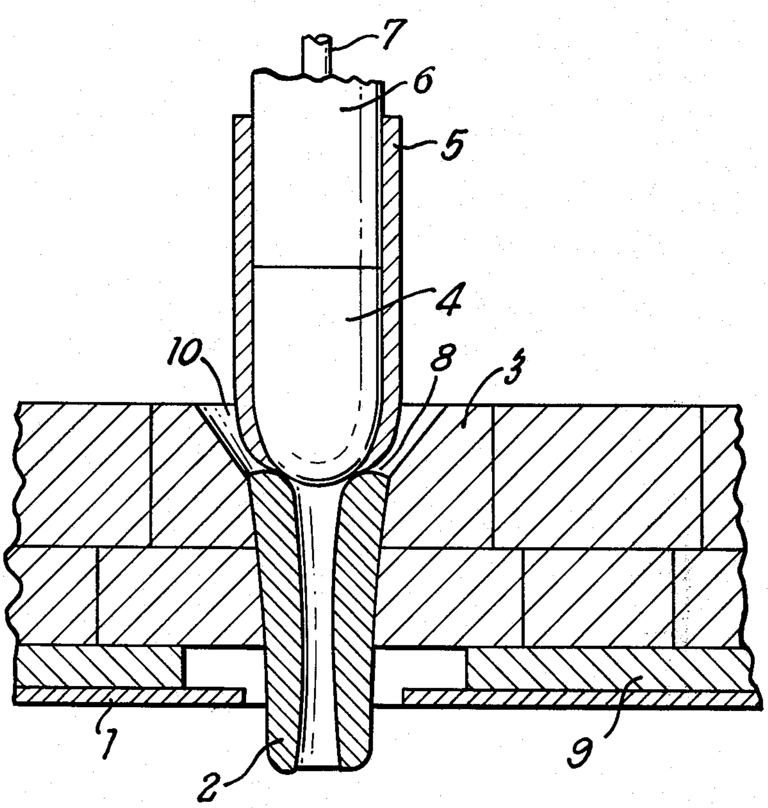
[57] **ABSTRACT**

In molten metal handling using a stopper rod to close a nozzle in the base of a ladle, the end of the rod is covered by a sleeve of 45 – 94% by weight of particulate refractory, 5 – 50% fibrous refractory and 1 – 15% of binder.

6 Claims, 1 Drawing Figure

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STOPPER ROD HAVING FIBROUS PROTECTIVE SLEEVE

This invention relates to molten metal handling.

A commonly practiced method of molten metal handling consists in pouring molten metal into a container provided with a nozzle set in the base of the container, the molten metal being discharged by opening the nozzle by raising a stopper rod. Such stopper rods are normally formed of a central steel shaft clad with a number of refractory sections, e.g. refractory cylinders.

In ladle. ingots, molten metal is generally poured into a ladle provided with such a stopper rod, and then poured into one or more ingot moulds from a nozzle located in the base of the ladel. In continuous casting, metal is fed into a tundish and this may also be provided with a stopper rod and nozzle assembly in similar fashion to a ladle. Suitable apparatus is provided associated with the ladle or tundish to enable the stopper rod to be moved towards and away from the nozzle to close off metal flow or allow the metal to flow out from the nozzle. The sleeves on the steel shaft forming the stopper rod are usually made of bonded graphite or chamotte.

Although such apparatus works well in theory, there are practical difficulties. Thus, when molten metal is initially poured into the ladle or tundish, if the stopper rod is, as is normal, in the position engaging the nozzle to close it, molten metal tends to penetrate into the narrow gap between the stopper rod and nozzle and to solidify therein on account of the chilling effect as the nozzle, stopper rod and surrounding refractory materials heat up. This is particularly severe at the base of a stopper rod since the refractory materials of the sleeves and head of the stopper rod are of fairly high thermal conductivity. Likewise, nozzles are generally made of high quality but not particularly heat insulative refractory material. If such solidification takes place, then the stopper rod becomes stuck and can only be released with considerable force. Even if such release is achieved, the nozzle may be difficult to reclose because the metal which has solidified tends to adhere to the nozzle or to the stopper rod and to make it difficult to mate them together sealingly.

In the past various methods have been suggested to try and avoid the above disadvantages. Thus, Japanese Pat. Publication No. 23253/73 proposes covering the end of a stopper rod with a fragile covering material. Such materials are difficult to handle and necessitate the operation of applying the material to the end of the stopper rod.

A further suggestion is made in Japanese Pat. Publication No. 39234/71 to place a preformed fibrous material sleeve on the end of the stopper rod. Typically a cellulosic fibre containing sleeve is used which burns, melts or softens at the temperature of the molten metal applied. When such a preformed shape is submerged in the molten metal it burns and melts and as soon as molten metal is poured by raising the stopper rod and freeing the nozzle the residues of such materials are washed away. Thus, although this provides a solution to the difficulty of initial sticking when the metal is first filled into the container, it does not avoid difficulties arising during subsequent operations.

According to the present invention there is provided a method of molten metal handling wherein molten metal is discharged from a nozzle set in the base of a vessel by raising a stopper rod therefrom, wherein the stopper rod is covered by a sleeve closely fitted on the end of the rod and contacting the nozzle, the sleeve being formed of a composition comprising by weight, 45 – 94% particulate refractory material, 5 – 50% fibrous refractory material and 1 – 15% binder.

Slabs, sleeves and shapes made of such materials are already known. They have been used in the construction of hot tops in ingot moulds and ingot mould head boxes. However, their use wholly immersed in molten metal to provide improved molten metal handling has not previously been proposed. In the use of these materials as hot topping materials, the heat insulative properties of the material are of considerable importance, as is, for example, their resistance to slagging. In the use of such materials in the present invention, in contrast thereto, the thermal conductivity of the material should not be too high, but it is the mechanical properties of the materials which are of particular importance in order to make them suitable for use in the present invention.

By way of illustration, the accompanying drawing shows a section through a nozzle and stopper rod assembly set in a ladle for use in molten metal handling according to the present invention.

Referring to the drawing, a molten metal ladle consists down a metal casing **1** lined with refractory bricks **3.** Set in the base of brick lining **3** is a nozzle **2** made of high quality refractory material. The upper end of the nozzle is closed by the engagement therewith of a stopper rod formed of a central steel shaft **7,** a number of refractory sleeves **6** and a refractory head **4.** The refractory head and the lowest of the sleeves **6** are surrounded by a sleeve **5** formed of a composition as set forth above. As can be seen from the drawing, the sleeve **5** should extend at least as far downn as to contact the nozzle piece **2** and it may extend right round the nozzle head **4.**

Normally, without the use of sleeve **5,** metal tends to solidify in gaps **8** and **10.** By applying a sleeve **5** these gaps are provided on one side with a layer of refractory heat insulating material constituted by the sleeve **5,** which aids in reducing heat loss from molten metal flowing into those gaps, and on the other hand, sleeve **5** provides an intermediate sealing gasket between the head **4** and nozzle **2.**

The material of sleeve **5** contains fibrous refractory material and granular refractory material bonded by means of a binder to form a monolithic body, which is of good heat insulating properties and which does not readily burn or collapse. This sleeve does not absorb the heat of the molten metal very rapidly and keeps its shape for a comparatively long time. Thus molten metal which penetrates between sleeve **5** and the refractory brickwork does not readily solidify and the stopper rod can normally be moved without difficulty. The surface of the materials of sleeve **5** is generally not wet by molten metal and accordingly there is little tendency for adherence of metal thereto or for build-up of residues thereon.

Referring now to the specific composition of the sleeves, particulate refractory material may be selected from silica, alumina, refractory silicates, chamotte, quartz, magnesia, diatomaceous earth and other like particulate refractor materials used in the foundry and metallurgical industries. Mixtures of two or more of these materials may be used.

If the sleeve contains less than 45% by weight of such particulate refractory material, the sleeve tends to be fused by the action of the molten metal. If more than 94% of particulate refractory material were used, the sleeve would be of poor stability owing to too low a content of fibre and binder.

The fibrous refractory material in the sleeve may be asbestos, slag wool, rock wool, glass wool, aluminium silicate fibre, calcium silicate fibre or other similar refractory fibre. Mixtures of two or more kinds of fibre may be used. If less than 5% by weight of fibre were used in the sleeve, the heat insulation of the sleeve would be insufficient, and the sleeve would not hold together sufficiently well, i.e., it would be too fragile. If more than 50% by weight of such fibres were included, the sleeve would be liable to melting on contact with the molten metal.

A wide variety of binding agents may be used to consolidate the sleeves used in the present invention. Thus inorganic binding agents such as colloidal silica sol, colloidal alumina sol, sodium silicate, potassium silicate and fireclay may be used as well as organic binders such as starches, resins such as phenol-formaldehyde, urea-formaldehyde and furane resins and vinyl-acetate-containing polymers. Mixtures of two or more binding agents may be used, and the binding agent is preferably present in a proportion of 4 – 10% by weight.

If desired the sleeves may also contain up to 10% by weight of fibrous organic material, for example, paper pulp, waste paper, chopped synthetic staple fibre or the like. Not more than 10% of such organic fibrous material should be included since any inclusion above this level leads to sleeves which are easily destroyed due to attack by the molten metal and sleeves which have poor strength.

The sleeves used to fit over the end of the stopper rod may be made by any convenient method. The preferred method of forming such sleeves is to make a slurry of the ingredients, generally containing 10 – 30% by weight solids, and to dewater suitable quantities of such slurry on a mesh mould or pattern under the action of pressure. On dewatering, a damp shape of size and dimensions corresponding to the perforate mould is formed and this may then be dried and fitted over the end of the stopper rod. By forming the sleeve a suitable size it may be made a push or press fit over the end of the rod.

The following examples will serve to illustrate the invention.

EXAMPLE 1

The following materials were mixed in the following proportion:

silica	75%	by weight
slag wool	10%	"
asbestos	10%	"
phenol-formaldehyde resin	5%	"

The above mixture was mixed into an homogeneous slurry by diluting it with about four times its weight of water. The slurry was made into a sleeve shape by employing suction to deposit it onto a perforated pattern. Then the formed shape was dried for about four hours at approximately 180°C. The covering material thus made fitted the external end shape of a refractory stopper rod. The lower part of the sleeve touched the nozzle of the container at its upper end and the sleeve was 30 mm in thickness.

The covering material was put on the stopper rod of a 150 ton capacity ladle used to make steel ingots. In use the initial operation of the stopper rod could be smoothly done without any difficulty. The closure of the nozzle during pouring was perfect and there was no molten metal leakage. Inspection of the stopper rod and the nozzle after use showed little damage to either and the heat insulating sleeve maintained almost its original form.

EXAMPLE 2

The following materials were mixed in the following proportions:

silica	55%	by weight
alumina	14%	"
slag wool	14%	"
vinyl-acetate resin	1%	"
phenol-formaldehyde resin	3%	"
fireclay	10%	"
pulp of paper	3%	"

The above mixture was made into a covering material in the same way as Example 1. The shape and dimensions were almost the same as Example 1.

The use of it in the same way as Example 1 showed almost the same results as Example 1. After use, there was found little damage on either the stopper rod or the nozzle and the covering material maintained almost its original form.

EXAMPLE 3

The following materials were mixed in the following proportions.

silica	48%	by weight
slag wool	27.5%	"
asbestos	3%	"
phenol-formaldehyde resin	4.5%	"
silica sol	8%	"
crushed waste paper	9%	"

The above mixture was made into a covering material in the same way as Examples 1 and 2. It fitted the external form of a stopper rod and was closed at its lower end. The thickness was 35 mm. The covering material was put on a stopper rod of a tundish for continuous casting and was used for about two hours continuously. The initial operation of the stopper rod was smooth and the closing of the nozzle during pouring was perfect. Although the used covering material was decreased to about one third in thickness, there was no damage on the stopper rod and damage to the nozzle was slight.

I claim as my invention:

1. In the method of molten metal handling wherein molten metal is discharged from a nozzle set in the base of a vessel by raising a stopper rod therefrom the improvement which comprises providing on the stopper rod a covering sleeve, closely fitted on the end of the rod and contacting the nozzle, the sleeve being formed of a heat-insulating composition which resists thermal disintegration, said sleeve consisting essentially of, by weight, 45 – 94% particulate refractory material, 5 – 50% fibrous refractory material and 1 – 15% by weight binder.

2. The method of claim 1 wherein the composition of the sleeve includes up to 10% by weight of fibrous organic material.

3. The method of claim 1 wherein the sleeve is a friction fit over the end of the stopper rod.

4. In apparatus for handling molten metal which includes a vessel having a molten-metal discharge nozzle and longitudinally movable stopper rod having an inner end disposed in the vessel for opening and closing the inner end of the nozzle, the improvement comprising a refractory, heat-insulating, non-disintegrating sleeve push-fitted over the inner end of the stopper rod so as to be engageable with the nozzle, said sleeve being non-wetted by the molten metal and being constructed essentially of, be weight, 45–94% particulate refractory material and 5–50% fibrous refractory material bonded together with 1–15% by weight binder to form a monolithic body.

5. Apparatus as in claim 4 wherein the particulate refractory material is selected from the group consisting of silica, alumina, refractory silicates, chamotte, quartz, magnesia, diatomaceous earth and mixtures threof, wherein the fibrous refractory material is selected from the group consisting of asbestos, slag wool, rock wool, glass wool, aluminium silicate fibre, calcium silicate fibre and mixtures thereof, and wherein the binder is selected from the group consisting of colloidal silica sol, colloidal alumina sol, sodium silicate, potassium silicate, fireclay, starches, resins and vinyl-acetate-containing polymers.

6. Apparatus as in claim 4 wherein said stopper rod is constructed of a central metal rod surrounded by a relatively thick layer of refractory material and wherein said sleeve is substantially thinner than said layer.

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