(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 062 524**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **82301782.7**

(22) Date of filing: **05.04.82**

(51) Int. Cl.³: **B 22 D 35/04**

(30) Priority: **04.04.81 GB 8110605**

(43) Date of publication of application: **13.10.82 Bulletin 82/41**

(84) Designated Contracting States: **AT BE CH DE FR GB IT LI NL SE**

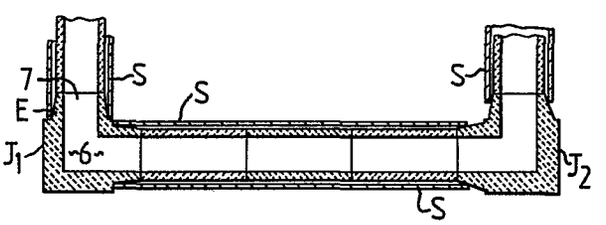
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(54) Improved casting apparatus and method.

(57) A transfer system for molten metal e.g. a gating system for feeding a mould is surrounded by compacted particulate material e.g. sand. The system comprises lengths of refractory pipe joined end-to-end and according to the invention to prevent ingress of sand, the lengths are placed in an outer sheath e.g. a cardboard tube, which is sealed at its ends. For junctions the invention provides a junction box having extensions which taper away from the box and onto which the ends of the sheath may be fitted.



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IMPROVED CASTING APPARATUS AND METHOD

This invention relates to the casting of molten metal and is particularly concerned with improved apparatus and method for supplying molten metal to a metallurgical mould.

Refractory gating systems for casting moulds are built by abutting a number of separate, standard proprietary pieces known collectively as "refractory holloware", to form conduits or channels which conduct molten metal from the pouring ladle or tundish into the mould cavity. The most common piece of refractory holloware in refractory gating systems is a short length of cylindrical piping having a nominal inner diameter and a nominal larger outer diameter. Longer lengths are made by assembling these lengths end to end to produce for example, horizontal and vertical channels. To conduct the molten metal around bends, junction boxes are used which have facilities for connecting two or more pipes mutally perpendicular to each other. The gating system assembly is normally held in position by a particulate material e.g. sand, which is rammed up around and against the outer surface of the system. It

is also known to supply molten metal via pouring trumpets leading to moulds for bulk steel such as ingot moulds.

There is no simple method for aligning the various pieces of refractory holloware and for sealing the joints such that sand cannot enter the gating system or remain trapped between the joints and be subsequently carried into the mould cavity by the flowing steel. If sand is carried into the mould cavity, there will be inclusions in the casting which can be very expensive to remove and can even lead to the casting being scrapped.

The refractory holloware is usually made from a fired fireclay or the like and it is recognised that these materials tend to shrink when cast in moulds. The industry standards will accept a $\pm$ 1.5% variation in diameter from the nominal value - see British Standard BS 2496:1968. The variation in tolerances aggravates the risk that adjacent lengths of pipe may not fit accurately together, and there will be gaps. It is known to provide the individual pipe lengths with a male and female spigot joint which is an improvement but the spigot joints do not form a tight fit and there are still often gaps between joints through which sand can penetrate. Also, in certain foundries there are large numbers of patterns with a small number of moulds made from each

pattern and this precludes the use of standard length refractory pipes. The standard lengths are often cut to size on site and the benefit of having refractory holloware formed complete with spigot joints is lost. Severe misalignment between the refractory pieces often occurs reducing the cross-sectional area of the gating system at these points which results in low pouring rates and throttled ladle streams which can reduce casting quality.

It is also known to tape or glue refractory pieces together. These methods are slow and require much skill and care to ensure that the pieces are correctly aligned and the joints are sealed tight. Furthermore, when the molten metal contacts any glue used in aligning the gating system, a vigorous reaction can occur, leading to turbulent metal flow and gas defects within the metal, both of which are detrimental to casting quality.

One object of the invention is to provide apparatus and method which can, in a rapid and simple manner, allow the improved alignment of separate pieces of refractory holloware. Another object of the invention is to prevent sand entering the gating system through gaps at the positions where the pieces are joined

together.

According to one aspect of the invention there is provided apparatus for the casting of molten metal including a transfer system for feeding molten metal to a casting vessel, the system comprising a refractory conduit which is held in compacted particulate material, the conduit comprising a plurality of lengths of refractory pipe joined end-to-end characterised in that the lengths are enclosed in an outer sheath the ends of which are sealed against the ingress of particulate material.

According to one particular aspect of the invention there is provided a mould box containing a mould cavity surrounded by compacted particulate material, a conduit for ingress of molten metal connected to the cavity, the conduit comprising a plurality of lengths of refractory pipe joined in end-to-end relation and including a junction box where the conduit changes direction characterised in that the lengths of refractory pipe are disposed within an outer sheath and in that the junction box has an extension piece and the sheath engages with the extension piece in sealed manner.

Most preferably the extension piece projects

from a wall of the junction box and reduces in external diameter away from the wall so forming a flare or taper arranged to receive the sheath at any point along its length dependent on the relation between the inner diameter of the sheath and ther outer diameter of the extension piece.

Most preferably the outer sheath is relatively much longer than any one length of refractory pipe or extension piece so that a joint of the sheath with the junction box is longitudinally spaced from a joint of the refractory pipe by a sufficient distance to define a tortuous path to the ingress of particulate material. In this way if particulate material enters a joint in the sheath it will not readily be able to travel sufficient distance to a joint of the refractory pipes to penetrate through and foul the conduit.

The sheath is a tubular element adapted to engage the junction box extension piece at each end. It is not however necessary that the sheath be of substantially constant shape and configuration along its length. For example the sheath may have a longitudinal cut or seam, the edges of which may be urged together to form a fluid tight seal and held in that condition e.g. by a tape.

Preferably the sheath comprises one or more close fitting cardboard paper or metal tubes, the inner diameter of which is selected to be slightly greater than the nominal outer diameter or the refractory pieces. Whereas the lengths of holloware cannot be made to close tolerances, such tubes can be made to very close tolerances. Tubes of paper or cardboard are preferred for economy and lightness of weight while metal tubes are more reusable. The sheath allows simple alignment of the various refractory pieces since they can be loaded one at a time into the tubes and this eliminates any reduction in cross sectional area of the gating system due to misalignment. It also eliminates the need for spigot joints on all the refractory pieces thereby reducing the cost of these refractory pieces.

In a much preferred embodiment of the invention the relative dimensions of the sheath and the pipes are chosen such that the sheaths are sufficiently tight-fitting to enable pre-assembly of part or all of the gating system to form a freestanding rigid unit. This can then be lifted and transported as one unit, so simplifying movement, positioning and alignment of the pre-assembled parts and reducing the assembly time. The assembled unit is then placed in a mould box and connected to the pattern and particulate material e.g. a foundry sand,

is then rammed around the pattern and its conduits.

The invention may be applied to a variety of techniques involving the casting of metal shapes in mould boxes. The invention is ideally suited to the so-called "V" process, especially for larger moulds. In such a case the gating system is incorporated in the lower ("drag") half of the mould box and not on the parting line. Gating from below is preferred since this results in much better metal flow characteristics. After forming the plastics sheet over the drag pattern and with the box in position the gating system is assembled and the ends of the sheath are sealed to the sheet with e.g. tape. Loose sand is then fed in and the mould box vibrated; the system is sufficiently self supporting and sand tight not to be affected by the vibration. The mould is completed as usual and in this way is provided with a vacuum tight and erosion resistant gating system providing optimum flow characteristics of metal into mould.

A junction box is necessary to accommodate changes in direction in the refractory holloware and to present a highly erosion resistant refractory surface on to which molten metal may fall. In some cases however, especially when the channel bore is of low diameter the

junction box may be omitted. In that event the sheathed pipe lengths of the invention may still be used in order to reduce the risk of ingress of sand and to ensure alignment.

The invention includes as another aspect a method of assembling a conduit for ingress of metal including a mould box, comprising locating lengths of refractory pipes in an outer sheath, connecting an end of a pipe with a junction box having an extension piece and disposing the sheath to extend over the extension piece of the junction box so to form a sealed joint.

The invention also includes for use in the method a junction box formed of refractory material and having a passageway with at least one inlet bore and at least one outlet bore and including an angled portion, an extension piece disposed on a wall of the box about each bore, the extension piece being shaped and dimensioned to engage the sheath in a sealed manner. The junction box may have any required combination of inlet and outlets and may be of various shapes e.g. like the letters "L", "T", "X" and "Y". The invention further includes for use in the method a length of sheath housing a plurality of lengths of refractory pipe.

In order that the invention may be well understood it will now be described by way of example with reference to the accompanying diagrammatic drawings, in which

Figure 1 is a view of a mould box a wall of which has been removed to show the interior;

Figure 2 is a sectional view of part of the gating system;

Figure 3 is a perspective view of a junction box drawn to a much enlarged scale.

The mould box of Figure 1 comprises two halves 1, 2, the lower 1 being the drag half and the upper being the cope half. A mould pattern 3 is present in the box and below this is located a gating system G. Molten metal is fed into the gating system G via a downrunner A. The mould and the gating system are supported in compacted foundry sand 4 which extends almost to the top of the box.

The gating system is built up of a number of lengths of refractory pipes P. Each pipe is cast of a refractory material e.g. a fired fireclay and has flat end walls whereby adjacent lengths may be abutted together. The pipe lengths are about 30 cm long and can be moulded to a nominal external diameter of about 147 mm. In practice the diameter will vary within a tolerance of

about ± 1.5%. According to the invention, the lengths of pipe P are received in a sheath S, preferably a cardboard sheath being a factory made item; for a pipe having a nominal external diameter of 147 mm, the sheath S should have an internal diameter of 150 mm. The wall thickness may be about 4 mm and the cardboard may be fireproofed.

In use, the sheath S is fitted over one or more lengths of pipe P. Depending on the length of pipe and the number of pipes the sheath may extend over them all or may be cut to size; exposed ends of sheath S may be sealed to the pipe P using tape T or the like. When the pipe lengths are received in the sheath, then depending on the variation from tolerance they may be a relatively tight fit or there may be an annular gap of from say 0.5 mm to 2.5 mm: despite this they are held in the sheath which thus is a selfsupporting unit for transport. Because there is a substantial longitudinal distance from one end of the sheath to a joint between two abutting lengths of pipe, there is no risk that sand 4 will enter the sheath S and pass through the joint into the metal stream. Even if the sand enters the gap between the sheath and the joint it must travel a tortuous path, changing direction through a right angle and it is most unlikely that sand could travel in this way. The gating system G thus comprises a conduit of constant internal diameter, which is sand tight despite

being surrounded by compacted foundry sand.

Where the gating system has a change of direction e.g. a corner unit or a T joint, use is made of a junction box J of the invention. The junction box comprises a body 5 moulded of refractory fireclay. The box has a throughbore 6 having one or more inlets and outlets. The mouth of each bore end is surrounded by an extension piece E which is integrally moulded with the body. The extension piece measures about 50 mm in length and has a bore extension 7 which is the same as that of the bore 6. The external diameter of the extension piece at its root to the junction box body 5 is about 150 mm and the extension piece tapers towards its free end 4 to an external diameter of about 147 mm. (These are nominal dimensions and in accordance with conventional practice they may vary within a tolerance of about $\pm$ 1.5%).

One end of the sheath S is forced over the extension piece E of one junction box and then over the other so forming a sealed system. Despite the fact that parts are not made to close tolerances, the system is nonetheless sealed. For example and as shown in Figure 2, the extension piece of junction box J1 is below nominal; the vertical sheath S and the horizontal sheath S thus fit over the extension and abut the wall. In the case of

junction box J2, the extension piece exceeds nominal external diameter and so the vertical sheath S and the horizontal sheath S only engages a sloping portion thereof.

In the foregoing description the mould box was used to cast an article of a defined shape. The invention may however be used to good effect in the uphill teeming of ingots of molten metal e.g. steel.

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CLAIMS

1. Apparatus for use in the casting of molten metal including a transfer system for feeding molten metal from a holding vessel to a casting vessel, the system comprising a conduit embedded in particulate refractory material such as sand, the conduit comprising a plurality of lengths of refractory pipe joined in end-to-end relation characterised in that the lengths are enclosed in an outer sheath which is sealed at its ends against ingress of particulate material.

2. Apparatus according to Claim 1 characterised in that the system includes a junction box where the conduit changes direction and in that the junction box has an extension piece and the sheath engages with the extension piece in sealed manner.

3. Apparatus according to Claim 2, characterised in that the extension piece projects from a wall of the junction box and reduces in external diameter away from the wall and in that the sheath abuts against the wall or engages the extension piece at a point along the length thereof.

4. Apparatus according to Claim 1, 2 or 3 characterised

in that the outer sheath is relatively much longer than any one length of refractory pipe or extension piece.

5. Apparatus according to Claim 1, 2, 3 or 4 characterised in that the sheath comprises one or more close fitting cardboard, paper or metal tubes, the inner diameter of which is slightly greater than the nominal outer diameter of the lengths of refractory pipe.

6. Apparatus according to Claim 5 characterised in that the sheath is sufficiently tight-fitting with respect to the lengths to enable part or all of the gating system to form a freestanding rigid unit.

7. Apparatus according to any preceding Claim characterised in that the pipe lengths have male and female complementary engaging end walls.

8. Apparatus according to any preceding Claim characterised in that the apparatus comprises a mould box and the conduit comprises the gating system therefor and in that the conduit is surrounded by compacted particulate material which is chemically unbonded.

9. Apparatus according to Claim 8, characterised in that the joints of the sheath with the lengths of refractory pipe and the extension pieces are sealed with

tape or the like to form airtight seals so that a vacuum may be drawn in the compacted particulate material.

10. A method of assembling apparatus including a conduit for ingress of metal, and according to any preceding Claim characterised by locating lengths of refractory pipes in an outer sheath, connecting an end of a length of refractory pipe with a junction box having an extension piece and disposing the sheath to extend over the extension piece of the junction box so to form a sealed joint.

11. A junction box for use in apparatus according to any of Claims 1 to 9 or a method according to Claim 10, the box being formed of a refractory material and having a passageway with at least one inlet and at least one outlet and including an angled portion characterised in that an extension piece is disposed about the outlet of each bore and is dimensioned and arranged to engage a sheath in a sealed manner.

12. A box according to Claim 11 characterised in that the extension piece projects from a wall of the box and reduces in external diameter away from the wall.

13. For use in apparatus according to any of Claims

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1 to 9 or a method according to Claim 10, a conduit comprising lengths of refractory pipes joined together characterised in that the lengths are enclosed in a relatively longer sheath dimensioned to fit over the lengths.

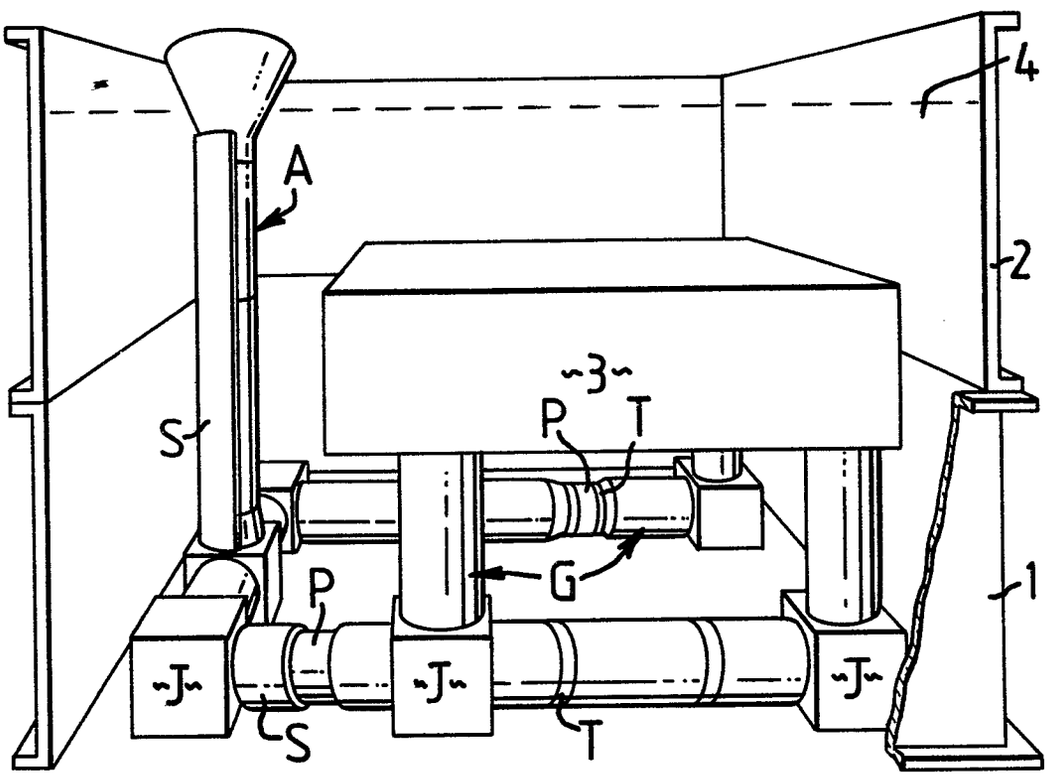


FIG.1

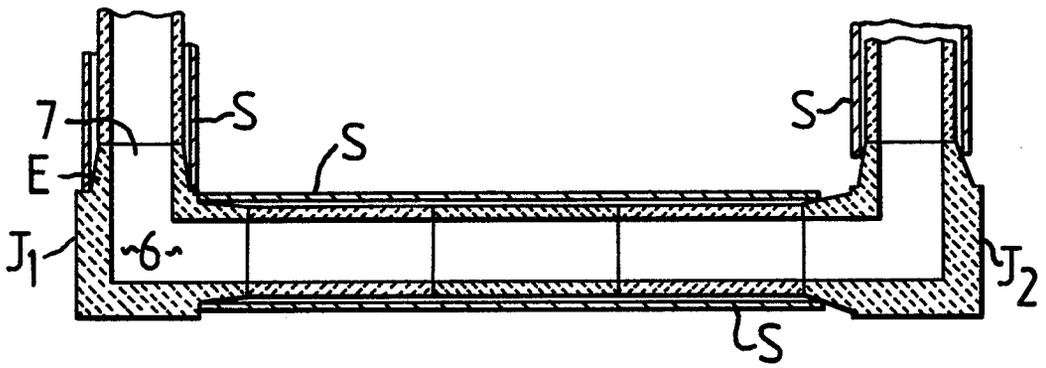


FIG. 2

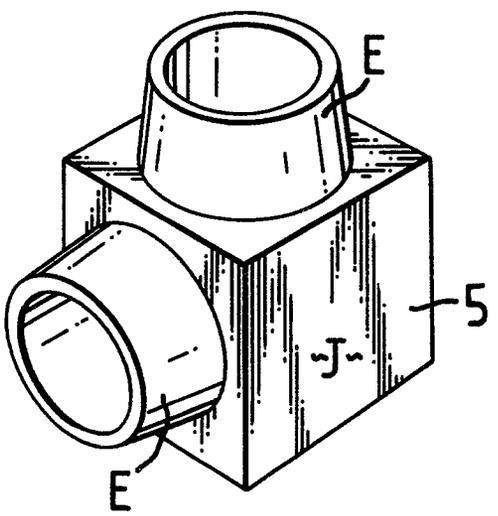


FIG. 3