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## Description

This invention relates to the casting of molten metal and is particularly concerned with improved apparatus 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 mutually 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 stream 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.

BE—A—886139 discloses a transfer system for supplying molten metal from a vessel via a runner to a series of ingot moulds. The runner comprises a conduit built up of plurality of lengths of refractory pipe joined in end-to-end relation, the lengths being enclosed by an outer sheath in the form of a refractory tube, the annular clearance between the pipes and the refractory tube being filled with set refractory material. The end of the refractory tube is stood on a distribution box. DE—C—529889 discloses a runner system comprising a set of inner and outer tubes, these being formed of the same material and length. The inner tubes are received as a tight fit within the outer tubes so that molten metal within the inner tube is prevented from reaching sand in which the runner system is embedded.

One object of the invention is to provide apparatus 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 this invention there is provided mould apparatus comprising a mould box containing a pattern in the shape of an article to be cast of molten metal, a gating system connected to a pattern and comprising a conduit formed of lengths of refractory pipe joined in end-to-end relation, whereby these lengths of refractory pipe are enclosed in an outer sheath characterised in that the gating system includes at least one junction box where the conduit changes direction, and in that the junction box has extension pieces, each extension piece projecting away from a wall of the junction box and reducing in its outer diameter, and in that the outer sheath is sealed at its ends to the extension pieces of the boxes.

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 of the refractory pieces. Whereas the lengths of hollowware 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 said 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 hollowware and to present a highly erosion resistant refractory surface on to which molten metal may fall.

The invention also includes for use with apparatus a junction box formed of refractory material and having a passageway with at least one inlet and at least one outlet and including an angled portion, an extension piece is present about the outlet of each bore and projects from a wall of the box and reduces the external diameter away from the wall. 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".

In order that the invention may be well under-

stood 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 pipe 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  $\pm 1.5\%$ . 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 4mm 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 of 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 through bore 6 having one or more inlet 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.

#### Claims

1. Mould apparatus comprising a mould box (1, 2) containing a pattern (3) in the shape of an article to be cast of molten metal, a gating system (G) connected to the pattern (3) and comprising a conduit formed of lengths of refractory pipes (P) joined in end-to-end relation, whereby these lengths of refractory pipe (P) are enclosed in an outer sheath (S) characterised in that the gating system (G) includes at least one junction box (J1, J2) where the conduit (P) changes direction, and in that the junction box (J1, J2) has extension pieces (E), each extension piece projecting away from a wall of the junction box and reducing in its outer diameter, and in that the outer sheath (S) is sealed at its ends to the extension pieces of the boxes (J1, J2).

2. Apparatus according to Claim 1 characterised in that the outer sheath (S) is relatively much longer than any one length of refractory pipe (P) of extension piece (E).

3. Apparatus according to Claim 1 or 2 characterised in that the sheath (S) 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 (P).

4. Apparatus according to Claim 3 characterised in that the sheath (S) is sufficiently tight-fitting with respect to the lengths (P) to enable part or all of the transfer system (G) to form a freestanding rigid unit.

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

6. Apparatus according to any preceding Claim

characterised in that the sheath conduit (P) is surrounded by compacted particulate material which is chemically unbonded.

7. Apparatus according to any preceding Claim, characterised in that the joints of the sheath with the lengths of refractory pipe (P) and the extension pieces (E) are sealed with tape or the like to form airtight seals so that a vacuum may be drawn in the compacted particulate material.

8. A junction box for use with apparatus according to any of Claims 1 to 7 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 (E) is present about the outlet of each bore (6), and projects from a wall of the box (J1, J2) and reduces in external diameter away from the wall.

#### Revendications

1. Appareil de moulage comprenant une boîte de moulage (1, 2) contenant un modèle (3) de la forme de l'objet devant être moulé en métal fondu, un système de sorties (G) relié à l'objet (3) et comprenant un conduit formé par des longueurs de tuyaux réfractaires (P) emmanchés les uns dans les autres, ces longueurs de tuyaux réfractaires (P) étant enchassées dans une gaine extérieure (S), le caractèreisation réside dans le fait que le système de sorties (G) comprend au moins une boîte de dérivation (J1, J2) où le conduit (P) change de direction et également dans le fait que la boîte de dérivation (J1, J2) a des rallonges (E) et que chaque rallonge est à un angle opposé à la paroi de la boîte de dérivation, sont diamètre extérieur est réduit et que la gaine extérieure est bouchée aux extrémités vis à vis aux rallonges des boîtes (J1, J2).

2. L'appareil selon la prétention 1 est caractérisé par le fait que la gaine extérieure (S) est relativement beaucoup plus longue que n'importe quelle autre longueur de tuyau réfractaire (P) ou de rallonge (E).

3. L'appareil selon la prétention 1 ou 2, est caractérisé par le fait que la gaine (S) comprend un ou plusieurs tubes bien ajustés fabriqués en carton, papier ou en métal, le diamètre intérieur de ces derniers étant légèrement supérieur au diamètre nominal extérieur des longueurs de tuyaux réfractaires (P).

4. L'appareil selon la prétention No 3 est caractérisé par le fait que la gaine (S) est suffisamment bien ajustée aux longueurs (P) pour qu'une partie ou la totalité du système de transfert (G) puisse former une unité rigide non encastrée.

5. L'appareil selon n'importe quelle prétention précédente est caractérisé par le fait que les longueurs des tuyaux (P) possèdent des parois extérieures d'extrémités complémentaires mâles et femelles.

6. L'appareil selon n'importe quelle prétention précédente est caractérisé par le fait que le conduit gainé (P) est entouré d'une masse com-

pactée formée de particules dont la liaison est séparée chimiquement.

7. L'appareil selon n'importe quelle prétention précédente est caractérisé par le fait que les joints de la gaine avec les longueurs de tuyaux réfractaires (P) et les rallonges (E) sont scellées avec du bolduc ou un autre produit similaire de façon à obtenir des joints étanches pour qu'un vide puisse être effectué dans la masse compactée formée de particules.

8. Une boîte de dérivation pouvant être employée l'appareil selon n'importe quelle des prétentions de 1 à 7, la boîte étant composée et formée d'un matériau réfractaire et ayant un passage avec au moins une entrée et au moins une sortie comprenant une proportion à un certain angle caractérisé par le fait que la rallonge (E) est présente à la sortie de chaque calibre (6) et est en saillie d'une paroi de la boîte (J1, J2), son diamètre extérieur est à la sortie de la paroi.

#### Patentansprüche

1. Giessvorrichtung, bestehend aus einem Giesskasten (1, 2) mit einer Giessform (3) in Form eines aus Schmelzmetall zu giessenden Artikels; einem an die Giessform (3) angeschlossenen Schleusensystem (G), bestehend aus einer Rohrleitung aus Längen feuerfesten Rohrs (P), stossverbunden, wobei diese Längen feuerfesten Rohrs (P) in einer äusseren Hülle (S) eingeschlossen sind, insofern charakterisiert, als dass das Schleusensystem (G) mindestens einen Abzweigkasten (J1, J2) beinhaltet, wo die Rohrleitung (P) ihre Richtung ändert und insofern, als dass der Abzweigkasten (J1, J2) mit Verlängerungsstutzen (E) versehen ist, die aus einer Wand des Abzweigkastens vorstehen und sich im Aussendurchmesser verjüngen, und insofern, als dass die äussere Hülle (S) an ihren Enden mit den Verlängerungsstutzen der Kästen (J1, J2) versiegelt ist.

2. Vorrichtung gemäss Antrag 1 insofern

charakterisiert, als dass die äussere Hülle (S) relativ weitaus länger ist als jegliche Länge des feuerfesten Rohrs (P) oder des Verlängerungsstutzens (E).

3. Vorrichtung gemäss Antrag 1 oder 2 insofern charakterisiert, als dass die Hülle (S) aus einer oder mehreren eng passenden Karton-, Papier- oder Metallröhren besteht, deren Innendurchmesser etwas grösser als der äussere Nenndurchmesser der Längen feuerfesten Rohrs (P) ist.

4. Vorrichtung gemäss Antrag 3 insofern charakterisiert, als dass die Hülle (S) hinsichtlich der Längen (P) ausreichend eng passt, um zu ermöglichen, dass das Transfersystem (G) teilweise oder zur Gänze eine freistehende, starre Einheit bildet.

5. Vorrichtung gemäss jeglicher vorhergehender Anträge insofern charakterisiert, als dass die Rohrlängen (P) komplementäre Einsteck- und Aufsteckverbindungsenden aufweisen.

6. Vorrichtung gemäss jeglicher vorhergehender Anträge insofern charakterisiert, als dass die umhüllte Rohrleitung (P) von chemisch ungebundenem Partikelpressmaterial umgeben ist.

7. Vorrichtung gemäss jeglicher vorhergehender Anträge insofern charakterisiert, als dass die Verbindungen der Hülle mit den Längen feuerfesten Rohrs (P) und den Verlängerungsstutzen (E) mittels Band oder ähnlichem abgedichtet sind, um luftdichte Dichtungen zu bilden, so dass in dem Partikelpressmaterial ein Vakuum gebildet werden kann.

8. Ein Abzweigkasten zum Einsatz mit der Vorrichtung gemäss jeglichen Antrags 1 bis 7, wobei der Kasten aus feuerfestem Material geformt ist und einen Durchlass mit mindestens einem Einlass und mindestens einem Auslass einschliesslich eines Bogens aufweist, insofern charakterisiert, als dass ein Verlängerungsstutzen (E) am Auslass jeder Bohrung (6) vorhanden ist, der aus einer Wand des Kastens (J1, J2) hervorragt und sich im Aussendurchmesser von der Wand weg verjüngt.

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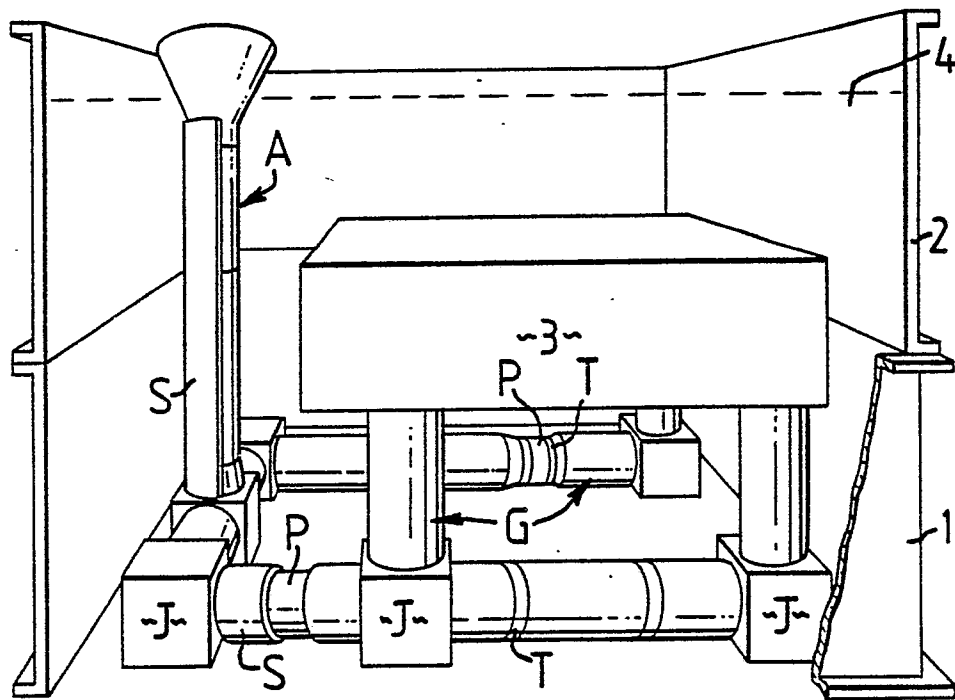


FIG. 1

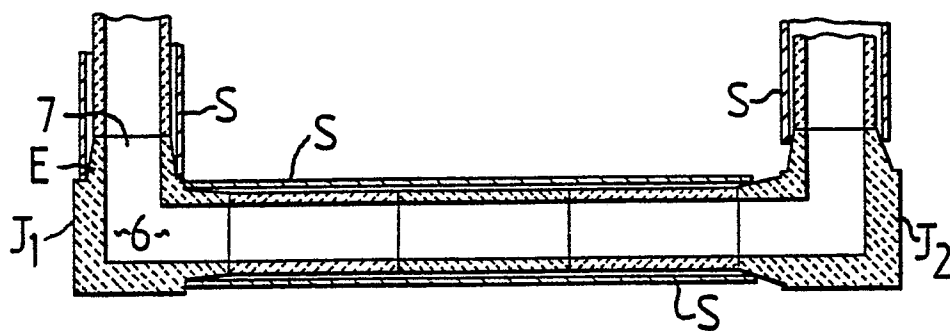


FIG. 2

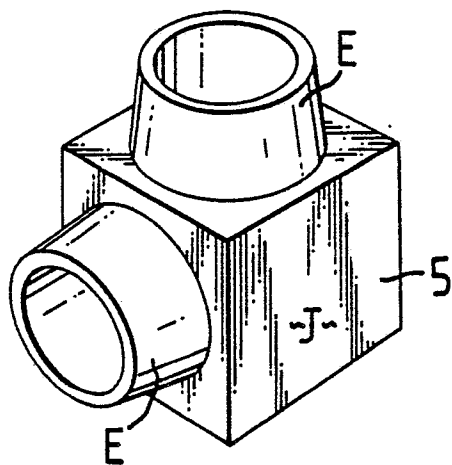


FIG. 3