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(72) Inventor: **Kennedy, Colin James
Forfar DD8 2NN (GB)**

(74) Representative: **Szczuka, Jan Tymoteusz et al
Marks & Clerk Scotland
19 Royal Exchange Square
Glasgow G1 3AE
Scotland (GB)**

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(71) Applicant: **Rautomead Limited
Dundee, DD2 4UH (Scotland) (GB)**

(54) Die mounting

(57) The present invention provides a horizontal continuous casting apparatus comprising an inert gas-purged resistance-heated type furnace 1, a crucible 6 for containing molten metal and having an outlet 8 for molten metal, coupled to a casting die 14, and a first clamping device 28-30,32 for securing the die 14 in sealing communication with the crucible 6. A carrier adaptor 44 of an oxidation resistant refractory material comprises: a feed nozzle 50 between the crucible outlet 8 and a

casting die inlet 39, a female mounting portion 52 for receiving, in sealing inter-engagement, a male mounting portion 54 of the die 14, and sealing means 58 for inter-engagement with the furnace wall 34 around the aperture 36. A second clamping device 68,70,72, is provided for releasably securing the carrier adaptor 44, in sealing inter-engagement, to the crucible 6 and furnace wall 34. The first clamping device 28-30,32 releasably secures the casting die 14 to the carrier adapter 44.

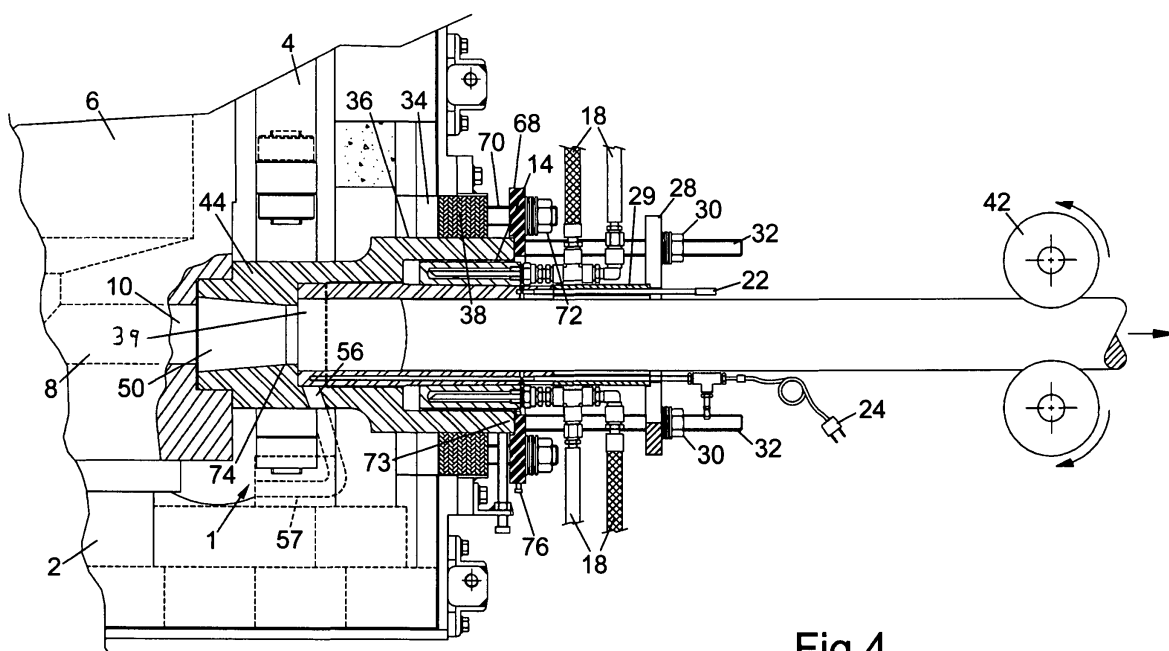


Fig.4

Description

[0001] The present invention relates to an apparatus, for the continuous casting of metals, in which the crucible containing the molten metal is connected to the casting die or mould (hereinafter referred to as "die") by means of a carrier adaptor which permits replacement of the die without the need for cooling of the crucible furnace.

[0002] In the continuous casting of metals, especially non-ferrous metals and alloys, a typical procedure involves the melting and alloying of the metal to be cast in a separate melting furnace. The molten metal or alloy is then poured into a heated holding crucible or tundish from which a semi-finished rod, hollow bar or section is continuously cast through a water-cooled casting die, typically made of graphite, which is connected to a bottom outlet of the crucible. The holding crucible can be heated by various means, for example by a resistance heated furnace. In some applications the initial melting or alloying of the metal to be cast is carried out in the holding crucible. Generally the outlet of the crucible is formed and arranged to deliver the molten metal horizontally to the die which, in turn produces the cast product horizontally.

[0003] Graphite is a particularly suitable material for holding and casting molten metals, having several desirable properties including strength, machineability, non-wetting behaviour and it also has a naturally reducing effect. Consequently graphite has been successfully used as the material of construction for crucibles and dies in continuous casting apparatus. However, at elevated temperatures, especially above 400°C, graphite must be used in a non-oxidising atmosphere in order to avoid degradation and erosion caused by atmospheric oxygen.

[0004] A similar issue arises when the furnace heating the crucible and casting die assembly utilises electrical resistance heating with graphite elements. These heating elements are also susceptible to degradation by oxygen at elevated temperatures.

[0005] Nevertheless, by providing a sealed furnace protected by an inert gas atmosphere, many high-copper alloys, brasses, tin bronzes, phosphor-bronzes, aluminium bronzes and a full range of precious metals, including gold, silver and low-palladium alloys can be successfully cast from graphite crucible and die assemblies, using graphite or silicon carbide electrical resistance heaters.

[0006] In a typical graphite crucible based system the furnace becomes a sealed unit while at elevated operating temperature and a positive pressure of inert gas is maintained to exclude oxygen and thus to avoid erosion of the graphite heating elements and the exterior surfaces of the graphite crucible which is located inside the furnace box. (The inner surface of the graphite crucible, may also be protected by an inert gas atmosphere but this is not generally required). In such an arrangement, the casting die is thrust against an orifice at the base of the crucible using a special seal (feeder tube) and is held

in place by a thrust plate which secures the die in close contact with the furnace wall. The gas-tight seal is completed by the provision of a thermal and gas sealing ring fitted around the die at the junction with the outside furnace wall. Jacket coolers around the casting die or a combination of jacket coolers and probe coolers are used to cool and solidify the metal as the casting process continues. The casting die has a relatively short service life, depending on the alloy and section profile, at the end of which the die must be changed. Alternatively, production requirements may dictate that a die should be changed before the end of its service life for a die for a different product size or profile.

[0007] A disadvantage of this arrangement is that in order to effect replacement of the casting die the gas-tight seal between the furnace wall, the casting die and any associated sealing rings must be broken. Ingress of air into the furnace at temperatures above 400°C would cause rapid erosion of all the graphite parts i.e. the crucible and the heating elements. A particular concern is the sealing face on the orifice at the base of the crucible. If damaged, molten metal leaks are likely during subsequent casting operations. Accordingly replacement of the graphite die necessitates careful cooling of the furnace before the inert gas atmosphere is released. After replacing the die the furnace is then reheated to working temperature under an inert gas atmosphere. Cooling and reheating of the furnace can take many hours, thus reducing the efficiency of the production process. Such regular thermal cycling of the equipment may also introduce undesirable thermal stresses in the furnace construction.

[0008] It is an object of the present invention to avoid or minimise one or more of the foregoing disadvantages by the provision of a horizontal continuous casting machine having a carrier adaptor which connects the molten metal outlet at the base of the metal holding crucible with the casting die in a manner which permits safe and efficient exchange and replacement of the casting die, without the furnace having to be cooled or powered down.

[0009] The present invention provides a horizontal continuous casting apparatus comprising an inert gas-purged resistance-heated type furnace, a crucible for containing molten metal inside said furnace, in use of the apparatus, and having an outlet for molten metal, coupled, via an aperture in a wall of said furnace, to a casting die, and a first clamping device formed and arranged for securing said casting die in sealing communication with said crucible, wherein is provided a carrier adaptor of an oxidation resistant refractory material and comprising: a feed nozzle formed and arranged for providing fluid communication between said crucible outlet and an inlet of said casting die, a female mounting portion formed and arranged for receiving, in sealing inter-engagement, a male mounting portion of said casting die, and sealing means formed and arranged for sealing inter-engagement with said furnace wall around said aperture, and wherein is provided a second clamping device formed and arranged for releasably securing said carrier

adaptor to said crucible and said furnace wall, in sealing inter-engagement therewith, and said first clamping device is formed and arranged for releasably securing said casting die to said carrier adaptor.

[0010] The inert gas-purged resistance-heated type furnace and crucible are of generally the same forms as found in prior art casting machines. Typically the heating elements of the furnace are of graphite or silicon carbide and the crucible is of graphite.

[0011] The carrier adaptor is made of a refractory oxidation resistant material, suitable for use in metal casting operations, that is sufficiently durable to be semi-permanently attached to the crucible and furnace for a substantial number of casting campaigns. A low cost, oxidation resistant clay/graphite mixture has been found to serve the purpose very well, but other suitable oxidation resistant refractory materials can also be contemplated provided they give good sealing with the crucible and the casting die and have reasonable thermal conductivity. Conveniently the carrier adaptor is circular in cross-section and is mounted concentrically with the outlet orifice of the crucible and the corresponding aperture in the furnace wall.

[0012] Preferably the carrier adaptor feed nozzle has a frusto-conical form, narrowing slightly to a diameter less than that of the casting die inlet at the casting die end of the nozzle. This has the effect of providing a 'lip' at the downstream end of the feed nozzle adjacent to the casting die inlet. This lip has the benefit of resisting residual metal running into the casting die at the end of a casting campaign, when the crucible is substantially emptied of molten metal.

[0013] Additionally the carrier adaptor is conveniently provided with a drain passage through the wall of the carrier adaptor, preferably at the upstream end of the female mounting portion adjacent to the feed nozzle. This drain passage is normally occluded by the casting die. However when the casting die is removed for replacement, residual molten metal from the crucible, not held back by the lip of the feed nozzle, drains safely downwards via a suitable return passage back into the body of the furnace, rather than running out of the carrier adaptor where it could endanger the operator changing the die.

[0014] The second clamping device, for securing the carrier adaptor conveniently comprises a thrust plate with releasable fasteners, the thrust plate engaging with a downstream end facing clamping face of the carrier adaptor, which is conveniently disposed outside the furnace. The thrust plate urges the carrier adaptor into sealing inter-engagement with the crucible outlet orifice, when the releasable fasteners are fastened. Sealing with the crucible outlet may be assisted by the use of refractory cement, gaskets or other suitable seals.

[0015] At the same time the sealing means of the carrier adaptor, which may, for example, simply comprise a portion of the outer wall of the carrier adaptor, is used to form a substantially gas tight seal between the carrier adaptor and the wall of the furnace around the orifice in

the furnace wall through which the casting is produced. Sealing contact may be made directly between the sealing portion of the carrier adaptor and the sides of the furnace wall orifice, possibly with the assistance of refractory cement or a gasket. Other means of obtaining the seal can also be envisaged. For example, where the carrier adaptor is formed and arranged to protrude through the furnace wall aperture, a sealing ring mounted on the furnace wall, around the furnace wall aperture, may be used to engage the sealing portion of the carrier adaptor. Such a sealing ring can provide all of the sealing between the furnace wall and the carrier adaptor or can be in addition to direct sealing between the carrier adaptor and the sides of the furnace wall orifice.

[0016] Casting dies used with the carrier adaptor of the invention can be of the conventional water-cooled graphite construction, fitted with an inert gas purging system to protect the graphite casting surface during use. Casting dies made of alternative materials, such as cast iron, for example, may also be employed depending on the metal or alloy being cast. The female mounting portion of the carrier adaptor is formed and arranged for receiving the male mounting portion of the casting die. Generally a close sealing fit is made between the carrier adaptor and the die at the upstream end of the female mounting portion proximal the feed nozzle, with a small clearance being provided between the mountings elsewhere. This clearance helps to avoid seizing between the carrier adaptor and the die, which would make replacement of the die more difficult.

[0017] The casting die is secured to the carrier adaptor by the first clamping device. This clamping device conveniently comprises a thrust plate, or a thrust plate and thrust collar mounted by releasable fasteners such as, for example, studs and nuts or bolts.

[0018] Conveniently the fasteners used to mount the thrust plate of the casting die include fastener elements secured to the carrier adaptor, in which case the carrier adaptor further comprises means for mounting these fasteners, such as threaded boreholes.

[0019] Alternatively the clamping device for the casting die may also be secured to the wall of the furnace.

[0020] In use the casting apparatus operates in the same fashion as prior art casting machines during casting operations. However, when the casting die becomes worn or eroded through use, then it can be changed, when the crucible is substantially empty, without the need to cool the furnace and break the gas tight seal formed between the furnace wall and the carrier adaptor. The casting die is simply released from the carrier adaptor by unfastening the casting die clamping device, without disturbing the carrier adaptor, and then removed and replaced. Replacement of the die can readily be safely carried out by a low skilled operator due to the positive location of the die into the female mounting portion of the carrier adaptor. Precise location can be further assisted by the provision of locating screws (adjusted on first fitting of a die to the carrier adaptor). Any sealing gaskets used

in the mounting of the die are conveniently replaced during die replacement.

[0021] Thus in a further aspect the present invention provides a method of die replacement in a casting apparatus, comprising the steps of:

providing a horizontal continuous casting apparatus according to the present invention;
releasing the casting die from the carrier adaptor by unfastening the casting die clamping device, without disturbing the carrier adaptor;
removing the released casting die from the carrier adaptor; replacing the removed casting die with a fresh casting die;
and then securing the fresh casting die in the carrier adaptor by fastening the casting die clamping device.

[0022] Further preferred features and advantages of the present invention will appear from the following detailed description of some preferred embodiments illustrated with reference to the accompanying drawings in which:

Fig. 1 is a partially sectioned partial elevation of a horizontal continuous casting machine with a prior art coupling arrangement between the crucible and the water cooled casting die;

Fig. 2 is a schematic sectioned elevation of a carrier adaptor for the casting apparatus of the invention together with a casting die in alignment for insertion into the female mounting of the carrier adaptor;

Fig. 3 is a schematic sectioned elevation of the carrier adaptor of Fig. 2 with a casting die inserted into the operating position; and

Fig. 4 is a partially sectioned partial elevation of an embodiment of the horizontal continuous casting machine of the invention.

[0023] Figure 1 (prior art) shows a partial view of a resistance heated furnace assembly generally indicated by the reference numeral 1. The gas furnace interior 2 is kept under a pressurised inert gas atmosphere during casting operations. Resistance heating elements 4, typically graphite, maintain the furnace and its graphite crucible 6 at the appropriate operating temperature. The crucible outlet 8 is connected in sealing contact at the outlet orifice 10 with a feeder tube 12 which provides fluid communication and sealing connection with the casting die 14. In this case the casting die 14 is of simple tubular form for producing a single rod of circular cross section. Dies for the production of more complex castings such as tubes, 'U' shaped or other sections or multiple rods can readily be substituted. The casting die 14 is secured to the feeder tube 12 by securing screws 16. The casting die 14 is supplied with water cooling via connections 18 to its cooling jacket 20 and with inert gas protection (typically low oxygen content nitrogen) via inlets 22. A thermocouple connection 24 is provided to monitor temper-

ature in the thermocouple pocket 26. The feeder tube 12 and casting die 14 assembly is held in position by a clamping device comprising a thrust plate 28 and collar 29 tensioned by nuts 30 located on studs 32 secured to the furnace wall 34. The casting die 14 projects through an aperture 36 of the furnace wall 34 and gas tight sealing is ensured by means of the sealing ring 38 which is, for example, of mineral wool construction.

[0024] In use the molten metal held in the crucible 6 flows through the outlet 8 into the casting die inlet 39 via the feeder tube 12. The cooling applied via the cooling jacket 20 solidifies the molten metal in the casting die 14 at or near to, the point indicated by the line 40. The cast solid is continuously withdrawn by means of the casting rollers 42. The disadvantage of this arrangement is that the furnace 1 must be cooled whenever the casting die 14 is to be exchanged as the gas tight sealing at the furnace wall 34 is made between the casting die 14, the furnace wall 34 and/or the sealing ring 38.

[0025] Figure 2 shows a generally cylindrical carrier adaptor 44 of the invention together with a casting die 14, ready for insertion into the carrier adaptor. The position of the furnace wall when the carrier adaptor is located for use in a casting machine is indicated by the double lines 46. The carrier adaptor 44 has a feed nozzle end 48, which in use forms a sealing connection with a crucible (not shown) and a feed nozzle 50 of frusto conical section. A female mounting portion 52 of the carrier adaptor 44 is sized to receive the male mounting portion 54 of the casting die 14. A drain passage hole or slot 56 is provided at the end of the female mounting portion 52 nearest the feed nozzle 50. The sealing portion 58 of the carrier adaptor 44 consists of a machined outer surface 59 of the carrier adaptor 44 sized to fit an aperture 36 in a furnace wall 34 and any associated seals used to ensure gas tight integrity of the furnace during use.

[0026] Figure 3 shows the carrier adaptor 44 and the casting die 14 of Figure 2 fitted together for use in continuous casting of metal. Sealing contact 60 is made between the end of the female mounting portion 52, nearest the feed nozzle 50, and the male mounting portion 54 of the casting die. This can be assisted if required by the provision of gaskets or a sealing cement. Elsewhere a small clearance 62 is left between the carrier adaptor 44 and the casting die 14 to minimise the possibility of seizing. The carrier adaptor 44 is held securely in place during use by a clamping device, (not shown in Figs. 2, 3 but see Fig. 4) applying securing force to the end 64 of the carrier adaptor projecting through the furnace wall 34 generally in the direction indicated by the arrows A. A separate clamping device (see Fig. 4) is used to secure the casting die 14 to the carrier adaptor 44.

[0027] Figure 4. shows a partial view of a horizontal continuous casting machine of the invention featuring a crucible, carrier adaptor and casting die assembly. The furnace 1 and graphite crucible 6 are arranged and operate in the same way as described for the prior art apparatus described in Figure 1. The casting die 14 and

the carrier adaptor 44 are as shown in Figures 2 and 3 and previously described.

[0028] The carrier adaptor 44 projects through an orifice 36 of the furnace wall 34 forming a substantially gas tight seal with the assistance of the sealing ring 38. The carrier adaptor 44 is held securely in place by a clamping device comprising a thrust plate 68 studs 70 and nuts 72. The casting die 14 is secured by its own thrust plate 28, collar 29, studs 32 mounted 73 on the carrier adaptor 44, and nuts 30.

[0029] In use, during casting operations, the apparatus operates as the prior art machines such as shown in Figure 1 and described before. However, when the casting die 14 has to be replaced the furnace 1 and crucible 6 can be maintained at or near operating temperature with the pressurised inert gas atmosphere maintained in the furnace interior 2. Replacement of the casting die 14 is simply carried out at the end of a casting campaign, when the crucible 6 is substantially empty of molten metal, by removing the nuts 30 the thrust plate 28 and collar 29 and withdrawing the casting die 14 from the carrier adaptor 44. Residual molten metal from the crucible 6 is held in check by the 'lip' 74 of the feed nozzle with any molten metal passing this point draining safely through slot 56, as the casting die 14 is removed, to a suitable diversion passage 57, rather than exiting the furnace via the adaptor 44 where it might harm the operator. A replacement casting die is fitting and secured in the same fashion as the previous one. Accurate location of the casting die 14 is assured by the provision of docking support screws 76.

[0030] It will be appreciated that various modifications may be made to the above described embodiments without departing from the scope of the invention.

Claims

1. A horizontal continuous casting apparatus comprising an inert gas-purged resistance-heated type furnace (1), a crucible (6) for containing molten metal inside said furnace, in use of the apparatus, and having an outlet (8) for molten metal, coupled, via an aperture (36) in a wall (34) of said furnace, to a casting die (14), and a first clamping device (28-3-,32) formed and arranged for securing said casting die (14) in sealing communication with said crucible (6), wherein is provided a carrier adaptor (44) of an oxidation resistant refractory material and comprising: a feed nozzle (50) formed and arranged for providing fluid communication between said crucible outlet (8) and an inlet (39) of said casting die, a female mounting portion (52) formed and arranged for receiving, in sealing inter-engagement, a male mounting portion (54) of said casting die (14), and a sealing system (58) formed and arranged for sealing inter-engagement with said furnace wall (34) around said aperture (36), and wherein is provided a second clamping device (68,70,72) formed and arranged for

releasably securing said carrier adaptor (44) to said crucible (6) and said furnace wall (34), in sealing inter-engagement therewith, and said first clamping device (28-30,32) is formed and arranged for releasably securing said casting die (14) to said carrier adaptor (44).

2. An apparatus according to claim 1 wherein the carrier adaptor (44) is made of a refractory oxidation resistant material, suitable for use in metal casting operations, that is sufficiently durable to be semi-permanently attached to the crucible (6) and furnace (1) for a substantial number of casting campaigns.

3. An apparatus according to claim 2 wherein the carrier adaptor (44) is made of a low cost, oxidation resistant clay/graphite mixture.

4. An apparatus according to any one of claims 1 to 3 wherein the carrier adaptor (44) is circular in cross-section.

5. An apparatus according to any one of claims 1 to 4 wherein the carrier adaptor feed nozzle (50) has a frusto-conical form, narrowing slightly to a diameter less than that of the casting die inlet at the casting die end of the nozzle, so as to provide a 'lip' (74) at the downstream end of the feed nozzle (50) adjacent to the casting die inlet (39).

6. An apparatus according to any one of claims 1 to 5 wherein the carrier adaptor (44) is provided with a drain passage (56) through the wall of the carrier adaptor, formed and arranged so that said drain passage is normally occluded by the casting die (14), whilst being opened when the casting die (14) is removed for replacement, so as to allow residual molten metal from the crucible, not held back by the lip (74) of the feed nozzle (50), to drain safely out of said carrier adaptor (44) away from said female mounting portion (52) thereof.

7. An apparatus according to any one of claims 1 to 6 wherein the second clamping device (68,70,72) for securing the carrier adaptor (44), comprises a thrust plate (68) with releasable fasteners (70,72), the thrust plate (68) engaging with a downstream end-facing clamping face of the carrier adaptor (44), so that the thrust plate urges the carrier adaptor into sealing inter-engagement with the crucible outlet orifice, when the releasable fasteners (70,72) are fastened.

8. An apparatus according to any one of claims 1 to 7 wherein the sealing system (58) of the carrier adaptor (44), comprises: an outer surface (59) of the carrier adaptor, formed and arranged to form a substantially gas tight seal between the carrier adaptor (44)

and the wall of the furnace around the aperture (36) in the furnace wall (34) through which the casting is produced.

9. An apparatus according to any one of claims 1 to 8 5
 wherein, where the carrier adaptor (44) is formed and arranged to protrude through the furnace wall aperture (36), the sealing system (58) of the carrier adaptor, comprises: a sealing ring (38) mounted on the furnace wall, around the furnace wall aperture (36), formed and arranged to engage the sealing portion (59) of the carrier adaptor (44). 10

10. An apparatus according to any one of claims 1 to 9 15
 wherein is used a water-cooled graphite construction casting die (14), fitted with an inert gas purging system (22) to protect the graphite casting surface of said casting die during use thereof.

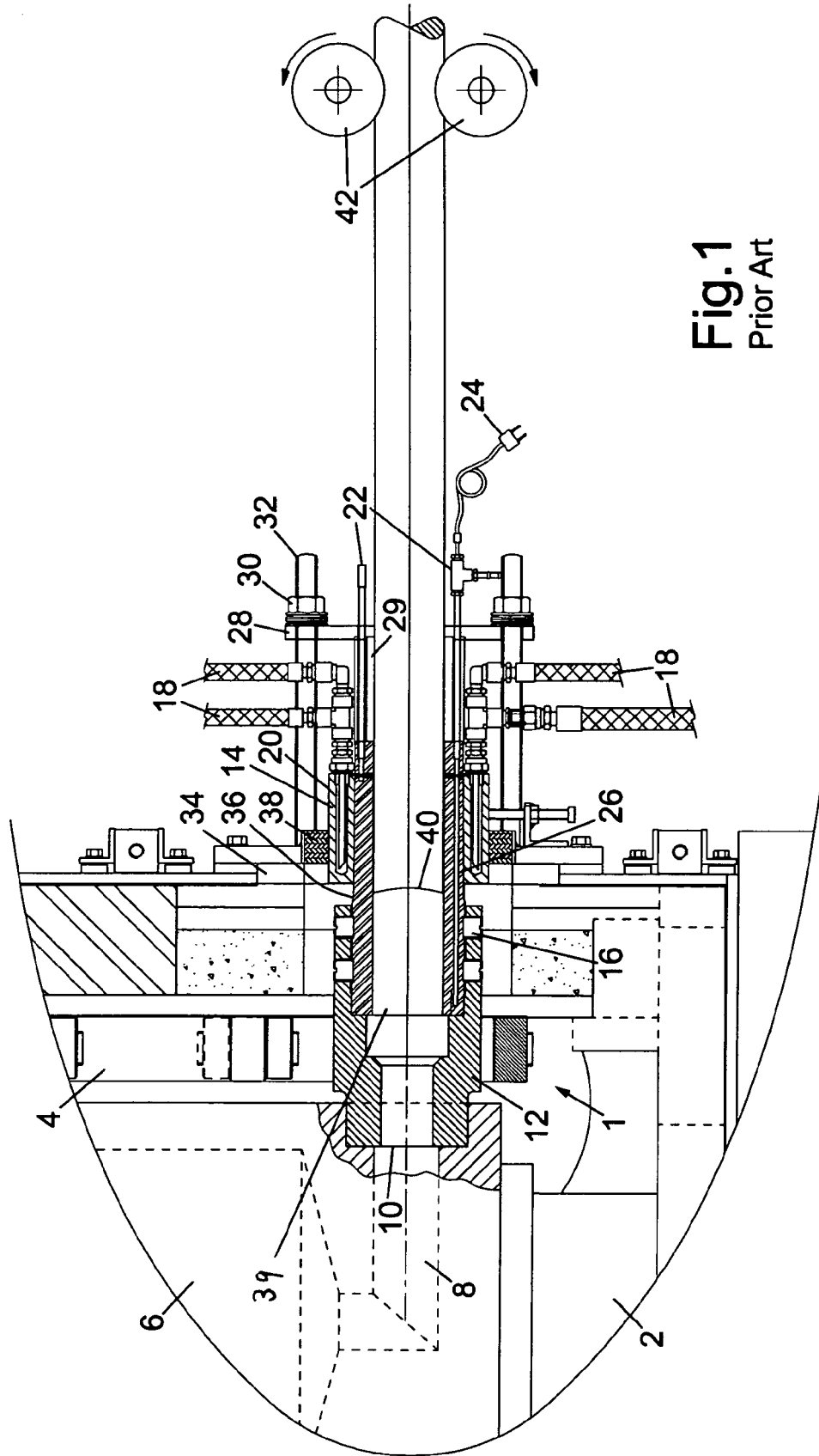
11. An apparatus according to any one of claims 1 to 10 20
 wherein the female mounting portion (52) of the carrier adaptor (44) is formed and arranged for receiving the male mounting portion (54) of the casting die (14) with a close sealing fit (60) between the carrier adaptor (44) and the die (14) at the upstream end of the female mounting portion proximal the feed nozzle, and with a small clearance (62) being provided between the mountings elsewhere, so as to help avoid seizing between the carrier adaptor (44) and the die (14). 25 30

12. An apparatus according to any one of claims 1 to 11 35
 wherein the first clamping device (28-30,32) comprises a thrust plate (28), mounted by releasable fasteners (29,30,32).

13. An apparatus according to claim 12 wherein the fasteners used to mount the thrust plate (28) of the casting die (14) include fastener elements secured to the carrier adaptor (44), in which case the carrier adaptor further comprises mounting portions for these fasteners. 40

14. A method of die replacement in a casting apparatus, comprising the steps of: 45

 providing a horizontal continuous casting apparatus according to claim 1;
 releasing the casting die (14) from the carrier adaptor (44) by unfastening the casting die clamping device (28-30,32), without disturbing the carrier adaptor (44); 50
 removing the released casting die (14) from the carrier adaptor (44);
 replacing the removed casting die (14) with a fresh casting die; and then securing the fresh casting die in the carrier adaptor by fastening the casting die clamping device. 55



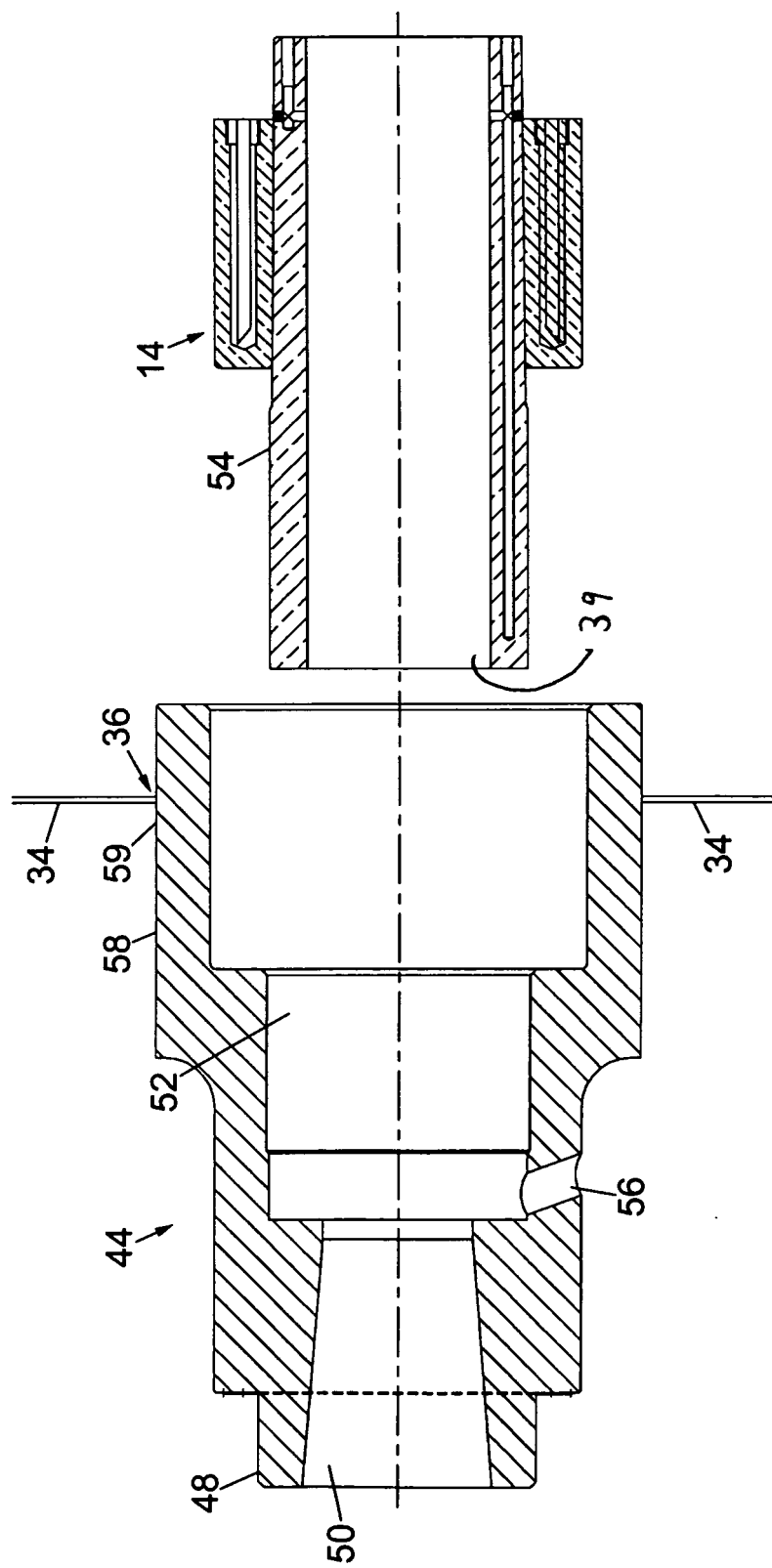


Fig.2

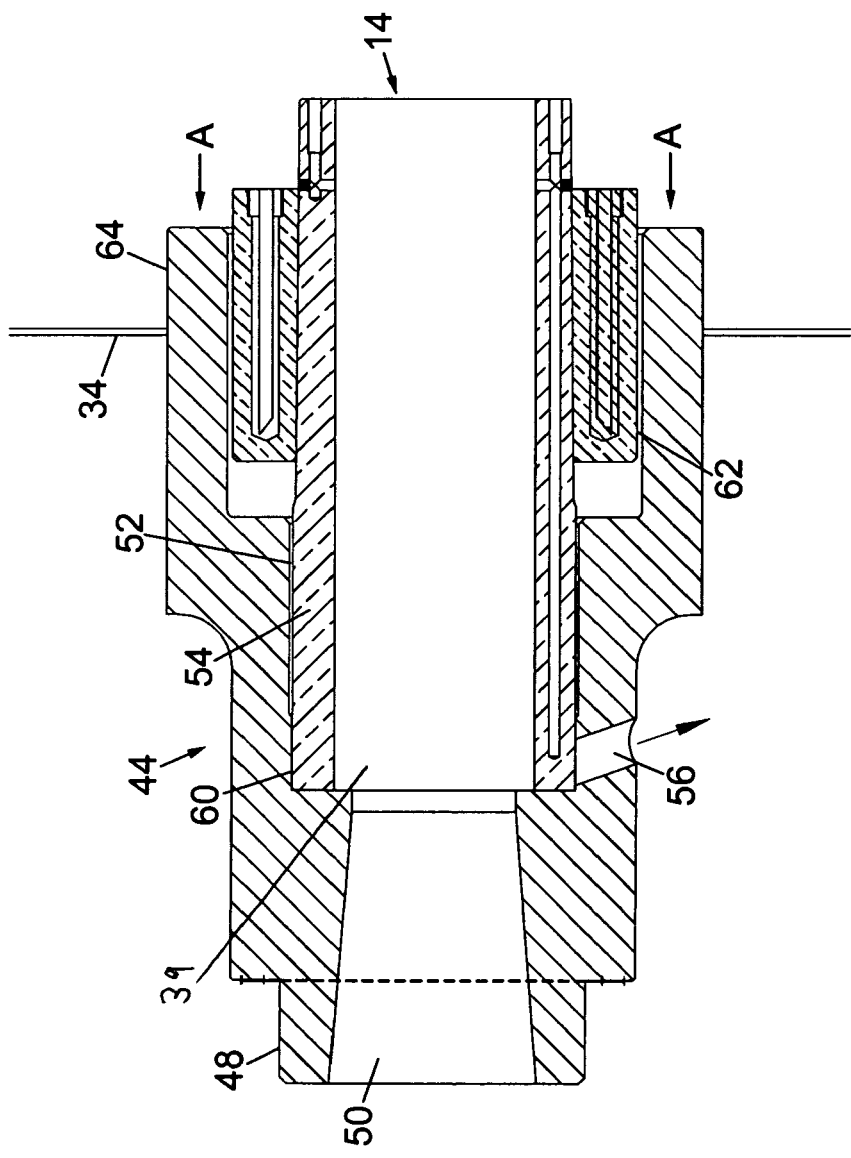
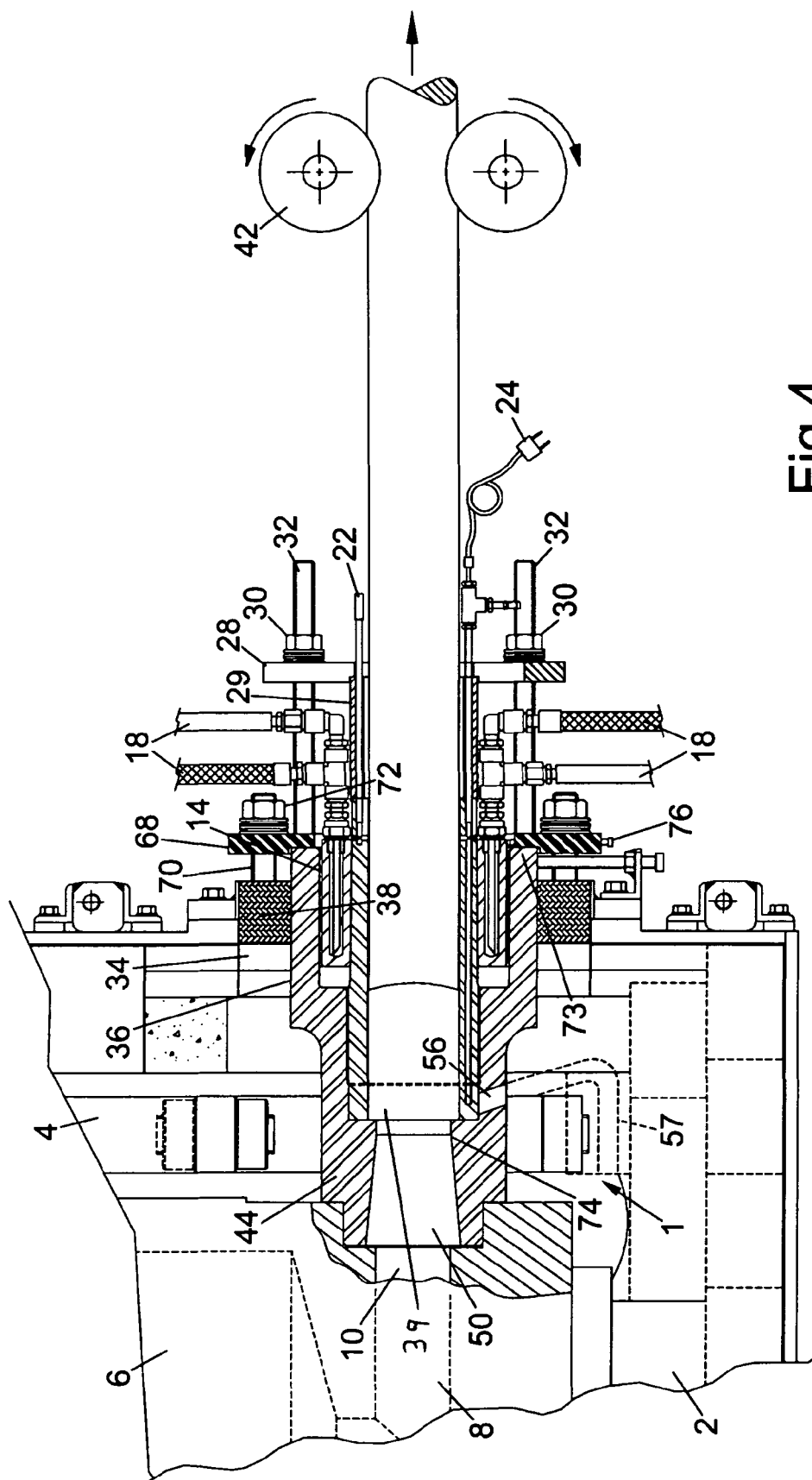


Fig.3





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 25 5609

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 90/07997 A (DAVY MCKEE LIMITED) 26 July 1990 (1990-07-26) * abstract *	1,14	B22D11/045
A	----- DATABASE WPI Section Ch, Week 198346 Derwent Publications Ltd., London, GB; Class M22, AN 1983-819305 XP002362852 -& SU 990 411 A (DON DONETSKVTORTSVETMET) 23 January 1983 (1983-01-23) * abstract; figure * -----	1,14	
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			B22D
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 16 January 2006	Examiner Hodiamont, S
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 05 25 5609

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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16-01-2006

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