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(54) **Method and device for die casting molten metal, in particular molten light alloy.**

(57) A die-casting device for melt metals and light alloys is provided, comprising a body (2) rigidly associated above one of the chill forming elements defining the casting die (3), which body (2) has an inner cavity (5) communicating, through a passage port (6), with a filling compartment (7), a piston (15) being sealingly movable in the cavity to operate as a metering device for the melt to be poured in the casting die (3).

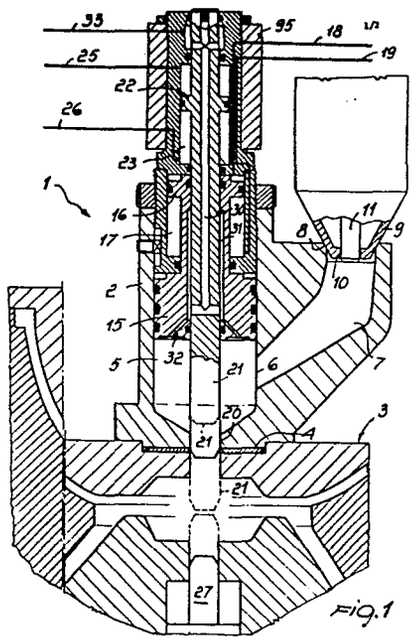

Fig.1

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TITLE
see front page

This invention relates to a die-casting device for melt metal, in particular melt light alloy.

According to current practice, for die-casting molten metal, in particular light alloys, various techniques are employed which, while having specific merits, are not entirely devoid of disadvantages, some of which can be quite substantial.

Among the conventional casting techniques, of relevant import is the very high pressure light alloy casting technique, wherein the aluminum or light alloy melt is injected at a very high pressure into a casting die. That technique has the advantage of a high casting rate and good compacting of the molten aluminum or light alloy throughout the casting die inside, such that even the remotest areas from the injection nozzles are reached therein.

On the other hand, a drawback of that technique is that it may result in a non-uniform production, since the melt undergoes a considerable stress, as due to the sharp application of a very high pressure and to the powerful introduction of the melt into the die, which in many cases may result in the intrinsic characteristics of the material being altered.

Thus, a casting technique of that type involves a high percentage of reject, because a successful casting is allowed to rely in practice on uncontrollable random factors during the production stage, and above all on account of the disuniform

compactness achieved.

Another drawback is that the casting apparatus and die must be constructed and dimensioned to withstand the high pressure levels involved, of at least a hundred atmospheres, which results in a substantially high plant cost.

Other casting methods, such as the one disclosed in U.S. Patent No. 3,196,501 by A.T. Balevsky et al., provide a melt-containing reservoir or header which opens at the bottom to the casting die; in this case, the casting process is carried out by applying a pressure to the free surface of the molten metal in the reservoir, which molten metal is then introduced into the casting die, wherein a counterpressure causes the melt to flow gradually and smoothly into the casting die without undergoing any significant stresses.

That apparatus has the disadvantage of requiring a preliminary metering of the melt to be introduced into the casting die, which involves the necessity of opening the reservoir to the external environment, in order to pour the molten metal therein, with attendant unavoidable oxidation of part of the molten metal.

Moreover, risers of large size are thus obtained which result in a substantial waste of melt.

Other devices which relate in principle to the apparatus disclosed in the cited patent provide for an apparatus wherein the melt reservoir is formed in

the chill or die itself beside the casting cavity, such that it can be uncovered as the die or casting cavity is opened to withdraw the casting. In such apparatus, the amount of molten metal which is poured into the reservoir is preset externally to the apparatus, such as to have a volume of molten metal which substantially equals the volume required to fill the casting die, plus an allowance for the riser and the meniscus which forms at the reservoir bottom after the casting step.

This has been purposely designed to enable the removal of that melt portion, specifically the area of the meniscus, wherein slag builds up as due to the oxidation of the molten metal occurring while the molten metal is poured into the side reservoir.

Thus, such devices afford the advantage of providing castings in which the gradual introduction of the melt into the casting die allows a good compaction of the material, owing to the pressure exerted on the reservoir during the introduction of the molten metal into the casting die, as well as to the gradual introduction of the molten metal into the die, which avoids the stressing and ill-treatments which are typical of the very high pressure method.

On the other hand, such devices have the disadvantage of requiring a long production time of the castings, because it is necessary to wait for the casting to completely solidify before the reservoir can be opened for the next

introduction of fresh melt therein, so that it is unthinkable that such devices can be utilized in a carousel or continuous cycle casting machine, unless several sprue holes, i.e. one for each chill, are provided.

Furthermore, a serious problem is represented by the considerable amount of waste due to the risers and occasionally to the meniscus portion where oxidation slag has collected.

The German Patent No. 2720352 to Zeppellini discloses a device which enables a continuous cycle production of castings. It comprises in essence a casting die, which may obviously have any desired shape, having at the top a molten metal filling hole whereto a large ladle can be secured in sealed relationship which has at the bottom an outlet nozzle, located at the casting die filling hole, which nozzle is closed tightly by a movable shutter.

This approach affords the possibility of scavenging the die with an inert gas to be admitted through a conduit coaxial to the shutter and controlled by a closure plate or cap provided at the bottom end with a stem which extends coaxially inside the shutter.

The shutter element is movable to put the ladle in communication with the casting die, such as to enable the molten metal to be poured into the die. Moreover, to the inside top of said ladle, which is tight sealed, there opens an air or compressed gas intake conduit which exerts a low pressure of the

order of a few atmosphere units, which facilitates the introduction of the melt into the casting die and causes it to reach the remotest corners of the die or chill.

After the molten metal has been poured into the casting die, the die can be rotated such that a more complete and uniform distribution of the melt is achieved by centrifugal action.

As the molten metal has solidified within the die, the ladle is removed and, after refilling at the holding furnace, it is applied to a successive casting die to go through the same steps described hereinabove.

The apparatus according to the cited German patent, therefore, has over the previous ones the advantage of enabling the casting of aluminum into a die, wherein an inert atmosphere has been formed , which is sealingly closed by the ladle itself. A casting can thus be obtained which is virtually free of impurities due to oxidation.

Moreover, the apparatus just described also provides for a moderate pressure action which facilitates the introduction of the melt into the die, by compensating for the difference in height between the pouring hole and upper portion of the chill. Also, the apparatus just described allows the size of the risers to be minimized, because the shutter closes the casting apparatus bottom tightly upon completion of the metal pouring into the die, thus preventing material waste.

On the other hand, the apparatus, in addition to a number of drawbacks of a practical nature, has the disadvantage of a low output rate because it requires that the metal has completely solidified within the die, before the ladle can be removed for application to a successive die, as dictated by the fact that it is the very ladle which provides the pressure during the solidification stage as the die is closed.

Another problem is of a constructional nature, in that the seal between the ladle and casting die is in practice critically affected, in view of the fact that it should allow for the rotation of the die while the ladle is held stationary.

This invention sets out to provide a die -casting device for metal, in particular melt light alloy, which in addition to providing an absolutely faultless casting is also capable of a very high hourly output, such as cannot be found in similar conventional devices.

Within that general aim, it can be arranged that the casting device according to this invention allows the metering of an accurate amount of melt in an inert gas environment, thus completely eliminating the presence of slag and impurities from the resulting casting.

It can be further arranged that the casting device of this invention allows the ladle to be removed immediately after the melt has been poured

and prior to its beginning to solidify in the die, thus affording a drastic reduction of the production time and making the device specially suitable for use with a continuous casting machine.

It is further possible to arrange that the die - casting device according to this invention is highly reliable in operation and safe to use, while being mechanically simple and requiring a greatly reduced amount of maintenance.

According to one aspect of this invention, there is provided a die-casting device for melt metals, in particular melt light alloys, characterized in that it comprises a body rigidly associated at the top thereof with one of the chill forming elements defining the casting die, said body having an internal cavity in communication, through a passage port, with a filling compartment adapted for being closed at the top in sealed relationship by a molten metal feeder removably attachable to the mouth of said filling compartment, a piston being provided sealingly movable in said cavity adapted to operate as a metering device for the melt to be poured into the casting die and to sealingly close said passage port upon completion of the melt pouring step, a shutter element being also provided to control the passage orifice between said cavity and said casting die.

Further features and advantages will become more clearly apparent from the following description

of a preferred, though not limitative, embodiment of a die-casting device for melt metals, in particular melt light alloys, with reference to the accompanying exemplary drawings, where:

Figure 1 is an axial sectional view of the die - casting device of this invention; and

Figure 2 is a schematical plan view of an apparatus incorporating a number of die -casting devices, according to the invention.

With reference to the drawing figures, the die - casting device, according to this invention, is generally indicated at 1 and comprises a body 2 located at the top of one of the elements composing a casting die generally indicated at 3 and no further described because known per se, the die being shaped to match the shape of the castings to be produced; for example purposes, the drawings show a die intended for casting a wheel.

Said body 2 is rigid with at least one of the elements making up the casting die 3 and is associated therewith through an intervening seal 4.

Within the body 2, there is defined a cavity 5 which has an orifice 20 at the bottom for communication with the casting die defined by the chill 3.

Said cavity 5 communicates, at its bottom portion and through a passage port 6, with a filling compartment 7 which extends substantially upwards and terminates with a top mouth 8.

Said filling compartment 7 can be closed at the top tightly by means of a molten metal feeder, e.g. comprising a ladle 9 which removably engages in sealed relationship with the cited top or upper mouth 8.

The ladle 9 is provided, at the area of engagement with the mouth 8, with a delivery outlet or mouth 10 controlled by means of a shutter stem 11.

In said cavity 5, there is slidable, in sealed relationship, a piston 15 driven by a double-acting cylinder 16 arranged to slide in a chamber 17 formed in the upper portion of the body 11. To said chamber 17 lead at the top and bottom, a delivery conduit 18 and return conduit 19 which follow the movements of the cylinder 16, and accordingly of the piston 15 rigid therewith.

The orifice 20 which communicates the cavity 5 with the casting die is controlled by a shutter 21 which penetrates in sealed relationship coaxially to the piston 15 and chamber 17 and is driven, for its vertical direction movement, by an auxiliary cylinder 22 arranged to slide in sealed relationship in an auxiliary chamber 23 provided above the chamber 17 and being fed above and below said auxiliary cylinder 23 through a first conduit 25 and second conduit 26.

The shutter 21, additionally to functioning as an orifice closing element, can also act as a

punch for compacting the central portion of the cast melt during the centrifugation thereof, as will be explained hereinafter.

Furthermore, at the lower portion of the casting die, preferably in alignment with the shutter 21, there is provided a pusher piston 27 which, by penetrating the cast melt, is effective to compact the metal still in its molten state to compensate for any shrinkage during the final stage of the melt solidification. Inside the cited shutter 21, there extends an inert gas feeding conduit 30 which opens to an annular interstice or gap 31 defined within the piston 15 and in communication with the cavity 5 through small channels 32 which opens to the bottom or lower face of the piston 15.

Said inert gas feeding conduit is in communication with an inert gas delivery valving unit, over the line 33, which unit is enabled, as will be explained hereinafter, to admit low pressure inert gas, i.e. gas at a pressure of the order of a few atmospheres, or possibly an inert gas at a high pressure, of the order of several dozens atmospheres.

The casting process is carried out as follows.

Initially, the chill 3 is assumed to be empty and ready for casting; the shutter element 21 is in its raised position, that is such as to allow free communication of the cavity 5 with the casting die; the piston 15 is positioned such that the volume defined by the cavity 5 and filling compartment 7

is equal to, or slightly larger than the volume of molten metal to be introduced into the casting die; the ladle 9 is applied to the top mouth 8 such as to seal off the filling compartment 7; and the stem shutter 11 holds the delivery mouth 10 of the ladle 9 closed.

Preliminarly to casting, through the channel 30, an inert gas, such as nitrogen and the like, is admitted into the cavity 5, filling compartment 7, and casting die 3, such as to practically scavenge those areas whereto the melt will flow.

After carrying out this preliminary scavenging step, the shutter 21 is lowered to close the orifice 20 communicating to the casting die 3 tightly. Then, the stem shutter 11 of the ladle 9 is opened to pour the melt out of the ladle; the melt will fill the cavity 5 and filling compartment 7, practically flowing by gravity into the metering chamber, formed by the cavity 5, which has a variable volume in accordance with the position of the piston 15, and by the filling compartment, which has obviously a constant volume capacity. After filling the cavity 5 and filling compartment 7, the stem shutter 11 is operated to close the delivery mouth of the ladle 9, whereafter the orifice 20 is opened by raising the shutter 21.

The fluid melt will fill by gravity almost every part of the casting die defined by the chill, to leave the filling compartment 7 and a part of the

cavity 5 left empty by the metal.

At this time, the piston 15 begins to move downwards and, through the conduit 30, low pressure neutral gas is introduced which, as mentioned hereinabove, facilitates an optimal filling of the die and enables the height difference between the pouring area and the highest areas of the casting die to be compensated; this avoids the formation of very high risers.

The piston 15 will cover, in its downward travel, the passage port 6, thus completely breaking the communication between the cavity 5 and compartment 7.

At this time, it becomes possible to introduce, again through the conduit 30, very high pressure neutral gas, which will accurately compact the melt within the die, while the downward movement of the piston 15 can furthered to increase the pressure action exerted on the liquid metal.

It should be noted that the application of a very high pressure after the melt has been poured into the die will not induce stresses in the material, as it occurs with conventional very high pressure methods, but simply it will improve the distribution of the material within the die to achieve a uniform compaction thereof.

It should be specifically noted that, after the piston 15 has covered the port 6, it becomes possible to remove the ladle 9, because the communication with the die 3 outside is shut off by the piston 15 which,additionally to serving as a metering device

as mentioned, also allows, by covering the port 6, the ladle 9 to be removed prior to the beginning of the melt solidification within the chill 3.

It is also possible, with castings of circular configuration, to rotate the die 3 together with the body 2 rigid therewith, to carry out a centrifugation of the material contained in the die, where the uniform distribution of the material requires further improvement.

The centrifugation has the very important function of feeding the remote or outward portions of the casting being produced, whereat solidification occurs in advance owing to the smaller thickness dimensions, to compensate for the shrinkage of the material by adding material which is in practice absorbed by the central portion where the metal is still in its liquid state.

It should be pointed out, moreover, that the centrifugation is carried out after the die has been completely filled with the melt, thus avoiding the formation of foams because the metal has already set in the die.

The drawing of material from the central portion toward the outer portions might create problems in the central portion of the casting; to obviate them, a high pressure can be applied through an inert gas, as mentioned hereinabove. Alternatively, a mechanical compressive action may be exerted directly on the melt, at the center portion thereof, through the shutter 21 which is passed through the

orifice 20 in sealed relationship, and through the thrust piston 27 provided at the lower or bottom region of the chill.

From the foregoing procedure, it will be appreciated that any contacts of the melt with the surrounding atmosphere are effectively prevented, thus preventing its oxidation, while it becomes possible to accurately meter the amount of molten metal required, thus reducing the risers to practically negligible percentages and appreciably reducing the percentage of the rejects, while, and this is an extremely important feature, the time for applying the ladle to the device is reduced to the time strictly required for pouring the melt, the ladle being readily removable already before solidification takes place. This allows the device according to the invention to be utilized in a continuous cycle machine, such as the carousel one shown in Figure 2, without involving the use of several casting units.

The machine shown in Figure 2 comprises a casting unit which includes a dual body melting furnace 40 feeding a holding furnace 41 through doors or gates 42 and 43 which are opened alternately in synchonization with their related furnace bodies.

A cross carriage device 45, which will not be described in detail herein because known per se, picks up the molten metal from the holding furnace 40 and introduces it, through the ladle 9 described hereinabove, into the body 2.

The arm 50 of the cross carriage 45 enables the ladle 9 to be unloaded outside of the working area for its periodical replacement.

It should be further added that for introducing the melt into the body 2, other means may be utilized than the ladle, which be effective to completely fill, as described hereinabove, the filling compartment 7 and cavity 5.

After the melt has been introduced into the device 1, the operational steps described hereinabove take place.

It should be noted that the last step of introducing high pressure neutral gas may be carried out while the device 1 is being moved to the successive station.

For this purpose, the device 1 is practically carried by the extensions 60 of a carousel element 61 which is rotated intermittently at regular time intervals to bring sequentially the various devices 1 to the loading station.

The device 1 is brought, by successive rotational movements, to the unloading station 70, whereat the pressure applied to the melt is released and the now solidified casting is withdrawn from the chill and started along the casting cooling conveyor 71.

The carousel rotation evidently occurs in steps, the rate of advance being a function of the time required by the number of the casts relatively to the solidification of each single cast.

A manifold 80 connects the carousel 60 to a control unit 81 and electro-hydraulic control 82.

Alternatively, or additionally to the above, the casting process may include a final centrifugation step, thereby the chills 3, as described hereinabove, instead of being held stationary, would be made rotatable by means of motors, generally hydraulic ones, provided below the carousel and so designed that, during the passage from the casting station to the following station, a controlled acceleration of the chill occurs which is then maintained as far as the last but one station. From the latter to the unloading station, a deceleration takes place, until a full stop condition is reached at a preset position as determined by clutches 90 having the function of positioning the device 1 such that the mouth 8 of the filling compartment 7 is located at the path followed by the ladle 9.

The rotation of the various chills is again interlocked with the introduction of pressurized inert gas, wherefor rotating manifolds , shown schematically at 95 in Figure 1, are provided, and optionally interlocked with the action of the shutter 21 and thrust piston 27.

It should be pointed out, moreover, that the type of acceleration imparted to the chill, and the deceleration and constant velocity, can be adjusted as desired and programmed in accordance with the type of cast to be effected.

It will be apparent from the foregoing that the invention achieves its objects, and in particular that a continuous and substantially automated casting process has been provided which has a high rate of casting output, thanks to the combination of a carousel carrying either stationary or rotary chills with a device which enables, in sequential steps, casting by gravity, at a low and high pressure, throughout the path travelled by a chill on the carousel up to the automatic casting unloading station, while other casts may follow one another alternately, which take place prior to the complete solidification of the metal which has been poured into the preceding chills.

Furthermore, by providing the piston 15, one is enabled, first of all, to effect an accurate metering of the melt directly at the pouring time, while the piston will ensure a tight sealed closure of the communication with the outside environment, thus permitting the ladle to be removed prior to the melt within the die beginning to solidify.

Moreover, the piston 15 can be utilized to further increase the pressure applied during the final stage of the casting process, when very high pressure inert gas is introduced.

Also noteworthy is the fact that the method described, and the device utilized, allow the pouring of molten metal in an inert gas environment to thus prevent oxidation of the metal, which oxidation is well known to be a significant source

of impurities and slag in the resulting castings.

To conclude with, it is to be added that this device affords the possibility of providing an extremely versatile and functional plant, capable of meeting the requirements of any users; in fact, the inventive device can be used singly and operated manually, or be incorporated in a semi-automatic or fully automatic cycle carousel type of casting machine with an hourly output which can be adjusted to suit the individual requirements of its users.

The invention as described is susceptible to many modifications and variations without departing from the scope of the instant inventive concept.

Moreover, all of the details are replaceable with other, technically equivalent elements.

In practicing the invention, the materials employed, if compatible with the specific intended application, and the dimensions and contingent shapes may be any ones, depending on individual requirements.

CLAIMS

1. A die-casting device for melt metals, in particular melt light alloys, characterized in that it comprises a body (2) rigidly associated above one of chill forming elements defining the casting die (3), said body (2) having an internal cavity (5) in communication, through a passage port (6), with a filling compartment (7) adapted for being closed at the top in sealed relationship by a molten metal feeder removably attachable to the mouth (8) of said filling compartment (7), a piston (15) being provided sealingly movable in said cavity (5) adapted to operate as a metering device for the melt to be poured into the casting die (3) and to sealingly close said passage port (6) upon completion of the melt pouring step, a shutter element (21) being also provided to control the passage orifice (20) between said cavity (5) and said casting die (3).

2. A die-casting device according to the preceding claim, characterized in that it comprises means (30) for introducing an inert gas in said cavity (5).

3. A die-casting device according to the preceding claims, characterized in that said inert gas introducing means comprise an inert gas feeding channel (30) provided within said shutter (21) and extending coaxially within said piston (15) in sealed relationship, said channel (30) opening into an annular space (31) defined in said piston (15)

and communicating with said cavity (5) through small channels (32) opening at the bottom face of said piston (15).

4. A die-casting device according to one or more of the preceding claims, characterized in that said piston (15) is rigidly connected to a cylinder (16) arranged to be movable in sealed relationship within a chamber (17) defined in said body (2) above said cavity (5), into said chamber (17) there opening, at the bottom and top respectively, a delivery conduit (19) and return conduit (18) adapted for producing the axial movement of said piston (15).

5. A die-casting device according to one or more of the preceding claims, characterized in that it comprises an auxiliary cylinder (22) rigidly associated with said shutter (21) and sealingly movable in an auxiliary chamber (23) fed, below and above said auxiliary cylinder (22) respectively, by a first conduit (26) and second conduit (25) for moving said shutter element (21) in an axial direction.

6. A die-casting device according to one or more of the preceding claims, characterized in that said inert gas feeding channel (30) is in communication with a valving unit for feeding low and/or high pressure inert gas.

7. A die-casting device according to one or more of the preceding claims, characterized in that it comprises, within said body (2), a metering chamber defined by said cavity (5) and having a

variable volume in accordance with the positioning of said piston (15), and by said filling compartment (7) of fixed volume.

8. A die-casting device according to one or more of the preceding claims, characterized in that said shutter element (21) is passed in sealed relationship through said passage orifice (20).

9. A die-casting device according to one or more of the preceding claims, characterized in that it comprises, located in the lower portion of said casting die (3), a thrust piston (27) adapted for introduction into said casting die (3) for compacting the liquid metal at the center portion of said casting die (3).

10. A die-casting device according to one or more of the preceding claims, characterized in that it comprises means for rotating, about the axis of said casting die (3), the casting chill together with said body (2) such as to centrifugate the melt.

11. A method of die-casting light alloy castings, characterized in that it comprises the steps of: scavenging with an inert gas a metering chamber and a casting die (3); filling said metering chamber with molten metal; introducing said molten metal by gravity into said casting die (3); applying, by means of an inert gas, a low pressure to the molten metal being introduced into said casting die (3); applying, by means of an inert gas, a high pressure on the molten metal introduced into said casting die;and withdrawing, following solidification, the resulting casting from said casting die.

12. A method of die-casting according to the preceding claim, characterized in that a centrifugation of said casting die (3) is effected in conjunction with the high pressure action.

13. A method of die-casting according to one or more of the preceding claims, characterized in that said high pressure step is carried out by introducing a high pressure inert gas, followed by a further compression applied to said inert gas by said piston (15) moving downwards.

14. A die-casting method according to one or more of the preceding claims, characterized in that a pressure is applied directly to the molten metal, at the center portion of said casting die (3), through said shutter element (21) of said metering chamber and/or through a thrust piston (27) provided at the lower or bottom portion of said casting die (3).

15. An automatic cycle light alloy casting machine, characterized in that it comprises a carousel (61) having a plurality of arms (60) uniformly distributed and carrying each a device (1) according to the preceding claims, said machine being provided with an automatic loading station for introducing molten metal in said device, with intermediate stations, and with an end or final station whereat the solidified casting withdrawn from the casting die (3) is unloaded.

16. A casting machine according to the preceding claim, characterized in that it comprises

means for rotating said device (1) about the axis of said cavity (5) to centrifugate the molten metal in the casting die, said means including hydraulic motors provided at each arm (60) of said carousel (61).

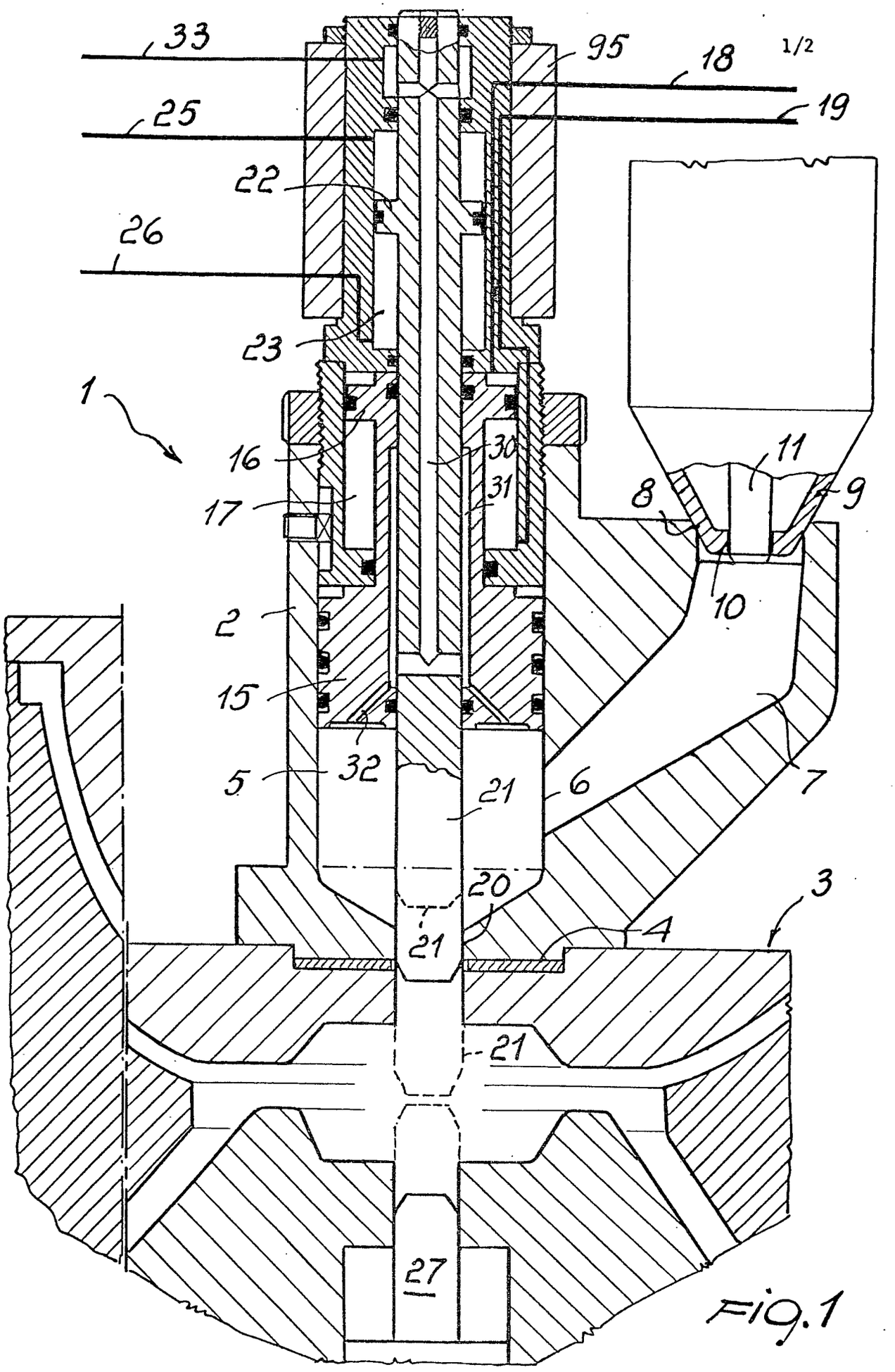
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Fig.1

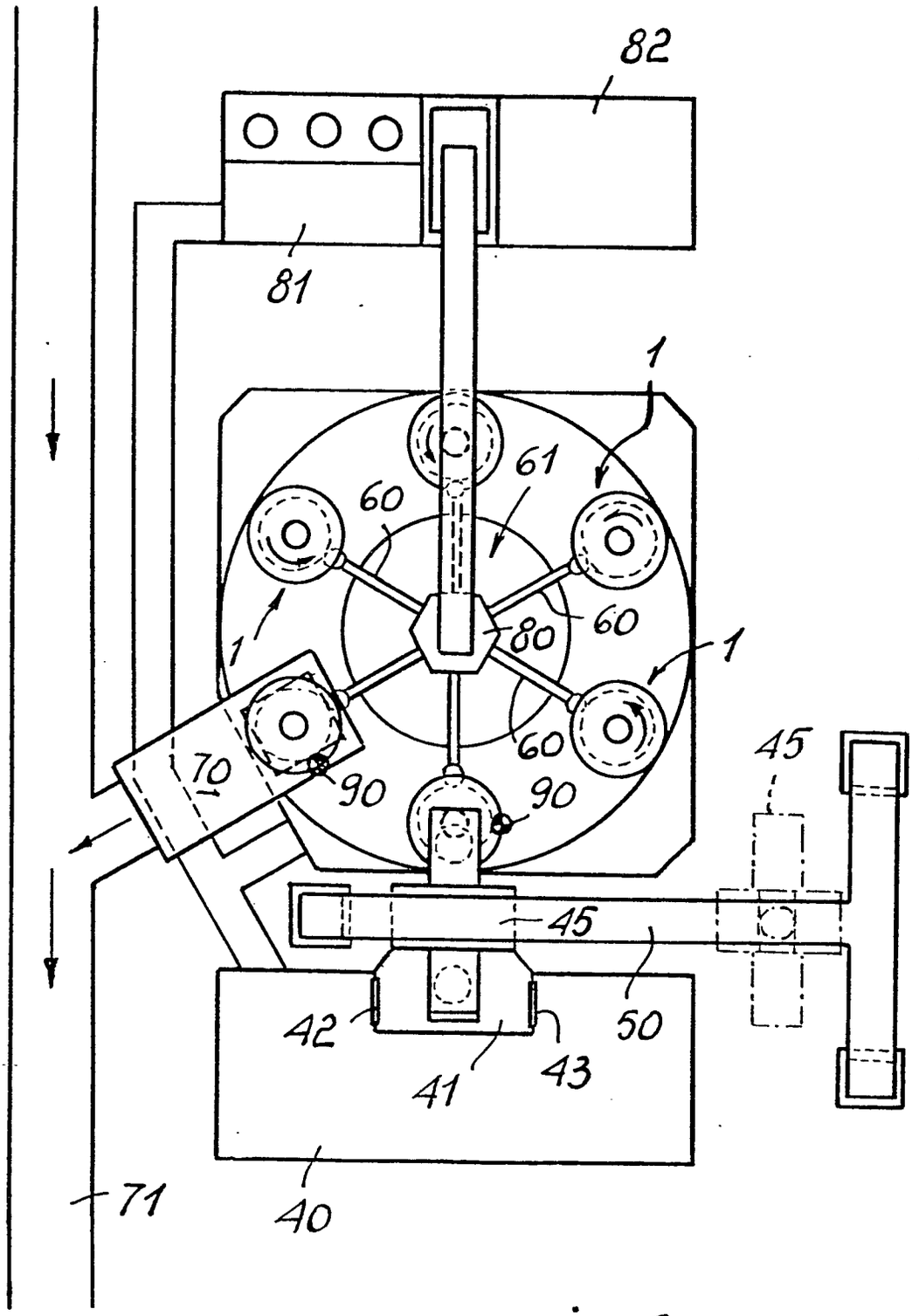

Fig.2

0029511

European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 80 10 6557

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	FR - A - 575 542 (BRUMM) * Complete patent * --	1,2,6, 7,11
	DE - B - 1 160 259 (VEREINIGTE ALUMINIUM-WERKE) * Column 3, lines 52-61 * --	9
	US - A - 3 128 912 (CASH) * Column 2, lines 18-65 * --	1,7
A	DE - C - 745 944 (STRECKER)	
DA	DE - A - 2 720 352 (ZEPPELLINI)	
A	CH - A - 230 300 (SILUMIN)	
A	GB - A - 122 133 (FAIRWEATHER)	
A	US - A - 3 188 703 (LE JEUNE) ----	

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

B 22 D 21/04
18/04
39/02
27/13
27/11

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

B 22 D 18/00
18/02
18/04
27/13
27/15
17/02
17/04
21/04
23/00
39/02
39/00
17/06
27/11

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	18-02-1981	SCHIMBERG