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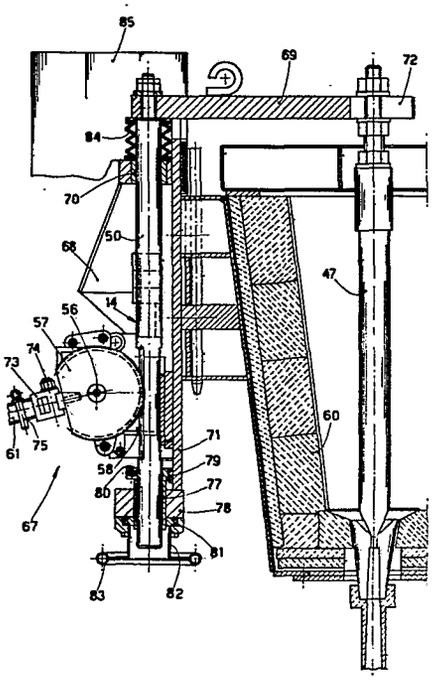
## (54) Commutable device for regulating the stopper of a ladle.

(57) The invention concerns a commutable device for regulating the stopper (47) of a ladle (60), whereby the stopper (47) immersed in the ladle (60) is connected to a shaft (50) which moves in a direction axial to the stopper (47) itself and which comprises advantageously a tract (58) cooperating with axial drive means (57), said device including in mutual cooperation and coordination:

– an actuator means (14) cooperating with said axial drive means (57), whereby intermediate safety means are advantageously present,

– and means to control and regulate the actuator means (14).

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Description of the invention entitled:
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Submitted on under No.

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This invention concerns a commutable device for regulating the stopper of a ladle.

To be more specific, the invention concerns a device able to impart and regulate an axial motion in the stopper so as to govern the flow of the casting of molten metal through the outlet of a ladle.

In particular, the invention in question envisages the embodiment of a device which can be commuted, depending on the source of energy used, so as to employ electromechanical and/or only mechanical means belonging to said device.

It is known that in continuous casting plants the regulation of the flow of the casting of molten metal from the ladle into an appropriate ingot mould is brought about by varying the aperture of the discharge outlet of the ladle.

In practice this operation is generally carried out by using a stopper which is immersed in the molten metal in the ladle and positioned above the outlet.

Variation of the outgoing flow is brought about by moving said stopper axially. If the operation to fill the ingot mould is to be carried out properly, it is important that



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the displacement of the stopper should be very accurately controlled. This is necessary to prevent even small variations in the flow from leading to variations in the volume of molten metal in the ingot mould.

Said variations cause grave risks of a possible overflow of said molten metal and of a defective quality in the finished product.

It is also necessary to bear in mind the fact that the personnel engaged in the continuous casting process carry out regulation of the stopper at a safe distance from the casting flow and ingot mould, and this does not permit a good visual control of the level of molten metal.

For these reasons the displacement of the ladle stopper in the known art is obtained very often with operations which are not manual; in fact, hydraulic actuators are widely employed but, on the other hand, involve considerable risks and shortcomings.

Above all there exists the noteworthy danger due to the presence of the highly inflammable oil used in the hydraulic equipment under high pressure.

There is also the drawback that it is necessary to use pipes to convey the oil which are bulky and deteriorate readily, particularly in surroundings where incandescent materials are being cast.

The properties of the oil itself, which undergoes considerable changes in temperature, may be altered and thereby modify the response of the hydraulic actuator itself.

The invention in question, therefore, proposes to embody a device to regulate the temporary position of the ladle stopper in a very accurate manner, said device being able to cooperate, by means of its mechanical part, with a rod or axial structure substantially parallel to the stopper so as to govern the movements of the stopper itself.

The device is extremely safe or indeed is free from risks and is affected to a negligible extent by creep due to changes in temperature. Moreover, the invention enables a fully automated regulating device to be obtained.

In fact, one or more signals can be derived from a suitable transducer device able to measure the level of the molten metal in the ingot mould, and said signals can be employed to govern the device in question for regulating the stopper.

In substance it is the level itself of the molten metal in the ingot mould which governs the movement of the stopper for opening or closing the outlet of the ladle.

The invention, therefore, consists of a commutable device to regulate the stopper of a ladle, whereby the stopper immersed in the ladle is connected to a rod which moves axially in respect of the stopper itself and which comprises advantageously a tract cooperating with axial drive means, said device being characterized by including in mutual cooperation and coordination:

- an actuator means cooperating with said axial drive means, intermediate safety means being advantageously present,
- and means to control and regulate the actuator means.

We give hereinafter, as a non-restrictive example, the description of a preferential embodiment of the invention, at the same time referring to the attached tables, wherein

Fig. I shows diagrammatically a regulating circuit and a system for activating the ladle stopper;

Fig. 2 shows diagrammatically a variant of the regulating circuit of Fig. I;

Fig. 3 shows an example of the application of the actuator system to a ladle stopper;

Fig. 4 shows a view of an actuator system in orthographic projection;

Fig. 5 show a plan view in orthographic projection of the actuator system of Fig. 4 partially cut away;

Fig. 6 shows diagrammatically a structural variant for application of the actuator system ;

Fig. 7 shows diagrammatically a variant of the manual operation of Fig. 6;

Fig. 8 shows diagrammatically a further structural variant for application of the actuator system;

Fig. 9 shows diagrammatically a variant of the manual operation of Fig. 8.

In the Figures the same parts of parts performing the same functions bear the same reference numbers.

Fig. I show diagrammatically the connections between the regulating and actuating elements comprised in the device in question.

In the example given the signal I0 indicating the level II is picked up by a transducer I2 of any desired type and is conformed and sent in the form of a signal I5 of a suitable nature to an absolute comparator I6. Said comparator I6 controls the level II of the molten material in the ingot mould I7.

The comparator I6 is placed within the means I3 controlling and regulating the speed of the actuator I4, which in our example is of an electromechanical type.

The signal I0 is also sent to a summation means I8. In the absolute comparator I6 are preset, by means of suitable regulators I9 and 20, values of maximum and minimum threshold corresponding to the maximum and minimum values respectively of the level II in the ingot mould I7.

If the level II surpasses the margin established with the values of maximum and minimum threshold, this fact is indicated by suitable luminous or optical signalling means 2I and 22 or by suitable analogue or digital indicator in-



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struments.

The signal I5 is added algebraically in the summation means I8 to a comparison signal 23 which is of the same physical nature as the signal I5 and which corresponds to the value of the optimal level II and is sent by a suitable adjustable 25 generator 24.

The error signal 26 obtained from the algebraic sum of the signals I5 and 23 is compared in a comparator 27.

In the comparator 27 the margin of the variations in level II, as permitted in good working practice, is preset with a threshold of a positive value and a threshold of a negative value by means of two regulators 28 and 29.

Suitable signalling means 30, 3I and 32 indicate either the surpassing of the value of the one or the other of said thresholds by the error signal 26 or else a condition of optimal level II determined by the presence of said level II within the field of values enclosed between said thresholds.

The error signal 26 is also sent to a regulation system 33 which comprises two regulating groups 34 and 36 suitably controlled (38-39-40-4I and 42-43-44-45), a summation means 35, a position transducer 37 and a converter 48.

In particular, the error signal 26 is sent to a regulating group PID 34 having a proportional, integrating and derivative action.

The respective factors of proportionality, integration and derivation and the initial value of integration of said group PID 34 are preset and governed by means of suitable regulators 38, 40 and 4I.

To lessen the inertia of the response of the regulation system to variations in level II, within the summation means 35 there is carried out an algebraic addition of the signal of position 46 of the stopper 47 (as coming from the regul-

ation group PID 34) to the signal of retroaction 49 of position of the stopper 47.

Said signal of retroaction 49 of position of the stopper 47 is obtained by monitoring the movements of the rod 50 by means of the position transducer 37.

A converter 48 processes the signals coming from the position transducer 37 and emits the retroaction signal 49 conformed in such a way that it can be compared with the signal of position 46 of the stopper 47.

The summation means 35 sends a position error signal 5I to the regulating group PID 36, where the regulation parameters are controlled by means of the regulators 42, 43, 44 and 45.

The signal 52 emitted by the regulating group 36 is amplified by an amplifier 53 and is used thereafter to regulate the speed of the actuator I4 or the position of the stopper 47.

In particular, regulation of the speed of the actuator I4 can be done continuously or step-by-step or in a proportional manner.

A clutch 54, which can be operated by hand with means 55 that are rod means in our example, enables the shaft 56 of the actuator I4 to be connected to the drive means 57.

Said axial drive means, which are conformed with a toothed sector 57 in our example, are meshed with a suitable equipped tract 58, which in the present example is conformed rack-wise and is present on the shaft or axial structure 50 able to cooperate with the closure stopper 47 of the outlet hole 59 of the ladle 60.

The toothed sector 57 can also be operated by hand with a suitably placed rod 6I.

In particular, operation by hand is usually carried out after the toothed sector 57 has been disconnected from

the shaft 56 of the actuator I4 by means of the clutch 54. In actual fact the clutch 54 acts also as a means to limit torque for the actuator I4.

Said clutch allows its parts to be released from each other whenever, owing to accidental causes, the electro - mechanical actuator I4 forces the stopper 47 against an obstacle. In such a case it is possible to act by hand on the shaft 50 in an emergency so as to bring the stopper 47 back to its released position without disengaging the clutch 54 beforehand.

In this way overheating and possible burning of the windings of the electromechanical actuator I4 are avoided.

An "ON-OFF" transducer 62 monitors the condition of the clutch 54 and signals by means of an appropriate indicator (or signalling means) 63 the connection of the actuator I4 to the toothed sector 57.

Furthermore, the transducer 62 governs the disconnection of the activator I4 from the regulating group PID 36 and the restoring of electrical conditions of starting the regulation in both the regulating groups 34 - 36.

This governing takes place when the actuator I4 is disconnected from the toothed sector 57 by means of the clutch 54.

The variant shown in Fig. 2 and indicated there with the reference number I33 enables the structure of the regulating circuit 33 of Fig. I to be simplified.

In particular, the regulating circuit 33 is employed advantageously with actuators which have a very quick response in time, and its performance is excessive if used with slow actuators.

In the specific example shown, it is enough to carry out regulation with one single group PD 64 having a proportional and derivative action, since the actuator employed,

being of an electromechanical type in this case, normally has a very slow response in time.

In the example of Fig. 2 the error signal 26 coming from the summation means I8 enters the group PD 64 employed to regulate the speed of the actuator I4 or the position of the stopper 47.

The factors or parameters of proportionality and derivation used in the regulation are preset and controlled by means of suitable regulators 65 and 66.

The descriptions and considerations set forth in the case of the description of the example of Fig. I are also applicable to the remaining part of the control and regulation means I3.

Fig. 3 gives an example of the application of the actuator system 67 to the ladle 60 stopper 47.

The actuator system 67, which is suitably anchored to a supporting structure 68, comprises the toothed sector 57; which in the examples of Figs. I, 2, 3, 4 and 5 is connected axially 56 to the actuator I4 and to the clutch 54 having a mechanical coupling and is connected radially to the hand-operated rod 6I by fork means 73.

The toothed sector 57 cooperates with the tract provided with a rack 58 on the shaft having an axial structure 50.

For illustrative simplicity said Fig. 3 does not show the clutch 54, which is shown instead in Fig. 4 and 5.

The shaft 50 is anchored substantially parallel to the stopper 47 with a rigid arm 69 and is guided at its upper end by a bush 70 upheld by the plate 7I screwed to the ladle 60. The stopper 47 is clamped to the rigid arm 69 inside a lateral regulation slot 72.

The fork 73 is connected to the toothed sector 57 with a bolt 74 and nut which permit a given sideways angulation of the rod 6I so as to facilitate the work of the machine

operator.

The fork 73 is connected to the rod 6I with a locking pin 75 so as to make replacement easy.

In cooperation with the tract having a rack 58 there is envisaged on the plate 7I a reaction block 76, which can be replaced and is employed to prevent bending of the shaft 50 and to maintain good mechanical connection between the rack 58 and toothed sector 57 so as to improve their manoeuvrability and working life.

The reaction block 76 includes an upper layer made of wear-resistant material; said material can be of a plastic type, for instance, of the type commercially known under the name of Rulon-LD.

The shaft 50 slides with its lower part in a movable sleeve 77, which is guided axially by a support 78 and guide 79 which are solidly fixed to the plate 7I.

The movable sleeve 77 includes an elastic clamping half-ring 80, which makes it solidly fixed to the shaft 50, and a threaded tract 8I cooperating with a threaded ring 82 that can be revolved by means of the handwheel 83.

By acting on the handwheel 83 circumferentially, the threaded ring 82 is caused to revolve and displaces axially the sleeve 77 and the shaft 50 solidly fixed thereto.

The rotation of the handwheel 83 leads to micrometric displacements of the shaft 50 and thereby to a fine adjustment of the course of the ladle 60 stopper 47.

In substance, regulation of the ladle 60 stopper 47 by hand is normally carried by acting with the rod 6I on the toothed sector 57, while it is also possible to position the ladle 60 stopper 47 with micrometric movements by means of the handwheel 83.

The upper part of the shaft 50 is protected by means of bellows 84 and an insulated enclosing screen 85.

By means of its weight the shaft 50 enables the whole mechanical structure of the actuator system 67 to be loaded or pre-loaded so as to eliminate mechanical play which could be created in said structure owing to the stresses which it undergoes during working.

This is done so as to prevent mechanical play, even of a small entity, from being able to interfere with the movements, sometimes only millimetric, of the stopper 47.

The actuator system 67 shown in Figs. 4 and 5 can be readily put in a working position or withdrawn from said position; in the example shown it is equipped with pins 86 positioned above it and with two engagement devices 88.

The pins 86 are suitable for being lodged in two appropriate containing seatings 87 machined in the supporting structure 68 placed near the shaft 50, while the two engagement devices 88 can be inserted into the engagement seatings 89 so as to clamp the whole actuator system 67.

Fig. 5 shows the elements constituting the actuator I4, clutch 54 and toothed sector 57. In particular, the actuator I4 comprises a motor 90 the rotation of which is transmitted to a toothed wheel 9I by known means.

The magnitude of the output of the actuator I4 is represented by the angular speed of the shaft 56 to which the toothed wheel 9I is keyed.

The motor 90 employed in the actuator I4 is fed with low tension so as to obviate the risks caused by the presence of high tensions.

In our example a geared motor or step motor fed with direct current can be employed advantageously.

The toothed sector 57, the shaft 92 of which is coaxial with the shaft 56 of the actuator I4, is solidly fixed with a coupling pin 93 to the outer housing 94 of the clutch 54. The hub 95 of the clutch 54 is solidly fixed to the shaft 56.

To make the toothed sector 57 and actuator I4 solidly fixed together, it is necessary to revolve the rod means 55 of the clutch 54.

A torsional pin 96 which is engaged with the means 55 by means of a clamping knob 97 is able to rotate a fork means 98 cooperating with a grooved ring (drum) 99.

Said grooved ring (drum) 99 is conformed outwardly in such a way as to be able to operate a suitably hinged IOI lever IOO between two extreme stable positions corresponding with the engagement or disengagement of the clutch 54 when said ring 99 is displaced by rotation of the fork means 98.

In the engaged position the lever IOO compresses the clutch plates Io2 - Io3 and clamps them together and thereby compresses the outer housing 94 against the hub 95, thereby connecting the motor 90 to the toothed sector 57.

When the motor 90 is disengaged from the toothed sector 57, it is possible to rotate the latter 57 only by hand by means of a rod 6I lodged in an appropriate seating I04 and clamped therein with a screw element I05.

Two frames I06 and I07 able to support and hold the actuator I4 and clutch 54 respectively are solidly fixed together with suitable connecting elements I08 which surmount the toothed sector 57 and remain separate therefrom.

There are comprised in the actuator system 67 some bearings I09 positioned between the frame I06 of the actuator I4 and the toothed sector 57; said bearings enable said toothed sector 57 to rotate freely in respect of the frames I06 and I07.

Other bearings II0 positioned between the shaft 56 of the actuator I4 and the toothed sector 57, together with the aforesaid bearings I09, enable said toothed sector 57 to rotate freely in respect of the shaft 56 when the actuator

I4 is disengaged.

Some variants to the embodiment of the invention are possible.

Thus in a first variant shown diagrammatically in Fig. 6 the actuator I4 can be connected axially through the clutch 54 to a toothed wheel III. Said toothed wheel III is positioned axially parellel to a toothed wheel II3 in such a way as to cooperate therewith II3.

The toothed wheel III, however, can be positioned diversely and be inclined diversely in respect of the wheel II3 by using transmission means and supplementary toothed wheels.

The toothed wheel II3 is axially solidly fixed to a toothed wheel II4 so as to constitute axial drive means II2. Said axial drive means II2 comprise axially a threaded cylindrical through hole II5 cooperating with a circumferentially threaded tract 58 of the shaft 50.

By engaging the actuator I4 with the toothed wheel III through the clutch 54, it is possible to revolve the axial drive means II2, which in turn impart a vertical movement to the shaft 50.

The relative vertical movement as between the axial drive means II2 and the shaft 50 takes place because they are engaged separately from each other.

In particular, the shaft 50 can be engaged with some guide blocks II6 cooperating with lengthwise flat guide tracts II7 present in the upper and/or lower part of the shaft 50. Said guide blocks II6 enable the shaft 50 to move vertically and prevent it from rotating.

The axial drive means II2 can be fixed and contained in a frame wherein the actuator I4, clutch 54 and toothed wheel II2 can also be lodged.

The regulation of the shaft 50 by hand is brought about

by rotating with the rod 6I a toothed sector 57 cooperating at right angles with the toothed wheel II4 of the axial drive means II2.

It is possible to position the toothed sector 57 and toothed wheel II3 differently and incline them differently in respect of each other by visualizing the employment of different profiles for the cooperating screw threads.

Thus, for example, it is possible to make the toothed sector 57 and toothed wheel II4 coplanar. It is possible to make the toothed sector 57 and toothed wheel II3 coplanar by eliminating the toothed wheel II4.

A further regulation by hand can be carried out with suitable means II8 present in the lower part of the axial drive means II2.

A different structuring of the manual activation can be envisaged, as shown in Fig. 7.

In particular, a toothed wheel II9 can be envisaged as being solidly fixed to the toothed wheel III. Said toothed wheel II9 cooperates with a toothed wheel I20 positioned at right angles to itself II9.

The toothed wheel I20 can be operated by hand with crank means I2I able to adhere at least partially to the outer flat side I22 of the said wheel I20 during said operation.

In particular, said crank means I2I comprise pins I23 able to be engaged in suitable seatings I24 machined in the outer flat side I23 of the toothed wheel I20 in such a way as to make the crank means I2I and toothed wheel I20 firmly fixed together during rotation by hand.

Disengagement of the crank means I2I from the toothed wheel I20 is ensured with elastic axial repelling means I25 cooperating with a catch I26.

It is possible to visualise the employment of different

means to rotate the toothed wheel I20.

It is possible to position the toothed wheels II9 and I20 differently and incline them differently in respect of each other by using once again the connection of the actuator I4 and clutch 54 as shown in Figs. 6 and 7.

It is possible to position and incline the actuator I4 in different ways in respect of the shaft 50, and transmission means and supplementary toothed wheels can be employed for this purpose.

According to another variant of the embodiment of the invention shown in Fig. 8, the actuator I4 and clutch 54 are positioned on the same axis as the shaft 50, an actuator I4 of a linear type being employed in this case.

Vertical displacement of the shaft 50 takes place as an effect of the rotation of the inwardly threaded axial drive means II2 cooperating axially with said shaft 50.

The axial drive means II2 can be connected to the actuator I4 through the clutch 54 so as to be operated thereby I4.

Vertical displacement of the shaft 50 accompanied by the guide block II6 takes place in the way described for Fig. 6.

Rotation by hand of the axial drive means II2 to cause vertical displacement of the shaft 50 can be brought about by acting on the toothed sector 57 meshed with the toothed wheel II3 belonging to said axial drive means II2.

Said rotation by hand can also take place by acting with the means connected to the rotor of the actuator I4 after the axial drive means II2 have been connecetd to the actuator I4 by the clutch 54.

It is possible to foresee solutions through cooperation between the toothed sector 57 and toothed wheel II3 or the axial drive means II2, said solutions being wholly like

those already put forward in the example of Fig. 6.

Fig. 9 shows a variant of Fig. 8 wherein the crank activating means already shown in Fig. 7 are employed.

In said Fig. 9 the positioning and way of working of the actuator I4 and clutch 54 remain substantially unchanged as compared to Fig. 8.

We have described here some possible embodiments of the invention, but other variants are possible for a technician in this field without departing thereby from the scope of the idea of the solution.

Thus the action on the stopper can be continuous or can take place step-by-step or with self-controlled proportional operations, etc.

The action on the stopper can also be carried out axially; instead of the electromechanical or electrical actuator an electro-hydraulic actuator can be fitted; where an electro-hydraulic actuator is employed, a safety valve or by-pass valve, for instance, can be fitted instead of the clutch 54, etc.

It is also possible to vary the proportions and sizes and to add, remove, replace and integrate parts, etc., all these and other variants being possible.

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# C L A I M S

I. Commutable device for regulating the stopper (47) of a ladle (60), whereby the stopper (47) immersed in the ladle (60) is connected to a shaft (50) moving in a direction axial to the stopper (47) itself and comprising advantageously a tract (58) cooperating with axial drive means (57-II2), said device being characterized by including in mutual cooperation and coordination:

- an actuator means (I4) cooperating with said axial drive means (57-II2), whereby intermediate safety means (54) are advantageously comprised,
- and means (I3) to control and regulate the actuator means (I4).

2. Commutable device for regulating the stopper (47) of a ladle (60), as in Claim I, characterized by the fact that the actuator means (I4) is an electrical or electromechanical actuator means.

3. Commutable device for regulating the stopper (47) of a ladle (60), as in Claim I, characterized by the fact that the actuator means (I4) is an electro-hydraulic actuator means.

4. Commutable device for regulating the stopper (47) of a ladle (60), as in Claim I and in one or the other of the Claims thereafter up to Claim 3 inclusive, characterized by the fact that the intermediate safety means (54) are clutch means.

5. Commutable device for regulating the stopper (47) of a ladle (60), as in Claim I and in one or the other of the Claims thereafter up to Claim 3 inclusive, characterized by the fact that the intermediate safety means (54) are valve means.

6. Commutable device for regulating the stopper (47)

of a ladle (60), as in Claim I and in one or another of the Claims thereafter up to Claim 5 inclusive, characterized by the fact that the actuator (I4) is positioned sideways to the shaft (50), whereby there are intermediate transmission means.

7. Commutable device for regulating the stopper (47) of a ladle (60), as in Claim I and in one or another of the Claims thereafter up to Claim 5 inclusive, characterized by the fact that the actuator (I4) lies on the same axis as the shaft (50).

8. Commutable device for regulating the stopper (47) of a ladle (60), as in Claim I and in one or another of the Claims thereafter, characterised by the fact that the control and regulation means (I3) comprise at least one regulating circuit (33), whereby said control and regulation means (I3) are conditioned by the level (II) in the ingot mould (I7).

9. Commutable device for regulating the stopper (47) of a ladle (60), as in Claim I and in one or another of the Claims thereafter, characterized by the fact that the conditioning of the control and regulation means (I3) takes place at least through one summation means (I8) that also performs comparison functions.

I0. Commutable device for regulating the stopper (47) of a ladle (60), as in Claim I and in one or another of the Claims thereafter, as described and shown and for the purposes granted.

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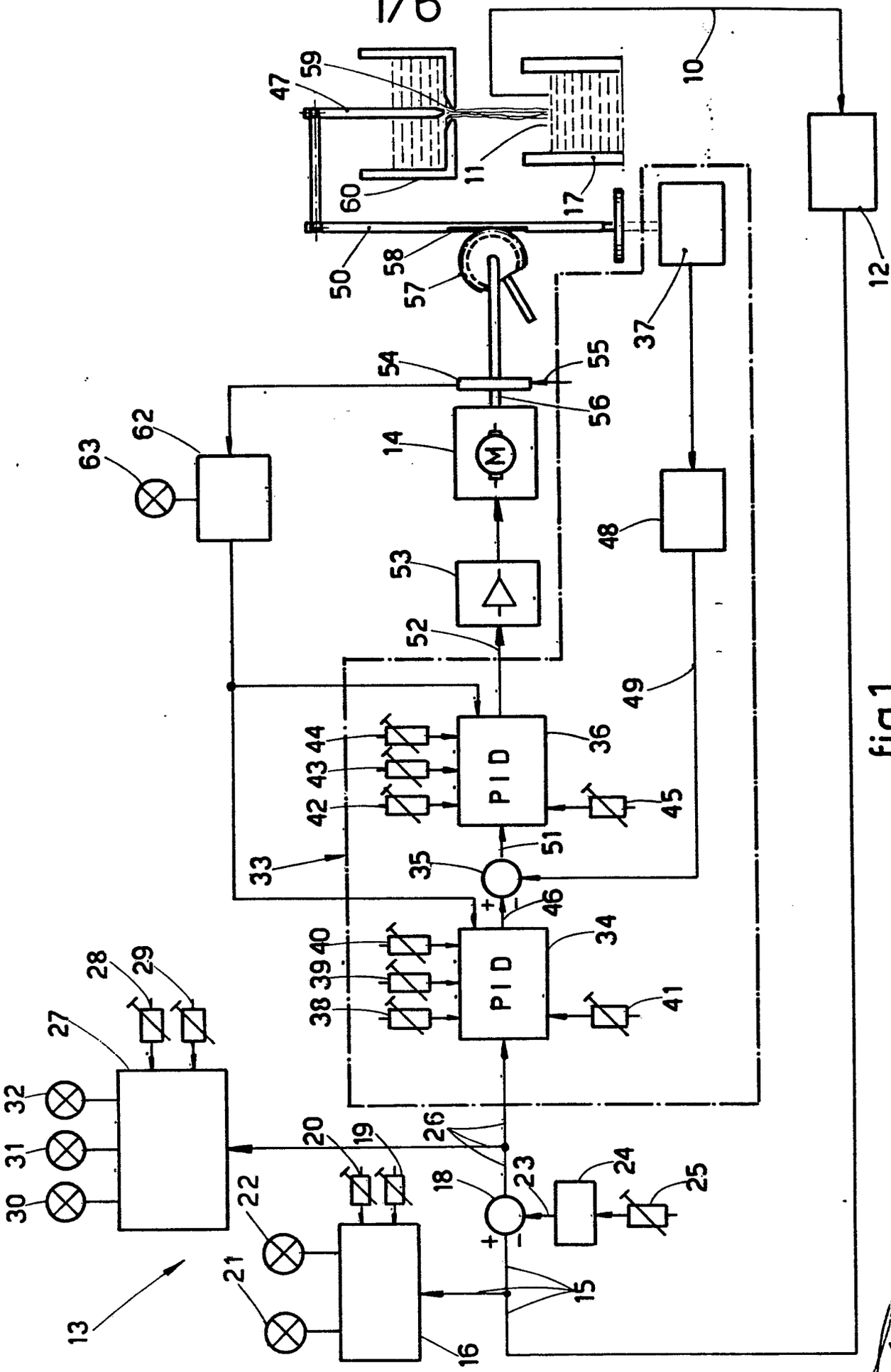


fig.1

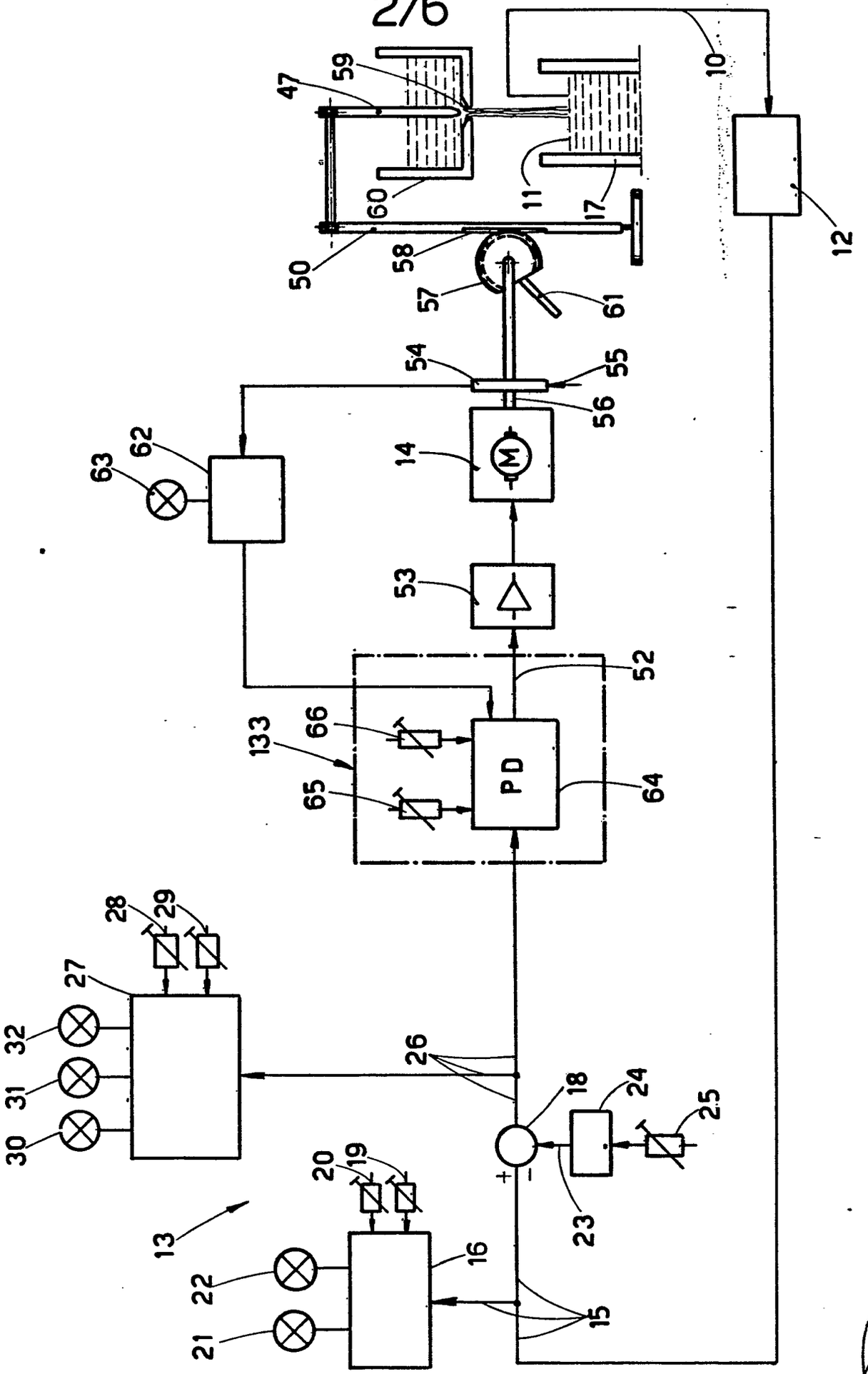
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fig.2

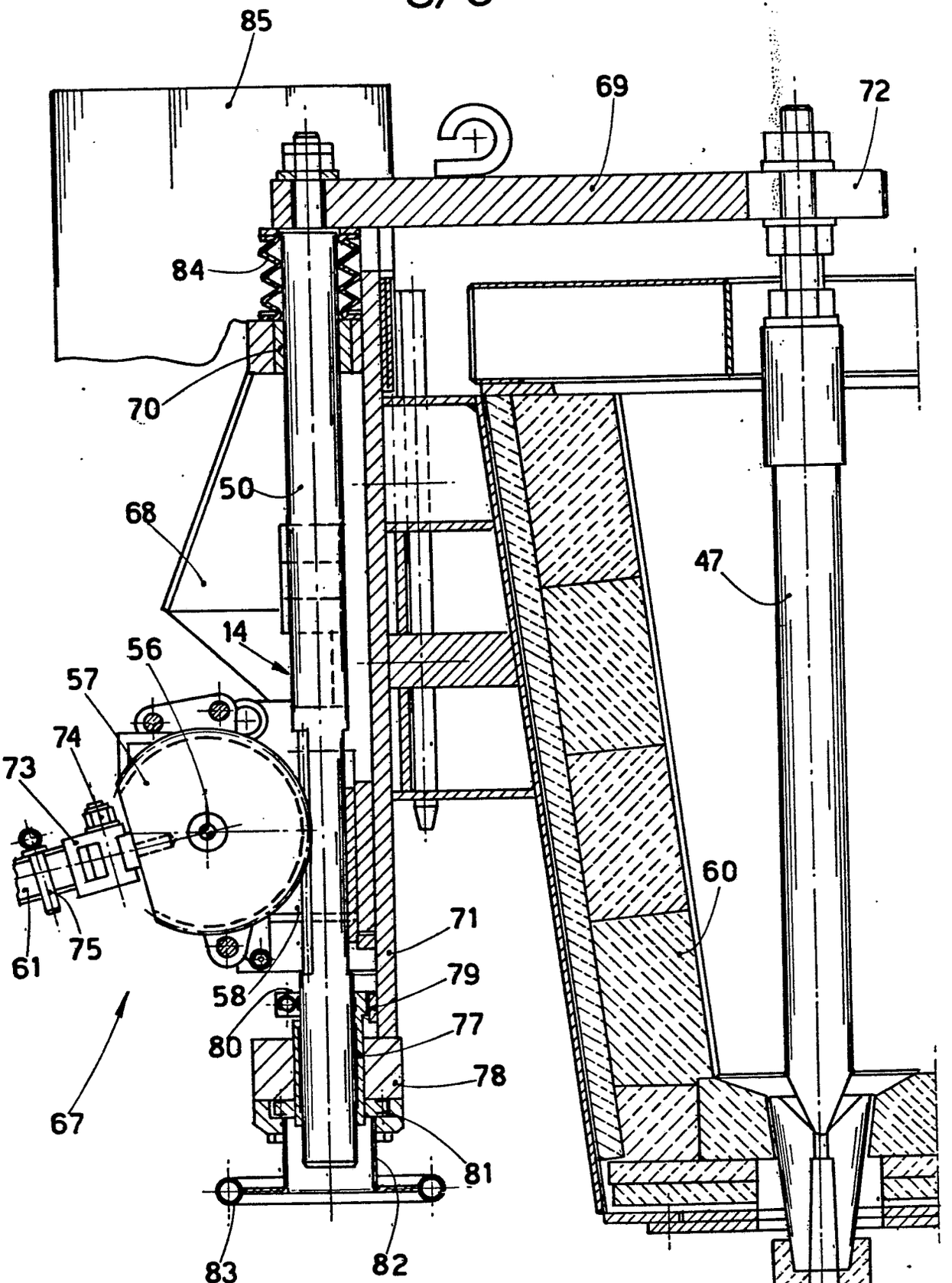
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fig.3

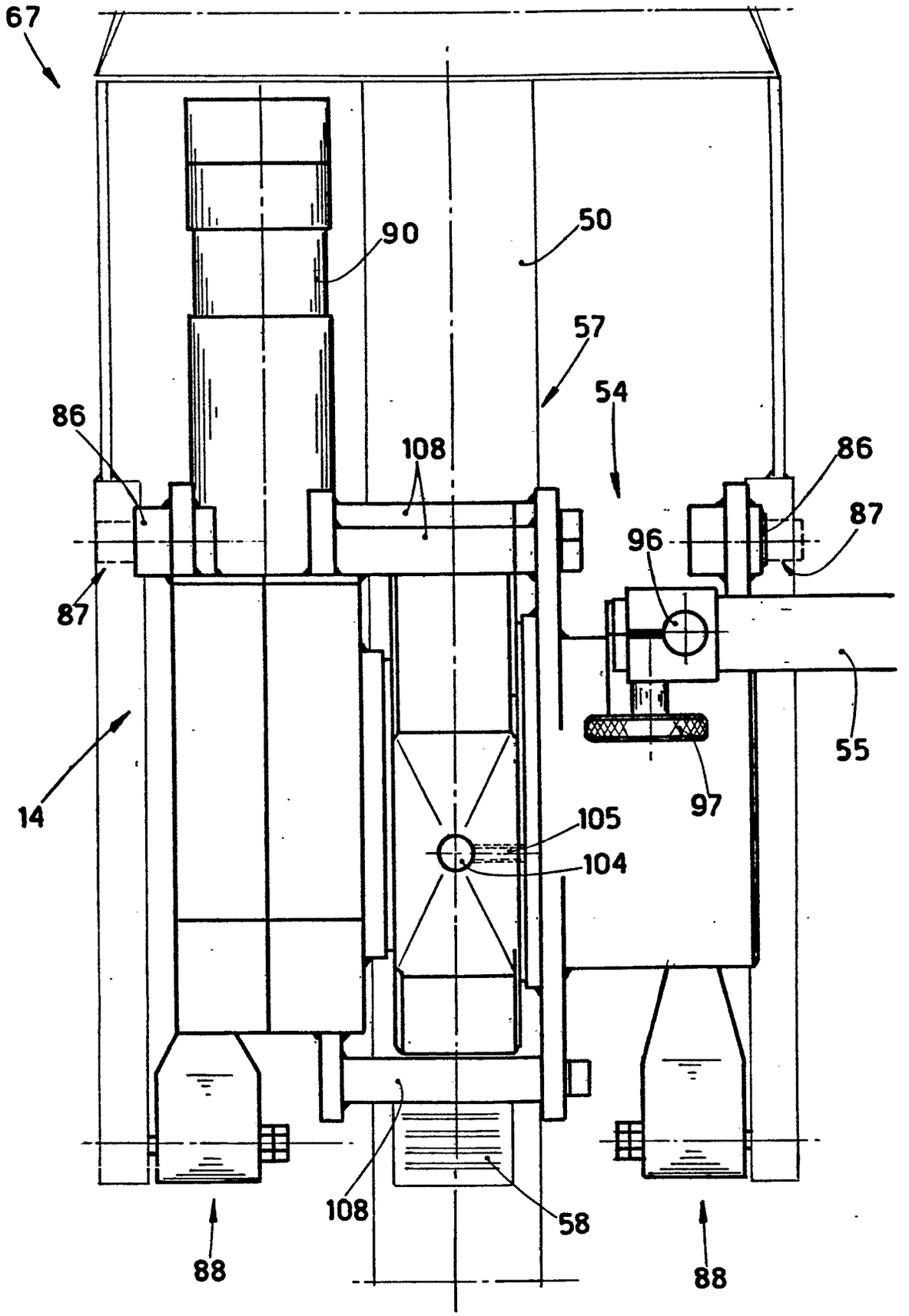


fig.4

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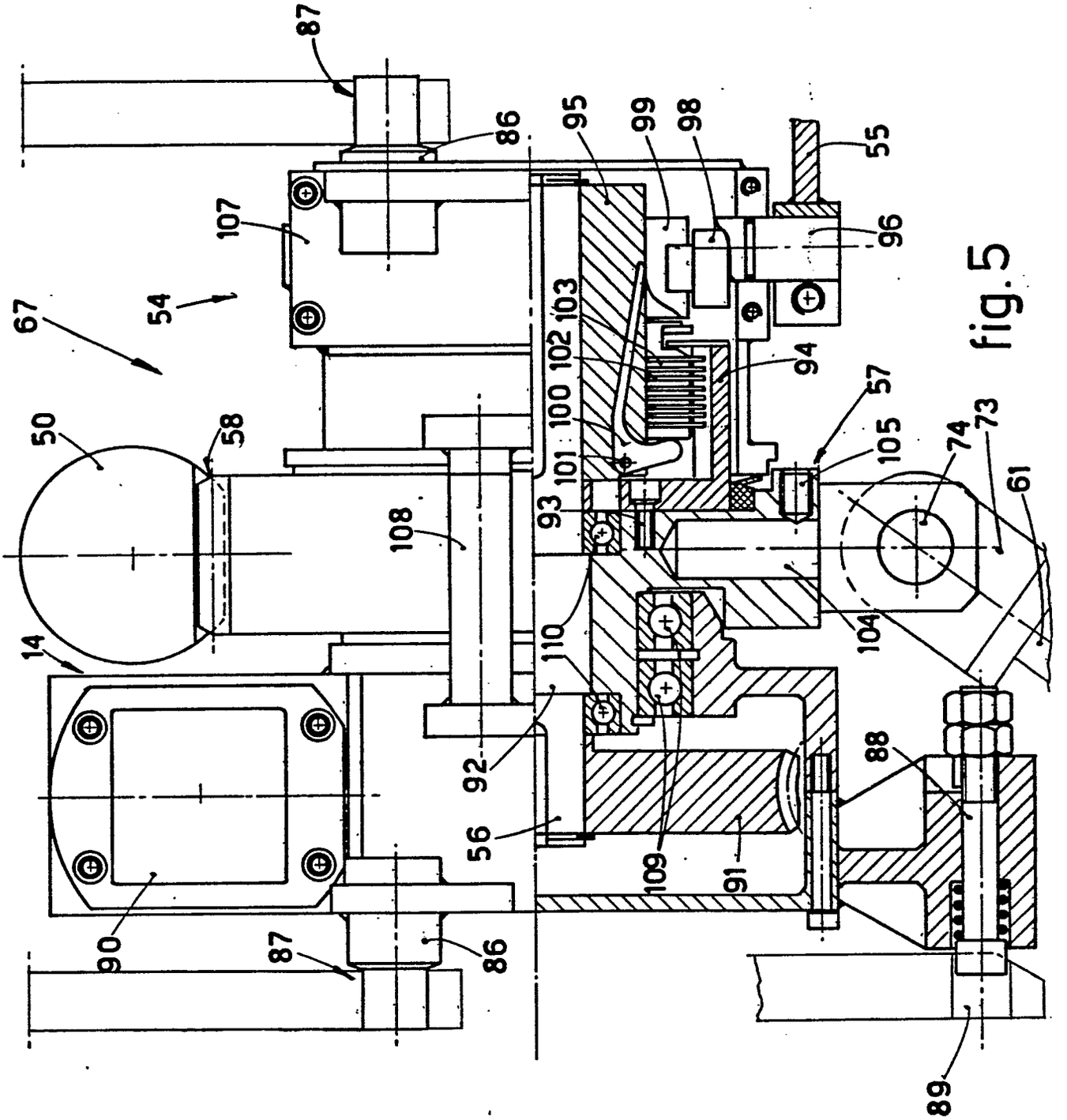


fig.5

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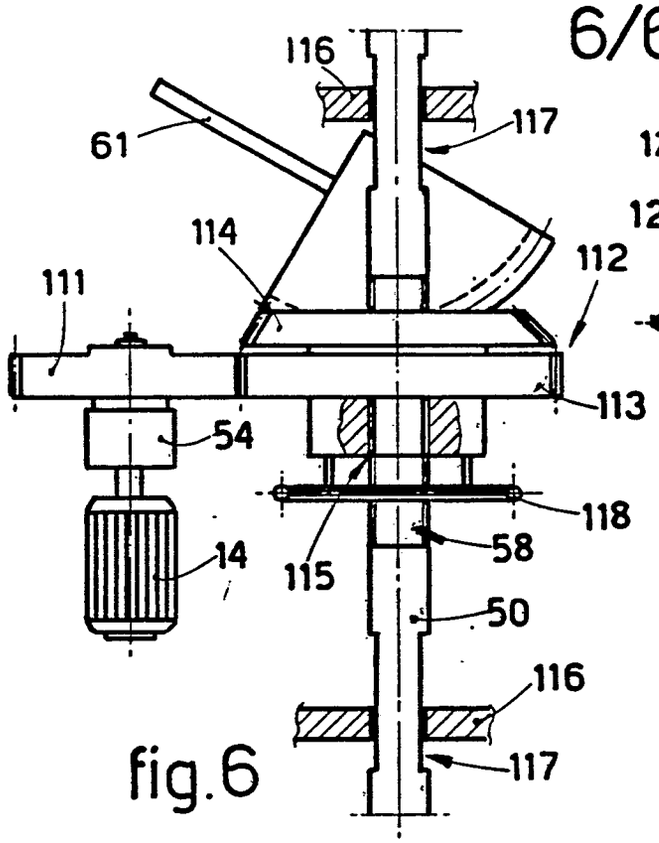


fig.6

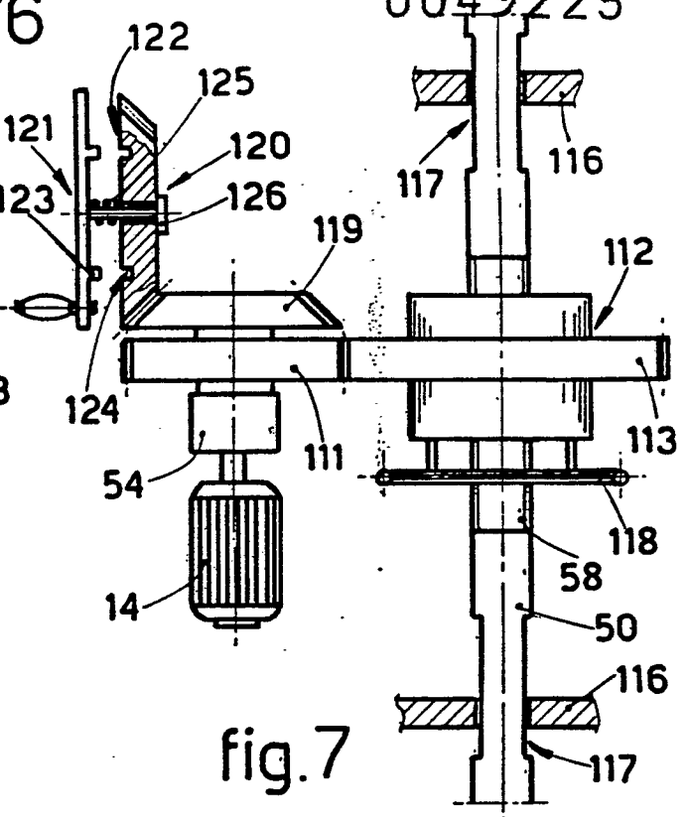


fig.7

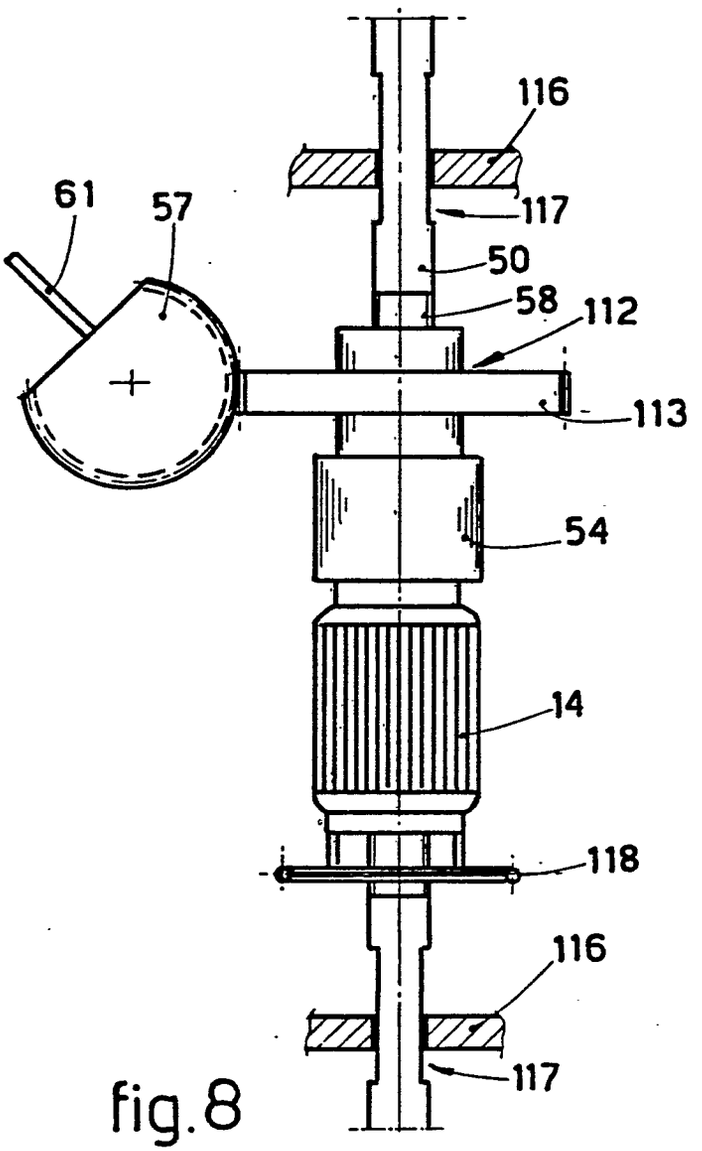


fig.8

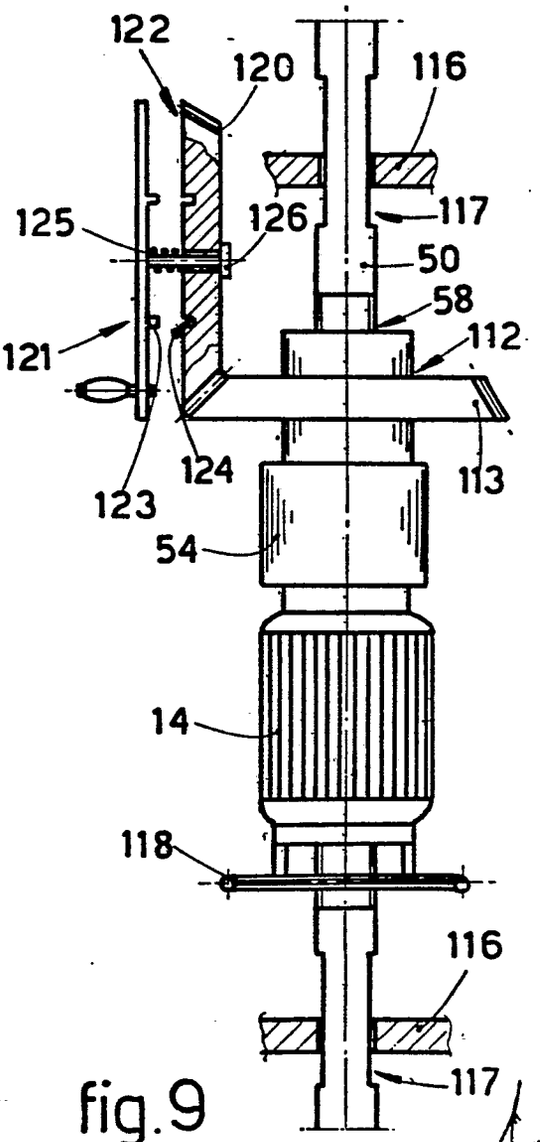


fig.9

0049225

European Patent Office

# EUROPEAN SEARCH REPORT

Application number
EP 81 83 [illegible]

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim |
|---|---|---|
| X | EP - A - 0 006 433 (SOCIETE DES ACIERS FINS DE L'EST)<br>* page 2, lines 6-34; page 3, line 3 - page 4, line 35 * | 1,2,4, 6,8 |
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| A | DE - B - 1 232 604 (KRUPP HUTTEN-WERKE) | |

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

B 22 D 41/10
11/16

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

B 22 D 41/10
11/16

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 | 30-12-1981 | SCHIMBERG |