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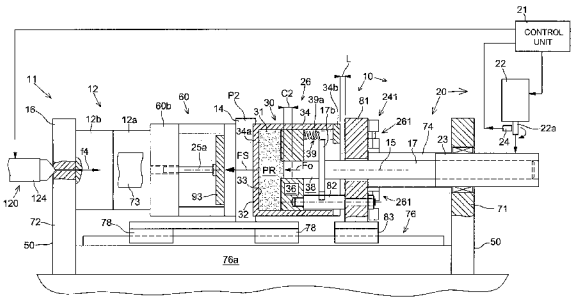
(54) **Title:** MACHINE WITH IMPROVED STRUCTURE, FUNCTIONS AND PERFORMANCES FOR THE INJECTION MOULDING OF PLASTIC MATERIALS



(57) **Abstract:** An innovative injection moulding machine (11) for plastic materials, comprising a mobile mould-bearing platen (14) and a fixed mould-bearing platen (16) bearing respectively a first mobile half-mould (12a) and a second fixed half-mould (12b) of a mould (12); an actuating unit (20) including an actuating rod (17) to move the mobile mould-bearing platen (14) towards the fixed mould-bearing platen (16) in such a way as to close the two half-moulds (12a, 12b) together; a closing unit (26, 30) operatively connected to the mobile mould-bearing platen (14) in order to close it, in the closed position (P2) corresponding to the contact between the two half-moulds (12a, 12b), against the fixed mould-bearing platen (16); and blocking means (241, 261) associated with the closing unit (26, 30) to block the mobile mould-bearing platen (14) when it is in the closed position (P2), wherein the closing unit (26) comprises a hydraulic force amplifier (30) which is adapted for receiving, from a piston (38) defined at one end (17a) of the actuating rod (17), a given input force (Fo) and applying in response, upon the mobile mould-bearing platen (14) in the closed position (P2), a given closing force (FS) that is amplified with respect to the input force (Fo). The fixed structure (50) of the moulding machine comprises two tie bars (73, 74) which extend between two sides (71, 72) in the longitudinal direction parallel to the stroke (C) of the mobile mould-bearing platen (14) and which are suitable for receiving and contrasting totally the amplified closing force (FS) produced by the hydraulic amplifier (30). The moulding machine (11) also comprises an injecting unit (120) provided with a special reflux device (141) which enables the molten plastic material (PL) to flow backwards during the final stage of injecting and compacting of the plastic material injected into the mould (12).

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MACHINE WITH IMPROVED STRUCTURE, FUNCTIONS AND PERFORMANCES FOR THE INJECTION MOULDING OF PLASTIC MATERIALS

Technical field

This invention relates generally to the sector of machines for the injection moulding of plastic materials, and more specifically it relates to an injection moulding machine that includes important improvements in both its operative functional units and its global supporting structure as compared with the conventional moulding machines for plastic materials in current use.

Background art

The injection moulding machines for plastic materials known and used in the industry today have a series of common characteristics such as a mobile mould-bearing platen and a fixed mould-bearing platen, upon which are mounted respectively a mobile half-mould and a fixed half-mould of a mould.

In operation of the moulding machine, the mobile mould-bearing platen is moved in linear fashion relatively to the fixed mould-bearing platen in such a way as to close the mobile half-mould against the fixed half-mould.

At this point, plastic material in the fluid state is injected into the mould by an injecting unit, while the two respective half-moulds are secured one against the other by suitable closing means to prevent them from coming apart on account of the high pressure at which the plastic material is injected into the mould.

In the known injection moulding machines the actuating means that actuate the mobile mould-bearing platen to move it towards the fixed mould-bearing platen generally also perform the function of exerting the closing force necessary to clamp the mobile mould-bearing platen against the fixed mould-bearing platen and thus keep the two half-moulds together during the injection and moulding stage.

In these moulding machines therefore, the closing force is supported mostly by the actuating means, consisting of hydraulic jacks for instance, with the result on the one hand that high closing force values may compromise functionality of the actuating means, as well as implying a significant energy cost for the power needed to drive them, and on the other hand that low closing force values, still acceptable for the actuating means, may however not suffice for many applications in the field of injection moulding.

In the known injection moulding machines the mobile mould-bearing platen is guided all through its linear horizontal movement from and towards the fixed mould-

bearing platen by suitable guides extending longitudinally, usually taking the form of a plurality of columns, in particular cylindrical and for example four in number, which cooperate with corresponding bushes or similar guiding organs arranged in correspondence with the apexes of the mobile mould-bearing platen.

The longitudinal columns or guides are configured, within the overall fixed bearing structure of the injection moulding machine, not only to guide the mobile mould-bearing platen in its linear movement before and after the stage of injecting plastic material into the mould, but also to support and contrast the closing force that is applied to the two parts of the mould while they receive the injected plastic material.

Therefore these guides are subjected both to continuous sliding by the bushes of the mobile mould-bearing platen and to a traction force, acting periodically, of considerable entity corresponding to the closing force, with the result that the guiding system of the mobile mould-bearing platen may in time become subject to wear, play and permanent deformations that could prevent perfect and precise closing between the mobile half-mould and the fixed one, and then compromise proper operation of the injection moulding machine.

It is also noted that these problems, whereas no satisfactory solution should be found for them, could hold back and hinder the development and construction of injection moulding machines capable of producing closing forces, between the two separable parts of the mould, of an even greater entity than on the current machines, and thereby permitting the injection pressure of the plastic material to be further increased.

Finally various solutions are currently used for the injection unit mounted on the moulding machine and adapted for injecting the plastic material in the molten state into the mould.

One of the most common solutions adopted on current injection moulding machines comprises a rotating plasticizing screw, housed inside a plasticizing cylinder, which is suitable for receiving, on rotating, from a reserve or external container the raw material, normally in granulated or powder form, and feeding it while subject to a plasticizing process towards an injection chamber, where the plasticized material is finally injected into the mould through an injecting nozzle.

Other solutions are known in which the injection unit also comprises, in addition to the plasticizing screw, a piston or similar element, which is suitable for advancing in the axial direction along a pass-through guide hole formed axially via the rotating

plasticizing screw for injecting into and compressing in the mould the plasticized raw material that fills the injection chamber.

These solutions do not however come without drawbacks and, at least in general terms, appear in need of further improvement.

In particular it would be beneficial to further improve control of the pressure present in the plasticized fluid material that is injected into the mould, both during the injecting and mould filling step true and proper, and also at the end of the step when the plastic material injected is definitively compressed and compacted in the mould.

Another possible improvement would also be to produce a less cumbersome injection unit than the current ones, characterized in particular by having a ratio between the axial length or extension of the plasticizing screw and the latter's diameter that is much lower than in the injection units currently in use.

Disclosure of invention

Accordingly a first object that this invention intends to achieve is that of producing a machine for the injection moulding of plastic materials that is capable of applying and developing high closing forces to keep the two half-moulds joined during the piece moulding step, in keeping with the current expectations and requirements of the art in the injection moulding field, without these closing forces of considerable entity being able to encumber or negatively impact the means that actuate and move the mobile mould-bearing platen to close it against the fixed mould-bearing platen.

A second object that this invention intends to achieve is that of producing an injection moulding machine that, though being capable of applying high closing forces to keep the two parts of the mould joined during the plastic material injection step, is able to ensure a proper and exact guiding of the mobile mould-bearing platen in time, without wear or other phenomena arising that could compromise operation of the mobile mould-bearing platen guiding system and hence the proper closing of the two parts making the mould, and thereby require frequent maintenance work as often happens with the conventional machines.

A third object that this invention intends to achieve is that of producing an injection unit that is able to develop considerably higher injection pressure values than those obtainable with the currently used injection units, and which at the same time is suitable for effectively keeping the injection pressure under control during the entire step of injecting plastic material into the mould, so as to further improve the

performance and efficiency of the moulding machine on which the said injection unit is installed.

A fourth object, associated with the previous one, is that of producing an injection unit characterized by having a compact and less cumbersome structure than the injection units mounted on today's plastic material injection moulding machines.

The above objects may be considered to be fully achieved by the machine for the injection moulding of plastic materials which possesses the characteristics set out in the various independent claims.

Particular embodiments for carrying out the invention are also defined by the independent claims.

Numerous advantages and performances are associated with the machine for injection moulding of plastic materials according to this invention, which is characterized by having a significantly improved structure and functions compared with the current machines.

Some of such advantages are cited in the following purely by way of example:

- the possibility of keeping the mould closed and blocked during the plastic material injection step by way of closing forces of a very high value, in spite of the fact that actuating forces of a relatively low entity are applied by the mould actuating and movement means, without these high closing forces having a negative influence on the functionality of the actuating means and/or damaging them;
- limited stresses acting on the guiding system of the mobile parts and therefore wear of said guiding system practically absent in time;
- effective control of the injection pressure with optimal compacting of plastic material in the molten state inside the mould;
- greater regulation possibilities of the moulding machine's parameters (stroke, advancing speed of the mobile mould-bearing platen, etc.).

Brief description of drawings

These and other objects, characteristics and advantages of this invention will become apparent in the description that follows of a preferred embodiment, provided purely by way of example with reference to the accompanying drawings, where:

Fig. 1 is a schematic and partial plan view, of a machine for the injection moulding of plastic materials, according to this invention, represented in a first initial configuration with the two half-moulds of a mould mounted on this moulding machine open and set apart from one another;

Fig. 2 is a plan view, with a number of sectioned areas, of the machine for the injection moulding of Fig. 1, in the starting configuration;

Fig. 3 is a partially sectioned lateral view according to the line III-III of Fig. 2;

Fig. 4 is a lateral view with a number of parts sectioned according to the line IV-IV of Fig. 2;

Fig. 5 is a section view according to the line V-V of Fig. 2;

Fig. 6 is a section view according to the line VI-VI of Fig. 2;

Fig. 7 is a section view according to the line VII-VII of Fig. 4;

Fig. 7a is an enlarged section, according to the line VII-a – VII-a of Fig. 4;

Fig. 7b is an enlarged section, according to the line VII-b – VII-b of Fig. 4;

Fig. 7c is an enlarged section, according to the line VII-c – VII-c of Fig. 4;

Fig. 7d is an enlarged section, according to the line VII-d – VII-c of Fig. 7c;

Fig. 8 is a partial schematic view, with a number of sectioned parts, which represents overall an injection unit of the moulding machine of Fig. 1;

Fig. 8a is a schematic, enlarged section view of an area, including a reflux device, of the injection unit of Fig. 8;

Figs. 8b and 8c are respectively a plan view and a section view, according to the line VIII-c - VIII-c of Fig. 8b, of a first detail of the reflux device of Fig. 8a;

Figs. 8d and 8e are respectively a plan view and a section view, according to the line VIII-e - VIII-e of Fig. 8d, of a second detail of the reflux device of Fig. 8a;

Figs. 8f and 8g are respectively a partial plan view and a section view, according to the line VIII-g - VIII-g of Fig. 8f, of the area of the reflux device of Fig. 8a, represented in a first, closed operating configuration;

Fig. 9 is a lateral, schematic and partial view of the injection moulding machine of the invention of Fig. 1, represented in a second intermediate configuration corresponding to the contact between the two half-moulds, immediately before their final closing;

Fig. 9a is a lateral view of an area of the injection moulding machine of Fig. 9, in the intermediate configuration;

Fig. 9b is an enlarged view of an area, indicated by a dot and dash circle, of the injection moulding machine of Fig. 9a;

Fig. 10 is a lateral, schematic and partial view, of the injection moulding machine for plastic materials of Fig. 1, in a third final configuration with the two half-moulds closed and definitively clamped for receiving the plastic material injected into the mould;

Fig. 10a is a partial, schematic plan view of the moulding machine in the third, final configuration of Fig. 10;

Figs. 11a and 11b are respectively a partial plan view and a section view, according to the line XI-b - XI-b of Fig. 11a, of the area of the reflux device of Fig. 8a, represented in a first, closed operating configuration;

Figs. 11c and 11d are respectively a partial plan view and a section view, according to the line XI-d - XI-d of Fig. 11c, of the area of the reflux device of Fig. 8a, represented in a second, open operating configuration; and

Fig. 12 is a partial, schematic plan view of the injection moulding machine for plastic materials of Fig. 1, in a fourth configuration following the final one, while the piece is being extracted from the mould at the end of a moulding cycle;

Fig. 13 is a flow diagram which schematically illustrates the general functioning of the injection moulding machine of Fig. 1;

Fig. 13a is a flow diagram which illustrates in detail the specific injection stage, of the general functioning of Fig. 13, in which plastic material is injected into mould;

Fig. 14 is a partial schematic view, with some parts sectioned, of a variant of the injection unit of Fig. 8; and

Fig. 14a is a section view according to the line XIV-a - XIV-a of Fig. 14.

Best mode for carrying out the invention

This patent application claims the priority of a number of previous Italian patent applications filed by the same Applicant, and in particular, as will be seen better in the following, it relates to a machine generally provided for the injection moulding of plastic materials that includes and incorporates the innovations variously set out in the above-mentioned previous patent applications.

For clarity's sake and also to permit a smooth and easy link between the contents of this patent application and those of the above-mentioned previous patent applications filed by the Applicant, the current description will, as much as possible, maintain, when indicating similar and corresponding parts, the same numerical references as already established and used in these previous applications.

Moreover, where it proves useful and necessary to provide new indications, it will use and adopt additional and coherent numerical references, in particular incremented by 100 or multiples of 100 with respect to the already established ones.

With reference to Fig. 1, a plastic material injection moulding machine, according to this invention, is generically designated by the numeral 11, and comprises:

- a fixed structure 50;
- a mobile mould-bearing platen 14 and a fixed mould-bearing platen 16, the first suitable for moving with respect to the fixed structure 50 and the second integral

with the latter, which are provided for bearing respectively a first mobile half-mould 12a and a second fixed half-mould 12b, separable from one another and represented by a dot and dash line, which make up a mould 12;

- an actuating and closing assembly, generically designated by the numeral 10 and associated with the fixed structure 50, the function of which is to actuate and move the mobile mould-bearing platen 14 towards the fixed mould-bearing platen 16, in such a way as to close and secure the mobile half-mould 12a against the fixed half-mould 12b and thus arrange the mould 12 for injection inside it of the fluid plastic material;
- blocking means, associated with the actuating and closing assembly 10 and generically designated with the numeral 241, which are suitable for blocking with respect to the fixed structure 50 the parts, in particular the mobile mould-bearing platen 14, bearing the mobile half-mould 12a, so as to keep stably clamped the two half-moulds 12a and 12b, once closed one against the other, during the step of injecting plastic material into the mould 12;
- an injection unit, generically designated with the numeral 120 and associated with the fixed mould-bearing platen 16, the function of which is to inject the plastic material in the fluid state into the closed mould 12; and
- an extracting device 125 the function of which is to extract the moulded piece from the mould 12, at the end of each moulding cycle.

The mobile half-mould 12a is intended to be rigidly secured on the mobile mould-bearing platen 14 by means of a removable mounting structure or tool 60 which also accommodates a number of parts of the extracting device 125, as described later in detail.

In addition the two mobile and fixed half-moulds 12a, 12b are associated with centering elements, designated overall with the numeral 12' and consisting for instance of plugs and corresponding holes, which are suitable for cooperating in contact during the step of closing the two half-moulds 12a, 12b so as to ensure proper and exact coupling between them.

<u>General structure of the injection moulding machine of the invention</u>

As shown in the Figs. 1 to 4, the fixed structure 50 of the injection moulding machine 11 is essentially made of two vertical fixed plates or flanks or walls, designated respectively with numerals 71 and 72, which are arranged in correspondence with the ends of the moulding machine 11;

of two tie bars 73 and 74, also called link bars or columns, the function of which will be better explained in the following, which extend horizontally from opposite ends along the sides of the moulding machine 11, with each of these rigidly connected at the ends to the two fixed walls 71 and 72; and

of two longitudinal guides 76 and 77 which also extend horizontally, parallel to the tie bars 73 and 74, and have the function of guiding the mobile mould-bearing platen 14 in its relative motion with respect to the fixed mould-bearing platen 16, i.e. of closing the two half-moulds 12a and 12b one against the other and of subsequently separating them, as will be described below.

Both the tie bars 73 and 74 and the guides 76 and 77 extend in the longitudinal direction of the moulding machine 11 parallel to the stroke, indicated with C, made by the mobile mould-bearing platen 14 through the moulding machine 11 to cover the distance that separates the two half-moulds 12a and 12b so that they close together.

One of the two fixed walls of the structure 50, i.e. the fixed wall 72, constitutes the fixed mould-bearing platen 16 that supports the fixed half-mould 12b and accordingly defines the injection side of the moulding machine 11, i.e. the side in correspondence with which the plastic material is provided to be injected inside the mould 12 through the injection unit 120, as also schematically indicated by an arrow f4 in Fig. 1.

In detail, with reference to Figs. 5 and 6, each longitudinal guide 76, 77 is for instance made of a base plate, respectively 76a, 77a and a corresponding rail or similar element 76b, 77b, which is arranged on the top of the base plate 76a, 77a and extends in such a way as to cover at least all of the travel of the mobile mould-bearing platen 14 through the moulding machine 11.

In turn, the mobile mould-bearing platen 14 is suitable for sliding along the rails 76b e 77b of the guides 76 and 77 by means of two corresponding slide shoes 78 and 79, for instance of the bearing recirculating type, integrally attached to the mobile mould-bearing platen 14.

The slide shoes 78 and 79 may be provided with a certain longitudinal extension, as shown in Figs. 2 and 3, in order to give the guiding system as described above of the mould-bearing platen 14 the stability and robustness it needs on the longitudinal guides 76 and 77.

It should be noted how with this configuration the weight of the mobile mould-bearing platen 14 and respective mobile half-mould 12a, together with that of the parts integral with it and described later, is borne totally by the longitudinal horizontal guides 76 and 77.

As shown in Fig. 1, the mobile mould-bearing platen 14 is provided with two pass-through holes14d each of which receiving in the axial direction a corresponding tie bar 73 and 74, in such a way as to permit movement of the mobile mould-bearing platen 14 through the moulding machine 11.

Actuating and closing assembly

The actuating and closing assembly 10 of the moulding machine 11 includes an actuating unit, designated generically with the numeral 20, which is associated with the mobile mould-bearing platen 14 to actuate it and command it to move with respect to the fixed structure 50 so as to close the mobile half-mould 12a against the fixed half-mould 12b.

With reference to Figs. 2 and 3 the actuating unit 20 comprises an actuating rod, designated 17 and also called advancing rod, which is operatively connected in correspondence with one of its ends 17a to the mobile mould-bearing platen 14 by means of a hydraulic amplifier as described in detail later on.

The actuating rod 17 is suitable for moving axially backwards and forwards along a respective axis 15, which also defines the longitudinal axis of the moulding machine 11, in order to move the mobile mould-bearing platen 14 through the stroke C between an open position, represented in Figs. 1-3 in which the two half-moulds 12a and 12b are separated and remote from one another, and a closed position, represented in Figs. 9-10 in which the two half-moulds 12a and 12b are arranged in contact with one another, i.e. closed between the mobile mould-bearing platen 14 and the fixed mould-bearing platen 16 so as to permit injection of the plastic material into the mould 12 and the moulding of a piece.

Movement in the two directions of the actuating rod 17 and the corresponding movement of the mobile mould-bearing platen 14 are represented in Fig. 1 by double arrows f1.

In particular, as shown in schematic form in Fig. 3, the axial movement of the actuating rod 17 is intended to be driven, under the control of a controller or control unit 21, by a drive assembly that includes a rotating motor 22, for example of the brushless type, and a mechanical assembly 23, for instance of the screw/lead screw, ball bearing recirculating type, arranged in turn between the motor 22 and the actuating rod 17 in order to convert the rotation motion produced by the motor 22 into a linear translating motion corresponding to the axial movement of the actuating rod 17 along the respective axis 15.

For this purpose the lead screw of the assembly 23 is rotatingly mounted via rotating supports 27 on the fixed structure 50 to cooperate with a corresponding screw integral with the actuating rod 17, so that the rotation of the lead screw results in axial advancing of the rod 17 in the direction of the arrow f1.

The motor 22 is associated with a respective position transducer 24 also known as an encoder, provided to constantly sense the angular position of a shaft 22a of the motor 22 so that the controller 21 can know exactly and at all times, through a position signal S1 generated by the position transducer 24, the linear position of the actuating rod 17 along the respective axis 15, and therefore also in relation to the other parts of the assembly 10.

The actuating and closing assembly 10 also comprises a closing unit generically designated with numeral 26, which is associated with the mobile mould-bearing platen 14 to exert upon it, in the closed position, a given closing force suitable for keeping the two half-moulds 12a and 12b stably closed during the plastic material injection stage, and thus suitable to oppose the separating force, induced by the pressure of the injected material, which would instead tend to separate them.

In particular according to one characteristic of this invention, the closing unit 26 comprises a hydraulic amplifier 30 which is configured to be actuated by the actuating rod 17 so as to receive from the latter a given input force and to apply, in response, on the mobile mould-bearing platen 14, when it is in the closed position, a given closing force of an amplified value with respect to that of the input force received.

In detail, as shown in Figs. 2 and 3, the hydraulic amplifier 30 comprises an intermediate, cylindrical-shape hollow body 34 arranged between the end 17a of the actuating rod 17 and the mobile mould-bearing platen 14 and defining on its inside a corresponding, cylindrically shaped cavity 33; a mobile body or wall 36 accommodated slidingly inside the cylindrical cavity 33; and an amplification chamber 31 delimited by the walls of the intermediate body 34 defining the cylindrical cavity 33 and by the mobile wall 36, inside which is contained a hydraulic fluid 32, for instance hydraulic oil or another equivalent fluid.

The mobile wall 36 is such as to cooperate in a sealing relationship with the hydraulic fluid 32 contained in the amplification chamber 31, so as to constitute a kind of mobile piston inside the intermediate body 34 to cooperate with the fluid 32.

The mobile wall 36 also has, in correspondence with a central area, a through hole 37, in which a cylindrical portion 38 of the end 17a of the actuating rod 17 is

accommodated slidingly to cooperate in a sealing relationship with the fluid 32 contained inside the amplification chamber 31.

In this way, the cylindrical portion 38 on the end of the actuating rod 17 constitutes a piston movable axially along the through hole 37 which is suitable for interacting and exchanging forces with the fluid 32 contained inside the amplification chamber 31, so that the end 17a of the actuating rod 17 is operatively connected with the mobile mould-bearing platen 14 through the interposition of the hydraulic amplifier 30, as anticipated above.

The intermediate hollow body 34 is integrally attached along a respective base 34a to the mobile mould-bearing platen 14, and more particularly to the side of the latter that faces the actuating rod 17 i.e. opposite the side of the same mobile mould-bearing platen 14 that is facing and bears the mobile half-mould 12a.

In turn this base 34a constitutes a wall that delimits inside the intermediate body 34 the amplification chamber 31 at the end opposite that of the mobile wall 36.

Summing up then, the amplification chamber 31 of the hydraulic amplifier 20 has, along the various walls that delimit its inner space and as shown in Fig. 3, a first circular section 31a, of lesser area, corresponding to the section or area of the through cylindrical hole 37 made in the mobile wall 36, and a second circular section 31b, of greater area than the section 31a, which is defined by the wall 34a of the intermediate body 34 opposite the mobile wall 36 and attached rigidly to the mobile mould-bearing platen 14.

In this way, true to the typical operation of a hydraulic amplifier, the hydraulic fluid 32 contained in the amplification chamber 31 is suitable, in correspondence with the lesser section 31a, for interacting with and receiving external forces and stresses from the piston 38 integral with the actuating rod 17, and in response is suitable, in correspondence with the greater section 31b, for applying on the mobile mould-bearing platen 14 forces of amplified value or entity with respect to that of the forces and stresses received, depending on the ratio between the greater section 31b and the lesser section 31a, corresponding to the surface of piston 38, of the amplification chamber 31 as will be explained better below.

Suitable means are provided both to keep permanently connected the actuating rod 17 and the mobile mould-bearing platen 14 during the movement along the stroke C between the open position and the closed position and also to allow proper operation of the hydraulic amplifier 30 at the end of the stroke C, with the mobile mould-bearing platen 14 in the closed position.

For this purpose the actuating rod 17 is provided integrally with a flange 17b in the respective end area 17a, i.e. adjacent to its tip portion defining the piston 38.

In addition elastic means 39 made of a plurality of pre-loaded compression springs 39a, for instance six as in the embodiment illustrated in the drawings (Fig. 5), are arranged between the mobile wall 36 of the amplification chamber 31 and a profiled plate 34b, also called backing plate, in turn fixed on the edge of the intermediate hollow body 34 opposite the respective base 34a mounted on the mobile mould-bearing platen 14.

Therefore, with this configuration of the elastic means 39, the compression springs 39a exert through the mobile wall 36 a certain pressure on the fluid 32 contained in the amplification chamber 31 and therefore also on the piston 38 accommodated in the hole 37, thus tending to constantly press the flange 17b of the rod 17 against the backing plate 34b integral with the intermediate body 34, and therefore keep the actuating rod 17 and the mobile mould-bearing platen 14 stably connected during movement between the open position and the closed position.

As better described later, these elastic means 39 are also such as to re-establish the contact between the flange 17b of the actuating rod 17 and the intermediate body 34 at the end of intervention of the hydraulic amplifier 30 for exerting an amplified closing force on the mobile mould-bearing platen 14 in the closed position.

Means for blocking mould in the closed position

As anticipated, the blocking means 241 have the function of keeping the mobile half-mould 12a stably closed against the fixed half-mould 12b during the step of injecting plastic material into the mould 12, and for this purpose they are provided to block, at the end of the stroke C and therefore in correspondence with the closed position of the mobile mould-bearing platen 14, any displacement of the latter towards the open position to prevent the mould 12 from opening.

More specifically, in the moulding machine 11 of this invention, the blocking means 241 are operative to block, in the closed position P2 of the mobile mould-bearing platen 14, any displacement with respect to the fixed structure 50 of the mobile wall 36 that delimits one side of the amplification chamber 31.

In this way, the hydraulic amplifier 30 can intervene and operate properly for applying the amplified closing force on the mobile mould-bearing platen 14, as will be better explained later when describing operation of the moulding machine 11 itself.

In detail the blocking means 241 comprise a blocking plate 81 which is rigidly connected to the mobile wall 36 of the hydraulic amplifier 30 through a set of bars or pins 82, for example three in number as illustrated in Fig. 5, which extend parallel to the axis 15, and a pair of blocking devices 261 mounted on the blocking plate 81 and each associated with a corresponding tie bar 73 and 74 of the fixed structure 50.

The bars 82 are sized in length so that in the starting configuration of the moulding machine 11, i.e. when the two half-moulds 12a and 12b are separated and remote from one another as illustrated in Figs. 1 and 2, the blocking plate 81 is arranged adjacently or very close to the backing plate 34b mounted on the edge of intermediate hollow body 34 of the hydraulic amplifier 30, though the blocking plate 81 is not rigidly connected thereto.

For simplicity's sake, in Figs. 1-4 this blocking plate 81 is depicted as being practically in contact with the backing plate 34b, in the starting configuration of the moulding machine 11.

Similarly to the mobile mould-bearing platen 14, the blocking plate 81 is also suitable for moving slidingly along the longitudinal guides 76 and 77 by means of corresponding slide shoes 83 and 84 rigidly connected to the blocking plate 81, so that the weight of the blocking plate 81 and of the parts integral with it is discharged entirely on the horizontal guides 76 and 77.

As illustrated in Figs. 2, 6 and 9a the blocking plate 81 is provided with two lateral through holes 81a each of which axially receives a corresponding fixed tie bar 73, 74, and a central hole 81b through which the actuating rod 17 extends, in order to allow movement of the blocking plate 81 through the moulding machine 11, parallel to the axis 15.

Referring to Fig. 6, each blocking device 261 comprises two toothed elements 261a and 261b, arranged at opposite ends with respect to the respective tie bar 73, 74, which are associated with suitable guide 263 mounted on the blocking plate 81 so as to be able to move along the latter.

In particular, the two toothed elements 261a and 261b of each device 261 are provided so as to be driven in the two directions, forwards and backwards, as indicated by double arrows f2, by corresponding actuators 262 of known characteristics, for instance of pneumatic, hydraulic or electromechanical type, in such a way as to selectively engage with and close upon a toothing or rack 242, arranged on the corresponding tie bar 73, 74, or disengage and move away from the same.

Preferably, for structural solidity reasons, the rack 242 is made all of a piece on the corresponding tie bar 73, 74.

Therefore the two toothed elements 261a and 261b of each blocking device 261 define with the rack 242 of the respective tie bar 73 or 74 a toothed coupling or clutch suitable for selectively intervening to rigidly block the blocking plate 81 with respect to the tie bars 73, 74 and therefore also with respect to the fixed structure 50, or leave it free to move in the axial direction, as will be better described below.

Plastic material injection unit

With reference to Figs. 8 and 8a, the injection unit 120 having the function of injecting plastic material into the mould 12 is arranged adjacently to the fixed mould-bearing platen 16 on which the fixed half-mould 12b is mounted, and comprises a hollow shaped plasticizing cylinder 121 inside which an plasticizing screw 122, also called screw conveyor or worm feeder, is accommodated.

The plasticizing screw 122 is suitable for rotating relatively to the plasticizing cylinder 121 about an axis 123, also corresponding to the axis of the plasticizing cylinder 121, as indicated by arrow f12.

The plasticizing cylinder 121 is associated at one end with an injection body 124, which is mounted integrally, for instance by means of a threaded coupling, on the plasticizing cylinder 121, and is in turn provided with an injection nozzle 130 for injecting the plastic material into the mould 12 through the fixed mould-bearing platen 16, both represented by a dot and dash line in Fig. 8.

A feeding container or equivalent device, of known characteristics and therefore not depicted in the drawings, is provided for feeding, through a duct 135 and as indicated by the arrow f11, the plasticizing screw 122 with a certain quantity of raw material, indicated MP, intended for being plasticized, i.e. for forming the plastic material or plasticized raw material to be subsequently injected through the injection nozzle 130 into the mould 12.

The plasticizing screw 122 is provided along the external cylindrical surface, adjacent to the internal surface of the plasticizing cylinder 121, with a series of helical windings 122a which, during rotation of the plasticizing screw 122, operate in such a way as to feed the raw material MP received from the duct 135 along the plasticizing screw 122, i.e. in the direction of the axis 123, while the raw material MP undergoes a plasticizing process, in a known way and typically though a heating effect, that makes it assume a fluid form suitable for injection into the mould 12.

The plasticizing screw 122 is mounted rotatingly on a support structure indicated with 128 and integral with the plasticizing cylinder 121, suitable rotating support members

129 having been interposed capable of bearing the radial and axial thrusts acting on the plasticizing screw 122 while the moulding unit 120 is in use, and for instance including thrust bearing type ball bearings.

An injection chamber 126 is provided at one end of the plasticizing cylinder 121, between the latter and the injecting body 124, to receive from the rotating plasticizing screw 122, as indicated by arrows f13 in Fig. 8a, the raw material, in the fluid and plasticized form, as indicated with PL, assumed as a result of the plasticizing process during the feeding through the plasticizing screw 122.

The injection chamber 126, along one of its surfaces 126a, facing the inside of the injection chamber 126 and corresponding to the base of the plasticizing cylinder 121, also has a flow hole 127, which extends right through the injection body 124 along the same axis 123 as the plasticizing cylinder 121 and the plasticizing screw 122, and which is provided to permit evacuation and flow from the injection chamber 126 of the plasticized raw material PL and its injection into the mould 12 through the injection nozzle 130.

The flow hole 127 preferably has a circular section of diameter D1 which remains constant for a certain stretch along the respective axis 123 through the injection body 124, starting from the inner surface 126a, that is from the entrance section of the flow hole 127 facing the injection chamber 126.

The moulding unit 120 also comprises an injection piston 131, suitable for moving linearly and alternatively, i.e. forwards and backwards, as indicated by respective arrows f14' and f14" in Fig. 8, on a guiding through hole 122b which is formed along the axis 123 of the plasticizing screw 122 so as to pass through it completely.

The injection piston 131 is preferably cylindrical in shape and defines along its axis, which coincides with the axis 123 of the guide hole 122b, a first portion 131a, in the tip area of the injection piston 131, of lesser diameter, also called compression diameter, and also defines, adjacent to said first portion 131a, i.e. along the remaining extension of the injection piston 131 a second portion 131b of greater diameter D2, also called filling diameter, than the reduced diameter of the first tip portion 131a.

In particular the reduced diameter of the first portion 131a, corresponding to the tip of the injection cylinder 131, is substantially equal to the diameter D1 of the flow hole 127 associated with the injection chamber 126 and therefore indicated using the same symbol D1.

In this way the first portion 131a can couple with the flow hole 127 in such a way as to seal it hermetically, when the injection cylinder 131 reaches and penetrates into the

flow hole 127 to inject and compress the plasticized material PL in the mould 12, as will be explained later in detail when describing operation of the moulding machine 11 of the invention.

This same control unit 21, sketched in Fig. 8, which is part of the actuating unit 20 of the actuating and closing assembly 10 and is provided for regulating general operation of the moulding machine 11, also has the function of controlling rotation of the plasticizing screw 122 inside the plasticizing cylinder 121 and the linear, alternating motion of the injection piston 131, and also of regulating overall operation of the injection unit 120.

In particular, rotation of the plasticizing screw 122 about the axis 123 is commanded, under the control of controller 21 by a brushless type motor 151 which is in turn associated with a position transducer 152, also called encoder, suitable for constantly sensing angular position of a rotating shaft 151a of the motor 151 connected integrally in rotation with the plasticizing screw 122.

Accordingly, in this way the control unit 21 is capable of knowing exactly and at all times, through a position signal S11 received from the position transducer 152, the angular position of the plasticizing screw 122.

Similarly the linear, alternating motion of the injection piston 131 along the axis 123 is commanded, under the control of controller 21, by a command group 155 in turn including another rotating motor 153, also brushless type, and a mechanical group 156, for instance of the screw/lead screw type, which is located between the motor 153 and the injection piston 131 and has the function of converting the rotation motion produced by the motor 153 into a linear, translation motion suitable for commanding movement of the injection piston 131 in the guide hole 122b.

In the same way as motor 151, motor 153 is also associated with a respective position transducer or encoder 154, provided for permanently sensing the angular position of a shaft 153a of the motor 153, so that controller 21 is capable of knowing exactly and at all times, through a position signal S12 generated by the position transducer 154, the linear position of the injection piston 131 in the guide hole 122b, or relatively to the other parts of the injection unit 120.

According to a characteristic of this invention the injection unit 120 also comprises a reflux device 141, also called reflux valve, or reflux butterfly valve, which is associated with the injection chamber 126 and has the function of controlling and permitting the backward reflux, i.e. towards the plasticizing screw 122 and relative windings 122a, of at least part of the plasticized raw material or molten raw material PL contained in the injection chamber 126 and not injected into the mould 12, as will be explained more

clearly later when describing operation of moulding machine 11 and relative injection unit 120.

In particular, with reference to Figs. 8a-8e, this reflux device 141 is made of two discs, placed one on top of the other, of which a first upper disc 142 is suitable for rotating integrally with the plasticizing screw 122, and a second lower disc 143 is instead mounted integrally on the plasticizing cylinder 121.

To this end the first disc 142 is coupled with the end of the plasticizing screw 122 that faces the injection chamber 126, for instance through a grooved coupling 134 made on a boss 142c of the upper disc 142 and on the plasticizing screw 122, while the lower disc 143 is connected stably in correspondence with its outer circumference to the plasticizing cylinder 121.

The discs 142 and 143 have respective complementary portions which are suitable, depending on the relative position between these two discs 142, 143 and as will be better explained below, for permitting or preventing reflux through the device 141 of plasticized material PL from the injection chamber 126 towards the plasticizing screw 122 and relative windings 122a.

In particular, the upper disc 142 is provided, all along its outer circumference, with a plurality of radial notches 142a having a given width LA, wherein each of these notches 142a, open towards the outside, is delimited on the sides by walls perpendicular to the plane of the disc 142, and at the back, towards the centre of the disc 142, by a surface 142b which develops along an inclining plane between the two faces of the disc 142, that is to say the upper face in contact with plasticizing screw 122 and the lower face arranged in contact with disc 143.

The lower disc 143 in turn has a shape comprising a truncated conical, central inner body 143b, a ring-shaped outer body 143e and a plurality of radial elements or bodies 143a placed between the bodies 143b and 143e, defining with this shape a plurality of bays 143c between two adjacent elements 143a and the inner and outer bodies 143b, 143e.

The radial elements 143a are of the same number and have the same angular disposition about the centre of the respective lower disc 143 as the notches 142a of the upper disc 142, with respect to which they are of equal or slightly greater width.

Further the outer tips of these elements 143a are inserted in corresponding seats 121a, made in the plasticizing cylinder 121 for integrally securing the lower disc 143 on the latter.

The central, truncated-conical body 143b laterally defines a conical surface 143d which develops between a lesser diameter, in correspondence with the lower face of the disc 143, facing the injection chamber 126, and a greater diameter, in correspondence with the upper face of the disc 143 arranged in contact with the disc 142, wherein this conical surface 143d has the same inclination as and continuously joins with the inclined inner wall 142b of each of the notches 142a of the upper disc 142, as clearly shown in Fig. 8a.

In turn, the inner surface of the ring-shaped body 143e has an inclination joining that of the walls of the body 124 that delimits the injection chamber 126, so as to encourage and convey the flow of plastic material PL through injection chamber 126, avoiding in particular any possible stagnation therein of plastic material PL during the injection and reflux steps, as will be described better below.

Moulded piece extracting device

As anticipated, the extracting device 125 (Fig. 2) is associated with a removable mounting structure or tool, generically designated with numeral 60, which is provided for being installed and fixed rigidly on the mobile mould-bearing platen 14 for the purpose of preparing it for assembly of the mobile half-mould 12a.

This mounting tool 60 essentially comprises a first plate 60a which is fixed directly on the mobile mould-bearing platen 14, a second plate 60b parallel to the first plate 60a and on which the mobile half-mould 12a is mounted directly, and one or more transversal plates 60c that rigidly connect the two plates 60a and 60b.

In this way, the mounting tool 60 acts as a rigid support structure between the mobile half-mould 12a and the mobile platen 14, with the function of supporting and rigidly fixing the mobile half-mould 12a on the mobile mould-bearing platen 14.

In greater detail, the extracting device 125 comprises two extraction motors 91, mainly brushless type, which are suitable for driving in rotation two corresponding extraction shafts 92, and also an extraction plate 93, bearing an extracting or pushing element 25a, which plate 93 is adapted for being driven by the rotation of the extraction shafts 92 in such a way as to translate with respect to the fixed structure 50 of moulding machine 11, in the direction of the respective longitudinal axis 15.

The two extraction motors 91 are mounted on the outside of the fixed vertical wall 72 corresponding to the injection zone of the moulding machine 11, that is on the side of the fixed mould-bearing platen 16 opposite that on which the fixed half-mould 12b is mounted.

The two extraction shafts 92 extend parallel and at opposite ends with respect to the longitudinal axis 15 of moulding machine 11, and are for instance accommodated in respective hollow seats 73a, 74a (Fig. 7), formed in the tie bars 73, 74.

As depicted in Fig. 4, each of these extraction shafts 92 is mounted rotatingly, in correspondence with an end 92a, on the mobile mould-bearing platen 14, and is slidingly coupled local to the opposite end 92b with the respective motor 91 in such a way as to be able to slide axially through it.

For this purpose, each motor 91 has a hollow rotor defining an axial cavity 91a which totally traverses the motor 91 and which receives the end 92b of the corresponding extraction shaft 92.

Further each motor 91 is provided for commanding rotation of the respective extraction shaft 92 by means of a drive member integral with the hollow rotor of the motor 91 and made of a flange 94, depicted in detail in Figs. 7c and 7d, wherein this flange 94 in turn bears a plurality of rollers 94a which mesh with a first grooved portion 92c of the extraction shaft 92 adjacent to the end 92b.

In this way, when the mobile mould-bearing platen 14 slides with respect to the fixed structure 50 on the guides 76 and 77 as described below, each extraction shaft 92 can advance axially with the end 92b through the cavity 91a of the respective motor 91, while remaining coupled in rotation with the latter, as illustrated for clarity's sake in the dot and dash line again in Fig. 4.

Each extraction shaft 92 also has a second portion 92d consisting of a screw which is associated with a corresponding lead screw 92e, which the extraction plate 93 rests on and is removably coupled with for being moved with respect to the fixed structure 50, as described better below.

In turn extraction plate 93 is accommodated within the mounting tool 60 between the respective plates 60a, 60b and 60c, in such a way that it is suitable for being mounted or dismounted in a removable way together with the mounting tool 60 on moulding machine 11, as indicated by the dot and dash line and by double arrows f3 in Fig. 7.

For this purpose, the extraction plate 93 laterally has a profile that defines two recesses 93a, in fork form, that are suitable for coupling with corresponding seats or grooves made in the outer surface of lead screws 92e associated with extraction shafts 92, so as to permit easy coupling or uncoupling between extraction plate 93 and lead screws 92e.

The extraction plate 93 integrally bears the pushing element 25a, schematically represented in Figs. 1 and 2, which is suitable for moving axially through a hole 60d made in the plate 60b to penetrate inside the mobile half-mould 12a and therefore cause the expulsion or extraction from the latter of the moulded piece, at the end of each moulding cycle as described more clearly later when describing operation of moulding machine 11.

Operation of the injection moulding machine

Operation of the injection moulding machine 11, according to this invention, will now be described in detail while referring in general to the flow diagram of Fig. 13.

Initial step of advancing and closing the mould

At the beginning of a generic moulding cycle, with the fixed half-mould 12b stably mounted on fixed mould-bearing platen 16 and the mobile half-mould 12a stably fastened with respect to the mobile mould-bearing platen 14, the moulding machine 11 has a starting configuration represented in Fig. 1 wherein the mobile mould-bearing platen 14 is arranged in an open position, indicated with P1, distant from the fixed mould-bearing platen 16 and therefore with the two half-moulds 12a and 12b separated and at a distance one from the other.

The mobile half-mould 12a is mounted on the mobile mould-bearing platen 14 through the mounting tool 60, which is itself also fixedly mounted on the mobile mould-bearing platen 14 between the latter and the mobile half-mould 12a.

In this starting configuration the extraction plate 93 of the extracting device 125 is stably mounted on the moulding machine 11 together with the mounting tool 60 by coupling the respective forks 93a with the two lead screws 92e of the extracting device 125 which in turn are arranged in a starting position adjacent to the mobile mould-bearing platen 14.

Accordingly the extraction plate 93 is arranged in a starting position adjacent to the plate 60a of the mounting tool 60, with the pushing element 25a which, in turn, is arranged in a rest position wherein its tip does not protrude from the plate 60b of the mounting tool 60.

Again, still in this starting configuration of the machine 11, the actuating rod 17 is in a retracted starting position, while the clamping devices 261 are disengaged from the teeth of the rack 242, thus allowing free movement of the blocking plate 81 along the tie bars 73 and 74.

Lastly, again in the starting configuration, the blocking plate 81 is arranged adjacent to the backing plate 34b that delimits the closing unit 26.

When the moulding cycle is activated, the control unit 21 commands, during a first step 51, the axial advancing of the actuating rod 17 so as to move the mobile mould-bearing platen 14 along the stroke C, corresponding to the distance separating the two half-moulds 12a and 12b in the starting configuration of machine 11, and thus bring the mobile half-mould 12a to close against the fixed half-mould 12b.

Therefore the mobile mould-bearing platen 14 advances and slides horizontally with respect to the fixed structure 50, sliding by means of the slide shoes 78 and 79 on the guides 76 and 77 as indicated in the drawings by the arrow f1.

During this movement of the mobile mould-bearing platen 14 along the advancing stroke C from the open starting position P1 towards the fixed mould-bearing platen 16, the various parts of the closing unit 26 associated with the mobile mould-bearing platen 14 are kept stably connected to one another thanks to the holding action exerted by the compression springs 39a of the elastic means 39.

In fact, the thrust of the compression springs 39a produces a pressure in the fluid 32 contained inside the amplification chamber 31 which, acting on the piston 38, is such as to keep the flange 17b stably in contact against the backing plate 34b, thereby overcoming both the friction resistance met by the mobile mould-bearing platen 14 in movement towards the fixed mould-bearing platen 16 and also the inertia of the masses that are displaced together with the mobile mould-bearing platen 14.

In this way, during the advancing stroke C, piston 38 formed on the end of the actuating rod 17 maintains a substantially fixed position in through hole 37, wherein piston 38 is accommodated, of the mobile wall 36 of the hydraulic amplifier 30, and in the same way the mobile wall 36 maintains a fixed position in relation to the walls of the cavity 33 of the hollow body 34 where it is arranged.

Further, the mobile mould-bearing platen 14, while it advances and translates horizontally sliding on the guides 76 and 77, in this translating movement also drags the blocking plate 81, also sliding on the guides 76 and 77, by means of the closing unit 26 integral with the mobile mould-bearing platen 14 and connected to the extraction plate 81 by means of the bars 82.

Again, during the advancing motion of the mobile mould-bearing platen 14 towards the fixed mould-bearing platen 16, the two extraction shafts 92 slide axially, without rotating, with their ends 92b through the cavities 91a of the respective extraction motors 91.

Thus, at the end of stroke C i.e. when half-mould 12a comes into contact with half-mould 12b, exactly as shown in Fig. 9, the mobile mould-bearing platen 14 stops

immediately in a corresponding closed position P2 with the actuating and closing assembly 10 having the configuration also depicted in Fig. 9.

This closed position P2 of the mobile mould-bearing platen 14, corresponding as said to the contact between the two half-moulds 12a and 12b, is for instance signalled in a step 52 to the controller 21 by the position transducer 24.

Step of blocking the mobile mould-bearing platen and activating the hydraulic amplifier

At this point, in response to the mobile mould-bearing platen 14's reaching of position P2 being sensed, controller 21 reacts, in a step 53, by immediately driving the clamping devices 261 of the blocking means 241, so that the respective toothed elements 261a and 261b engage with the teeth of the rack 242 made in the tie bars 73 and 74 of the fixed structure 50, as represented and indicated by arrows f2 in Figs. 9a and 9b.

For this purpose, local to the position P2 of the mobile mould-bearing platen 14, the toothed elements 261a, 261b of the clamping devices 261 are arranged substantially aligned with the teeth of the rack 242, so as to be able to mesh regularly and properly with the latter without mismatches, as it is clearly represented in enlarged scale with the dot and dash and continuous line in Fig. 9b.

On this respect various solutions may be implemented in order to provide this alignment between the toothed elements 261a, 261b of the clamping devices 261 and the teeth of the rack 242, at the position P2 of the mobile mould-bearing platen 14.

For instance the mould 12, mounted on the injection machine 11, may be sized and selected with a total thickness indicated H in Fig. 9 and defined by the sum of the thicknesses of the fixed and mobile half-moulds 12a and 12b, so that at the time contact is made between the two half-moulds 12a and 12b, that is in correspondence with the closed position P2, the toothed elements 261a and those of the rack 242 are perfectly aligned and thus suitable for meshing properly with one another.

More specifically in connection with this solution the moulds 12 used on the machine 11 are sized with a total thicknesses H that varies in a discrete and modular way according to the pitch of the teeth of the elements 261a, 261b and rack 242.

Or, alternatively, the mould 12 which is used on moulding machine 11 may be of any thickness, but in this case it is mounted on the tool 60 with extra plates, not depicted in the drawings and of suitable thickness, placed in between, in such a way that, in correspondence with the closed position P2, the toothed elements 261a of the clamping devices 261 are substantially aligned with the teeth of the rack 242.

So if one of these solutions is adopted, or others described later, it is always possible to obtain an aligned configuration between the toothed elements 261a, 261b of the clamping devices 261 and the teeth of the rack 242 in correspondence with the closed position P2 of the mobile mould-bearing platen 14, whatever the type of mould 12 mounted on the moulding machine 11 thus permitting proper functioning and meshing of the blocking means 241.

Having made this necessary point concerning the alignment condition occurring, at the time the closed position P2 is reached by the mobile mould-bearing platen 14, between the toothed elements 261a, of each clamping device 261, moving with the blocking plate 81, and the corresponding fixed teeth, of the rack 242, integral with the tie bar 73 or 74, description of operation of the machine 11 can be now resumed.

Immediately after the contact between the two half-moulds 12a and 12b, with the mobile mould-bearing platen 14 now stopped and motionless in the closed position P2 and therefore with the intermediate body 34 also motionless, the actuating rod 17 continues advancing with the respective piston 38 in hole 37, for a certain distance C2 of limited entity which is added to the stroke C made by the mobile mould-bearing platen 14.

The flange 17b of the rod 17 thus comes away from the backing plate 34b integral with the intermediate body 34, contrasting the action tending to keep them joined exerted by the compression springs 39a, as depicted in Fig. 10, while at the same time the actuating rod 17 reacts to the resistance encountered by compressing with the piston 38 the hydraulic fluid 32 contained in the amplification chamber 31.

This further advancement of the piston 38 in through hole 37 immediately following the contact between the two half-moulds 12a and 12b also produces a corresponding and limited backward sliding movement of the mobile wall 36 in the cavity 33 of the intermediate body 34.

This backward movement of the mobile wall 36, corresponding to the further advancing stroke C2 of the piston 38, in turn causes the blocking plate wall 81, integral with the mobile wall 36, to retreat slightly and thus come away from the plate 34b forming a clearance L, as depicted in Fig. 10.

In this way any clearance existing between the teeth of the toothed elements 261a, 261b and those of the rack 242 is recovered, thus ensuring a stable and rigid coupling between the clamping wall 81 and the tie bars 73 and 74.

For clarity's sake, the clearance L is represented in Fig. 10 with a deliberately greater entity than that which it is presumed it would have in reality.

It should be noted that during this backward movement of the mobile wall 36 relative to the intermediate body 34, the compression springs 39a which are pre-loaded so as to keep the flange 17b of the actuating rod 17 and the intermediate body 34 stably in contact during stroke C towards the closed position P2 of the mobile mould-bearing platen 14, undergo a further but small deformation, tending to compress them even further.

The actuating and closing assembly 10 and respective hydraulic amplifier 30 are thus positioned in the final configuration again illustrated in Fig. 10.

In such a configuration, therefore, with the mobile wall 36 blocked and prevented from moving with respect to the fixed structure 50 and with respect to the intermediate body 34 following the action of the clamping devices 261, the piston 38 integral with the actuating rod 17 can exert and correctly apply, in correspondence with the hole 37 and during a step 54, its thrusting action consisting of a given input force Fo on the fluid 32 contained in the amplification chamber 31 and consequently activate the hydraulic amplifier 30.

In turn, the fluid 32 reacts to the input force Fo received from the piston 38 by applying on the mobile mould-bearing platen 14, in correspondence with the wall 34a of the amplification chamber 31 located adjacent and attached to the mobile mould-bearing platen 14 an amplified closing force FS, i.e. one of an entity that is amplified with respect to the input force Fo received from the piston 38 of the actuating rod 17.

In greater detail and in quantitative terms, the input force Fo applied by the piston 38 activates on the fluid 32 contained in the amplification chamber 31 a pressure PR, equal to the ration of the input force Fo itself to the area of the hole 37, which in turn generates an amplified closing force FS, acting on the mobile mould-bearing platen 14, with respect to the input force Fo, wherein the entity of this amplification is given by the ratio of the circular section 31b (Fig. 2) of greater area, corresponding to the wall 34a of the amplification chamber 31 attached to the mobile mould-bearing platen 14, to the circular section 31a (Fig. 2) of lesser area, corresponding to the through hole 37 made through the mobile wall 36.

Accordingly by sizing the diameter of the section 31b of the intermediate body 34 and the diameter of the section 31a, i.e. of the piston 38, and therefore by suitably establishing the ratio between them, the amplification factor of the hydraulic amplifier 30 may be defined exactly, so as to obtain broad range of closing forces FS, capable of answering the various requirements in the plastic materials moulding field.

For example, and purely indicatively, according to calculations and tests conducted by the inventor and explained in greater detail below, the actuating and closing assembly 10 of the invention could make it possible to obtain an amplified closing force FS acting on the mobile mould-bearing platen 14 of an entity at least 20-30 times in magnitude that of the input force Fo exerted by the piston 38; thus with, for instance, the application of an input force of 2 tonnes, it would be possible to obtain a final closing force of approx. 50 tonnes.

Summarizing therefore, in the closed position P2 of the mobile mould-bearing platen 14 the actuating rod 17 applies, via the respective piston 38 and in correspondence with the through hole 37, a given input force Fo on the hydraulic fluid 32 contained in the amplification chamber 31, and in response the hydraulic fluid 32 applies a corresponding closing force FS on the mobile mould-bearing platen 14 intended to stably clamp the two half-moulds 12a and 12b, amplified with respect to the input force Fo received and applied by the piston 38 on the fluid 32.

From what has been described it is also clear that the hydraulic amplifier 30 is put in condition to operate properly, i.e. to activate and apply the amplified closing force FS on the mobile mould-bearing platen 14 in response to the input force Fo exerted by the piston 38, thanks to the contribution of the blocking means 241 which, while the hydraulic amplifier 30 is operative, keep the mobile wall 36 rigidly clamped with respect to the tie bars 73 and 74 of the fixed structure 50 via the clamping devices 261 and thus allow the amplified closing force FS to discharge and act totally on the mobile mould-bearing platen 14.

The amplified closing force FS which is intended to keep the two half-moulds 12a and 12b closed and joined during the successive step of injecting plastic material into the mould 12 so as to prevent them from opening, is in turn entirely sustained and balanced through the blocking means 241 by the portions of the longitudinal tie bars 73 and 74 which extend from the blocking plate 81, rigidly clamped on the same tie bars 73 and 74, and the fixed mould-bearing plate 16 corresponding to the injection side of the moulding machine 11.

In particular this amplified closing force FS in distributed in equal parts, i.e. with an entity of FS/2, along these portions of the tie bars 73 and 74 where it causes a corresponding traction stress.

For clarity's sake the schematic plan view of Fig. 10a illustrates how the amplified closing force FS generated by the hydraulic amplifier 30 is distributed and balanced through the parts of the structure of the moulding machine 11.

Further Fig. 10a also shows how the input force Fo /2 discharges and is distributed in equal parts, i.e. with an entity equal to Fo/2, through the portions of the tie bars 73 and 74 which extend from the blocking plate 81 towards the side 71 opposite the injection side of the moulding machine 11.

Step of injecting plastic material into the mould

At this point, during an injection step 56 the plastic material in the molten state can be injected inside the mould 12, as symbolically indicated by the arrow f4 in Fig. 10 to form the moulded piece.

To make it clearer, the injection step 56 will be described by referring to the flow diagram of Fig. 13a wherein it is represented in greater detail and subdivided into various sub-steps.

In particular, during a preliminary step 161 of step 56, as in any conventional type injection moulding machine, the plasticizing screw 122 turns for a certain time in a predetermined direction of rotation, for instance in the direction of arrow f12 (Figs. 8 and 8a), so as to receive the raw material MP and fed it towards the injection chamber 126 and thus fill it.

The raw material MP being fed towards the injection chamber 126 in the direction of the axis 123 of the plasticizing screw 122 undergoes a plasticizing process according to known methods which, for brevity's sake will not be described herein, and then reaches the injection chamber 126 from where it will subsequently be injected into the mould 12 through the injection nozzle 130 in fluid, i.e. plasticized, form PL and suitable for injection.

In this step 161 the plasticized material PL reaches the injection chamber 126 through the reflux device 141 passing through the open passage areas which, during the relative rotation among the discs 142 and 143, are formed when the notches 142a of the upper disc 142, rotating integrally with the plasticizing screw 122, are overlapping with the bays 143c, defined between the radial elements 143a of the lower disc 143 integral with the plasticizing cylinder 121, as indicated by arrows f13 in Fig. 8a.

Rotation of the plasticizing screw 122 to feed the plasticized material PL to the injection chamber 126 is commanded by motor 151 under the constant control of controller 21 depending on the signal S2 indicating the instantaneous angular position of plasticizing screw 122.

This control, provided by controller 21, is such that the plasticizing screw 122 at the end of its rotation for completely filling the injection chamber 126 with plasticized material PL stops in a predetermined angular position, in which the notches 142a of the upper

disc 142 are exactly in correspondence with and above the radial elements 143a of the lower disc 143 of the reflux device 141.

In this way, the reflux device 141 assumes a closed configuration wherein it closes any passageway between the injection chamber 126 and the area of the plasticizing screw 122 so as to prevent any reflux of plasticized material PL, which is contained in and fills the injection chamber 126, through the device 141 and towards the windings 122a of the plasticizing screw 122.

Such a closed configuration indicated with CON1 and assumed by the reflux device 141 at the end of the step of filling the injection chamber 126 is illustrated in Figs. 11a and 11b.

During the preliminary step 161, the injection piston 131 is stationary in a retracted, rest position, shown as P11 in Fig. 8a, with the tip portion 131a remote from the injection chamber 126 so that the latter assumes the maximum volume configuration and can be completely filled with plasticized material PL fed by the plasticizing screw 122.

The injection true and proper of plasticized material PL from the injection chamber 126 into the mould 12 takes place in a subsequent step 162, and is obtained by commanding via the motor 153 advancing of the injection piston 131 from the retracted starting position P11, as shown by arrow f14' in Fig.11b.

In this way injection piston 131 advances and penetrates into the injection chamber 126 so as to compress the plasticized material PL contained therein and inject it into the mould 12 through flow hole 127, as indicated by arrow f4 in Fig. 11b.

In this advancing movement from the retracted position P11 the injection piston 131 acts on the plastic material PL, contained in the injection chamber 126, to press it and then inject it into the mould 12 at a certain pressure PR-1, also called injection or filling pressure, via a thrusting or filling section which substantially corresponds to the cylindrical portion 131b of greater diameter and defined by the filling diameter D2 of the injection piston 131.

In this injection step the reflux device 141 still stays in the closed configuration CON1 to prevent any reflux of the molten plastic material PL contained in the injection chamber 126 towards the area of the plasticizing screw 122 and, as a result, material PL which is subject to the pressure PR-1 exerted by the injection piston 131 flows only through flow hole 127 for being injected into and filling the mould 12.

In this way, thanks to the thrusting action exerted by the higher diameter section D2 of the injection piston 131, in combination with the closed configuration of the reflux device 141 which prevents backward reflux of the plasticized raw material PL contained

in the injection chamber 126, optimal and efficient injection and filling of the mould 12 with plasticized material PL is obtained.

According to a characteristic of this invention, in a subsequent step 163, as soon as the tip portion 131a, of lesser diameter D1, of the injection piston 131, reaches position P12 indicated with the solid line in Fig. 11b, in which the tip 131a of the injection piston 131 is perfectly in line with the entrance section of the flow hole 127 and thus closes it, controller 21 through motor 153 immediately commands rotation of a predetermined entity θo (Fig. 11c) of the plasticizing screw 122, and therefore of the upper disc 142, integral with the latter, of the reflux device 141, in the opposite direction, as indicated by an arrow f16 in Fig. 11c, to that, corresponding to the arrow f12 of Fig. 8a, previously activated during the step 161 for feeding the plasticized material PL into the injection chamber 126.

For this purpose, controller 21 senses the entry position P12 of the injection piston 131 in the flow hole 127 to command in response immediate rotation in the opposite direction of plasticizing screw 122, on the basis of the signal S12 emitted by position transducer 154 associated with motor 153 which commands advancing of the injection piston 131.

Entity of the predetermined rotation θo of the plasticizing screw 122 is established so that, when it ends, the notches 142a of the upper disc 142 are above the underlying bays 143c of the lower disc 143 so as to form apertures through the reflux device 141 that put the injection chamber 126 and the area of the plasticizing screw 122 in communication.

In this way the reflux device 141 is switched from the closed configuration, indicated CON1 and represented in Figs. 11a and 11b, wherein the injection chamber 126 and the area of the plasticizing screw 122 are not in communication and are therefore hermetically separated one from the other, to the open configuration, indicated with CON2 and represented in Figs. 11c and 11d, wherein the injection chamber 126 and the area of the plasticizing screw are in reciprocal communication through the reflux device 141.

At the same time, in a step 164 the injection piston 131 continues advancing for a certain distance in the direction of arrow f14' and as indicated by position P13 in the flow hole 127, until it completes its advancing stroke and so as to definitively compress with its tip portion 131a of lesser diameter D1, the fluid material PL injected into the mould 12.

The counter-rotation of the plasticizing screw 122 in the direction of arrow f16, with the consequent switching of the reflux device 41 from the closed configuration CON1 to

the open configuration CON2 has the important effect that, while the injection piston 131 continues to advance in flow hole 127 to definitively compress the molten material PL injected into the mould 12, the remaining part of molten material PL which has not been injected into the mould 12 by the earlier advancing of injection piston 131, but stays instead in the injection chamber 126, can now escape and flow backwardly towards the plasticizing screw 122 and relative windings 122a, under the thrust produced by the annular section of the injection piston 131 defined by the difference between the diameter D1 of its central portion and that D2 of its tip portion 131a, as indicated by arrows f17 in Fig. 11d, thanks also to the concurrent suction action that the counter-rotation of plasticizing screw 122 exerts on the remaining part of the molten material PL.

Reflux of the plasticized material PL from the injection chamber 126 is also encouraged by the continuous shape assumed by the passageways created through the device 141 when in the open configuration CON2, as shown in Fig. 11d, with the walls of the injection chamber 126 and the inclined surfaces 143d and 142b, respectively of the lower disc 143 and upper disc 142, reciprocally connecting at the same inclination.

In particular, such a continuous and connected shape has the advantage of preventing plastic material PL from stagnating inside injection chamber 126, in the reflux step just as in the injection step.

Therefore the further advancing motion, beyond position P12, of the injection piston 131 in flow hole 127 for definitively compressing the plastic material PL injected into the mould 12 can take place regularly, without being impeded in any way.

Differently, i.e. without the possibility of the fluid material PL that remains in the injection chamber 126 after injection piston 131 has entered with its tip portion 131a the flow hole 127 escaping in some way and and/or flowing backwardly towards the plasticizing screw 122, the further advancing through the injection chamber 126 of the portion 131b of greater diameter D2 of the injection piston 131 would have the negative effect of causing a considerable increase of pressure within this remaining fluid material PL, with the resultant rising of reaction forces acting on the injection piston 131, capable of preventing or in any event hindering its proper advancing movement for compressing optimally and definitively the plastic material PL injected into the mould 12.

It is clear therefore from what has been said that in the injection unit 120 of this invention, the further and final advancing of the tip 131a of lesser diameter D1 of the injection piston 131 in flow hole 127 has the considerable advantage of producing a corresponding and definitive compression of the molten material already injected into the mould 12 by the previous advancing of the injection piston 131 through the injection

chamber 126, so as to ensure a complete filling with molten material PL of all the portions and cavities of the mould 12, even the smallest and those farthest away from the injection area.

This final pressure, also called compression or compacting pressure, present in the molten material inside the mould 12, which is produced by the injection piston penetrating into the flow hole 127 and which assumes a significantly higher value than the injection pressure PR-1 reached in the previous steps, is indicated as PR-2 in Fig. 11d.

Clearly the entity of the closing force FS which is applied by the hydraulic amplifier 30 on the two half-moulds 12a and 12b is determined and selected so as to be, in any instant during the injection step, greater than the pressure which is created inside the mould 12 while it receives the plastic material PL injected by the injection piston 131, and in particular than the final compacting pressure PR-2 produced by the same injection piston 131 at the end of the step of injecting plastic material PL into the mould 12.

In this way, as depicted in Figs. 10 and 10a, the closing force FS is such as to sustain with a good margin of safety the variable pressure acting inside the mould 12, so as to keep it stably closed and prevent the respective half-moulds 12a and 12b from coming apart and opening during the entire conduction of the step of injecting plastic material PL.

More specifically the desired value of the closing force FS is determined depending on the current application, i.e. on the plastic material that is being used and/or the characteristics of the piece being produced, by suitably setting the input force Fo that is applied to the input of the hydraulic amplified 30 by the piston 38 defined by the tip of the actuating rod 17.

Therefore, at the end of the injection and final compression of the plastic material PL in the mould 12, control unit 21 commands axial retracting in the direction of arrow f14" of the injection piston 131, which thus returns to the starting position P11.

In this way, the injection unit 120 prepares to commence a new injection cycle, similar to the one just described, and therefore to feed via the rotation of the plasticizing screw 122 the injection chamber 126 with new plastic material PL to be injected into the mould 12.

Step of return of the mould and extraction of the moulded piece

Further, again at the end of injection of the plastic material into the closed mould 12, controller 21 intervenes to command return movement of the mobile mould-bearing platen 14 towards the open position P1, so as to open mould 12 and allow extraction

therefrom of the moulded piece, in a global opening and extraction step indicated with 57 in the diagram of Fig. 13.

In detail, immediately after the moulding of the piece, controller 21 commands the blocking means 241 so as to disengage the respective blocking means 261 from the tie bars 73 and 74, and thus free movement both of the blocking plate 81 and of the mobile mould-bearing platen 14 with respect to the fixed structure 50.

At the same time, control unit 21 activates the return movement of the actuating rod 17, the effect of which is to cause immediate lowering of the pressure in the fluid 32 contained in the amplification chamber 31 of the hydraulic amplifier 30 and a corresponding resetting of the amplified closing force FS acting on the mobile mould-bearing platen 14.

As a result, also because of the action of the resilient means 39, the mobile wall 36 is pushed forwards so as to allow the clamping devices 261 to easily disengage from tie bars 73 and 74, while at the same time contact is again established between flange 17b and plate 34b integral with the intermediate body 34.

In other words the mobile wall 36 and together therewith the blocking plate 81, no longer clamped with respect to the tie bars 73 and 74 and no longer subject to the direct force intended to contrast the amplified closing force FS, return to their respective starting positions under the action of resilient means 39, with flange 17b and plate 34b pressed one against the other and blocking plate 81 again adjacent to plate 34b.

In the first step of this return movement, schematically indicated in Fig. 12 with arrow f5, of the mobile mould-bearing platen 14 from closed position P2 to open position P1, controller 21 also commands the extracting device 125 to extract the moulded piece, represented with the dot and dash line and indicated PS in the same Fig. 12, from the mould 12.

To do this, controller 21 commands the two motors 91 to produce rotation of the extraction shafts 92 and consequently advancing of the lead screw 92e along the screw portion 92d of the shafts 92.

Therefore, as depicted in Fig. 12, the extraction plate 93 comes away from the base 60a of the mounting tool thereby causing the pushing element 25a to come out of the plate 60b and to penetrate inside the mould 12, as indicated by arrow f6, with consequent expulsion of the moulded piece PS.

Meanwhile the mobile mould-bearing platen 14 continues its return stroke to again come to the open position P1.

When the mobile mould-bearing platen 14 is again in the open position P1, a new moulding cycle, absolutely identical to the one described above, can begin, and so on.

Advantages and performances obtainable with the moulding machine of the invention

As will be easily understood from the description provided above, with the machine 11 for the injection moulding of plastic material according to this invention a host of important advantages may be obtained with respect to the known art.

First and foremost, the actuating and closing assembly 10 typical of the moulding machine 11 of the invention allows a very high closing force to be obtained, without excessive reaction forces caused by such closing force bearing and discharging on the actuating unit.

In fact the actuating unit 20 has to apply a considerably lower input force than the final closing force as produced by the hydraulic amplifier 30, given that the task of sustaining the closing force and thus contrasting the forces tending to open the mould during moulding of the piece is carried out by suitable blocking means 241 distinct from the actuating unit 20.

Correspondingly the amount of energy consumed for powering the actuating unit 20 is also very low.

For instance, purely indicatively and according to calculations and tests carried out by the inventor, the moulding machine 11 of the invention, thanks to its innovative actuating and closing assembly 10 and assuming a hydraulic amplifier 30 is produced with a cylinder (intermediate hollow body 34) having diameter 140 mm and a piston (the cylindrical end 38 of the actuating rod 17) having diameter of 25 mm, could make it possible to obtain a closing force between the two half-moulds 12a, 12b of approx. 15,000 Kg, i.e. 15 tonnes, in response to a thrust of 480 Kg exerted by the piston 38 on the fluid 32 of the hydraulic amplifier 30.

Again, unlike the traditional systems, regulation of the advancing stroke C of the mobile mould-bearing platen 14 to close the two half-moulds 12a and 12b against one another is predetermined and adjustable electronically through the control of opportune advancing motors, i.e. without resorting to lever systems complex to adjust.

Even the speed of the forward and backward motion of the mobile mould-bearing platen 14 respectively towards and from the fixed mould-bearing platen 16, which speed is of course such as to condition the duration of a complete moulding

cycle, can be easily regulated electronically by controlling the motor 22 which commands the axial advancing of the actuating rod 17.

Further advantages derive from the innovative structure of the moulding machine 11 of the invention.

In fact, thanks to this innovative structure, the forces induced by the injection pressure of the plastic material in the mould 12 are totally contrasted by the two tie bars 73 and 74 of its fixed structure 50, which do not fulfil guiding functions of the mobile parts of the injection machine 21, particularly of the mobile mould-bearing platen 14 bearing the mobile half-mould 12a, and can therefore be built without any particular precision requirements.

In other words, the tie bars or longitudinal ties 73 and 74 of the fixed structure 50 of the moulding machine 11 receive and contrast totally the amplified closing force FS produced by the hydraulic amplifier 30, while the function of guiding the mobile mould-bearing platen 14 in movement towards and away from the fixed mould-bearing platen 16 is carried out by the guides 76 and 77, which bear only the weight of the mobile half-mould 12a and of the parts integral with it, so that the two half-moulds 12a and 12b close one against the other with the maximum precision without the negative effects induced by deformations and different thermal expansions as in conventional moulding machines.

Besides a host of important advantages are also associated with the injection unit 120 included in the moulding machine 11 proposed with this invention.

Specifically, with reference to Fig. 8, one of the characteristics which, in association with the others, qualify the injection unit 120 and make it particularly advantageous and innovative compared to the current solutions, is represented by an advantageous value of the ratio between the length LUN of the plasticizing screw 122, along which raw material MP undergoes the plasticizing process so as to be prepared for the injection step true and proper, and the diameter DIA of the same screw 122, value which is much lower and indicatively between 2 and 6 than the values which this ratio assumes, typically 20 or another very similar value, in conventional injection moulding units.

Accordingly, that is thanks to this low ratio between length LUN of the plasticizing screw 122 and related diameter DIA, the injection unit 120 has a shape which as well as being considerably more compact is also such as to request less power than the known moulding units to command rotation of the plasticizing screw 122, as has been shown by experimental tests and checks carried out by the inventor.

Further, again according to estimates and tests carried out by the inventor, the injection or filling pressure PR-1 may reach values of 2-3 tonnes per cm^2, whereas the compression or compacting pressure PR-2 may reach values of 6-7 tonnes per cm^2.

Variants and improvements of the moulding machine of the invention

Naturally, without departing from the principle and basic concepts of this invention, the embodiments and construction details may be varied compared with what has been described and illustrated up to now, without exiting from the scope of the invention itself.

For instance the closed position P2 of the mobile mould-bearing platen14 may also be sensed instead of with the position transducer 24 associated with motor 22 in other ways considered more suitable and effective, for instance with position transducers cooperating directly with the mobile mould-bearing platen 14 or with parts integral therewith.

The same system as is arranged for commanding the forward and backward motion of the mobile mould-bearing platen 14 may comprise, instead of electric motor 22 connected to the actuating rod 17, a hydraulic actuator, such as a hydraulic jack, or similar device having an actuating rod that defines at one end the piston 38 suitable for cooperating with the fluid contained in the hydraulic amplifier 30 for applying thereon input force Fo.

Or, on the basis of another variant alternative to the solution described above of using moulds 12 having only predetermined thicknesses, or of adapting a generic mould 12 of any thickness on the mounting tool 60 by means of plates of suitable thickness, the condition of alignment between the toothed elements 261a, 261b of the clamping devices 261 and the teeth of the rack 242, the purpose of which is to permit proper operation and meshing of the blocking means 241 in correspondence with the closed position P2 of the mobile mould-bearing platen 14, may be achieved by varying the quantity of fluid or oil 32 contained in the chamber 31 inside the hydraulic amplifier 30.

In particular, according to this variant, a regulation tank 96 schematically represented with a dot and dash line in Fig. 2 is connected through a system of valves 97 to the amplification chamber 31, wherein the valves 97 are controlled by controller 21 for inputting to or removing from the amplification chamber 31, as indicated by double arrow f10, at the start of a moulding cycle made with a new mould 12 of different thickness from the previous one, a sufficient amount of hydraulic fluid or oil 32 to restore the condition of alignment between the toothed elements 261a and the rack 242 in correspondence with the closed position P2 of the mobile mould-bearing platen 14.

In other words the flow of the hydraulic fluid between the regulation tank 96 and the amplification chamber 31 is used to regulate at each mould change the relative position between the mobile mould-bearing platen 14 and the blocking plate 81, and thereby also between the latter and the backing plate 34b integral with the intermediate hollow body 34, by the amount necessary for, when position P2 is reached by the mobile mould-bearing platen 14, the blocking plate 81 to have toothed elements 261a, 261b perfectly in line with those of rack 242 and thus permit proper meshing therebetween.

The regulation tank 96 may for instance contain pressurized nitrogen to encourage the flow of hydraulic fluid 32 towards the amplification chamber 31.

For clarity's sake it should be remembered that this regulation is possible because the blocking plate 81 and the mobile mould-bearing platen 14 are not rigidly connected but are coupled so as to be able to have a limited degree of movement with respect to one another, thanks to interposition of the mobile wall 36 of the hydraulic amplifier 30, integral with the blocking plate 81, said mobile wall 36 being housed slidingly inside the hollow body 34 of hydraulic amplifier 30, in turn integral with the mobile mould-bearing platen 14, as described earlier.

Again, referring to the fixed structure of the injection moulding machine, the longitudinal tie bars 73 and 73 may be placed, and thus connect to the end walls 71 and 72, instead of on the same horizontal level, according to a diagonal configuration (not shown in any of the drawings), that is to say with one tie on high and the other low down symmetrically to the central axis 15, so as not to encumber the sides of the moulding machine and thus facilitate the operations of assembling and disassembling the mould 12 with the relative mounting tool 60.

Other variants may concern the injection unit of the moulding machine of the invention.

For instance, with reference to Figs. 14 and 14a, one variant, indicated generically with numeral 320, of the injection unit for injecting plastic material into the mould 12 in which for clarity's sake parts similar or corresponding to those of the previous embodiment 120 are indicated with numerical references incremented by 200, comprises:

a plasticizing cylinder or body 321; an injection body 324 fixed integrally to the plasticizing cylinder 321 and defining internally an injection chamber 326; a plasticizing screw 322 housed inside the plasticizing cylinder 321 and having an end portion extending through the injection chamber 326; and a reflux device 341 adjacent to the injection chamber 326 and in turn comprising a first upper disc 342 and a second lower

disc 343, place one above the other and both provided with apertures, wherein this reflux device 341 has a function and operation substantially similar to that 141 of embodiment 120.

The plasticizing screw 322 is suitable for rotating about an axis 323 corresponding to the longitudinal axis of the plasticizing cylinder 321, and is provided in the end zone or tip, along axis 323, with a cylindrical portion 322a that has a diameter D1' of a lower value than that of the remaining part of the plasticizing screw 321, wherein this lower diameter D1' corresponds exactly to that of a flow hole 327, which also lies along the axis 323 and which is facing the injection chamber 326 so that the tip portion 322a of the plasticizing screw 322 defines a piston suitable for cooperating with flow hole 327 to close it as described later.

The first upper disc 342 of the reflux device 341 is suitable for rotating integrally with plasticizing screw 322 and for this purpose is coupled with the latter through a grooved coupling or similar, indicated with 350, which is made from two complementary grooved profiles formed respectively on a portion 322b of the plasticizing screw 322 and on a central hole of the upper disc 342.

More particularly this grooved coupling 350 as well as coupling the plasticizing screw 322 and the disc 342 in rotation, is also such as to permit a relative axial movement between these.

The second lower disc 343 is instead stationary and for this purpose is fitted integrally with the plasticizing cylinder 321, for example via protrusions 343a made on its circumference and housed in corresponding seats made in the plasticizing cylinder 321.

The plasticizing cylinder 321 also defines internally a ring-shaped conveying chamber 325 which extends on the axis 323 so as to surround and accommodate the end part of the plasticizing screw 322, and which has the function of conveying the flow of molten plastic material PL fed by the plasticizing screw 322 towards the injection chamber 326.

Unlike embodiment 120, the plasticizing screw 322 as well as being provided for rotating about the axis 323 is also suitable for moving axially on the axis 323 for injecting the molten plastic material PL into the mould 12.

In operation of the injection unit 320, similarly to injection unit 120, at the start of a generic moulding cycle and during a first loading step, the plasticizing screw 322 rotates for instance in the direction of arrow f32 to feed and plasticize the plastic material in such a way as to fill the injection chamber 326 with molten plastic material PL.

The plastic material PL in turn in this step reaches the injection chamber 326 by passing through the reflux device 341 as indicated by arrows f33, the respective two discs 342 and 343, of which the upper disc 342 rotates together with the plasticizing screw 322, being such as to put conveying chamber 325 and injection chamber 326 in communication, and therefore allow fluid material PL to pass each time the apertures in the upper disc 342 overlap with those of the lower disc 343.

When the injection chamber 326 is filled with the right amount of plastic material PL, the plasticizing screw 322 stops in a predetermined angular position in correspondence with which the upper disc 342, integral with the plasticizing screw 322, obstructs with its closed portions the apertures in the lower disc 343, so as to close the reflux device 341 and thus prevent any communication between the injection chamber 326 and the conveying chamber 325.

Then in a later step, under the control of suitable actuating means, the plasticizing screw 322 advances axially, without rotating, as indicated by arrow f34 so as to inject the fluid plastic material fluid PL contained in the injection chamber 326 into the mould 12.

In this way, during a first step the axial advancing of the plasticizing screw 322 results in the plastic material PL being injected by the injection chamber 326 passing through the hole 327, into the mould 12 so as to fill it.

Then, as soon as the piston 322a reaches and closes the flow hole 327, the plasticizing screw 322 is commanded so as to rotate and stop according to a predetermined angle of rotation in the direction opposite the feeding direction indicated by arrow f32 of the plastic material in the injection chamber 326, thus producing a corresponding rotation of the upper disc 342 such as to put the injection chamber 326 in communication with the ring-shaped conveying chamber 325 and thus permit reflux towards the latter, through device 341, of the plastic material PL not injected into the mould 12 but remaining in the amplification chamber 326.

Meanwhile the further axial advancing of the plasticizing screw 322 in the hole 327 results in final compacting of the molten plastic material PL, already injected, inside the mould 12.

Then when injection and compacting are complete, the plasticizing screw 322 stops and retracts axially so that it returns once more to the starting position to feed new plastic material and commence a new moulding cycle.

Obviously in this variant 320, the starting position of the plasticizing screw 322 assumed at the start of a moulding cycle may vary and, in particular, it may depend on the quantity of fluid plastic material PL that first has to be fed into the injection

chamber 326 to fill it, before the step true and proper of injection of plastic material from injection chamber 326 to the mould 12, produced through the subsequent axial advancing of the same plasticizing screw 322.

This variant 320 of the injection unit appears capable of providing significant performances.

For example, purely indicatively and according to calculations and tests performed by the inventor, if the injection unit 320 is sized with a diameter D3 of plasticizing screw 322 of 20 mm, and a diameter D1' of piston 322a, defined by the tip of the plasticizing screw 322, of 13 mm, a final compacting pressure of the plastic material in the molten state inside the mould 12 of approx. 4,000 Kg/cm2 may be obtained, following an injection pressure applied during the injection and mould filling step of 1,300 Kg/cm2.

Other variants may concern the moulded piece extracting device.

For instance this extracting device may be configured so that the extraction motors 91 that command advancing of the extraction plate 93 are mounted, not on the external side of the wall 72, but on that of the fixed wall 71, that is on the side of the fixed structure 50 of the moulding machine opposite the injection side.

Naturally, without prejudice to the principle and basic concepts of this invention, the embodiments and construction details of this injection moulding machine may be widely varied with respect to what has been described and illustrated up to now, without departing from the scope of the invention.

CLAIMS

1. Machine (11) for injection moulding of plastic materials (PL), comprising:

- a fixed structure (50, 73, 74, 71, 72);
- a mobile mould-bearing platen (14) and a fixed mould-bearing platen (16) bearing respectively a first (12a) and a second half-mould (12b) of a mould (12), the mobile mould-bearing platen (14) being mobile along a stroke (C) between an open position (P1), wherein the two half-moulds (12a, 12b) are separate and removed from one another, and a closed position (P2), wherein the two half-moulds (12a, 12b) are in contact with one another to permit the injection of plastic material (PL) into the mould (12);
- an actuating and closing assembly (10) in turn including;

  an actuating unit (20, 17) suitable for commanding movement of the mobile mould-bearing platen (14) between the open (P1) and closed (P2) positions, and

  a closing unit (26, 30) operatively connected to the mobile mould-bearing platen (14) for closing it in the closed position (P2) against the fixed mould-bearing platen (16); and
- blocking means (241, 261, 81), associated with said closing unit (26, 30), for blocking said mobile mould-bearing platen (14), in said closed position (P2), with respect to said fixed structure (50, 73, 74),

said moulding machine (11) being **characterized in that** that said closing unit (26) comprises a hydraulic force amplifier (30) of the type having a hydraulic fluid (32) suitable for receiving from said actuating unit (20) a predetermined input force (Fo) for producing and applying in response, on said mobile mould-bearing platen (14) in the closed position (P2), a given closing force (FS) amplified with respect to said input force (Fo),

wherein said blocking means (241, 261) are suitable for cooperating with said hydraulic force amplifier (30) to activate the application of said amplified closing force (FS) on said mobile mould-bearing platen (14) in said closed position (P2).

2. Moulding machine (11) according to claim 1, wherein said actuating unit (20) comprises an actuating rod (17) movable axially (f1) and operatively connected at one end (17a) to said mobile mould-bearing platen (14), and

wherein said hydraulic force amplifier (30) comprises:

a hollow-shaped intermediate body (34), mounted integrally on said mobile mould-bearing platen (14) and located between said end (17a) of the actuating rod

(17) and said mobile mould-bearing platen (14) to join them in the movement between said open (P1) and closed (P2) positions,

a mobile wall (36) movably accommodated in said intermediate body (34) to define with the latter an amplification chamber (31) containing said hydraulic fluid (32), and

a piston (38) defined by said end (17a) of said actuating rod (17), said piston (38) being slidingly accommodated in a through hole (37) made in said mobile wall (36) to cooperate with the hydraulic fluid (32) contained in said amplification chamber (31), and

wherein said blocking means (241, 261) are suitable for acting to block said mobile wall (36) with respect to said fixed structure (50), when said mobile mould-bearing platen (14) reaches said closed position (P2), so as to arrange said hydraulic amplifier (30) to receive from said piston (38), at said through hole (37), said input force (Fo) on the hydraulic fluid (32) contained in said amplification chamber (31), and to then apply in response on said mobile mould-bearing platen (14), through said intermediate body (34), said amplified closing force (FS).

3. Moulding machine (11) according to claim 2, further comprising resilient means (39) operating on said end (17a) of said actuating rod (17) and on said intermediate body (34) to keep them integrally connected during the stroke (C) of said mobile mould-bearing platen (14) between said open position (P1) and said closed position (P2),

wherein said resilient means (39) are suitable for flexing, when, at the end of said stroke (C), said piston (38) applies said input force (Fo) on the hydraulic fluid (32) inside said amplification chamber (31) and in response said hydraulic fluid (32) applies said amplified closing force (FS) on said mobile mould-bearing platen (14) in the closed position (P2).

4. Moulding machine (11) according to claim 3, wherein said resilient means (39) comprise at least one compression spring (39a) accommodated between said mobile wall (36) and a backing member (34b) integral with said intermediate body (34), said compression spring (39a) being suitable for pressing, through said hydraulic fluid (32), said intermediate body (34) against a flange (17b) integral with said actuating rod (17) and adjacent to said piston (38) defined at the end of the latter (17).

5. Moulding machine (11) according to any one of the claims from 2 to 4, wherein said blocking means (241, 261) further comprise a blocking plate (81) which is integral with said mobile wall (36) of the hydraulic amplifier (30) so as to be movable

together with said mobile mould-bearing platen (14) through said moulding machine (11),

wherein said blocking means (241, 261) are suitable for rigidly blocking said blocking plate (81) and therefore also said mobile wall (36) with respect to said fixed structure (50, 73, 74), when said mobile mould-bearing platen (14) reaches said closed position (P2).

6. Device according to claim 5, wherein said blocking means (241) comprise at least one toothed clutch (261, 261a, 261b, 242) suitable for acting between said blocking plate (81) and said fixed structure (73, 74) to clamp them rigidly one to the other when said mobile mould-bearing platen is in said closed position (P2).

7. Device according to claim 6, wherein said toothed clutch (261) comprises a rack (242) integral with a longitudinal tie bar (73, 74) of said fixed structure (50).

8. Moulding machine (11) according to claim 6, further comprising regulating means (96, 97) for changing, at each change of a mould (12) with another mould of different thickness (H), the volume of hydraulic fluid (32) inside said hydraulic amplifier (30, 31) so as to regulate and re-establish the alignment between the teeth (261a, 261b, 242) of said clutch (261) respectively integral with said blocking plate (81) and with said fixed structure (50, 73, 74), in correspondence with the closed position (P2) of said mobile mould-bearing platen (14), and thus permit proper operation of said blocking means (241, 261).

9. Moulding machine (11) according to any one of the previous claims, wherein said actuating unit (20) is associated with means (24) suitable for sensing when said mobile mould-bearing platen (14) reaches said closed position (P2).

10. Moulding machine (11) according to any one of the claims from 2 to 9, wherein said actuating unit (20) comprises a brushless type rotating motor (22) and a screw-lead screw assembly (23) suitable for receiving and converting the rotation motion of said motor to command the axial movement (f1) of said actuating rod (17).

11. Method for the closing of a mould (12) consisting of two separable half-moulds (12a, 12b), in a machine (11) for the injection moulding of plastic materials (PL), comprising the following steps:

- moving (51), by means of an actuating unit (20), a mobile mould-bearing platen (14), bearing a first (12a) of said half-moulds, from an open position (P1), in which the two half-moulds (12a, 12b) are separate and remote from one another, to a closed position (P2), in which the two half-moulds (12a, 12b) are closed and in

contact with one another to permit the injection of plastic material (PL) into the mould (12);

- blocking (53) said mobile mould-bearing platen (14), when it is in said closed position (P2), with respect to a fixed structure (50, 73, 74) of said moulding machine (11), and

- applying (54), through said actuating unit (20, 17, 38), a predetermined input force (Fo) on a hydraulic amplifier (30) associated with said mobile mould-bearing platen (14), so that said hydraulic amplifier (30) reacts by applying, on said mobile mould-bearing platen (14) in the closed position (P2), a given closing force (FS) amplified with respect to said input force (Fo), whereby the two half-moulds (12a, 12b) are closed one against the other by said amplified closing force (FS),

wherein the blocking step (53) is associated with the blocking, with respect to said fixed structure (50, 73, 74), of at least a part (36) of said hydraulic amplifier (30) so as to activate, in response to said input force (Fo), the application of said amplified closing force (FS) on said mobile mould-bearing platen (14) in said closed position (P2).

12. Method according to claim 11, wherein said blocking step (53) is carried out by means of at least one toothed clutch (261, 261a, 261b, 242) acting between said at least a part (36) of said hydraulic amplifier (30) and said fixed structure (73, 74) to clamp them rigidly one to the other when said mobile mould-bearing platen is in said closed position (P2).

13. Machine (11) for the injection moulding of plastics materials, comprising:

- a fixed structure (50);

- a mobile mould-bearing platen (14) and a fixed mould-bearing platen (16) respectively bearing a first (12a) and a second half-mould (12b) of a mould (12), the mobile mould-bearing platen (14) being mobile along a stroke (C) between an open position (P1), wherein the two half-moulds (12a, 12b) are separate and remote from one another, and a closed position (P2), wherein the two half-moulds (12a, 12b) are closed and in contact with one another to permit the injection of plastic material into the mould (12);

- an actuating and closing assembly (10for per said mould (12) including

an actuating unit (20, 17) suitable for commanding movement of the mobile mould-bearing platen (14) between the open (P1) and closed (P2) positions, and

a closing unit (26, 30) operatively connected to the mobile mould-bearing platen (14) for clamping it, in the closed position (P2), against the fixed mould-bearing platen (16); and

- blocking means (241, 261, 81) for clamping and preventing any displacement of said mobile mould-bearing platen (14), when it is in said closed position (P2), towards the open position (P1),

said moulding machine (11) being **characterized in that** that said fixed structure (50) includes at least one tie bar (73, 74) which extends in the longitudinal direction parallel to the stroke (C) of said mobile mould-bearing platen (14), and

a system of horizontal guides (76, 77) to guide said mobile mould-bearing platen (14) in movement (C) between the open (P1) and closed (P2) positions, and

in that said blocking means further comprise a blocking plate (81) connected to said mobile mould-bearing platen (14) through said closing unit (26, 30) so as to be mobile together with said mobile mould-bearing platen (14) through said moulding machine (11),

wherein said blocking means (241, 261) are suitable for rigidly clamping said blocking plate (81) on said at least one tie bar (73, 74), when said mobile mould-bearing platen (14) is in said closed position (P2),

so that said system of horizontal guides (76, 77) receives and supports the weight of said mobile mould-bearing platen (14) and of the parts connected thereto during the movement (C) between said open position (P1) and said closed position (P2), and

said at least one tie bar (73, 74) receives and supports totally the closing force (FS) exerted by said closing unit (26, 30) on said mobile and fixed mould-bearing platens (14, 16), when said mobile mould-bearing platen (14) is in said closed position (P2).

14. Moulding machine (11) according to claim 13 **characterized in that** said closing unit (26) comprises a hydraulic force amplifier (30) located between said actuating unit (20) and said mobile mould-bearing platen (14),

wherein said hydraulic amplifier (30) contains inside a volume of hydraulic fluid (32) provided to receive from said actuating unit (20) a predetermined input force (Fo) and to produce and apply in response, on said mobile mould-bearing platen (14) in the closed position (P2), a predetermined closing force of amplified entity (FS) with respect to said input force (Fo), and

in that said blocking plate (81) is connected in movement with said mobile mould-bearing platen (14) via the interposition of said hydraulic amplifier (30).

15. Moulding machine (11) according to claim 14, wherein said actuating unit (20) comprises an actuating rod (17) movable axially (f1) and operatively connected at one end (17a), via the interposition of said hydraulic amplifier (30), to said mobile mould-bearing platen (14) to move it between the respective open (P1) and closed (P2) positions,

wherein said hydraulic force amplifier (30) comprises:

a hollow-shaped intermediate body (34), fastened integrally at one part on said mobile mould-bearing platen (14),

a mobile wall (36) accommodated slidingly in said intermediate body (34) to define with the latter an amplification chamber (31) containing said volume of hydraulic fluid (32), said mobile wall (36) being integral with said blocking plate (81), and

a piston (38) defined by said end (17a) of said actuating rod (17), said piston (38) being accommodated slidingly in a through hole (37) made in said mobile wall (36) to cooperate with the hydraulic fluid (32) inside said amplification chamber (31),

so that said blocking means (241, 261), when they intervene in correspondence with the closed position (P2) of the mobile mould-bearing platen (14) in order to rigidly clamp said blocking wall (81) and therefore said mobile wall (36) with respect to said at least one tie bar (73, 74), they prepare and activate said hydraulic amplifier (30) to receive from said piston (38) said input force (Fo) on the hydraulic fluid (32) inside said amplification chamber (31), and to apply in response on said mobile mould-bearing platen (14) said amplified closing force (FS).

16. Moulding machine (11) according to claim 15, further comprising resilient means (39) operating on said end (17a) of said actuating rod (17) and on said intermediate body (34) to keep them integrally connected during the stroke (C) of said mobile mould-bearing platen (14) between the respective open (P1) and closed (P2) position,

wherein said resilient means (39) are suitable for flexing, when, at the end of said stroke (C), said piston (38) applies said input force (Fo) on the hydraulic fluid (32) inside said amplification chamber (31) and in response said hydraulic fluid (32) applies said amplified closing force (FS) on said mobile mould-bearing platen (14) in the closed position (P2).

17. Moulding machine (11) according to claim 16, wherein said actuating rod (17) is provided, in the end zone (17a) defining said piston (38), with a flange (17b), and said intermediate body (34) is integrally connected, in correspondence with the side opposite said mobile mould-bearing platen (14), to a blocking plate (34b), and

wherein said resilient means (39) comprise at least one compression spring (39a) which is located between said mobile wall (36) accommodated slidingly in said intermediate body (34) and said blocking plate (34b) integral with the latter, in order to press and keep said flange (17b) and said blocking plate (34b) constantly in contact with one another, during the movement of said mobile mould-bearing platen (14) between the respective open (P1) and closed (P2) positions.

18. Moulding machine (11) according to claim 13 or 14, wherein said blocking means (241) comprise at least one toothed coupling or clutch (261, 261a, 242) suitable for intervening between said blocking plate (81) and said at least one longitudinal tie bar (73, 74).

19. Moulding machine (11) according to any one of the claims from 13 to 18, wherein said fixed structure (50) includes at least two tie bars (73, 74) which extend in the longitudinal direction from opposite sides with respect to a central axis (15) of said moulding machine (11),

wherein said blocking plate (81) is suitable to be guided in motion through said moulding machine (11) by the same system of horizontal guides (76, 77) as said mobile mould-bearing platen (14), and

wherein said blocking means (241, 261) are suitable for intervening to rigidly clamp said blocking plate (81) on said two tie bars (73, 74) when said closed position (P2) is reached by said mobile mould-bearing platen (14).

20. Machine (11) for the injection moulding of plastics materials according to any one of the claims from 13 to 19, further comprising extracting device (125) for extracting a moulded piece (PS) from said mould (12),

wherein said extracting device (125) comprises at least one extraction shaft (92) arranged parallel to said system of horizontal guides (76, 77) and movable together with said mobile mould-bearing platen (14) through said moulding machine (11), and

an extraction plate (93) movable together with said mobile mould-bearing platen (14) and bearing an extracting member (25a) suitable for cooperating with the mobile half-mould (12a) mounted on said mobile mould-bearing platen (14) in order to extract therefrom a moulded piece (PS),

wherein, after injection of plastic material (PL) in said mould (12) and during the return motion of said mobile mould-bearing platen (14) from said closed position (P2) to said open position (P1), said extraction shaft (92) commands said extraction plate (93) so as to move it relatively with respect to said mobile half-mould (12a) and thereby cause extraction of the moulded piece (PS).

21. Machine (11) for the injection moulding of plastic material according to claim 20, wherein said extraction plate (93) and said extraction shaft (92) are connected by means of a screw-lead screw assembly (92d, 92e), and

wherein said extraction shaft (92) comprises a screw portion (92d) which is part of said screw-lead screw assembly (92d, 92e) and a grooved portion (92c) which is suitable for sliding axially through a corresponding hollow extraction motor (91), during movement of said mobile mould-bearing platen (14) between the open (P1) and closed (P2) positions.

22. Injection moulding unit (120; 320) for the moulding of plastic materials, comprising:

a plasticizing cylinder (121; 321);

a plasticizing screw (122; 322) accommodated in said plasticizing cylinder(121; 321), said plasticizing screw (122; 322) being suitable for rotating f12; f32) in order to advance and feed a raw material (MP) while it is subject to a plasticizing process along the feeding path through said plasticizing screw (122; 322);

a injection chamber (126; 326) associated with said plasticizing cylinder (121; 321) for receiving the plasticized raw material (PL) fed by said rotating plasticizing screw (122; 322), said injection chamber presenting a flow hole (127; 327) through which the plasticized material (PL) flows from said injection chamber (126; 326) for being injected into a mould (12); and

an injecting member (131; 322) suitable for advancing (f14'; f34) through said injection chamber (126; 326) to press the plasticized material (MP) contained therein and inject it (f4) into the mould (12),

wherein said injection moulding unit (120; 320) is **characterized in that** it further comprises a reflux device (141; 341) located between said injection chamber (126; 326) and said plasticizing screw (122; 326), said reflux device (141; 341) being switchable from a closed configuration (CON1), so as to impede reflux of the plasticized material (PL) from the injection chamber (126; 326) to the plasticizing screw, to an open configuration (CON2), so as to allow the reflux (f17), towards said plasticizing screw (122; 322), of the plasticized material (PL) contained in said

injection chamber (126), when said injecting member (131, 131a; 322; 322a), in the advancing motion through said injection chamber (126; 326), reaches and substantially closes (P12) said flow hole (127; 327).

23. Injection moulding unit (120) according to claim 22, wherein said injecting member consists of a piston (131) which is suitable for moving alternatively in a guiding through hole (122b), formed along the axis (123) of said plasticizing screw (122), and which has at the tip a first portion (131a) having a section (D1) substantially equal to that (D1) of said flow hole (127), and

wherein said reflux device (141) is suitable for being switched from said closed configuration (CON1) to said open configuration (CON2), to allow reflux of said plasticized material (PL) from said injection chamber (126) to said plasticizing screw (122), when, in the advancing motion of said injection piston (131), said first portion (131a) reaches and is therefore aligned, in an alignment position (P12), with the input section of said flow hole (127), so as to close it, and

wherein said injection piston (131) is intended to advance further, with the respective first portion (131a), in said flow hole (127) so as to definitively compress the plasticized material (MP) injected and contained in the mould (12).

24. Injection moulding unit (120) according to claim 23, wherein said injection piston (131) has in a central area, adjacent to said first portion (131a), a second portion (131b) having a greater section (D2) than that (D1) of said first portion (131a).

25. Injection moulding unit (120) according to claim 24, wherein the first and the second portion (131a, 131b) of said injection piston (131), and said flow hole (127) are cylindrical in shape.

26. Injection moulding unit (20) according to any one of the claims from 22 to 25, wherein the switching of said reflux device (141) from said closed configuration (CON1) to said open configuration (CON2) is associated with a rotation (θo), of predetermined amplitude, of said plasticizing screw (122) in the direction (f16) opposite the direction of rotation to feed and advance the plasticized material towards said injection chamber (126), so that said plasticizing screw by rotating in the opposite direction cooperates with said reflux device (141) to encourage reflux of the plasticized material from said injection chamber (126) to said plasticizing screw (122).

27. Injection moulding unit (120) according to claim 23, comprising first motor means (151) and second motor means (153) for respectively commanding rotation of said plasticizing screw (122) in said injection cylinder (121), and linear advancing of

said injection piston (131) along said guide hole (122b), and further first (152) and second (154) sensing means for respectively sensing the current angular position of said plasticizing screw (122) and the current linear position of said injection piston (131), and wherein said first motor means (151) are suitable for inverting (f16) the rotation of said plasticizing screw (122), when said injection piston (131) reaches said alignment position (P12), as sensed by said second sensing means (154).

28. Injection moulding unit (120) according to claim 27, wherein said first motor means (151) and said second (153) motor means both consist of brushless type motors, associated respectively with said first (152) and second (154) means for sensing the position of said plasticizing screw (122) and of said injection piston (131).

29. Injection moulding unit (20) according to claim 27 or 28, wherein said second motor means (153) consist of a rotating motor and are provide for commanding the linear advancing motion of said injection piston (131) by means of a screw-lead screw assembly (156) located between said rotating motor and said injection piston.

30. Injection moulding unit (120) according to claim 22, wherein said reflux device 1(41) is of the type comprising two discs (142, 143), suitable for rotating one relative to the other, a first disc (142) of which is integrally connected in rotation with said plasticizing screw (122), and a second disc (143) of which is integrally secured to said injection cylinder (121), said first and second disc defining respective complementary apertures (142a, 143c) so shaped that, when said reflux device is in said closed configuration (CON1), they do not overlap, so as to prevent reflux of the plasticized material, and, when said reflux device assumes said open configuration (CON2), they overlap so as to allow reflux (f17) of the plasticized material (PL) through said reflux device (141).

31. Injection moulding unit (120) according to claim 30, wherein said apertures in the discs (142, 143) of said reflux device (141) are associated with inclining profiles (142b, 143d) suitable for encouraging reflux of the plasticized material (PL) to said plasticizing screw (122).

32. Injection moulding unit (320) according to claim 22, wherein said injecting member is in fact the same plasticizing screw (322),

so that the plasticizing screw (322) is suitable, as well as for rotating (f32) to feed the plasticized material towards the injection chamber (326) but also for advancing (f34), after having fed it, to inject the plasticized material from the injection chamber (326) into the mould (12),

said plasticizing screw (322) having a tip portion (322a) with a lower diameter (D1') than that (D3) of the remaining part of the plasticizing screw (322) and substantially equal to the diameter of said flow hole (327).

33. Machine (11) for the injection moulding of plastic materials, comprising an injection moulding unit (120) according to any one of the claims from 22 to 32.

34. Method for the injection moulding of plastic materials, comprising the following steps:

- feeding (161), through a rotating plasticizing screw (122, f12; 322, f32), a plasticized material (PL) to an injection chamber (126; 326) of an injection moulding unit (120; 320) for the moulding of plastic materials, wherein the injection chamber (126; 326) has a flow hole (127) for the flow of plasticized material (PL) from the injection chamber (126; 326) to a mould (12);
- advancing (162, f14') an injecting member (131; 322) through the injection chamber (126; 326) to press the plasticized material (MP) contained therein and inject it (f4; f34) into the mould (12), at the same time preventing reflux of the plasticized material (PL) from the injection chamber (126; 326) to the area of the plasticizing screw; and
- enabling (163) reflux (f17), to the area of the plasticizing screw (122; 322), of at least a part of the plasticized material (PL) contained in the injection chamber (126; 326), when the injecting member (131, 131a; 322; 322a), advancing through the injection chamber (126; 326), reaches and substantially closes (P12) said flow hole (127; 327).

35. Method for the injection moulding of plastic materials according to claim 34, further comprising the following step:

- further advancing (164), during reflux of the plasticized material (PL) to the area of the plasticizing screw, a tip portion (131a; 322a) of said injecting member in said flow hole (127; 327) to definitively compress (PR-2) the plasticized material (PL) injected into the mould (12).

36. Method for the injection moulding of plastic materials according to claim 34, further comprising the following step:

- inverting (f16), with respect to the feeding step, the rotation of said plasticizing screw (122) when the injecting member (131, 131a; 322, 322a) reaches and closes (P12) said flow hole (127; 327), so as to encourage reflux of the plasticized material (PL) from the injection chamber to the area of the plasticizing screw (122; 322).

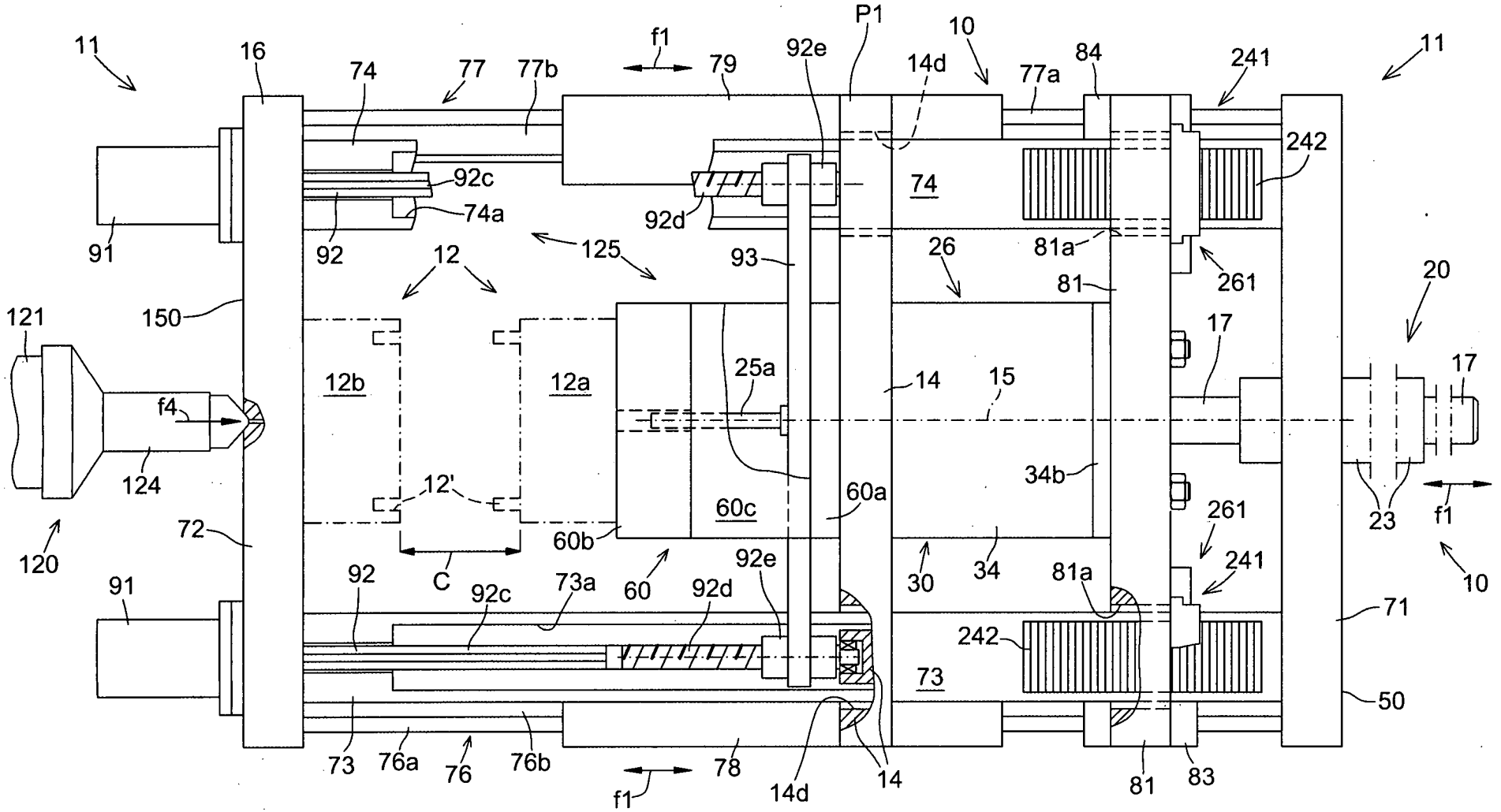
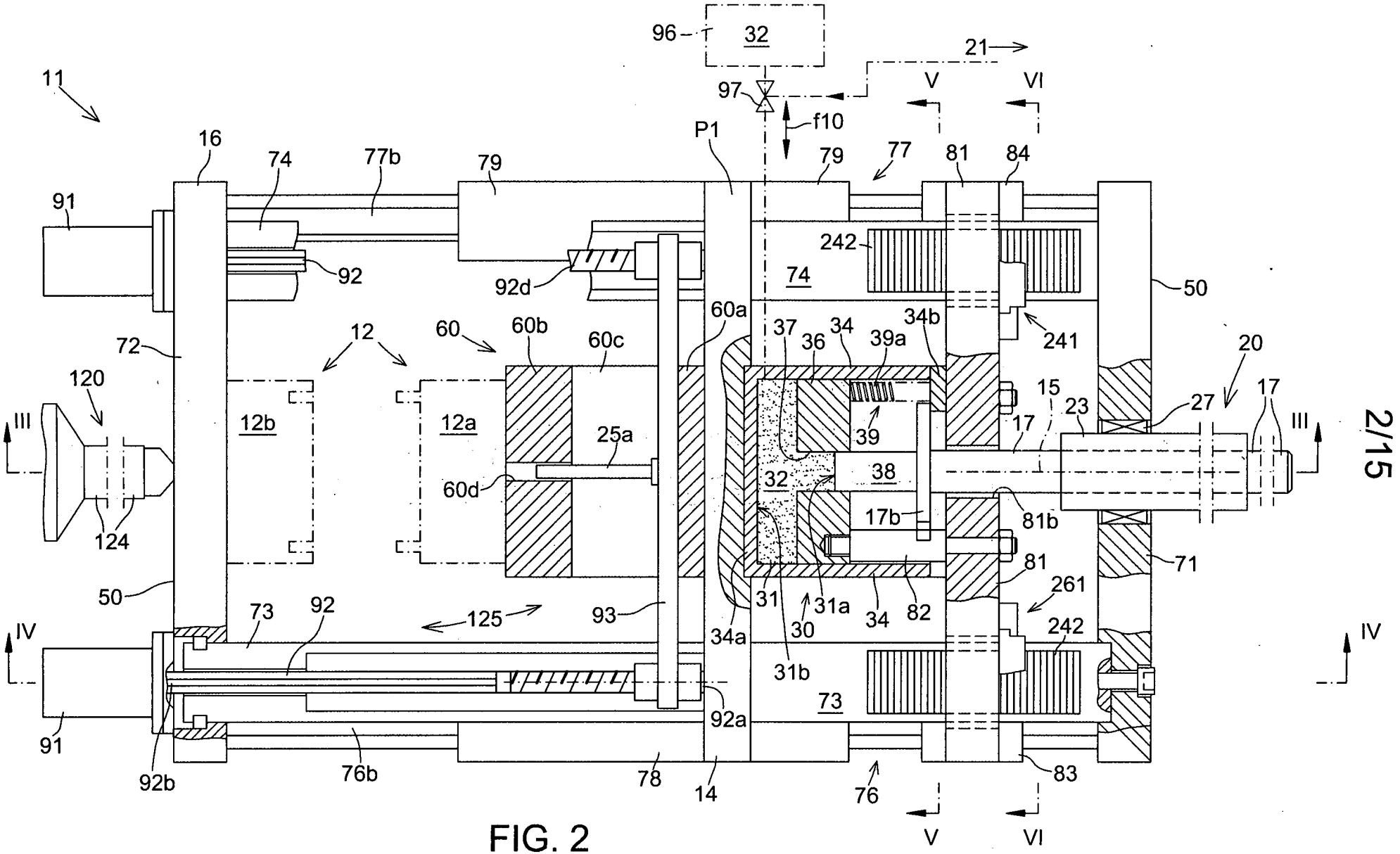

11
16
74
77
77b
f1
79
92e
P1
10
14d
77a
84
241
11
242
92c
74a
92d
74
91
92
125
93
26
81a
261
12
81
20
121
150
17
12b
12a
25a
14
15
17
f4
34b
124
12'
60c
60a
261
23
f1
120
72
60b
C
92e
30
34
81a
241
10
91
92
92c
73a
60
92d
71
242
73
50
73
76a
76
76b
78
14d
14
81
83
f1

FIG. 1


11
96
32
21
97
V
VI
f10
P1
16
74
77b
79
77
81
84
91
92
92d
242
74
50
60a
60
60b
60c
37
36
34
39a
34b
241
20
72
12
120
12b
12a
25a
39
15
23
27
17
III
III
60d
38
32
17b
81b
124
81
71
261
50
73
92
125
93
31
31a
34
82
242
IV
IV
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30
31b
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92a
91
92b
76b
78
14
76
83
V
VI

FIG. 2

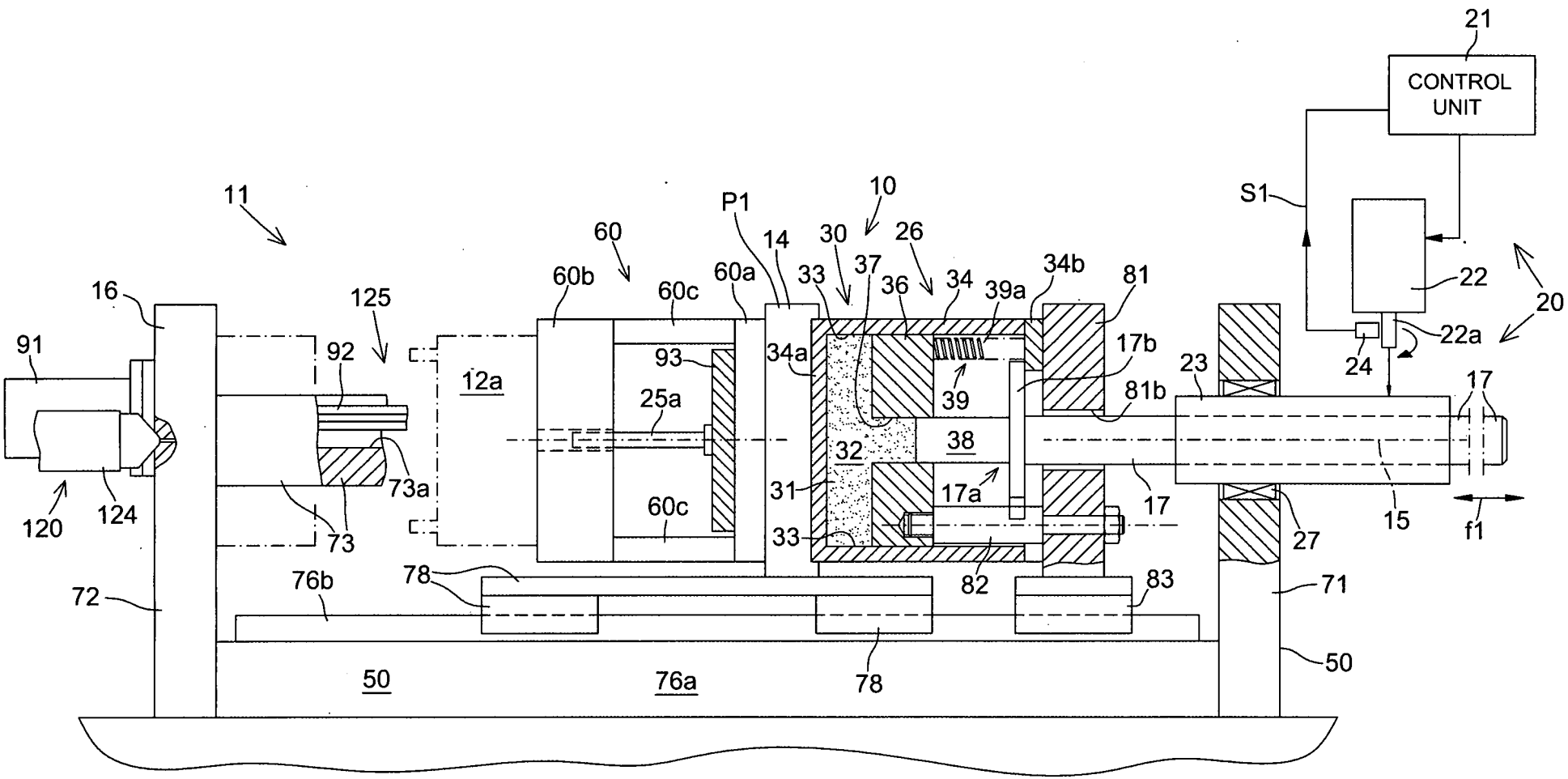

21
CONTROL UNIT
S1
11
10
P1
60
14
30
26
16
125
60b
60c
60a
33
37
36
34
39a
34b
81
22
20
91
92
12a
93
34a
17b
22a
24
23
17
25a
39
81b
120
124
73a
32
38
15
f1
73
31
17a
17
60c
27
33
72
76b
78
82
83
71
50
76a
78
50

FIG. 3

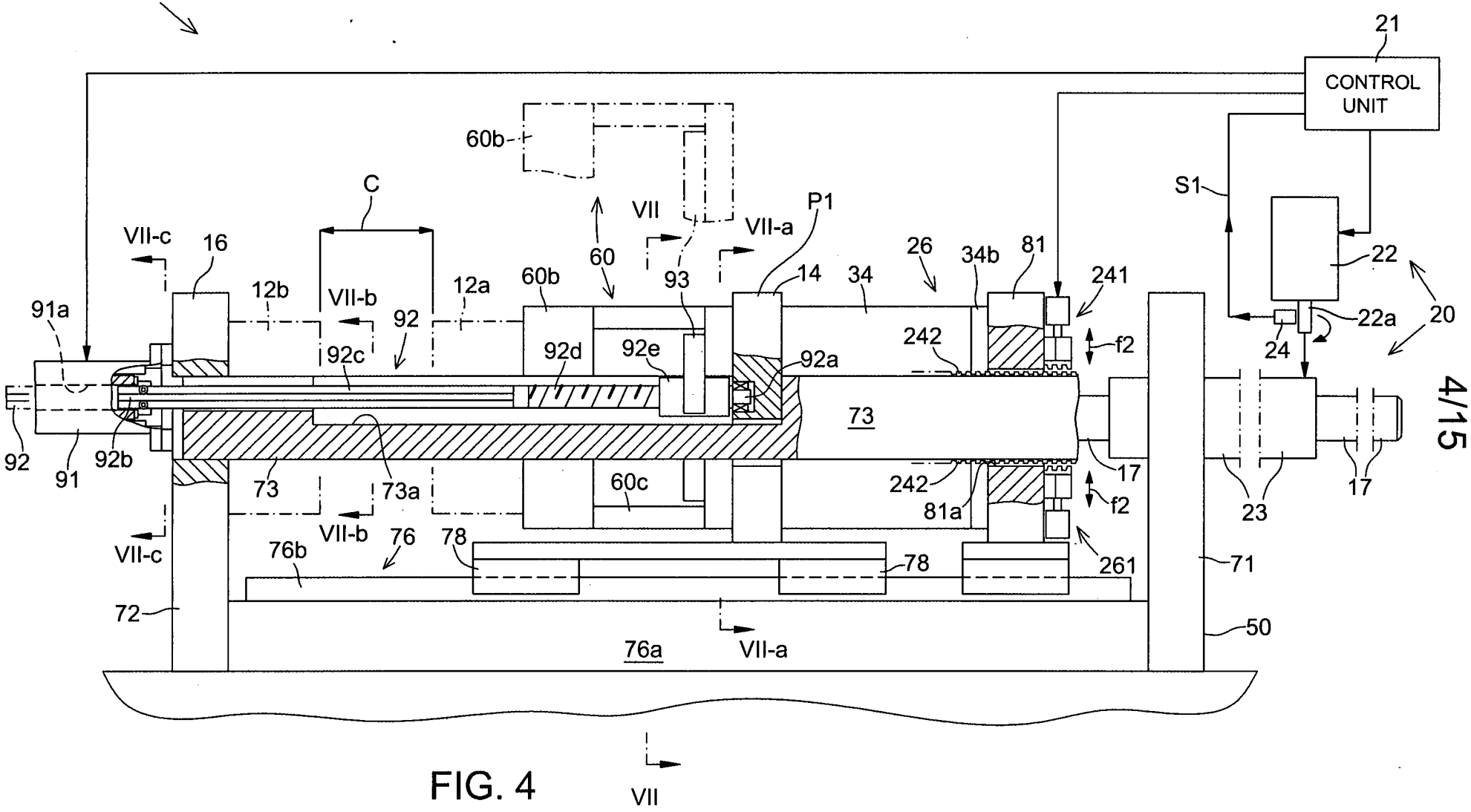

11
21
CONTROL UNIT
60b
C
VII
VII-a
P1
S1
VII-c
16
60
93
14
26
34b
81
241
22
12b
VII-b
12a
60b
34
22a
20
91a
92
92c
92d
92e
92a
242
f2
24
73
92
91
92b
73
73a
60c
242
17
17
81a
f2
VII-b
76
78
261
23
VII-c
76b
78
71
72
50
76a
VII-a
VII

FIG. 4

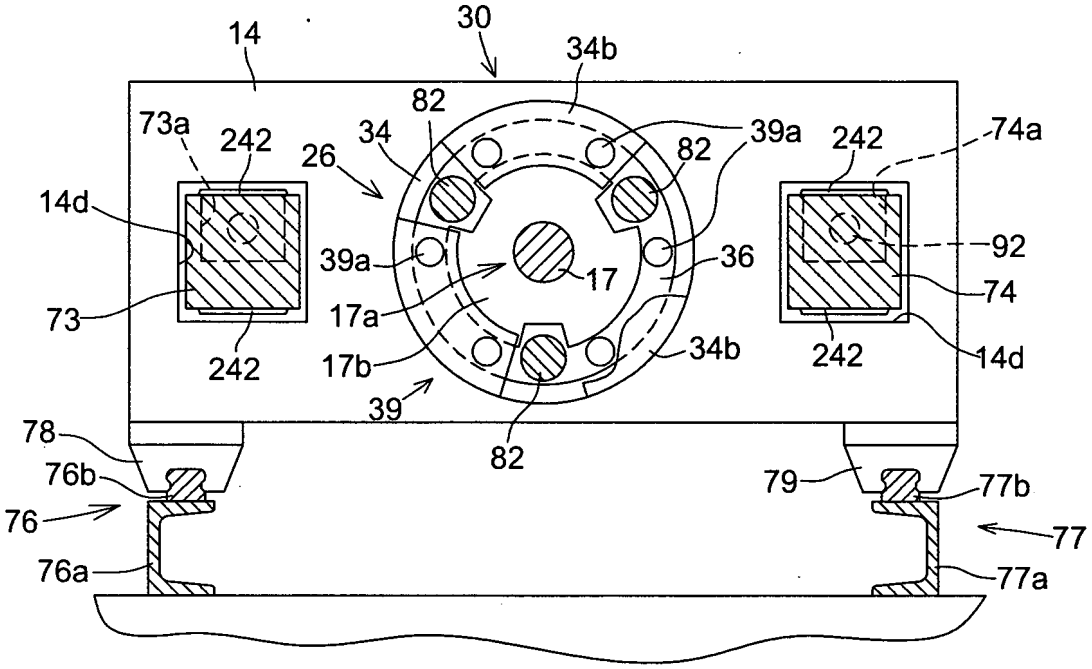

14
30
34b
82
73a
242
34
26
39a
82
242
74a
14d
39a
17
36
92
73
17a
74
242
17b
34b
242
14d
39
82
78
76b
79
77b
76
77
76a
77a

FIG. 5

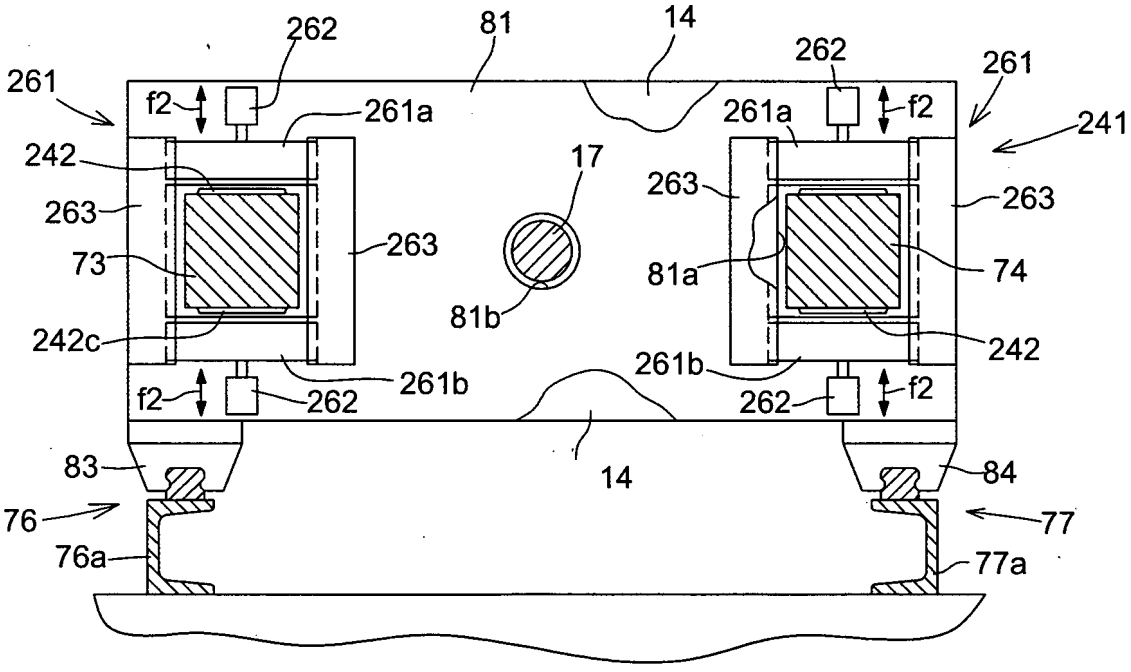

262
81
14
262
261
261
f2
261a
261a
f2
241
242
17
263
263
263
263
73
74
81a
81b
242c
242
261b
261b
f2
262
262
f2
83
84
14
76
77
76a
77a

FIG. 6

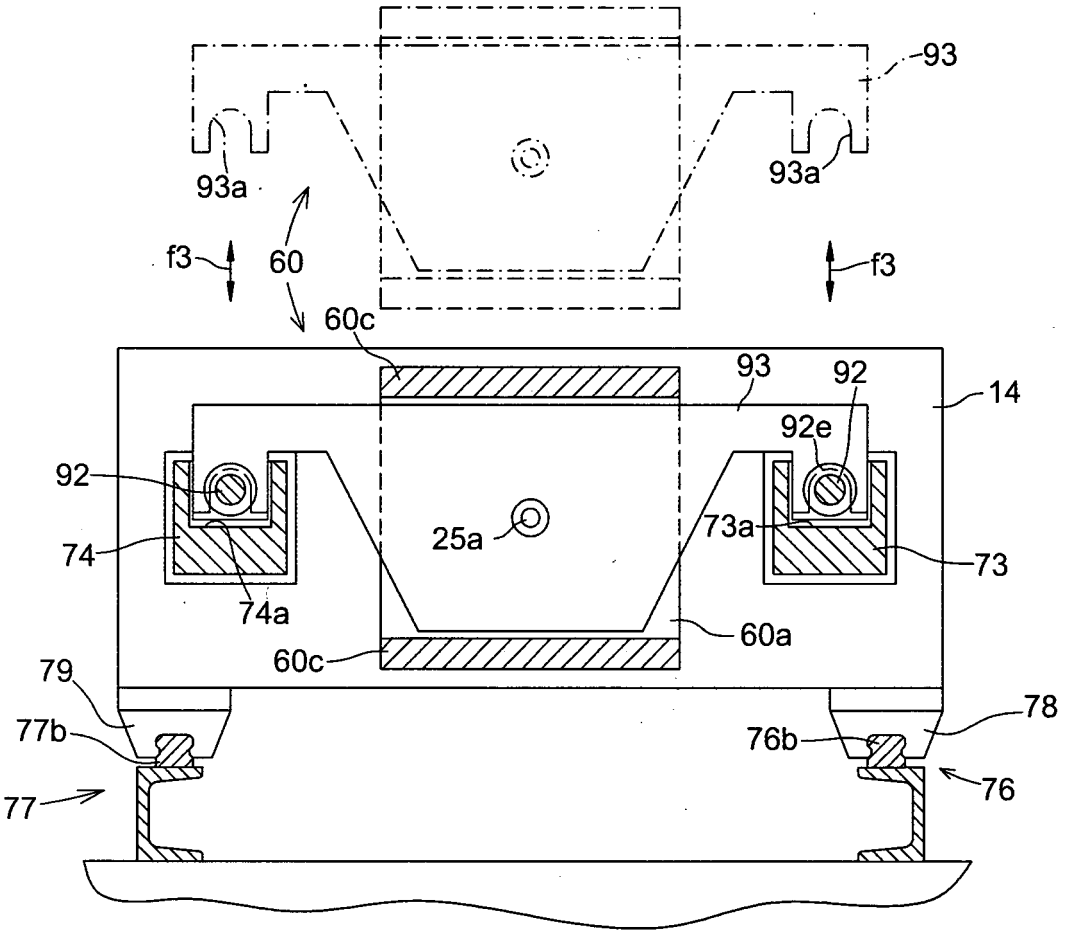


FIG. 7

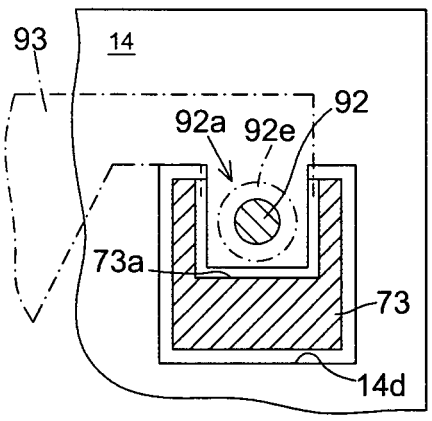


FIG. 7a

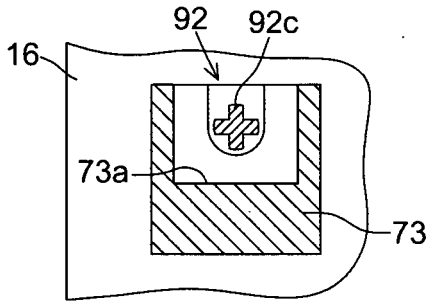


FIG. 7b

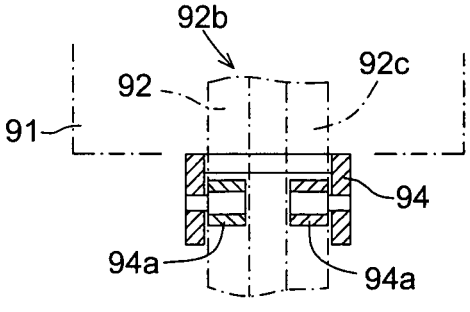


FIG. 7d

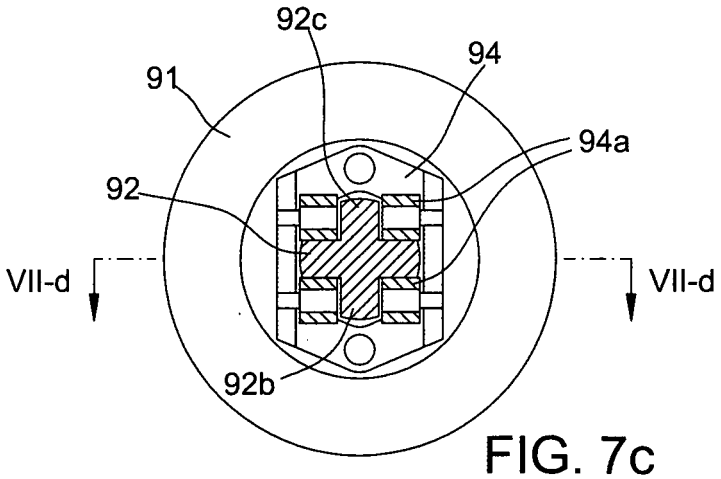


FIG. 7c

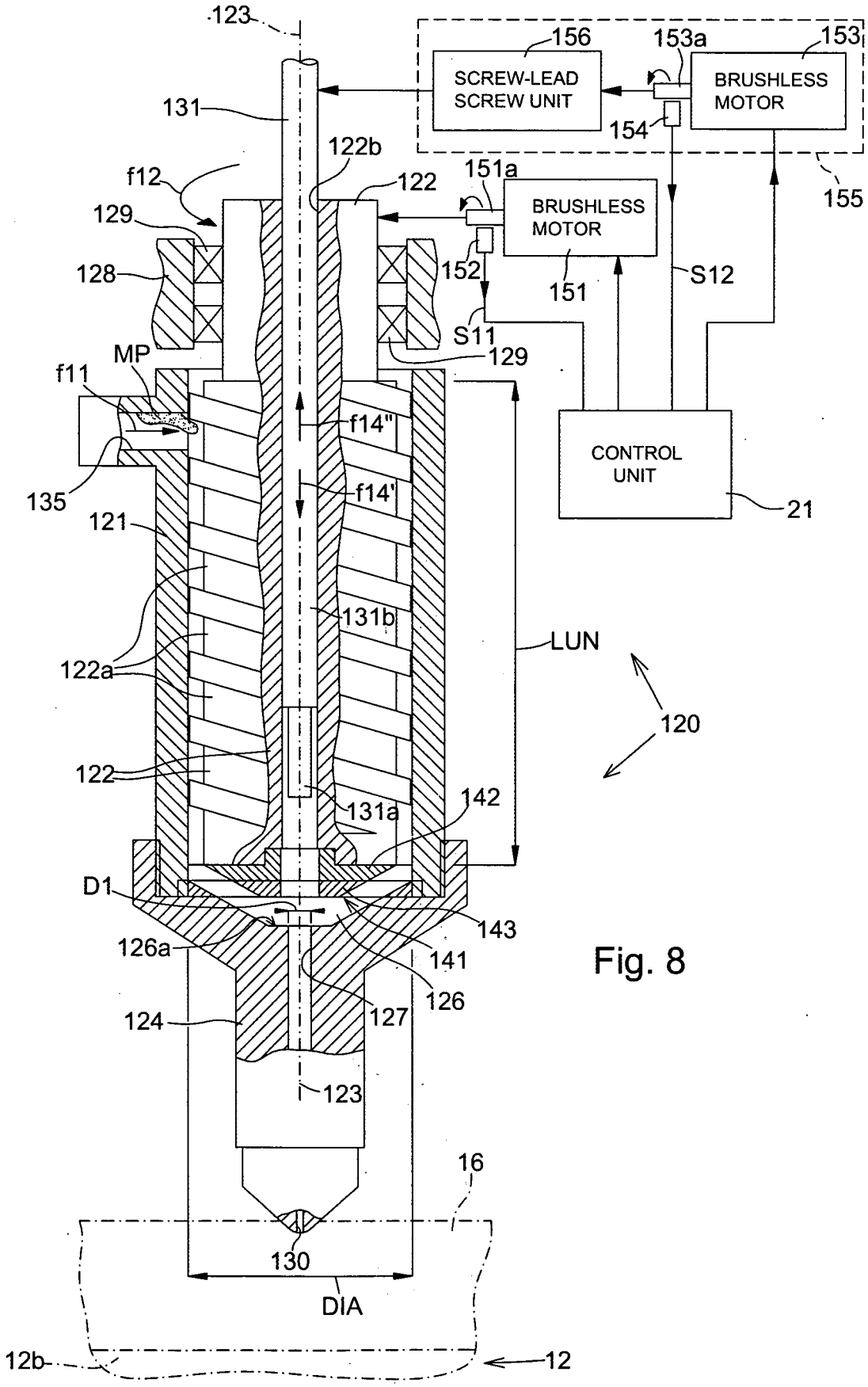

123
156
153a
153
SCREW-LEAD SCREW UNIT
BRUSHLESS MOTOR
131
154
122b
151a
f12
122
155
BRUSHLESS MOTOR
129
152
151
S12
128
S11
129
MP
f11
f14"
CONTROL UNIT
135
f14'
21
121
131b
LUN
122a
120
122
142
131a
D1
143
126a
141
126
124
127
123
16
130
DIA
12b
12

Fig. 8

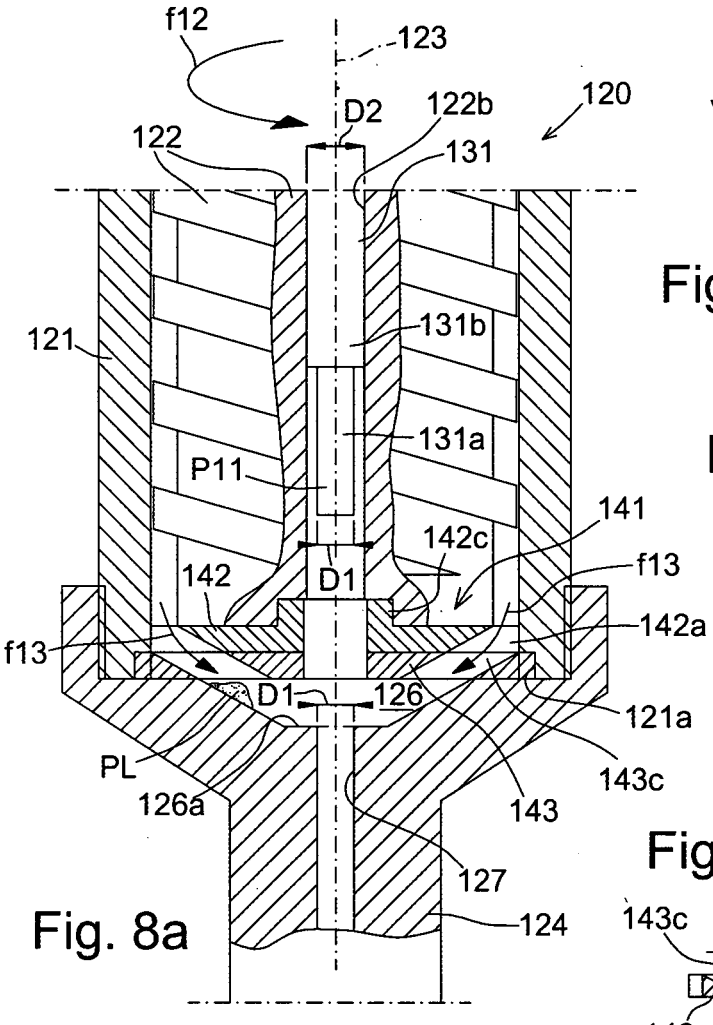


Fig. 8a

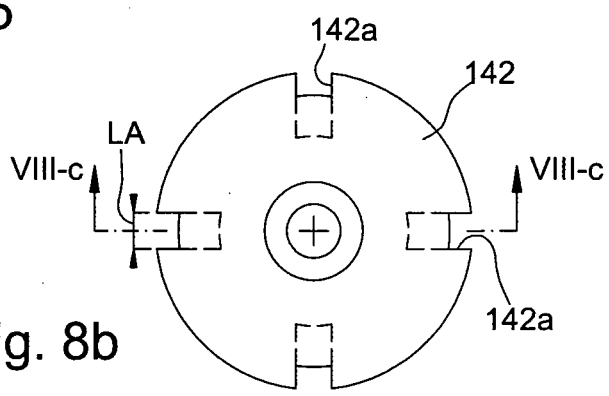


Fig. 8b

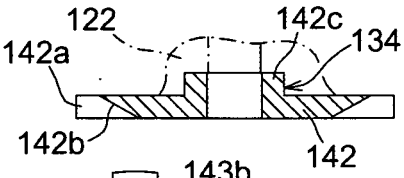


Fig. 8c

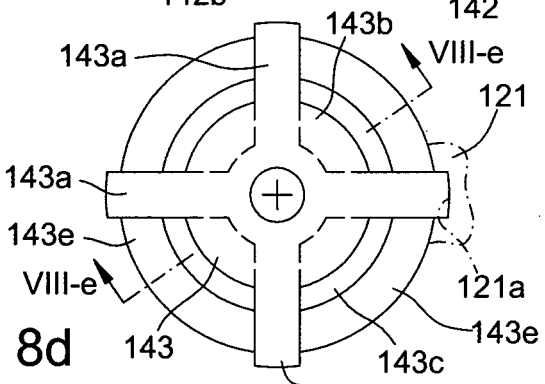


Fig. 8d

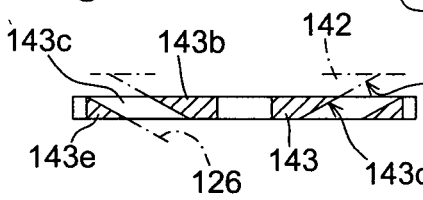


Fig. 8e

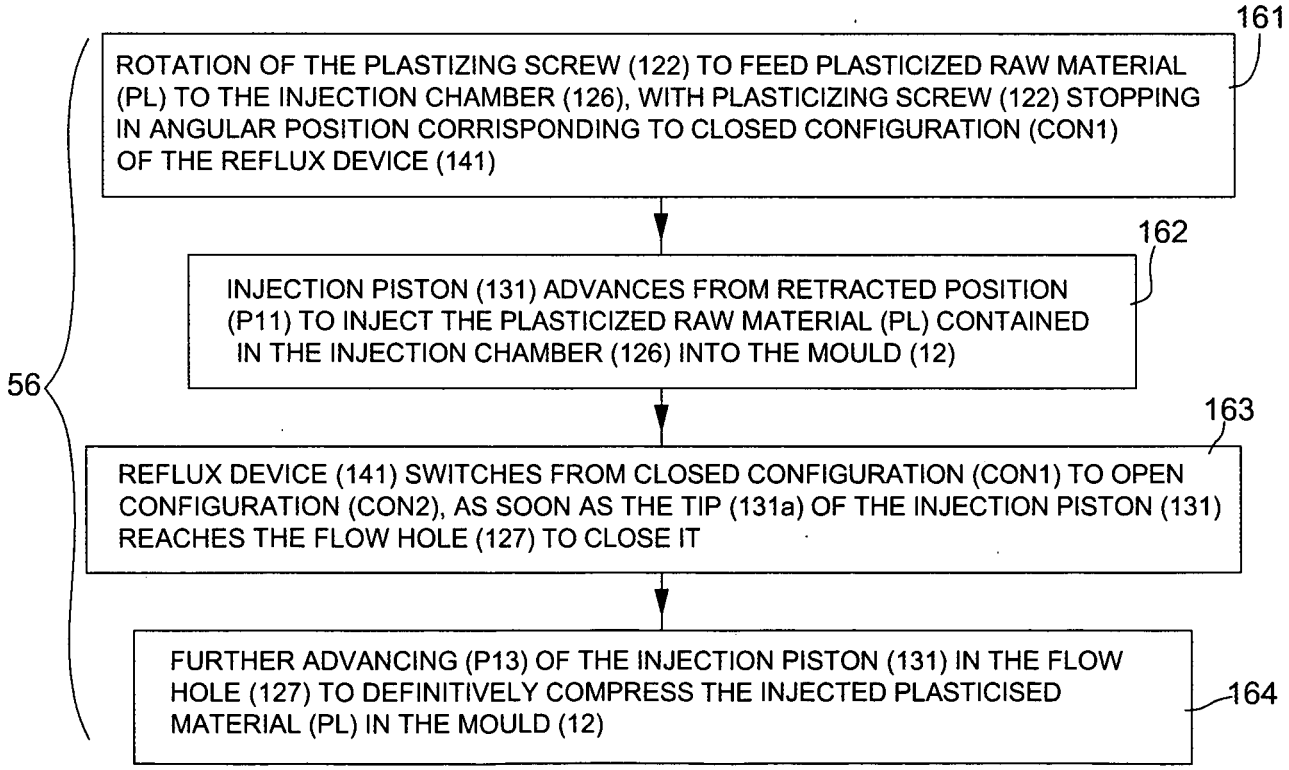
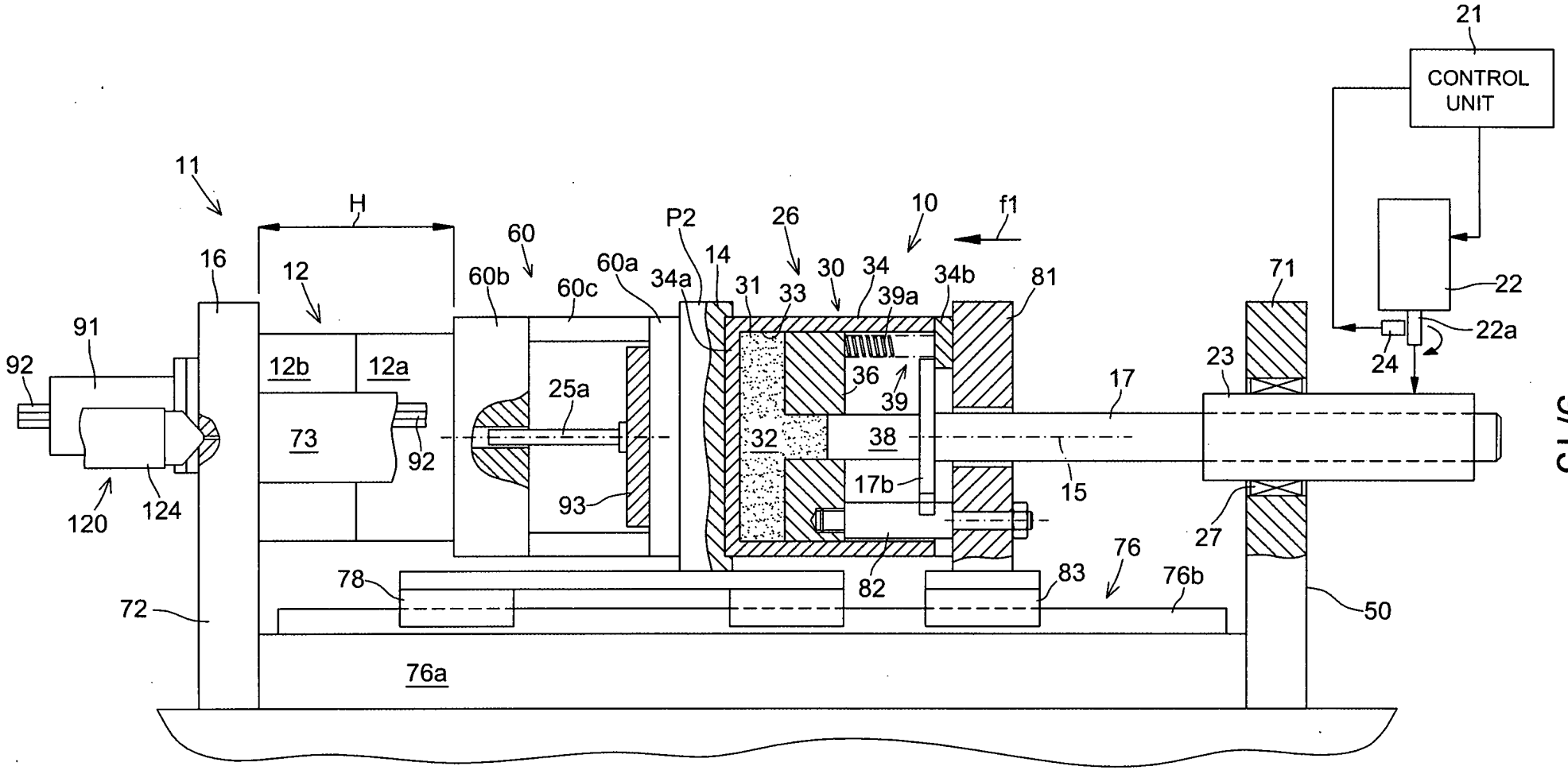


Fig. 13a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CONTROL UNIT
11
H
10
f1
16
12
60
P2
26
14
60b
60c
60a
34a
31
33
30
34
39a
34b
81
71
22
22a
24
91
92
12b
12a
25a
36
39
17
23
73
92
32
38
15
120
124
93
17b
27
76
78
82
83
76b
72
50
76a

FIG. 9

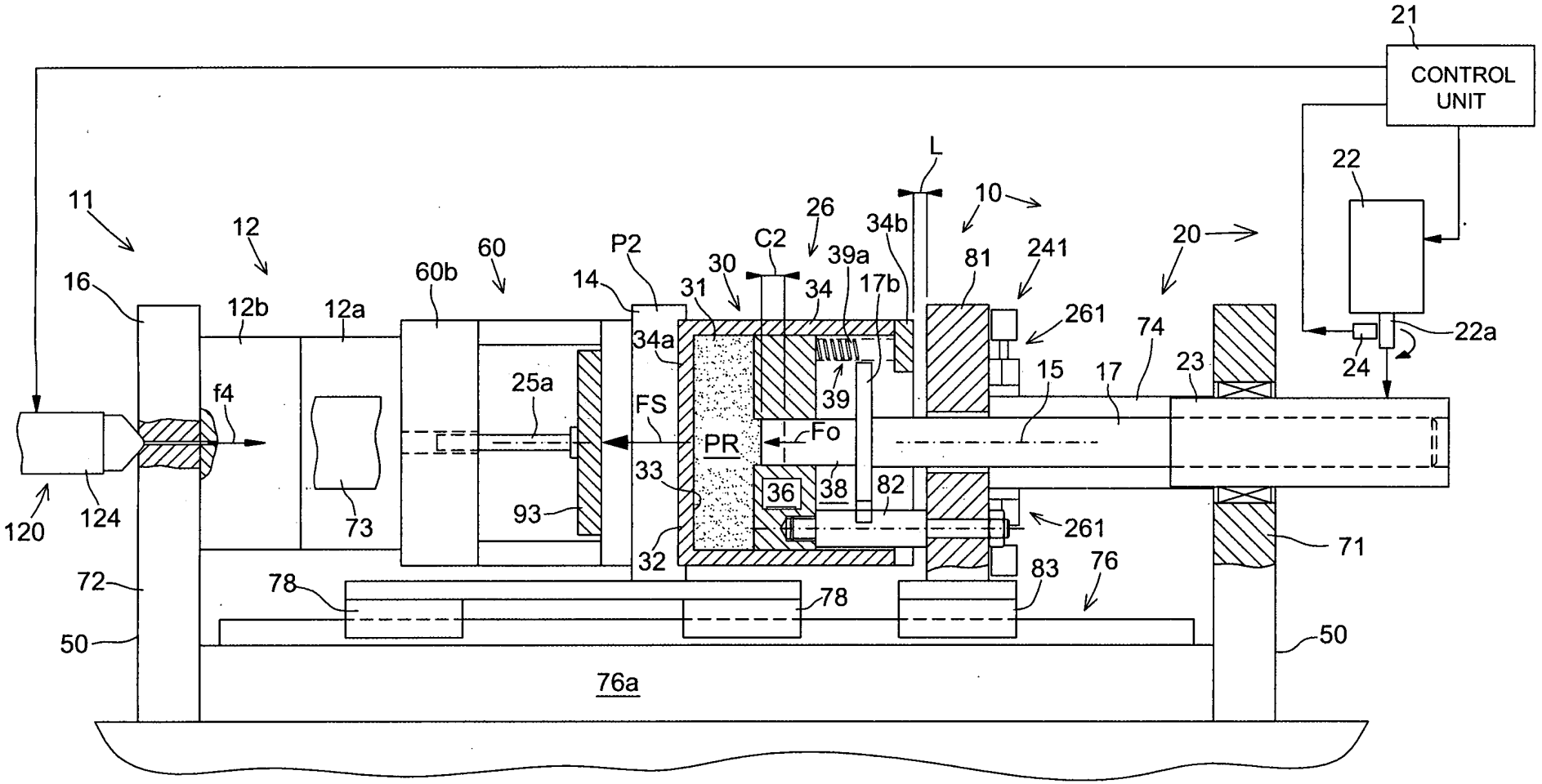

21
CONTROL UNIT
22
22a
24
L
10
11
12
16
12b
12a
60b
60
14
P2
C2
26
30
31
34
34b
39a
17b
81
241
20
261
74
23
15
17
f4
25a
FS
PR
Fo
39
34a
33
36
38
82
93
32
261
71
83
76
78
78
72
50
50
76a
120
124
73

FIG. 10

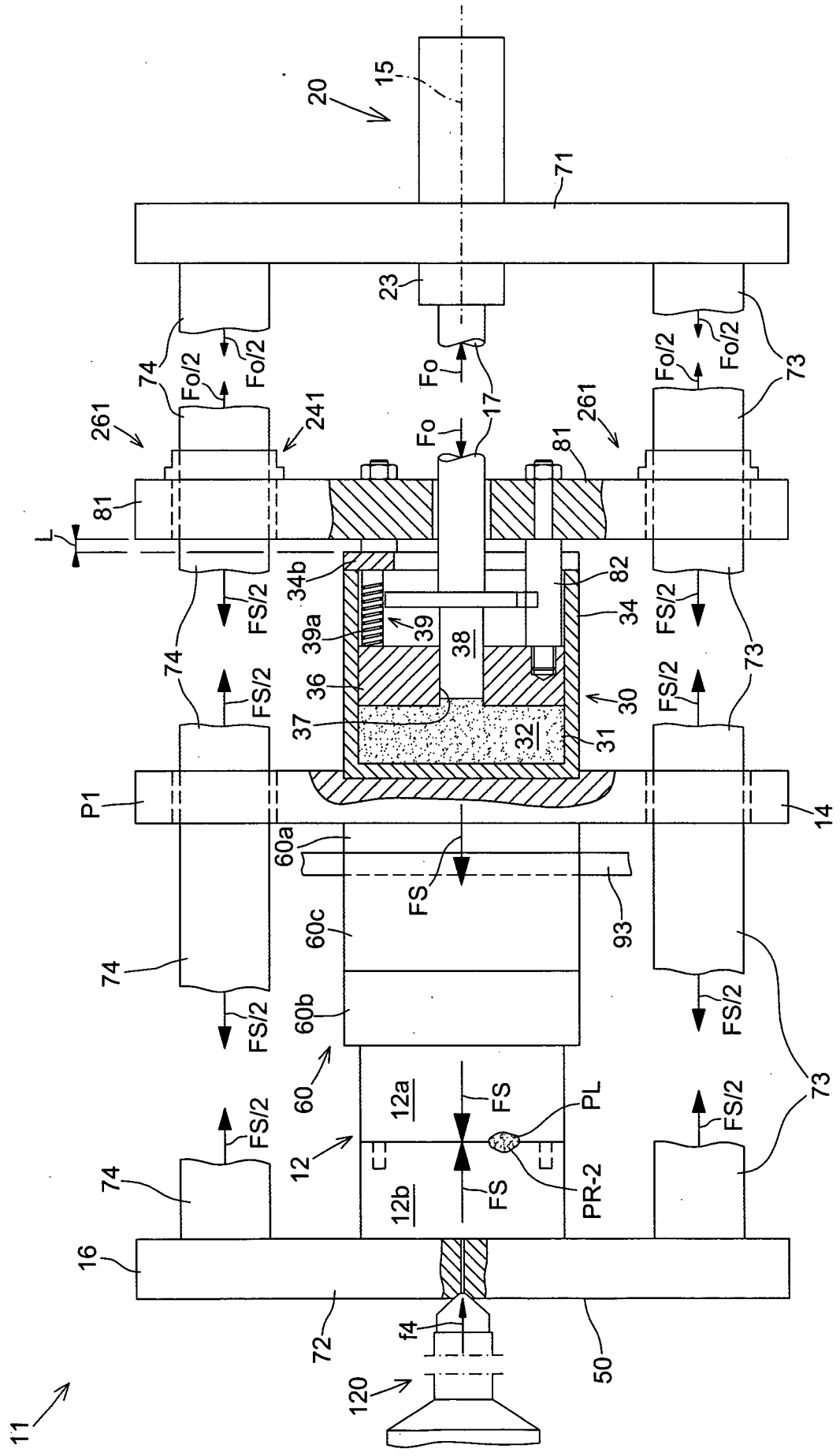

11
20
15
71
23
74
Fo/2
Fo
17
73
261
241
81
L
34b
82
34
39a
39
38
36
37
32
31
30
FS/2
P1
14
60a
FS
93
60c
60b
60
12a
12
12b
PL
PR-2
16
72
f4
50
120

FIG. 10a

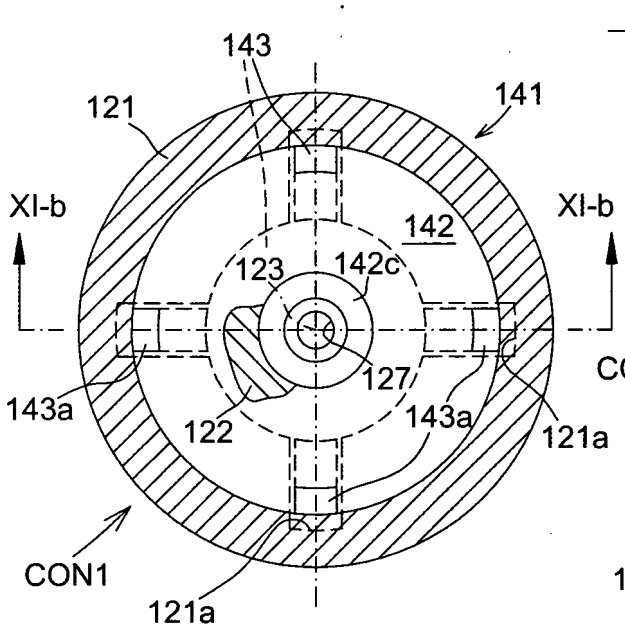


Fig. 11a

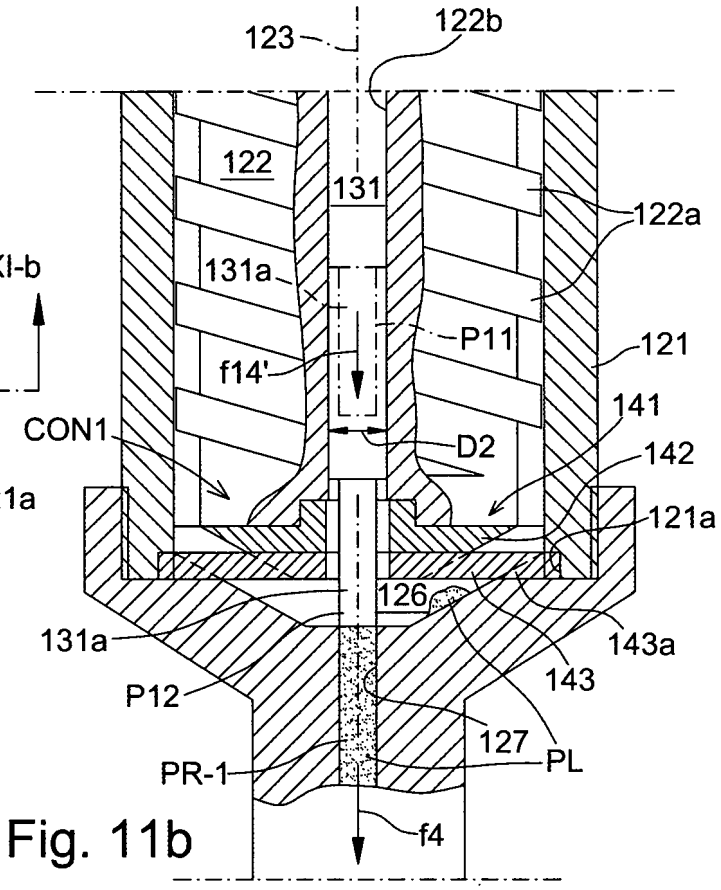


Fig. 11b

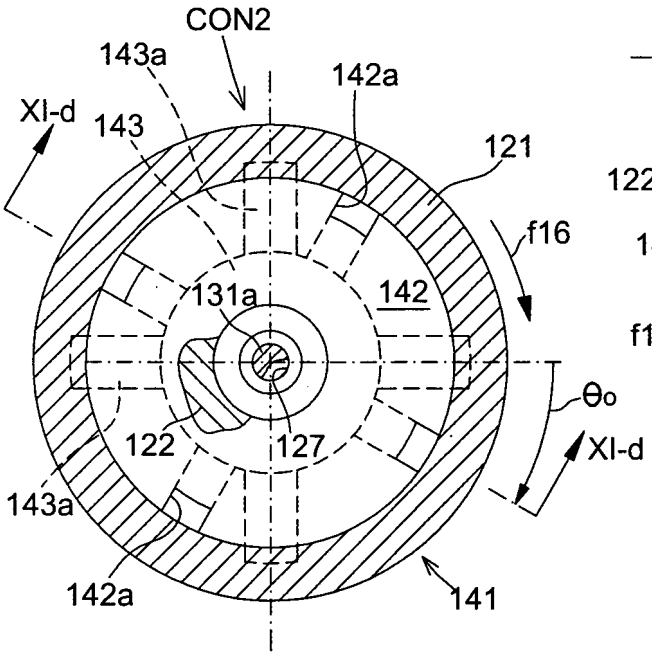


Fig. 11c

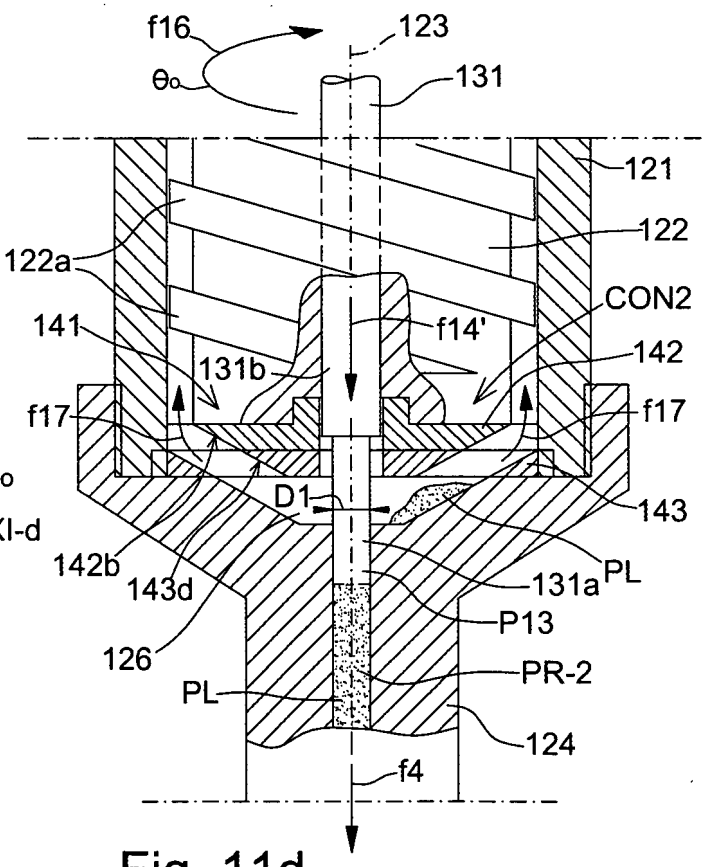
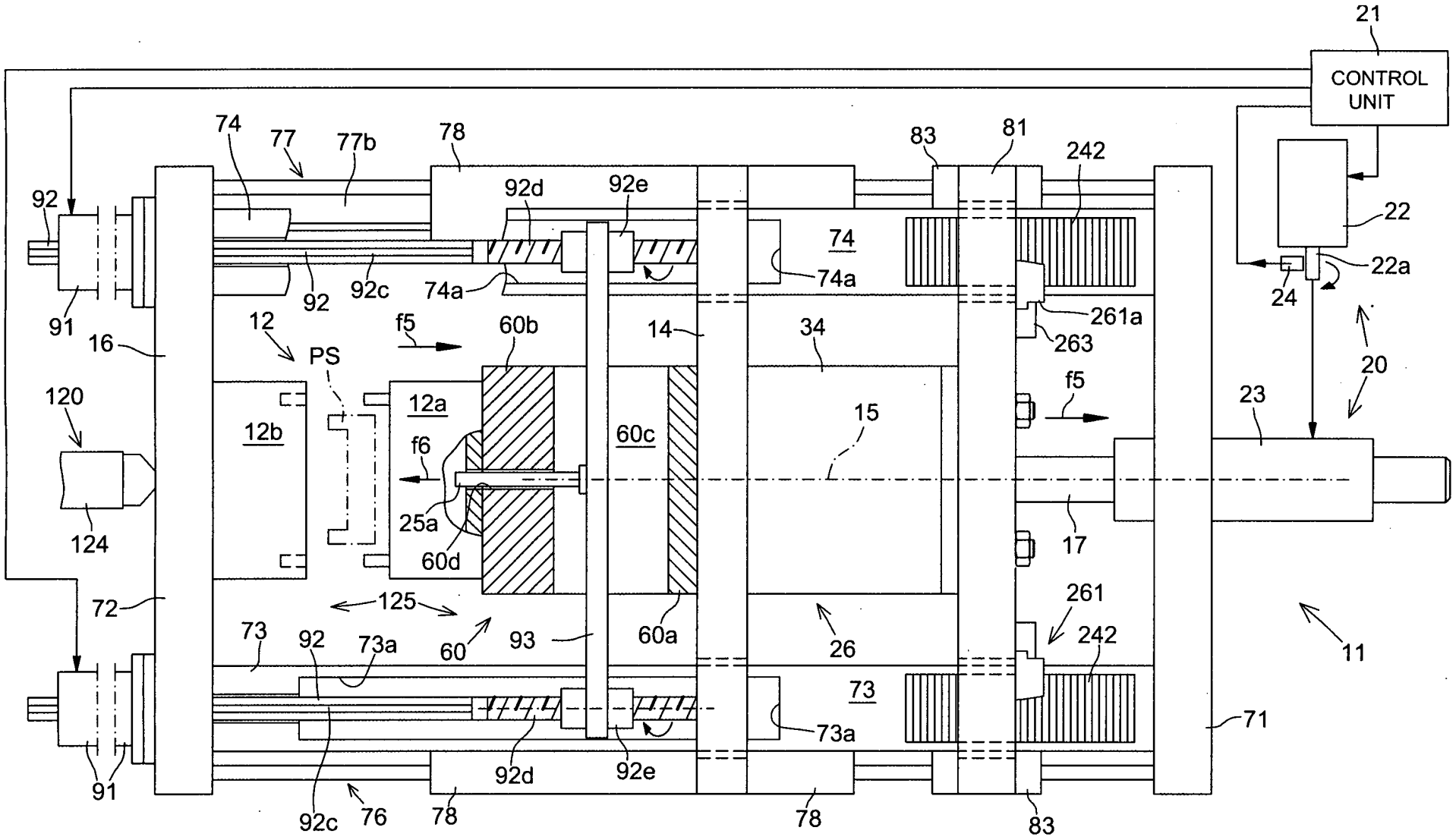


Fig. 11d


21
CONTROL UNIT
74
77
77b
78
83
81
242
92
92d
92e
22
74
74a
22a
24
92
92c
74a
261a
263
91
16
12
PS
f5
60b
14
34
20
120
12a
f5
23
12b
60c
15
f6
25a
60d
124
17
72
125
261
73
92
73a
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93
60a
26
242
11
73
73a
71
91
92d
92e
92c
76
78
78
83

FIG. 12

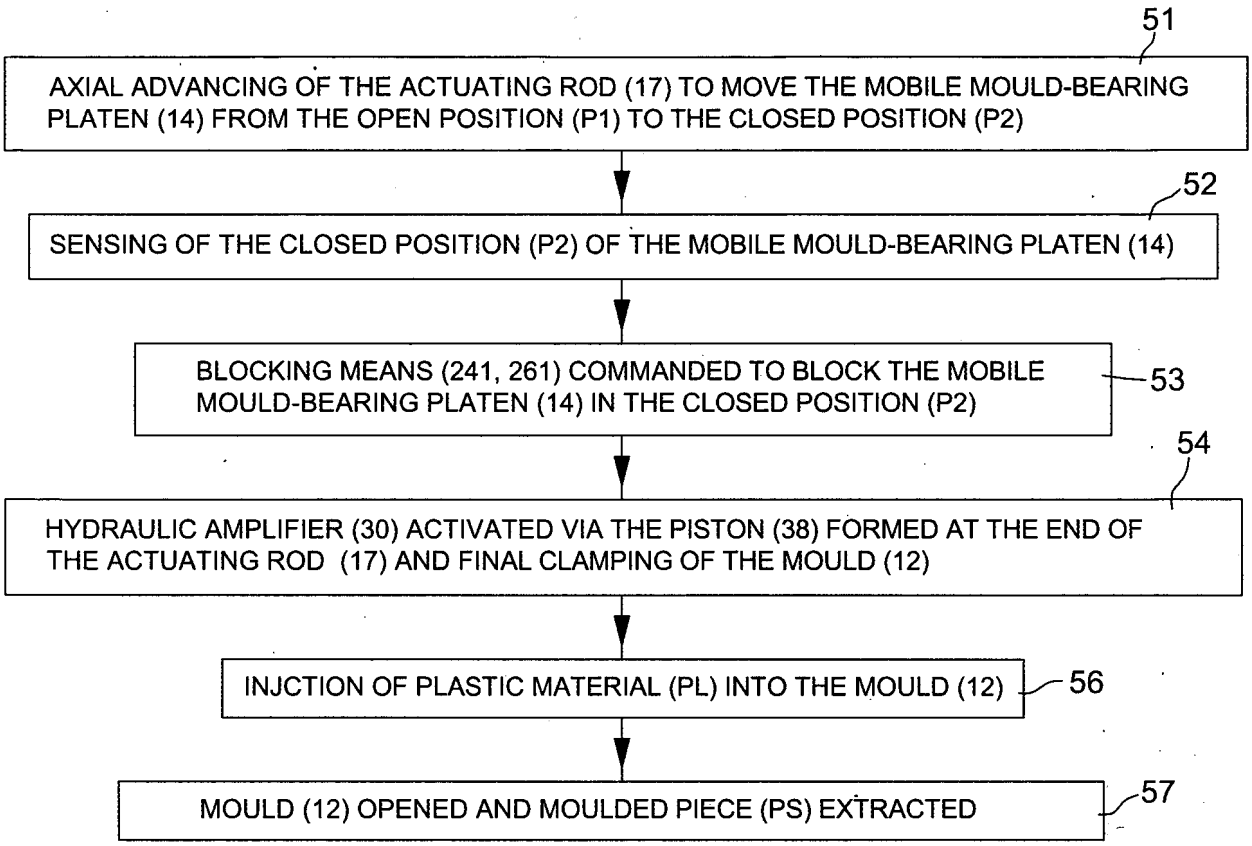

Fig. 13

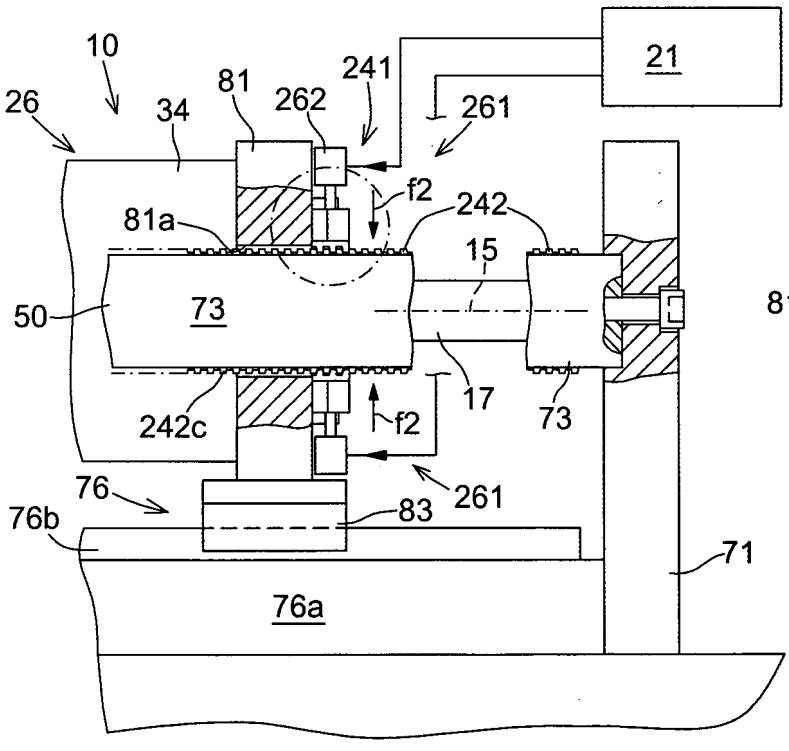

FIG. 9a

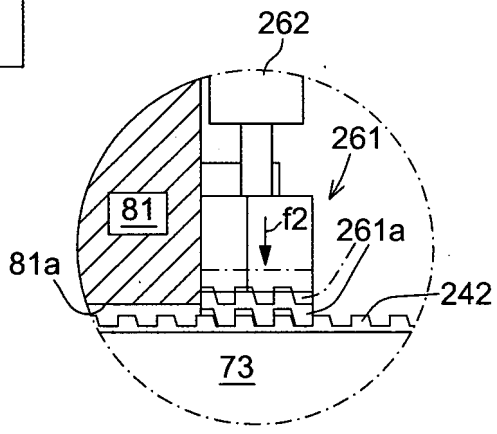

FIG. 9b

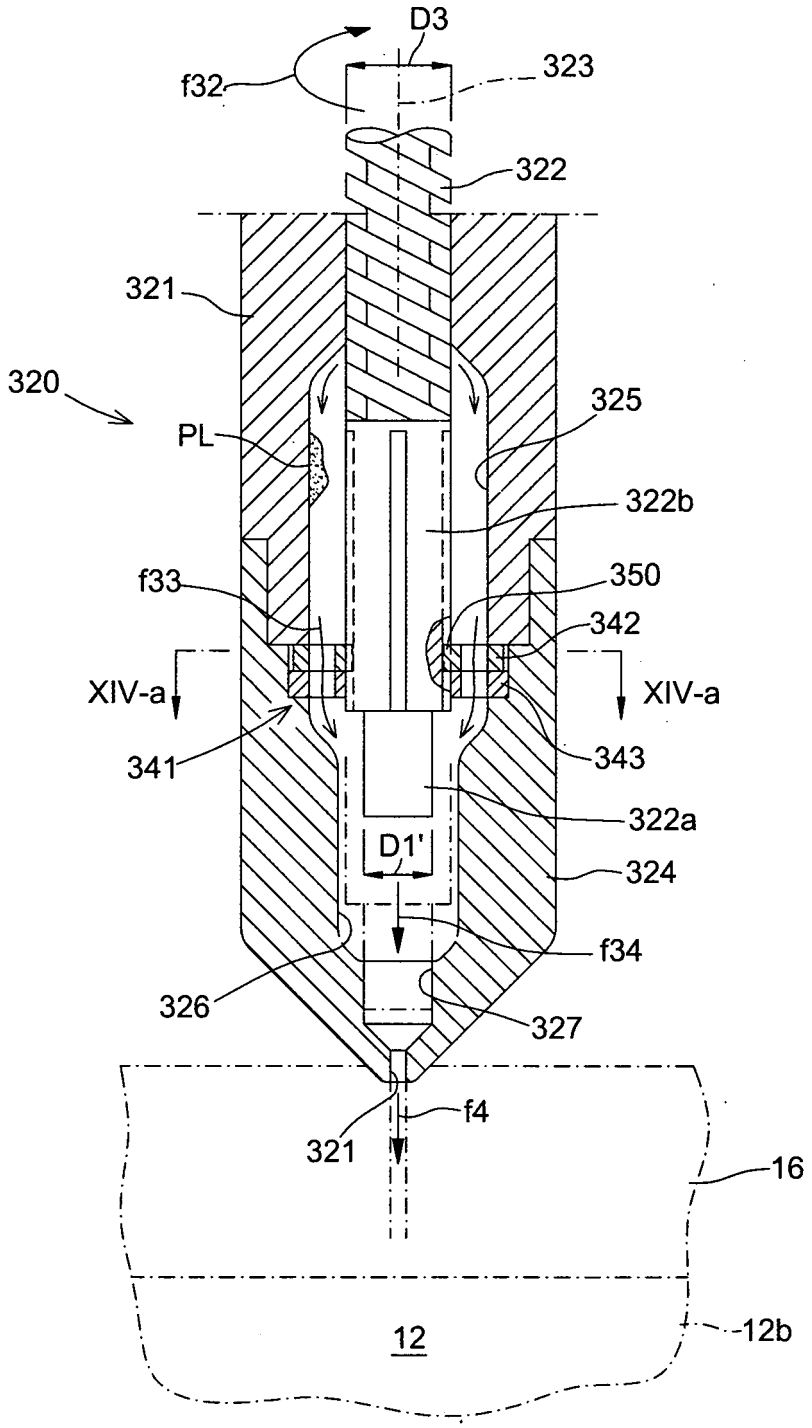

Fig. 14

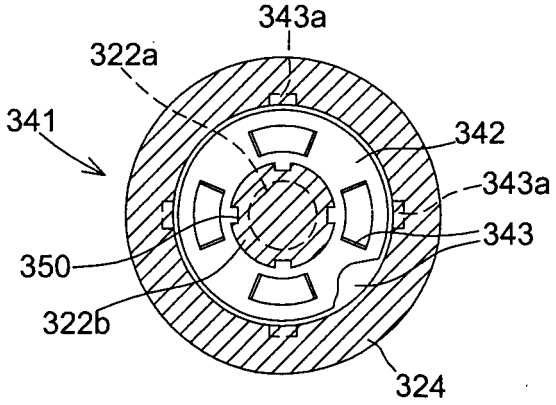

Fig. 14a