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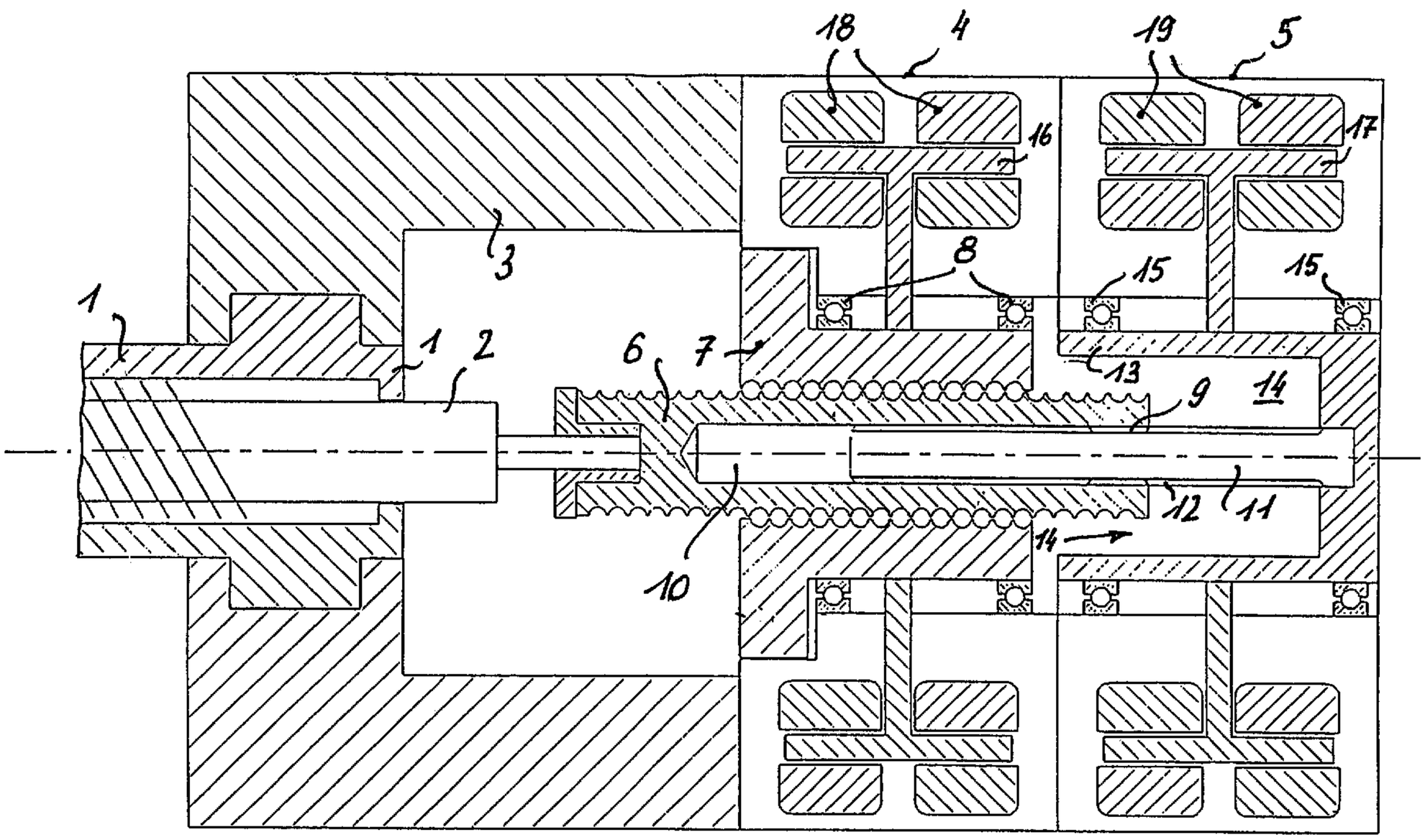
(54) Title: INJECTION UNIT FOR INJECTION MOLDING MACHINE



(57) Abrégé/Abstract:
The extruder screw drive has a first and a second motor, a screw mechanism connected to the first motor and to the extruder screw for translating it in the extrusion cylinder, and a slide mechanism connected to the second motor and to the extruder screw for rotating it in the extrusion cylinder. The screw mechanism and the slide mechanism are coaxial and partially fit into one another to provide an axially compact arrangement. The motors can be hollow shaft electric motors axially aligned together, and pressure regulated hydraulic axial force can be added to the extruder screw during plasticating as it retracts due to increased volume of plastic at an output end of the extrusion cylinder.

ABSTRACT OF THE DISCLOSURE

The extruder screw drive has a first and a second motor, a screw mechanism connected to the first motor and to the extruder screw for translating it in the extrusion cylinder, and a slide mechanism connected to the second motor and to the extruder screw for rotating it in the extrusion cylinder. The screw mechanism and the slide mechanism are coaxial and partially fit into one another to provide an axially compact arrangement. The motors can be hollow shaft electric motors axially aligned together, and pressure regulated hydraulic axial force can be added to the extruder screw during plasticating as it retracts due to increased volume of plastic at an output end of the extrusion cylinder.

INJECTION ASSEMBLY FOR AN INJECTION MOLDING MACHINE

FIELD OF THE INVENTION

The invention relates to an injection assembly for an injection molding machine of the type having an extrusion screw cylinder, an extruder screw and a screw drive having two electric motors, one of which being used for turning the feed screw and one of which being used for axial movement of the feed screw. More particularly, the invention relates to a drive apparatus for the extruder screw of screw plasticating injection molding equipment.

BACKGROUND OF THE INVENTION

An injection molding machine of this type is known from European Patent 0 204 002 in which the drive apparatus for the extrusion screw consists of two electric motors, one for the injection process and the other for the plastication process. Both motors are provided parallel to one another relatively far apart in which the substantial power transmission devices are provided for performing the necessary turning and axial movements.

German patent publication 42 06 966 to Tetra Pak Romont describes an extrusion screw drive system which has a pulley wheel through which a shaft slides which is connected to the extrusion screw for turning the same. A lead screw is also connected to the shaft and threaded into a complementary feed screw which is free to turn with the extrusion screw during plasticating. During injection, a clutch locks the feed screw so that turning the shaft advances (or retracts) the lead screw and thus the extrusion screw to push out the molten plastic.

SUMMARY OF INVENTION

It is an object of the present invention to improve a device of the above-described type such that the size of the power transmission device is reduced as much as possible into a compact construction.

This object is achieved by arranging two electric motors with their axes in line with the axis of the extrusion screw with at least one of the electric motors having a hollow shaft.

As a result of the power transmitted by the motors directly to the drive axle connected to the extrusion screw, a high efficiency is achieved resulting in considerably reduced required operating power.

The invention provides an extruder screw drive apparatus for a screw plasticating injection molding machine having an extruder screw rotatable and slideable in an extrusion screw cylinder, said apparatus comprising: a first and a second motor; screw means connected to said first motor and to said extruder screw for translating said extruder screw in said cylinder; and slide means connected to said second motor and to said extruder screw for rotating said extruder screw in said cylinder, said screw means and said slide means being coaxial.

The invention also provides an injection assembly for an injection molding machine for processing of thermoplastic material substantially comprising a extruder screw cylinder, an extruder screw and an extruder screw drive having two electric motors, one of said motors being for turning the extruder screw and another of said motors being for axial movement of the extruder screw, characterized in that both said electric motors are arranged with their axes aligned with an axis of the extruder screw

and at least one electric motor of said motors is a hollow shaft motor.

Due to the fact that the essential elements such as the axle nut (feed screw), the drive axle (lead screw) and the drive stem are arranged inside of the hollow shaft of the motors, the entire drive apparatus is substantially determined only by the exterior dimensions of the motors. It thus provides the advantage of a simple enclosure for the motors such that the drive apparatus according to the invention is particularly suitable for operation in clean room conditions. The lack of transmission elements (e.g. belt drives) also has an advantageous effect in this respect since no dust particles can be generated as in the case with belt drives.

In a preferred embodiment of the invention, an inner cylinder is provided inside the drive axle in which a piston is inserted, the piston being connected to the drive stem. A conduit leading to a hydraulic tank through the piston and the drive stem to a regulator valve allows hydraulic oil to flow from the inner cylinder under hydraulic load of the feed screw to the tank whereby the desired hydraulic pressure is assured by the regulator valve.

Preferably, the motors are transverse flux motors having a high torque and, on the one hand, comprise the advantageous shortness or disc-shaped construction for the object of the invention and, on the other hand, provide a wide interior diameter inside the hollow shaft.

Preferably, both motors are hollow shaft electric motors arranged or "stacked" disc-like next to one another. The housings of both hollow shaft motors may be connected to one another, wherein one of the housings is connected to the housing of the extruder screw cylinder. Preferably, a first one of the motors may have an axle nut or feed screw mounted

in a hollow shaft thereof, the nut or feed screw being threaded on a drive shaft or lead screw connected at one end to the extruder screw and connected at another end to a drive stem. The drive stem may have an axial groove corresponding to an axial ridge or key in the inside of the drive shaft to turn therewith while allowing axial movement, with the drive stem being connected to a hollow shaft of a second one of the motors.

The feed screw or nut may be integral with the hollow shaft solidly connected to the armature of a first one of the motors, and the hollow shaft of the second motor may be solidly connected to the drive stem leaving an annular space for receiving the drive axle. An axial bearing for withstanding axial forces from the feed screw may be integrated in the first hollow shaft motor.

The hollow shaft motors are preferably speed controllable motors and may be transverse flux motors having cylindrical magnets surrounded on both sides by windings. Also, both motors are preferably driven with a differential speed in accordance with measured control signals indicative of the state of melting in the extruder screw cylinder.

BRIEF DESCRIPTION OF DRAWINGS

A preferred embodiment of the invention will be described in detail with reference to the appended drawings, in which:

Figure 1 is a lengthwise cross-section of the drive system of an injection apparatus of a screw plasticating injection molding machine; and

Figure 2 shows the embodiment of Figure 1 having an additional hydraulic device to ensure the desired back pressure.

DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 shows the rear portion of extrusion screw cylinder 1 and of the extrusion screw 2 contained therein of an otherwise not shown injection molding machine. The extrusion screw cylinder 1 is connected to a housing 3 to which a first hollow shaft motor 4 and a second hollow shaft motor 5 are mounted. The extrusion screw 2 is solidly connected to a drive shaft or axle 6 seated in an axle nut (feed screw) 7. A ball bearing screw drive system is used, i.e. one in which direct thread contact is replaced by thread to ball bearing contact. The axle nut 7 is the hollow shaft of the first hollow shaft motor 4 which is mounted directly in the motor housing by means of an axial bearing 8.

A drive stem 11 projects into a cavity 10 in the drive shaft 6. The cavity is provided with an axial ridge 9 which mates with an axial groove 12 of the stem 11, such that the drive shaft turns with the stem 11 while being axially mobile thereon. The drive stem 11 is solid with the hollow shaft of the second hollow shaft motor 5, the hollow shaft surrounding the stem 11 leaving an annular space 14. The hollow shaft 13 is supported directly in the motor housing by an axial bearing 15.

The hollow shaft motors 4 and 5 are transverse flux motors having cylindrical magnets 16 and 17, each surrounded on both sides by windings 18 and 19.

In the embodiment of Fig. 2, the drive stem 11 is provided with a piston 20 inserted into inner cylinder 21. A conduit 22 extends through piston 20 and stem 11 from cylinder 21 to a regulating valve 23 to a tank T. When there is an overpressure on extrusion screw 2, hydraulic oil flows from cylinder 21 into tank T. When the extrusion screw is returned, hydraulic oil is drawn from tank T through check valve 24 back into cylinder 21.

In operation, the extrusion screw 2 carries out two main movements. During injection, extrusion screw 2 is pushed forward and not rotated. During plastication, extrusion screw 2 is rotated and pushed axially back by the plasticized material pressed into the extrusion screw end chamber (not shown). As a result, a definite resistance force (back pressure) is generated.

During injection and plastication, the hollow shaft motors 4 and 5 are operated as follows:

Injection:

The first motor 4 turns nut 7 and extrusion screw 7 is pushed axially (to the left in Figs. 1 and 2). The second motor 5 does not turn.

Plastication:

The second motor 5 turns extrusion screw 2 using stem 11 with the required plastifying torque (pressure).

The first motor 4 turns with approximately the same speed as the second motor 5. The speed differential results in the speed of withdrawal of extrusion screw 2 for accommodating the plasticated material filling the extrusion screw end chamber.

As can be appreciated, the nut 7 and threaded drive shaft 6 provide screw means for advancing and retracting screw 2. Stem 11, cavity 10, ridge key 9 and groove 12 provide slide means for turning the extrusion screw 2. While in the preferred embodiment, the lead screw drive shaft 6 is provided with cavity 10 and thus receives stem 11, it would also be possible to reverse the arrangement and connect a larger diameter grooved keyed collar to motor 4 for turning a slideable shaft connected to screw 2. A threaded bore in the slideable shaft would receive a threaded shaft connected to motor 5

like stem 11. This reverse arrangement has the disadvantage that the piston arrangement of Fig. 2 cannot be implemented. It can also be appreciated that an axially compact drive is provided by having the screw means and the slide means fit into one another. Additional size reduction is provided by using a hollow shaft motor 5 which receives an axially translatable member of the screw means or the slide means, as the case may be.

Claims

1. Injection assembly for an injection molding machine for processing of thermoplastic material substantially comprising an extruder screw cylinder, an extruder screw and an extruder screw drive having two electric motors, a first one of said motors being for turning the extruder screw and a second one of said motors being for axial movement of the extruder screw, both said electric motors being arranged with their axes aligned with an axis of the extruder screw and at least one electric motor of said motors is a hollow shaft motor, said first one of said motors having an axle nut mounted in a hollow shaft thereof, said nut being threaded on a drive shaft connected at one end to said extruder screw and connected at another end to a drive stem, said drive shaft comprising an inner cylinder adapted to be pressurized to act against back pressure on said extruder screw and to permit controlled return movement thereof.

2. Injection assembly according to claim 1, wherein both said motors are hollow shaft motors, said motors being arranged disc-like next to one another.

3. Injection apparatus according to claim 2, wherein the housings of both hollow shaft motors are connected to one another, wherein one of said housings is connected to a housing in which said extruder screw cylinder is provided.

4. Injection assembly according to claim 2 or 3, wherein the drive stem has an axial groove corresponding to an axial ridge in the inside of the drive shaft to

turn therewith while allowing axial movement, said drive stem being connected to a hollow shaft of said second one of said motors.

5. Injection assembly according to claim 4, wherein said nut is the hollow shaft solidly connected to the armature of said first one of said motors, said hollow shaft of said second one of said motors is solidly connected to the drive stem leaving an annular space for receiving said drive axle.

6. Injection assembly according to claim 5, wherein an axial bearing for withstanding axial forces from said nut is integrated in said first one of said hollow shaft motors.

7. Injection assembly according to one of claims 1, 2, 3, 5 or 6, wherein each of said hollow shaft motors is a transverse flux motor having cylindrical magnets surrounded on both sides by windings.

8. Injection assembly according to one of claims 1, 2, 3, 5 or 6, wherein one of said two motors is speed controllable.

9. Injection assembly according to claim 8, wherein both said motors are driven with a differential speed in accordance with measured control signals indicative of the state of melting in said extruder screw cylinder.

10. Injection assembly according to claim 1, wherein said inner cylinder is filled with hydraulic fluid in which a piston provided at one end of said drive stem is inserted, wherein an outward leading conduit passes

through said piston and through said drive stem, said conduit conducting hydraulic fluid which passes through a pressure regulating valve to a reservoir tank as a result of back pressure on said extruder screw, hydraulic fluid being conducted from said reservoir tank in the reverse direction through a check valve during a return movement of said extruder screw.

11. Injection assembly according to claim 5, 6, 9 or 10, wherein said drive shaft inserted into said nut is a ball bearing screw drive system.

12. An extruder screw drive apparatus for a screw plasticating injection molding machine having an extruder screw rotatable and slideable in an extrusion screw cylinder, said apparatus comprising:

a first and a second motor;

screw means connected to said first motor and to said extruder screw for translating said extruder screw in said cylinder;

slide means connected to said second motor and to said extruder screw for rotating said extruder screw in said cylinder, said screw means and said slide means being coaxial; and

said screw means comprising a feed screw and a lead screw connected to said extruder screw, and said slide means comprising a drive stem and a cylindrical cavity in said lead screw, said cavity comprising fluid therein adapted to be pressurized such that fluid pressure in said cavity can be used to act against back pressure in

said screw means and to permit controlled return movement thereof.

13. The apparatus as claimed in claim 12, wherein said screw means and said slide means fit partially into one another, whereby an axially more compact arrangement is provided.

14. The apparatus as claimed in claim 12, wherein said feed screw is solidly connected to said first motor for driving said lead screw forward and backward when said lead screw is rotationally stationary, and said stem is connected to said second motor and slideable in said cavity while turning said lead screw.

15. The apparatus as claimed in claim 14, wherein said first motor is a hollow shaft motor, said feed screw being mounted inside said hollow shaft.

16. The apparatus as claimed in claim 15, wherein said second motor is a hollow shaft motor, said hollow shaft partially receiving said lead screw when said extruder screw is retracted.

17. The apparatus as claimed in claim 12, wherein said stem is provided with a groove receiving a ridge key at an orifice of said cavity, a piston at one end inside said cavity and a conduit communicating with said cavity.

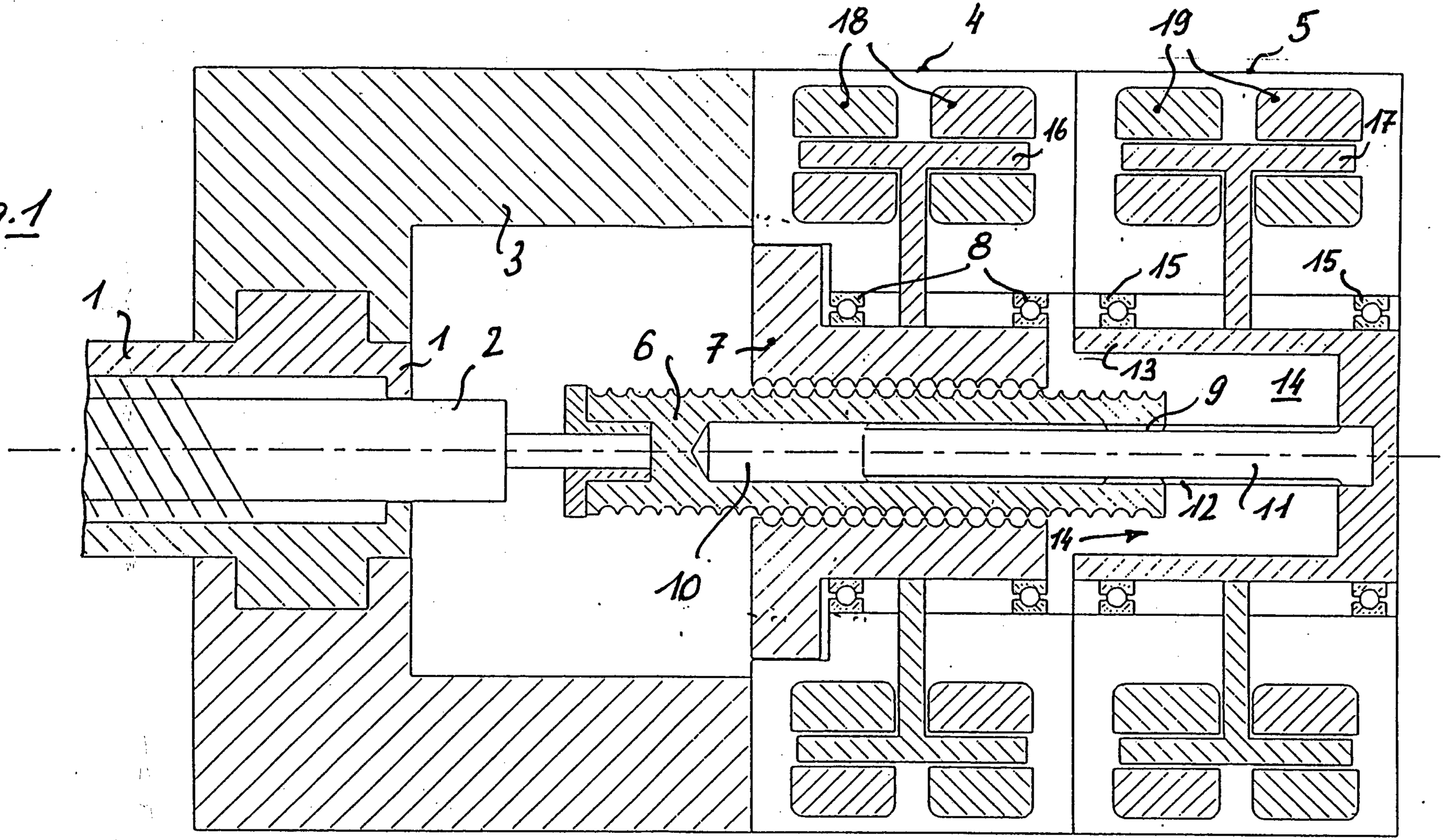
18. The apparatus as claimed in claim 17, further comprising a fluid reservoir, a regulator valve communicating overpressure fluid from said conduit to said reservoir, and a check valve communicating fluid from said reservoir to said conduit when under negative

pressure, whereby said regulator valve maintains a predetermined pressure on said extruder screw during plasticating as it retracts due to increased volume of plastic at an output end of said extrusion cylinder, and said check valve allows fluid to refill said cavity during injection and return of said extruder screw.

19. The apparatus as claimed in claim 14, 15, 16, 17 or 18, wherein said motors are speed regulated.

20. The apparatus as claimed in claim 19, wherein a differential speed of said motors for controlling retraction of said extruder screw during plasticating is set according to a measured state of melting in said extrusion cylinder.

Fig.1



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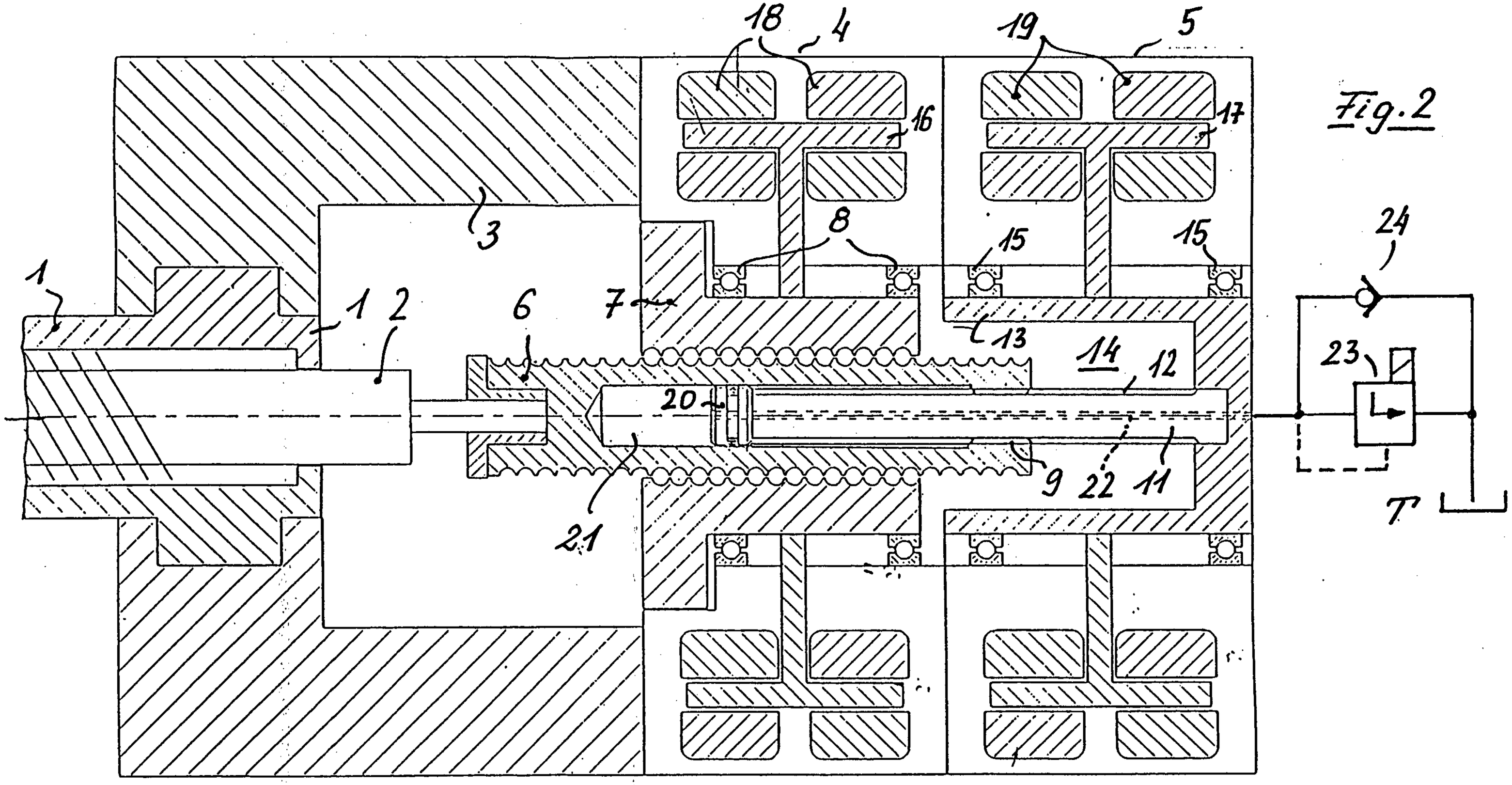

Fig. 2

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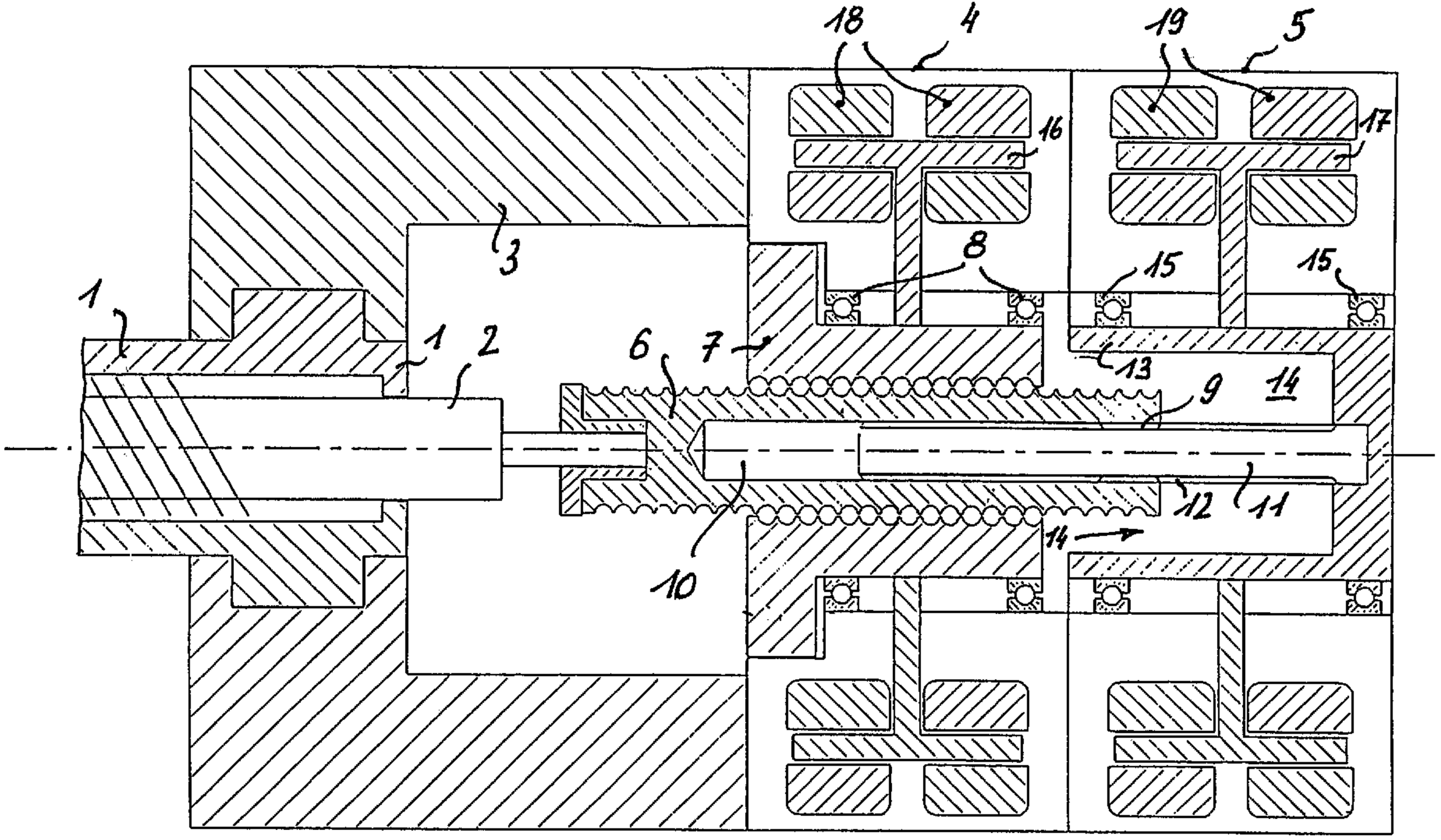
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