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(12) # EUROPEAN PATENT APPLICATION

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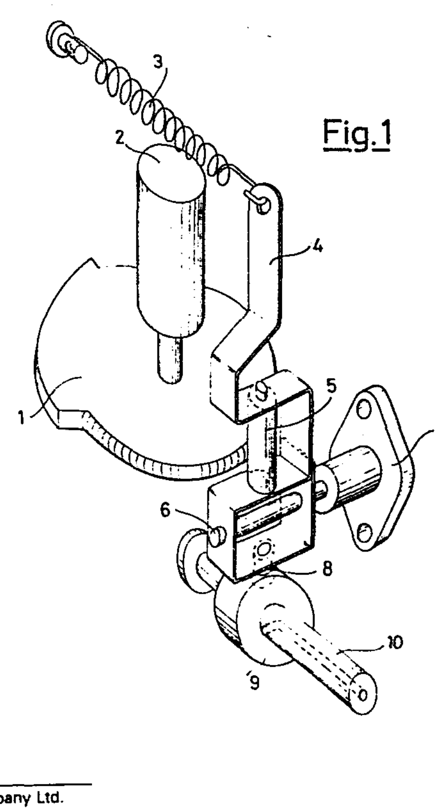
(54) **Improvements in injection pump regulator systems.**

(57) The invention relates to an improvement in electronically controlled throughput regulators for injection pumps, which consists of interposing a cam between the actuator controlled by the control system and the mobile regulator member for the pump throughput; in this manner, the law of motion of the actuator as a function of the electronic control signal is correlated in the required manner with the law of movement of the regulator member, and thus with the pump throughput variation.



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"IMPROVEMENTS IN INJECTION PUMP REGULATOR SYSTEMS."

With fuel injection pumps there must be associated a control device which regulates the fuel delivery as a function of the position of a control member controlled by the operator, and of the braking load applied to the internal combustion engine.

This control device is commonly known as a speed regulator, and is mostly constructed on mechanical or hydraulic principles. Certain drawbacks are however associated with these types of regulator. The main drawback is the timing delay due to the regulator frequency characteristics and the inertia of the injection pump control members. Moreover, complicated devices have to be added in order to perform other auxiliary functions (torque correction, maximum throughput limitation in accordance with the booster feed pressure, excess fuel on starting etc.).

To obviate these drawbacks, various types of electrically or electronically controlled regulators have appeared in recent years, and which by acting on suitable actuators enable complicated regulation programmes to be fulfilled, such as those required when using diesel engines in motor vehicles.

Currently known electrical regulator means generally have linear proportionality between the variation in the electrical signal and the corresponding variation in the delivery of the injection pump. In those cases where such linearity does not exist or is undesirable, the regulator designer must define the law of variation at the design stage, and this will then remain an unchangeable characteristic of that particular regulator. Because of this invariability, the prechosen law is a compromise between the various requirements, and cannot therefore be optimised for specific uses.

One example of the known art is offered by GB patent 2,034,400 A. In this design, the movement of the delivery regulator valve of a distributor injection pump is effected by the rotation of an eccentric shaft driven by a rotating magnet. It is apparent that once the system is defined, the sensitivity of the regulation is related to the electromechanical characteristics of the actuator, and is therefore very difficult to change.

It is however sometimes necessary to obtain, for the same application, a greater control precision in certain particularly critical operational regions of the pump, such as the low throughput regions. In currently known systems, this greater control precision limited to certain regions could be obtained only by complicated electronic means of variable amplification.

The object of the present invention is however to provide a simple and convenient system for obtaining from an electronically controlled throughput regulator for injection pumps the most wide and variable range of choice of the law of throughput regulation as a function of the modulation of the electrical signal.

To this end, the invention provides for the use of a suitably profiled cam element operated by electrical actuators, in order to act, in opposition to elastic means, directly and constantly against the regulator lever connected to the injection pump delivery control element.

The law followed by the cam lift can assume any pattern required by the specific application. Thus, cams can be of linear pattern in which the relationship between the angle of rotation and the relative movement of the throughput control element always remains constant over the entire range of operation, or cams can be of differential pattern in order to increase sensitivity of regulation in a required range of throughputs. There can also be provided limit abutments on the cam in order to provide the electronic means with a reference signal.

In order to reduce friction and wear caused by sliding, the contact between the cam and regulator lever can be effected by means of a rotatable roller element.

The cam disc is operated by an electric motor of the servo-controlled or stepping type, which following instructions received from a central electronic control unit provides for effecting the angular movement of the cam until the exact fuel delivery corresponding to the engine operating conditions has been obtained.

The advantages offered by the application of the cam disc can also be extended to regulators of mechanical or hydraulic operation.

Special control functions such as the delivery of the fuel supplement necessary for engine cold-starting, or rapid interruption of delivery in order to stop the engine, can be performed either by the cam disc itself or by the addition of a separately controlled mobile fulcrum on the regulator lever.

The axis of the electric motor - cam disc assembly can either be horizontal or vertical, as dictated by size requirements.

The structural and operational characteristics of the invention, and its advantages over the known art, will be more apparent from an examination of the description given hereinafter by way of example, with reference to the accompanying diagrammatic drawings in which:

Figure 1 illustrates a possible electronic regulator design with a control cam of vertical axis, for injection pumps of the distributor type;

Figure 2 is a diagram showing three different possible laws of variation of the throughput delivered by the injection pump as a function of the angle of rotation of the cam disc;

Figure 3 is an example of a cam disc;

Figure 4 shows a possible electronic regulator design with a control cam of horizontal axis, for injection pumps of the distributor type;

Figure 5 shows a possible design of a regulator with a control cam of horizontal axis and a regulator lever with a mobile fulcrum;

Figure 6 shows a cam disc driven by a linear electromagnet of variable force;

Figure 7 shows an electronic regulator design with a cam disc acting directly on the control member of an injection pump of the distributor type;

Figure 8 shows an electronic regulator design with a cam disc acting directly on the control member of an injection pump of the in-line type;

Figures 9 and 10 show regulator designs using cams of linear movement.

Figure 1 shows in diagrammatic form one embodiment of the device according to the invention which is particularly suitable for regulating an injection pump of the distributor type, and which uses a discoidal cam of vertical axis.

The cam 1 is driven by the electric motor 2, which constitutes the actuator of a control circuit rigid with the injection pump casing (not shown). The return spring 3, acting on the transmission lever 4, keeps the roller 5, connected to said lever 4, in constant contact with the circular surface of the cam 1.

The transmission lever 4 is pivoted on the pin 6 of the flange 7, also rigid with the pump casing, to transmit, by means of the spherical pin 8, the regulation movement to the control member 9 of the pumping element 10 of the injection pump.

The axial position of the ring 9 which, according to the known art determines the delivery of the injection pump, is thus defined by the corresponding angular position of the cam disc 1. This disc therefore acts as the delivery control element over the entire engine operational range.

The lateral contact surface of the cam 1, on which the roller 5 rests, is suitably convexed in order to ensure the progressiveness of the law governing the regulation.

The effects and advantages of the device will be more apparent from an examination of Figure 2, which shows a diagram in which the angular positions of the cam, indicated by α, are shown as abscissae, and the unit throughput of the pump, ie the delivery Q for each stroke of the piston, are shown as ordinates.

From the graph it is apparent that for equal variations in the regulator control signal, and thus for equal variations in the angular position of the cam disc, it is possible to obtain different variations in the delivered throughput according to the absolute value of the throughput itself. The dashed curve (C), for example, allows better regulation at low deliveries where the throughput varies to a lesser extent as the cam disc rotates. The dashed and dotted curve (B) shows the reverse characteristic.

Figure 3 shows a cam disc 1 with variable pitch. As can be seen from the drawing, the variation in lift per unit rotation of the cam increases considerably in the quadrant between 180° and 270°. If however it were required to maintain the same proportionality over the entire range (continuous line A of Figure 1), the cam disc would assume the form of a constant pitch spiral.

The disc of Figure 3 also comprises two limiting abutments (F.C.) in order to supply the required references to the cam control logic.

Figure 4 shows a regulator mechanism which is functionally similar to that of Figure 1, but comprises a control unit of horizontal axis. The choice between the different possible positions of the control unit is dictated by size or accessibility reasons.

Figure 5 shows a modified embodiment in which the lever 4 which carries the follower of the cam 1 is pivoted at 6 to a lever 16 oscillating about the pin 17 for controlling an actuator 12. In this manner it is possible to move the fulcrum 6 and obtain an individual position of the regulator element 9, to separate particular regulator functions, such as additional delivery on starting, or throughput interruption for stopping the engine.

Figure 6 shows a different system for operating the cam disc. This is again an electrical modulation means, but instead of the stepping or servo-controlled motor a linear electromagnet of variable force 13 is used. The force (F) of the electromagnet is opposed by the reaction (R) of the return spring 14. The wider freedom of choice in positioning these two elements can be noted.

The throughput delivered by the injection pump can be easily set at a predetermined angular position of the cam disc from the outside of the regulator by making the fulcrum pivot 6 of the transmission lever 4 shown in Figure 1 mobile.

This mobility can be obtained for example by means of a pin which is eccentric to the support flange 7, or by means of a double lever system similar to that shown in Figure 5.

In the text and figures described heretofore, the delivery control element has been shown in the form of a ring cooperating with the piston of the injection pump pumping element. This structure is used in certain known versions of distributor pumps. The use of regulation by means of a cam disc can however be extended to any type of injection pump without leaving the scope of the invention.

A similar consideration applies to using or not using the transmission lever between the cam disc and the delivery control element of the injection pump. In this respect, said cam can be made to act directly on the control ring 9 of a distributor pump (Figure 7). In this case the follower 5 of the cam 1 can be made to simply translate in a guide indicated diagrammatically by 20, so that when it moves it drags the regulator ring of the distributor pump.

The device, such as shown in Figure 8, for controlling an injection pump in which throughput regulation is effected by a rack-type rod 15 can assume a similar structure. In this case, the follower 5 can be mounted rigidly with this latter.

The type of cam can vary. Instead of being of the rotating disc type it can be of the linear movement type.

Figure 9 shows such a device configuration, in which a cam 21 slides on guides 22 controlled by an electromagnet 23 of variable pulling force, which is opposed by the return spring 24. The follower 25, which acts on the cam profile, is carried by the lever 26, which is pivoted at 27 and is constrained to the translating element 28 which regulates the pump throughput. The return spring 29 ensures contact between the follower and the cam.

It is apparent that this linkage is mechanically equivalent to that described with reference to the preceding figures.

Whatever the cam configuration, either a control system with a follower which makes unidirectional contact, ie by means of elastic thrust, can be chosen or a bidirectional positive control system. For example, the device of Figure 9 can assume the structure illustrated in Figure 10 in which the follower guide is a slot, which means that the elastic return system constituted by the spring 29 is not necessary.

CLAIMS :

1. A speed regulator for an injection pump feeding internal combustion engines, provided with a throughput regulator member, and an electronic regulation control unit which receives the signals in accordance with which the throughput is to be varied, and correspondingly controls the movement of a control element by means of an electrical actuator, characterised in that said control element moves the throughput regulator member by way of a linkage in which there is interposed a cam which defines a law relating the movement of the control element to the movement of the throughput regulator member.

2. A speed regulator as claimed in claim 1, characterised in that said cam is of planar type, on which there acts a cam follower provided with means to keep it resting on said cam for every position thereof.

3. A speed regulator as claimed in claim 1, characterised in that said planar cam is in the form of a rotating disc.

4. A speed regulator as claimed in claim 1, characterised in that said planar cam is of linear translating form.

5. A speed regulator as claimed in claim 2, characterised in that said means are constituted by an elastic thrust element.

6. A speed regulator as claimed in claim 2, characterised in that said means are constituted by a coupling of positive type.

7. A speed regulator as claimed in claim 1, characterised in that said actuator is an electric motor of the servo-controlled or stepping type.

8. A speed regulator as claimed in claim 1, characterised in that said actuator is an electromagnet of proportional linear

movement.

9. A speed regulator as claimed in claim 2, characterised in that said cam follower is constituted by a roller which rolls on the active surface of said cam.

10. A speed regulator as claimed in claim 2, characterised in that the circular surface of said cam disc comprises barrel-shaped crowning.

11. A speed regulator as claimed in claim 3 or 4, characterised in that between the regulator and the planar cam there is interposed a transmission lever, of which the fulcrum is movable in order to adjust the relative position of said regulator member to said cam.

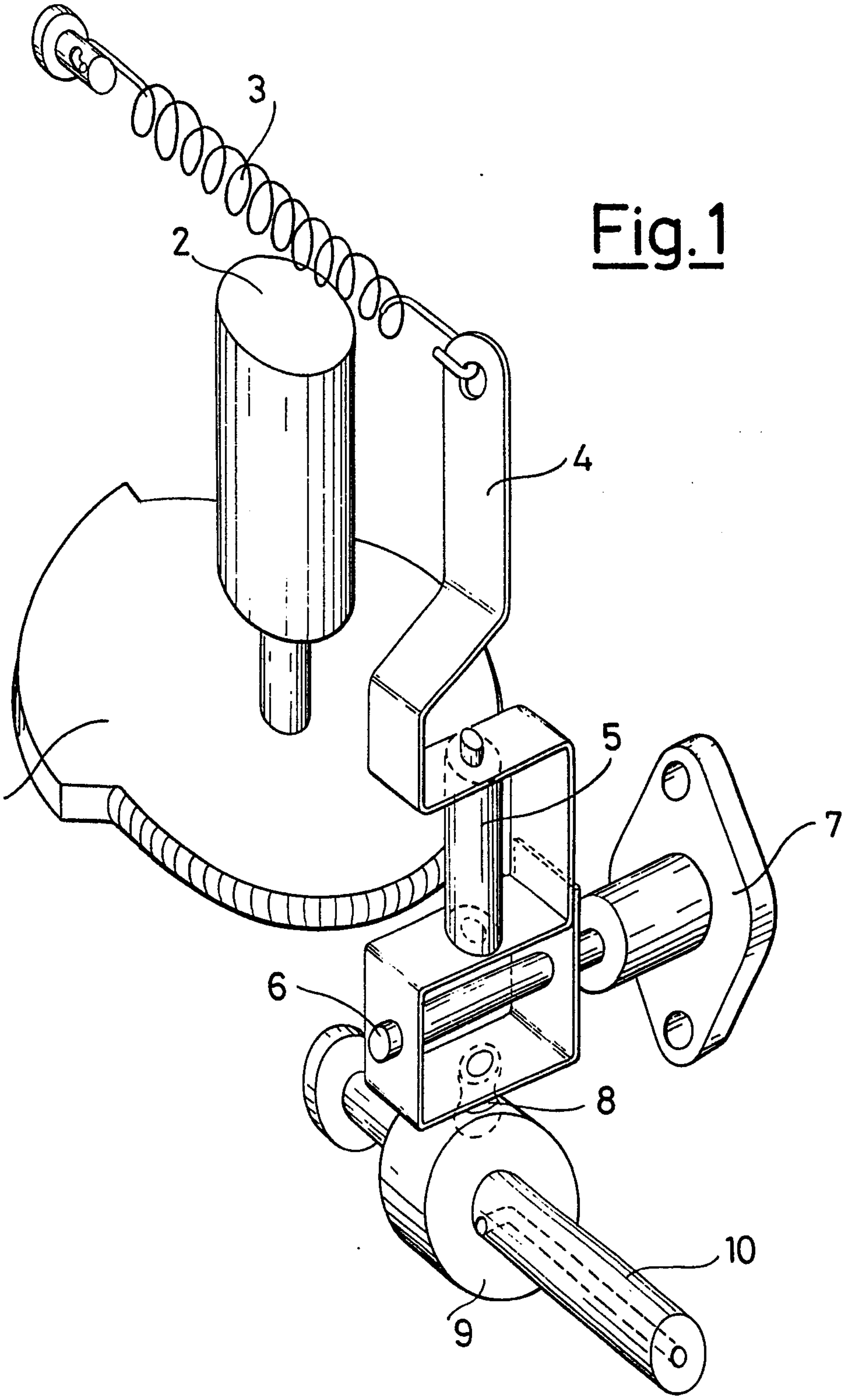


Fig.1

Fig. 2

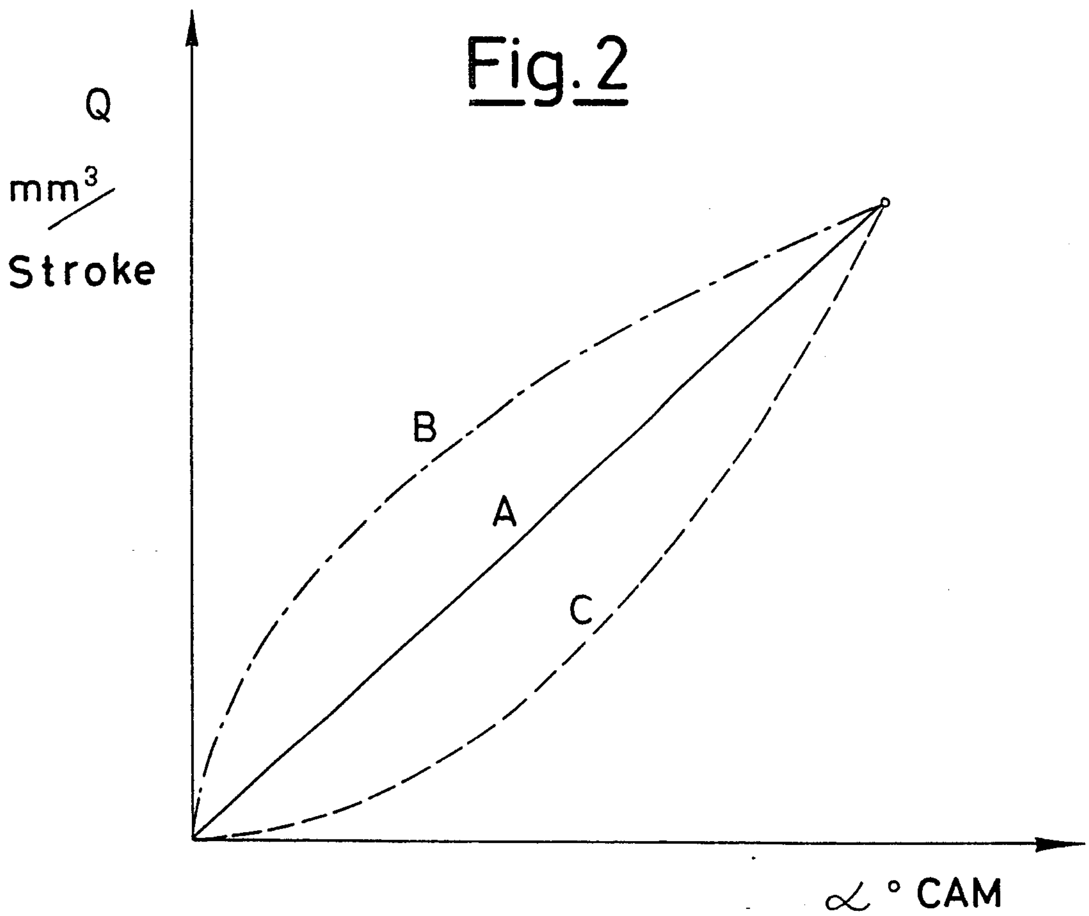


Fig. 3

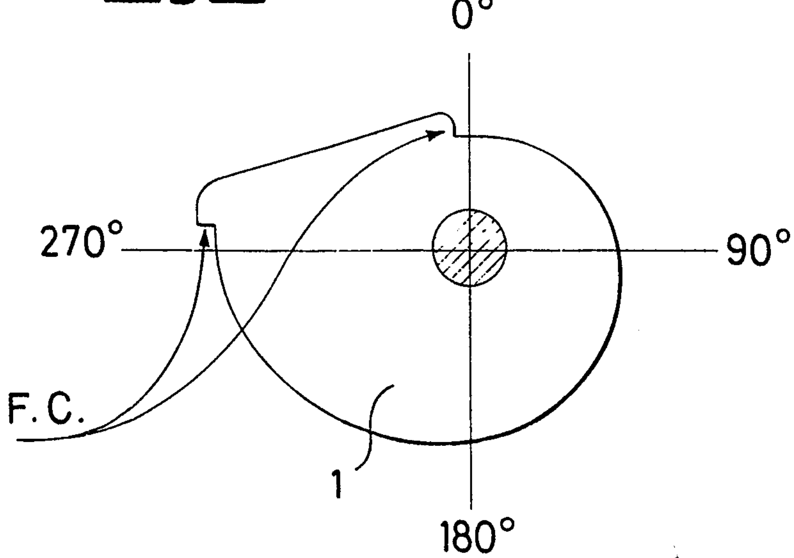
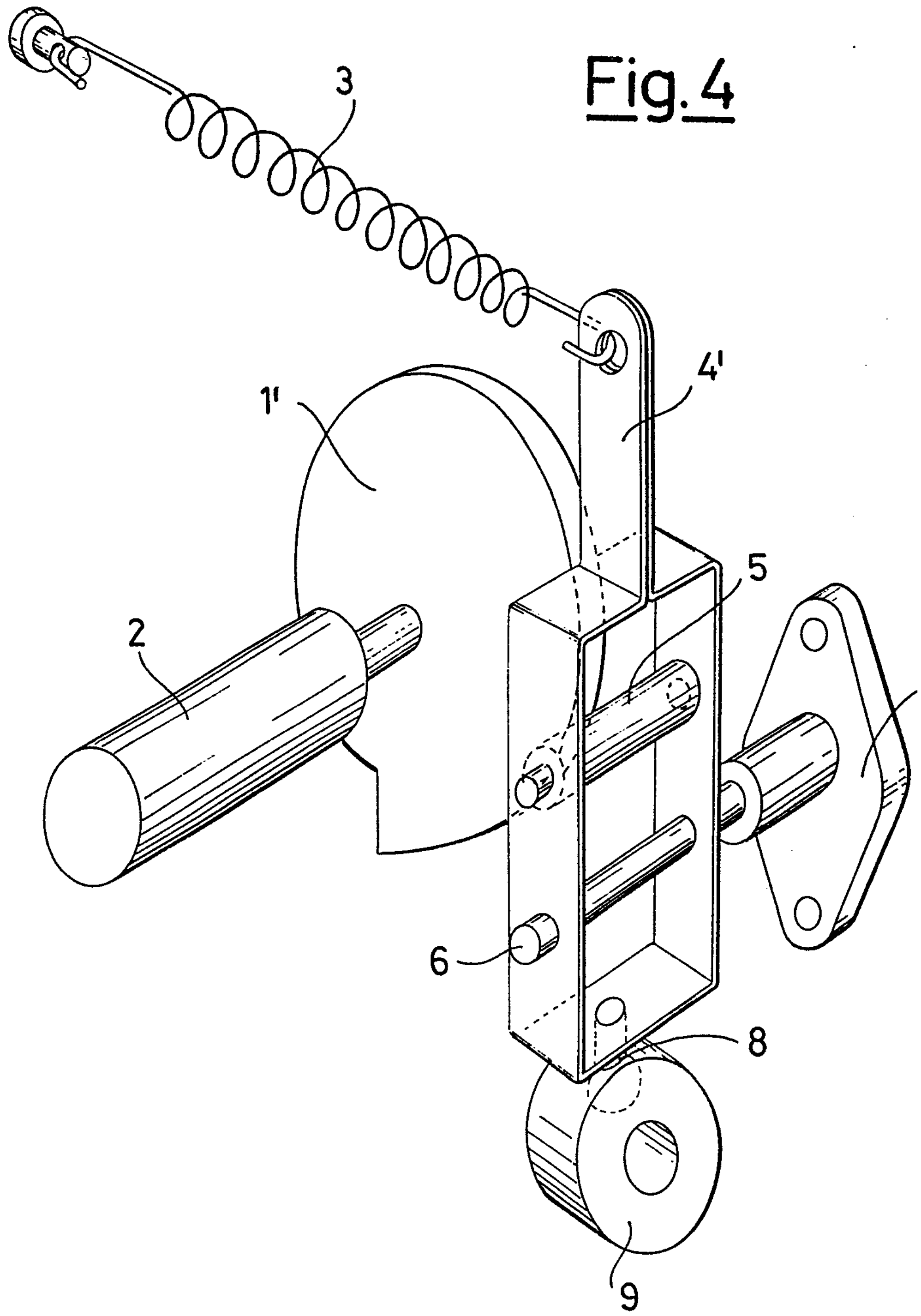


Fig. 4



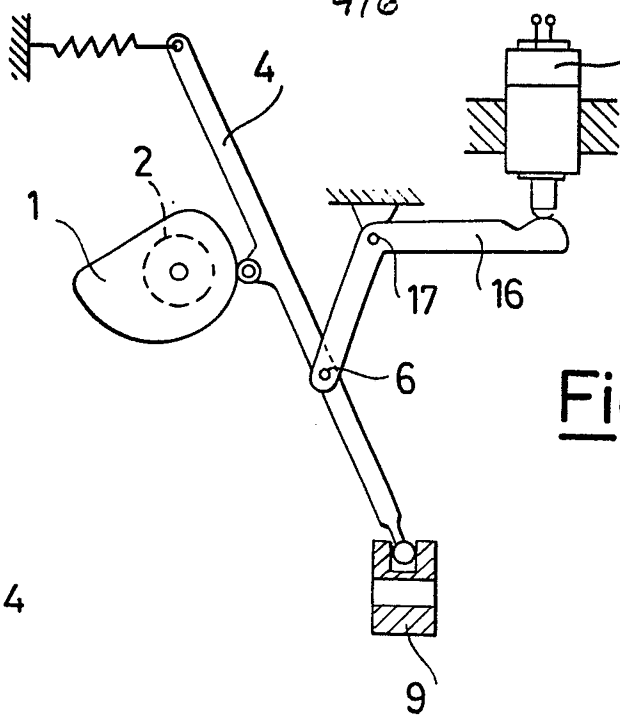


Fig. 5

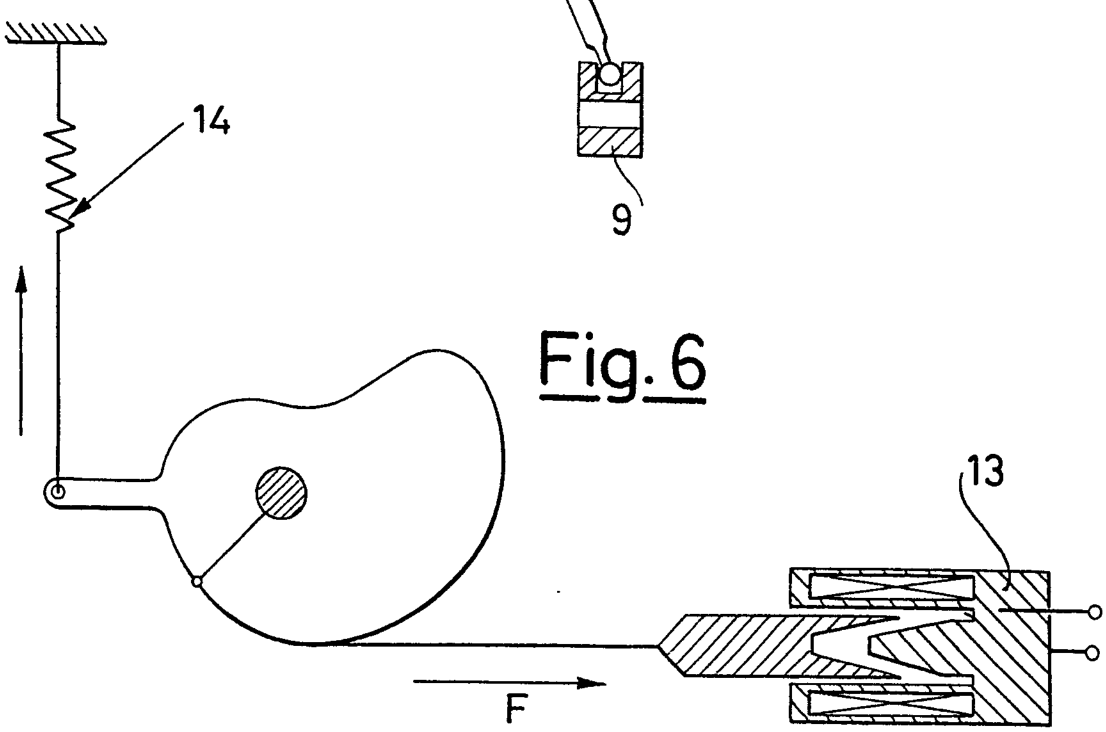


Fig. 6

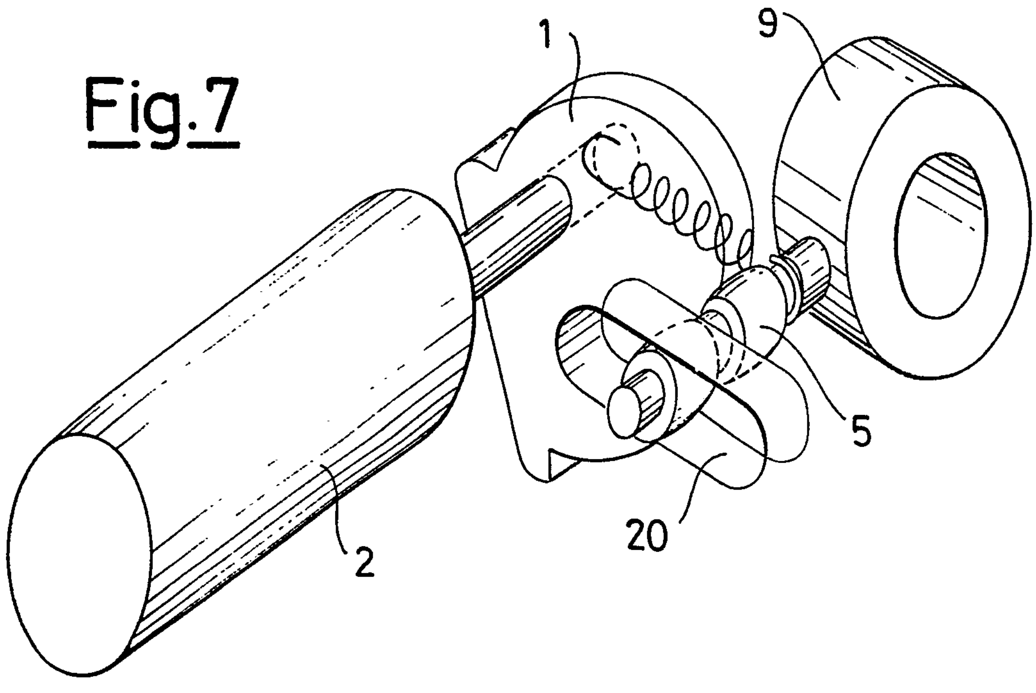


Fig. 7

Fig. 8

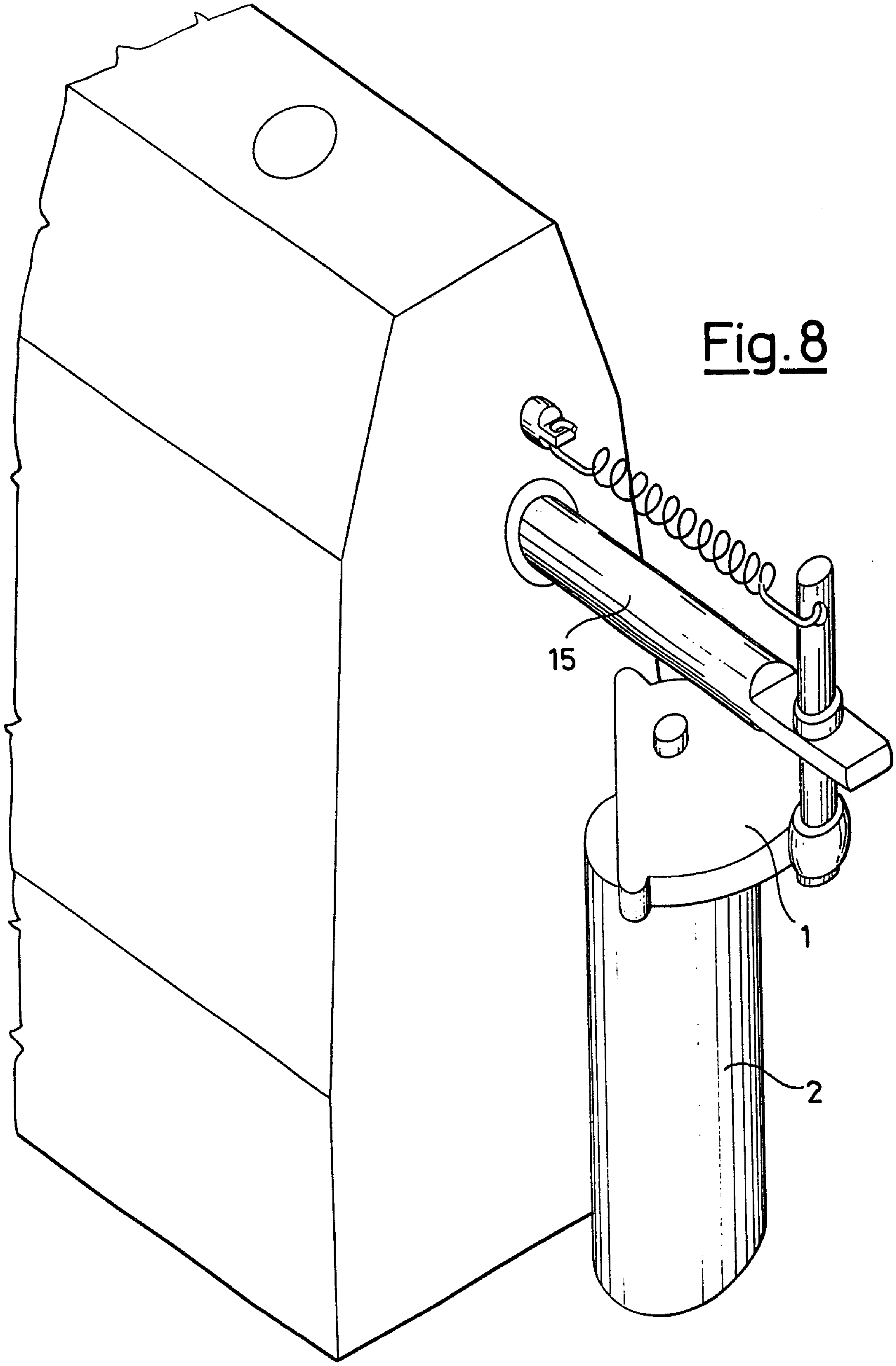


Fig. 9

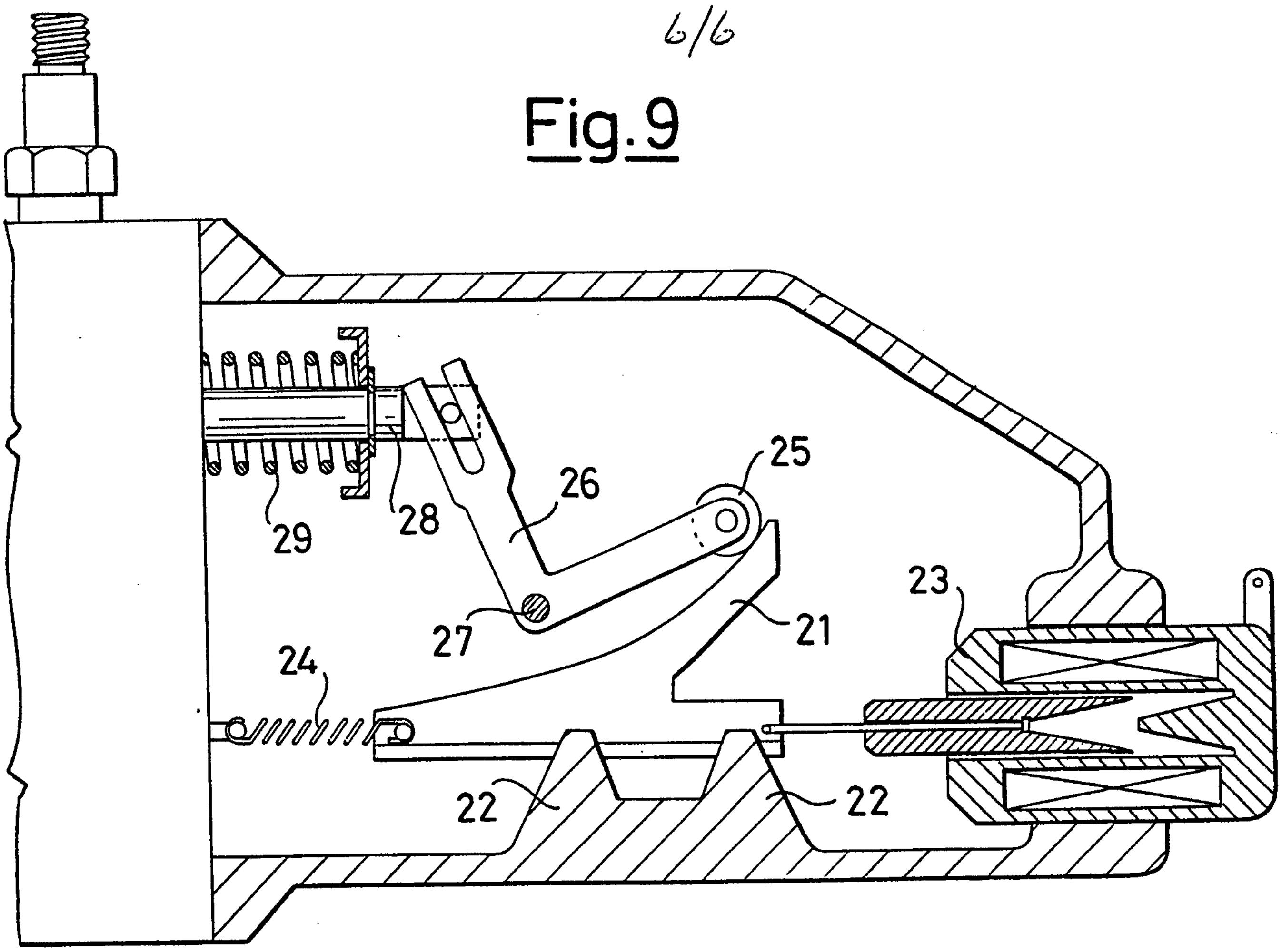
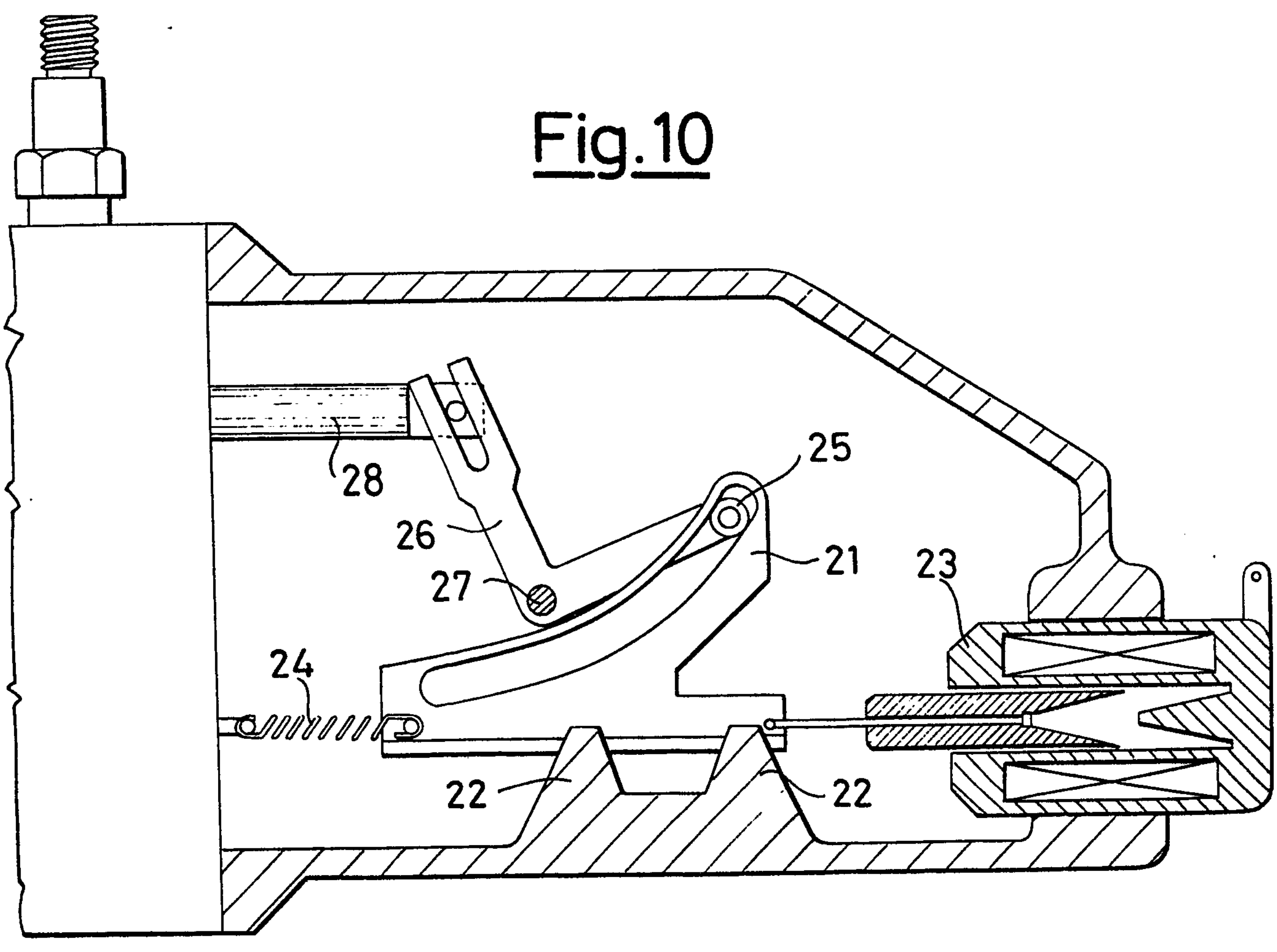


Fig. 10



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EUROPEAN SEARCH REPORT

EP 83 20 0913

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	FR-A-2 160 672 (NIPPON DENSO). * Page 2, line 37 - page 5, line 37; figure 1 *	1,6,7	F 02 M 59/28

A	FR-A-2 225 632 (C.A.V.) * Page 1, line 28 - page 4, line 14; figures 1-4 *	1,2,6,7	

A	EP-A-0 020 320 (FRIEDMANN & MAIER)		

TECHNICAL FIELDS SEARCHED (Int. Cl. 3)

F 02 D
F 02 M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14-10-1983	SCHMID R.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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