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(54) Door actuating apparatus

(57) To provide a door opening and closing apparatus for an electric train which facilitates smooth driving of the door without overstraining the door and eliminates cumbersome fine tuning, a linear motor (14), comprised of stator coils (2) and a moving field means (3), is mounted in a frame (1); and the moving field means (3)

is slid along the stator coils (2) by controlling current flow through the linear motor (14); and a door (6) coupled with the moving field means (3) is smoothly driven. An emergency power supply (12) is provided to allow opening of the door (6) in the event of a power failure.

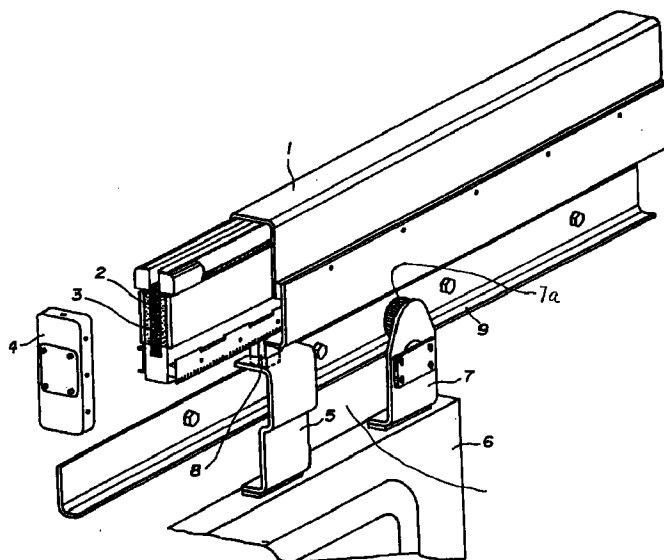


Fig. 1

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Description

The present invention relates to a door actuators, and particularly concerns a door opening and closing apparatus for an electric train.

In Figures 3a and 3b, there is seen a schematic perspective view of a conventional door opening and closing apparatus for a train, and a schematic section of the pneumatic actuator.

As shown in Figure 3a, a pair of doors 25 are arranged between an upper rail 26 and a lower rail 27, and are driven to be opened and closed by a door operating mechanism 28. As shown in Figure 3b, the door operating mechanism 28 uses compressed air as a power source and converts reciprocating motion of a piston in a differential air cylinder 281 to opening and closing motion of the door 25 through a rack and semi-circular pinion gear 282 and a coupling link 283 to open or close the doors 25, 25.

An example of a control portion for controlling the door closing mechanism 28 is shown in Figure 4.

The control portion comprises an electromagnetic valve 31, choke valves 32 and ball valves 33. The control portion continuously supplies air to the smaller diameter cylinder 37, and selectively admits air into the chamber of a large diameter cylinder 36, which houses a large diameter piston. When air is supplied to both the large cylinder chamber 36 and to the smaller diameter cylinder 37, the piston rod and pistons 34 and 35 move to the left as seen in Figure 4. When air is supplied only to the smaller diameter cylinder 37, the piston rod and pistons 34 and 35 move to the right as seen in Figure 4.

The control portion controls the flow of air into and out of the two cylinder chambers, and also the space between the pistons, by means of two ball valves 33, 33, and choke valves 32, 32, and by means of the positional relation between two air exits and the cylinders, the driving speed of the door is decreased during the last stage of its opening or closing movement. Hereinafter, such a door driving scheme as described above will be referred to as "pneumatic driving".

However, the door opening and closing apparatus according to the prior art suffers from the following difficulties:

(1) Since the door opening and closing apparatus, shown in Figure 3, exerts, in addition to necessary horizontal drive force, unnecessary strong force obliquely to the door, door suspension rollers and the upper rail are overstrained. Since this overstrain often causes displacement of the door suspension rollers and the upper rail from their right positions, and abnormal friction between the door suspension rollers and the upper rail, fine adjustment of the fitting positions of the door suspension rollers and the upper rail becomes very difficult.

(2) Such a controller as is shown in Figure 4, exclusively annexed to the door opening and closing apparatus for regulating driving force and door

speed, causes operational delay and makes rapid and accurate motion of the door very difficult to achieve.

(3) The controller of Figure 4 also causes an increase in the number of parts required, because the controller further needs a door locking mechanism, and ancillary components and devices such as piping, etc. for each door. Since these additional devices and parts are frequently operated repeatedly, troubles such as fatigue, wear, rattles, air leaks, etc. are often caused and maintenance and inspection of these additional devices are serious problems.

In view of the foregoing, an object of the present invention is to provide a door opening and closing apparatus which does not overstrain the door of an electric train, eliminates troublesome fine tuning of the door mechanism, eliminates operational delay of the door by avoiding the pneumatic drive, and drives the door finely and quickly. A further object of the present invention is to provide a door opening and closing apparatus which facilitates opening and closing the door of an electric train in an emergency when normal electrical power supply is interrupted.

According to the present invention, a door opening and closing apparatus for an electric train, comprises a linear motor, and further comprises stator coils and a moving field means, and is mechanically coupled with a door of an electric train to drive the door along a linear path, an electric power converter for supplying electric power to the linear motor; a control circuit for controlling the electric power converter, by which to control the linear motor; and an emergency power supply means for supplying electric power to the electric power converter in an emergency, so as to enable opening and closing of the door in an emergency.

By driving the door of the electric train with a linear motor, the door is not overstrained. Additionally, the door is opened and closed by the emergency power supply means and the control circuit in an emergency when the normal power supply to the power converter is interrupted.

The present invention will now be described in detail with reference to the accompanying drawings which illustrate the preferred embodiment of the present invention. In the Figures:

Figure 1 is an isometric view showing an embodiment of the present invention;

Figure 2 is a block diagram showing a control portion of the linear motor;

Figure 3 is a schematic showing an outline of the door opening and closing apparatus according to the prior art; and

Figure 4 is a block diagram showing an example of a control portion for the door opening and closing apparatus of Figure 1

Referring now to Figures 1 and 2, a linear motor comprising stator coils 2 and a moving field means 3 is disposed in a frame 1. The moving field means 3 may be formed by a plurality of field magnets or field coils. In Figure 1, an end cap 4 of the frame 1 is shown removed, and the linear motor is pulled out from the frame 1 so as to be illustrated clearly. A door 6 is coupled with the moving field means 3 of the linear motor through a drive arm 8 and a coupling 5 so that the door 6 may be moved in parallel with a rail 9. The door 6 is supported on the rail 9 by suspension members 7 and wheels 7a.

In the structure described above, since the moving field means 3 is driven in parallel with the stator coils 2 by controlling current flow through the linear motor, the door 6 moves along the rail 9, by which opening and closing of the door 6 is facilitated. Since only horizontal force is exerted between the stator coils 2 and the moving field means 3 and since any unnecessary vertical or oblique force is not exerted, problems such as displacement of the fitting position of the door, wear of the structural constituent elements, etc. are not caused.

Figure 2 is a block diagram showing a control portion (control circuit) of the linear motor. In Figure 2, a DC power supply 11 is fed to an inverter 13 and thence to a linear motor 14. A capacitor 12 is coupled to the DC supply, with a diode to prevent reverse current flow. An encoder 15 associated with the linear motor 14 provides information on the position of the door, while a current detector 16 monitors current being supplied to the linear motor 14. A magnetic pole speed and position detector 17 receives signals from the encoder 15, and provides signals to a current regulator 18 and a speed regulator 19. A position and speed pattern addresser 20, a parameter setting device 21 and an interface 22 receiving external signals 23 complete the apparatus.

In Figure 2, the linear motor 14 is driven by the inverter 13. The inverter 13 is connected with a major speed regulation loop comprising a speed regulator 19 and with a minor current regulation loop comprised of the current regulator 18 by which the switching elements of the inverter 13 are controlled, for example, by pulse width modulation. In controlling the inverter 13, position and speed of the magnetic pole or position of the moving field means (door) are detected by a magnetic pole speed and position detector 17, based on the output of an encoder 15 associated with the linear motor 14. The output of the magnetic pole speed and position detector 17 is fed to the current regulator 18, the speed regulator 19, and a position and speed pattern addresser 20.

The position and speed pattern addresser 20 generates a speed command from an operation command fed from the interface 22 as the external signal 23 based on the output of the magnetic pole speed and position detector 17, and feeds the speed command to the speed regulator 19. The speed regulator 19 executes a predetermined regulation operation so as to bring the speed signal from the magnetic pole speed and position detector 17 into conformity with the speed command

from the position and speed pattern addresser 20. At the same time, the current regulator 18 converts the output of the magnetic pole speed and position detector 17 to a current command, and executes a predetermined regulation operation so as to bring the current value detected by the current detector 16 in coincidence with the current command value. Position-speed patterns can be set at will in the position and speed pattern addresser 20.

The capacitor 12 stores electrical power supplied from the DC power supply 11 while the door is closed, that is while the linear motor is not driven (while the electric train is running), and supplies this stored electric power to the inverter 13 when the normal power supply from the DC power supply 11 is interrupted by any cause. Therefore, by properly selecting the value of the capacity of the capacitor 12, the door may be opened and closed as many times as needed even in an emergency.

The present invention, which is explained by way of example in relation to the opening and closing of the door of an electric train, is applicable to other sliding doors in the similar way as described above.

According to the present invention, by driving the door of an electric train by a linear motor, the door mechanism is not overstrained, and cumbersome fitting and tuning of the door mechanism are eliminated. And by the provision of an emergency power supply, the door can be opened and closed predetermined times in an emergency when the normal power supply to the electric power converter which controls linear motor is interrupted.

Claims

1. A door actuating apparatus comprising;
 - a linear motor (14), further comprising stator coils (3) and a moving field means (4), and mechanically coupled with a door (6) for driving said door along a linear path;
 - an electric power converter (13) for supplying electric power to said linear motor (14);
 - a control circuit for controlling said electric power converter, whereby to control said linear motor (14); and characterised by comprising an emergency power supply means (12) for supplying electric power to said electric power converter (13) in the event of a power supply failure, thus enabling opening and closing of the door (6).
2. A door actuating apparatus according to claim 1, characterised in that the emergency power supply means is formed by a capacitor (12).

Fig. 1

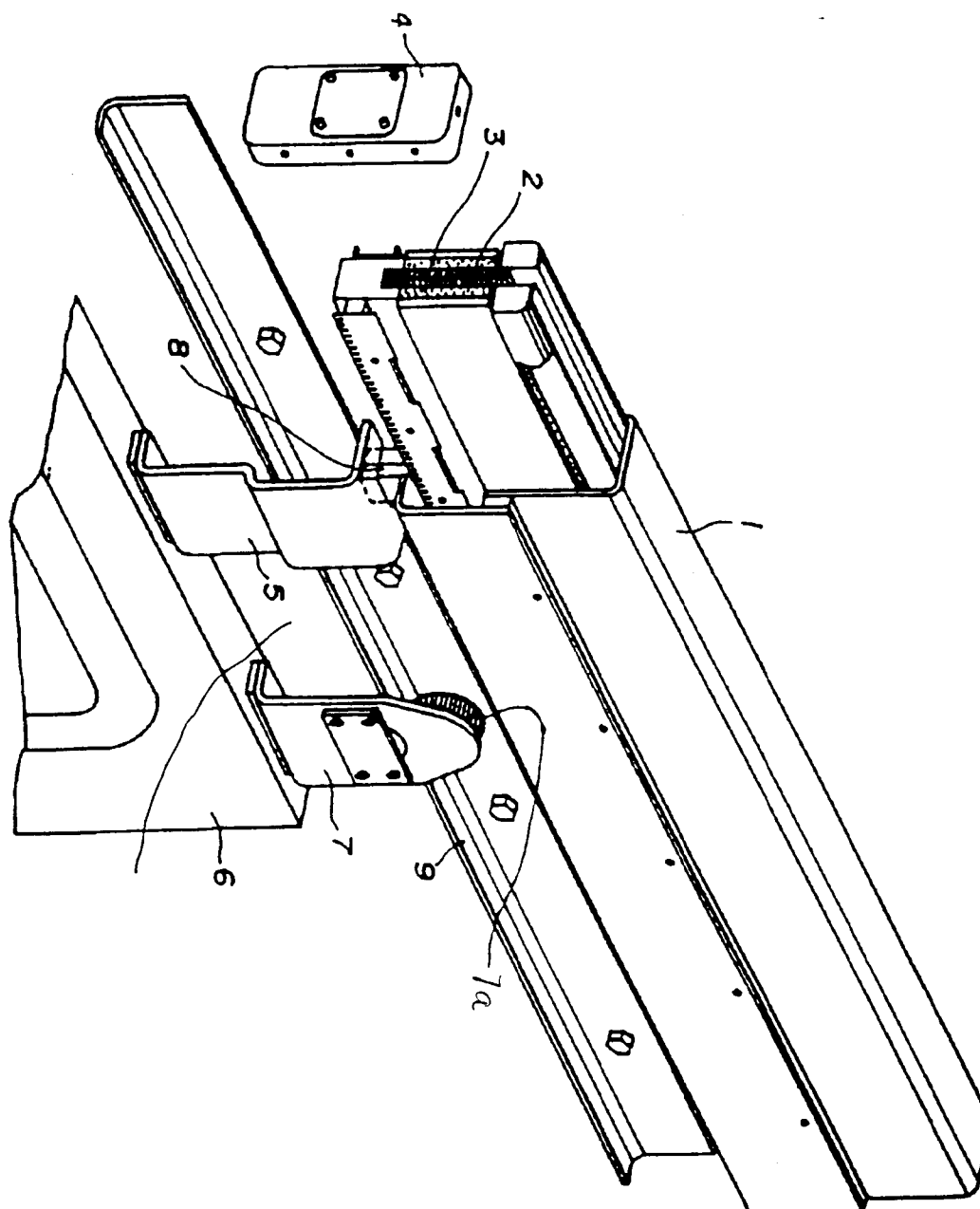


Fig. 2

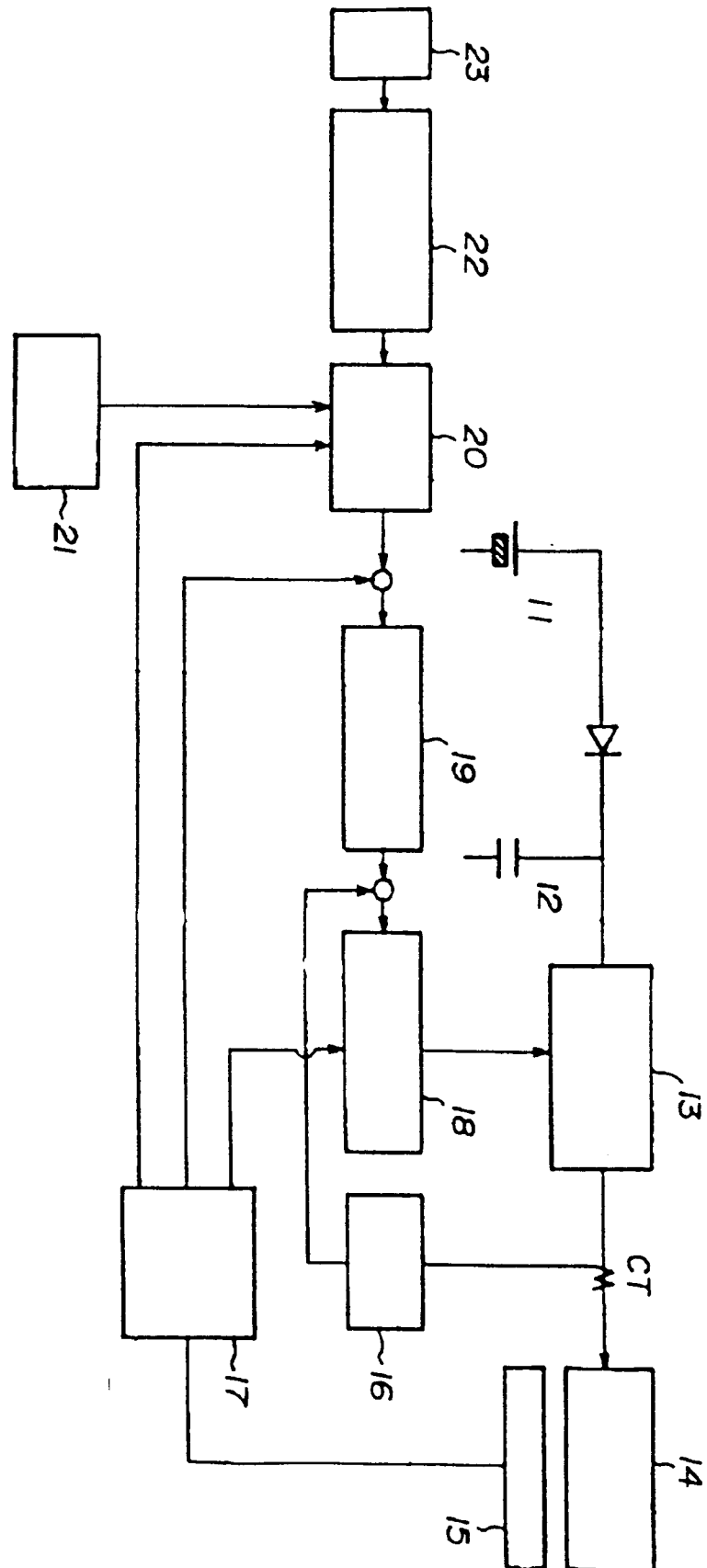


Fig. 3

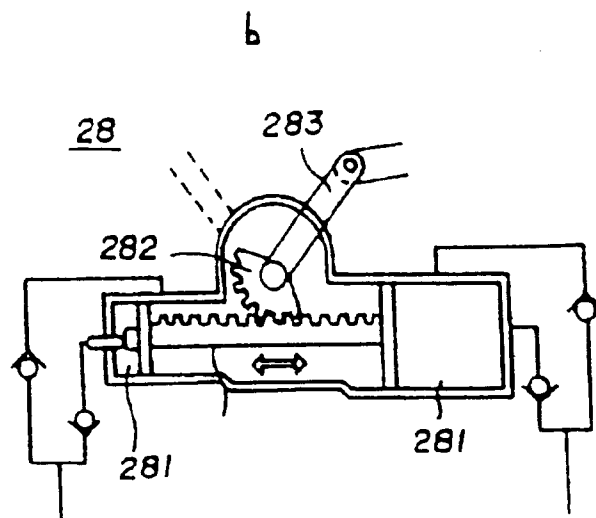
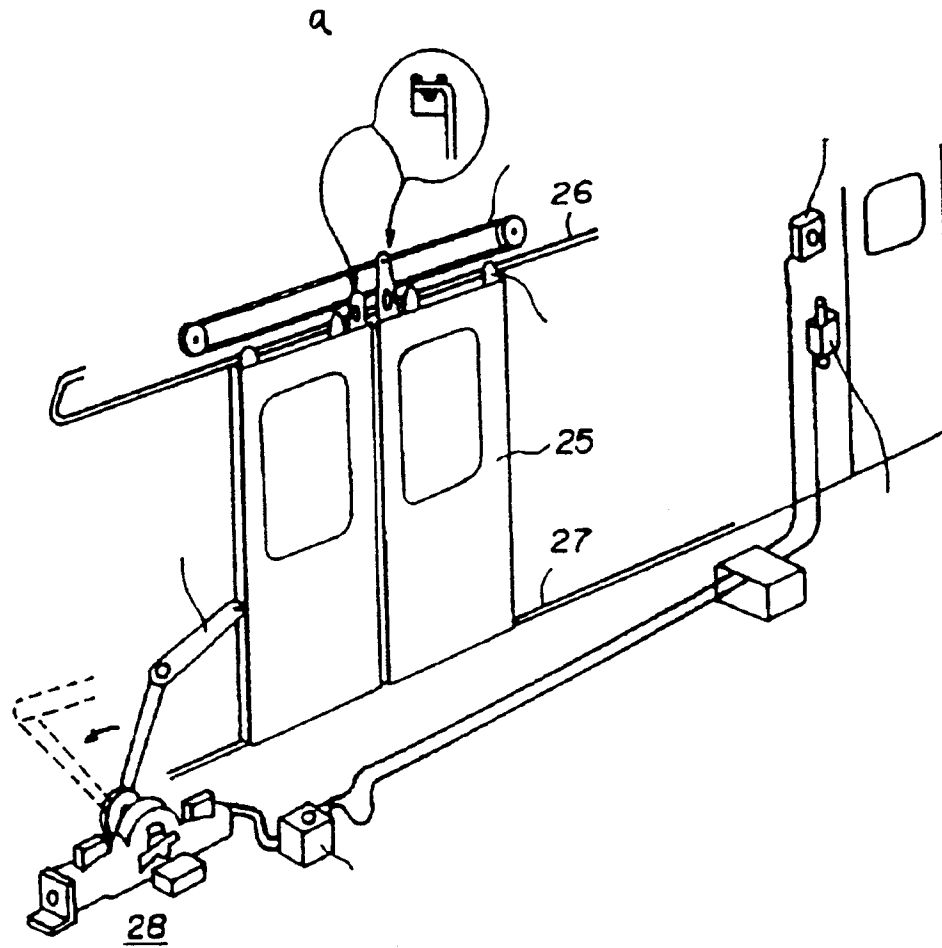
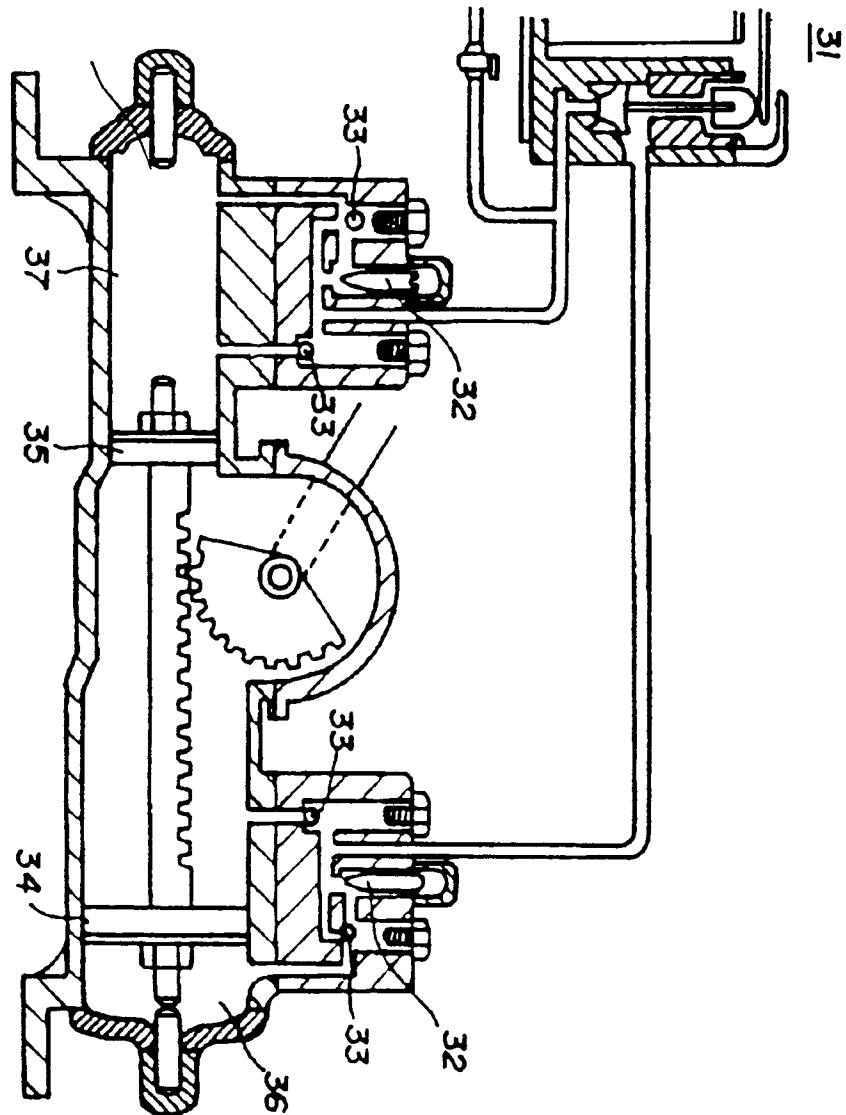


Fig. 4





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EUROPEAN SEARCH REPORT

Application Number
EP 95 20 0484

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.6)
Y	US-A-1 979 569 (PARVIN) * page 1, line 1-9 * * page 1, line 68 - line 92 * * page 2, line 73 - line 75 * * page 2, line 81 - line 84 * * page 2, line 95 - line 100 * * figure 1 *	1	E05F15/18 E05F15/10
Y	US-A-4 904 880 (YOSHIDA) * abstract *	1	
A	EP-A-0 330 828 (BKS GMBH) * column 4, line 24 - line 39 *	2	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			E05F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 26 July 1995	Examiner Van Kessel, J
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