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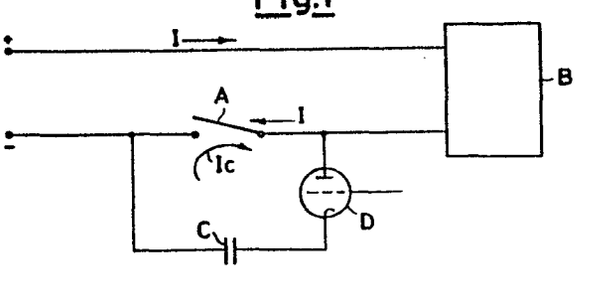
(54) Device for predetermining the arcing time in a direct current, low-medium voltage vacuum switch.

(57) In order to increase the electrical life of a direct current, low-medium voltage vacuum switch, a device is proposed for predetermining the arcing time during switch opening. The device consists of an optical sensor, in particular of optical fibre type, able to determine the instant of contact separation, and to provide by way of a delay circuit the enabling command for discharging a capacitor bank which causes the current to pass through zero.

Fig.1



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This invention relates to electrical vacuum switches of the type especially for direct current, low-medium voltage circuits, and specifically relates to a device for predetermining the arcing time during the opening of such switches.

During the opening of an electrical switch, an arc is known to form between the contacts in the opening stage, and lasts from the instant of effective contact separation to the instant the current passes through zero. If direct current is concerned, as in the case considered herein, in which in contrast to alternating current there are no periodic passages through zero, a short current pulse must be created across the switch pole ends which is of equal magnitude but of opposite sign to the load current passing through the switch. For this purpose it is known to use an auxiliary circuit connected in parallel with the switch pole ends, this circuit containing in series a capacitor bank and a means for providing the enabling command for discharging the capacitors at the required instant, which means can be an ignitron. In this case, the arcing time coincides practically with the time, of the order of milliseconds, between the instant of effective switch contact separation and the instant in which the ignitron is triggered, the time between the triggering of the ignitron and the discharge of the capacitor bank being negligible.

The switch contacts are opened by providing an electromechanical tripping device connected to the mobile switch contact and comprising an opening coil, the armature of which is connected to said mobile contact by way of a lever system. From the instant in which current is fed to this opening coil to the instant in which the mobile contact

effectively separates from the fixed switch contact, a certain time elapses which in practice cannot be predetermined accurately because of the tolerances and play in the mechanical part which causes the opening. The contact opening time is therefore variable and cannot be exactly controlled during the electrical life of the switch.

In known switches, the ignitron is triggered in order to discharge the capacitor bank and cause the current through the switch to pass through zero by means of a timer acting simultaneously with the current feed to the opening coil, to thus obtain a predetermined time between the instant in which current is fed to said coil and the instant in which the load current through the switch passes through zero, and thus the arcing time is not constant but depends on the variable contact opening time.

According to the known art, it is therefore impossible to control and accurately guarantee the arcing time.

It is also a known fact that the electrical life of a switch is closely related to the arcing time. The longer the arcing time, the shorter the electrical life of the switch.

It is therefore extremely important to be able to control the arcing time and predetermine it with maximum precision.

An object of the present invention is therefore to provide a device for predetermining the arcing time for application to a direct current, low-medium voltage vacuum switch, which makes it possible to control this arcing time with maximum precision, thus increasing the electrical life of the switch.

A further object of the invention is to create a device of this kind which can be easily fitted, even to live parts of the switch,

while ensuring excellent insulation.

These objects are attained by making the control of the arcing time independent of the variable and not exactly predeterminable contact opening time, by determining the precise instant of separation of the switch contacts and emitting from this instant the enabling command for discharging the capacitor bank which causes the current to pass through zero.

The invention therefore proposes a device for predetermining the arcing time in a direct current, low-medium voltage vacuum switch provided with an electromechanical tripping device for its closure and opening and with an auxiliary circuit connected across the ends of the switch pole and comprising, in series, a capacitor bank and an actuatable enabling means for the discharge of this capacitor bank, the device being characterised by comprising an optical sensor associated with the mobile contact rod external to the evacuated switch bulb and arranged to emit, at the instant of separation of the switch contacts, a signal to a delay circuit which after a predetermined delay activates said enabling means for the discharge of the capacitor bank.

In an advantageous embodiment, the optical sensor is of the optical fibre type and comprises two optical fibre cables connected respectively to a transmitter (light source) and to a receiver (photoelectric cell), the two respective free ends of these optical fibre cables opposing each other axially a certain distance apart, a light-impermeable appendix rigid with the switch mobile contact rod being mobile in the space between said opposing ends, said appendix comprising a slot which allows light to pass from the end of the

optical fibre cable connected to the transmitter to the end of the optical fibre cable connected to the receiver only at the instant in which the mobile switch contact separates from the fixed contact.

Preferably, the opposing ends ofthe two optical fibre cables are retained in suitable seats provided in a block which comprises a slot in which the appendix rigid with the mobile contact rod moves, and which is adjustable relative to a support rigid with the fixed part of the switch. In this manner it is possible to adjust the position of the optical fibre cables relative to the position assumed by the mobile switch contact at the instant in which it separates from the fixed contact.

The characteristics and advantages of the invention will be more apparent from the detailed description given hereinafter with reference to the accompanying drawings, in which:

Figure 1 is a basic diagram of the direct current circuit into which the vacuum switch with the device according to the invention is connected;

Figure 2 shows some curves for explaining the principle of operation;

Figure 3 is a diagrammatic view of the vacuum switch with the device according to the invention;

Figure 4 is a perspective view of said device; and

Figure 5 is a block diagram of this device complete with the accessories essential for its operation.

As can be seen from Figure 1, a low-medium voltage vacuum switch A is connected into a direct current circuit for feeding a load B, this circuit being traversed by a load current I when the switch A is closed. Across the pole ends of the switch A there is connected

an auxiliary circuit comprising in series a capacitor bank C and a controllable enabling means for the discharge of the capacitor bank C, this means consisting of an ignitron D in the case considered. When the capacitor bank C discharges, a current I_c arises which is of equal magnitude but of opposite sign to the load current I, said current I_c thus nullifying the current I with consequent passage of this latter through zero. This is the essential condition, during the opening of the switch A, for extinguishing the arc which is generated between the switch contacts at the instant of their separation.

The switch A is provided in known manner with an electromagnetic tripping device, diagrammatically indicated by E in Figure 3, with a lever system F acting on the rod 10 of the switch mobile contact 11, said mobile contact 11 together with the fixed contact 12 being surrounded by a casing 13 which is under vacuum. An opening coil and a closing coil forming part of the tripping device E can act on the lever system F in known manner.

The principle of operation of the switch A during the opening of its contacts will now be described with reference to Figure 2. The curve a in Figure 2 is a plot of the current in the switch opening coil against time, the curve b shows the instant in which the switch mobile contact separates from the fixed contact, the curve c shows the instant in which the ignitron D is triggered, the curve d is a plot of load current I against time for the circuit into which the switch is connected, the curve E shows the discharge current pulse I_c of the condenser bank, and the curve f is a plot of the voltage across the ends of the switch pole against time.

Starting from the instant in which the opening coil for the switch A is fed with current, a certain time passes until the instant in which the contacts separate, this time, known as the opening time, being indicated by X in Figure 2. When the contacts separate, an arc forms between them and lasts for a time Y determined by the moment in which the load current I passes through zero. As stated, the current I is made to pass through zero by virtue of the discharge current I_c of the capacitor bank C, as the current I_c is of equal magnitude but of opposite sign to the current I. The enabling command for the discharge of the capacitor bank C is given by the triggering of the ignitron D. From the instant in which the opening coil is fed with current to the instant in which the arc between the switch contacts becomes extinguished there therefore passes a total time of X + Y, of which the time portion X cannot be controlled and predetermined accurately as it depends on and is influenced by various factors and in particular by the play in the lever system which mechanically connects the opening coil to the rod of the mobile switch contact. If the arcing time Y is to be predetermined and kept constant with maximum precision, this must be made independent of the variable opening time X, which means that the effective instant of contact separation must be accurately determined. The sensor shown in detail in Figures 3 and 4 is provided for this purpose. This is an optical-fibre sensor comprising two optical-fibre cables 14 and 15, the free ends of which are retained in respective seats provided in a U-shaped block 16 in such a manner that said free ends of the cables 14 and 15 are coaxial and oppose each other at a certain distance apart in correspondence with a slot 17 provided in the block.

A flat appendix 18 rigid with the body 19 penetrates into and can slide in the slot 17, the body 19 being rigid with the rod 10 of the mobile contact 11 of the switch A. The appendix 18 comprises a slot 20 which by the movement of the appendix can be moved into a position in which it intersects the common axis of the opposing ends of the optical-fibre cables 14 and 15, thus allowing light to pass from the end of one of said cables to the end of the other. The arrangement is such that the slot 20 reaches said position exactly in the instant in which the mobile contact 11 of the switch A separates from the fixed contact 12. To allow exact setting of this position, the block 16 is mounted on a support 21 rigid with the fixed part of the switch A in such a manner as to allow it to be adjusted in a direction parallel to the direction of movement of the rod 10 of the mobile contact 11. The support 21 has a part 21a which penetrates between the two arms of the U block 16, and in this part 21a there is provided a guide slot 22 with its axis parallel to the axis of the rod 10, said slot 22 being traversed by two bolts 23, 24 screwed into the arms of the block 16 and arranged to lock this latter in the correct position on the support 21.

The optical-fibre sensor is thus able to emit a signal exactly in the instant in which the switch contacts separate during the opening stage.

As can be seen from the block diagram shown in Figure 5, the optical-fibre cable 14 runs from a transmitter (light source) 25, whereas the optical-fibre cable 15 runs to a receiver (photoelectric cell) 26. Consequently when the slot 20 of the appendix 18 rigid with the rod 10 of the mobile switch contact 11 is in the position

in which light from the optical-fibre cable 14 can pass to the optical-fibre cable 15, a signal is generated in the receiver 26 and fed to a delay and pulse formation circuit indicated by the block 27, which after a predetermined time emits a triggering pulse for the ignitron D, to cause discharge of the capacitor bank C.

Having thus determined with maximum precision the instant in which the mobile contact 11 of the switch A separates from the fixed contact 12 and consequently the instant in which the arc begins to form between the two contacts, it is possible by means of the delay circuit 27 to predetermine with like precision the arcing time Y, which can be chosen for example at 5 ms.

This arcing time Y is constant during the electrical life of the switch and is independent of variable factors. This leads to an increase in the electrical life.

The transmitter 25, receiver 26 and delay circuit 27 can be combined into a single unit. A mechanical delay device could be used instead of the electronic delay circuit.

The use of an optical-fibre sensor has the advantage of enabling it to be applied to live parts while ensuring excellent insulation.

By way of non-limiting example, Figure 2 shows values of the load current I passing through the circuit in which the switch A is connected (eg. 25 kA) and of the voltage U across the pole of the open switch (eg. 20 kV).

CLAIMS:

1. A device for predetermining the arcing time in a direct current, low-medium voltage vacuum switch provided with an electromechanical tripping device for its closure and opening, and an auxiliary circuit connected across the ends of the switch pole and comprising, in series, a capacitor bank and an activatable enabling means for the discharge of this capacitor bank, characterised by comprising an optical sensor associated with the mobile contact rod external to the evacuated switch bulb and arranged to emit, at the instant of separation of the switch contacts, a signal to a delay circuit which after a predetermined delay activates said enabling means for the discharge of the capacitor bank.

2. A device as claimed in claim 1, characterised in that said optical sensor comprises two optical-fibre cables connected respectively to a transmitter and to a receiver, the two respective free ends of said optical-fibre cables opposing each other axially at a certain distance apart, a light-impermeable appendix rigid with the switch mobile contact rod being mobile in the space between said opposing ends, said appendix comprising a slot which allows light to pass from the end of the optical-fibre cable connected to the transmitter to the end of the optical-fibre cable connected to the receiver only at the instant in which the mobile switch contact separates from the fixed contact.

3. A device as claimed in claim 2, characterised in that the opposing ends of the two optical-fibre cables are retained in seats provided in a block comprising a slot in which the appendix rigid with the mobile contact rod moves.

4. A device as claimed in claim 3, characterised in that said block can be adjusted, in a direction parallel to the direction of movement of the mobile contact rod, relative to a support rigid with the fixed part of the switch.

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Fig.1

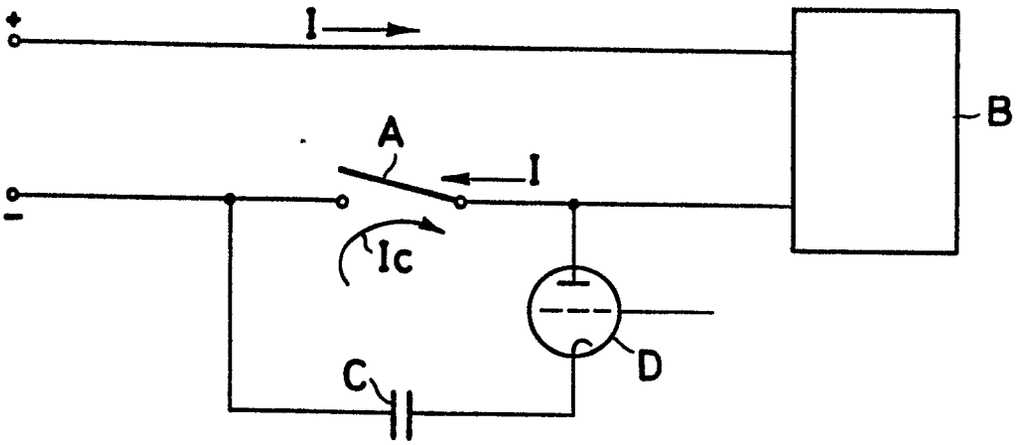

Fig.3

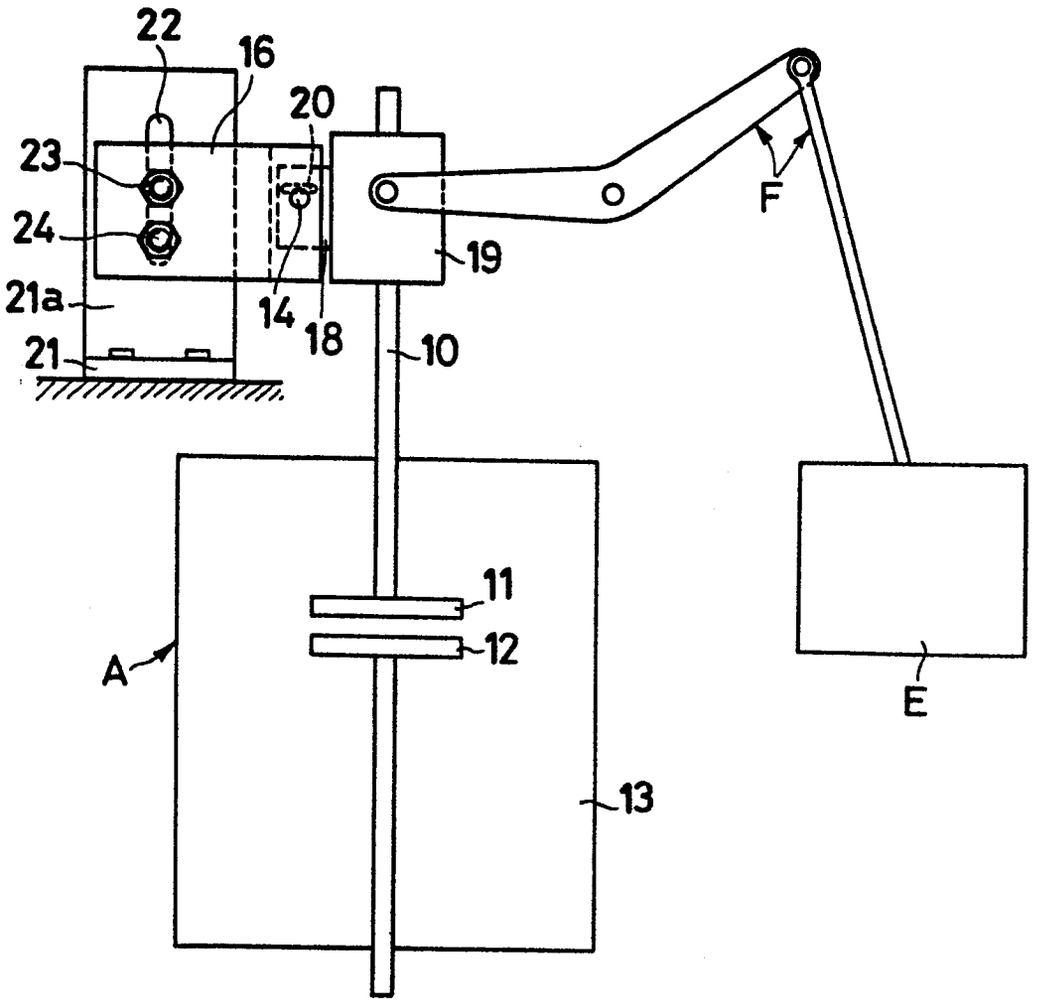

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Fig.2

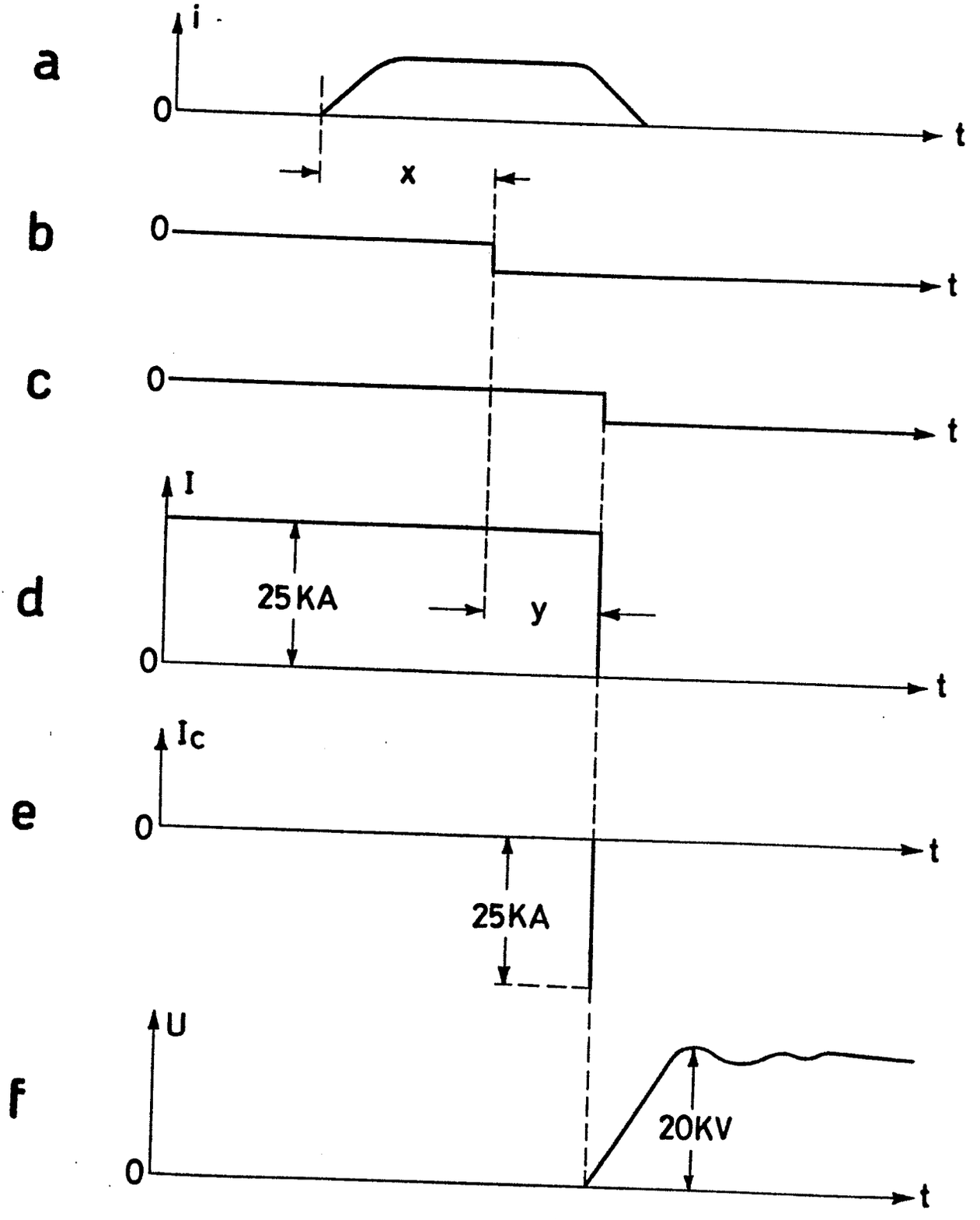

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Fig.4

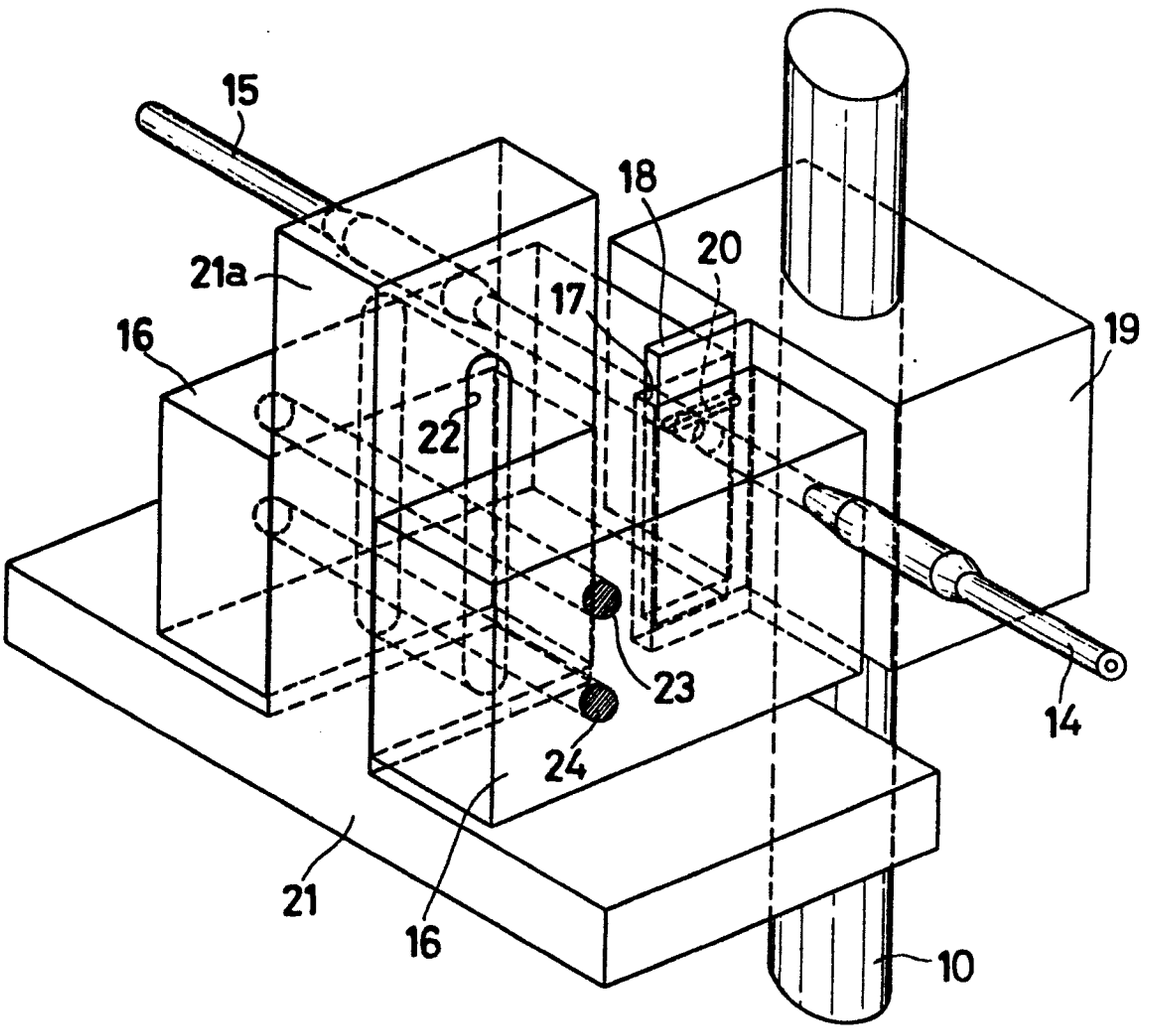

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Fig.5