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Apparatus for dispensing small amounts of liquid.

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An apparatus for dispensing liquids in small and controlled amounts is described. The apparatus comprises a syringe having a discharge end, discharge from which is controlled by a valve. The other end of the syringe is securable to an adapter through which pressurised air can be supplied to force liquid through the discharge end, when this is open. In use the syringe is filled with liquid which is constantly under pressure. Means are provided for opening the valve for a pre-determined period of time.

EP 0 375 462 A2

This invention relates to syringes for dispensing liquids and in particular to syringes for dispensing small amounts of liquid in a controlled fashion.

Recently, as a result of the swift growth of industries such as the electronic industry, the amount of liquid micro painting operations, such as the deposition of adhesive, coatings and insulative materials in very small controlled amounts, has increased rapidly.

A known system for dispensing small amounts of liquids comprises firstly a syringe, generally formed of plastic material in the form of a tube. One end of the tube is connectable to an adaptor whilst the other is shaped as a nozzle or is provided with connection means whereby a nozzle may be attached thereto.

The syringe is provided filled with the liquid paint material and with both ends closed by stoppers. In operation, the stoppers are removed and the syringe is attached to the adaptor. The adaptor is connected to a source of pressurised air and includes a passage whereby the air is fed to the syringe to force the liquid therein through the discharge end thereof. The supply of pressurised air is controlled by a valve which is in turn activated by a solenoid which is energised by a switch. Generally a timer is interposed between the switch and the solenoid which is operable, when the switch is pressed, to energise the solenoid for a preset period of time and thus cause the valve, which controls the supply of pressurised air to the syringe to also be opened for the preset period of time.

The arrangement has been found to have certain disadvantages. Firstly the quantity of liquid discharged cannot be exactly controlled. This is because the pressure inside the syringe takes a finite amount of time to build to its maximum level when the valve is opened and also to reduce to zero when the valve is closed. The discharge velocity, and hence the discharge flow rate of the liquid, which is proportional to the applied pressure, is also therefore not constant with the result that the amount discharged is not directly proportional to the time for which the valve is open. This is a significant problem when very small amounts of liquid are to be discharged.

Secondly, it has been found that liquid forced from the syringe by the pressurised air tends to form a drip on the nozzle which does not fall from there until its weight is greater than the adhesive force between the nozzle and the drip. Rather than waiting for the liquid to drop, in order to save time, deposition of liquid is normally carried out by moving the end of the nozzle manually towards the substrate to be painted to bring the drip into contact with the substrate. Thus the arrangement is not suitable for automation.

Further problems are, in particular, liquid tends to evaporate inside the syringe when the pressurised air supply is closed by the valve. Furthermore there is a tendency for liquid to be discharged from the nozzle even when the valve is closed.

Apparatus for dispensing liquid in accordance with the invention comprises a syringe having a discharge end and an adaptor securable to the other end of the syringe through which pressurised air can be supplied to force liquid contained in the syringe to be discharged through the discharge end characterised in that a valve is provided for controlling the discharge of liquid from the discharge end of the syringe.

The advantage of this is that the discharge from the syringe can be accurately controlled simply by opening or closing the valve. With the valve closed no liquid can be discharged and thus the problem found with the known arrangements, that liquid was sometime discharged even when the air pressure supply valve was closed, is obviated.

Very preferably the arrangement is such that the liquid in the syringe is constantly pressurised. This ensures that when the valve is opened the full discharge velocity is almost instantaneously reached whereby the amount dispensed is directly proportional to the time the valve is open and can thus be very accurately controlled. Furthermore the fact that the maximum dispensing velocity is reached so quickly means there is little chance for liquid to stick to the nozzle end and form a drop which has to be manually brought into contact with the surface to be coated.

Suitably the valve stem passes through at least part of the pressurised air supply passage in the adaptor. The valve seat may be provided by a suitably shaped section of the discharge end of the syringe or of a nozzle attached thereto or may comprise an O-ring mounted on the discharge end or a nozzle attached thereto.

Suitably, means are provided for opening the valve to allow discharge for a predetermined period of time.

In one preferred form the valve stem is biased towards the valve seat by a spring to close the valve. In one embodiment the valve stem is moved away from the valve seat to allow discharge by the action of air pressure on a piston attached to the valve stem. Alternatively, the valve stem is provided with an iron core section mounted between two coils which can be electrically activated, the arrangement being such that this causes the iron core and hence the stem to move away from the valve seat.

The invention will now be further described by way of example with reference to the accompanying drawings in which:

Figure 1 is a side view of a syringe suitable for use in an apparatus in accordance with the invention;

Figure 2 is a vertical section through a known apparatus for dispensing liquid;

Figure 3 illustrates the method of use of the apparatus of Figure 2;

Figure 4 is a series of graphs illustrating the operational characteristic of the apparatus of Figure 2;

Figure 5 is a vertical section through an apparatus in accordance with the invention;

Figure 6 is a series of graphs illustrating the operational characteristics of the apparatus of Figure 5;

Figure 7 is a vertical section through an alternative embodiment of the apparatus of Figure 5;

Figure 8 is a side view of a valve stem suitable for use with the apparatus of Figures 5 and 7, and

Figures 9-11 show three alternative arrangements for the discharge end of the apparatus of Figures 5 and 7.

The syringe 1 shown in Figure 1 comprises a tube 2 having a flange 3 near one end, the other end being shaped to form a discharge tube 4. The syringe is generally made of plastic material, for example, polyethylene or polypropylene. Typical dimensions for the syringe are a diameter of between 15 to 25mm, a length of between 100 and 300mm, a tube wall thickness of between 1 and 1.5mm and a capacity of about 500cc. As shown, for some syringes, the discharge tube 4 is formed with an internal screw 5 whereby a metallic nozzle 10 with a corresponding external screw can be attached thereto.

A quantity of liquid paint material is filled into the syringe 1 and the openings at either end of the syringe are sealed with stoppers P11, P12. The syringe is to be on sale in this form and, as such, is commonly referred to as a "capsule of paint material".

Referring now to Figure 2, the method of operation presently employed with syringe 1 is as follows. The filled syringe is purchased by a manufacturer who first removes the sealed stoppers P11, P12 at the end of the syringe 1. The flange 3 of the syringe 1 is then inserted into a "male - female" socket 78 of an adaptor 76 and then turned half way to produce a so-called quick pipe join.

The adaptor 76 serves to supply pressurised gas to the syringe 1. In general the gas employed is air and we will therefore hereinafter refer to the gas as air. The adaptor 76 contains a passage for the pressurised air 60 and, after mounting the adaptor on the syringe, a tube 61 is connected to the adaptor which communicates with the passage

60. The tube 61 feeds compressed air (CA) at a fixed pressure from an air tank 75 to the adaptor 76 through a switch valve 63, provided in the tube 61. The switch valve 63 is electronically operated by means of a solenoid system which forms part of an air pressure supply device 62. The solenoid 64 is activated by a signal from a timer 67, which in turn may be controlled by a foot switch 68, to open the valve 63 and thus cause pressurised air to be passed into the syringe 1 through the air supply passage 60. The air acts on the surface of the liquid L inside the syringe, the liquid therefore being discharged from the nozzle 10 attached thereto.

The timing of the steps of the process is shown in the graphs of Figure 4. First a discharge signal (H line) is issued by the foot switch 68. If the discharge time does not have to be very accurately controlled then the signal from the foot switch is passed directly to the solenoid. If the time has to be accurately controlled (to a number of micro sections), the signal is input into timer 67 which converts the signal to an exact time signal which is transmitted to the solenoid (I line). The time signal communicated to the solenoid 64 cause that to actuate the valve 63 (J line) which causes pressurised air (CA) to be fed from the tank 65 for the set amount of time. The air (CA) passes through the passage 60 in the adaptor 76 and enters the syringe 1. The pressure of the air takes a finite amount of time to increase to the desired level after the valve is opened, and to decrease back to zero when the valve is closed, as shown in the K line. The reason for this is the period of time required for the valve to move from the closed to the open position and also acts on the elasticity of the air, the length of the tube, the resistance within the tubing and the inertia of the air. The velocity of the liquid discharged is proportional to the applied pressure (K line) and therefore the M line, which shows this, also has a slope at either end. The slope is in fact greater due to the additional factors of the resistance of the discharge path 4H and the nozzle exit 10H. The discharge flow rate is approximately proportional to the velocity of the discharge (M line).

The result of the non-constant pressure applied to the liquid is that the discharge set time (I line) and the discharge quantity, which is proportional to the discharge flow rate (M line), do not agree with each other precisely. Thus the amount discharged cannot be exactly controlled, which when the amount of paint to be applied is small, could be important.

The arrangement shown in Figure 2 has certain further drawbacks. As liquid reaches the pointed end part of the nozzle, under the action of the pressurised air, it tends to form a liquid drop d1

and, when it is a small amount, the liquid drops, in most cases, gather and stick to the pointed end part of the nozzle under the action of cohesive force between the liquid molecules themselves and the adhesive force between the pointed end part of the nozzle and the liquid. When the weight of the liquid becomes greater than the adhesive force, the drop separates and falls from the nozzle end painting is commonly performed by moving the liquid drop d2 attached to the pointed end part of the nozzle to the object W to be painted manually - see Figure 3. Therefore, as shown in Figure 3, the painting operation has been performed by grasping the syringe manually, as with a pen, and moving it towards the object W on substrate CB.

Figure 5 shows an apparatus in accordance with the invention. The same type of syringe 1 is employed and those parts which are identical to those employed in the known arrangement described above will not be further described herein. In this arrangement the adaptor C has a valve stem 11 passing through air passage 13. The pointed end part "of the valve stem" is dimensioned to fit closely in the inlet of the discharge port 4H of the syringe 1. The opposite end of the valve stem is secured to a columnar iron core 12, housed inside the adaptor 6, a wire coil 15 being provided around the peripheral part of the iron core. A spring 16 is mounted between the upper end of the iron core and the adaptor, and an adjusting screw 17 passes through the centre of the spring and thus restricts the valve stroke. The air supply passage 13 branches approximately midway along its length, the branch line 14 being connected to an air joint fixture 18 which has a passage therein which serves to connect the branch line 14 and tubing 19. Pressurised air from an air source 28 passes to the adaptor through the tubing 19 via a flow rate adjusting valve 24, a pressure adjusting valve 25 and an on/off valve 26. The coil 15 inside the adaptor 6 is electronically connected to a timer 27 and thence to a foot switch 35.

The operation of the apparatus shown in Figure 5 is as follows. The syringe, as purchased, has its stoppers removed and is affixed to the adaptor 6. The electric current to the coil 15 at this point is disconnected and the valve stem 11 is biased downwardly by the spring 16 to close the discharge end of the syringe 1. To perform a painting operation, the on/off valve 26 is opened and the pressure adjusting valve 25 and flow rate adjusting valve 24 are adjusted to supply air at the required pressure to the adaptor 6, that is, during the painting operation a constant pressure of air is always applied. In this state an electrical signal is sent by timer 27, either alone or as a result of closing of foot switch 35, which activates the coil 15 inside the adaptor 6. This causes the iron core 12 to

become excited and rise upwards in the direction of the arrow with the result that the valve stem "and pointed end 11b" also move upwards to open the valve. Liquid L, which is already fully pressurised, passes through the path thus provided and is discharged from the discharge part 4H.

The process is shown pictorially in the graphs of Figure 6. The required constant air pressure is provided inside the syringe 1 (A line). The discharge command is issued either directly from the timer 27, or via the foot switch 35 (B line). The signal from the foot switch is converted inside the timer 27 and issued therefrom (C line). The solenoid 15 inside the adaptor therefore, activates and is excited causing the iron core 12 and valve stem attached thereto to move upwards, thus opening the valve (D line). The difference between the C line and the D line is a time lag caused by the inertia of the iron core which is very short, in the order of 0.1 ms, and therefore can be regarded as negligible. As liquid is discharged from the syringe, the air pressure lowers a little (E line). However, the little air is replenished continuously. Thus the air pressure line does not contain a slope as is found with the known arrangement. It lowers a little as shown in the E line but it is flat. Thus the velocity of the discharge (F line) and the quantity of discharge (G line) appears flat too. The quantity of discharge becomes even and equal to the discharge time which, as explained above, does not occur with known systems.

As a result of the fact that a constant pressure is applied to the liquid inside 1, the liquid passes through the discharge port and through the nozzle 10 at the required discharge velocity and there is no chance for liquid to stick to the pointed end part of the nozzle.

When the required quantity has been discharged, the flow control valve is closed and the discharge interrupted. The quantity discharged is determined by the degree to which the valve is opened and the time for which it opened which means that discharge of a very small amount can be performed. As mentioned above, no liquid drops stick and remain at the pointed end of the nozzle and it is thus not necessary to move the syringe manually towards the place or object to be painted. It is simply sufficient to direct the nozzle 10 of the syringe 1 horizontally (H direction) above the object to be painted and thus automation of the process is possible.

The solenoid valve provided inside the adaptor described above can be replaced by an air cylinder system valve 36, as shown in Figure 7. The arrangement is generally similar but in place of the iron core, the upper end of valve stem 4 is provided with a piston 42. The valve stem is caused to move upward to open the liquid flow control valve

by the action of air supplied via passage 48 in the adaptor, below the piston 42. The piston is biased to close the valve by a spring 46 and a screw 47 is provided to limit the travel of the valve stem.

The difference between these two systems is that the solenoid system responds faster. However, when the control of the discharge quantity does not have to be strictly adhered to, the air cylinder system can be employed.

The liquid flow control valve of Figures 5 and 7 generally comprises a needle valve. To increase accuracy even further and to ensure a strict cut-off when the valve is closed, a valve 52 made of elastic material, e.g. rubber, may be fitted to the pointed end part of the needle valve 51.

In the arrangements described above, the discharge port of cylinder was employed as the valve seat. However, the valve seat can be provided by the inlet port of a nozzle screwed to the discharge end of the syringe. Nozzles are generally formed from metal and this means that the valve seat can be very accurately constructed by machining. Figure 9 shows this, a nozzle 55 having a valve seat 55S provided at the inlet part of the nozzle port 55H by means of precision machining. In Figure 9, the nozzle 10 is connected to the syringe by means of threads cut in the external face of the nozzle and corresponding threads cut at the inner side of the outer tube of the double tube discharge section of the syringe. In Figure 10 the nozzle threads are provided on the nozzle internal face, whilst those on the syringe are provided on the outer side of the inner tube. Alternatively again, as illustrated in Figure 11, an O-ring can be employed as a valve seat.

With the apparatus of the invention it is possible to perform discharge painting quickly and in the exact position required with very small quantity of paint. Automation of the discharge painting operation is possible. The apparatus allows reduction of time and cost of materials in the manufacturing process and gives a great improvement in the quality of the product.

Claims

1. Apparatus for dispensing liquid comprising a syringe have a discharge end, and an adapter securable to the other end of the syringe through which pressurised air can be supplied to force liquid contained in the syringe to be discharged through the discharge end, characterized in that a valve is provided for controlling the discharge of liquid from the discharge end of the syringe.

2. An apparatus as claimed in Claim 1 wherein the liquid in the syringe is constantly under pressure.

3. Apparatus as claimed in either Claim 1 or Claim 2 means are provided for opening the valve to allow discharge for a pre-determined period of time.

4. An apparatus as claimed in any preceding claim wherein the valve comprises a valve stem and a valve seat, the valve stem passing through at least part of a pressurised air supply passage in the adapter.

5. Apparatus as claimed in Claim 4 wherein the valve seat comprises a section of the discharge end or of a nozzle attached thereto.

6. Apparatus as claimed in any one of Claims 3 to 5 wherein the valve stem is biased towards the valve seat to close the valve by a spring.

7. Apparatus as claimed in any one of Claims 3 to 6 wherein the means for opening the valve comprises a piston secured to the valve stem and means for supplying pressurised air against the piston in a direction to cause the valve stem to move away from the valve seat.

8. Apparatus as claimed in any one of Claims 3 to 6 wherein the means for opening the valve comprises an iron core section secured to the stem and mounted within a coil connectable to an electric source, connection to the source causing the core to move relative the coils and thereby move the valve stem away from the seat.

9. Apparatus as claimed in any preceding claim wherein the valve is a needle valve.

10. Apparatus as claimed in any preceding claim wherein at least part of the valve is formed from a natural or synthetic rubber.

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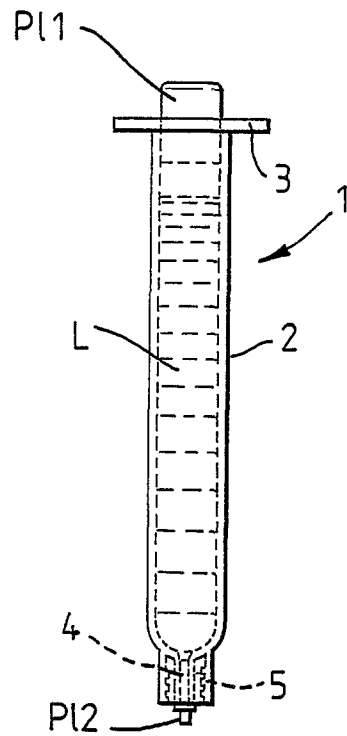


Fig. 1.

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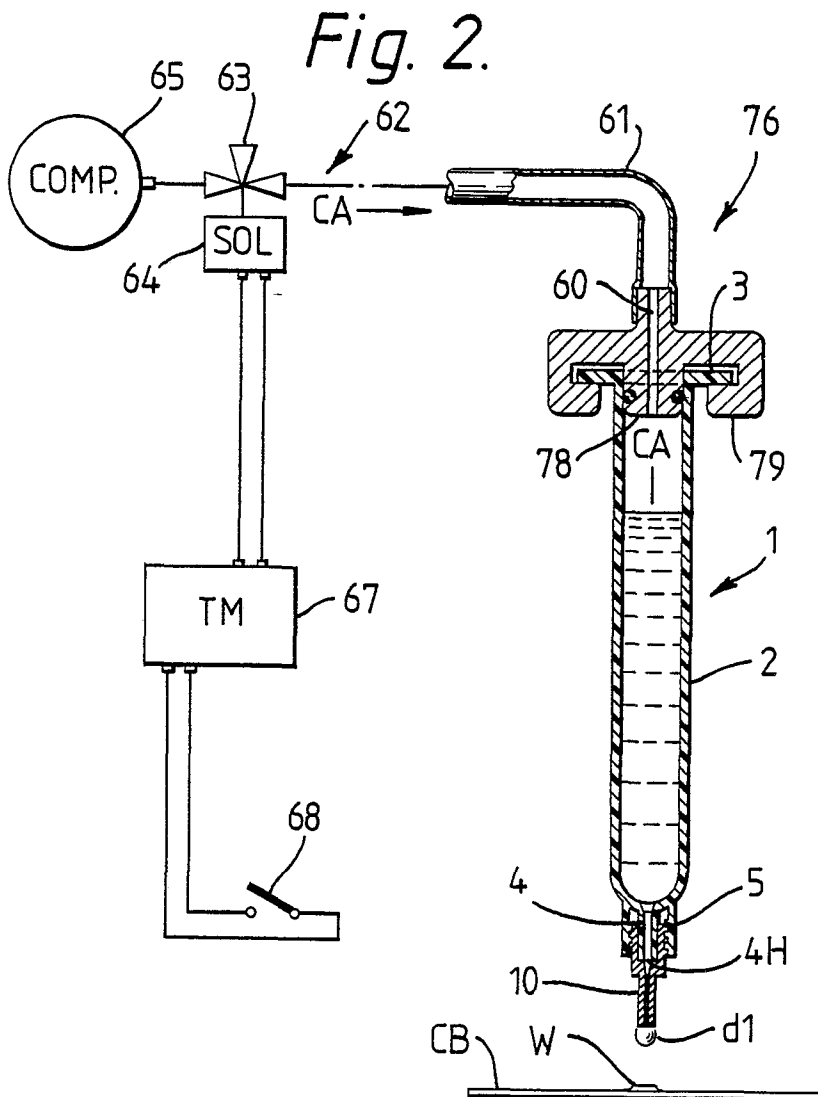


Fig. 2.

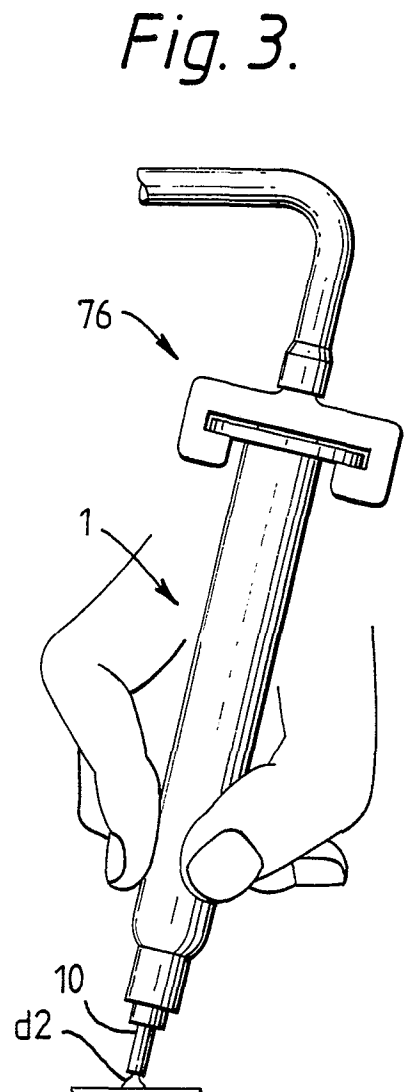
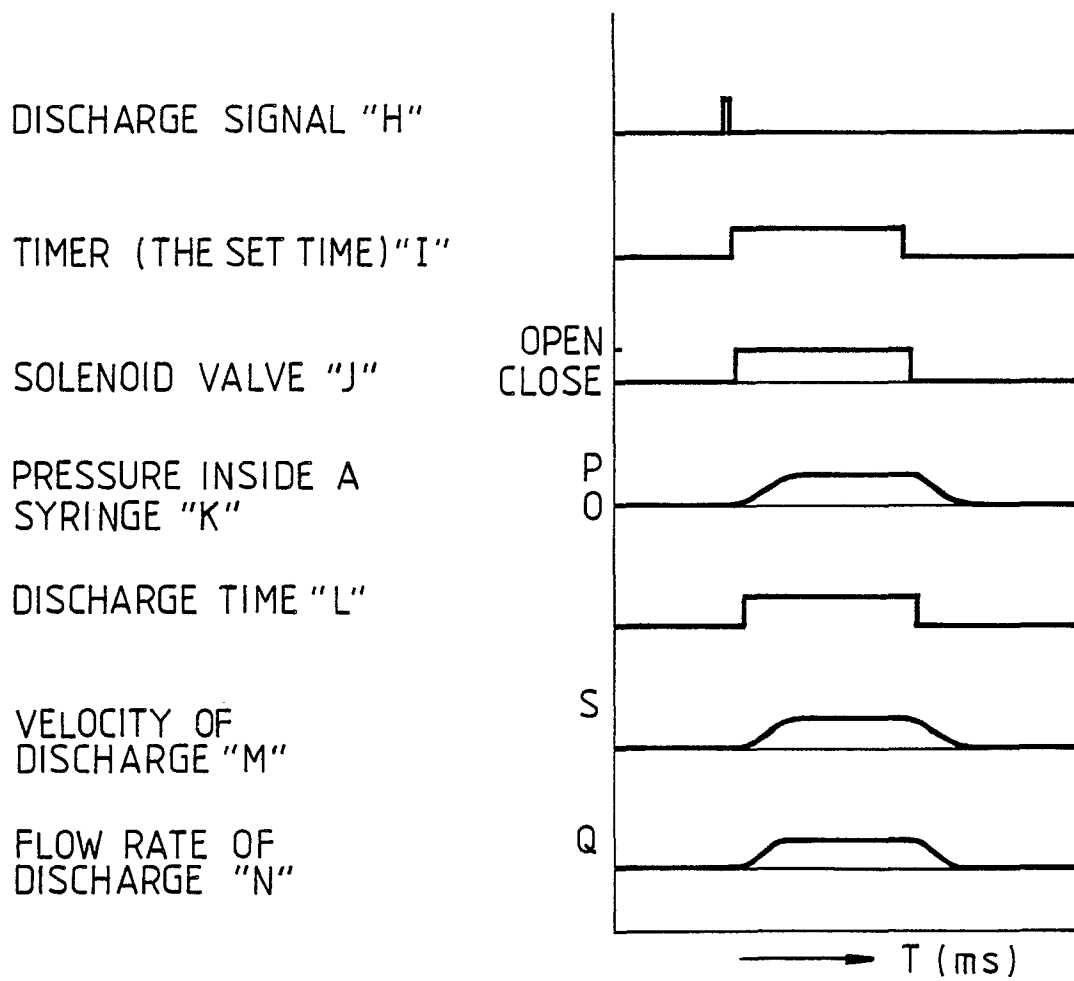


Fig. 3.

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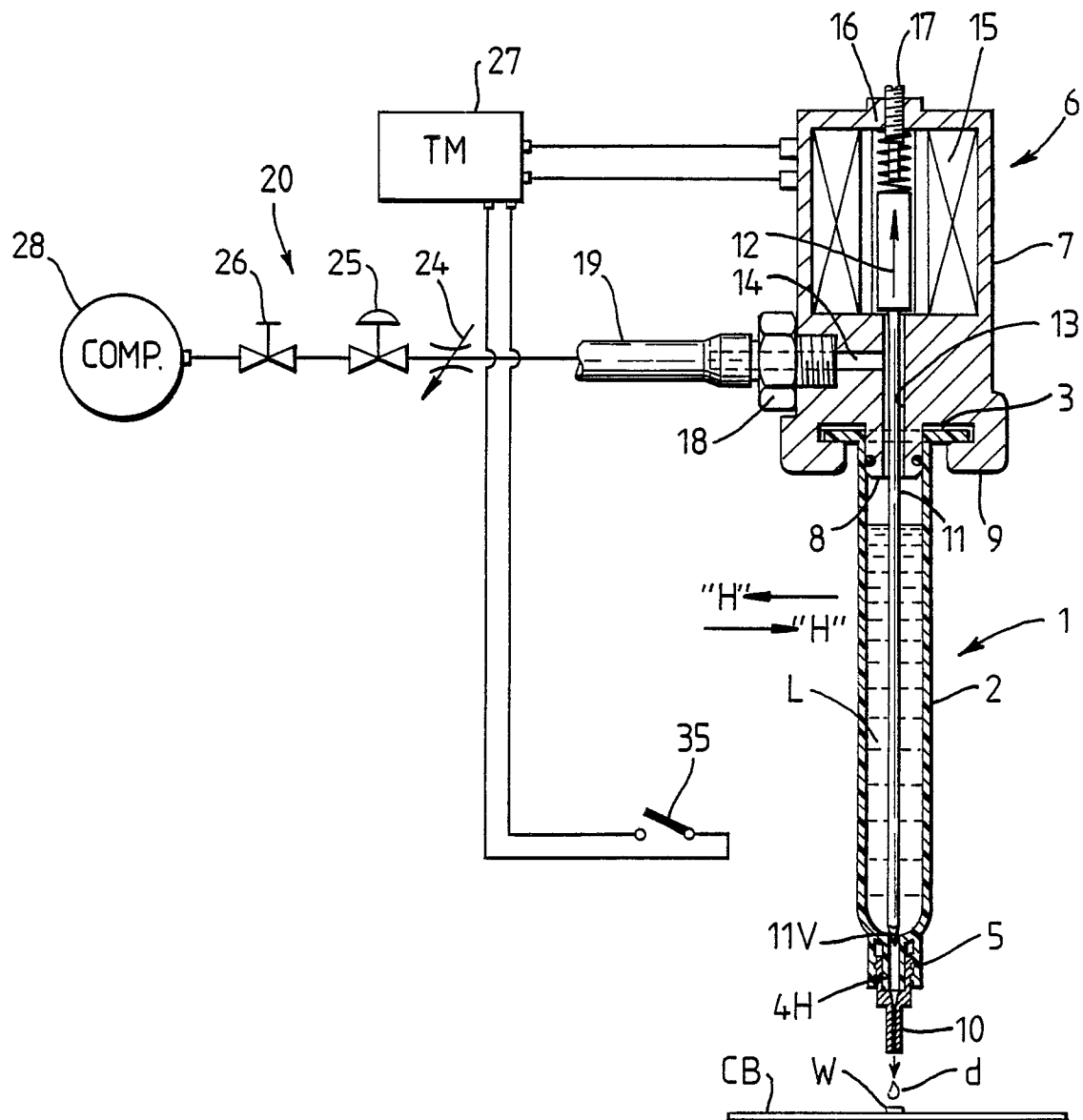
Fig. 4.

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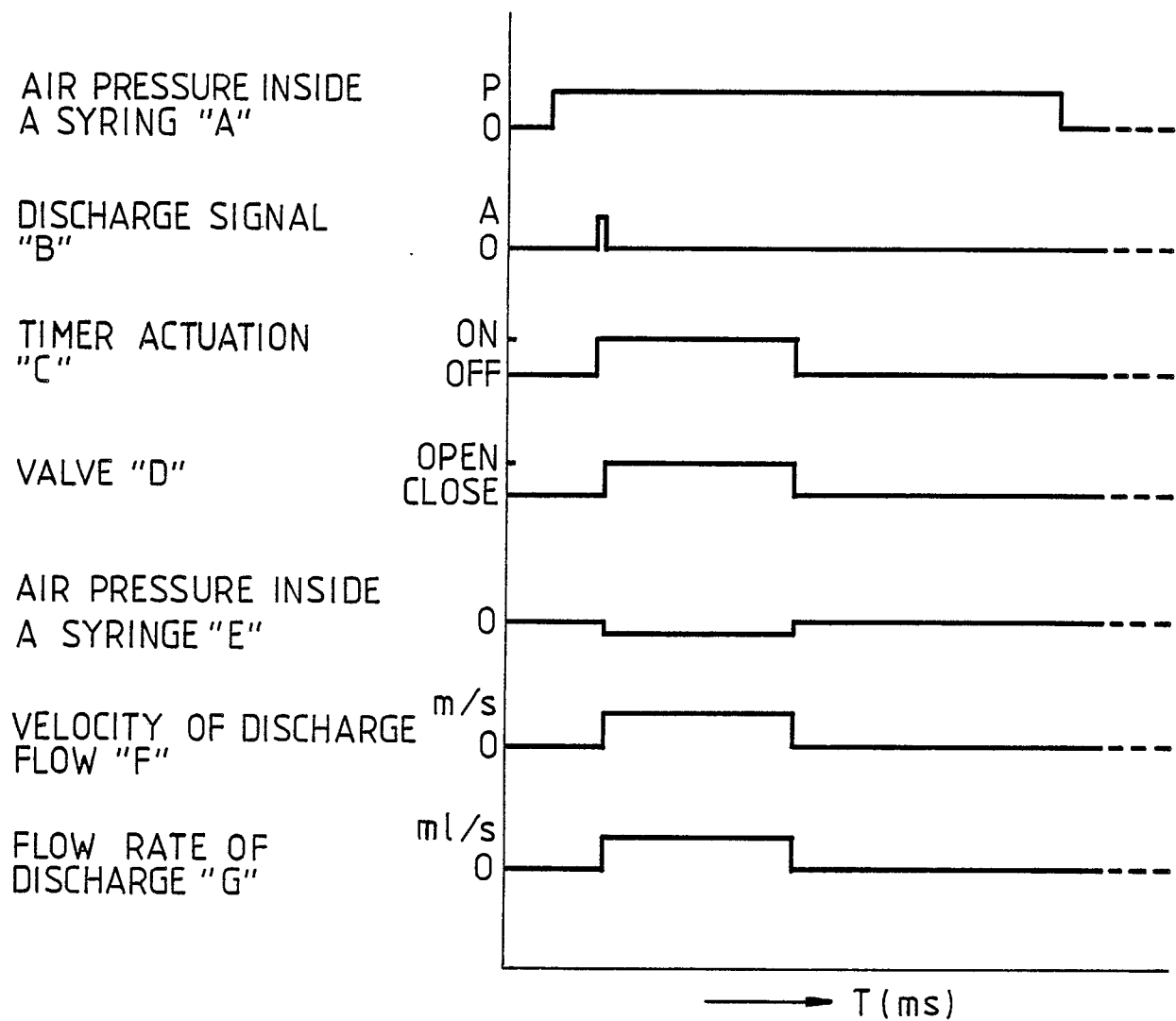
Fig. 5.



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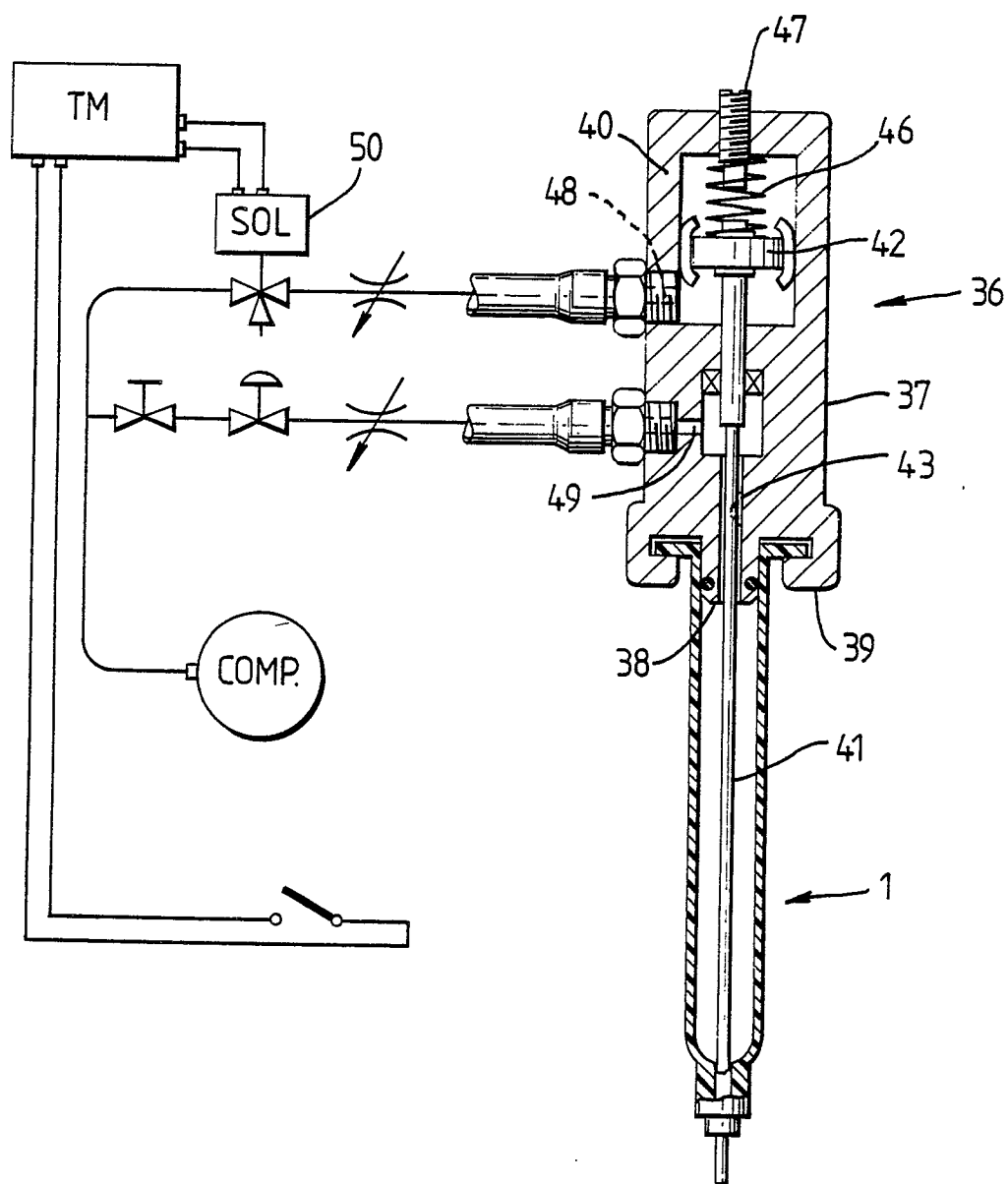
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Fig. 6.



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Fig. 7.



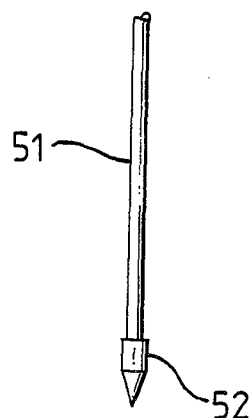


Fig. 8.

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Fig. 9.

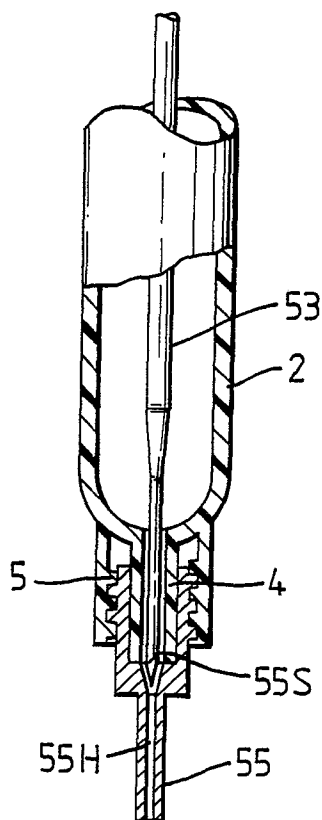


Fig. 10.

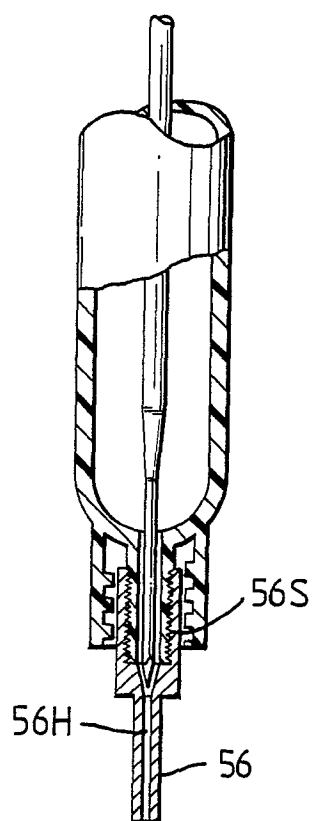


Fig. 11.

