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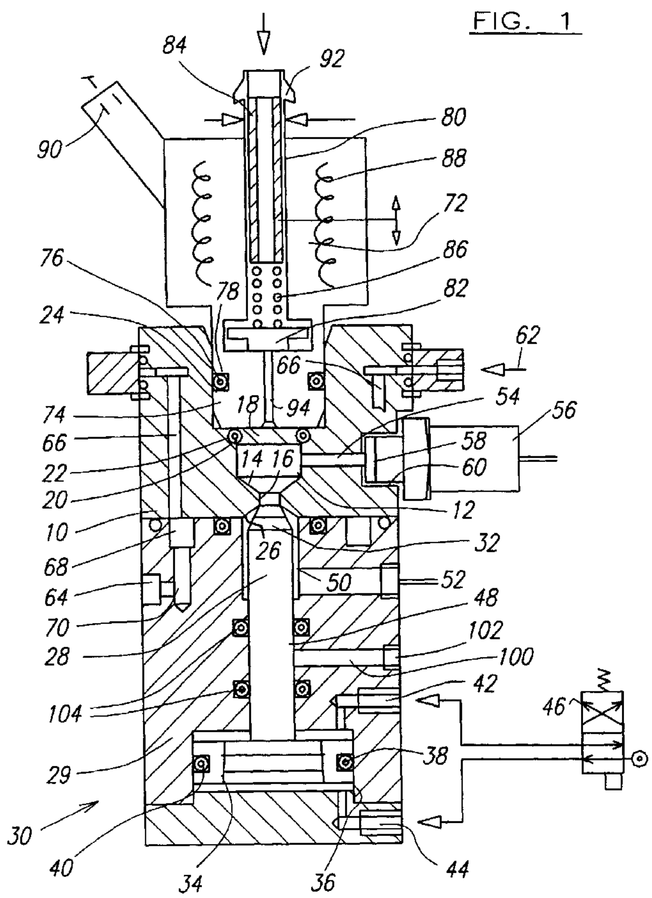
(54) Injection indication apparatus

(57) Apparatus for indicating an operating characteristic of an injector (72) or an injection system especially for an internal combustion engine., The apparatus is provided with a body (10) formed with a cavity (12) into which fluid is injected when the apparatus is in use, and a pressure transducer (56) coupled with the cavity (12) to provide an indication of the pressure therewithin.

FIG. 1



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Description

[0001] The present invention relates to apparatus for indicating an operating characteristic of an injector or an injection system, especially but not exclusively, for an internal combustion engine.

[0002] One such apparatus that has been proposed hitherto comprises metering means to measure the volume of injected fluid. However, such a system is relatively cumbersome.

[0003] The present invention seeks to provide a remedy.

[0004] Accordingly, the present invention is directed to apparatus having the construction set out in the opening paragraph of the present specification which is provided with a body formed with a cavity into which fluid is injected when the apparatus is in use, and a pressure transducer coupled with the cavity to provide an indication of the pressure therewithin.

[0005] In one embodiment of the present invention, the cavity is of a substantially fixed volume.

[0006] Preferably, the body is further provided with valve means to enable the cavity to be opened to ambient pressure or other predetermined pressure after one or more injections.

[0007] Control means may be connected to the valve means to open the valve means after each and every injection.

[0008] Alternatively, such control means may be constructed or programmed to open the valve means after a predetermined plurality of such injections.

[0009] In one particular embodiment of the present invention, for a plurality of injectors or for a single injector having a plurality of injector nozzles, the apparatus may be provided with a plurality of such cavities respectively for each injector hole, and pressure transducers in communication respectively with the cavities.

[0010] A processor may be connected to the output of the pressure transducer to process a signal received from the latter and to provide an indication of whether or not the signal falls within a predetermined tolerance of a predetermined ideal signal.

[0011] The processor may be constructed or programmed in this respect to check a gradient of the electrical output from the pressure transducer immediately following an injection.

[0012] Alternatively or in addition, the processor may be constructed or programmed to provide a measure of the gradient of the output signal from the pressure transducer over a predetermined number of injections.

[0013] The valve means may comprise a needle valve.

[0014] Alternatively, the valve means may comprise a first member provided with a slanting surface along which a closure member slides, so that movement of the first member results in a smaller movement of the closure member.

[0015] The present invention extends to a method of providing an indication of an operating characteristic of an injector or an injection system, in which fluid is injected into a cavity and a pressure transducer is used to provide an indication of the changes in pressure in the cavity following one or more injections.

[0016] Examples of apparatus made in accordance with the present invention, and examples of methods in accordance with the invention, will now be described with reference to the accompanying drawings in which:

Figure 1	shows an axial sectional view through a first construction of such apparatus;
Figure 2	shows an axial section view through a second construction of such apparatus;
Figure 3	shows an electrical circuit diagram of circuitry used with the apparatus shown in Figure 1 or Figure 2.
Figures 4, 5 and 6	show explanatory time graphs on the same time scale;
Figure 7	shows a further explanatory time graph; and
Figure 8	shows a further explanatory time graph on the same scale as Figure 7.

[0017] The embodiment of the present invention shown in Figure 1 comprises a block 10 in which is formed a cavity 12 having a calibrated volume and a lower boundary 14 which tapers towards an exhaust port 16 and an upper end 18 formed with an annular shoulder 20 to receive an 'O' ring 22. The upper end 18 opens into an injector nozzle seating 24. The surface 26 of the block 10 on the side of the exhaust port 16 further from the cavity 12 is flared to provide a seat for the needle 28 within the body 29 of a needle valve 30 positioned immediately underneath the block 10, the tip 32 of the needle 28 abutting the flared surface 26 of the block 10 in its closure position and being slightly spaced therefrom in its open position.

[0018] The needle 28 is integral with a piston 34, which is slidable up and down within a closed cylinder 36, opposite sides of the piston 34 being sealed from one another by way of an 'O' ring 38 seated within an annular groove 40 around the side of the piston 34. The valve body 29 is provided with ports 42 and 44 extending to the upper and lower sides respectively of the cylinder 36 to enable hydraulic or pneumatic fluid under pressure to be applied to those sides of the piston 34 respectively to open and close the valve under the control of a solenoid operated valve 46.

[0019] A bore 48 of the valve 30 which accommodates the needle 28 is, at an upper region thereof, of greater diameter than that of the needle to provide an annular passageway 50 extending downwardly from the exhaust port 12 to a test fluid outlet port 52 provided in the valve body 29.

[0020] A bore 54 is provided in the block 10 whereby a communication is provided between the cavity 12 and a pressure transducer 56 having a sensor end 58 received in a recess 60 in a side of the block 10.

[0021] An inlet port 62 formed in the side of the block 10 is in communication with an outlet port 64 in the valve body 29 via bores 66 in the block 10 and an annular gallery 68 and a bore 70 in the valve block 30, to enable fluid of a predetermined temperature to be passed through the block 10 and the valve body 30 and maintain the walls of the cavity 12 substantially constant at a predetermined temperature.

[0022] Figure 1 shows the apparatus ready for use with an elongate injector 72 to be tested having its nozzle end 74 fully inserted into the injector seat 24, a first end face 75 of the nozzle end 74 being in sealing contact with the O-ring 22. A seal is also formed between this nozzle end 74 and the injector seat 24 by means of an 'O' ring 76 accommodated within an annular groove 78 formed around the nozzle end 74 of the injector 72.

[0023] The injector 72 is provided with a central bore 80 extending along an elongate axis of the injector 72, the latter having a closure member 82 in its interior and also an adjustment tube 84 held by a tight fit in the bore 80 and forming an abutment for a helical spring 86 extending between the closure member 82 and the adjustment tube 84. The closure member 82, which is urged downwardly by the helical spring 86, can be raised by the passage of an electrical current through a coil 88 within the injector 72. An electrical current can be passed through the coil 88 via an electrical connection 90 on the side of the injector 72.

[0024] The injector 72 is further provided with an inlet port 92 at the upper end of the bore 80 which communicates all the way through to the nozzle 94 of the injector 72, but which communication is closed by the closure member 82 when the latter is in its lowered position under the action of the spring 86 and in the absence of any current through the coil 88. Flow of fluid through the injector 72 is affected by the position of the adjustment tube 84.

[0025] The bore 48 is provided in a position below the passageway 50 with a vent passageway 100 to a vent hole 102 in the side of the valve body 30, the valve passageway 100 opening into the bore 48 between two 'O' ring seals 104.

[0026] The apparatus is provided with electrical circuitry as shown in Figure 3, in which a processor 120 is connected to control the solenoid valve 46 via a drive circuit 110. The output from the pressure transducer 56 is also connected to the processor 120, and a display 122 is connected to be driven by the processor 120. In addition, the processor 120 is connected to control energising of the coil 88 via a driver 114 connected to the connection 90.

[0027] With the apparatus ready for use as shown in Figure 1, the injector clamped tightly in position with its inlet port 92 connected to a supply of test fluid under pressure and all electrical connections made, the processor 120 is in a starting condition for a test routine in which it has set the drive 110 to cause the solenoid valve 46 to apply hydraulic or pneumatic fluid pressure via the port 44 to close the valve 30. Furthermore, it has set the drive 114 to cause the coil 88 to be in the off condition so that the closure member 82 is in its closing position.

[0028] The processor 120 is programmed to switch the coil 88 on to the drive 114 at time t_1 shown in Figure 4, and to switch it off again at time t_2. Thus, the electrical current through the coil 88 as a function of time is a simple square function as shown in Figure 4. The processor 120 receives an output signal from the pressure transducer 56 having the characteristics shown in Figure 5. Thus, at time t_3, slightly delayed after time t_1 as test fluid starts to shoot through the nozzle, the measured pressure begins to rise with increasing gradient, then with substantially constant gradient, and then with a slightly decreasing gradient until it reaches its maximum at a time t_4 where it remains substantially constant for a period until the processor 120 switches the valve 30 by applying a signal to the drive 110 to change the solenoid valve 46 so that hydraulic or pneumatic pressure is now applied via the port 42 to the upper side of the piston 34. This opens the valve 30 and enables fluid to flow out from the cavity 12 via the exhaust port 16, the passageway 50 and the outlet port 52.

[0029] The processor 120 is programmed to record and evaluate the pressure curve between times t_3 and t_4, and in particular to ascertain the value of the gradient where it is substantially constant between those times. The result is provided on the display 122. (Alternatively, it could ascertain a relevant value from the regression curve). This may show whether the volume of an injection of fluid, or the flow rate, through the injector is normal, too large, or too small. For example, the left-hand curve in Figure 6 shows too steep a rise, or a rise which is too early, indicating that the injected volume is too large. The processor 120 may be calibrated to provide a measure of the actual volume of an injection. The adjustment tube 84 may be shifted accordingly, and a further test performed. Once the display 122 indicates normal, the inlet port 92 may be crimped to secure the adjustment tube 84 in the desired position. The injector is then ready for use having been correctly set with the aid of the apparatus.

[0030] Alternatively, with an appropriate size of cavity 12, the processor 120 may be programmed to exhaust the cavity 12 only after a number of successive injections have occurred, the processor 120 then views the mean gradient of the pressure increase as it builds up over time t_1 to t_2 shown in Figures 7 and 8.

[0031] The fluid passing through the injector 72 into the cavity 12 may be any one of a number of test fluids, for example, petrol, diesel oil, test oil having substantially the same density and viscosity as petrol or diesel oil, or air. The benefit of the latter is that the apparatus and the surrounding environment remain clean and dry. If a liquid is used, it may be desirable to provide a wall portion of the cavity 12 or the passageway 58 which will yield resiliently, but with increased resistance with increased volume of fluid injected into the cavity 12.

[0032] In the embodiment shown in Figure 2, the apparatus is modified to test simultaneously injections through each of the holes of a multi-hole, conically-tapering injector nozzle. For this it will be seen that there is a cavity 12 with an associated pressure transducer 56 and valve 30 for each and every hole 200 of an injection nozzle 210. In view of the relatively small size of each cavity 12, in comparison to the cavity 12 of the Figure 1 embodiment, bearing in mind that the fluid injected is distributed through all the holes, the valve 30 has been modified to give increased precision to provide a bleeding closure and pressure reduction valve. Thus, the needle 28 thereof has a slanting surface 212 on one side against which one end of a valve closure member 214 abuts. The incline 212 is such that a relatively large movement of the piston 34 results in a relatively small movement of the closure member 214. Each and every pressure transducer 56 and solenoid valve 46 is connected to the processor 120, the latter being constructed and programmed to deal with the output of each transducer 56 individually, and the display 122 likewise showing results for each nozzle hole individually.

[0033] Further tests may be made by the apparatus, for example sealing or pressure wave measurement.

[0034] The processor 120 may be provided with the pressure of the test fluid applied to the injector, and make calculations accordingly.

[0035] The apparatus shown in Figure 1, and also the apparatus shown in Figure 2, can be used to test, adjust and/or calibrate an injector or an injector system, with the advantages of a reduction in the time it takes to do that, lower cost, simpler components, smaller space requirement, and simpler maintenance.

[0036] It will be appreciated that the apparatus provides a measure of flow rate through an injector as well as total volume per injection under production conditions, and the processor 120 can be constructed and programmed to provide test results of both of these characteristics at the display 122.

[0037] Numerous variations and modifications to the illustrated apparatus will occur to the man skilled in the art without taking the resulting construction outside the scope of the present invention. For example, the valve 30 can be modified to operate along the lines of the electrical operation of the injector.

Claims

1. Apparatus for indicating an operating characteristic of an injector (72) or an injection system, especially but not exclusively, for an internal combustion engine, **characterised by** a body (10) formed with a cavity (12) into which fluid is injected when the appratus is in use, and a pressure transducer (56) coupled with the cavity (12) to provide an indication of the pressure therewithin.

2. Apparatus according to claim 1, **characterised in that** the cavity (12) is of a substantially fixed volume.

3. Apparatus according to any preceding claim, **characterised in that** the body is further provided with valve means (30) to enable the cavity to be opened to ambient pressure or other predetermined pressure after one or more injections.

4. Apparatus according to any preceding claim, **characterised in that** control means (46, 110, 120) are connected to the valve means (30) to open the valve means (30) after each and every injection.

5. Apparatus according to any one of claims 1 to 3, **characterised in that** control means (46, 110, 120) are connected and are constructed or programmed to open the valve means (30) after a predetermined plurality of such injections.

6. Apparatus according to any preceding claim, **characterised in that** it is for a plurality of injectors or for a single injector having a plurality of injector nozzles, and **in that** it is provided with a plurality of such cavities (12) respectively for each injector hole, and pressure transducers (56) in communication respectively with the cavities (12).

7. Apparatus according to any preceding claim, **characterised in that** a processor (120) is connected to the output of the pressure transducer (56) to process a signal received from the latter and to provide an indication of whether or not the signal falls within a predetermined tolerance of a predetermined ideal signal.

8. Apparatus according to claim 7, **characterised in that** the processor (120) is constructed or programmed to check a gradient of the electrical output from the pressure transducer (56) immediately following an injection.

9. Apparatus according to claim 7 or claim 8, **characterised in that** the processor (120) is constructed or programmed to provide a measure of the gradient of the output signal from the pressure transducer (56) over a predetermined

number of injections.

10. Apparatus according to any preceding claim, **characterised in that** the valve means (30) comprises a needle valve (30).

11. Apparatus according to any one of claims 1 to 9, **characterised in that** the valve means (30) comprises a first member (28) provided with a slanting surface (212) along which a closure member (214) slides, so that movement of the first member (28) results in a smaller movement of the closure member (214).

12. A method of providing an indication of an operating characteristic of an injector (72) or an injection system, in which fluid is injected into a cavity (12) and a pressure transducer (56) is used to provide an indication of the changes in pressure in the cavity (12) following one or more injections.

13. A method according to claim 12, **characterised in that** apparatus as claimed in any one of claims 2 to 11 is used to carry out the method.

FIG. 1

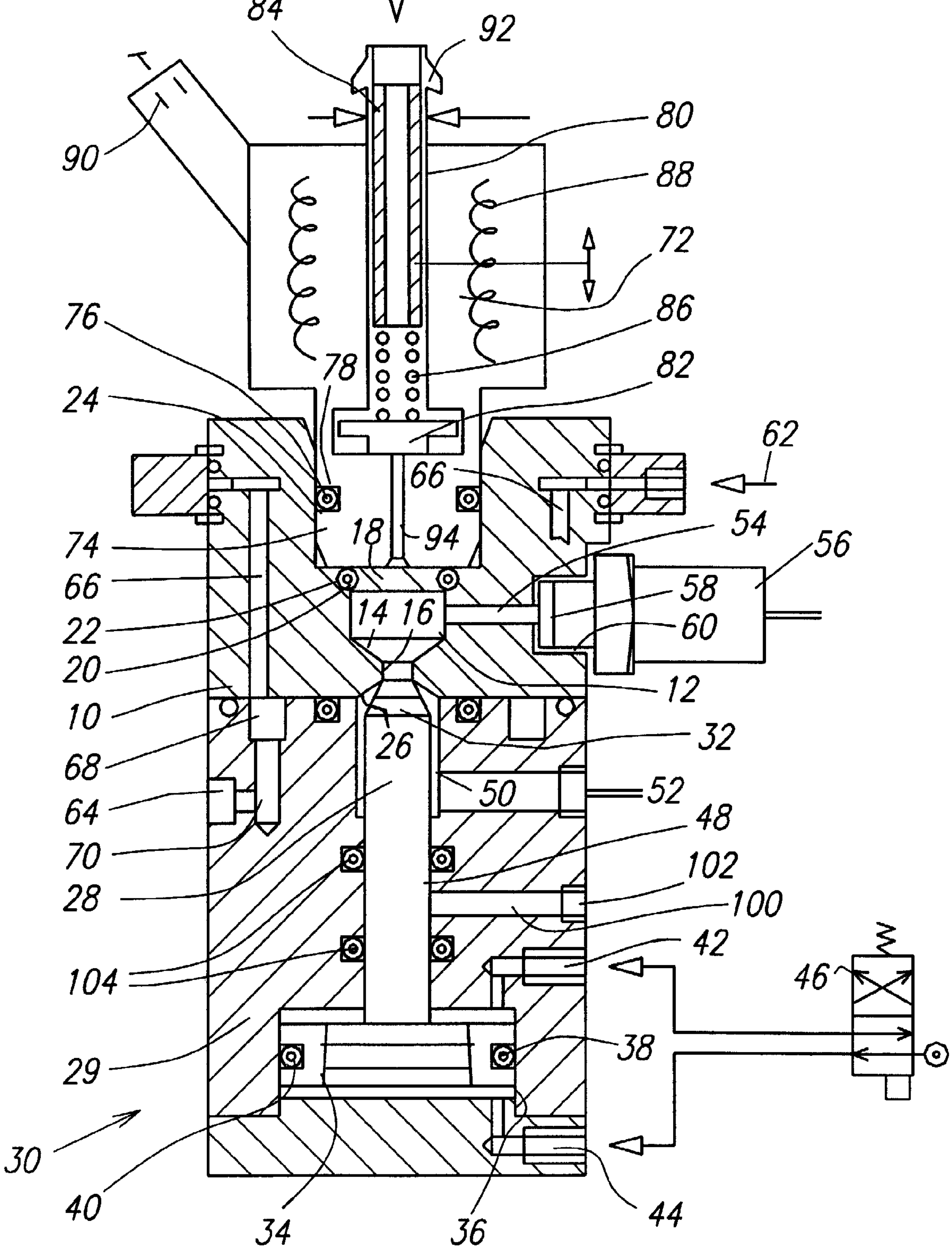
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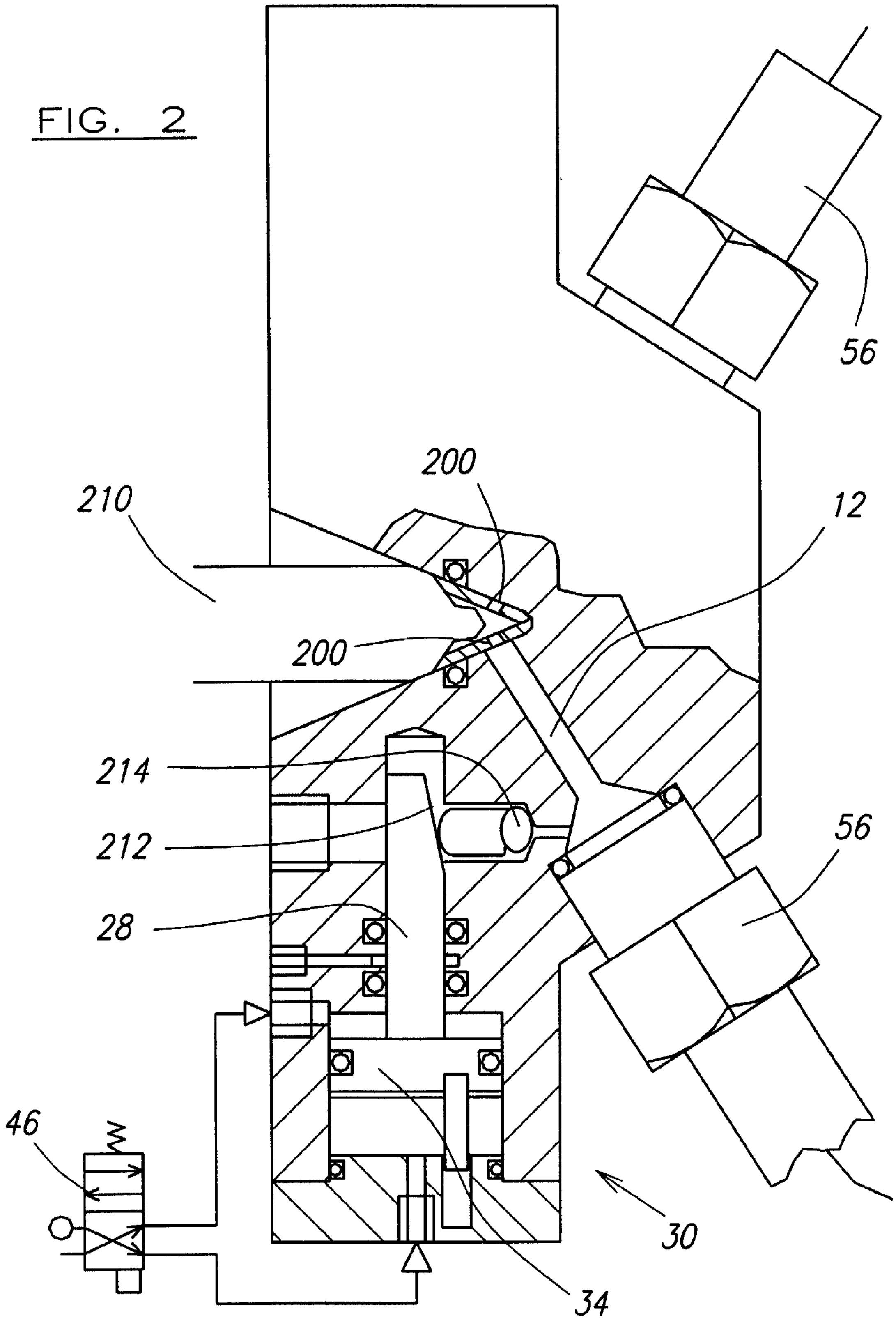
FIG. 2



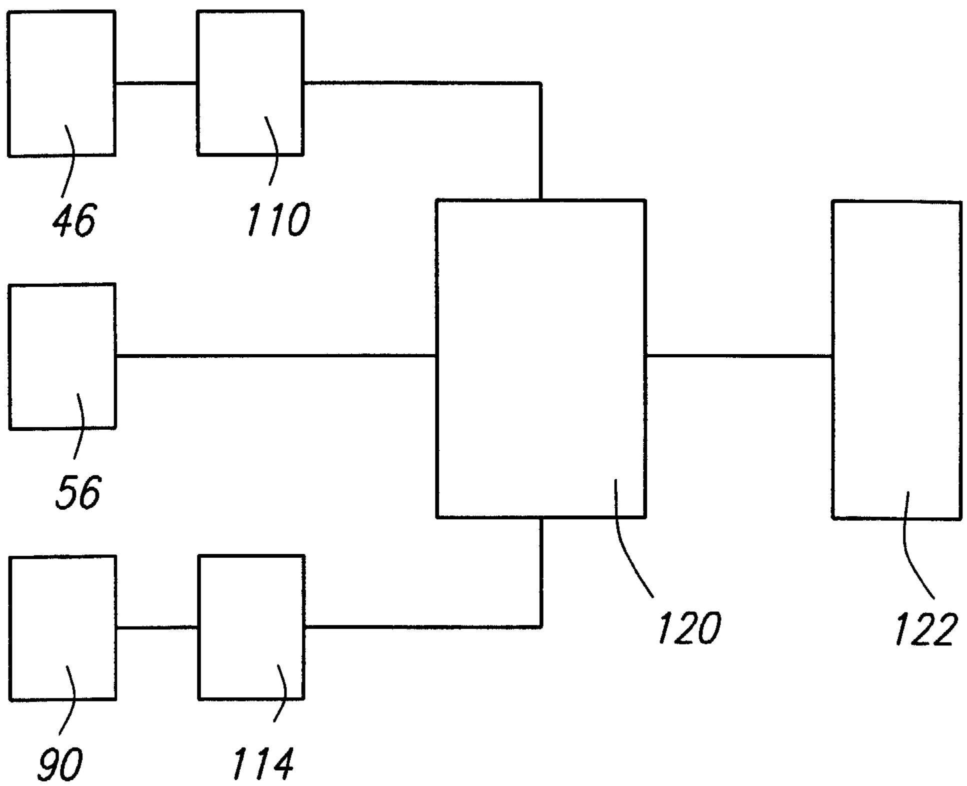


FIG. 3

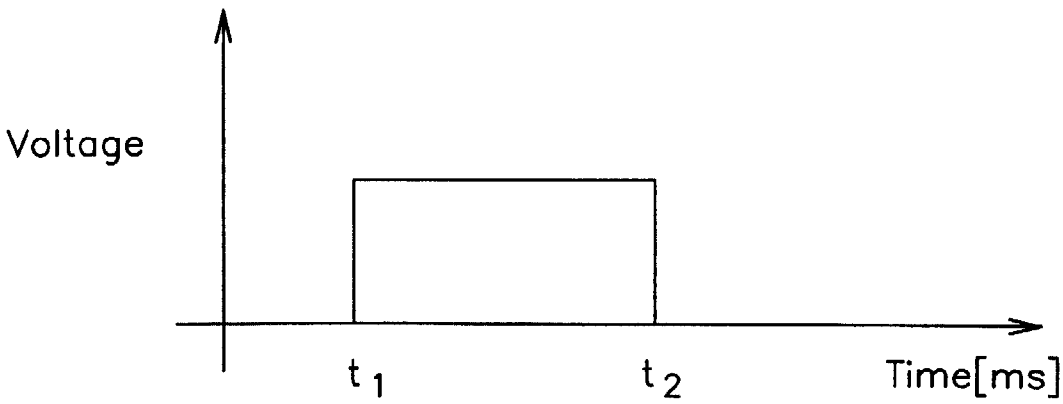


FIG. 4

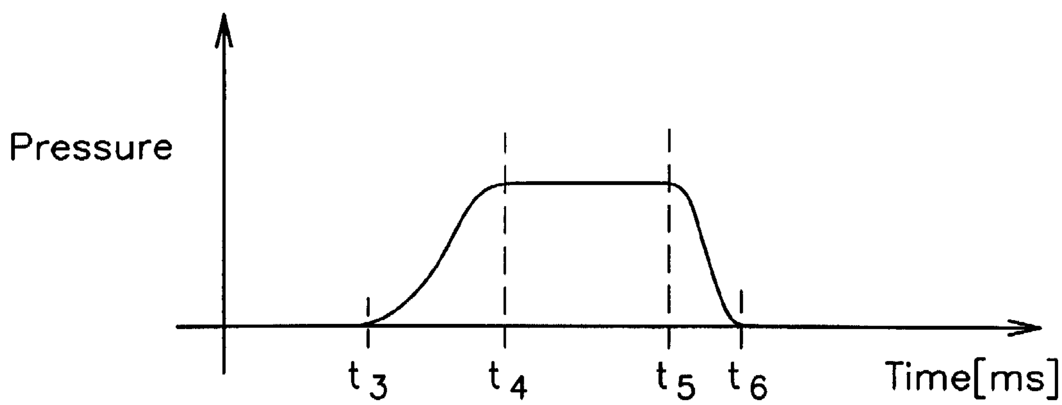


FIG. 5

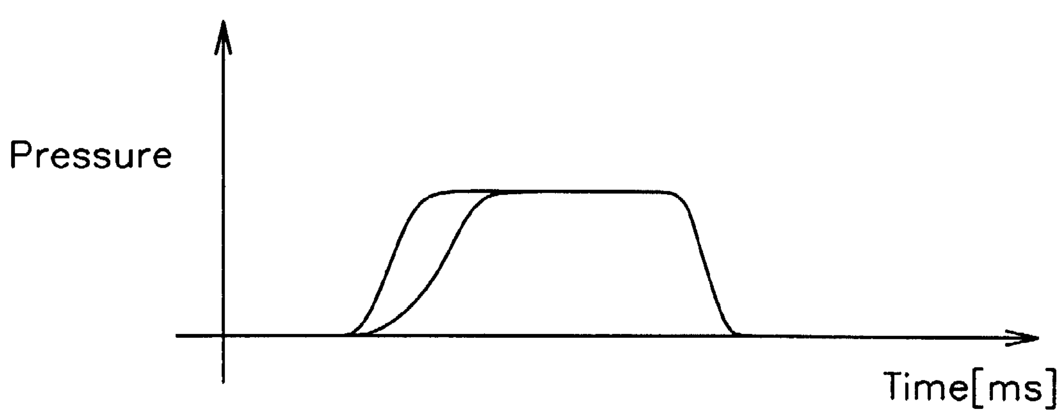


FIG. 6

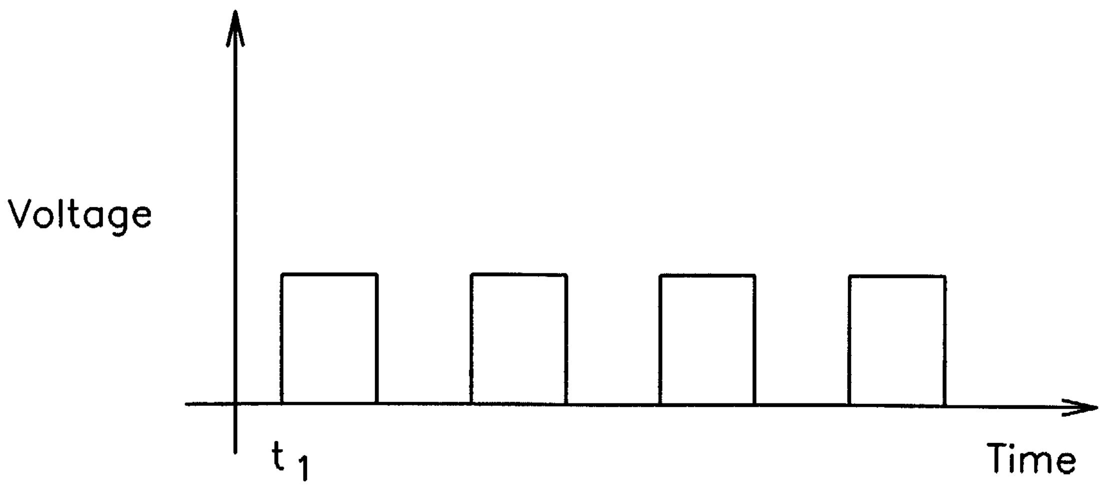


FIG. 7

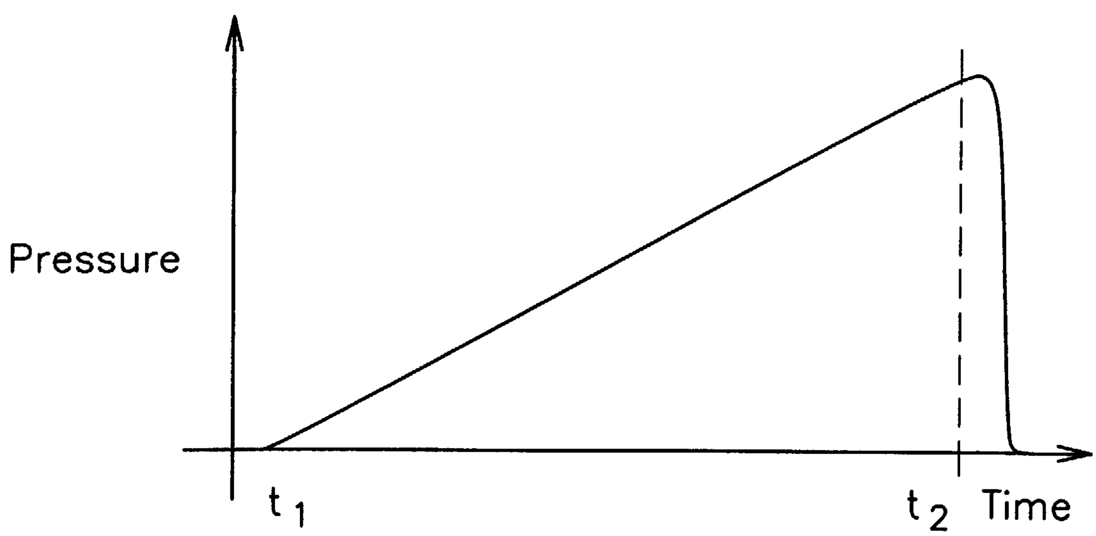


FIG. 8