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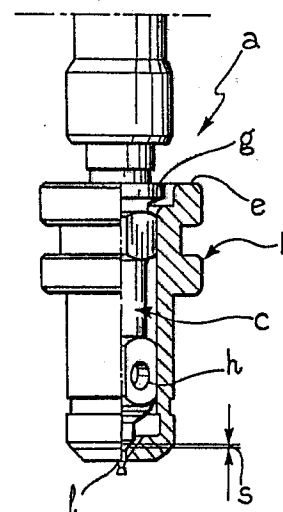
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54 **Method and apparatus for producing injector valves for internal combustion engines with controlled ignition.**

57 A method and apparatus for matching a valve body (b) with the relative needle (c) of an injector valve (a) for internal combustion engines with controlled ignition, by means of the measurement, under static conditions, of the rate of flow of a continuously-supplied test liquid through the outlet hole (d) of the valve. The measured value of the rate of flow is compared with a nominal reference value to check whether the percentage difference between the values falls within an acceptable range of variation. If this is not the case, the needle (c) is replaced with another needle selected in dependence on the compared percentage difference, and the test is repeated until a suitable needle is found. A leakage test is then carried out by the admission of a test liquid under pressure into the body (b) with the suitable needle (c) kept in the closed position, and the measurement of the fall in pressure of the liquid supplied after a predetermined time interval.

FIG. 1



DescriptionMethod and apparatus for producing injector valves for internal combustion engines with controlled ignition

The present invention relates in general to injector valves for internal combustion engines with controlled ignition, comprising a hollow valve body having an internal guide diameter of predetermined size and a fuel outlet hole, and a needle inserted in the valve body for axial sliding with a stroke of predetermined magnitude and having an external guide diameter of predetermined size and correlated to the internal guide diameter of the body so as to produce a limited radial clearance of predetermined magnitude between the guide diameters. The needle has an end part extending through the fuel outlet hole and including a cylindrical portion defining an outlet diameter whose size is variable due to working tolerances.

In injector valves of the type defined above, the correlation between the internal and external guide diameters of the hollow body and the needle respectively is determined by dividing the two elements into three dimensional classes, indicated respectively A,B and C in the following table in which the dimensional values are given in mm:

Class	Element	Hollow body guide $\varnothing$	Finished needle guide $\varnothing$
A		5.501 ± 0.001	5.494 ± 0.001
B		5.503 ± 0.001	5.497 ± 0.001
C		5.505 ± 0.001	5.499 ± 0.001

Within the range of each class A - B - C of the finished needle, there are sub-classes characterised by the dimensions of the outlet diameter. There are twelve of these sub-classes for each class, obtained by the selection of the outlet diameter (nominal diameter 0.9 mm) in increments of 0.001 mm from 0.784 to 0.795 mm.

During production of such injector valves, it is necessary to match needles of one of the three classes A,B or C with bodies from the corresponding class, so as to produce a clearance of 4-8 microns between their respective guide diameters.

The object of the present invention is to provide a method and apparatus for the automatic selection of a needle of a suitable sub-class in the class corresponding to that of the hollow body with which the needle is to be matched, in order to a clearance between the respective guide diameters within the range of values specified above.

According to the invention, this object is achieved by means of a method for producing injector valves for internal combustion engines with controlled ignition of the type specified above, characterised in that it consists:

- of matching a valve body with a needle considered to be approximately suitable,
- of displacing the needle axially relative to the body by a predetermined amount corresponding to the strokes,
- of supplying the valve continuously with a test liquid,
- of measuring the rate of flow of the continuously-supplied test liquid through the outlet hole,
- of comparing the value of the measured rate of flow with a nominal reference value and checking whether the percentage difference between these values falls within acceptable range of variation,
- if this is not the case, of removing and replacing it with another needle selected in dependence on the compared percentage difference,
- of repeating the test until a suitable needle is found which corresponds to a rate of flow of the continuously-supplied test liquid falling within the acceptable range of variation.

In practice, the needle-body match is carried out by monitoring the static flow and checking that the rate of flow is of the nominal value for a precise stroke of the needle. When the measured rate of flow is not within $\pm 1\%$ (or another predetermined value) of the nominal value, the needle is replaced with another suitable one selected in dependence on the deviation between the compared value and the nominal value. Suitability is linked to the fact the established variations in outlet diameter (needles of the various sub-classes) produce fixed variations in the rate of flow.

When the match has been carried out, that is, following the identification of the suitable needle, the method according to the invention envisages a leakage test of the whole valve by means of the admission of a test liquid under pressure into the body with the suitable needle kept in the closed position, and the measurement of the fall in pressure of the liquid supplied after a predeterminable time interval.

Subsequently, the invention involves the further operation of the grinding of the abutment surface of the

body, which defines the stroke of predetermined magnitude, the coupling of the needle and the valve body being maintained.

The needle-body matching operation is carried out, according to the invention, on a special bench controlled by an electronic processor programmed to find a suitable needle, starting with a first trial of a preferred needle and based on the experimental conclusion that variations of 1 micron in the outlet diameter cause variations in rate of flow of approximately 1%. 5

The apparatus bench carries at least one piece of equipment including abutment means for supporting the valve body in a position with its axis arranged vertically and containing a needle considered to be approximately suitable, motorised means for lateral centering and axial locking of the valve body relative to the abutment means, motorised means for causing axial displacement of the needle relative to the body by a predetermined amount corresponding to the stroke, means for the continuous and controlled supply of the test liquid to the valve body, means for measuring the rate of flow of the test liquid through the outlet hole of the body, means for measuring the fall in pressure of the test liquid with the needle in the closed condition, an electronic unit for controlling the supply and motorised means, which is connected to the measurement means for comparing the value of the measured rate of flow with a nominal reference value and for checking whether the percentage difference between these values falls within an acceptable range of variation, as well as for checking the magnitude of the fall in pressure of the test liquid and for supplying an indication of the result of the comparison and checking operations, and a support with drawers containing valve bodies and needles sorted in an orderly manner into respective dimensional classes and sub-classes, each drawer of needles being associated with luminous visual display means connected to the electronic control means for indicating, in the case of a negative result of the rate-of-flow measurement, the drawer from which to take a needle suitable for replacing that considered approximately suitable. 10 15 20

The invention will now be described in detail with reference to the appended drawings, provided purely by way of non-limiting example, in which:

Figure 1 is an elevational and partial longitudinal sectional view of an injector valve for internal combustion engines with controlled ignition, to which a method according to the invention as applied, 25

Figure 2 is an axial section of the valve body of Figure 1, on an enlarged scale,

Figure 3 is a partial axial sectional view of the valve needle of Figure 1, on an enlarged scale,

Figure 4 is a schematic front elevational view of apparatus for carrying out the method according to the invention, 30

Figure 5 is a plan view from above, taken on the arrow V of Figure 4, and

Figure 6 is a schematic view of a detail of the apparatus on an enlarged scale.

With reference initially to Figures 1 to 3, an injector valve for internal combustion engines with controlled ignition is generally indicated a and comprises essentially a hollow body b into which a needle or pin c is axially slidably inserted. 35

The general conformation of the valve a is generally known and will therefore not be described in detail. For the purposes of the present invention, it is sufficient to explain that the body b has an internal cylindrical cavity whose diameter F, referred to below as "the internal guide diameter", is slightly greater than 5.5 mm according to the data supplied in the above table relating to the dimensional classes A,B,C. 40

Below the cavity, the body b opens to the outside through an outlet hole d normally having a diameter G of the order of 0.9 mm. 40

At the opposite end, the wall of the body b has two annular enlargements, of which the upper one defines a reference or abutment surface e and the lower one a supporting surface f whose function will become clear from the following.

The needle c has an upper annular enlargement forming a reference or abutment surface g, and a lower guide part h axially slidably coupled in the cavity of the body b and having a diameter H, referred to below as "the external guide diameter", with a value slightly less than 5.5 mm, as indicated with reference to the three classes A,B,C in the table shown above. 45

The needle c has an end portion i which extends through the outlet hole d of the body b and includes a cylindrical portion m whose diameter L, referred to below as "the outlet diameter", has a value which is variable due to working tolerances and is of the order of 0.79 mm. 50

In known manner, the needle c is axially movable relative to the body b between a closed position in which the outlet hole d is obstructed, and an open position, illustrated in Figure 1, for allowing operation of the fuel injection. The magnitude of this movement, defined below as "stroke", is indicated S in Figure 1 and is normally of the order of 0.09 mm (or of 0.096 - 0.065 - 0.08 mm). This stroke S can be measured by the axial displacement between the reference surfaces e and g. 55

In order to ensure correct operation of the injector valve a, it is necessary that a needle c belonging to the class A,B or C corresponding to that of the body b should be selected from the sub-class of the twelve relative sub-classes which, for a stroke S, corresponds to the delivery of a well-determined rate of flow by the injector. In other words, a "suitable" needle c should correspond to the body b of the injector valve in the sense described above. 60

The method according to the invention, carried out with the apparatus which will now be described with reference to Figures 4 to 6, enables a suitable needle c for a corresponding body b to be identified precisely by mechanical and automatic means, by monitoring the static rate of flow, that is, by supplying the valve a continuously and checking whether or not the value of the rate of flow corresponds to a nominal reference 65

value. Suitability is linked to the fact that established variations of the outlet diameter L (needles c of various sub-classes) produce fixed variations in the rate of flow. When the percentage difference between the value of the measured static rate of flow and the nominal rate of flow does not fall within an acceptable range of variation ($\pm 1\%$), the needle c considered to be suitable must be replaced by a needle c which is actually

suitably identified in dependence on the compared percentage difference. In practice, therefore, the method provides for the static-flow-rate monitoring test to be repeated until a suitable needle c is found which corresponds to a value of the static rate of flow falling within the acceptable range of variation.

With reference to Figures 4 to 6, test apparatus, generally indicated 1, comprises essentially a support structure 2 defining a bench 3 which supports on its two sides two identical pieces of equipment, generally indicated 4, 5.

A magazine 6 rotatable about a vertical axis K is interposed between the two pieces of equipment 4,5 and is formed by three drawer units 7 forming the sides of an isosceles triangle and each comprising a lower row of three drawers 8 for containing valve bodies b of one of the three classes A,B,C, and four overlying rows of three drawers 9 each, for containing needles c of the twelve sub-classes of the corresponding classes A,B,C respectively. It is possible, by rotation of the magazine 6, to bring the drawer unit 7 corresponding to the required class A,B,C to the front position for access.

An electronic processing unit 10 is installed in the upper part of the apparatus 1 and is programmed to carry out the operative test cycle automatically according to the method described below. The processor 10 is provided at the front with luminous visual display units 11,12 (operatively associated with the pieces of equipment 4 and 5 respectively) and 13.

A respective push-button control panel 14,15 is associated with each of the two pieces of equipment 4,5, and each of the drawers 9 for the needles c of each of the three drawer units 7 is provided with a pair of luminous indicators 16 activated by the processor 10, as specified below.

The two pieces of equipment 4,5 have an identical conformation shown in greater detail in Figure 6. In short, each of these pieces of equipment comprises a support structure 17 including vertical uprights 18 fixed to an intermediate annular wall 19 to which is fixed a hollow supporting body, generally indicated 20, with a vertical axis.

The support 20 comprises an upper portion 21 forming a seat 32 for the insertion of an injector valve a positioned with its axis vertical and with the annular support surface f of the body b resting on the part 21 and the end portion l of the needle c facing downwards.

The lower portion of the support 20, indicated 21, acts as a guide for a push rod 22 aligned with the axis of the valve a and movable vertically from below, by means of a pneumatic jack 23, in order to cooperate with the end portion l of the needle c. A transverse locking member 24 is associated with the rod 22 and is operated by means of a pneumatic jack 25.

The wall 19 carries a pneumatic jack 25 arranged laterally and operating a gripping member 26 for inserting and removing a spacer transversely relative to the valve a positioned in the seat 32.

A movable element, generally indicated 27, is slidable along the upper portions of the uprights 18 and is driven by an upper pneumatic jack 31. The movable element 27 comprises a hollow body 28 for locking the valve a in position in the seat 22, in which there is axially slidable an abutment rod 29 which bears at its lower end on the top of the needle c and cooperates at its upper end with a transducer 30 for monitoring axial displacement of the needle.

Passages, not illustrated, are formed in the member 28 and the rod 29 for the supply of a test liquid (normally EXSOL D 40) to the valve a at a controlled pressure of the order of 3 bars, and thermoregulation system, not illustrated, is also provided for maintaining the test liquid at a temperature of the order of 25°C. The test liquid discharges from the valve a into the lower part of the cavity of the support 21, where a rate-of-flow meter (not illustrated, but of conventional type), is arranged to send corresponding electrical signals to the processing unit 10.

The two pieces of equipment 4 and 5 are arranged to operate independently to carry out the method according to the invention which, in summary, provides initially for a step of measurement of the static rate of flow of the test liquid through the injector valve a in order to identify a needle c suitable for the body b of the valve A, and then for a check of the sealing of the valve itself. In more detail, the cycle performed by one or other of the two pieces of equipment 4,5 of the apparatus 1 consists of the following steps:

- positioning an injector valve a formed by a body b of one of the three classes A, B, C and a needle c belonging to one of the twelve sub-classes of the corresponding class A,B,C and considered to be approximately suitable, in correspondence with the seat 32 of the support 21, with the movable element 27 kept in the raised position;
- the starting of the automatic cycle through one or other of the two push-button panels 14, 15 and the lowering of any protective cover (not illustrated) associated with the apparatus;
- the approach of the gripping member 26 for the insertion and removal of the spacer and the subsequent withdrawal of the member 26. It should be noted that these operations may not be necessary and are obtainable by means of a suitable selector;
- the locking of the valve a by the lowering of the movable element 27 operated by the jack 31,
- supply of the test liquid at controlled pressure and temperature by means of the relative hydraulic circuit;
- operating of the pneumatic jacks 23 and 25 and resultant raising of the needle c of the rod 22 through a stroke S of the stated order of 0.09 (or 0.08, 0.65, 0.60, etc.) mm;

- the draining of the test liquid through the outlet hole d of the valve a for a predetermined brief period of time following by measurement of the rate of flow of the liquid, during which corresponding electrical signals are supplied to the processing unit 10 which is arranged to compare the measured value of the rate of flow with a nominal reference value (normally of the order of 196 cm³/minute $\pm$ 1%) and to check whether the percentage difference between these values falls within an acceptable range of variation. This operation is carried out only after a check of the pressure of the test liquid, which must not be less than a predetermined value; if this is not the case, the cycle is suspended and the unit 10 causes the emission of an alarm signal; - if the comparison operation is positive, the processor 10 automatically causes lowering of the rod 22 and disengagement of the locking member 24 and the pressure of the test liquid is checked again. If this pressure is within the predetermined limits, the sealing test is carried out with the needle c in the closed position, and consists of interrupting the supply of the test liquid and, after a predetermined time interval (for example, 5 seconds), checking that the fall in the pressure of the test liquid is not higher than a predetermined threshold value.

If this is the case, the movable element 27 is raised by means of the jack 31 and the unit 10 provides an indication that the valve a may be removed. This valve may then be replaced by a new valve to be tested and the cycle repeated in a similar manner.

If the result of the comparison between the measured rate of flow and the reference rate is negative, the processor 10 provides a corresponding signal which causes flashing of one of the two lamps 16 of the drawer 9 from which the needle c under test has been taken. Simultaneously, one of the lamps 16 of the drawer 9 containing the needles c of a sub-class considered suitable on the basis of the difference detected between the measured rate of flow and the reference rate is illuminated continuously. One of these needles c is inserted in the body b under test, and the cycle is repeated in an identical manner, as described below.

In this case, the result of the measurement may also be positive or negative. If it is negative, the processor 10 causes flashing of the lamp 16 of the drawer 9 corresponding to the needle c under test, and continuous illumination of one of the lamps 16 of another drawer 9 containing needles c of the new sub-class considered suitable on the basis of the detected difference in the rate of flow.

This procedure is repeated a certain number of times until a suitable needle c is found. If, at the end of the repetitions, the result is still negative, the processor 10 produces a visual signal which informs the operator that the body b under test should be rejected. In practice, the reject message occurs in one of the following conditions:

- a detected rate of flow outside the limits imposed by the needles available;
- a seal which does not conform to predetermined limits;
- a higher number of tests carried out to find a match than the predetermined limit.

According to the invention, at the end of the matching operation, the injector valves a taken from the pieces of equipment 4 and 5 are subjected to an operation of grinding of the abutment surface e of the body b, the coupling of the needle c and the body b being maintained. This grinding operation has the function of enabling the needle c to effect the correct stroke S in use of the injector valve a.

Claims

1. A method for producing injector valves for internal combustion engines, comprising a hollow valve body having an internal guide diameter of predetermined size and a fuel outlet hole, and a needle inserted in the valve body for axial sliding with a stroke of predetermined magnitude and having an external guide diameter of predetermined size and correlated to the internal guide diameter of the body so as to produce a limited radial clearance of predetermined magnitude between the guide diameters, the needle having an end part which extends through the fuel outlet hole and includes a cylindrical portion defining an outlet diameter whose size is variable due to working tolerances, each injector valve body requiring a corresponding suitable needle whose outlet portion has a diameter with an exact predetermined value, the method being characterised in that it consists:

- of matching a body (b) of a valve (a) with a needle (c) considered to be approximately suitable,
- of displacing the needle (c) axially relative to the body (b) by a predetermined amount corresponding to the stroke (S),
- of supplying the valve (a) continuously with a test liquid,
- of measuring the rate of flow of the continuously-supplied test liquid through the outlet hole (d),
- of comparing the value of the measured rate of flow with a nominal reference value and checking whether the percentage difference between these values falls within an acceptable range of variation,
- of removing the needle (c) if this is not the case, and replacing it with another needle selected in dependence on the compared percentage difference,
- of repeating the test until a suitable needle (c) is found which corresponds to a rate of flow of the continuously-supplied test liquid falling within the acceptable range of variation.

2. A method according to Claim 1, characterised in that, when a suitable needle (c) has been found, the valve (a) is subjected to a leakage test by means of the admission of a test liquid under pressure into the body (b) with the suitable needle kept in the closed position, and the measurement of the fall in pressure

of the liquid supplied after a predetermined time interval.

3. A method according to Claim 2, in which the valve body has an abutment surface arranged to define the stroke of predetermined magnitude, characterised in that it also includes the operation of guiding of the abutment surface (e), the coupling of the needle (c) and the body (b) of the valve (a) being maintained.

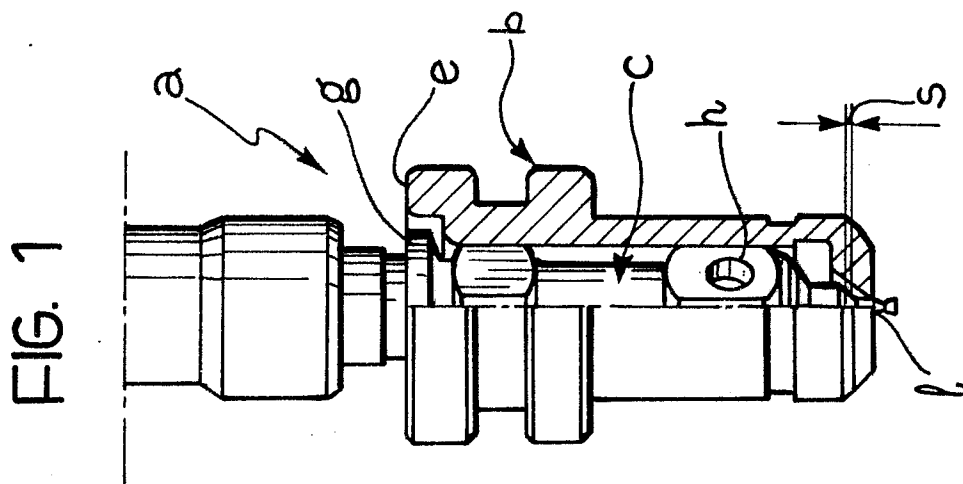
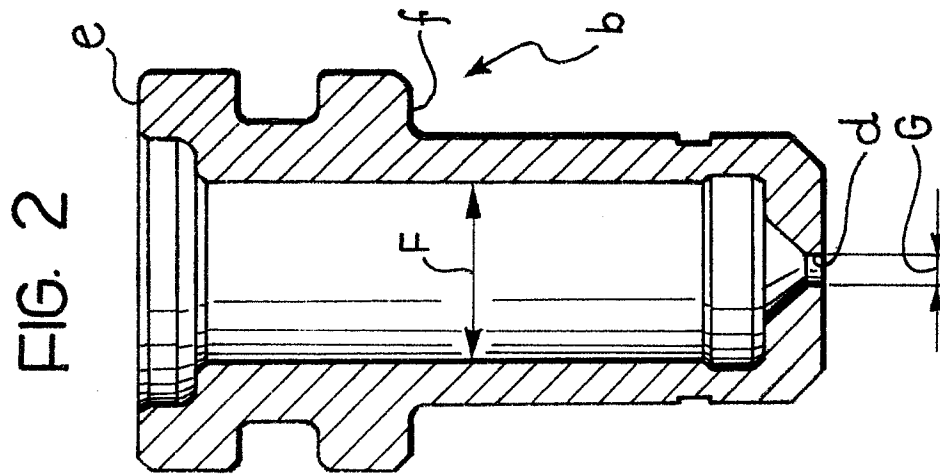
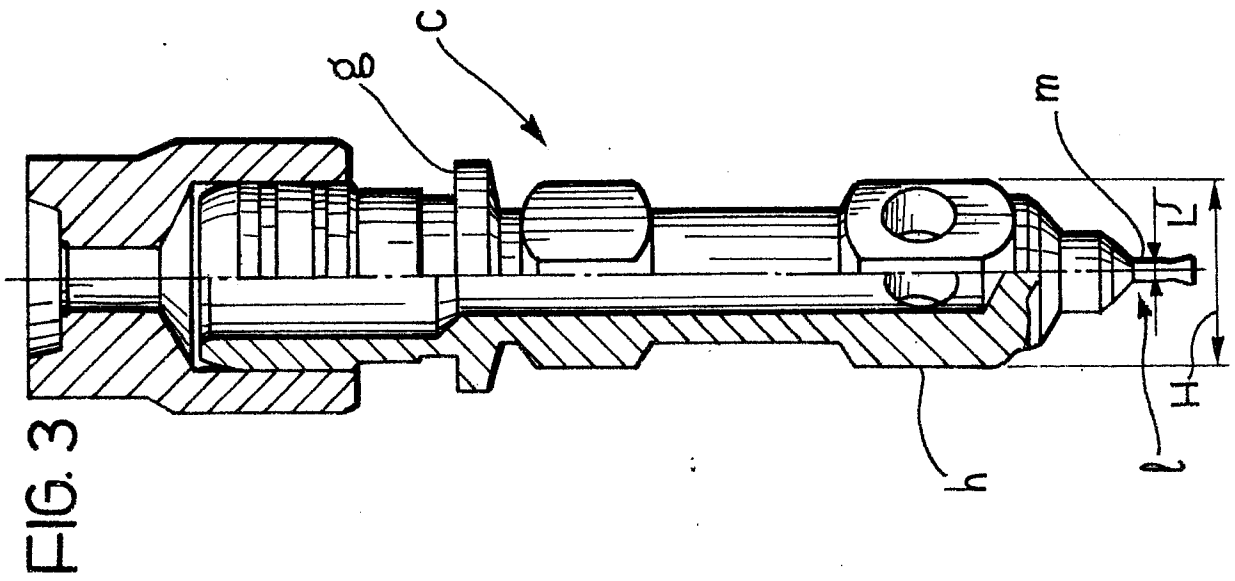
4. Apparatus for carrying out the method according to Claims 1 and 2, characterised in that it comprises a bench (3) carrying:

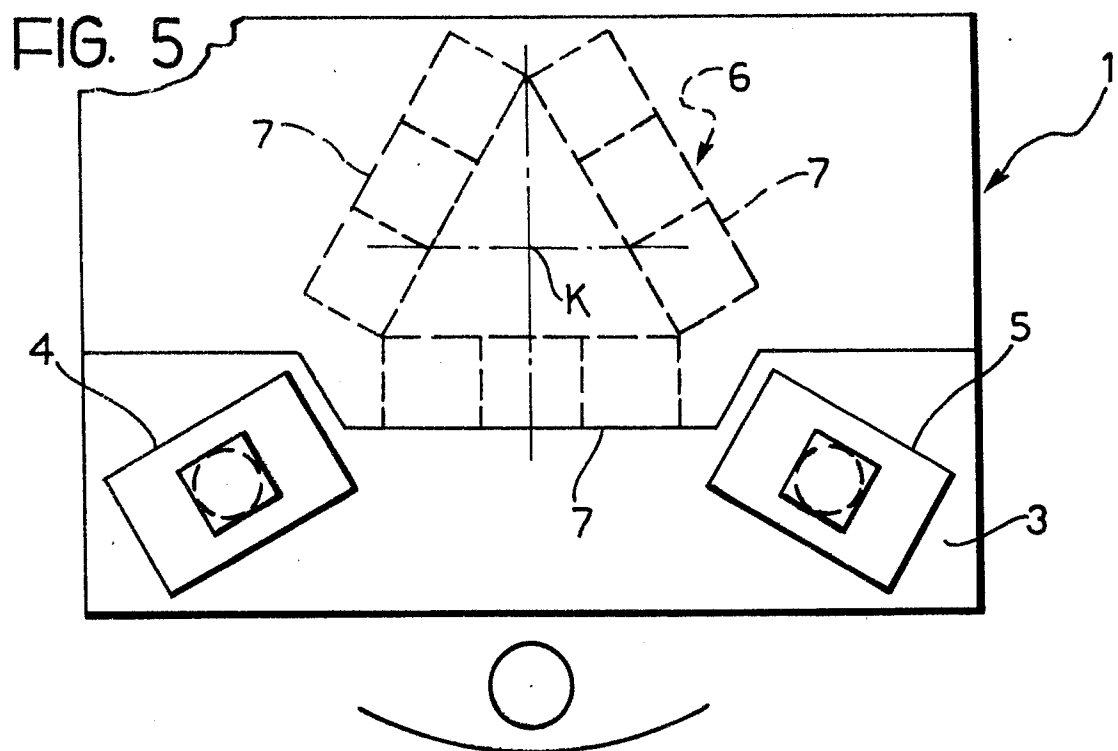
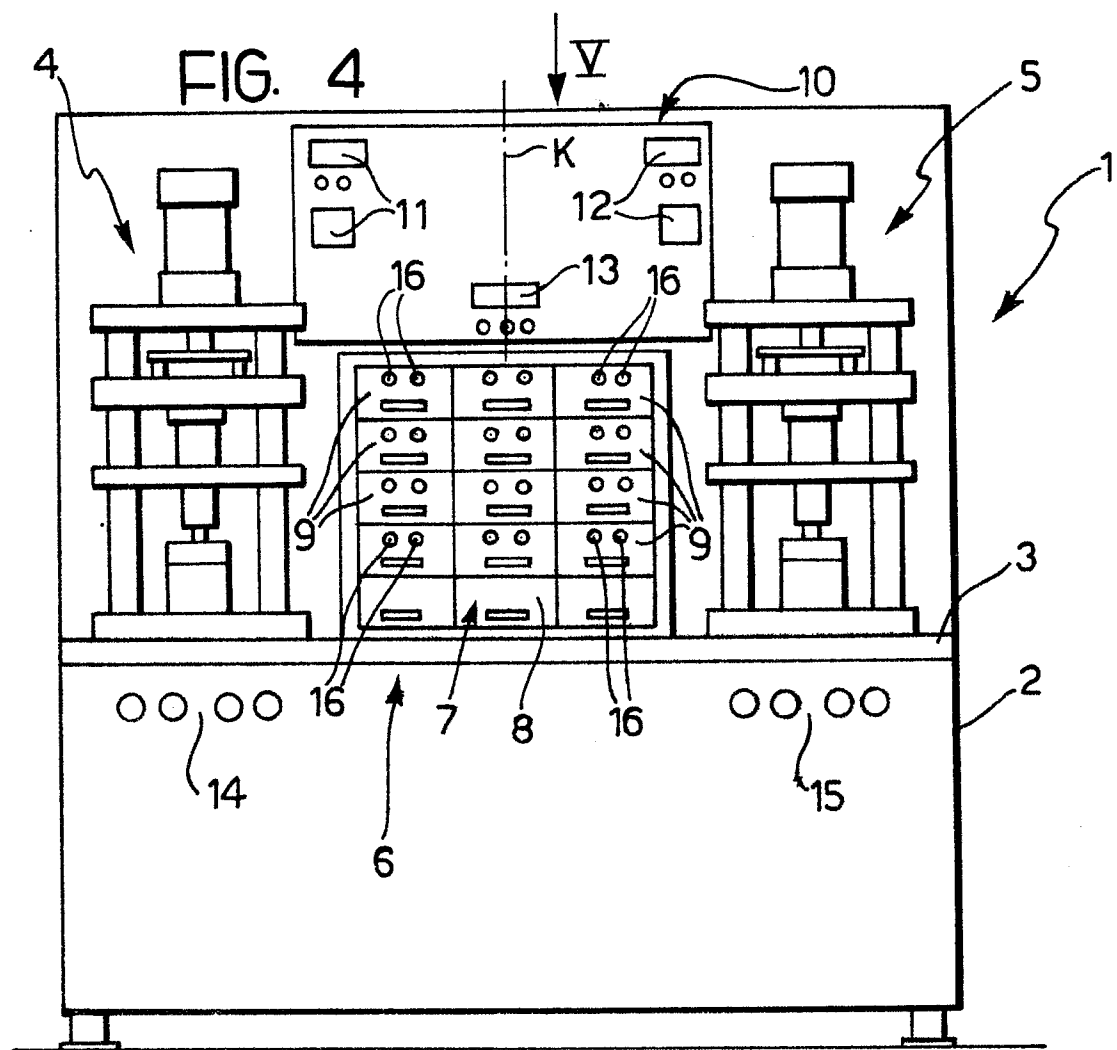
- at least one piece of equipment (4,5) including abutment means (21) for supporting the body (b) of the valve (a) in a position with its axis arranged vertically and containing a needle (c) considered to be approximately suitable, motorised means (27,31,25,26) for centring the body (b) of the valve (a) and locking it axially relative to the abutment means (21), motorised means (22, 23) for causing axial displacement of the needle (c) relative to the body (b) by a predetermined amount corresponding to the stroke (S), means for supplying the test liquid to the body (b) of the valve (a) in a continuous and controlled manner, means for measuring the rate of flow of the test liquid through the outlet hole (d) of the body (b), means for measuring the fall in pressure of the test liquid when the needle (c) is in the closed condition,

- an electronic unit for controlling the supply means and the motorised means, which is connected to the measuring means for comparing the measured value of the rate of flow with a nominal reference value and for checking whether the percentage difference between these values falls within an acceptable range of variation, as well as for checking the magnitude of the fall in pressure of the test liquid and for providing an indication of the result of the comparison and checking operations,

- a magazine (6) with drawers (8,9) containing bodies (b) of valves (a) and needles (c) sorted in an orderly manner into respective dimensional classes and sub-classes, each drawer (9) of needles (c) having associated luminous visual display means (16) connected to the electronic processor unit (10) for indicating, in the case of a negative result of the rate-of-flow measurement, the drawer (9) from which a new needle considered to be suitable should be taken.

5. Apparatus according to Claim 4, characterised in that the bench (3) carries two identical pieces of equipment (4,5) side by side, with the magazine (6) with drawers (8,9) interposed between them.







European Patent
Office

EUROPEAN SEARCH REPORT

Application number

DOCUMENTS CONSIDERED TO BE RELEVANT			EP 88830088.6
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
A	GB - A - 2 170 270 (R.BOSCH GMBH) * Totality * --	1	F 02 M 65/00
A	GB - A - 1 503 578 (R.BOSCH GMBH) * Totality * --	1	
A	GB - A - 2 086 984 (R.BOSCH GMBH) * Totality * ----	1, 2, 4	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl. 4) F 02 M 51/00 F 02 M 65/00
Place of search VIENNA		Date of completion of the search 16-06-1988	Examiner PIPPAN
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			