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(54) A DEVICE FOR CONNECTING A TOOL OR MEASURING SENSOR TO A MACHINE

(71) We, D.E.A. DIGITAL ELECTRONIC AUTOMATION S.p.A., an Italian Body Corporate, of Strada Torino, 70, 10024 Moncalieri, Turin, Italy, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to a device for connecting a tool or measuring sensor to a machine, for example, a measuring machine, and in general for connecting a tool to a column of the machine, possibly by way of a tool head.

There are known to exist machine tools and particularly measuring machines in which the required precision of connection is of the order of 1 μm. As this precision is also a function of the position of the tool, and because of the fact that when mounting the tool on the machine column by known methods errors in the repeatability of the positioning arise which are of an order of magnitude considerably exceeding the required precision limit, it is necessary to compensate such errors, for example by introducing correction parameters into the programme of a control processor for the machine tool.

At the present time, this compensation must be made at each tool change, because of which short machining cycles require lengthy and relatively complicated setting-up of the measuring machine, with a considerable effect on the cost and the average measuring time for each mechanical piece.

The invention provides a device for connecting a tool or measuring sensor to a machine comprising first and second members adapted to be secured to the machine and to the tool or sensor and having means whereby the members can be locked together and released in a completely detachable manner and means for positioning the members relative to each other such that the members can be uncoupled from a position relative to each other and recoupled in a substantially identical position, the means including a stem element having a radial bore provided by one member and a fixed coupling element provided by the other member and supporting a movable locking shaft for engagement with the stem element, and wherein said shaft includes an eccentric member, said shaft with said eccentric member engaging in said radial bore of said stem element by means of an axial movement and locking said two members together by means of a rotary movement.

Embodiments of the invention will be described by way of example and with reference to the accompanying drawings in which:

Figure 1 is an exploded perspective view of a first embodiment of a connection unit constructed in accordance with the present invention, and of one particular example of application;

Figure 2 is a partly sectional view from above to an enlarged scale of a detail of Figure 1;

Figure 3 is a section on the line III-III of Figure 2;

Figure 4 is a section on the line IV-IV of Figure 1 to an enlarged scale;

Figure 5 is a section on the line V-V of Figure 4;

Figure 6 is a section on the line VI-VI of Figure 5;

Figure 7 is a section on the line VII-VII of Figure 2; and

Figure 8 is a view from above of a detail of a second embodiment of a connection unit constructed in accordance with the present invention.

With particular reference to Figure 1, a connection unit, indicated overall by 1, comprises an upper member 2 and a lower

member 3, which can be connected respectively to a terminal portion 4 of a column of a measuring machine (not shown) and to a member 5 of a tool 6, particularly a sensor. In particular, the member 2 can be connected to the member 4 by bolts 9, and the lower member 3 can be connected to the member 5 by bolts 10 screwed into corresponding threaded bores 11. The terminal portion 4 and the member 5 also comprise a cavity 14 and bore 15 respectively, through which pass electrical connection cables, 16 and 17 respectively, for transmitting electrical signals originating from the sensor 6 to an external processing unit, not shown.

With particular reference to Figures 2 and 3, the member 2 comprises a circular support flange 20 with a substantially annular peripheral projection 21, which defines an inner circular chamber 22. A lower arm 25 of a leaf spring 2b is fixed to a base surface 24 of the chamber 22 by bolts 27, and a bored 28 of a printed circuit (not shown) is fixed to this base surface by connection screws 29 and spacer washers 30 preferably of insulating material. The leaf spring 26 is substantially in the form of a U and has an upper arm 33 which extends U-shaped into two end elements 34 and 35, the dimensions and positions of which are such that the inner seat defined between them is aligned with a substantially rectangular through bore 36 provided axially in the support flange 20, and having a lower portion 37 in the form of a truncated pyramid. The elements 34 and 35 have through bores 40 and 41 which are coaxial and define part of a duct in which can slide a shaft 42 having substantially the same diameter as said duct, and having in proximity to one of its ends a cylindrical pin 43 disposed axially in such a manner as to define an eccentric, and in proximity to its other end a cylindrical pin 44 disposed radially. The end element 34 also has on the inside of the bore 40, a circular groove 47 which houses internally a retaining ring 48 to enable the element 34 to be coupled to the shaft 42 by means of a corresponding circular groove 49 provided on said shaft 42. The end element 35 has an axial groove 53 to allow passage of the pin 43 of the shaft 42, and also houses a screw 54 which extends partly inside the bore 41 to cooperate with a groove 55 provided on the shaft 42, a first portion 56 of which extends through 180° in a circular direction, and the second portion 57 of which extends axially.

A substantially T-shaped handle 60, comprising internally, along a central member 61, an axial duct having a diameter substantially equal to the diameter of the shaft 42, can slide on said shaft in an axial direction between two limiting positions defined by the cooperation between the pin 44 of the shaft 42, and a corresponding axial slot 62 provided in the central member 61. The handle 60 also houses, in a circular groove 65 provided in the duct inside the member 61, a retaining ring 66 which cooperates with a corresponding circular groove 67 on the shaft 42 to enable the handle 60 to be coupled to the shaft 42. In particular, the groove 49 is deeper than the groove 67 on the shaft 42, to obtain a tighter coupling between the shaft 42 and element 34 than between the shaft 42 and handle 60. Thus when the handle 60 is pulled radially away from the flange 20 by an axial force, the handle 60 is firstly uncoupled from the shaft 42, and the shaft 42 is then uncoupled from the element 34. The central member 61 of the handle 60 also comprises (Figure 1) an end portion 70 of outer circular section, and a central portion 71 of square section, from which branch two arms 72 which enable the handle 60 to be gripped manually or by mechanical means. Thus the handle 60 cannot rotate when in the position shown in Figure 2, because rotation of the central portion 71 of square section is prevented by the vertical walls of the annular projection 21 on the flange 20. In said flange 20, the printed circuit board 28 extends partly inside the annular projection 21, and is connected to a plurality of electrical connectors 75 which are formed into a block and fixed to the flange 20 by a screw 76, and are protected from dust by a cover 77 fixed to the projection 21 by screws 78.

With particular reference to Figures 2, 3 and 7, three pairs of balls 82, 83 and 84 are mounted in the bottom of the flange 20 in three corresponding seats 81 disposed substantially at 120° to each other. Each ball is received in a corresponding conical seat 87 (Figure 7), and is retained in the seat 81 by an adhesive paste 88 with good adhesive characteristics in its pasty state, and an average hardening time. The balls of the pair 82 are mounted a fixed distance apart, while in the case of the pairs 83 and 84 a first ball is fixed and the second ball can be moved by means of a screw (not shown) engaged in a threaded bore 90 to act against the conical seat 87 so as to vary the distance between the balls 83 or balls 84 of each pair.

With particular reference to Figures 1 and 4, the lower member 3 comprises a circular support flange 92 with an upper annular projection 93 and a lower chamber 94. In an axial position in the flange 92, there is mounted a pin 96 comprising a lower threaded shank 97 and an upper substantially parallelepiped stem 98 having a radial bore 99. In particular, the diamensions and position of the stem 98 and its radial bore 99 are such that it can slide in the bore 36 of the flange 20 (Figures 2 and 3) and can be engaged by the shaft 42 and associated pin 43. In addition, the threaded shank 97 of the

pin 96 is connected to the flange 92 by a locking nut 102, a spherical bearing 103 fixed to the flange 92 by a circlip 104, and a nut 105 comprising a threaded dowel 106 screwed into a corresponding radial through bore in the nut 105 to prevent said nut slackening on the shank 97 by mechanical stresses during operation.

With particular reference to Figures 4, 5 and 6, the lower member 3 also comprises a slide 109 diposed at the connectors 75 of the upper member 2, and to which is connected a correponding plurality of electrical connectors 110 by means of a screw 111. Said connectors 110 extend downwards in the form of conducting tabs 113, to which are connected the connection terminals of a flexible printed circuit 114 fixed to the slide 109 and flange 92 by respective screws 115 and 116. More particularly, the slide 109 is mobile vertically relative to the flange 92 between two limiting positions defined by the cooperation between two lateral grooves 118 in the slide 109 and two corresponding screws 119 screwed into the flange 92, and the movement of the slide 109 is braked, to prevent repeated damaging mechanical stress, by the friction of a V-shaped strip 120 which is fixed to one end of the slide 109 by a screw 121, and slides by means of its vertex against a shoulder of the flange 92.

In the flange 92 (Figures 1 and 3) there are housed three substantially wedge-shaped elements 122, 123 and 124 disposed at 120° to each other, in such a manner as to be able to couple respectively with the three pairs of balls 82, 83 and 84 housed in the bottom of the flange 20.

Finally, Figure 8 shows a flange 127 of an analogous type to the described flange 20, and also comprising the leaf spring 26, the printed circuit 28 and the three pairs of balls 82, 83 and 84, but also housing in seats 130 a further three pairs of balls 132, 133 and 134, to permit the support of lower members of the type described with particular reference to Figure 4, but which are of considerably larger dimensions and with considerably larger loads to support.

During production, the respective support surfaces defined by the flanges 20 and 92 are set parallel to each other by adjusting the distance between the balls 83 and 84 before the adhesive paste 88 has completely hardened and so consequently enabling the conical seats 87 to be displaced.

In mounting the member 5 of the tool 6 on the terminal portion 4 of the column of the said measuring machine by means of the unit 1 according to the present invention, the members 2 and 3 are firstly fixed to the terminal portion 4 and member 5 respectively. The member 3 is then placed in contact with the lower part of the member 2, from which the handle 60 is extracted and turned through 180° relative to the position shown in Figure 1, so that the axial pin 43 of the shaft 42 is contained within the groove 53 of the end element 35 of the leaf spring 26. Under these conditions, the stem 98 of the pin 96 extends through bore 36 and is positioned in the seat lying between the end elements 34 and 35, so that an axial thrust exerted on the handle 60 causes the shaft 42 to slide along the axial portion 57 of its groove 55, to engage with the radial bore 99 of the stem 98 and then engage with the element 34 by way of the retention ring 48. Consequently, the members 2 and 3 are connected together, but this connection is loose because the axial pin 43 is pointing towards the member 3 and enables the pin 96 to make further axial movements. A tight connection between the members 2 and 3 is obtained during the next stage by extracting the handle 60 radially until its central portion 71 of square section has passed beyond the vertical walls of the annular projection 21 on the flange 20, by using a pulling force sufficient to release the connection between the handle 60 and shaft 42 but not the connection between the shaft 42 and element 34. The handle 60 is then rotated through 180°, enabling the shaft 42 to slide along the portion 56 of its groove 55 and engage with the upper end of the bore 99 in the stem 98 by means of the axial pin 43, as shown in Figure 4. The upper arm 33 of the leaf spring 26 thus bends slightly towards the lower arm 25, to put the pin 98 under traction and thus result in a tight connection between the member 2 and member 3 and hence between the terminal portion 4 of the measuring machine column and the tool 6. The members 2 and 3 are thus positioned relative to each other with precision in a stable position in which each element 122, 123 and 124 rests between the respective pairs of balls 82, 83 and 84. In particular, the traction force between the members 2 and 3 can be adjusted by axially displacing the pin by means of the nut 105 and locking nut 102, its value being checked for example by means of a load cell.

The mounting is finished by pushing the handle 60 radially inwards until its circular groove 65 engages with the circular groove 67 on the shaft 42 by way of the retention ring 66.

The members 2 and 3 are released from each other by a series of operations substantially the same as those described for the mounting, but in the reverse order. In particular, the handle 60 is extracted through a first distance, then rotated through 180° so releasing the tight connection between the shaft 42 and pin 96, and then extracted through a second distance to totally release the shaft 42 from the pin 96 and thus the member 2 from the member 3.

From the characteristics described, it is apparent that the connection unit according to the present invention allows very quick mounting, which is repeatable to an order of magnitude of within 1 μm. Consequently, the repeated compenasation of the processor associated with the measuring machine can be avoided, so leading to a considerable saving in the average measuring time and the total cost of measuring the mechanical pieces.

The facility for adjusting the traction force between the members 2 and 3 enables a single leaf spring 26 and one corresponding pin 96 to be used, together with the same shaft 42 even for connection units used to support very heavy tools which require much higher traction forces, as partly illustrated in Figure 8. The particular simplicity of the operations involved in mounting and dismantling the unit 1 means that complete automation could be used if it were required to substitute several tools, so giving a further saving in total time and cost.

Finally, modifications can be made to the described embodiment of the present invention.

For example, the bearing system comprising the three pairs of balls 82, 83 and 84 which cooperate with the three corresponding substantially wedge-shaped elements 122, 123 and 124 can be replaced respectively by a pair of balls which rest on a wedge element analogous to those described, or by three balls disposed at 120° which rest on one ball disposed in a central position relative thereto, or by a surface which can for example be that of one of the flanges 20 and 92, and which rests on a corresponding ball.

Further combinations of bearing forms are also possible, provided that the parallelism between the radial planes of the flanges 20 and 92 of the respective members 2 and 3 can be adjusted to define a precise relative position between the members 2 and 3. Instead of being wedge-shaped, the elements 122, 123 and 124 could be in the form of cylinders, to cooperate with the pairs of balls 82, 83 and 84 in known bearing arrangements.

WHAT WE CLAIM IS:

1. A device for connecting a tool or measuring sensor to a machine comprising first and second members adapted to be secured to the machine and to the tool or sensor and having means whereby the members can be locked together and released in a completely detachable manner and means for positioning the members relative to each other such that the members can be uncoupled from a position relative to each other and recoupled in a substantially identical position, the means including a stem element having a radial bore provided by one member and a fixed coupling element provided by the other member and supporting a movable locking shaft for engagement with the stem element, and wherein said shaft includes an eccentric member, said shaft with said eccentric member engaging in said radial bore of said stem element by means of an axial movement and locking said two members together by means of a rotary movement.

2. A device as claimed in claim 1, wherein said fixed coupling element comprises a U-shaped leaf spring with one free arm first and second end parts which between them define a seat for housing said stem element and which have coaxial bores defining part of a duct, inside said duct there being slidable said movable locking shaft.

3. A device as claimed in claim 1 or 2, wherein said axial and rotary movements of said shaft are guided by a surface groove in said shaft which comprises a first axial portion and a second radial portion and which surface groove is engaged with a first end part of said fixed coupling element by means of a coupling element.

4. A device as claimed in any of the preceding claims, wherein said axial and rotary movements of said shaft are made by way of a handle having a central member with an axial duct in which said shaft can slide between two limiting position defined by the cooperation between a pin, disposed radially in said shaft, and an axial slot, provided in said central member of said handle.

5. A device as claimed in claim 4, wherein said shaft has a first annular groove at one end to permit coupling to a corresponding circular groove provided in said axial duct of said handle by way of a first annular element of elastically deformable material.

6. A device as claimed in any of the preceding claims, wherein said shaft has a second annular groove at the other end to permit coupling to a corresponding circular groove provided in said axial bore of a second end part of said fixed coupling element by way of a second annular element of elastically deformable material.

7. A device as claimed in claims 5 and 6, wherein said coupling between said shaft and said second end element is tighter than said coupling between said shaft and said handle.

8. A device as claimed in any preceding claim, wherein said stem element is adjustable along its length on the one member.

9. A device as claimed in any of the preceding claims, wherein said relative positioning means comprise at least one first element provided by one member and which is disposed for contact with one or more positioning surfaces of a second element

provided by the other member.

10. A device as claimed in claim 9, wherein said first element is disposed for contact with mutually converging positioning surfaces of said second element.

11. A device as claimed in claim 9 or 10, comprising three said first elements disposed between three pairs of said second element.

12. A device as claimed in claim 11, wherein each of the three said first elements is of substantially triangular or cylindrical section.

13. A device as claimed in claim 11 or 12, wherein each element of the three pairs of said second element is a ball.

14. A device as claimed in any of the preceding claims, wherein in said first and second members there are mounted first and second printed circuits respectively, which can be connected together by corresponding electrical connectors to enable electrical signals to be transmitted from said tool or sensor to processing means connected to said machine.

15. A device as claimed in claim 14, wherein said second printed circuit is flexible.

16. A device as claimed in any preceding claim, wherein said relative positioning means allows said first and second members to be recoupled to a position which is within a tolerance of 1 μm of the position before uncoupling.

17. A device for connecting a tool or measuring sensor to a machine substantially as herein described with reference to and as shown in the accompanying drawings.

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1599751 COMPLETE SPECIFICATION
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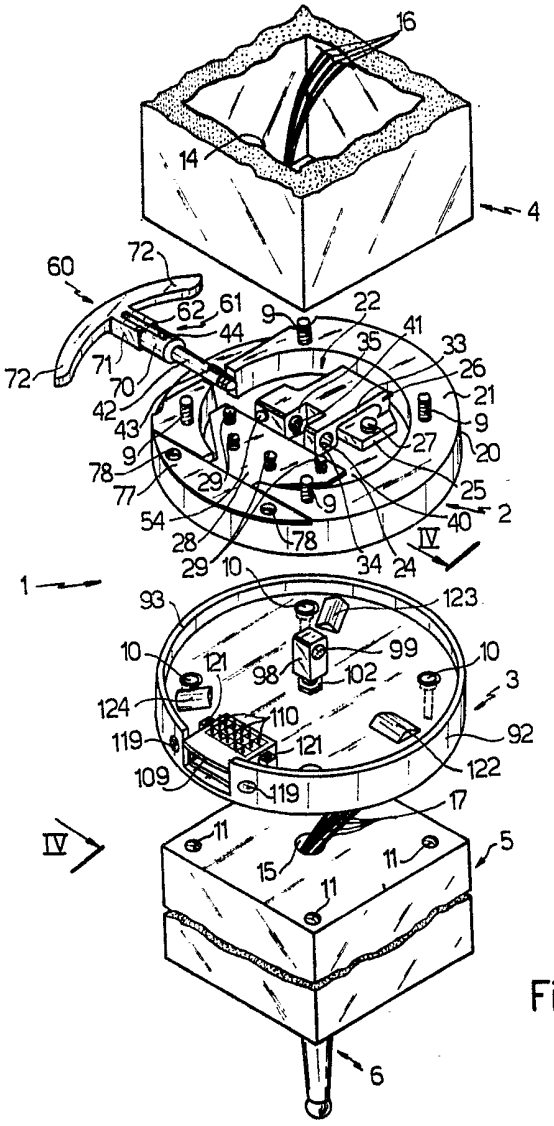

Fig.1

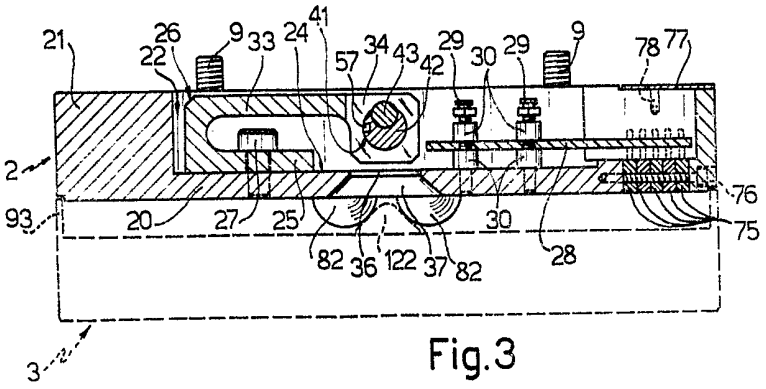
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Fig.3

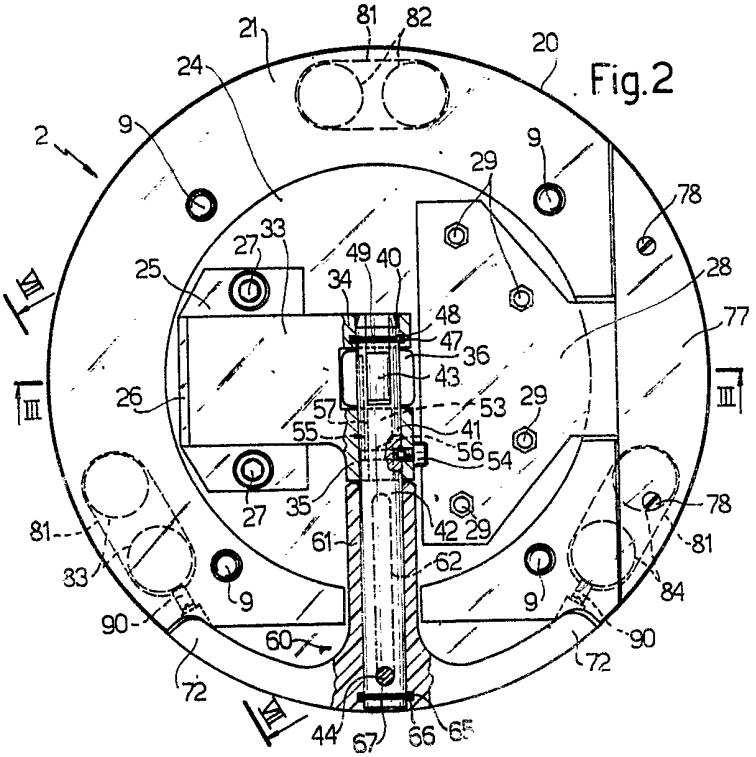
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Fig.2

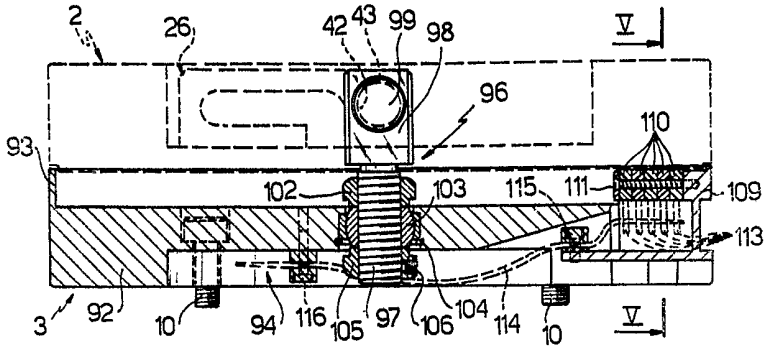


Fig.4

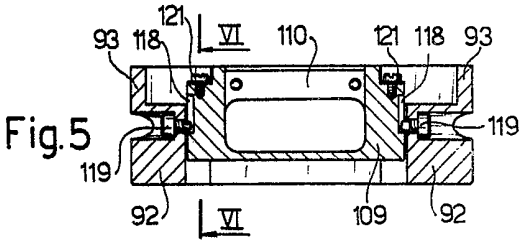


Fig.5

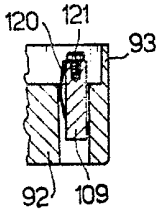
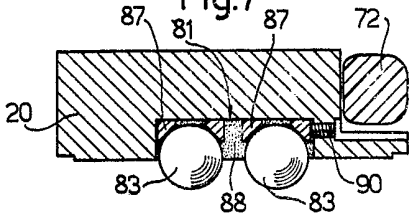


Fig.6

Fig.7



1599751 COMPLETE SPECIFICATION
4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 4

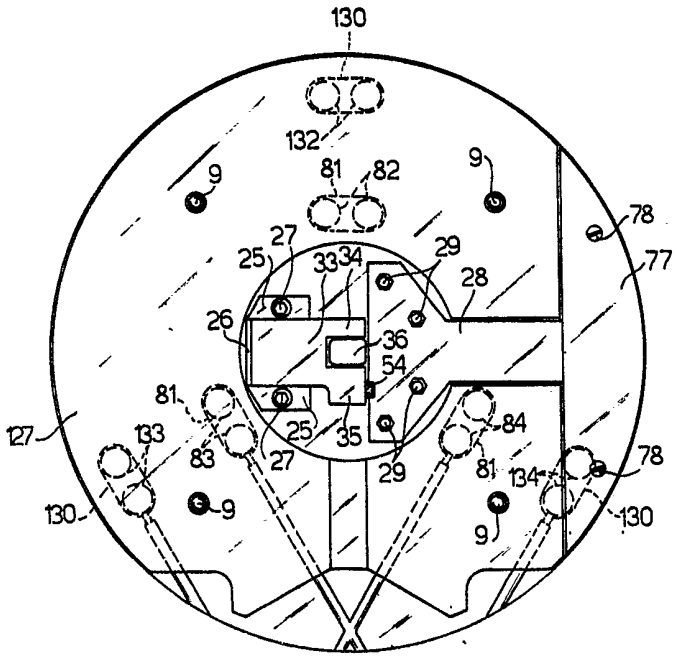


Fig.8