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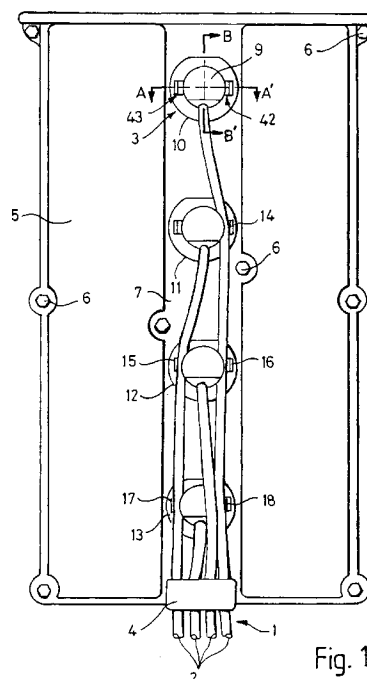
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(54) **Spark plug cable assembly**

(57) A spark plug cable assembly 1 has a number of spark plug connectors 3 and ignition cables 2 which lead to each connector 10, 11, 12, 13. The assembly 1 is seated in a channel 7 in a cam cover 5. At least one of the connectors 3 has one or more integrally moulded cable retaining clips 42, 43 which are adapted to hold and retain an ignition cable 2 which leads to another spark plug connector 3. The spark plug connectors 3 have a sleeve through which the ignition cable 2 passes to make contact with a spark plug clip, the sleeve being adapted to pass through a spark plug aperture in the cam cover channel 7 so that the connector may make electrical contact with a spark plug under the cam cover 5.

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Description

The present invention relates to a spark plug cable assembly and in particular to a moulded spark plug connector with integrally moulded clips for spark plug cables.

Motor vehicle spark plug ignition cables are commonly run in a cable bundle from an ignition coil to the engine spark plugs, with a separate cable to each spark plug connector. The cables need to be held in a safe and secure arrangement, while at the same time ensuring that no undue stresses are placed on any of the cables during the assembly, operation or servicing of the engine.

In particular, it is desirable that the cables are held as straight as possible, and away from contact with any moving parts or hot surfaces. Because of the high voltages within the cables, typically 10 to 20 kV, the cables must be kept as dry as possible, away from both direct contact with water and also from condensation.

One type of spark plug connector is described in patent specification GB 2 212 675 A. This prior art connector holds the cable in a rigid sheath that guides the cable through a right angle bend so that cables from several connectors can be routed together. A cable assembly must, however, be held together by other means such as clips fastened to the engine.

It is an object of the present invention to provide a spark plug cable assembly with a spark plug connector that holds the cables in a safe and secure arrangement and reduces the need for other means to route the cables together.

According to the invention there is provided a spark plug connector for making an electrical connection between an ignition cable and a spark plug, the connector comprising a sleeve with a channel therein adapted to accommodate the ignition cable and within which the connection may be made, characterised in that a cable retaining clip is integral with the connector for receiving and holding an ignition cable routed past the connector.

The invention also provides a spark-ignition engine comprising a plurality of spark plugs which are electrically connected to an ignition system through a spark plug cable assembly, in which the assembly comprises a number of spark plug connectors for making an electrical connection between an ignition cable and a spark plug, the connectors comprising a sleeve with a channel therein adapted to accommodate the ignition cable and within which the connection may be made, characterised in that a cable retaining clip is integral with a connector for receiving and holding an ignition cable routed past the connector.

The invention further provides a spark plug cable assembly comprising a number of spark plug connectors and the same number of ignition cables, wherein each ignition cable leads to one of the connectors for making an electrical connection therein with a spark plug, characterised in that at least one of the connectors

has a cable retaining clip integral with the connector, the cable retaining clip being adapted to hold and retain an ignition cable which leads to another spark plug connector.

The invention also provides a spark-ignition engine comprising a plurality of spark plugs which are electrically connected to an ignition system through a spark plug cable assembly, the assembly comprises a number of spark plug connectors and the same number of ignition cables, wherein each ignition cable leads to one of the connectors for making an electrical connection therein with a spark plug, characterised in that at least one of the connectors has a cable retaining clip integral with the connector, the cable retaining clip being adapted to hold and retain an ignition cable which leads to another spark plug connector.

Each connector may advantageously be integrally moulded with the clips. The cable retaining clip may preferably be integral with the sleeve.

In a preferred embodiment of the invention the spark plug connector comprises a sleeve with a channel therein through which the cable passes for making electrical contact with a spark plug, and the sleeve is adapted to pass through a spark plug aperture in an engine cover so that the connector may make contact with a spark plug under the engine cover. The engine cover may be a cam cover.

In order to make it easier to remove the spark plug cable assembly from the spark plugs, the spark plug connectors may advantageously be provided with a grip feature, which may be centrally located at the end of the sleeve. Since the grip will generally need to be as robust as the sleeve, it will usually have a cross section which is comparable in extent with that of the sleeve.

One side of the cable retaining clip may be formed by a surface of this grip feature and the cable clip may have an opening through which the cable may be pushed to seat the cable within the clip.

Since the cables will generally need to be removable from the clips, particularly when the cable assembly is removed from the engine, it is advantageous if the cable may be removed from the clip by pulling the cable back through the opening in the clip.

Since the grip feature may be relatively rigid to allow a firm grip to be had, when one side of the clip is formed by the grip feature, the other side of the clip may be formed from a more compliant construction to allow the cable to be seated within the clip.

It is generally preferred if the spark plug connector has two cable retaining clips on opposite sides of the connector, and this may be on opposite sides of the grip feature, although a third or further clip may be added so that more cables may be held.

In order to ease assembly of the connector, the ignition cable may enter the spark plug connector at an oblique angle to the axis of the sleeve so that the cable is bent through an angle less than 90° as it enters the sleeve. This also reduces the mechanical strain on the

cable and helps to direct the cable away from any surfaces surrounding the sleeve.

The sleeve may also be provided with a peripheral seal to prevent ingress of liquids or other contamination through the spark plug aperture when the connector is in contact with the spark plug and the seal may additionally have a cap which covers the spark plug aperture.

The cable retaining clip may have a base which tapers towards the connector in order to improve the mechanical integrity of the clip.

A spark plug connector according to the invention may advantageously be moulded from a rubber compound, such as a silicone rubber.

In one preferred embodiment of the invention for use with a spark-ignition engine having four cylinders, there are four connectors and cables, and the first connector does not clip to any cables, the second connector is adjacent to the first connector and clips to a cable from the first connector, the third connector is adjacent to the second connector and clips to cables from the first and second connectors, and the fourth connector is adjacent to the third connector and clips to two cables from the other connectors.

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

Figure 1 is a top view of a spark plug cable assembly according to the invention showing how the spark plug connectors and the ignition cables are arranged in use above a spark-ignition engine cam cover;

Figure 2 is a side view in partial cross section about the line A-A' of Figure 1, showing a spark plug connector seated through the cam cover;

Figure 3 is a side view in partial cross section at right angles to the view of Figure 2, and about the line B-B' of Figure 1, showing a spark plug connector seated through the cam cover;

Figure 4 is a top plan view of the spark plug connector of Figures 2 and 3;

Figure 5 is a view in cross section of the spark plug connector shown in Figure 2 through the line C-C', shown without the ignition cable and spark plug clip;

Figure 6 is a side view of the ignition cable and spark plug clip before assembly into the spark plug connector; and

Figure 7 is a side view in partial cross section of the spark plug connector of Figure 5, shown with a mandrel inserted for assembly of the connector to the ignition cable and spark plug clip.

Referring first to Figure 1, a spark plug cable assembly 1 for a four cylinder spark-ignition engine, has four ignition cables 2 and four identical spark plug connectors 10, 11, 12, 13, generally indicated by the reference numeral 3, and a cable bundle clip 4 formed from two snap together plastic pieces. The assembly is shown as it would be in use with the connectors inserted at right angles to the page through apertures in a cam cover 5 to connect with spark plugs (not shown).

The cam cover is bolted to the engine by a number of bolts 6 and has a central channel 7 through which the assembly 1 runs from the spark plugs to the ignition coil (not shown).

Each spark plug connector 3 is moulded from a silicone rubber compound and has two integrally moulded cable clips, generally indicated by numerals 42 and 43, on opposite sides of a grip feature in the form of a head 9 through which the cable 2 enters the connector 3. The assembly is manufactured so that the each cable 2 has a length sufficient to allow a connector 3 to reach a particular aperture in the cam cover channel 7.

The first spark plug connector 10 is the one farthest from the ignition coil, and so neither of the cable clips 42, 43 is used. This connector 10 could be formed without any integrally moulded cable retaining clips, but generally it will not be economic to manufacture different connectors with different numbers of cable clips for different points in the assembly 1. However, the unused clips do not present any disadvantage and it is an advantage of this particular embodiment of the invention that the same moulding may be used on all four connectors 10, 11, 12, 13.

The second spark plug connector 11, adjacent to the first connector 10, has one clip 14 used to retain the cable 2 from the first connector 10. The next, third, connector 12 has two clips 15, 16 used to hold the cables from the previous connectors 10, 11. The last, fourth, connector 13 has two clips 17, 18 used to hold the cables from the first and second connectors. The cable from the third connector passes over and is supported by the top of the fourth connector.

Finally, all four cables are held securely and flat by the cable bundle clip 4 at the point where the cables 2 pass out of the cam cover channel 7. There is no need for the cable bundle clip to be attached to the cam cover 5 since the cables 2 are held in a secure orientation at points close to and on both sides of the cable bundle clip 4. On one side of the bundle clip there are the clips 17, 18 on the fourth connector 13, and on the other side the ignition coil is very close. The bundle clip is also robust enough to rest on the edge of the cam cover to provide support at this point.

Each cable 2 is therefore arranged and clipped securely into place within the assembly to lead each cable in as straight a line as possible towards the connectors, while providing support points above the cam cover channel 7 at separations no greater than the separation between the connectors 10, 11, 12, 13.

The spark plug connector is shown in greater detail in Figures 2, 3 and 4. In Figure 2, the connector 3 is shown in a side view seated in a cam cover aperture 32 in the cam cover channel 7. The aperture has a cylindrical wall 34.

The connector 3 has a roughly cylindrical sleeve 35 which leads through the aperture 32 to make a connection with the spark plug (not shown). Four circular parallel flanges 36, which are thin and flexible, project at right angles from the sleeve to make contact with the inner wall of the aperture 32. These flanges help centre the sleeve of the connector within the aperture and also form a barrier to the ingress of moisture or other contamination. However, because of the temperature cycles within the cam cover from use of the engine, the flanges 36 must not provide a hermetic seal or air pressure differences will build up within the cover and may even dislodge a connector from a spark plug. Each flange is therefore provided with one peripheral notch 37 which serves as a vent hole past the flange, with alternate flanges having notches offset circumferentially. Offsetting the notches presents a long and convoluted path through the flanges 36 to deter moisture or contamination from passing from outside through the cam cover.

Above the flanges is another, thicker and less flexible parallel flange or cap 38, which extends outwardly beyond the edges of the aperture 32, to form a cover across the top of the aperture.

The head 9 at the top of the spark plug connector 3 has an overhanging projection 40 which may be gripped by a thumb. On the opposite side to this projection, the head has a flat surface 50 tapered at about 45° to the axis of the sleeve, through which the ignition cable 2 passes. The cable therefore projects upwards slightly as it leaves the connector 3, and this feature helps support the cable away from the bottom of the cam cover channel 7.

On either side of the head 9, and at right angles to the overhang 40 and the cable 2, are two cable retaining clips 42, 43. The innermost side 44, 45 of each clip is formed by a side surface of the head 9, and since this head is relatively robust and inflexible, each clip has a more flexible outer arm 46, 47. When a cable is pressed into the clip, the outer arm flexes outwards until the cable is seated in the space between the outer arm and the head.

Between the cap 38 and the adjacent flange 36, there is a web 48, 49 under each of the cable retaining clips 42, 43, which tapers towards the sleeve 35. These webs form a base for the clips to improve the mechanical integrity of the retaining clips and to prevent a downward force on a cable from disengaging the cable from a clip.

Figure 5 shows in cross section a spark plug connector 51 with the spark plug cable and clip removed from a channel 52 leading through the connector. The channel has a gentle bend 53 over about 45°. Apart from helping to keep the cable away from the cam cover

channel, as described above, this bend has two other advantages over a conventional 90° bend at this point. Firstly, it places less stress on the cable as it is bent, and secondly, as can be seen from Figure 7 and as will be explained below, it permits the integrally moulded spark plug connector 51 to be bent upon insertion of a mandrel 83 for insertion of the ignition cable.

Referring now also to Figure 6, the ignition cable 2 has attached at its end a spark plug clip 72, an upper half of which wraps around the cable, and is held on by several crimps 74, and a lower half of which forms a hollow tube 75 with a spring clip 76 at its end which pushes onto a terminal on the top of a spark plug. Just above the spring clip there is a hole 77 in the hollow tube 75.

The ignition cable 2 has a conductor formed from carbon impregnated glass fibre, which is held against a tab 78 to make electrical contact with the spark plug clip 72.

By comparison of Figures 5 and 6, it can be seen that the channel 52 has an internal profile which matches the external profile of the ignition cable 2 and spark plug clip 72. In particular, the channel 52 has a step 54, which matches the shoulder 73 where the cable 2 enters the clip 72.

Referring again to Figure 7, the spark plug connector 51 is assembled with the cable 2 and spark plug clip 72 in the following manner. First, as mentioned above, a mandrel 83 is inserted through the spark plug connection aperture 84 into the channel 52 of the connector 51, and forced past the bend and out the other side of the channel. The integrally moulded connector 51 is flexible and resilient enough to bend, thereby permitting the channel to straighten out to allow the mandrel 83 to pass through.

The mandrel 83 has at its end a hook 85. The diameter of the mandrel 83 and the size of the hook 85 are such that the mandrel may just be inserted into the hollow tube 75 of the spark plug clip, so that the hook may grip the hole 77 in the hollow tube 75. The mandrel is then hooked to the spark plug clip 72, and pulled back through the channel 52 in the connector 51, so pulling the cable 2 and spark plug clip 72 into the connector. Once the cable and clip are correctly positioned, the hook 85 is unhooked from the hole 77, and the mandrel 85 removed from the spark plug connection aperture 84.

In the absence of a spark plug cable assembly as described, a cam cover channel would generally have to be provided with other cable mounting means, such as individual cable clips. Cam covers may be cast from an aluminium alloy, and so the casting would then have to include extra material at several points for drilling and tapping in subsequent processing steps. The individual clips would have to be manually attached to the cover at these points before the spark plug cable assembly could be connected to the spark plugs.

The assembly described here reduces the costs inherent in the prior art spark plug cable assembly, by reducing the material needed in the cam cover casting,

and by eliminating extra process steps both in forming the mounting points on the casting, and in attaching clips at these points.

It has also been found from manufacturing experience with discrete mounting clips that occasionally a clip may inadvertently be dropped into one of the cam cover apertures. If this happens, the connection of the assembly to the spark plugs cannot proceed, and the cam cover may have to be removed to retrieve the clip. The assembly described prevents this potential problem, which can be a major inconvenience on a production line.

The present invention can therefore provide a spark plug cable assembly which reduces the number of cable assembly components and process steps and which improves the reliability, cost and speed of fitting the cable assembly to the engine and spark plugs.

Claims

1. A spark plug connector (3) for making an electrical connection between an ignition cable (2) and a spark plug, the connector (3) comprising a sleeve (35) with a channel (52) therein adapted to accommodate the ignition cable (2) and within which the confection may be made, characterised in that a cable retaining clip (42,43) is integral with the connector (3) for receiving and holding an ignition cable (2) routed past the connector (3).
2. A spark plug connector (3) according to Claim 1, in which the cable retaining clip (42,43) is integral with the sleeve (35).
3. A spark plug connector (3) according to Claim 1 or Claim 2, in which the connector (3) has a grip feature (9,40) to help release the connector (3) from a spark plug, one side (44,45) of the cable retaining clip (42,43) is formed by a surface on the grip feature (9,40), and the cable retaining clip (42,43) has an opening through which the ignition cable (2) may be pushed to seat the ignition cable (2) within the clip (42,43).
4. A spark plug connector (3) according to any preceding claim which has two cable retaining clips (42,43) on opposite sides.
5. A spark plug connector (3) according to any preceding claim, in which the cable retaining clip (42,43) has a base (48,49) which tapers towards the connector (3).
6. A spark plug connector (3) according to any preceding claim in which the connector (3) is moulded from a rubber compound.
7. A spark plug cable assembly (1) comprising a number of spark plug connectors (3) and the same number of ignition cables (2), wherein each ignition cable (2) leads to one of the connectors (3) for making an electrical connection therein with a spark plug, characterised in that at least one of the connectors (3) has a cable retaining clip (42,43) integral with the connector (3), the cable retaining clip (42,43) being adapted to hold and retain an ignition cable (2) which leads to another spark plug connector (3).
8. A spark plug cable assembly (1) according to Claim 8, in which the spark plug connector (3) comprises a sleeve (35) with a channel (52) therein through which the ignition cable (2) passes for making electrical contact with a spark plug, and the sleeve (35) is adapted to pass through a spark plug aperture (32) in an engine cover (5) so that the connector (3) may make contact with a spark plug under the engine cover (5).
9. A spark plug cable assembly (1) according to Claim 8 or Claim 9, in which the cable retaining clip (42,43) is integral with the sleeve (35).
10. A spark plug cable assembly (1) according to any of Claims 8 to 10, in which the spark plug connector (3) has a grip feature (9,40) to help release the spark plug connector (3) from a spark plug, one side of the cable retaining clip (42,43) is formed by a surface (44,45) on the grip feature (9,40), and the cable retaining (42,43) clip has an opening through which the ignition cable (2) may be pushed to seat the ignition cable (2) within the clip (42,43).
11. A spark plug cable assembly (1) according to any of Claims 8 to 11, in which the spark plug connector (3) has two cable retaining clips (42,43) on opposite sides of the connector (3).
12. A spark plug cable assembly (1) according to any of Claims 8 to 12, in which the cable retaining clip (42,43) has a base (48,49) which tapers towards the connector (3).
13. A spark plug cable assembly (1) according to any of Claims 8 to 13 in which the connector (3) is moulded from a rubber compound.
14. A spark plug cable assembly (1) according to any of Claims 8 to 14, in which there are four connectors (10,11,12,13) and ignition cables (2), and a first connector (10) does not clip to any ignition cables (2), a second connector (11) is adjacent to the first connector (10) and clips to an ignition cable (2) from the first connector (10), a third connector (12) is adjacent to the second connector (11) and clips to ignition cables (2) from the first and second connector (10).

tors (10,11), and a fourth connector (13) is adjacent to the third connector (12) and clips to two ignition cables (2) from the other connectors (10,11,12).

15. A spark-ignition engine comprising a plurality of spark plugs which are electrically connected to an ignition system through a spark plug cable assembly (1), in which the assembly (1) comprises a number of spark plug connectors (3) as claimed in any of Claims 1 to 7. 5 10
16. A spark-ignition engine comprising a plurality of spark plugs which are electrically connected to an ignition system through a spark plug cable assembly (1), in which the assembly (1) is as claimed in any one of Claims 8 to 15. 15

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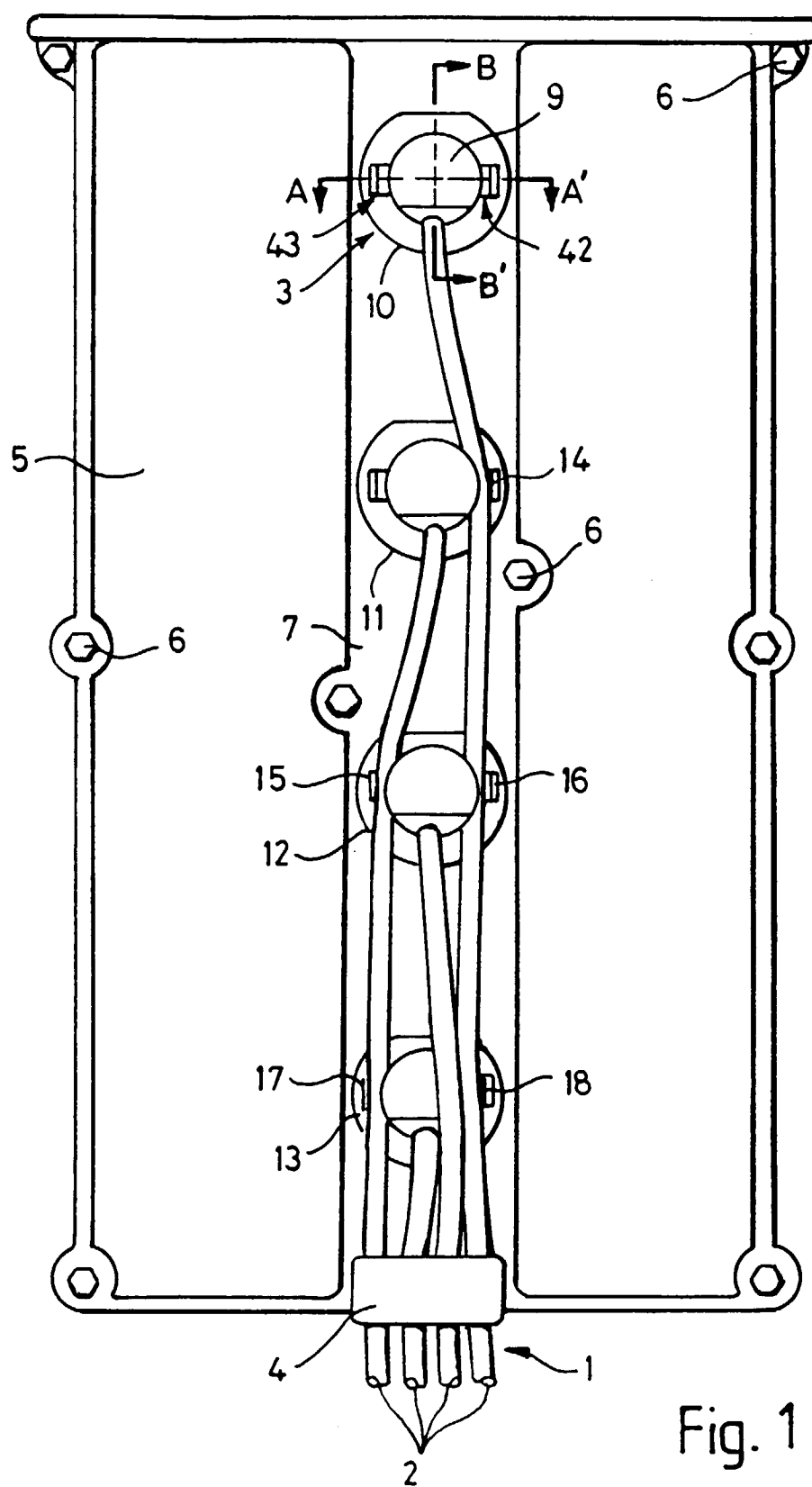


Fig. 1

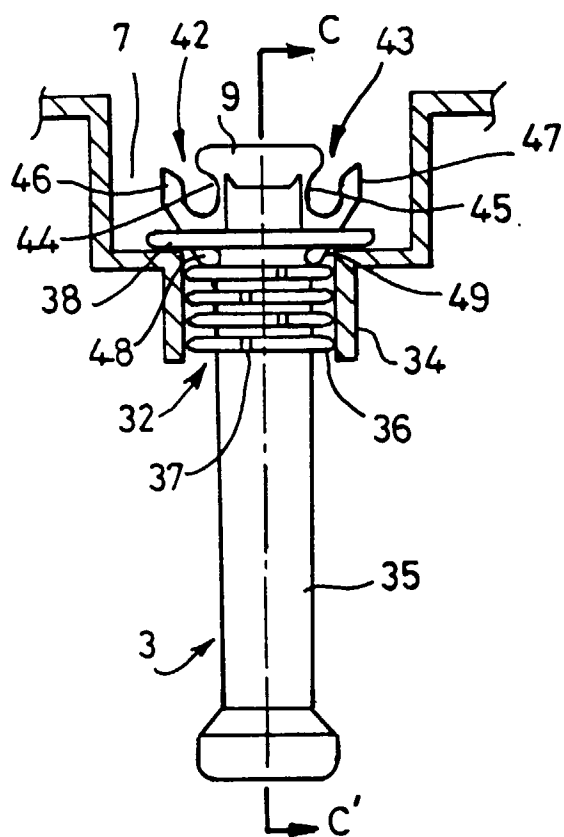


Fig. 2

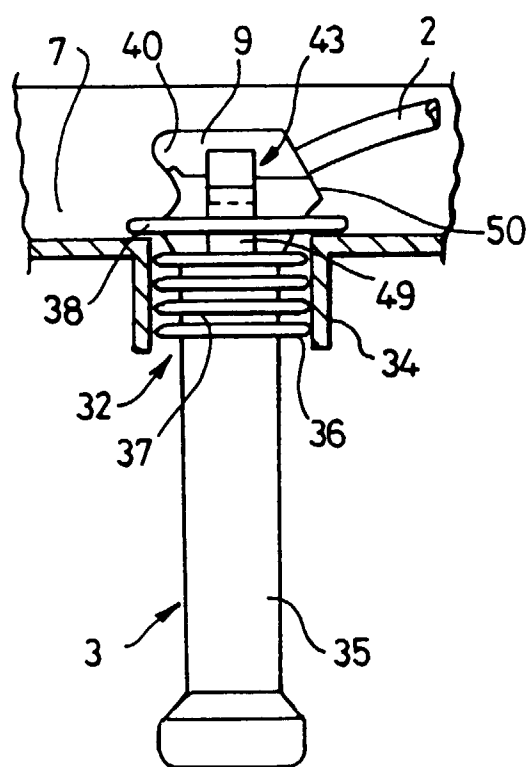


Fig. 3

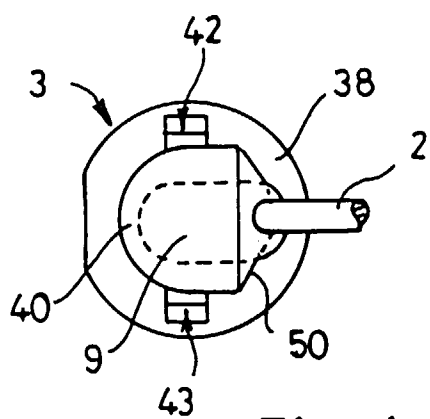
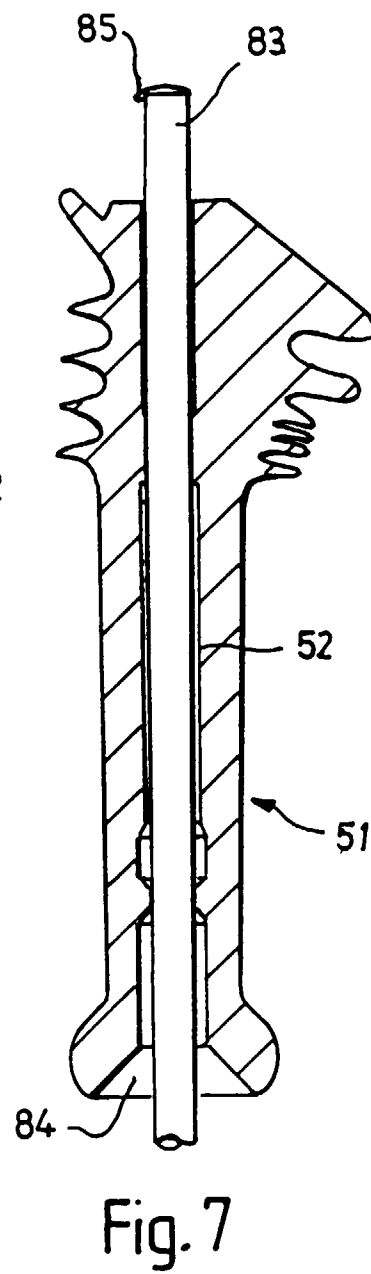
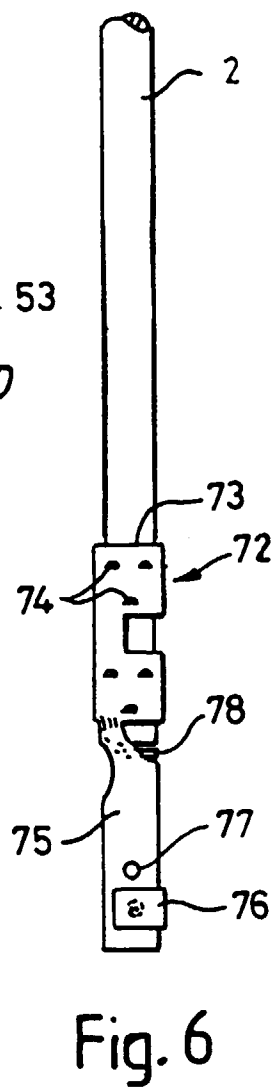
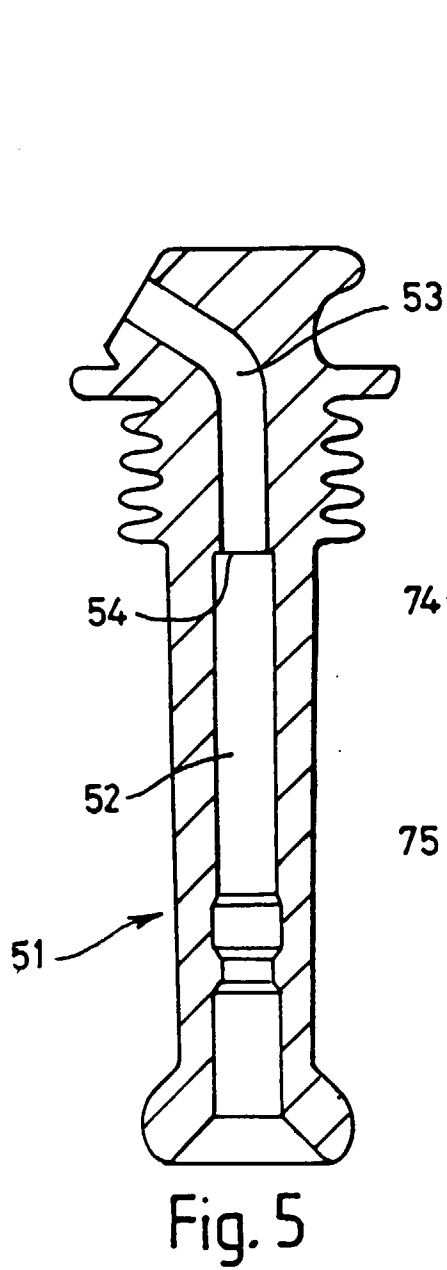


Fig. 4





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EUROPEAN SEARCH REPORT

Application Number
EP 96 30 2172

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	JP-U-61 167 479 (SUZUKI JIDOSHA KOGYO) 17 October 1986 * figures 1-3 *	1-3,5,7,8,10-12,14,16,17	H01T13/04
X	GB-A-2 231 366 (NISSAN MOTOR CIE) 14 November 1990 * page 2, line 1 - line 16 *	1-3,5,7,8,10-12,14,16,17	
Y	US-A-4 993 961 (HISATOMI MASAHIRO ET AL) 19 February 1991 * column 3, line 32 - column 5, line 21; figures 2-6C *	1,2,8,16,17	
Y	WO-A-94 05942 (PARVERIS JOHN IOANNIS) 17 March 1994 * page 16, line 8 - page 17, line 14; figure 3 *	1,2,8,16,17	
A	* page 18, line 6 - line 13 *	6,7,13,14	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	WO-A-85 00931 (SAAB-SCANIA) 28 February 1985 * page 3, line 4 - line 16; figure 1 *	9	H01T
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 9 August 1996	Examiner Bijn, E
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 I : document cited for other reasons & : member of the same patent family, corresponding document			

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