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(54) **A method for making a flexible conductor and a flexible conductor**

(57) There is described a method for making a flexible conductor (15) with connecting terminals (21) at both ends and consisting of one or more flexible, braided copper bands (4, 6), by which method a copper band, preferably from a coil, is supplied to a two-part forging tool (16) in a press, e.g. an eccentric press, that protective gas (nitrogen) is supplied to the forging tool for protecting the structure of the copper and for displacing oxygen and avoiding discolouring of the copper band, that the copper band (4, 6) is subjected to a very great current intensity between points at each side of the forging tool so that the part of the copper band situated in the forging tool (16) is heated to red-hot condition, that the current is switched off and that the press is simultaneously activated for bringing together the tool

parts for compressing and forging the said part of the copper band so that it subsequently appears as a solid and homogenous piece of copper of which the connecting terminals are formed, either by an immediately succeeding operation or by a later operation. Hereby it is achieved that by means of simple technical measures it becomes possible to make a new and improved flexible conductor making possible to reduce the number of conductors stocked very significantly as the conductor according to the invention, according to need, may consist of several parallel, preferably identical, copper bands with integrated end terminals of solid and/or homogenous copper.

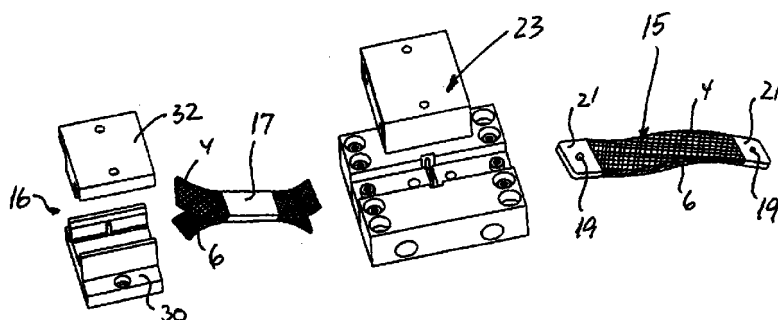


Fig. 8

Description

[0001] The present invention relates to a method for making a flexible conductor of the kind indicated in the preamble of claim 1.

[0002] Known flexible conductors consisting of braided, thin copper wires and, independently of whether the conductor is round or flat, are either fitted with so-called cable shoes at opposite ends, fixed by pressing, or with connecting terminals where a tubular bushing or a flat, box-shaped bushing is fitted on the end parts of the conductor and connected to these by compression under large pressure. Furthermore, it is known to combine such a method for making connecting terminals by tin-plating. These methods are, however, expensive since they are time-consuming to perform and also inferior as too large transition resistance may occur due to bad connection, either between bushing and the single wires of the conductor or between the single wires and a possible tin coating.

[0003] In connection with electric distribution panels, e.g. steel enclosed switch boards, a very large number of permanent connections between the rail systems and the various built-in components, e.g. contactors, power switches, gauges etc., are used. The said permanent connections usually consist of rigid connecting scarf joints of copper which have to be in stock in many different dimensions, lengths, and shapes for the common purposes of building in, since the actual scarf joints, which are often rather thick and often have complicated shape with several angular bends, cannot be adjusted on site instantly, i.e. possible adjustments of the connecting scarf joints require workshop facilities.

[0004] It is the purpose of the invention to provide a method of the kind indicated in the introduction and which by means of simple technical measures enables the making of a new and improved flexible conductor, further enabling a very significant reduction of the number of conductors in stock.

[0005] The method according to the invention is characterized in that a copper band, preferably from a coil, is supplied to a two-part forging tool in a press, e.g. an eccentric press, that protective gas (nitrogen) is supplied to the forging tool for protecting the structure of the copper and for displacing oxygen and avoiding discolouring of the copper band, that the copper band is subjected to a very great current intensity between points at each side of the forging tool so that the part of the copper band situated in the forging tool is heated to red-hot condition, that the current is switched off and that the press is simultaneously activated for bringing together the tool parts for compressing and forging the said part of the copper band so that it subsequently appears as a solid and homogenous piece of copper of which the connecting terminals are formed, either by an immediately succeeding operation or by a later operation.

[0006] Hereby it is achieved that by means of simple technical measures it becomes possible to make a

new and improved flexible conductor implying a very significant reduction in the number of conductors stocked as the conductor according to the invention, according to need, may consist of several parallel, preferably identical, copper bands with integrated end terminals of solid and homogenous copper.

[0007] The method according to the invention may be modified according to need in such a way that two, preferably identical, copper bands are used, which are supplied to the tool in the press from each their coil, and that the copper bands are connected to the secondary winding of a transformer at each side of the tool by means of squeezing jaws.

[0008] With the intention of avoiding discoloration of the copper bands and for minimising the mechanical load on the forging tool, by an embodiment of the invention the tool is maintained at an operational temperature of about 90°C by heating and/or cooling.

[0009] For shielding the mechanical surroundings against the magnet fields arising during the heating of the copper band, by an embodiment of the inventive method there is used a water cooled forging tool enclosed by aluminium (90%)/steel (10%) and that the enclosure is filled with protective gas during the whole process (heating, forging and cooling) for protecting the structure of the copper and for displacing oxygen around the copper band, so that the properties of the copper are retained and discolouring of the copper is avoided.

[0010] The invention also concerns a flexible conductor made by the indicated method and provided with connecting terminals at opposite ends, comprising one or more flexible, braided copper bands, the flexible conductor being characterised in that it consists of one copper band on which the connecting terminals are made by compressing and forging of a part of the band corresponding to twice the length of one connecting terminal between two conductors, where the part of the band is heated to red-hot condition prior to the forging by conducting a very great current intensity through it, and that the individual connecting terminals are formed subsequently by dividing up the part of the length and preferably simultaneous forming of connecting holes.

[0011] The flexible conductor according to the invention may suitably be designed so that it consists of two, preferably identical, copper bands disposed with their flat sides against each other and which at opposite end are designed with uniform common, integrated end terminals of solid and homogenous copper.

[0012] The invention will be explained more closely in connection with the drawing, on which:

Fig. 1 shows a schematic drawing of a facility for making flexible conductors according to the invention,

Fig. 2 shows a perspective view of the tool parts for an eccentric press for the facility shown in

Fig. 1,

Fig. 3 shows a photo in which the tool parts are separated and the upper tool part is placed beside (to the left of) the lower part,

Fig. 4 shows a photo corresponding to Fig. 2 of the tool parts for making conductors according to the invention,

Fig. 5 shows by a photo a front view of the complete tool system of the eccentric press for making conductors according to the invention,

Fig. 6 shows yet a photo with a perspective front view of the complete tool system of the eccentric press for making conductors according to the invention,

Fig. 7 shows a perspective view of a slightly different handling system for an eccentric press, where the tool parts themselves are removed, for making conductors according to the invention, and

Fig. 8 shows how a flexible conductor according to the invention is preferably made in four method steps.

[0013] The facility shown schematically in Fig. 1 for making conductors according to the invention consists of an unspooling apparatus 2 which in the shown example is arranged for simultaneous unspooling of two copper bands 4 and 6 from each their storage coil 8 and 10. Via an inlet duct 12, the copper bands 4 and 6 are supplied overlaid to an eccentric press 14 wherein a two-part forging tool 16 (Fig. 2) is mounted on a stationary pressing plane 5 and a movable pressing plane 7, respectively. At the opposite side of the eccentric press 14 the produced and still coherent conductors 15 are moved to a storage coil in a spooling apparatus 22 via an outlet duct 18.

[0014] Before the eccentric press 14 is shown an adjustable transformer 24, the secondary winding 26 of which, via water cooled squeezing jaws 28 and thereby co-operating secondary post jigs 50 and hydraulic cylinders 29, is arranged to be connected directly with the copper bands 4 and 6 by squeezing about these at opposite sides of the forging tools 16 (Figs. 5-7).

[0015] The forging tool 16, which consists of a lower part 30 mounted on a stationary pressing plane 5 and an upper part 32 mounted on a movable pressing plane 7 (Fig. 7), is shown in more detail in Fig. 2. The lower part 30 has a central form part 34 with a hollow 35 the opposite walls 36 of which are shaped with a large number of narrow, vertical inlet apertures 38 for protective gas (nitrogen). The upper part 32, which is guided

in relation to the lower part 30 by means of guide bushings 40 and post jigs 42, is designed with a central form part 44 fitting rather tightly in the hollow 35 of the form part 34 of the lower part.

[0016] As it appears more clearly from Figs. 3 and 4, both the lower part 30 and the upper part 32 of the forging tool 16 are provided with connecting stubs 46 for a water cooling system and with connecting stubs 48 for supplying protective gas (nitrogen) to the form part 34 of the lower part.

[0017] Besides, and shown most clearly in Fig. 3, the hollow 35 of the form part 34 of the lower part is provided with bevelled edges at the side walls 38 and at the bottom of the hollow 35 at opposite ends of the hollow 35, i.e. as seen in the direction of movement of the copper bands 4 and 6, so that there is ample space for the slightly wider central part of the copper bands 4, 6 and the conductor 15, respectively.

[0018] In Figs. 5 and 6 is seen how the forging tool 16 is mounted between the secondary post jigs 50 for the squeezing arrangement, also water cooled, at both sides of the forging tool 16. The squeezing arrangement comprises active upper and lower squeezing jaws 28 that are placed relatively close to the forging tool 16, and which in Figs. 5 and 6 are hidden by the side walls of the inlet duct 12 and the outlet duct 18, respectively, which at opposite sides of the central hollow 35 of the lower part 30 of the forging tool 16, in order to retain the protective gas, is furthermore sealed by suitable flexible packings allowing passage of the copper bands 4, 6 and the produced and still coherent conductor 15, respectively.

[0019] Figs. 5 and 6 also show that the upper and lower squeezing jaws 28 of the water cooled squeezing arrangement in practice are connected to the secondary winding 26 of the adjustable transformer 24 by means of thick, flexible, braided copper conductors 27.

[0020] To the left in Fig. 8 is suggested how a double conductor 15 by means of a lower part 30 and upper part 32 of the forging tool 16 are compressed and forged over a part of the length so that the part concerned appears as a solid and homogenous piece of copper which, as shown to the right in Fig. 8, is punched apart by means of a two-part tool 23 in direct connection thereto, e.g. in a separate eccentric press, so that in one and the same operation end terminals 21 are formed on each conductor 15, said terminals 21 simultaneously being shaped with connecting holes 19 and rounded end edges.

[0021] The simultaneous compressing and forging of the said part of the length of one or more copper bands occurs in the following way:

[0022] At each side of the forging tool, an adjusted current is transmitted from a transformer through two water cooled jaws between which the copper band or bands extending through the forging tool are fixed. The current from the transformer is regulated by means of a welding control in such a way that the current is

switched off when the copper band or bands are red-hot (about 1050°C). The signal switching off the current from the transformer is simultaneously the starting signal for the eccentric press which then runs a cycle. The result is that the copper band or bands on the part extending between upper and lower part of the forging tool are compressed and forged to a solid and homogeneous piece of copper as a fluid borderline, however, exists between the flexible and the solid copper. The forged, still coherent conductor may then be coiled on a storage coil for later finishing. Alternatively, the conductor may be passed directly to a combined punching/rounding/cutting tool mounted in a succeeding eccentric press where end terminals simultaneously are made on two neighbouring conductors. Finally, adapted/shortened insulation may be fitted onto the flexible part of the conductor (the flex conductor).

[0023] The conductor is made from flexible, braided copper bands, e.g. with the following dimensions:

Type A: 1 x 25 mm² (160 A)
 Type B: 2 x 25 mm² (250 A)
 Type C: 2 x 120 mm² (630 A)

[0024] In order to suffice for the most common amperages, the types of conductors may be combined, for example

a conductor for a current of 160 A may be constituted by one type A,
 a conductor for a current of 250 A may be constituted by two type A,
 a conductor for a current of 315 A may be constituted by two type B,
 a conductor for a current of 400 A may be constituted by two type B,
 a conductor for a current of 800 A may be constituted by two type C,
 etc.

Claims

1. A method for making a flexible conductor with connecting terminals at both ends and consisting of one or more flexible, braided copper bands, **characterized** in that a copper band, preferably from a coil, is supplied to a two-part forging tool in a press, e.g. an eccentric press, that protective gas (nitrogen) is supplied to the forging tool for protecting the structure of the copper and for displacing oxygen and avoiding discolouring of the copper band, that the copper band is subjected to a very great current intensity between points at each side of the forging tool so that the part of the copper band situated in the forging tool is heated to red-hot condition, that the current is switched off and that the press is simultaneously activated for bringing together the tool parts for compressing and forging

the said part of the copper band so that it subsequently appears as a solid and homogenous piece of copper of which the connecting terminals are formed, either by an immediately succeeding operation or by a later operation.

2. A method according to claim 1, **characterized** in that there are used two, preferably identical, copper bands which are supplied to the tool in the press from each their coil, and that the copper bands are connected to the secondary winding of a transformer at each side of the tool by means of squeezing jaws.
3. A method according to claim 1 or 2, **characterized** in that there is used a forging tool which is maintained at an operational temperature of about 90°C by heating and/or cooling.
4. A method according to any preceding claim 1, **characterized** in that there is used a forging tool which is enclosed in aluminium (90%)/steel (10%) and that the enclosure is filled with protective gas during the whole process (heating, forging and cooling) for protecting the structure of the copper and for displacing oxygen around the copper band.
5. A flexible conductor provided with connecting terminals at opposite ends made by the method according to claim 1, comprising one or more flexible, braided copper bands, **characterized** in that it consists of one copper band on which the connecting terminals are made by compressing and forging of a part of the band corresponding to twice the length of one connecting terminal between two conductors, where the part of the band is heated to red-hot condition prior to the forging by conducting a very great current intensity through it, and that the individual connecting terminals are formed subsequently by dividing up the part of the length and preferably simultaneous forming of connecting holes.
6. A flexible conductor according to claim 5, **characterized** in that it consists of two, preferably identical, copper bands disposed with their flat side against each other and which at opposite end are designed with uniform common, integrated end terminals of solid and/or homogenous copper.

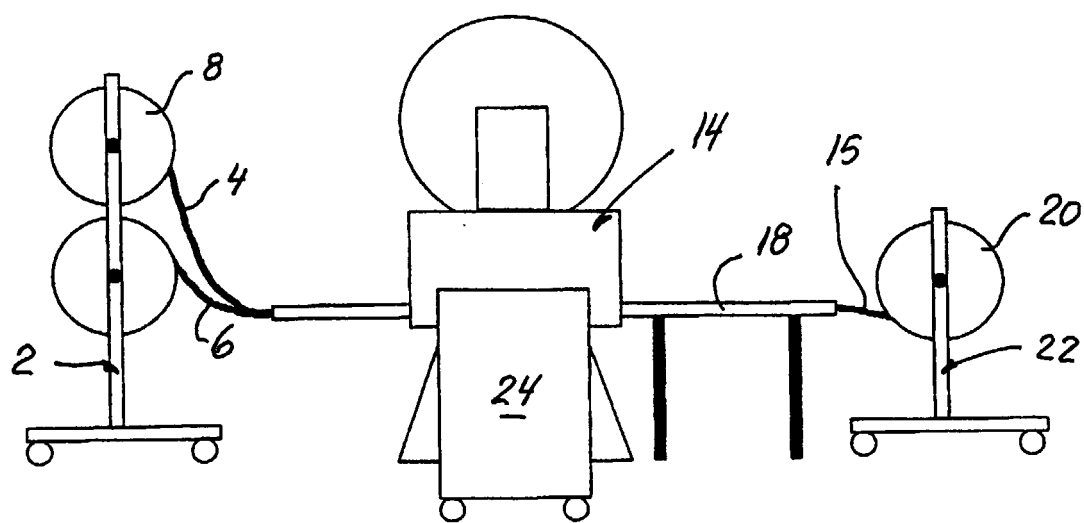


Fig. 1

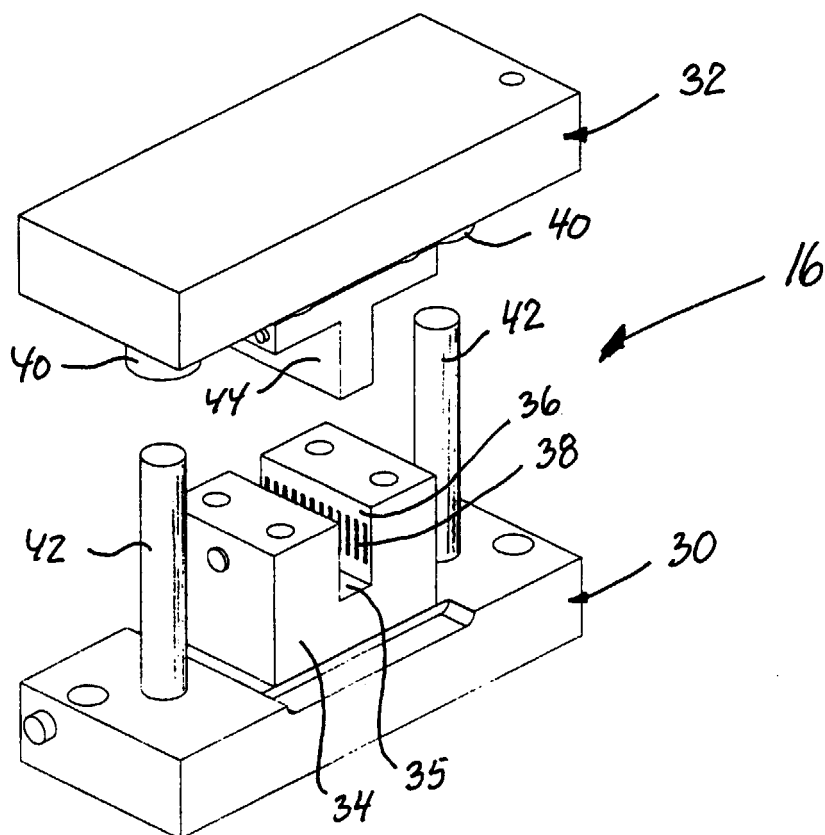


Fig. 2

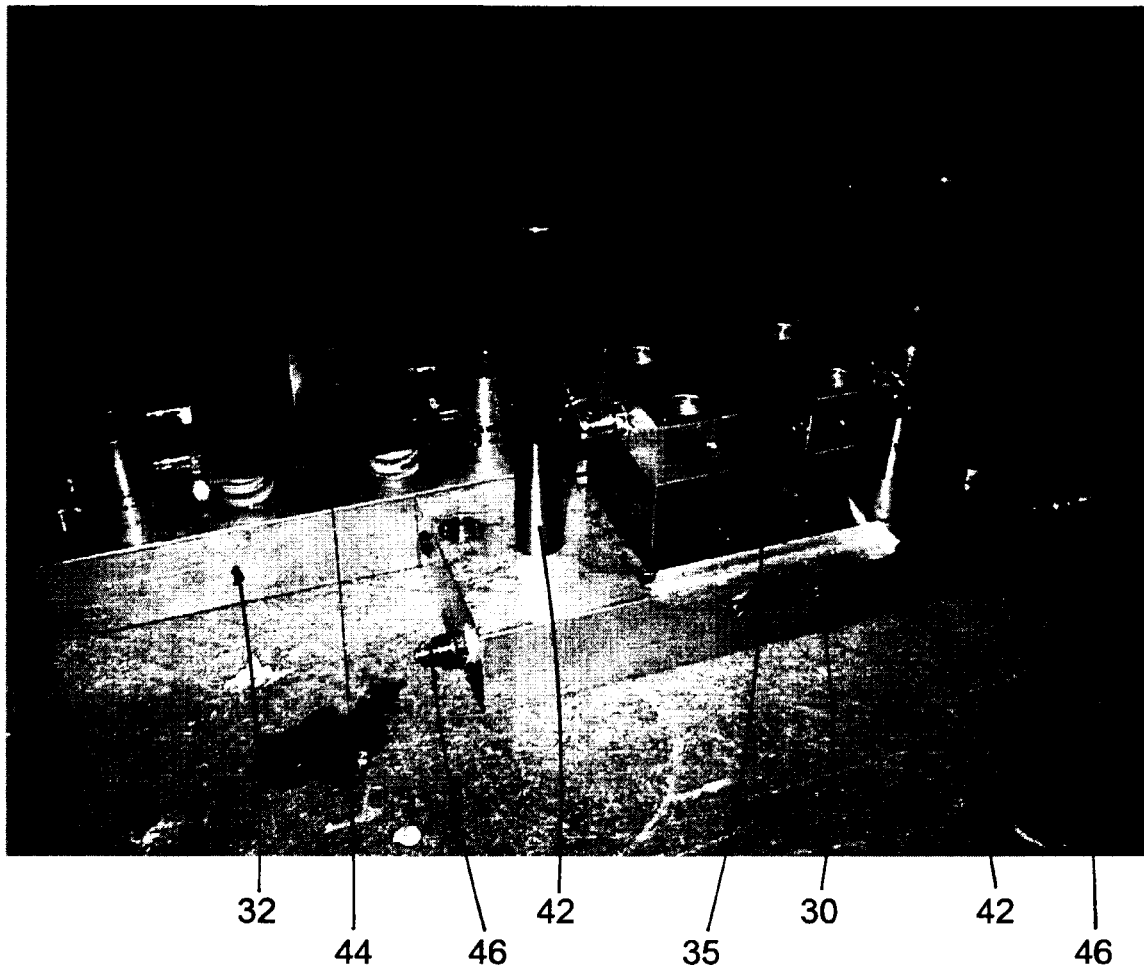


Fig. 3

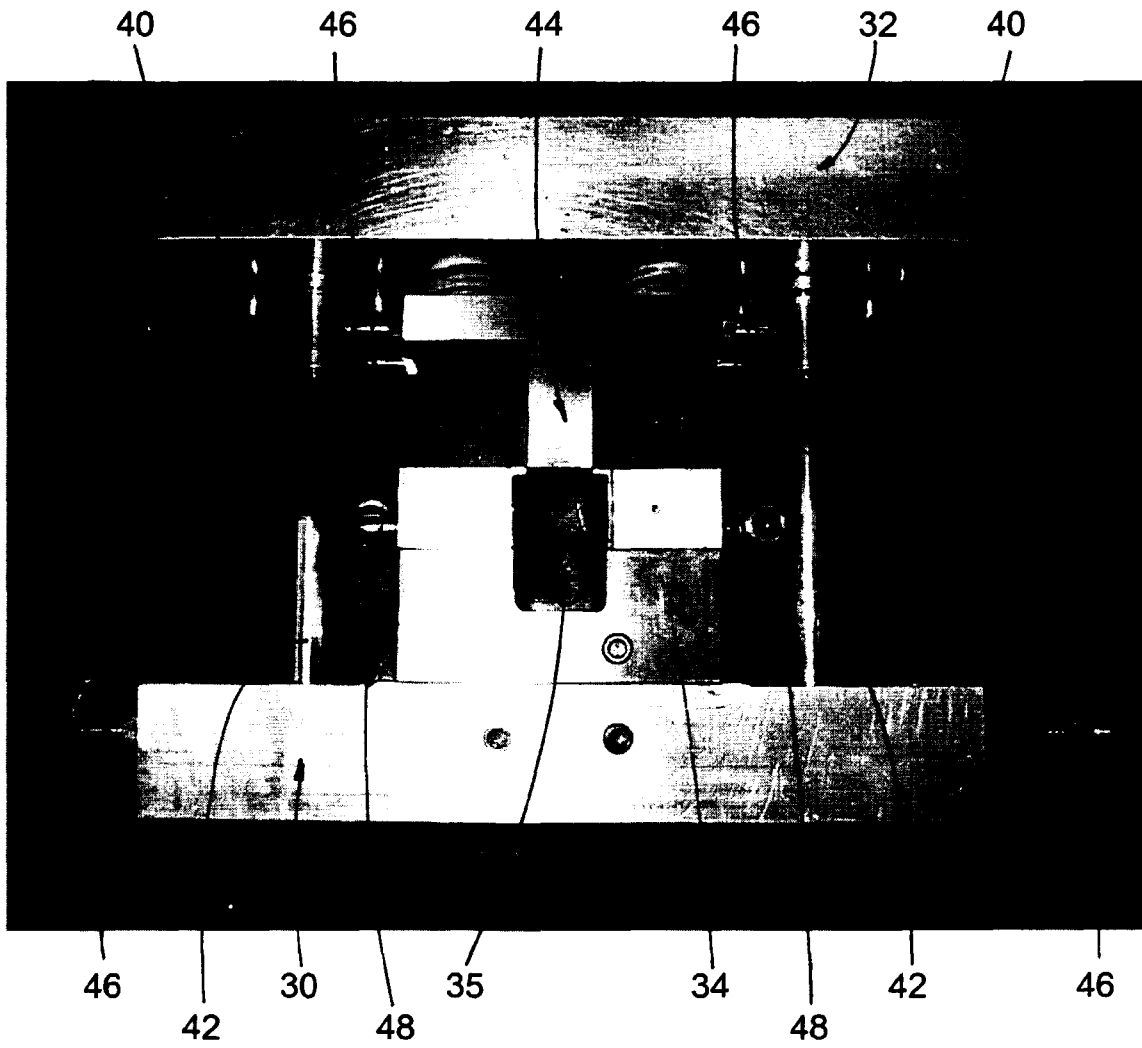


Fig. 4

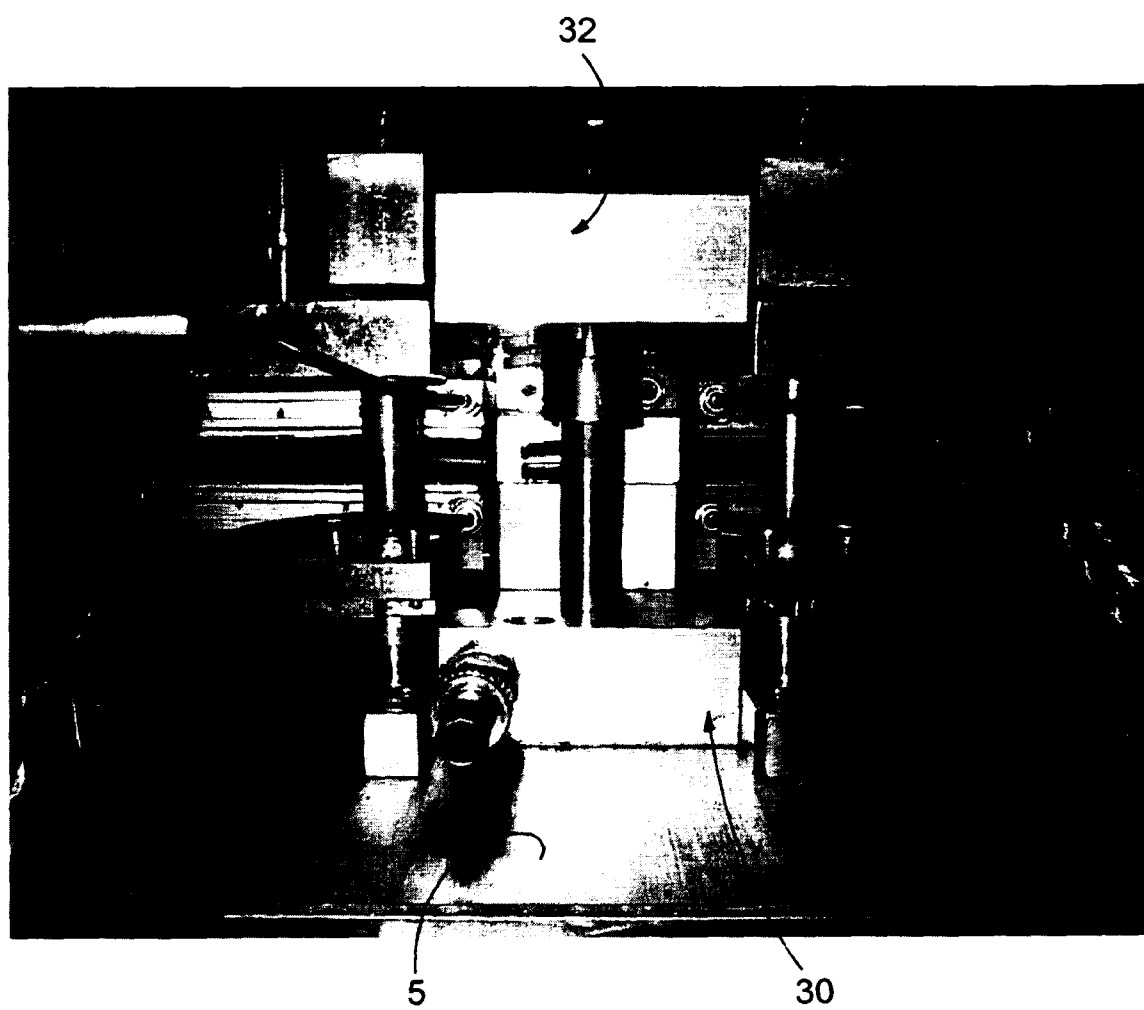


Fig. 5

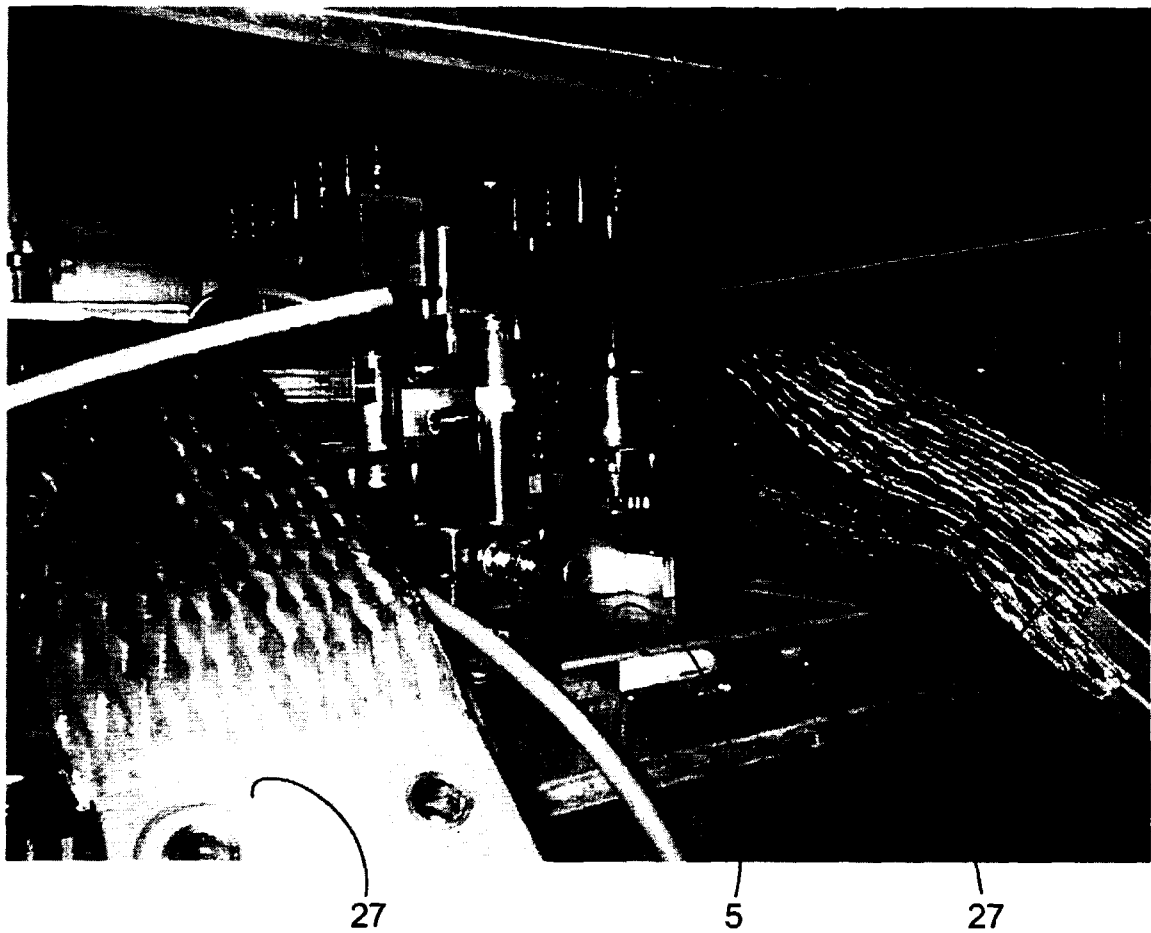


Fig. 6

