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TECHNIQUE FOR WIRING CONNECTIONS OF ELECTRICAL
APPARATUS OR A MODULE OF CIRCUIT ELEMENTS

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5 The invention relates to a technique for
wiring terminals of electrical apparatus or a
module of circuit elements with the aid of
controlled mechanical wire-laying means, in
particular to wire-laying means adapted to carrying
out this technique, as defined by the preamble to
10 Claim 20, and a terminal configured for use in this
technique, as defined by the preamble to Claim 28.

In practical applications on electrical
apparatus or of a module of circuit elements,
"wiring" means connecting terminals to an electric
15 wire and making contact with this wire at the
respective terminal, in order to establish an
electrical connection, for example with the
associated circuit element. This kind of wiring is
required in the majority of electrical apparatuses
operating in the low-current range, including
20 electronic switching-controlling and regulating
instruments and in modules of circuit elements,
this latter overall term being understood to
include in particular such elements as printed
25 circuit boards, plug-in units, etc., which in the
commercially usual fashion are designed as units
and are intended to be inserted into electrical
apparatuses. For the wiring itself, as a rule
circuit wires, which are provided with a lacquer
30 coating or a sheath of insulating material, or
insulated flexible cables are used as the
conductors. The conductors, from which the
insulation is removed at their ends, are connected
in the zone of contact of the respective terminal
35 by employing various known connecting techniques
(such as screwing, plug-in connection, soldering,
piercing-clamping technique, crimping). The
operations required for the wiring are even today
carried out predominantly by hand. This is time-

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consuming and frequently requires trained workers; the resultant expenses are therefore considerable.

For the sake of more-rational production, particularly in the manufacture of larger series of identical electrical apparatuses, it is known to
5 prepare the conductors or to produce partial or complete cable harnesses, i.e., to produce a typical preassembled product, in a first region far from the electrical apparatus. After that, this
10 preassembled product is mounted in the respective apparatus or the final product. This final assembly includes basically establishing contact or connecting the various conductors of the preassembled product in the zones of contact of the
15 terminals and laying out and fastening the prepared conductors or cable harnesses inside the apparatus. Nowadays automated preparation systems are already used for preparing the conductors, whereas the ensuing processing of the prepared conductors for,
20 say, the production of partial or complete cable harnesses, like the operations at the proper site of wiring, are carried out almost exclusively by hand.

A number of techniques and systems have been
25 known for the automated production of cable harnesses (US Patent 4,677,734, German Published Patent Applications DE-OS 36 08 243, 36 11 805, 38 20 636, and 38 20 638; and Swiss Patent 598 740), all of which employ the so-called laying boards and the like. However all these techniques require
30 very high industrial investments which can be acceptable only for relatively large series of apparatuses. In any case, with this technique there remains the basic problem that the final
35 assembly of the prepared conductors or cable harnesses involves considerable expenses for labour so that the attainable degree of rationalization remains limited. Besides that, layout of the wires within the apparatus often must be chosen with

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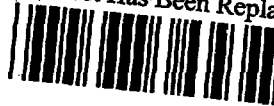
proper regard for the preparation of the conductors or cable harnesses, and this implies long layout lines, detours, branching, loops, and bi-directional movements of clamping means.

5 Therefore, the problem underlying the invention is to create a wiring technique for electrical apparatus and modules of circuit elements which makes it possible to substantially rationalize the wiring work in comparison with
10 known techniques, while at the same time high reliability of operation and a reduction of the chances for mistakes in the wiring are ensured.

In order to solve this problem, the technique according to the invention has the characteristic
15 features recited in Claim 1.

The new technique provides for rational complete automation of the wiring of electrical apparatus and modules of circuit elements. It makes it possible to do without prepared conductors
20 and partial or complete cable harnesses, because direct assembly of the conductors is carried out in the apparatus or the module of circuit elements proper. It is possible to make contact fully automatically with a conductor in the form of a
25 continuous wire at terminals provided with suitable, automation-fitting contact areas and to lay the conductor out in the wiring work in a well-defined fashion between the points of connection and to cut it finally. In this direct mounting of
30 the conductor, the requisite electrical connections are produced in series and fully automatically. Possible continuous wiring, i.e., connecting a conductor to a number of terminals, means an important advantage. It is in fact possible to do
35 without the plurality of conductors which in the past were needed for that purpose. This not only means savings in the number of conductors, but also avoids double connections at connection points and multiple laying out to the same connection points.

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Since the conductors are laid out directly and continuously and, since, as mentioned above, the production of preassembled products, i.e., the preparation of conductors, are redundant, a very high degree of rationalisation is obtained while, at the same time, fewer changes of directions are required in the laying operation proper. Branch points, loops, etc., which so far were required with a view to preassembly of conductors or the bundling of conductors in partial or complete cable harnesses, are to a great extent superfluous. But in comparison with the state of the art, there are fewer connection points, which implies increased reliability of the wiring and reduction of the chances for mistakes.

In the case of laying long lines of wire in dependence upon a structure, a support or retention point can be introduced within the working range of the wire-laying means and properly placed with respect to the same by means of a relative movement of the prepared apparatus or module of circuit elements, with the conductor being introduced by the wire-laying means into a wire holder at the support or retention point and affixed thereto. In the resumed direct wiring operation, the conductor is run from this support or retention point to the next connection point in the zone of contact of which contact is once more made with the wire which, if necessary, is then cut.

In the new technique, contact can be established with both the beginning and the end of the wire, as well as with a continuous wire, at the points of connection which are reached in successive controlled movements. Since the beginning of the wire is fixed when the wire laying operation is started, the strain relief required in direct laying of the wire can be obtained by simple forced synchronisation of length of wire paid out by the wire-laying means in a wire-laying operation

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between two terminals with the relative movement between the prepared apparatus or the module of circuit elements and its wire-laying means. The length of wire paid out by the wire-laying means may be dimensioned so that the wire laid out between the terminals is completely free of strain. If necessary, this wire may also be laid out with excess length, e.g., in sagging form. If it should be desirable in certain cases for the wire laid out between two terminals to be kept under a certain tensile strain, this may also be achieved by a simple appropriate tuning of the wire-laying means to the cited relative movement between the preassembled apparatus or the module of circuit elements.

It is advantageous for practising the novel wiring technique if by the relative movement between the preassembled apparatus or module of circuit elements and the wire-laying means, the wire-laying means are transferred only close to the respective terminal, whereupon the wire-laying means in a placing movement are transferred into the proper position relative to the terminal. It is achieved in this way that the movement of the wire-laying means along the preset path of wire laying does not have to satisfy excessive requirements in regard to accuracy, while, at the same time, precise initial placement of the terminals proper or of the components carrying the same in the electrical apparatus or the electrical module of circuit elements is unnecessary. The placement movement required for precise placement can be imparted to the wire-laying means, which were transferred close to the respective terminal, by direct cooperation between a laying tool of the wire-laying means and the appropriately configured terminal or guide means provided on the same, to mention a quite simple facility. But one may proceed also in such a way that with wire-laying

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means with position-filling means transferred close to the terminal, the deviation of the wire-laying means from the position of the terminal is determined and the deviation is thereafter
5 automatically compensated. Any sensor means can be employed to determine the deviation. An image-processing system associated with the wire-laying means proved to be particularly convenient for this purpose, which for recording an image is moved
10 close to the point of connection and which comprises image-evaluating means with which the compensation of the deviation is computed, whereupon there is outputted a corresponding control signal which is processed for controlling
15 one direction of motion of the wire-laying means.

In principle, the relative motions between the preassembled apparatus or module of circuit elements and the wire-laying means, which motions are required when the novel wiring technique is
20 practised in direct wiring, can be effected in various ways. For example, the wire-laying means may be controlled by a multiaxially movable manipulator or industrial robot whose movement is programmable along at least one axis. Before the
25 wiring work is initiated, the preassembled apparatus or module of circuit elements is arranged in some stationary position within the working region of the manipulator or industrial robot. Assigned to the same is a suitable control unit in
30 which the path coordinates required for the laying were programmed so that the wire-laying means perform the required travel and placement movements and carry out additional functions, such as, for example, the above-mentioned compensation for
35 deviations, by means of appropriate system components (sensor system, etc.).

Alternatively, however, one may proceed by arranging the wire-laying means in stationary position or at placement means imparting only a

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positioning movement, and by moving the preassembled electrical apparatus or module of circuit elements by transporting means movable relative to the wire-laying means. The transporting means are likewise connected to a programmable control unit which makes it possible to fully automatically obtain the appropriate laying lines for the directly wired conductors. Therefore the result of the operations is the same. Which of these two kinds of procedures will be chosen in a particular case depends, inter alia, on the type of apparatus or module of circuit elements which is to be wired.

The relative movement between the preassembled apparatus or module of circuit elements, which is carried out in the manner described for direct wiring, basically can be chosen in some way in dependence upon local conditions within the apparatus or module of circuit elements, with curved lines of laying being possible too. But as a rule, this relative movement is at least over sections substantially rectilinear so that straight lines of laying are obtained at least over sections.

The zones of establishing contact at the various terminals must be configured to conform to automation, i.e., after their placement at the respective terminal, the wire-laying means must be able to introduce the wire fully automatically into the respective zone of contact and to establish contact within the same. It was recognised that this requirement can be met in a particularly simple way by employing zones of contact with contact means acting according to the principle of the piercing-clamping technique, with the wire being pressed by the wire-laying means into the contact means, establishing electrical contact. The piercing-clamping [IDC] technique renders a high-quality electrical connection of the electric

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conductor of the line to be connected with the contact means because it effects large-area, gas-tight contact establishment in the manner of a cold weld. Since contact with the wire is established immediately after cutting open the insulation, oxidation of the conductor surface cannot occur as would be the case when the insulation is removed from the ends of the conductors in a special operation prior to establishing contact. For the purpose of attachment, when the wire is pressed in, the wire is conveniently retained by clamping on at least one side of the IDC terminal means. Insertion by pressing-in is advantageously carried out by exerting a pressing force on the wire on both sides of the IDC means so that when the wire is pressed in, it remains perfectly aligned and contact is reliably established and the wire is kept clamped.

If there is no continuous wire laying at the point of connection, the wire is cut directly at the wire-laying means or, by appropriate configuration of the IDC means, directly at the same, whereby protection against accidental contact of the wire end with which contact was established is produced at the same time. Since removal of insulation is redundant, at each point of contact there is saved a small length of wire in comparison with other techniques of making connections, which implies significant savings in the total length of the continuous line required for the entire wiring.

As already mentioned at the beginning, the novel fully automated technique of direct wiring can be employed basically in all electrical apparatuses and modules of circuit elements without previous preparation of conductors etc. However, it was observed that a very interesting application involves the automated wiring of luminaires or their parts. As a matter of fact, such luminaires have a relatively large light box the dimensions of

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which are chosen with proper regard for luminous elements to be housed therein, such as gas discharge lamps, etc., and also contain some standardized associated circuit elements accommodated in the light box. Today, wiring of the connection points of these circuit elements is often done entirely manually; this is expensive and laborious.

The novel wiring technique is carried out with appropriately configured wire-laying means which make it possible to carry out the various functions required in the work. An especially suitable embodiment of such wire-laying means for this purpose is the object of claim 20 preamble of which starts from a state of the art as defined by the wire-laying tools known from German Published Patent Applications DE-OS 36 06 059, 36 11 805 and 38 20 636.

The stated problem is to create wire-laying means which ensure fully automated, perfect attachment of, and contact with, the wire at the respective point of connection.

In order to solve this problem, the laying tool included in the wire-laying means has the features according to the invention as recited in the characterising part of Claim 20.

By arranging a pressure-application member near the mouth of the guide conduit or guide tube of the wire for the wire emerging from the mouth one accomplishes that the wire can be pressed in the contact area of the point of connection in aligned and perfectly supported fashion. In this way high safety of the wiring can be ensured at the point of connection and, at the same time, any finishing work becomes superfluous. The zone of contact at the point of connection is usually formed in the aforementioned IDC technique, but, in principle, the new tool can be used for other connection techniques as well in which it is

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important to introduce, particularly to press in, the end of a wire or a piece of a wire with a predetermined orientation into a slit or a matching receptacle of clamping means existing at the
5 respective point of connection,

In an advantageous embodiment, the pressure-application member is a ram guided for longitudinal movement along the housing or along a part of the laying tool joined with the same, with the ram
10 usually arranged in parallel relationship to the laying tool's so-called laying finger configured likewise as a ram and spaced from the same so that when the conductor is pressed into the zone of contact, the conductor is supported at equidistant
15 points. The mouth of the guide conduit or guide tube of the laying tool is conveniently situated on the side of the laying finger's side facing the pressure-application member, wherein the pressure-application member and the laying finger may have
20 at least in some sections substantially equal width as measured across the longitudinal direction of the wire emerging from the mouth of the guide conduit or guide tube. In this way a very simple design of the point of connection can be obtained.

In order to cut the wire at the point of
25 connection, one can use, for example, an IDC terminal having a cutting edge which acts when the wire is urged into the zone of contact. It suffices in this case to provide the aforementioned
30 pressure-application member on the laying tool. If such a cutting edge at the terminal is omitted, it is advantageous to provide on the laying tool controlled cutting means for the wire, which have
35 at least one movable cutting blade arranged in the area between the mouth of the guide channel and the pressure-application member. This cutting blade may be supported to act directly at the laying finger, with the edge of the mouth of the guide conduit being formed as a counterblade. The

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conductor can be cut near the zone of contact or directly in the zone of contact.

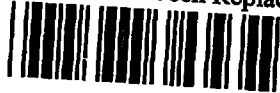
Finally, the laying finger of the laying tool is usually affixed to its housing or to a part joined with the same; but it may also be supported to be movable and may be coupled to proper setting means.

As mentioned above, the novel technique of direct wiring can be practised in a particularly simple fashion by using terminals the zones of contact of which are configured to conform to the so-called piercing-clamping [IDC] technique. This technique has been described, for example, in the journal "Messen + Prüfen/Automatik" [Measurement + Testing/Automatic Systems], July/August 1982, pp. 491, 492; as to the design of corresponding IDCs or IDC terminals, reference is made, for example, to German Model-of-Utility Patent DE-GM 88 04 388, to published French Patent Application 2 330 159 and to US Patent 2,501,187. Based on this prior art, the stated problem is to create a terminal [point of connection] to be used in the aforementioned technique and with application of the above-mentioned wire-laying means, which terminal is designed so that operationally safe contact establishment and fixation of the connected wire is ensured in a simple, efficient way and that, at the same time, automated execution of the technique is not impeded.

In order to solve this problem, the terminal according to the invention has the features recited in the characterising part of Claim 28.

The slit-like or groove-like indentation provided at the housing of the clamping terminal means ensures protected, all-insulated enclosure of the cut end of the wire, on the one hand, without need for additional operations or measures. On the other hand, if necessary, it may form centering means for the laying finger and/or the pressure-

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application member of the laying tool when the wire is introduced into the zone of establishing contact. When the wire is introduced, the IDC terminal itself causes some automatic height compensation because it is only important that the wire be firmly held in the piercing-clamping seat within a certain range of height variations.

The housing's insertion slit at the point of connection may have a width resulting in attachment of a pressed-in wire by clamping so that the wire is fixed independently of the zone of contact proper. The indentation in the housing may also be arranged to be confined on both sides by IDC terminals or on one or both sides of an IDC terminal.

The technique according to the invention is described below by way of an embodiment with reference to the drawing. In the drawing, there show:

Fig. 1, a perspective schematic view of a preassembled light box to be wired according to the technique of the invention;

Fig. 2, a partial perspective view of the terminals designed according to the invention, for a ballast unit of the light box of Fig. 1, on a different scale;

Fig. 3, a partial plan view of a terminal of the arrangement of Fig. 2, on a different scale;

Fig. 4, a plan view corresponding to Fig. 3 of a terminal of the arrangement of Fig. 2, in a modified embodiment;

Figs. 5-7, side views of a clamp of a terminal of the arrangement of Fig. 2, taken along the line V-V of Fig. 3 or of line VI-VI and line VII-VII of Fig. 5;

Fig. 8, a schematic perspective view of the terminals designed according to the invention, of the clamping block of the light box of Fig. 1, on a different scale;



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Fig. 9, a perspective view of the terminals according to the invention, of a lamp socket of the light box of Fig. 1, on a different scale;

5 Fig. 10, a schematic side view of a system for practising the technique according to the invention with the aid of an industrial robot;

Fig. 11, a plan view of the system of Fig. 10;

10 Fig. 12, a schematic side view of a system for practising the technique according to the invention with the aid of a portal-type manipulator;

Fig. 13, a schematic side view of a further embodiment of a system for practising the technique according to the invention, using a manipulator with a movable transport table;

15 Figs. 14 - 20, a schematic sectional representation of the laying tool of the system according to Figs. 10 and 11, in its placement relative to the point of connection of a ballast unit of the light box of Fig. 1, illustrating
20 various chronologically successive phases of the technique according to the invention when the continuously supplied wire is connected to the first terminal;

25 Figs. 21 - 29, each as a corresponding representation of the arrangement of Figs. 14-20, chronologically successive steps of the technique after attachment of the wire end, during laying of the wire to the next terminal, while making contact, and the subsequent cutting of the wire at
30 this point of connection;

Fig. 30, a schematic plan view of the light box of Fig. 1 in the state of wiring after conclusion of the part of the wiring illustrated by way of Fig. 14-29, on a different scale;

35 Figs. 31 - 33, in a representation similar to that of Fig. 14 to 19, the wire-laying means of the system according to Figs. 10 and 11, placed relative to an other ballast unit of the light box according to Fig. 1, with chronologically

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successive steps in practising the technique according to the invention, when the next section of wiring is being completed; and

5 Fig. 34, the light box of Fig. 30 in its state after completion of the wiring section made with the technique according to Fig. 31 to 33.

The technique for direct wiring of electrical apparatuses and modules of circuit elements will be described below by way of the wiring of a
10 rectangular light box 1, shown in Fig. 1, for two rod-shaped gas discharge tubes, not shown in further detail. For operation the light box is covered with a transparent acrylic glass hood or reflector, which is clamped in holder means 2 and
15 not shown in further detail.

The light box has already been preassembled insofar as the electrical circuit elements required for accommodating and operating the gas discharge lamps were firmly affixed to, or screwed onto, the
20 box bottom 3 in their proper positions according to a predetermined plan of the layout. As to details, four lamp sockets 4 of known design are provided in pairwise facing relationship near the front walls of the box, and two magnetic ballast units 5 are
25 associated with each pair and situated approximately along the centre line of the box bottom 3, on either side of the wire-inlet openings in equal distances from the front faces of the box. A socket of insulating material, which supports a
30 capacitor 8, is fixed near the wire-inlet openings 6 likewise on the centre line of the box bottom 3. On the lamp sockets 4, the ballast units 5, and the socket 7 of insulating material there are provided points of connection for electrical wires which are
35 denoted by 9 at the lamp socket 4, by 10 at the ballast units, and by 11 at the socket 7 of insulating material. All these points of connection 9, 10, 11 have a zone of contact conforming to the IDC technique following the same

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basic principle. Details of the design can be recognised in Figures 2 to 9; they will be explained specifically by way of the terminal 10 of a ballast unit 5 with reference to Fig. 2 to Fig. 7.

Each terminal 10 has a housing 12 of substantially rectangular cross section, made of insulating material, mounted on a base 13, likewise made from insulating material, so that there is obtained a unitary connection clamp or terminal which at 14 is attached to a stamped, upward-bent tab of a baseplate 15 of the ballast unit 5. The two side walls 16 of the housing 12, which is open on top, have on their inside two moulded facing ribs 17 which are situated approximately in the middle between the two faces 18 of the housing 12 and delimit inbetween a slightly wedge-shaped insertion slit 19 or an insertion slit with parallel sides (Fig. 6) which flares toward the top in the form of insertion ramps 20. The lower part of the insertion slit is locally somewhat broadened at 21 in a partially circular region.

Two narrow facing grooves 22 extend from below approximately to the level of the insertion ramps 20, to accommodate the two legs of an IDC terminal 25 made from spring steel or spring bronze, with the legs confining an IDC slit 23 which is open at the edges. The narrow, plate-shaped, substantially U-shaped IDC terminal 25 is embedded on all sides in the insulating material of the housing 12 except for the cutting sections formed on the legs 24 and facing the IDC slit 23, with the two legs 24 adapted to be guided for limited movement within the grooves 22. In a manner not shown in further detail, one end of the winding of the ballast unit 5 is connected to it. Together with the IDC slit 23, it forms the zone of making contact of the point of connection 20.

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As can be seen particularly from Figs. 3 to 7, the housing 12 has one groove-like indentation 26 of rectangular cross section on either side of the ribs 17 and, hence, near the insertion slit 19, with each indentation opening toward the top of the housing 12. The two groove-like indentations 26 are aligned with each other and with the insertion slit 19. On top they are likewise delimited by an insertion ramp 27. Figures 5, 7 show that the depth of the groove-like indentations 26 exceeds that of the insertion slit 19 and that also their width 28 substantially exceeds the width of the insertion slit 19.

The dimensions of the various parts are chosen so that for an insulated conductor pressed in through the insertion slit 19, the insulation is cut open in the IDC slit 23 by the legs 24 of the IDC terminal 25 and that, at the same time, gas-tight contact is established between the IDC terminal 25 and the conductor which is being deformed at the point of clamping. The pressed-in conductor is at the same time retained clamped in the insertion slit 19 between the two ribs 17, and the flaring section at 21 serves to ensure locking of the wire by its insulation upon pressing into the insertion slit 19. The connected wire which was fixed in this way runs through one of the groove-like indentations 26, whereas its cut end is situated within the other groove-like indentation 26, as will be described in detail hereinafter. The width and depth of the groove-like indentations 26 and their axial length are dimensioned so that protection against accidental contact results automatically for the cut end of the wire. This means that, in a test for shock protection, the standardized sensing finger cannot penetrate to the bare cut end at the depth of the respective groove-like indentation 26.

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In the above-described embodiment of the housing 12, two groove-like aligned indentations 26 are provided on both sides of the insertion slit 19 the widths and depths of which considerably exceed the diameter of the wire to be accommodated. One can also contemplate omitting one of the groove-like indentations 26, and this is of interest particularly if the wire is only run through the terminal, as will be explained below. In certain cases, the two groove-like indentations 26 may even be omitted.

Fig. 4 shows a plan view of an other embodiment of housing 12: In this embodiment, there is only one groove-like indentation 26 which is confined in the housing 12a on both sides by one pair 17 of ribs each with an insertion slit 19 inbetween and by a contact element 25 protruding with its legs 24 into the same. The ends of each of the pair of ribs are moulded to be flush with the side walls 16a in the housing 12a and have their insertion slits 19 aligned with the longitudinal axis of the groove-like indentation 26.

While in the embodiment of Figs. 2 and 3 a cut end of a wire is situated near the zone of contact formed by the IDC element 25 (see, for example, Figs. 27-29), in the embodiment of Fig. 4 it is ensured that the cut end will be within the zone of contact defined by the two IDC terminals 25, i.e., within the housing 12a which is closed on all sides except for the insertion slit.

The terminals 11 which are arranged on the base 7 of insulating material are basically of the same design as the terminals 10, as can be inferred from Fig. 8. Reference is therefore made to the description pertaining to Fig. 2 to 7. Identical parts have the same reference numbers.

A total of three terminals 11 are arranged on the base 7 of insulating material; two of them are combined to form a connection-clamp unit which is

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denoted by 28 and has a unitary housing 12b. Clamps for internal connection to the terminals of the capacitor 8 are indicated at 29.

5 The design of the terminals 9 of the lamp sockets 4 is basically identical with the design of the terminals according to Fig. 2, 3. Therefore, in Fig. 9 identical parts are characterised by the same reference numbers and reference is made to the description pertaining to Fig. 2, 3.

10 While the housings 12, 12b at the points 10, 11 of contact (Fig. 2, 8) point with their insertion slits 19 and the groove-like indentations 26 in the longitudinal direction of the ballast unit 5 or of the starter 6 and, hence, of the
15 bottom 3 of the light box (Fig. 1), the arrangement of the lamp sockets 4 is such that the housings 12 are mounted on a fastening base 30 of the respective lamp socket 4, with insertion slits 19 and groove-like indentations 26 extending
20 perpendicular to the longitudinal extent of the gas discharge lamps to be inserted and, hence, of the bottom 3 of the lamp box. Therefore, wires to be connected must be pressed into the insertion slit 19 at the lamp sockets 4 at right angles to the
25 longitudinal extent of the lamp box 3.

The wiring of the light box 1 described in connection with its circuit elements 4, 5, 7 and their terminals 9, 10, 11 is effected with the aid of an industrial robot as shown in Fig. 10, 11 or a
30 manipulator as shown in Figs. 12, 13 moving the wire-laying means, as will be described below by way of Figs. 13 et seq.:

35 The wire-laying means, generally denoted by 31, in the system according to Fig. 10, 11 are mounted on the two-component arm 32 of an industrial robot 33 which has a column 36 rotatable about a first stationary vertical axis 34, for



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instance by a stepper motor drive 35, which column supports a first arm member 37 connected at its free extremity with a second arm member 40 through pivotable bearing means 39 forming a second
5 vertical axis 38 parallel with the first axis 34 of rotation and incremental drive means, with the outer extremity of the second arm member supporting the wire-laying means 31. The two drives 35, 39 can move the second axis 38 of rotation on a circle
10 41 around the first axis 34 of rotation and, with the arm 32 extended, can move the wire-laying means 31 on a substantially circular path 42; lifting drive means 43 associated with the drive column 36 enable a controlled vertical raising and lowering
15 movement of the arm 32 and, hence, of the wire-laying means 31. The industrial robot 33 cooperates with a stationary work table 44 with an integrated conveying mechanism (indicated by the arrow 45 in Fig. 10) which facilitates transferring
20 in succession preassembled light boxes 1 of Fig. 1 on the horizontal working surface of the work table 44 from a remote standby position at 46 (Fig. 10) into the working range of wire-laying means 31 confined by the substantially circular path 42, as
25 indicated by the working position of the light box 1 at 47 shown in Fig. 10, 11. In this position 47, the light box 1 is clamped to the work table 44 in the proper position. The appropriate clamping means are of a known type; they are not shown in
30 detail in Figs. 10, 11. Within its operating range, the wire-laying means 31 can be moved by the programmable industrial robot 33 to any point within the light box 1 and can be moved along any preprogrammed, well-defined path inside the light
35 box 1.

Basically the same is at hand when one uses the portal manipulator 48 shown in Fig. 12 in which the preassembled light box 1 is clamped in its proper position on a light box receptacle 50 on a

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stationary work table 49 and the wire-laying means 31 are arranged on a carriage 51 which is mounted at a portal 52 in such a way that it can be freely programmably moved both in an X direction indicated by a double arrow in the longitudinal direction of the light box and in a transverse Y direction, likewise indicated by a double arrow. Moreover, the wire-laying means 31 are mounted on the carriage 51 and adapted to rotate around a vertical axis 53 of rotation (c axis). Each of the axes X, Y, c of motion, as well as the axis of lifting (z axis) have associated stepper drive means which, controlled by a freely programmable control unit, can transfer the wire-laying means 31 to any point inside the clamped, preassembled light box 31 on the respective preprogrammed path.

Finally, the relative motion which is required between the wire-laying means 31 and the preassembled light box 1 for laying out the wires, i.e., for wiring the points 9, 10, 11 of connection of the preassembled light box 1, can also be obtained with the system of Fig. 13. There the preassembled light box 1 is clamped to an XY table 54 by means of the light box receptacle 50 and each of the axes of its X and Y movements is indicated by double arrows. The wire-laying means 31 are held by a placement system 56 mounted above the XY table 54 on a stationary support 55, with the placement system adapted to impart to the wire-laying means a lifting movement in the Z direction (indicated by a double arrow) and a rotational movement around the vertical axis 53 (c axis). Also in this case, incremental drive means for movement along the XY axis and the zc axis act upon the XY table 54 and the placement system 56 and are controlled by a freely programmable control unit in such a manner that the wire-laying means can be moved to any point within the light box 1 along the respective programmed path.

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The wire-laying means 31, in turn, basically comprise a so-called wire-laying tool 57, if necessary with a multi-component housing 58, which is mounted on the arm 32 of the industrial robot 33 (Fig. 10) or the carriage 51 (Fig. 12) or at the placement system 56 (Fig. 13). A vertical laying finger 59 of substantially rectangular cross section is arranged on the underside of the housing 58 and includes an L-shaped curved wire-guiding channel 62 which opens near a side wall at 60 a short distance from the flat bottom surface 61 of the laying finger 59. The wire-guiding conduit 62 (Fig. 14) contained in the laying finger 59 is continued in housing 57 in the form of a guide tube 65 preceded by a belt drive for a wire indicated at 68 and comprising two pairs 66 of belt rollers (Figs. 12, 13) and endless drive belts 67 wrapped around them.

The belts 67 are guided as parallel lengths of belt with a small spacing and are coupled via the belt rollers 66 with an incremental drive imparting them a controlled driving motion synchronised with the relative orbital movement between the preassembled light box 1 and the wire-laying means 31, which movement can be obtained by the systems according to Figures 10 to 13 when producing the wiring.

A measurement system preceding the belt drive means for the wire 68 and comprising a measuring wheel 70 and a drive roller 71 elastically prestressed into the position of engagement makes it possible to measure the exact advance of the wire 68 without any dependence upon the slip developing between the endless belts 67 of the belt drive so that perfect synchronization of the advance of the wire with the travel of the robot 33, the manipulator 48, or the XY table 54 is ensured.

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The laying finger 59 is usually nonmovably mounted on the housing 57 but it may also be mounted to move up and down along the vertical Z axis and may be provided with appropriately controllable setting means within the housing 58. This is indicated by a double arrow 72 in Fig. 12.

As can be inferred from, say, Fig. 14, at a lateral distance from the laying finger's vertical flat side face 60 enclosing the mouth 74 of the wire-guiding channel 62, or on the housing proper, as per Fig. 12, 13, there is arranged a pressure-application member in the form of a vertically movable ram 76 adapted to be moved up and down via associated drive means mounted inside the housing 58. The movement of the ram 76 is controlled by the control unit according to a program and in dependence upon the travel of the wire-laying means 31. A sensor 77 (Fig. 14) coupled with the ram 76 outputs a feedback signal indicating the respective position reached by the ram's 76 bottom face, which acts as a pressure-application surface, to the control unit so that an accurate setting of the level of the bottom face 78 of the ram 76 relative to the mouth 74 of the wire-guiding conduit 62 is possible.

On the vertical side face 60 of the laying finger 59 there is mounted a knife 79 adapted to move up and down, the drive mechanism of which is accommodated in the housing 58 and is not shown in detail. Its knife blade 80 (Fig. 16) mounted at the lower extremity can be advanced from the standby position illustrated in Fig. 14, 16, 17 into an operational position shown in Fig. 27 in which the wire's 68 end protruding from the mouth 74 of the wire-guiding channel 62 is perfectly cut. For this purpose, the knife blade 80 has transversed the mouth 74, with the underside 81 of the edge of the mouth of the wire-guiding channel

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62 acting as a counterpiece, as can be directly inferred from Fig. 27.

In principle, one can contemplate embodiments in which the knife 79 has a separate associated counterblade which is detached from the laying finger 59.

With the aid of the above-described wire-laying means 31 moved, for example, by the industrial robot 33 (Fig. 10, 11) according to a program along predetermined paths, a preassembled light box 1, which is provided at predetermined points of the light box bottom 3 with the terminals 9, 10, 11 of the above-described form, is automatically wired in the following way, with reference being made to Fig. 14 to 34:

An insulated wire 68 drawn, for instance, continuously from a coil 82 (Fig. 10) is threaded into the laying tool of the wire-laying means 31. It runs between the measuring wheel 70 and the roller 71 and between the two looped belts 67 of the belt drive and is fed by the same through the guide tube 65 into the L-shaped wire-guiding conduit 62. The belt drive has advanced the forward end of the wire 68 so far in the manner recognisable from Fig. 12 to 17 that a section 84 (Fig. 17) protrudes from the mouth 74 of the wire-laying channel 62 and extends under the pressure-application surface 78 of the ram 76.

A preassembled light box 1 was moved into the operational position 47 of Fig. 10 and into the operating range of the industrial robot 33 and clamped there in the correct position on the work table 44 (Fig. 11). The ram 76 is in its raised standby position as per Fig. 16; also the knife 79 is in its standby position above the mouth 74. The belt drive 66, 67 is not moving.

The appropriately program-controlled industrial robot 33 transfers the wire-laying means 31 with the laying finger 59 from a remote standby

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position to the vicinity of the first point of connection which, in this case, is a terminal 10 of the left ballast unit 5 as per Fig. 1. On this occasion, the laying finger 59 reaches about the position of Fig. 14 in which it is situated above, and laterally offset from, the terminal 10.

In this position of the laying finger 59, position-sensing means in the form of an image-processing system 85 with its image-recording unit 86 arranged on the housing 58 are situated above the terminal 10. The image-processing system 85 includes means for image evaluation with the aid of which the deviation of the laying prong's 59 place from the terminal 10 is computed and a corresponding compensating control signal is generated. This signal is processed in the control unit in such a way that the industrial robot 33 - or a placement system arranged between the same and the wire-laying means 31 in analogy to the placement system 56 of Fig. 13 - carries out the requisite compensation of position variations and sets the laying finger 59 into the proper place relative to the point 10 of connection. Once this has been achieved, the laying finger 59 assumes the position of Fig. 16 in which it is accurately aligned above the housing 12 and its groove-like indentations 26.

Then the ram 76 moves into its lower operational position of Fig. 17 in which it rests with its pressure-application surface 78 (provided on the bottom of a longitudinal groove) on the wire's end section 84, which was appropriately advanced out of the mouth 74 of the wire-guiding channel 92, and puts the same exactly horizontally. If necessary, the end section 84 of the wire can be moved forward to the end of the pressure-application surface 78.

The laying tool of the wire-laying means 31 and particularly their laying finger 59 and the ram

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76 are simultaneously lowered along the vertical Z axis. In doing so, the horizontal end section 84 of the wire is pressed through the insertion slit 19 of the housing 12 at the terminal 10 into the IDC slit 23 of the IDC terminal 25 until the wire section 84 locks itself in the wide part 21 of the slit (Fig. 6). In this pressing-in motion, an equally large, uniform pressing force is exerted from the upper side of the wire-guiding channel 62 and the pressure-application surface 78 on both sides of the insertion slit 19 upon the horizontally retained end section 84 of the wire so that the same cannot deviate and perfect introduction into the zone of making contact at the terminal 10 is ensured.

In this insertion and pressing-in motion, the insulation is cut open by the cutting edges on the legs 24 of the IDC element and perfect contact is established. The end section 84 of the wire is at the same time fixed in its position - with slight deformation of its insulation - by the two ribs 17 on both sides of the IDC terminal 25.

At their forward extremity, the ram 76 and the laying finger 59 are basically of the same width perpendicular to the plane of the drawing (Fig. 19), with the width matching the width of the groove-like indentations 26 so that perfect three-dimensional placement of the housing 12 relative to the laying finger 59 and the ram 76 is ensured when the wire section 84 is pressed in. Then the components are in the position as per Fig. 18.

Now the ram 76 rises into its end position or standby position and releases the end of the wire section. This situation is shown in Fig. 19.

Since the end of the wire section 84 is accommodated in the groove-like indentation 26 very close to the guide groove 19 and since the same has a length, width and height such that the free front end of the conductor cannot be touched from the

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outside, and since the IDC terminal 25 is embedded in the insulating material of the housing 12 and is likewise shut off from the outside in all-insulated fashion, perfect protection against accidental contact is obtained in this way at the point 10 of connection.

The control unit now controls the motion of the industrial robot 33 according to a program in such a way that the laying finger 59 moves from the terminal 10 at which contact was made to the next terminal - terminal 11 - on the base 7 of insulating material along the rectilinear path of laying which can be inferred from Fig. 30. This is illustrated in Fig. 20, 21.

During this, the belt drive 66, 67, controlled by the control unit, is actuated in synchronism with this travel of the laying finger 59 so that laying of the wire without stress is obtained. If necessary, in this travel, also a vertical movement along the Z axis may be imparted to the laying finger 59, for instance, in order to place the laid wire on the bottom 3 (Fig. 1) or to compensate for a difference in the levels of the terminals 10, 11, as indicated in Fig. 22.

In the course of this travel, the laying finger 59 is at first transferred only into the vicinity of the terminal 11, into the position shown in Fig. 21 or 22 in which the image-processing system 85 is above the terminal 11 and can sense its place in space which certainly may be influenced by unavoidable tolerances in mounting the components.

As before at terminal 10, the image-processing system 85 now determines the deviation of the laying finger 59 from the terminal 11 and, via the control unit of the industrial robot 33, compensates for the variation to obtain the accurate placement of the laying finger 59 relative to the terminal 11. As soon as this has been



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accomplished, the components have assumed the position according to Fig. 23 or Fig. 24.

Now the ram 76 is lowered from its end position or standby position into the operational position in which it bears with its pressure-application surface 78 on the wire's 68 part which is there horizontally guided and emerges from the mouth 74 of the wire-guiding channel 62 - see Fig. 25.

After that, the laying finger 59 and the ram 76 are lowered simultaneously in a fixed relationship with respect to each other and to the housing 12 of the terminal 11, while the wire section 84a extending between the pressure-application surface 78 and the top of the mouth's 74 edge is supported at two points on both sides of the zone of contact and pressed into the insertion slit 19 and the IDC slit 23 until the position of locking (described by way of Fig. 18, 19) has been reached. In this way contact with the wire 68 has been properly made at the wire section 84a and the wire 68 is clamped and fixed in the guide slit 19 near the point of connection on both sides at its insulation.

In the wiring work under consideration, the wire laid in the above-described manner is cut at the terminal 11. This is done with the knife 79 which moves downwards and severs the wire 68 directly at the wire-guiding channel's 62 mouth 74 which with its edge acts as a counterblade.

As shown in Fig. 27, when the wire 68 is severed, the laid wire section's end held in the guide slit 19 of the terminal 11 is bent downwards by the inclined surface 86 adjacent the blade 80 of the knife 79. This means that the bare front surface of the wire is directed toward the bottom of the enclosing groove-like indentation 26 and, as a consequence, that the protection against



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accidental contact is greatly increased. This bending causes at the same time additional mechanical attachment of the wire's end at the terminal 11.

5 Thus, the wiring between the two terminals 10 and 11 has been completed. The knife 79 returns to its end position or standby position as per Fig. 28.

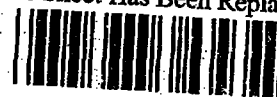
10 After that, the ram 76 is returned to its end position or standby position and the laying finger 59 is raised by the industrial robot 33, whereby the initial position for the next step of wiring work in in the light box 1 has been reached. This initial position is shown in Fig. 29.

15 Depending upon the wiring which has to be made, the wire 68 can be run through, for example, the terminal 11. In this case, severing the wire as per Fig. 27, 28 is not necessary; subsequently to the state as per Fig. 26, the ram 76 is rather
20 returned to its end position or standby position (see Fig. 19, 20), whereafter the control unit according to the program makes the industrial robot 33 move the wire-laying means 31 and, hence, the
25 laying finger 59 along a programmed, well-defined path to the next point of connection. This will be briefly explained with reference to Fig. 31 to 33:

The next terminal is once more a terminal 10, but now it is the one of the right ballast 5 of Fig. 1. The wire must be run past the ballast 5.
30 As can be inferred particularly from Fig. 2, the ballast 5 is at its two ends on top provided with two retaining elements 870 for wires 68. Each of the comb-like retaining elements 870 is provided with a row of parallel, continuous locking grooves
35 88 of semicircular cross section into each of which one wire 68 can be pressed through an insertion slit 89.

When wire is laid out between the terminals 10, 11 (Fig. 26 and 31), the industrial robot 33

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therefore first transfers the laying finger 59 along a programmed path to the vicinity of the respective retaining element 870. Once the laying finger 59 has been placed in the previously described manner with the aid of the image-processing system 85, the ram 76 sinks and presses, either alone or together with the laying finger 59, the wire into one of the locking grooves 88. After that, the ram 76 is transferred into its end position or standby position; the laying finger 59 rises and is moved to the next retaining element 870 where the same operation is repeated.

After that, the laying finger 59 is moved into the vicinity of the terminal 10 and placed above the same in the previously described manner, whereafter the ram 76 is advanced until its pressure-application surface 78 rests on the wire section 84a emerging from the mouth 74. The components assume the position shown in Fig. 32.

In the ensuing lowering motion of the laying finger 49 of the ram 76, the wire section 84a is horizontally aligned and perfectly supported to be fixed in the above-described manner in the insertion slit 19, with contact established in the IDC slit 23, and, at the same time, the wire 68 is bent downward to the level of the IDC terminal 25. Once contact has been made, the components assume the position according to Fig. 33.

As the next step, the wire 68 either can be cut (as per Fig. 27) or passed through to the next point of connection, e.g., a terminal 9 of a lamp base 4.

Since in the case of the lamp base 4, the insertion slits 19 at the points 9 of connection extend across the longitudinal direction of the light box, the industrial robot 33 must rotate over 90° the wire-laying means 31 and, more specifically, the housing 58 of the laying tool 57 with the laying finger 59 and the ram 76, around

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the vertical axis (c axis) before the wire section, which is bent in this operation, is introduced into the insertion slit 19 in the above-described manner.

5 The direct wiring work carried out with the above-described steps of the technique on the preassembled light box 1 is illustrated in Fig. 33, 34 for two cases, namely that the wire 68 is cut
10 after having reached the point 11 of connection (Fig. 27) or that the wire is passed on beyond this terminal (Fig. 31).

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CLAIMS:

1. A technique for wiring the points of connection of electrical apparatus or modules of circuit elements with the aid of controlled mechanical wire-laying means, wherein the following operations are carried out:

- a preassembled electrical apparatus or module of circuit elements is prepared to have terminals permanently arranged therein,

- by means of a relative motion between the preassembled apparatus or module of circuit elements and the wire-laying means, a first point of connection is moved into the working area of the wire-laying means and placed in the proper place relative to the same,

- by means of the wire-laying means, the end of a continuously supplied wire is introduced into a zone of establishing contact with the first terminal and fixed at that point of connection, with electrical contact being made,

- by means of an other relative motion each on a predetermined path between the preassembled electrical apparatus or module of circuit elements and the wire-laying means, each additional terminal is in succession moved into the working area of the wire-laying means while the wire is laid out and put into the proper place relative to the same, wherein, during each of these relative motions, the wire-laying means pay out at least a length of continuously supplied wire corresponding to the path of wire laying between the two respective points of connection,

- by means of the wire-laying means, the wire which is continuously fed to the same, is introduced at each point of connection into a zone of contact of that terminal and, while establishing an electrical contact, is fixed at this point of connection, and





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- the wire which was laid out in this way is thereafter severed at the end of the path of wire laying near the respective point of connection.

5 2. The technique according to Claim 1, characterized in that by a relative motion between the preassembled electrical apparatus or module of circuit elements, a point of support or retention is transferred into the operating range of the
10 wire-laying means and placed properly relative to the same and that by means of the wire-laying means, the wire is introduced into wire-holding means at the point of support or retention and fixed there.

15 3. The technique according to Claim 1 or 2, characterized in that the wire-laying means are moved by a multiaxially movable manipulator or industrial robot the motions of which are
20 programmable for at least one axis and that the preassembled electrical apparatus or module of circuit elements is placed in a stationary position prior to commencement of the wiring work.

25 4. The technique according to Claim 1 or 2, characterized in that the wire-laying means are stationary or are arranged at a placement system imparting a placement motion and that the preassembled electrical apparatus or module of
30 circuit elements is moved by transport means adapted to move relative to the wire-laying means.

5. The technique according to any one of the preceding claims, characterized in that the length
35 of wire, which is paid out by the wire-laying means between two points of connection during a wire-laying operation, is necessarily synchronised with the relative movement between the preassembled



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electrical apparatus or module of circuit elements and the wire-laying means.

6. The technique according to Claim 5, characterized in that the length of the wire paid out is chosen so that the wire laid out between the terminals is substantially free of tensile stress.

7. The technique according to any one of the preceding claims, characterized in that in the relative movement between the preassembled electrical apparatus or module of circuit elements and the wire-laying means, the wire-laying means come close to the respective point of connection and that the wire-laying means are subsequently placed in a placement motion into the proper position relative to the point of connection.

8. The technique according to Claim 7, characterized in that once the wire-laying means have been moved into the vicinity of the terminal, the deviation of the wire-laying means from the place of the terminal is determined with position-sensing means and the deviation is thereafter automatically compensated.

9. The technique according to Claim 8, characterized in that for the purpose of determining the deviation there is used an image-processing system cooperating with the wire-laying means, which system - for recording images - is moved close to the point of connection and which comprises image-processing means computing the compensation for the deviation and outputting an appropriate control signal.

10. The technique according to any one of the preceding claims, characterized in that after placing the wire-laying means, an insertion



movement of a well-defined length is imparted to the wire near the terminal, by which movement the wire is transferred into the zone of contact of the point of connection.

5

11. The technique according to any one of the preceding claims, characterized in that the relative movement between the preassembled electrical apparatus or module of circuit elements and the wire-laying means is substantially rectilinear at least over path sections.

10

12. The technique according to any one of the preceding claims, characterized in that zones of contact with IDC contact means acting according to the principle of the insulation-piercing/clamping (IDC) technique are used and that the wire is pressed by the wire-laying means into these contact means, while making electrical contact.

15

20

13. The technique according to Claim 12, characterized in that the wire upon being pressed in is subjected to a pressing-in force on both sides of the IDC contact means.

25

14. The technique according to Claim 12, characterized in that the wire is held clamped on at least one side of the IDC contact means.

30

15. The technique according to any one of the preceding claims, characterized in that the wire is cut at the wire-laying means proper.

35

16. The technique according to any one of Claims 12 to 14, characterized in that the wire is severed at the IDC contact means.

17. The technique according to any one of Claims 12 to 15, characterized in that the wire is



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cut between IDC contact means in the zone of contact.

18. The technique according to any one of the preceding claims, characterized in that the ends of the wire are automatically protected in an all-insulated fashion at the respective terminals.

19. The technique according to any one of the preceding claims, characterized in that it is employed for the automatic wiring of luminaires or parts thereof.

20. Wire-laying means, particularly for carrying out the technique according to any one of the preceding claims, comprising a laying tool with a housing provided with fastening means, a guide channel for a wire fed into a laying finger on one working side of the housing, and controlled wire-advancing means, characterized in that the laying tool has at least one pressure-application member (76) arranged near the mouth (74) of the guide channel (62) for the wire (68) emerging from the mouth (74), which member is supported to move substantially across the axial direction of the guide channel (62) in the mouth region and is coupled with proper setting means by which it is adjustable between a standby position far from the mouth (74) and an operational position in which it projects on one side beyond the edge of the mouth of the guide channel (62) with a pressure-application surface (78) aligned with the wire (84) protruding from the mouth (74) or in which it is substantially flush with the upper side of the edge of the mouth.

21. The wire-laying means according to Claim 20, characterized in that the pressure-application member is a ram (76) which is adapted to move in



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guided fashion along the housing (58) or a part joined with the same.

22. The wire-laying means according to Claim 5 21, characterized in that the ram (76) is mounted parallel to, and spaced from, the laying finger (59) which is likewise configured as a ram.

23. The wire-laying means according to any 10 one of Claims 20 to 22, characterized in that the mouth (74) of the guide conduit (62) is arranged laterally on the laying finger (50) on the side facing the pressure-application member (76).

24. The wire-laying means according to any 15 one of Claims 20 to 23, characterized in that the pressure-application member (76) and the laying finger (59) have at least over sections basically the same width measured across the longitudinal 20 direction of the conductor emerging from the mouth (74) of the guide channel (62).

25. The wire-laying means according to any 25 one of Claims 20 to 24, characterized in that controlled means (79) for severing the wire are provided on the laying tool and have at least one cutting blade (79) arranged to move within the region between the mouth (74) of the guide channel (72) and the pressure-application member (76).

30

26. The wire-laying means according to Claims 23 and 25, characterized in that the cutting blade (79) is supported to act directly at the laying finger (59) and that the edge of the mouth of the 35 wire-guiding channel (62) is configured as a counterblade.

27. The wire-laying means according to any one of claims 19 to 26, characterized in that the

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laying finger (59) is supported on the housing (57) for movement and is coupled with proper setting means.

5 28. Terminal, particular for use in the technique according to any one of Claims 1 to 19 and making use of the wire-laying means according to any one of Claims 20 to 27, with clamping
10 terminal means containing the zone of contact, which means comprise a housing of insulating material with at least one insertion slit, open at the edge, for a wire and at least one IDC terminal mounted inside the housing with an IDC slit open at the edge toward the side of insertion and aligned
15 with the insertion slit, characterized in that in the preassembled electrical apparatus or module of circuit elements, the housing (12, 12a) of the terminal clamping means is arranged with an insertion slit (19) accessible for the wire-laying
20 means (31); that the housing (12, 12a) on at least one side near the insertion slit (19) has a slit-like or groove-like wire-accommodating indentation (26) the width of which exceeds the width of the insertion slit (19); and that the dimensions of the
25 slit-like or groove-like indentation (26) are chosen so that near the IDC terminal (25), a free end of a wire with which contact is made in the IDC terminal (25) is accommodated in protected all-insulated fashion within the slit-like or groove-like indentation (26); and that the slit-like or
30 groove-like indentation (26) and the housing (12) match the dimensions of the laying finger (59) and of the pressure-application member (76) of the laying tool of the wire-laying means (31).

35

29. The terminal according to Claim 28, characterized in that the insertion slit (19) has a width which fixes a pressed-in wire by clamping it.



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30. The terminal according to Claim 28 or 29, characterized in that the slit-like or groove-like indentation in the housing (12) is arranged for confinement on both sides by IDC terminals (25).

5

31. The terminal according to any one of Claims 28 to 30, characterized in that the slit-like or groove-like indentation (26) is deeper than the insertion slit (19).

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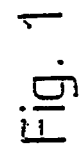


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ABSTRACT:

5 Wiring work on terminals of electrical
apparatus or modules of circuit elements is carried
out automatically by direct wiring operations. A
preassembled electrical apparatus or module of
circuit elements comprising points of connection in
10 it is prepared, whereafter, by means of an
automatically guided wire laying tool, a
continuously supplied wire is moved into the zones
of contact of the specially configured connection
terminals, where it is fixed and either severed or
15 passed through for further wiring.

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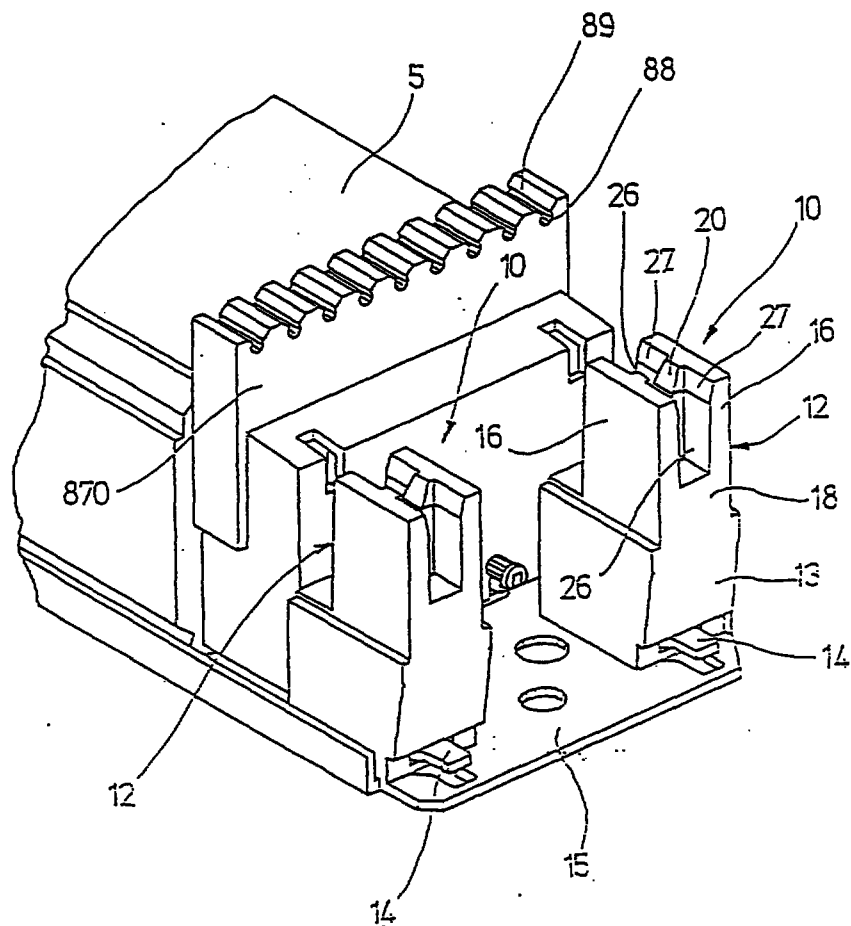


Fig. 2

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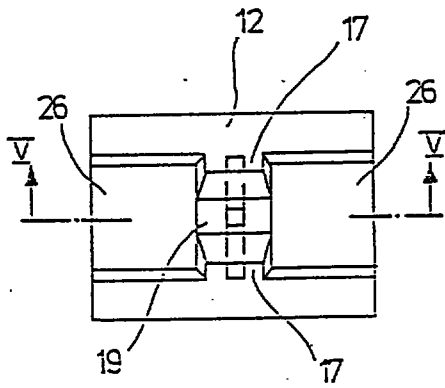


Fig. 3

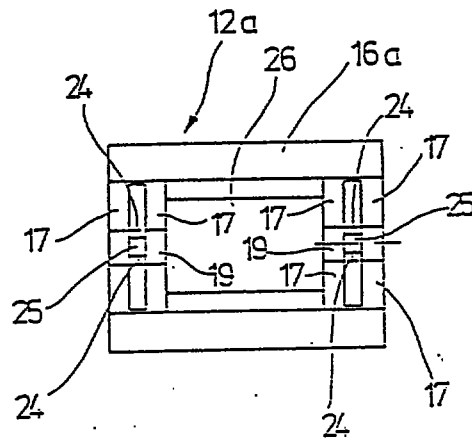


Fig. 4

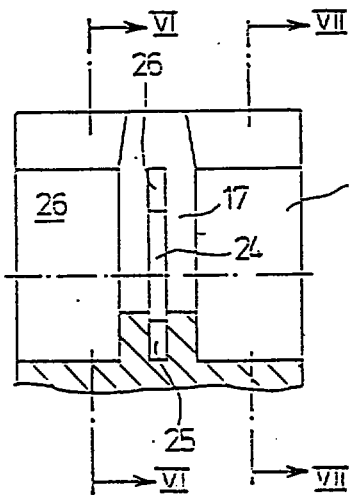


Fig. 5

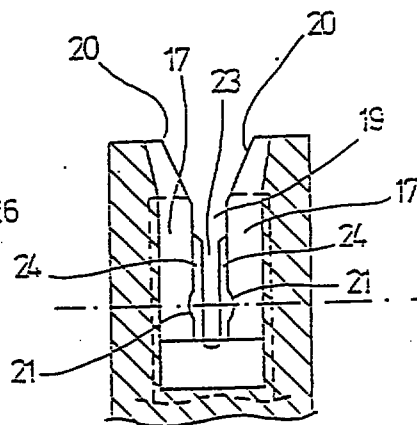


Fig. 6

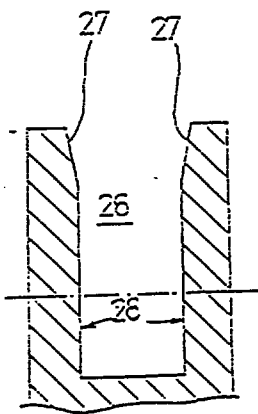
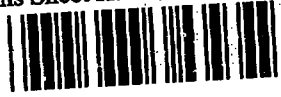


Fig. 7

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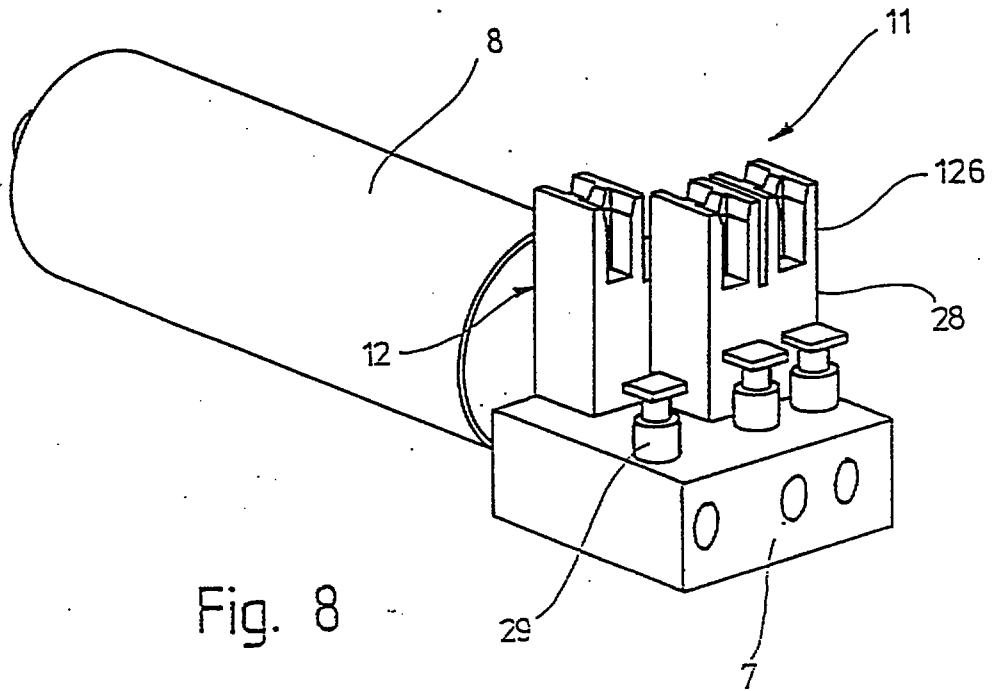


Fig. 8

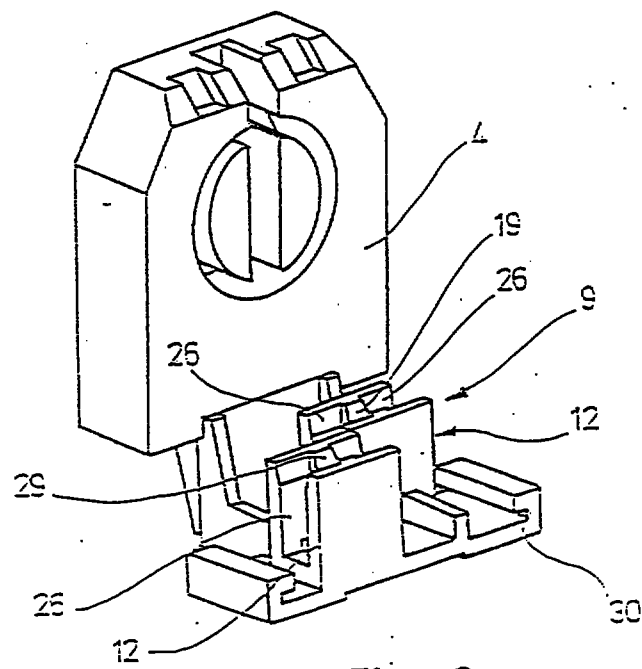
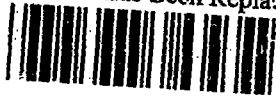


Fig. 9



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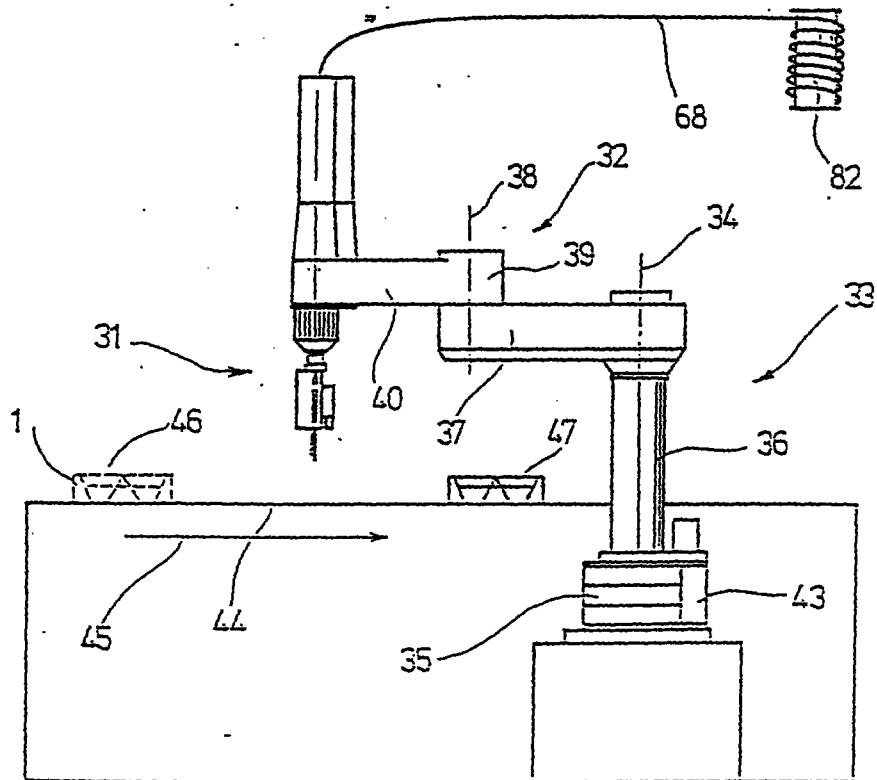


Fig. 10

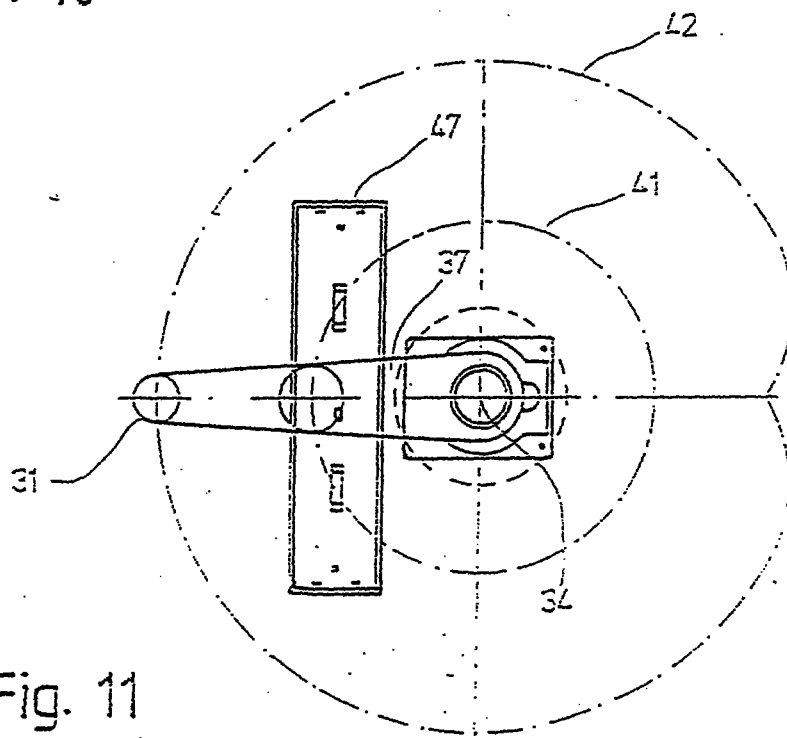
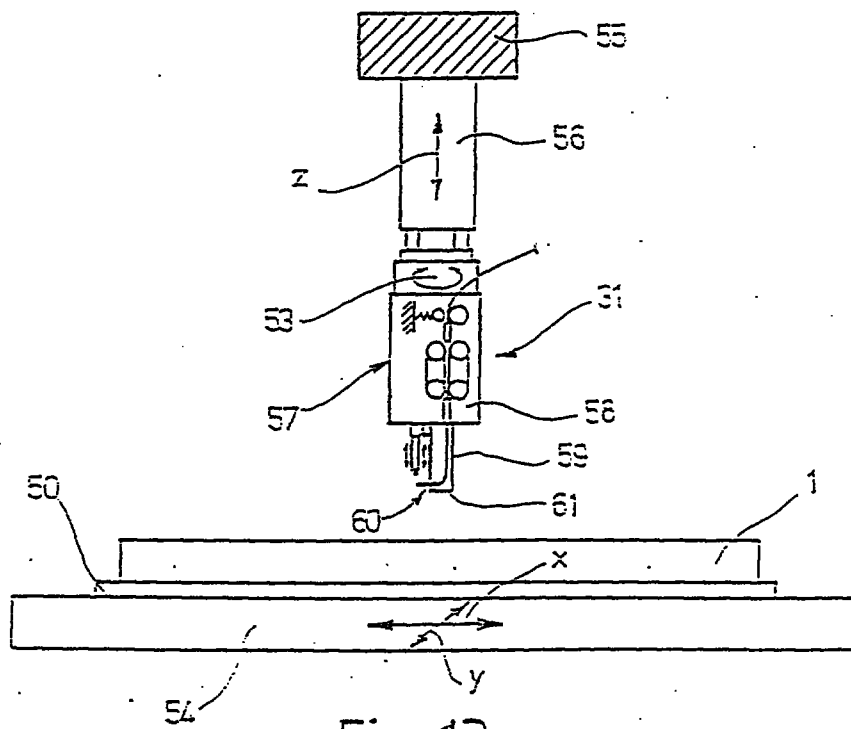
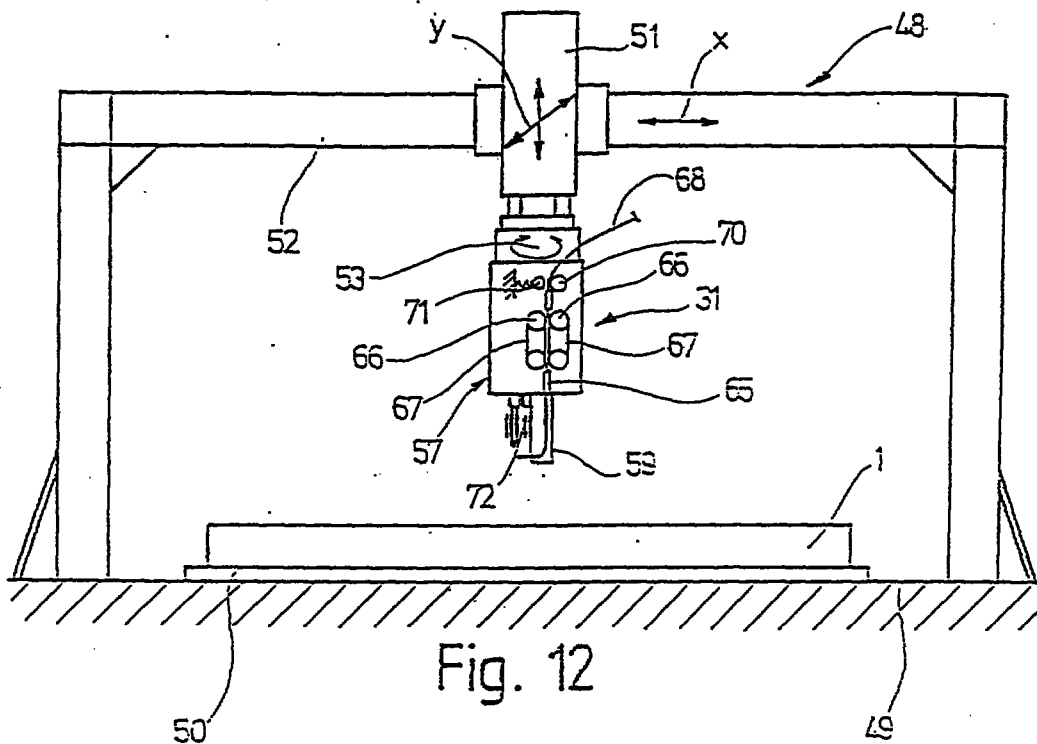


Fig. 11

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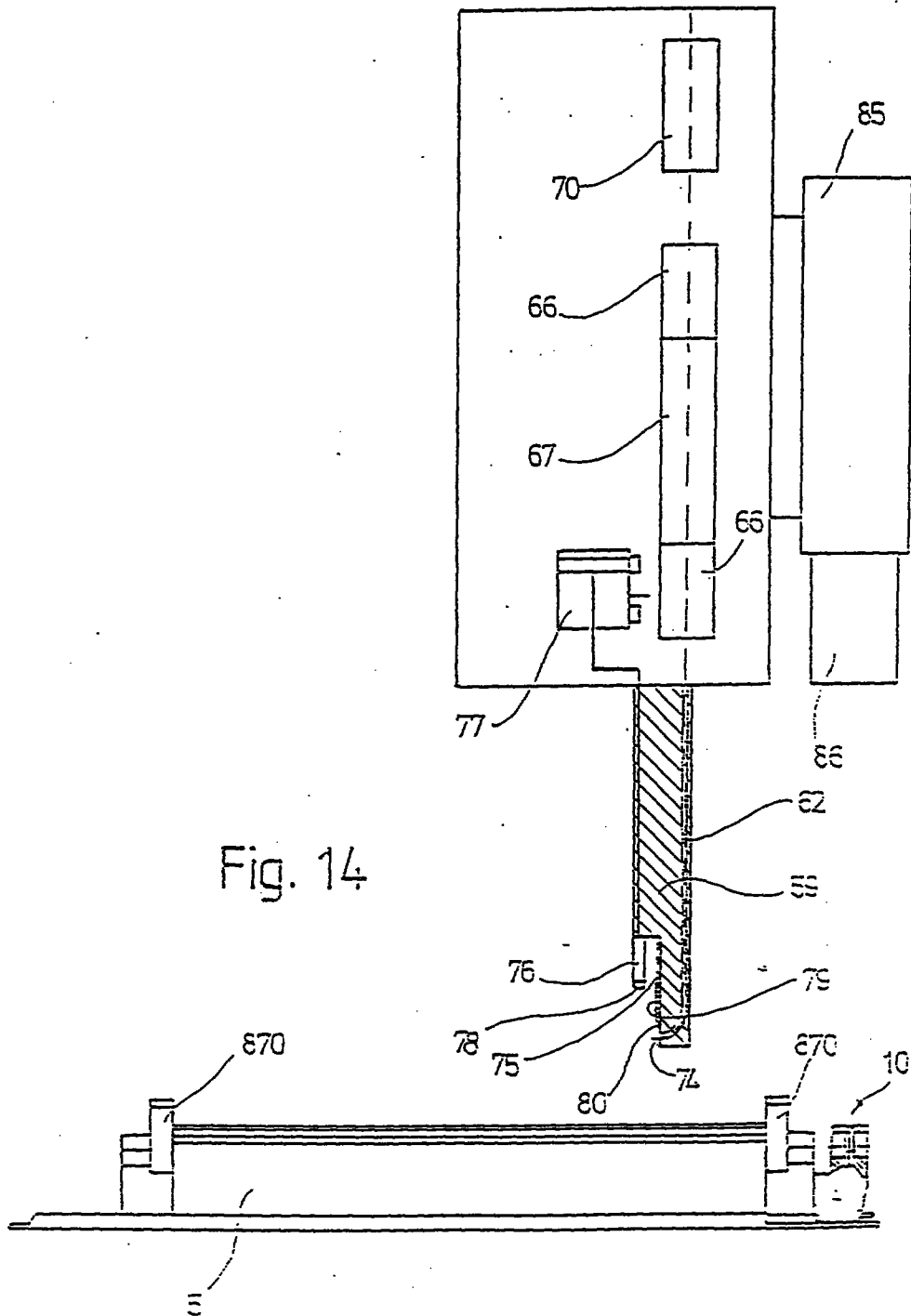


Fig. 14

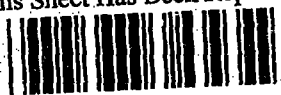
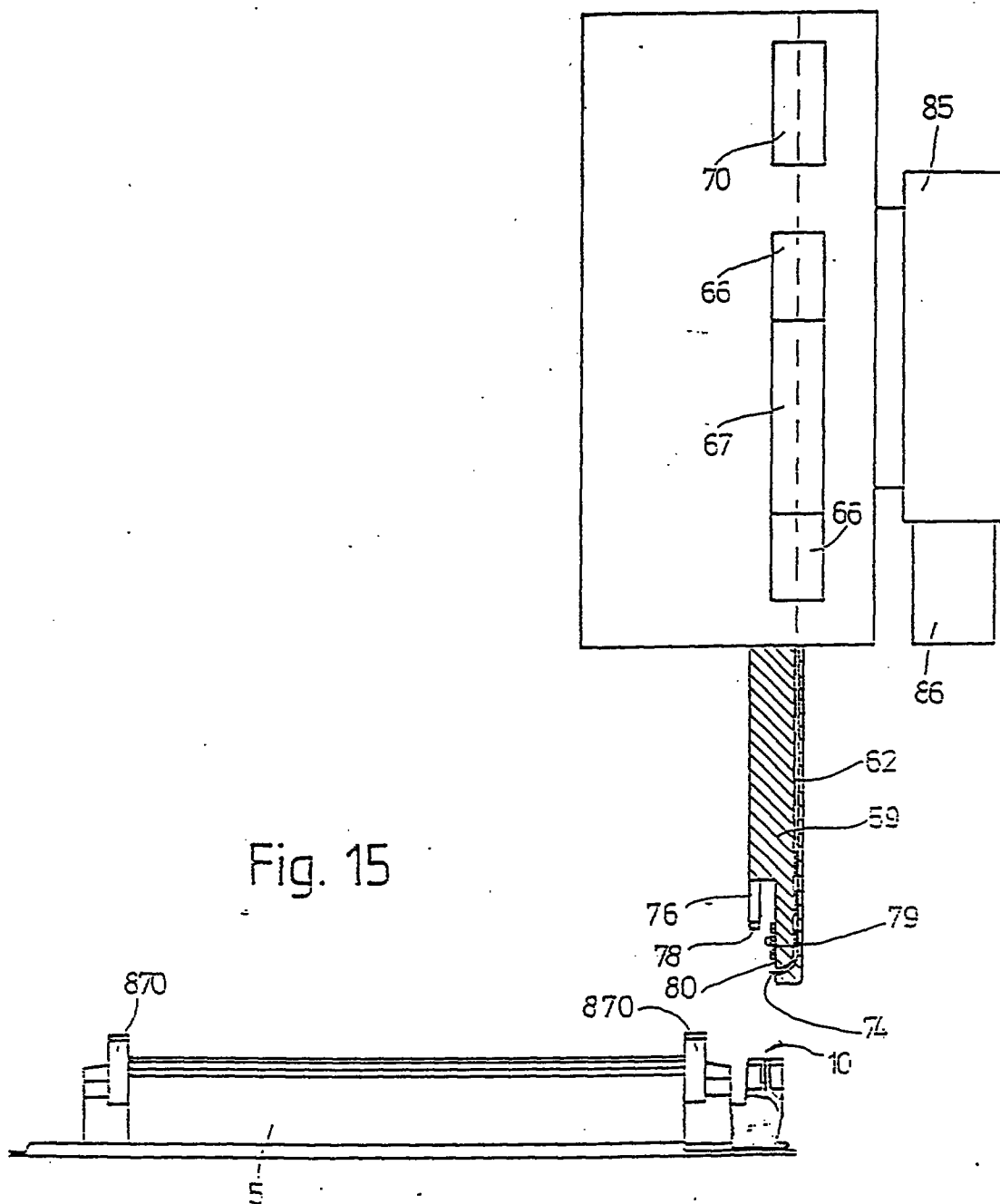


Fig. 15



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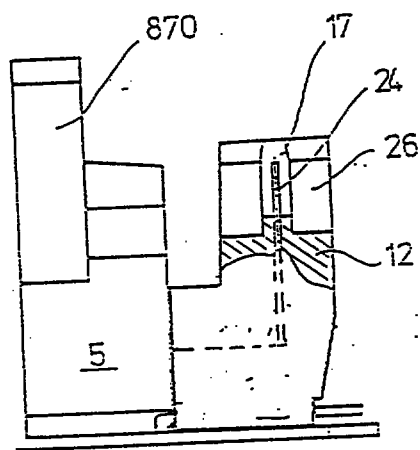
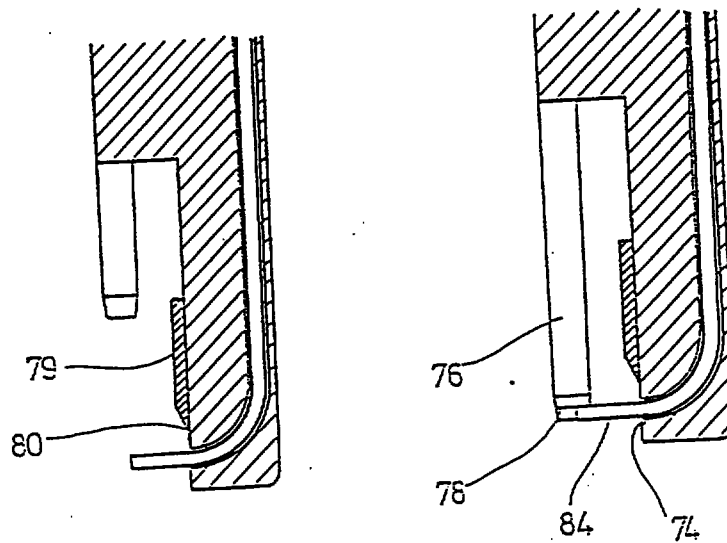


Fig. 16

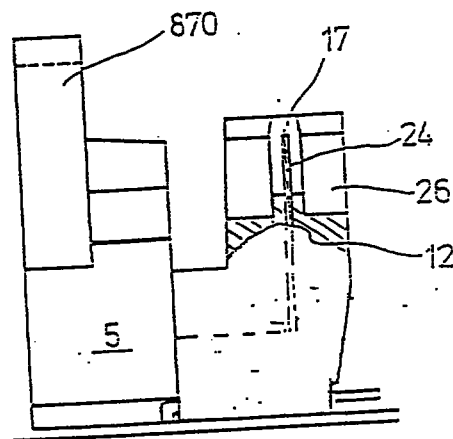


Fig. 17

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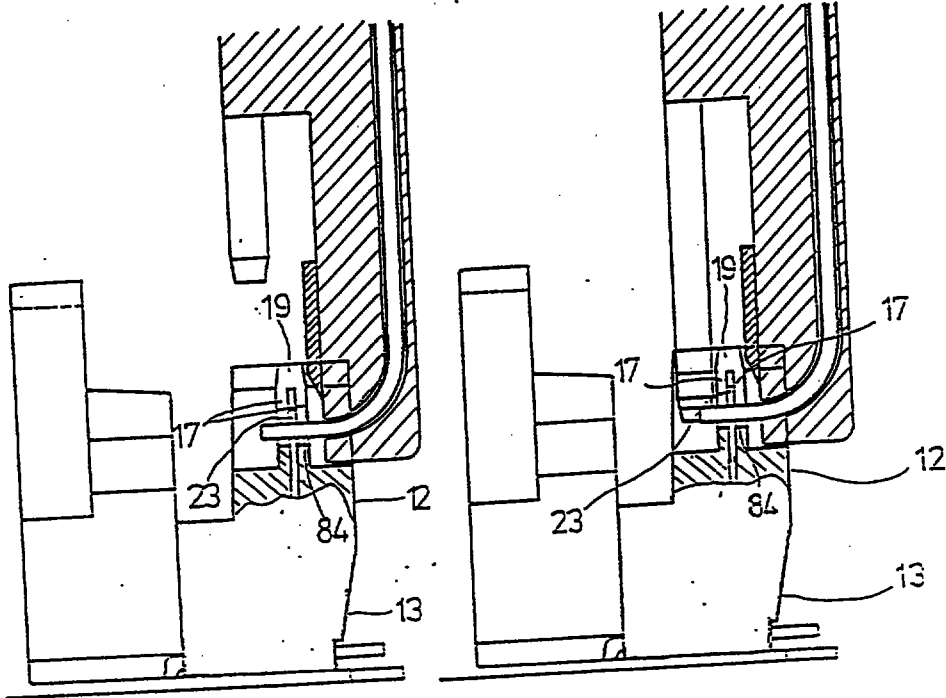


Fig. 19

Fig. 18

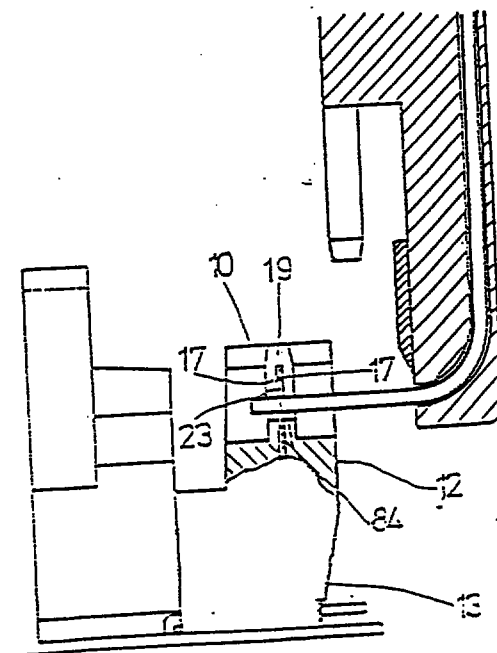


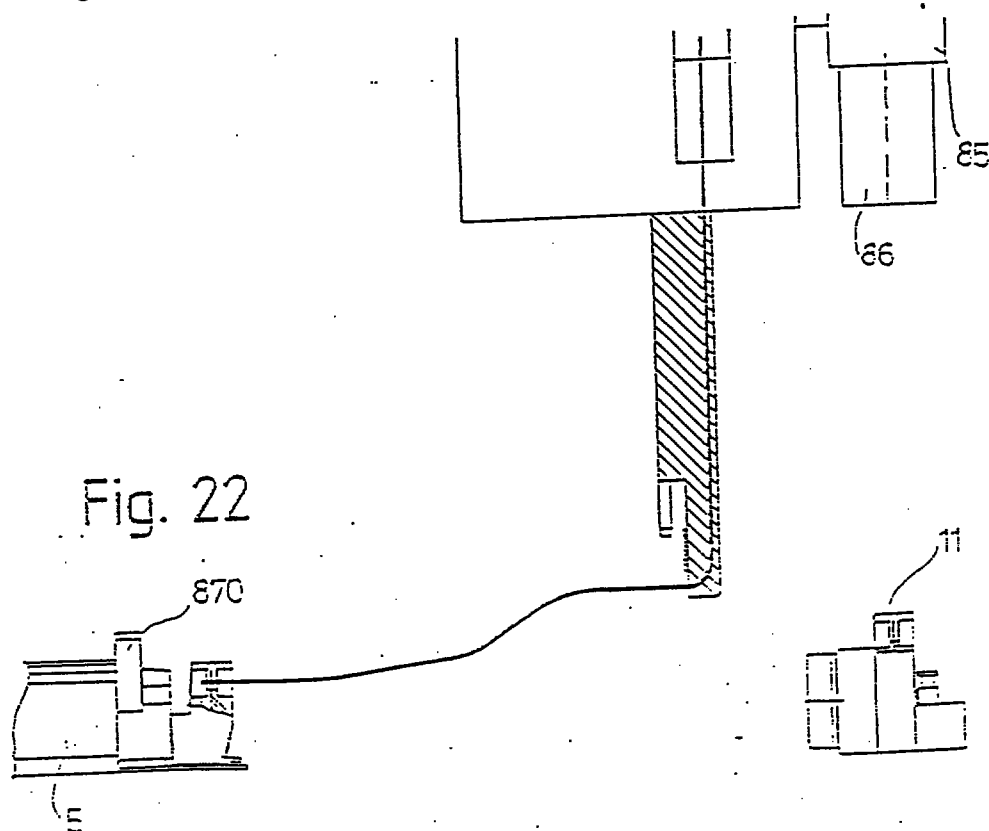
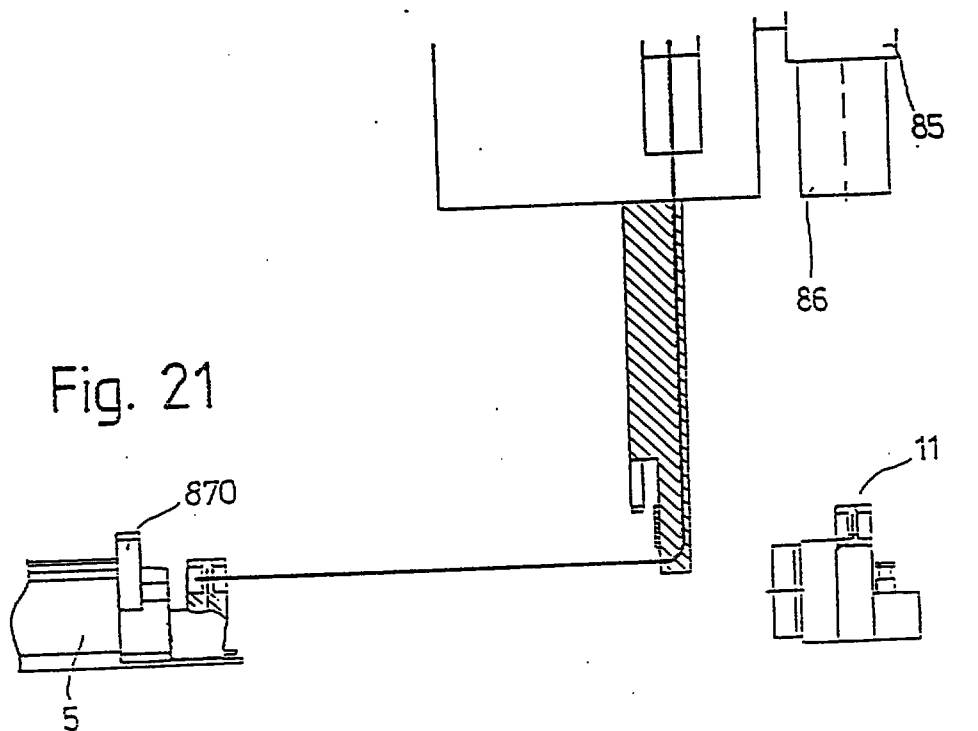
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Fig. 23

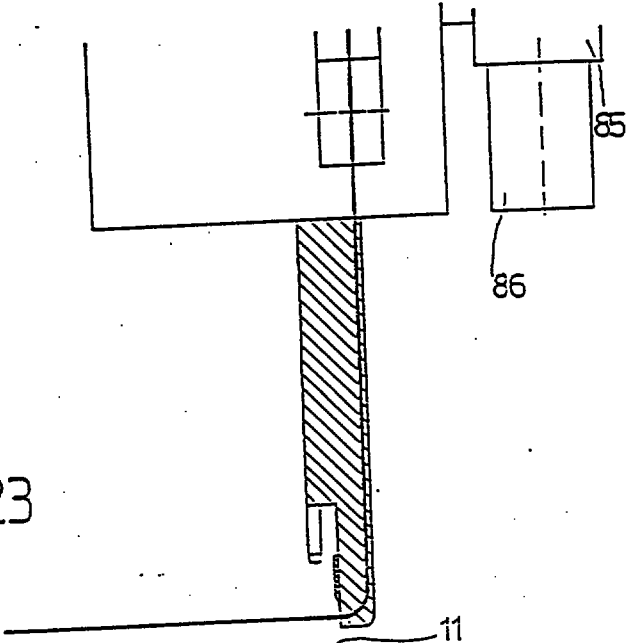
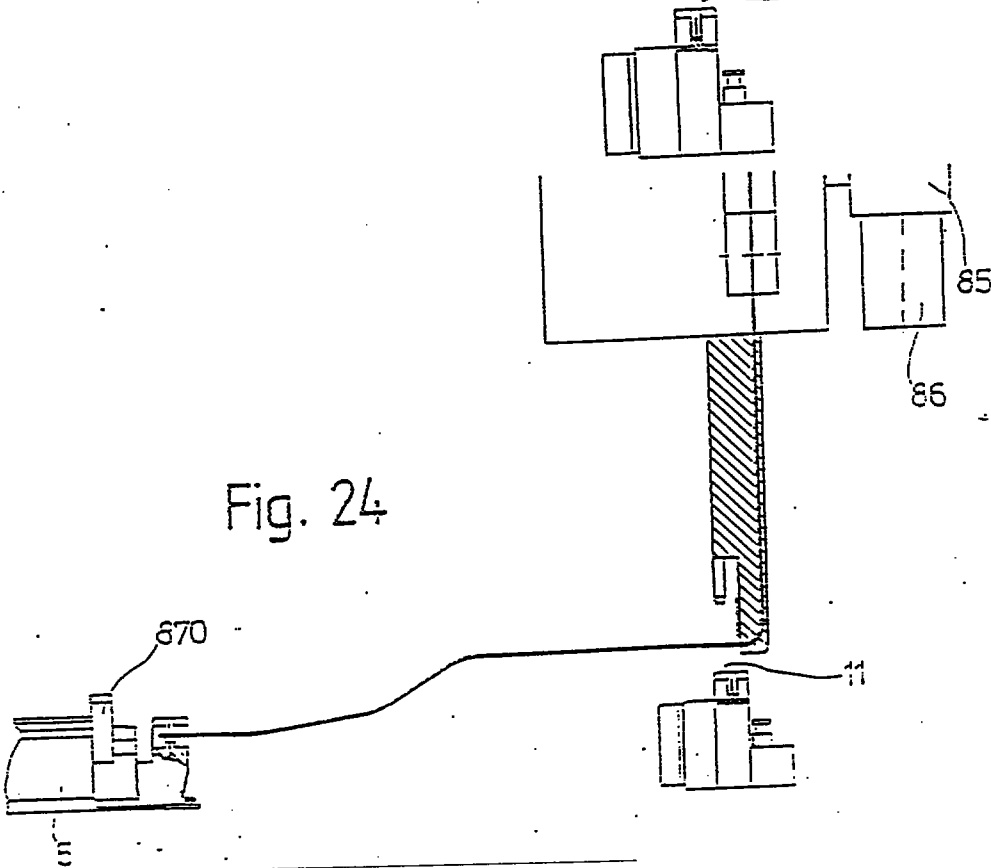


Fig. 24



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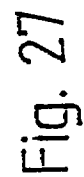


Fig. 26.

Fig. 25

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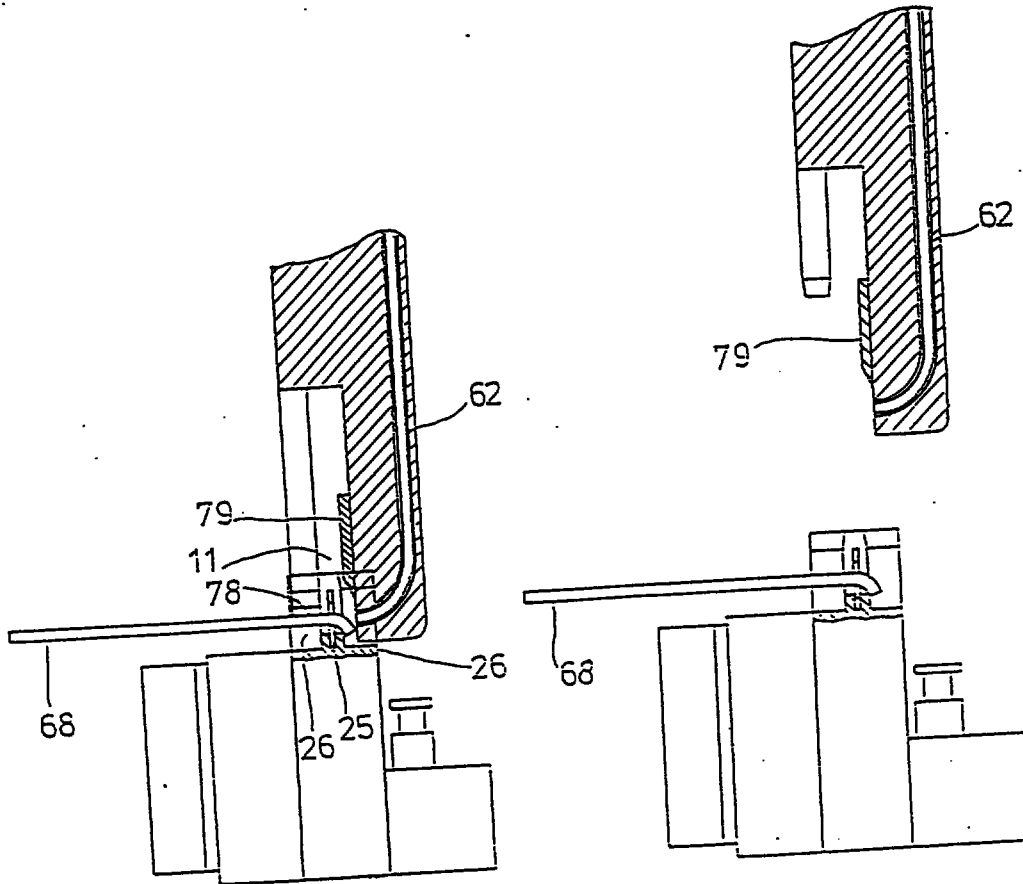


Fig. 28

Fig. 29

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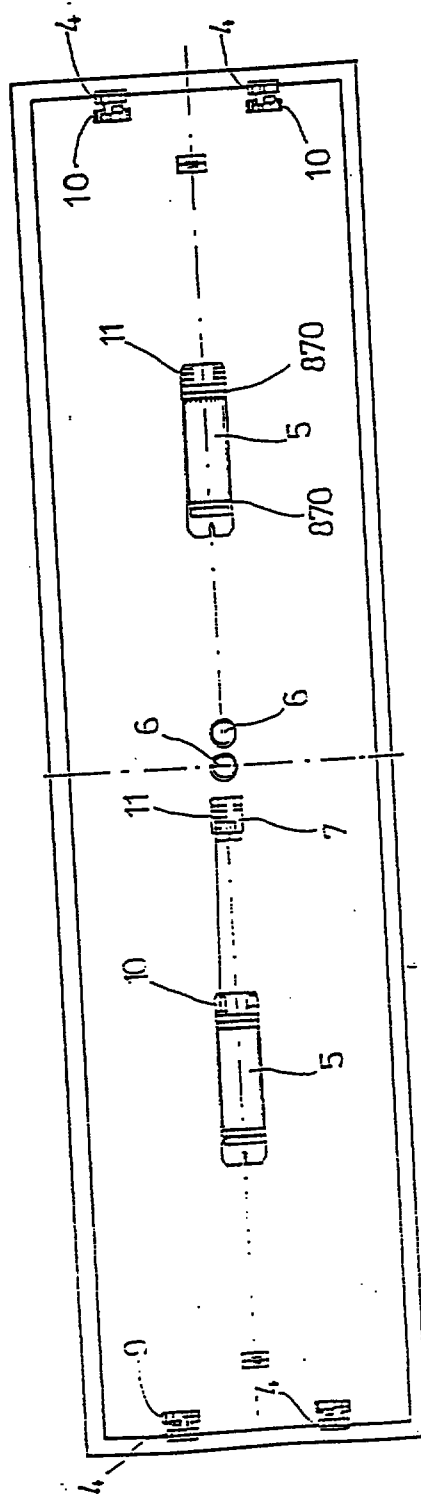


Fig. 30

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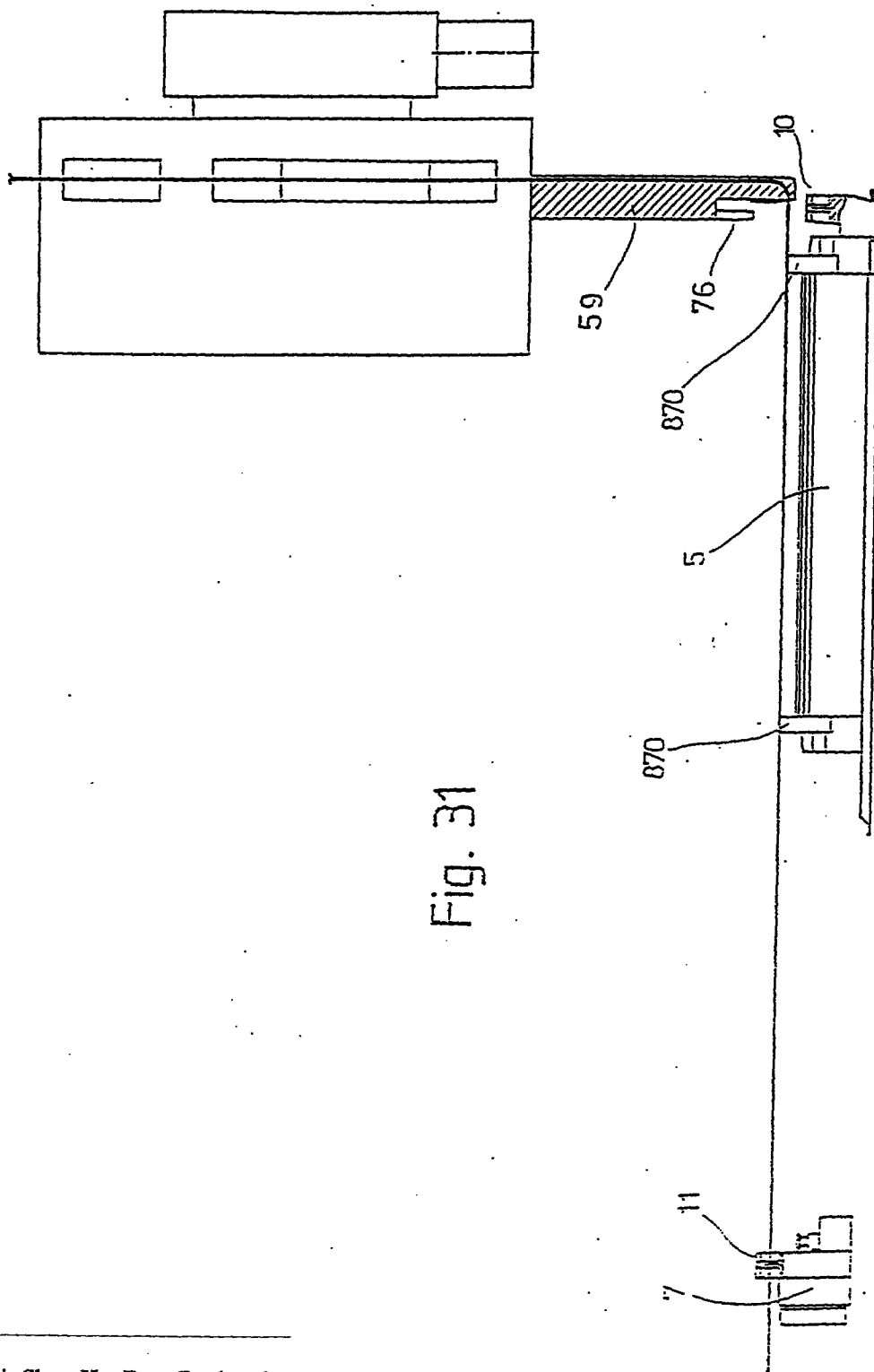


Fig. 31

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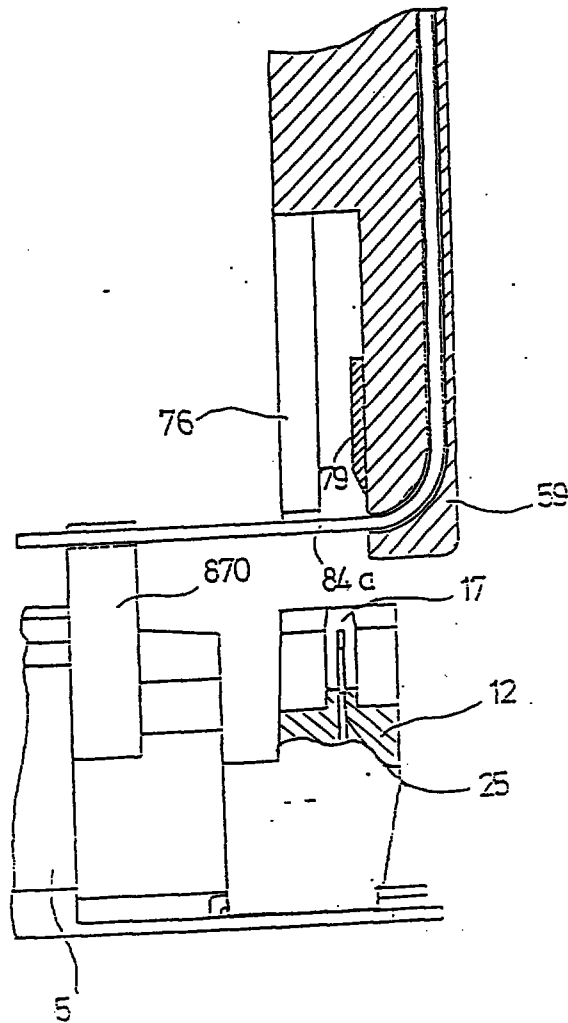


Fig. 32

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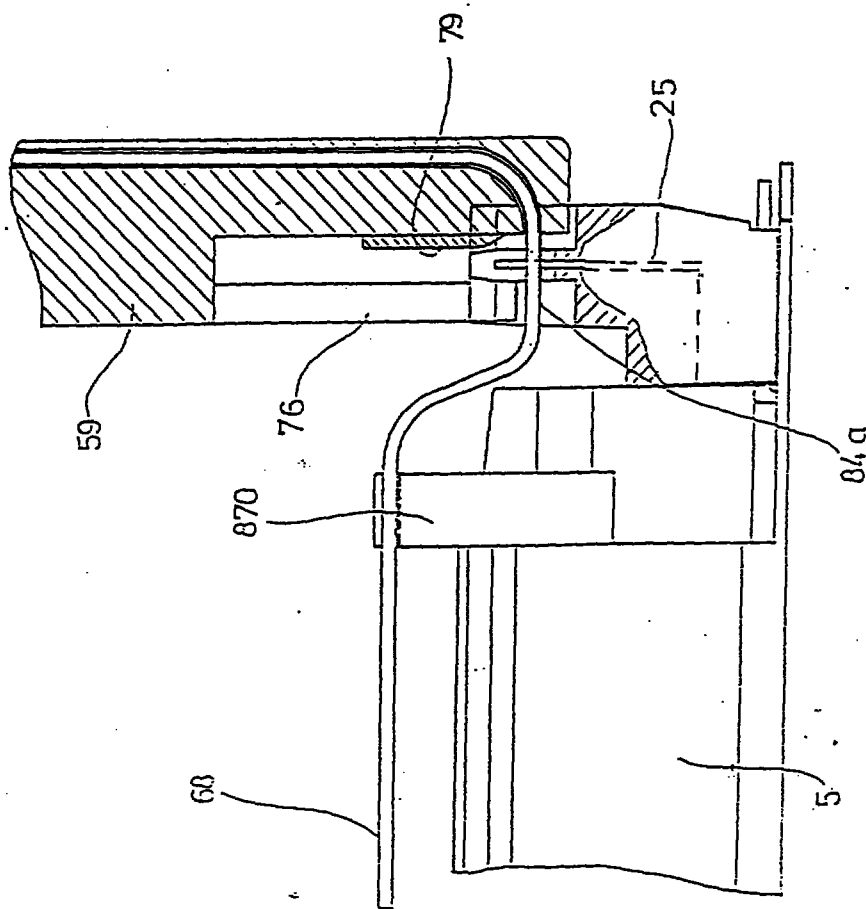
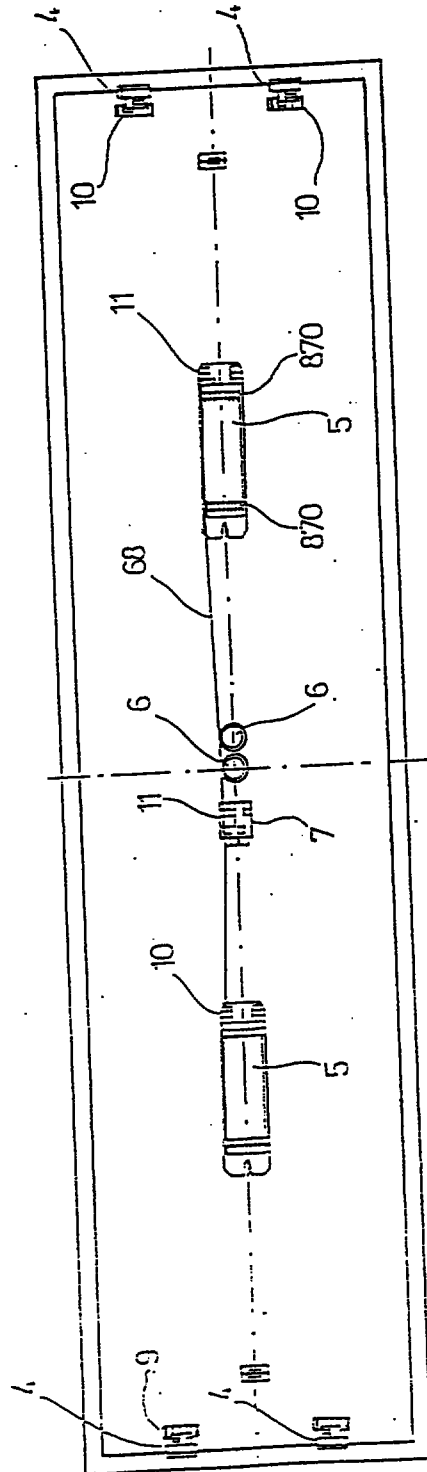


Fig. 33





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TECHNIQUE FOR WIRING CONNECTIONS OF ELECTRICAL APPARATUS OR A MODULE OF CIRCUIT ELEMENTS

ABSTRACT

Wiring work on terminals of electrical apparatus or modules of circuit elements is carried out automatically by direct wiring operations. A preassembled electrical apparatus or module of circuit elements comprising points (9, 10, 11) of connection in it is prepared, whereafter, by means of an automatically guided wire laying tool (31), a continuously supplied wire is moved into the zones of contact of the specially configured connection terminals (9, 10, 11) where it is fixed and either severed or passed through for further wiring.

FIG. 14

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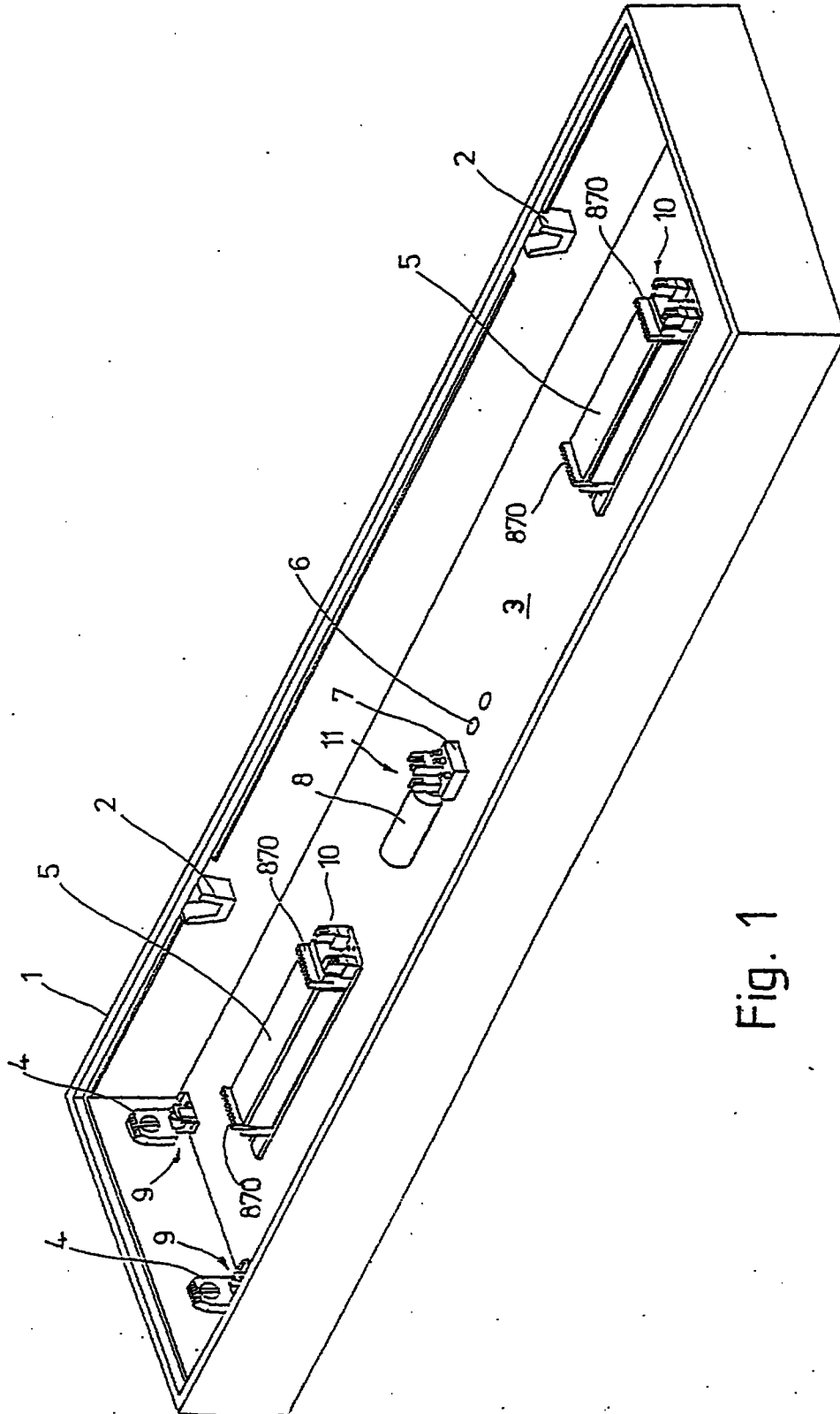


Fig. 1

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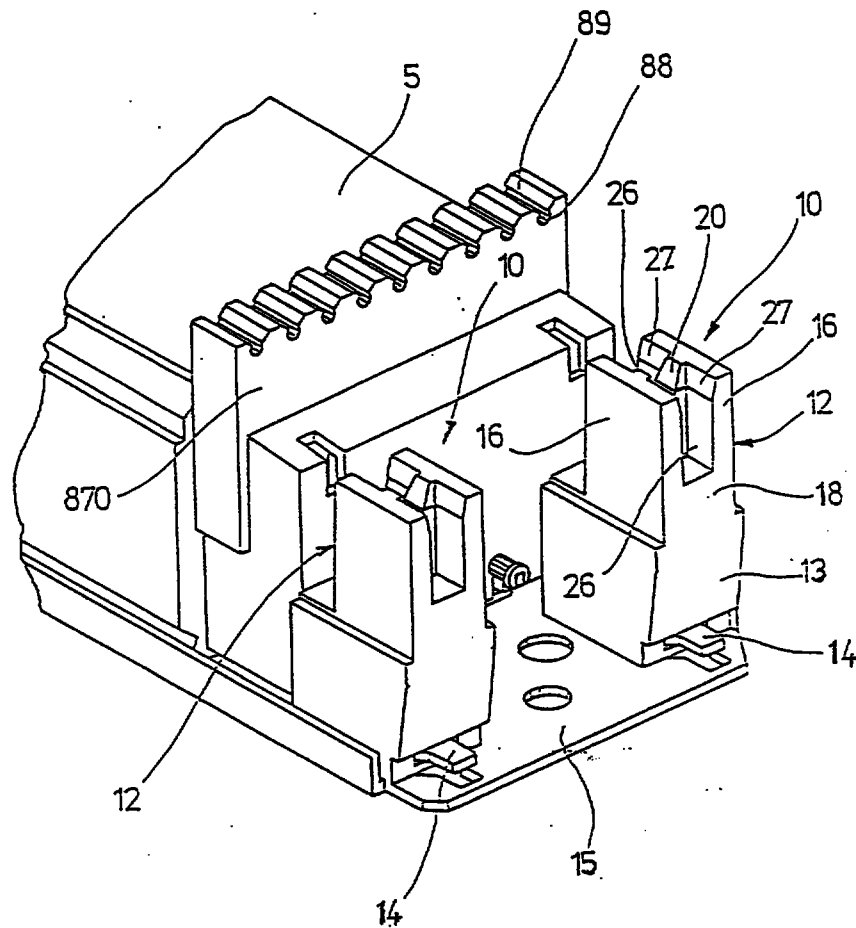


Fig. 2

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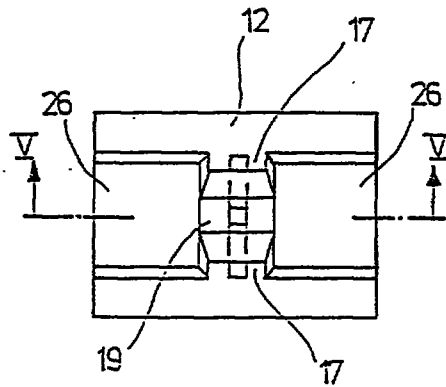


Fig. 3

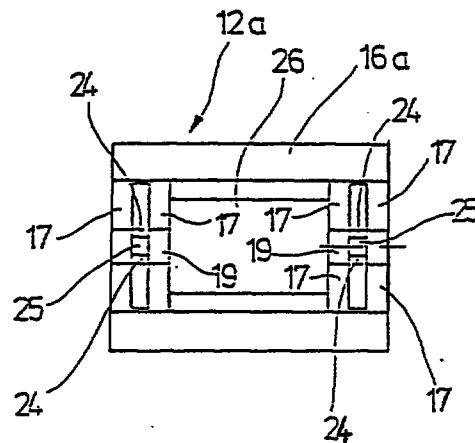


Fig. 4

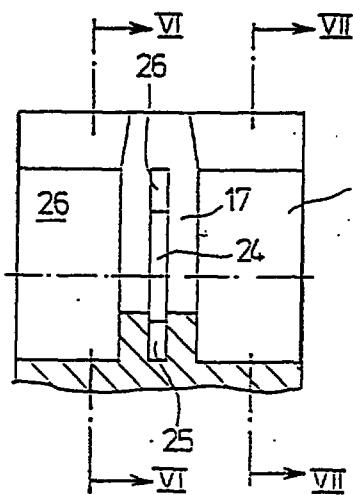


Fig. 5

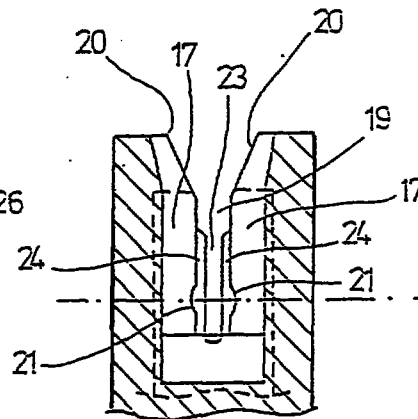


Fig. 6

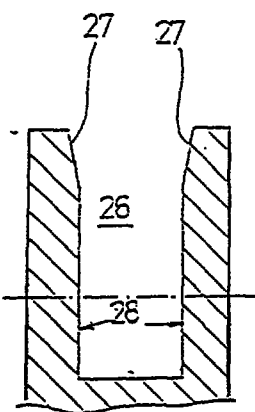


Fig. 7

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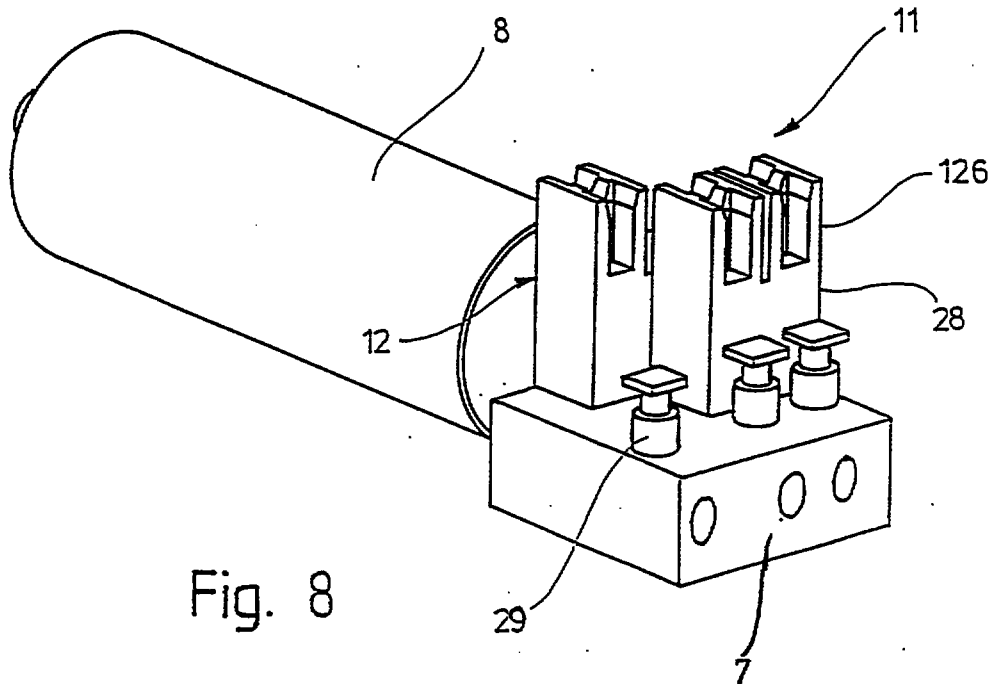


Fig. 8

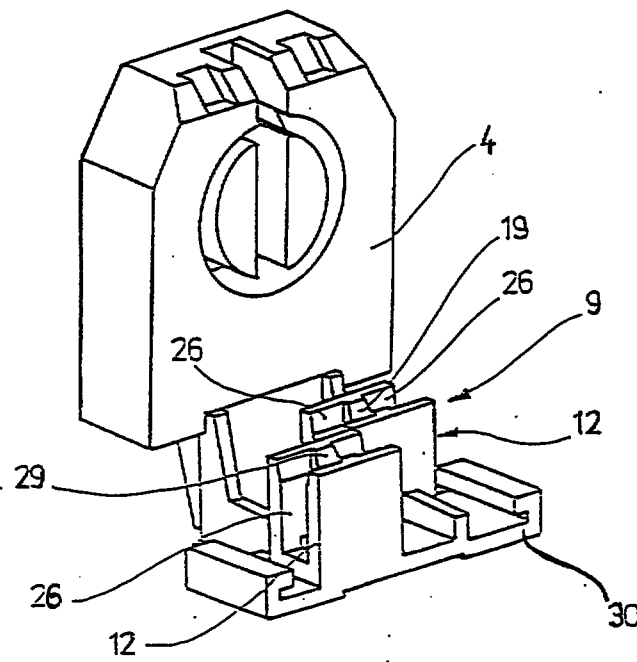


Fig. 9

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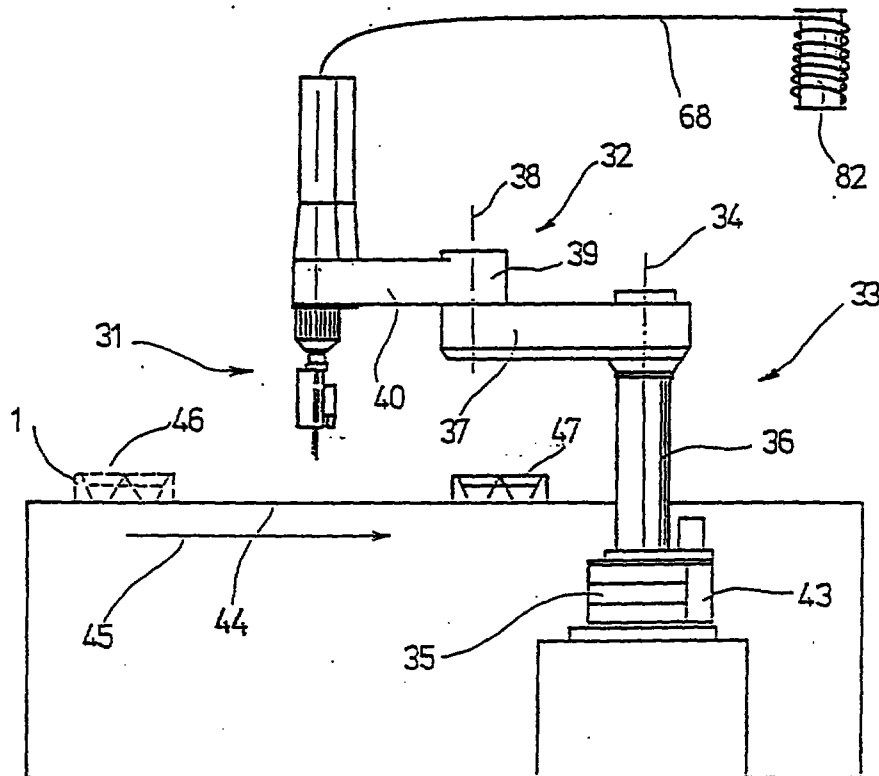


Fig. 10

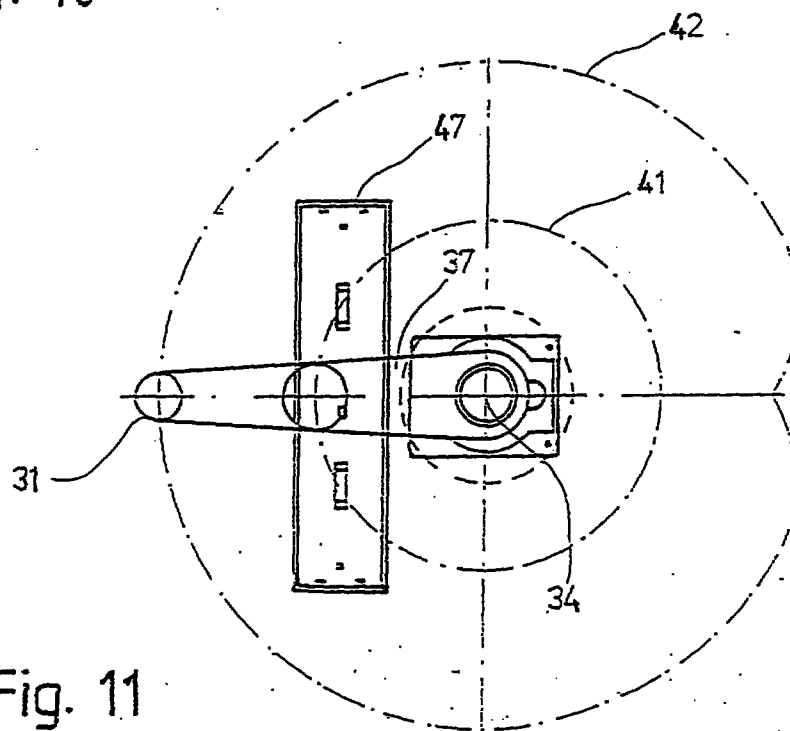
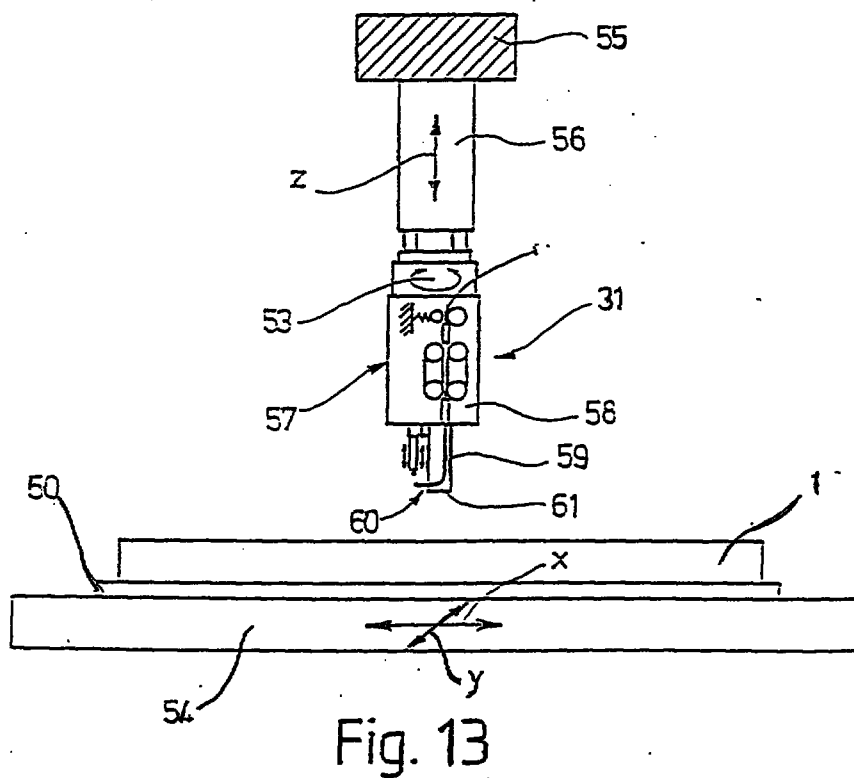
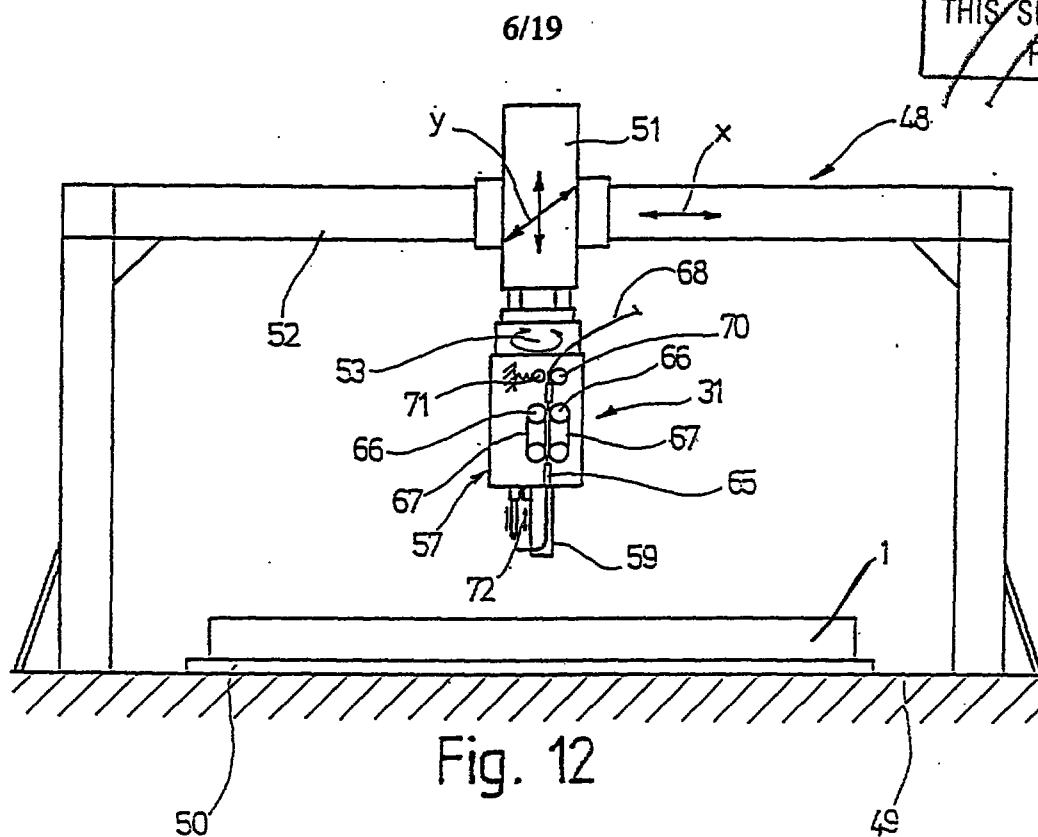


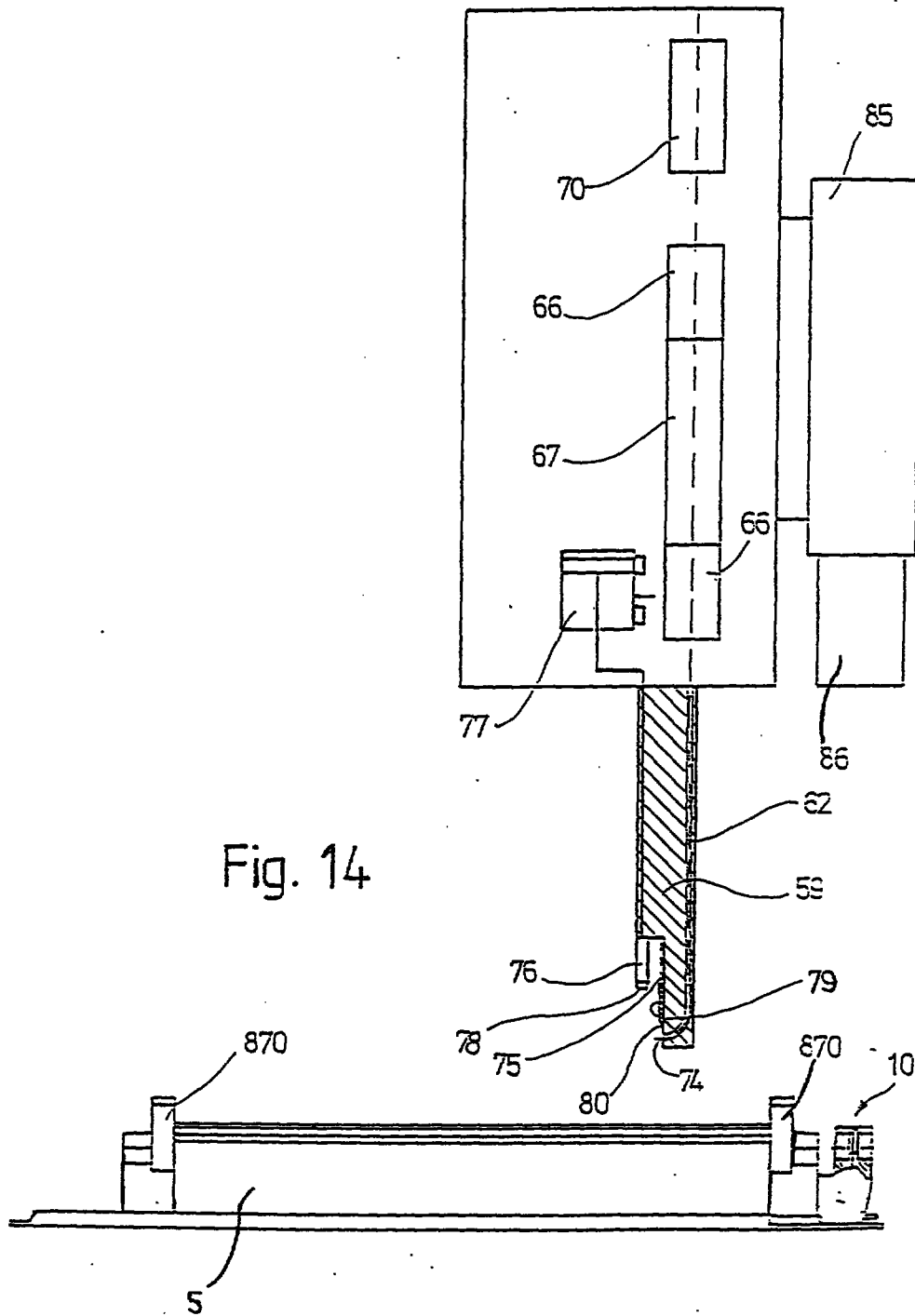
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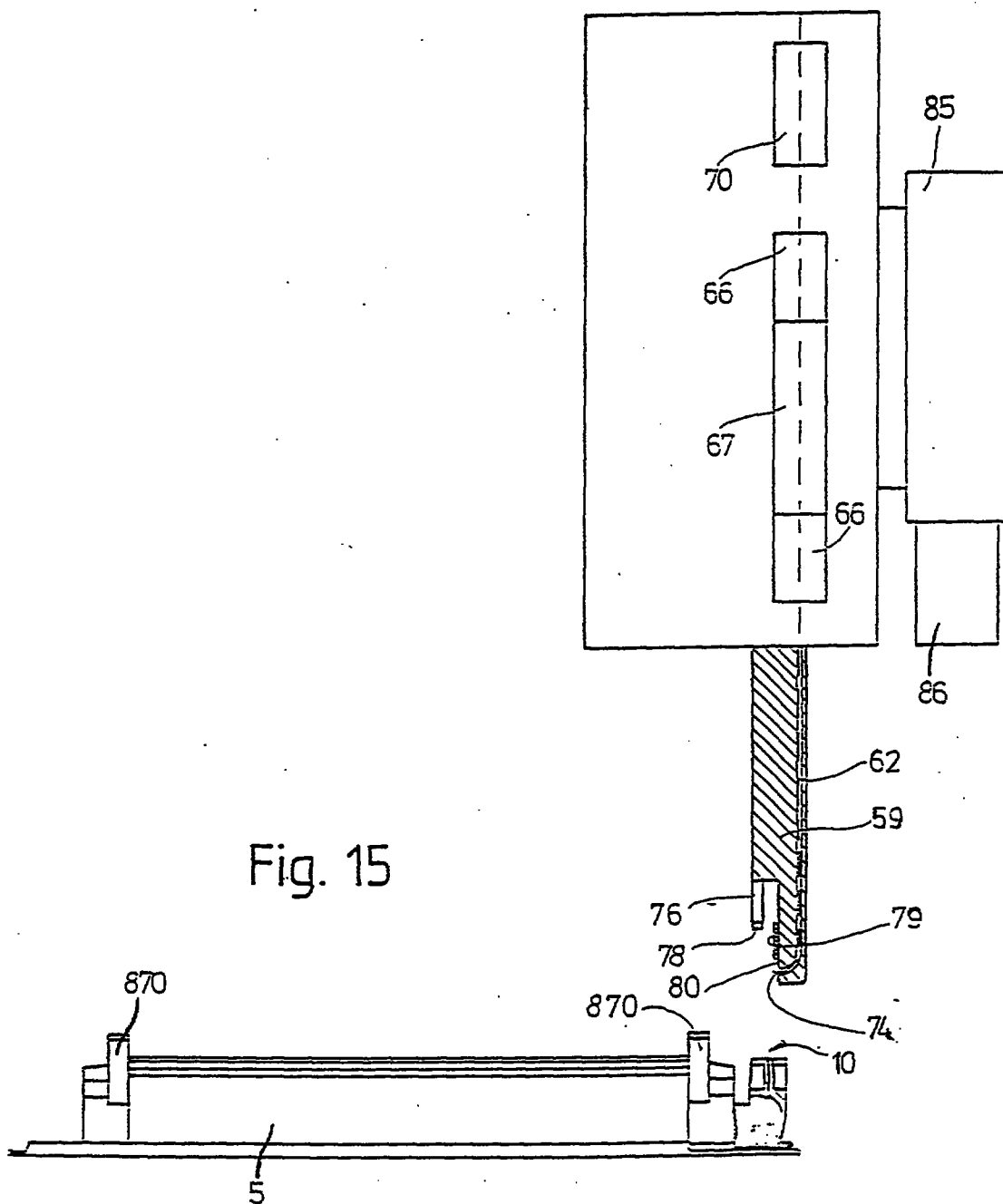
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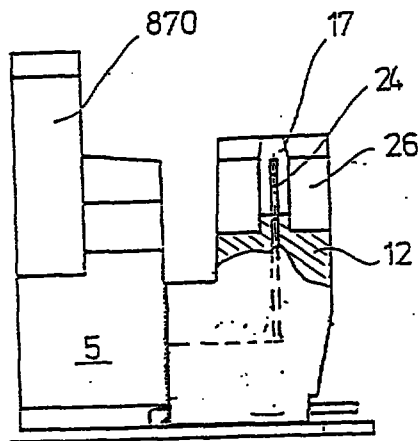
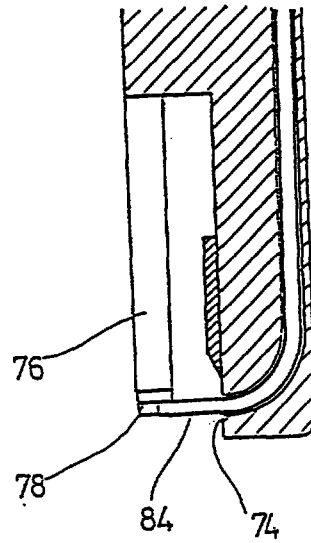
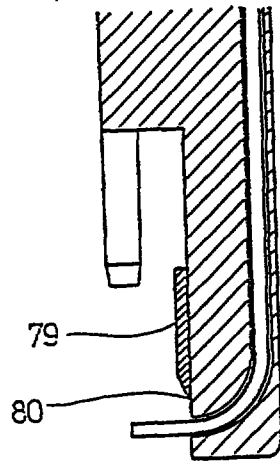


Fig. 16

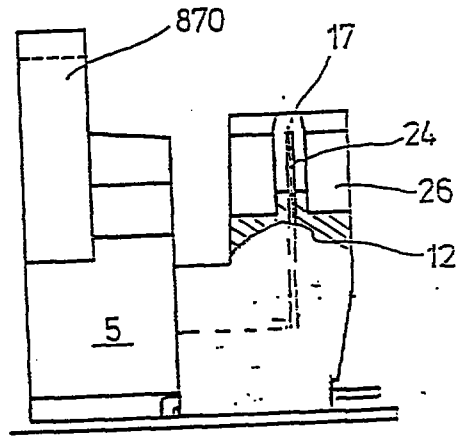


Fig. 17

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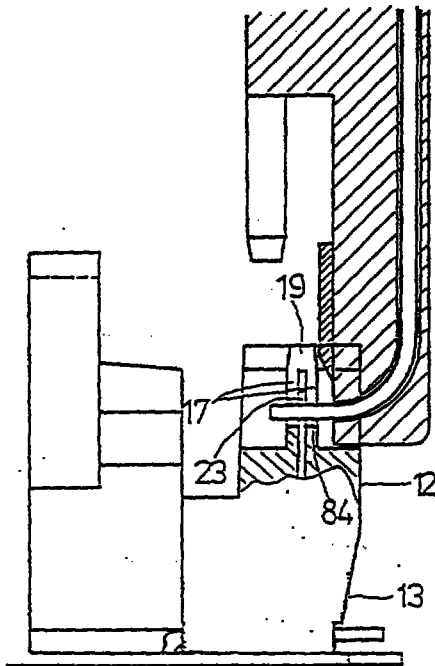


Fig. 19

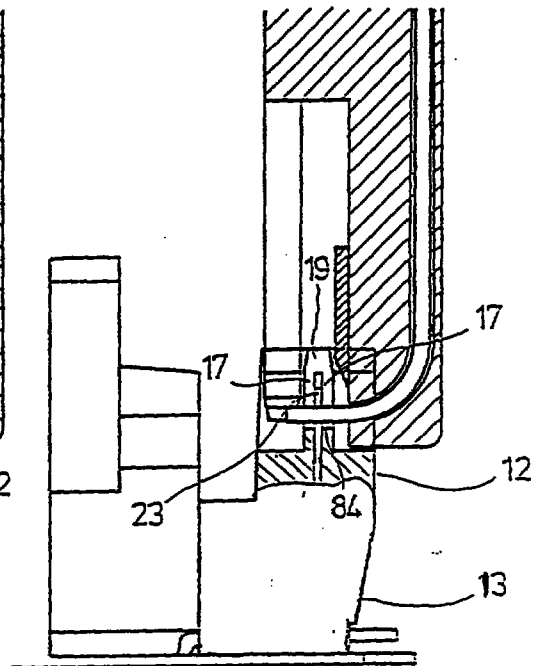


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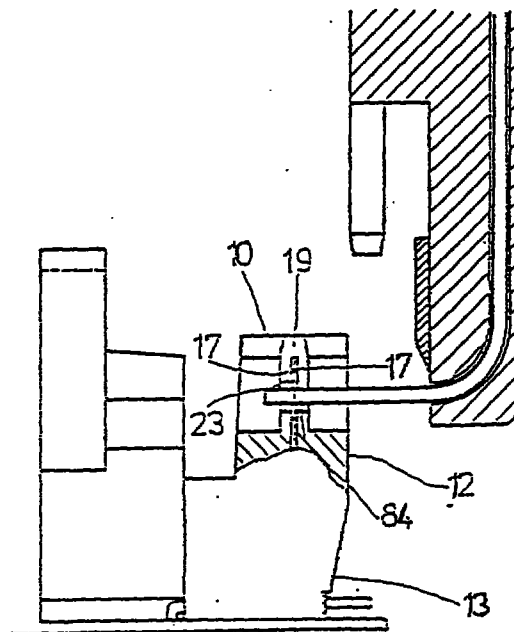


Fig. 20

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Fig. 21

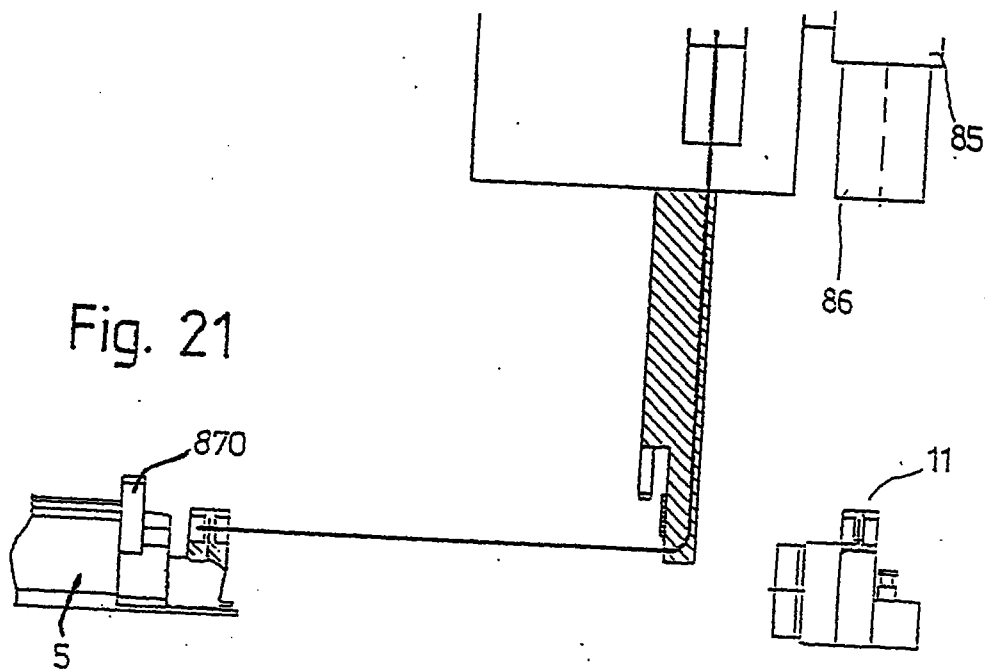
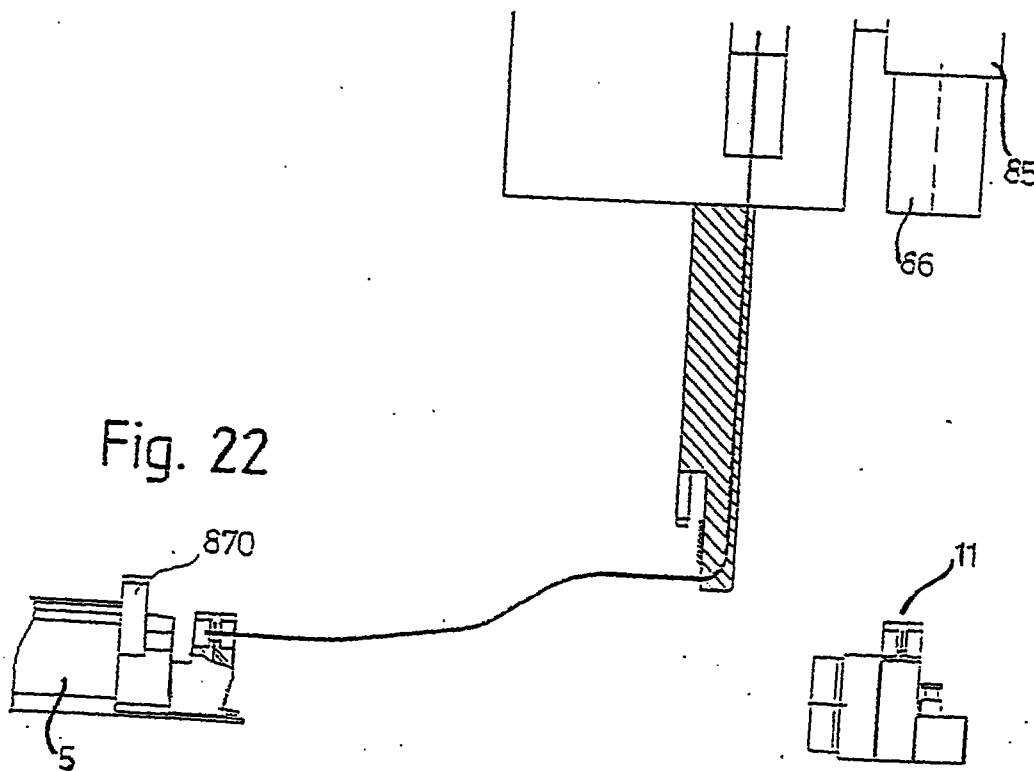


Fig. 22



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Fig. 23

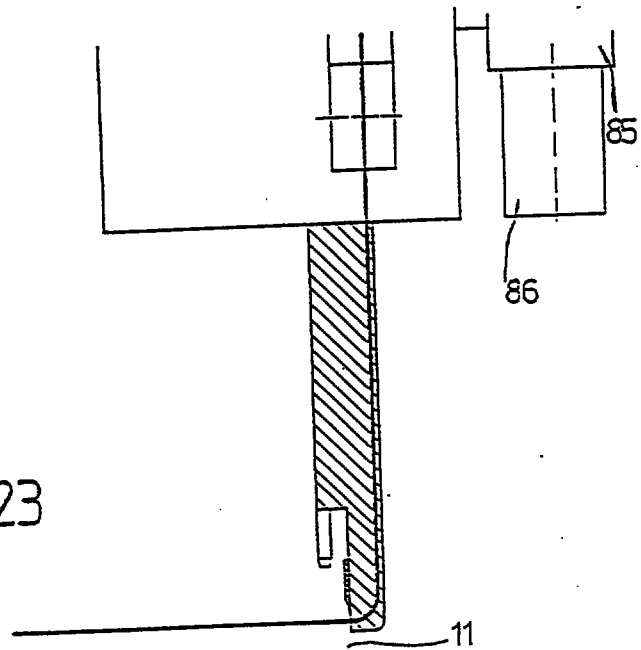
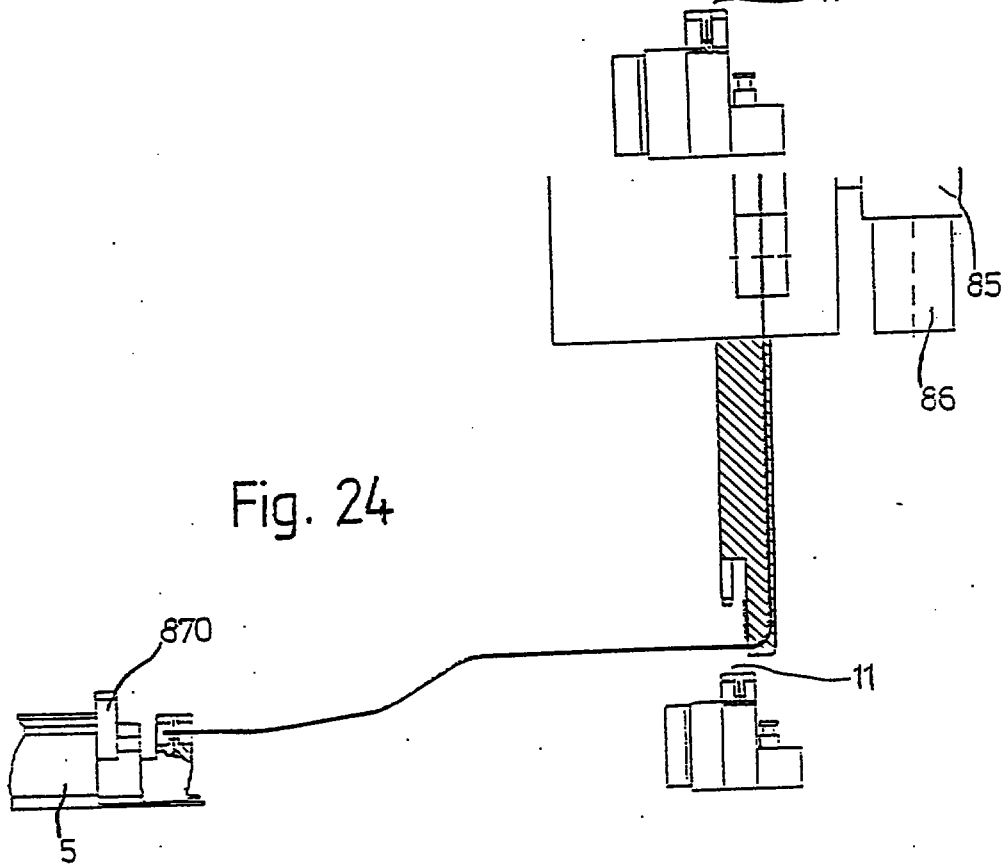


Fig. 24



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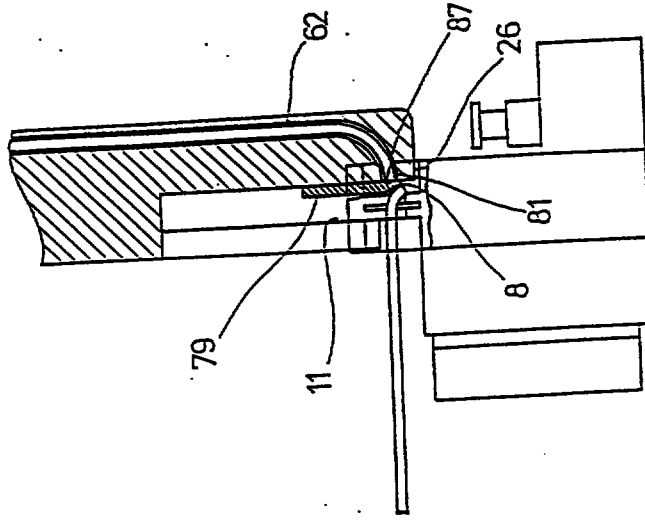


Fig. 27

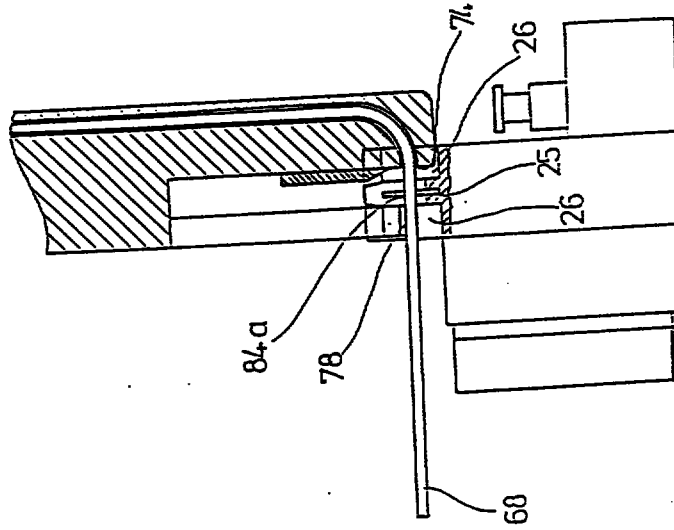


Fig. 26

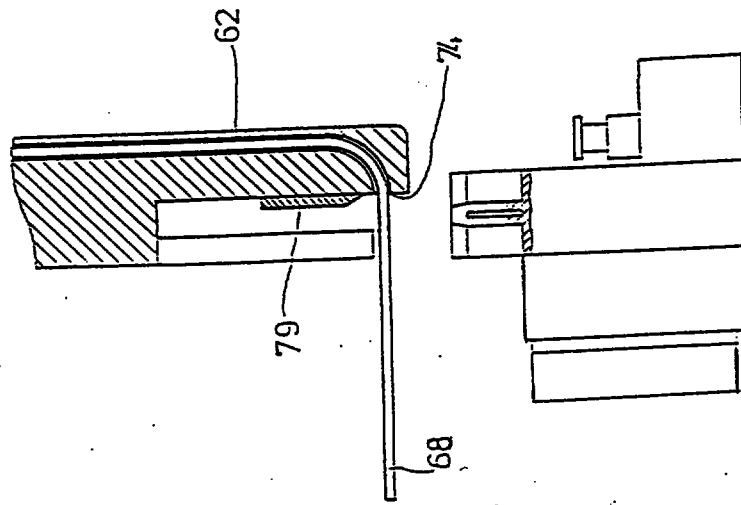


Fig. 25

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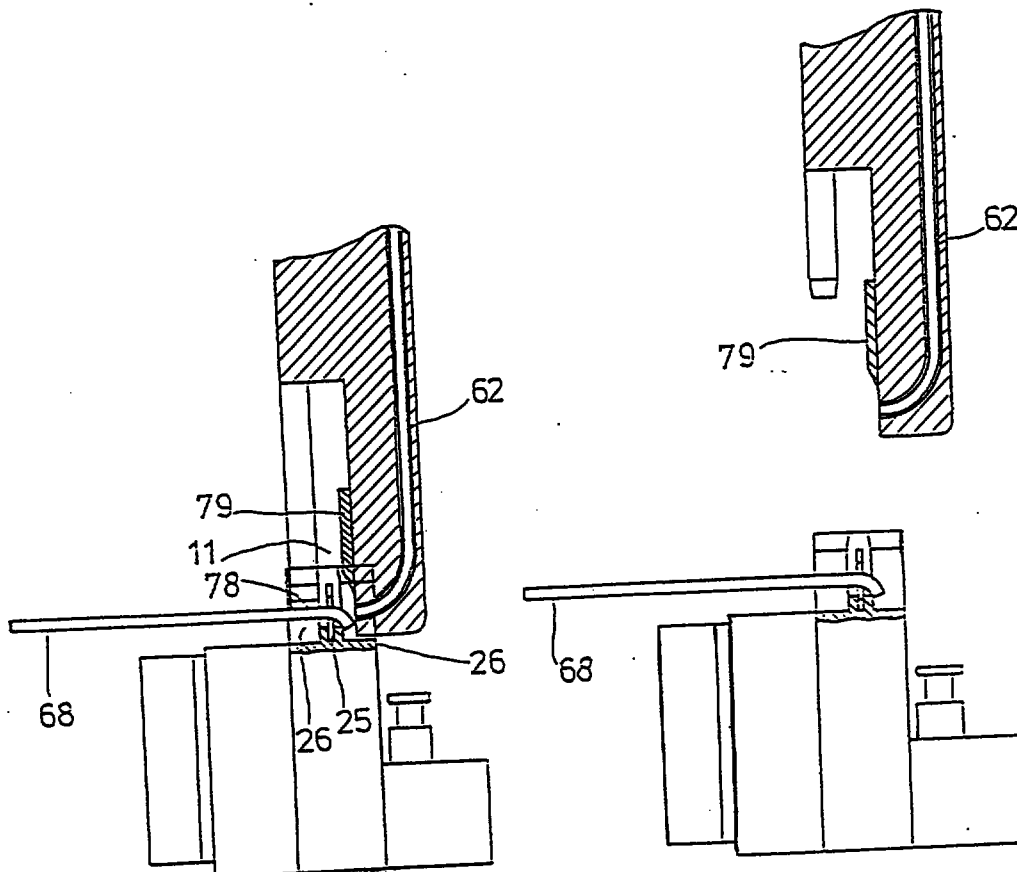


Fig. 28

Fig. 29

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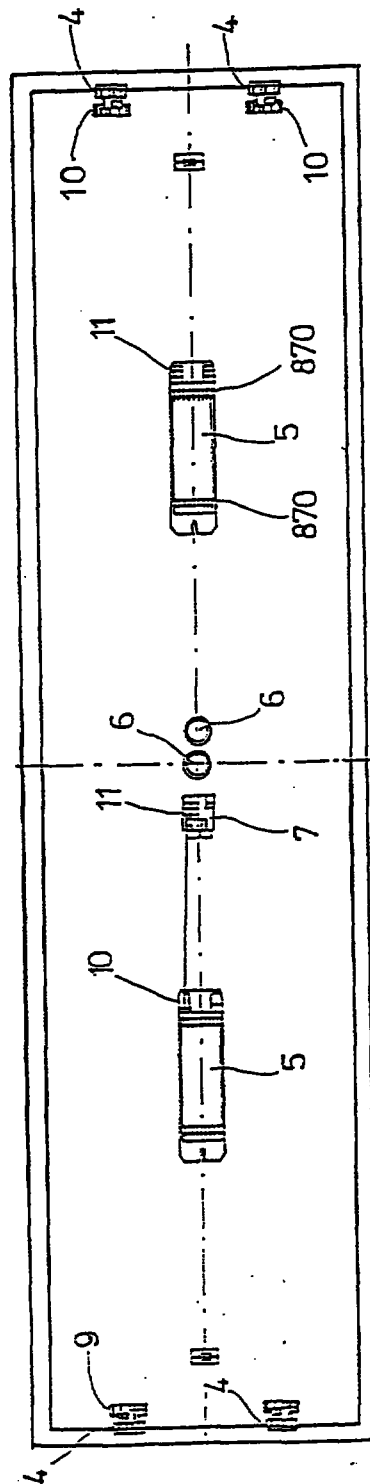


Fig. 30

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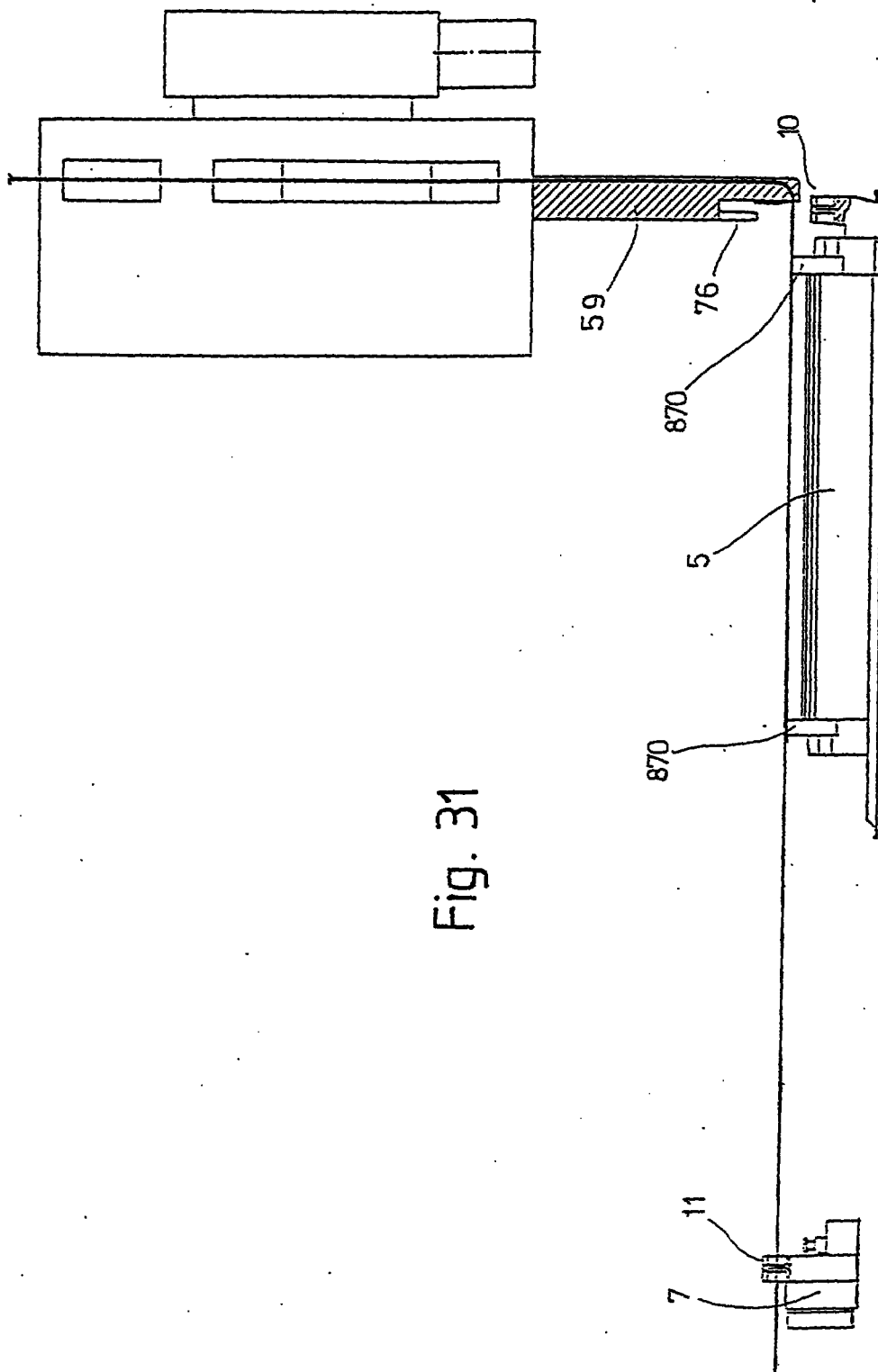


Fig. 31

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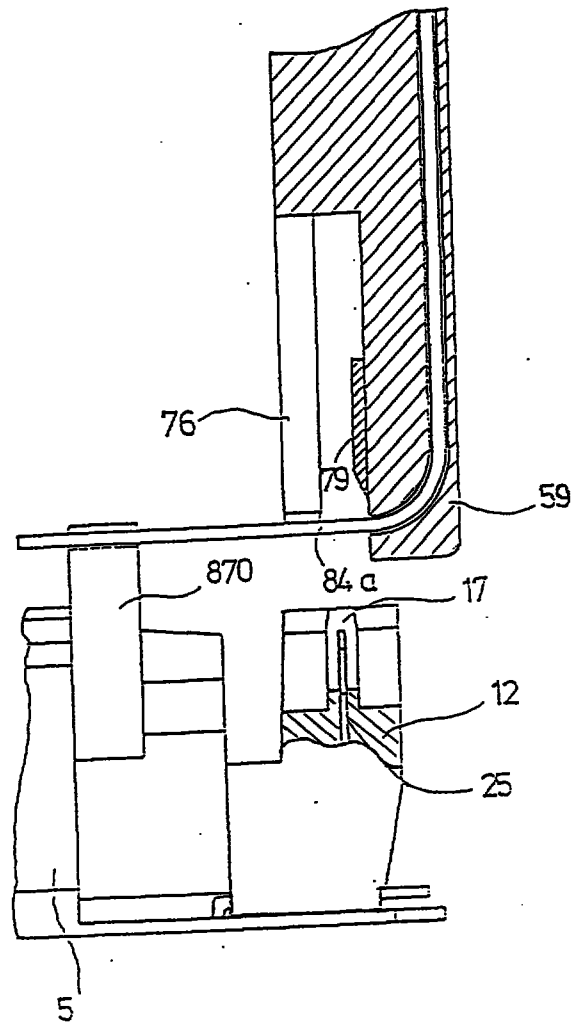


Fig. 32

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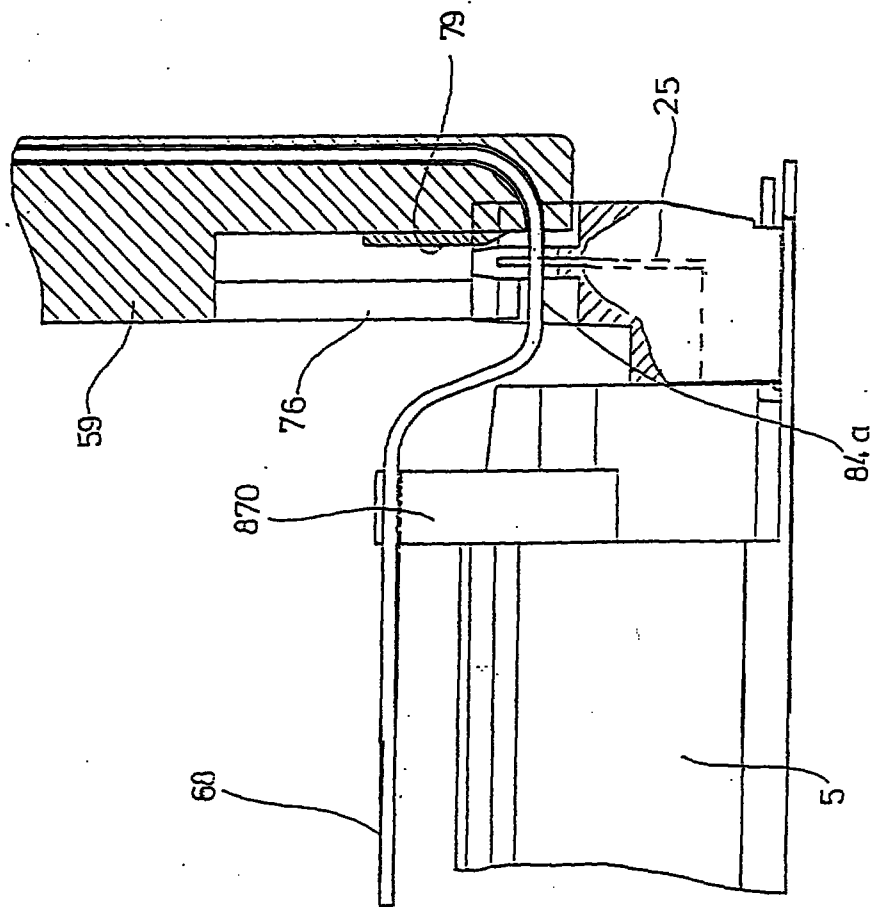
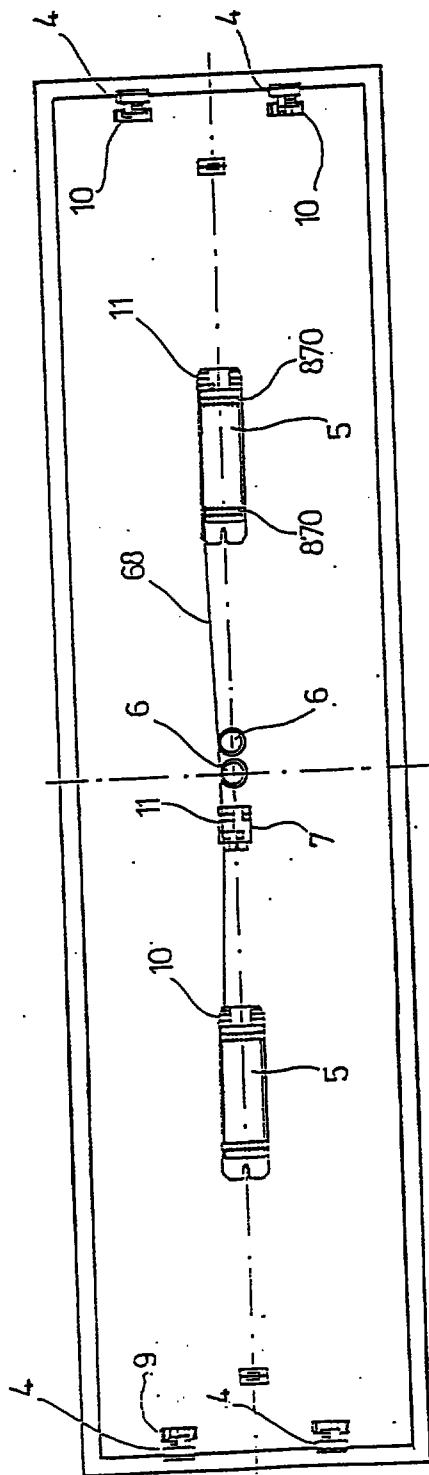


Fig. 33

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PROCESS FOR WIRING CONNECTIONS OF ELECTRICAL APPLIANCES OR COMPONENT ELEMENTS

The invention relates to a method for wiring of terminals of electrical apparatus or apparatus systems with the aid of controlled mechanical line-laying means, in particular line-laying means arranged for carrying out this method.

The term "wiring" is understood in the industry, in the case of electrical apparatus or apparatus systems, to mean the connecting of terminals to an electric line and the contacting of this line at the applicable terminal, in order to establish an electrical connection, for example with the associated switch element. This kind of wiring is required in the majority of electrical apparatuses operating in the low-current range, including electronic switch control and regulating equipment and in apparatus systems, this latter overall term being understood to include in particular such elements as printed circuit boards, plug-in packages or modules, etc., which as available on the market are designed as units and are intended to be inserted into electrical apparatuses. For the wiring itself, as a rule, switch wires, which are provided with a lacquer coating or a sheath of insulating material, or insulated flexible cables are used as the lines. Connecting the lines, which are insulated at the ends, in the contacting zone of the respective terminal is done using various known connecting techniques (such as screwing, plug-in connection, soldering, insulation displacement connection method of termination, and crimping). The operating steps required for the wiring are even today predominantly done by hand. This is

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time-consuming and frequently requires trained workers; the resultant expense is therefore considerable.

For the sake of more-rational production, particularly in relatively large-scale mass production of identical electrical apparatuses, it is known to prefabricate the lines or to produce partial or complete cable harnesses, or in other words a typical preassembled product, first in a first region, separately from the electrical apparatus. In a second region, the insulation of this preassembled product in the applicable apparatus or end product is then done. This final assembly includes essentially the contacting or connecting of the various lines of the preassembled product to the contacting zones of the terminals and laying and securing the prefabricated lines or cable harnesses in the apparatus. While automated prefabricating devices are already in use for prefabricating the lines, the ensuing further processing of the lines that have been produced, for instance to produce partial or complete cable harnesses, and the operations directly at the wiring site are still virtually without exception done by hand.

A number of methods and apparatuses are already known for automatic production of cable harnesses (US Patent 4,677,734; German Patent Disclosures DE-OS 36 08 243, 36 11 805, 38 20 636, and 38 20 638; and Swiss Patent 598 740), all of which employ what are known as wire-laying boards and the like. However, all these methods require very major technical effort and expense, which can be considered only for relatively large-scale mass-production of equipment. In any case, with this technique the fundamental problem still remains that the final assembly of the prefabricated lines or cable harnesses involves considerable labor, and so the attainable rationalization effect remains limited. Moreover, the

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course of the lines in the apparatus must often be chosen with a view to the prefabrication of the lines or cable harnesses, and this means long laying paths with detours, branches, loops, and bi-directional motions of clamping devices.

The object of the invention is therefore to create a wiring method for electrical apparatus and apparatus systems that makes it possible to substantially rationalize wiring compared with known methods, while at the same time assuring high operating safety while lessening the possibilities for error in the wiring.

To attain this object, the method according to the invention has the characteristics of claim 1.

The new method assures rational complete automation of the wiring of electrical apparatus and apparatus systems. It makes it possible to dispense with prefabricated lines and partial or full cable harnesses, because it performs direct assembly of the lines in the apparatus or apparatus system. It is possible to contact a line in the form of an endless line to be contacted fully automatically to the terminals provided with suitable automation-appropriate contacting zones, lay it in a defined way in the wiring process between the terminals, and finally to cut it off. With this direct assembly of the line, the requisite electrical connections are automatically produced serially and completely. The capability of through-wiring, that is, connecting a plurality of terminals with one line, offers a substantial advantage. It is in fact possible to dispense with the plurality of lines previously needed for that purpose. This not only represents economy in terms of the number of lines but also avoids doubling up at terminals and multiple laying out of the same terminals, since the lines are mounted directly and paid-out from a supply, and since as already noted, it is unnecessary to produce preassembled products,

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or in other words to prefabricate the lines, a very major rationalization effect is attained, while at the same time fewer changes in direction in the laying process itself are required. Branches, loops and the like that were previously needed with a view to the prefabrication of lines or combining lines into partial or full cable harnesses, are largely dispensed with. At the same time, in comparison with the prior art, there are fewer terminals, which increases the wiring safety and reduces the possibilities of error.

When long laying paths are structurally dictated, a support or retention location can also be brought into operating range of the line-laying means and positioned correctly relative to them by means of a relative motion between the preassembled apparatus or apparatus system; in that case, by means of the line-laying means, the line can be inserted into a line mount at the support or retention point and secured there. From this support or retention point, the line is then, in the next direct wiring operation, carried to the next terminal, at whose contacting zone it is again contacted and clipped as needed.

In the new method, both the beginning and the end of the line as well as a continuous line can be contacted at the corresponding successively contracted terminals. Since the beginning of the line is fixed at the terminals at the onset of laying a line, the tensile relief required in direct laying of the line can be attained simply in that the line length paid out during line-laying between two terminals by the line-laying means is automatically synchronized with the relative motion between the preassembled apparatus or apparatus system and its line-laying means. The line length paid out by the line-laying means may be dimensioned as long enough that the line laid between the

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terminals is completely free of tensile strain. If necessary, this line can also readily be laid with an excess line length, for example so that it sags. If it should be desirable in individual cases for the line laid between two terminals to be kept at a certain tensile strain, then this can also be achieved by a simple suitable adaptation of the line-laying means to the aforementioned relative motion between the preassembled apparatus or apparatus system.

For practical performance of the new wiring method it is advantageous if upon the relative motion between the preassembled apparatus or apparatus system in the line-laying means, the line-laying means merely come into the vicinity of the applicable terminal, whereupon next the line-laying means, in a positioning motion, are positioned precisely correctly relatively to the terminal. In this way it is attained that the displacement motion of the line-laying means, taking place along the path corresponding to the predetermined laying course, need not meet overly stringent requirements for accuracy, while at the same time, exact prepositioning of the terminals themselves or of the components carrying them in the electrical apparatus or electrical apparatus system becomes unnecessary. The positioning motion required for exact positioning can be imparted to the line-laying means, which have been brought to the vicinity of the applicable terminal, in direct cooperation between a laying tool of the line-laying means and the suitably designed terminal, or a guide device provided on it, to mention a quite simple possibility. The procedure may also be such, however, that with the line-laying means brought to the vicinity of the terminal, the positional deviation of the line-laying means from the position of the terminal is ascertained with position sensing means, and the

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positional deviation is then automatically compensated for. Sensing means that are intrinsically arbitrary may be used to ascertain the positional deviation. An image processing system assigned to the line-laying means has proved to be especially practical for this purpose; to take pictures, it is moved near the terminal, and it has means for image evaluation, in which the compensation for the positional deviation is calculated, whereupon a corresponding control signal is output that is evaluated for controlling a motion device of the line-laying means.

The relative motions between the preassembled apparatus or apparatus system and the line-laying means that are required in carrying out the new wiring method in the course of the direct wiring can in principle be produced in various ways. For instance, the line-laying means may be moved by a multiaxially movable manipulator or industrial robot, whose motion is programmable in at least one axis. The preassembled apparatus or apparatus system is then located prior to the beginning of the wiring in a stationary position within the operating range of the manipulator or industrial robot. The latter is assigned a suitable control unit, in which the course coordinates required for the laying courses are programmed, such that the line-laying means execute the moving and positioning motions necessary in the operating process, and by means of suitable system components (sensor system, etc.), perform further functions, such as the aforementioned positional tolerance compensation, by means of suitable system components (sensor system, etc.).

Alternatively, however, the procedure may be such that the line-laying means are stationary or located at a positioning device that imparts merely a positioning motion to them, while the preassembled electrical apparatus or apparatus system is moved by

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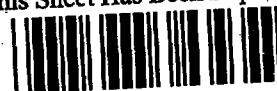
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means of a transport means movable relative to the line-laying means. The transport means is again connected to a programmable control unit, which makes it possible to fully automatically achieve the appropriate laying courses for the directly wired lines. The outcome of the work is therefore the same. Which of these two kinds of procedure will be chosen in a given case depends, among other factors, on the type of apparatus or apparatus system to be wired.

The relative motion between the preassembled apparatus or apparatus system, produced in the manner described for the direct wiring, can intrinsically be chosen arbitrarily as a function of local conditions within the apparatus or apparatus system, and even curved laying courses are possible. As a result, however, it is practical if this relative motion is at least intermittently substantially rectilinear, so that at least intermittently straight laying courses result.

Forming the contacting zones at the various terminals must be done in a way suitable for automation; that is, the line-laying means must be capable, after their positioning at the applicable terminal, of introducing the line into and contacting it in the applicable contacting zone fully automatically. As has been recognized, this requirement can be met especially simply by using contacting zones that have contact means operating by the principle of the insulation displacement connection or contact (IDC) method, or IDC technique; the line is pressed into the contact means by the line-laying means, producing the electrical contact. The IDC technique produces a very high-quality electrical connection of the electric conductor of the line to be connected and the contact means, because it brings about a large-surface area, gas-tight contacting in the manner of a cold weld. Since

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the conductor is contacted immediately after the insulation is cut, oxidation of the conductor surface cannot occur as it does if the line end are first insulated-off or stripped in a separate operation prior to the contacting. For fixation, the line upon being pressed in suitably firmly is clamped on at least one side of the IDC contact means. The pressing-in itself is advantageously done such that a pressing-in force is exerted upon the line on both sides of the IDC contact means, so that upon being pressed in, the line remains perfectly aligned and is reliably both contacted and firmly clamped.

If through-wiring does not occur at the particular terminal, the line is clipped immediately at the line-laying means or, by suitable formation of the IDC contact means, directly at the line-laying means; at the same time, shock-hazard protection for the contacted line end is produced. Since stripping of its own insulation is not provided, there will be savings at each terminal compared with other connection techniques of a small length of line, which over the length of line required for the entire wiring represents a noticeable economy.

As already referred to at the outset, the new fully automatic method of direct wiring can be employed without prefabrication of lines etc. in intrinsically all apparatus and apparatus systems. However, it has been found that a very valuable application is to employ it for automatic wiring of lighting fixtures or parts thereof. Such lighting fixtures in fact have a relatively large light box, whose dimensions are chosen with a view to the luminous bodies to be accommodated in it, such as gas discharge lamps, etc., and also have some standardised associated network elements such as ballasts that are accommodated in the light box. Wiring of the terminal of these network elements is often done entirely manually at present; this is expensive and difficult.

The novel wiring method is carried out with suitably defined line-laying means, which make it possible to carry out the various functions required for the operating

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process. An especially suitable embodiment of such line-laying means for this purpose is the subject of claim 20.

By providing a pressure member, located in the vicinity of the mouth of the guide conduit or guide tube of the line, for the like emerging from the mouth it is attained that the line in this region can be pressed into the contacting zone of the terminal in such a manner that it is aligned and perfectly supported. High wiring safety in the region of the terminals can thus be assured, while at the same time no remachining whatever is needed. The contacting zone of the terminal is as a rule formed by the aforementioned IDC technique, but the new tool can in principle be used for other connection techniques as well where it is crucial for a conductor end or conductor piece to be introduced and in particular pressed in a predetermined orientation exactly into a slit or into a corresponding receptacle of a clamping device

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present at the particular terminal.

In an advantageous embodiment, the pressure member is a ram guided longitudinally displaceably along the housing or along a part of the laying tool connected to it; as a rule, the ram is located parallel to and spaced apart from the so-called laying prong of the laying tool, the prong likewise being formed as a ram, so that the conductor on being pressed into the contacting zone is supported at two points spaced apart from one another by the same distance. The mouth of the guide conduit or tube of the laying tool is suitably located laterally on the laying prong on the side toward the pressure member, and the pressure member and the laying prong may have at least in some regions an essentially equal width, measured transversely to the longitudinal width of the conductor emerging from the mouth of the guide conduit or guide tube. A very simple design of the terminal can thus be achieved.

In order to clip the line at a terminal, an IDC contact may for instance used, which has a clipper edge that becomes operative when the conductor is pressed into the contacting zone. In that case it suffices to provide the aforementioned pressure member on the laying tool. If this kind of clipper edge at the terminal is dispensed with, then it is advantageous if controlled clipper means for the line are provided on the laying tool that have at least one movable clipper blade in the region between the mouth of the guide conduit and the pressure member. This clipper blade may be supported so that it acts directly at the laying finger, with the edge of the mouth of the guide conduit being formed as a counterpart knife. Clipping of the conductor can be done either next to the contacting zone or directly within the contacting zone itself.

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Finally, the laying prong of the laying tool is as a rule fixedly located on the housing thereof, or on a part connected to it; however, it may also be supported movably and coupled to its own adjusting means.

As already explained, the new method for direct wiring can be carried out especially simply using terminals whose contacting zones are designed in accordance with the so-called IDC technique. This technique is explained, for instance in the journal entitled "Messen + Prüfen/Automatik" [Measurement + Testing/Automatic Systems], July/August 1982, pp. 491, 492; the design of corresponding IDCs or IDC contacts may be learned for instance from German Utility Model DE-GM 88 04 388, published French Patent Application 2 330 159 and U.S. Patent 2,501,187. Based on this prior art, the preferred object is to create a terminal for use in the method referred to above, using the aforementioned line-laying means, that is designed such that in a simple, effective way it assures operationally safe contacting and fixation of the connected line and at the same time does not hinder carrying out the method automatically.

The terminal is formed according to a feature of the invention with a slitlike or groovelike indentation provided on the housing of the clamping terminal means. This assures on the one hand shock-hazard protection of the clipped end of the line, without requiring additional method steps or provisions for that purpose. Secondly, if necessary, it can also provide centering of the laying prong and/or pressure member of the laying tool upon introduction of the line into the contacting zone. The IDC contact itself that is used then upon introduction of the line brings about a certain automatic height compensation, because the

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only critical point is that the conductor be received firmly in the IDC seat with a certain height tolerance range.

The introduction slit in the housing at the terminal may have a width that brings about a clamping fixation of a pressed-in line, so that the line is fixed independently of the actual contacting zone. The indentation in the housing may also be defined on both sides of IDC contacts or located on one or both sides of an IDC contact.

DRAWINGS

The method of the invention is described below in terms of an exemplary embodiment, in conjunction with the drawing. Shown in the drawing with respect to an example are:

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Fig. 1 in a perspective schematic view, a preassembled light box of a fluorescent light fixture to be wired by the method of the invention;

Fig. 2, in a fragmentary perspective view on a different scale, the terminals, formed in the according with the invention, of a fluorescent lamp ballast choke for the light box of Fig. 1;

Fig. 3, a fragmentary plan view on a different scale of a terminal of the arrangement of Fig. 2;

Fig. 4, a plan view corresponding to Fig. 3 of a terminal of the arrangement of Fig. 2, in a modified embodiment;

Figs. 5-7, side views in section taken along the line V-V of Fig. 3, and line VI-VI and line VII-VII of Fig. 5, respectively, of a clamping terminal of one of the terminals of the arrangement of Fig. 2;

Fig. 8, a schematic perspective view on a different scale of the terminals, formed according to the invention, of the clamping block of the light box of Fig. 1;

Fig. 9, in a perspective view on a different scale, the terminals formed according to the invention of a lamp socket of the light box of Fig. 1;

Fig. 10, a schematic side view of an apparatus for carrying out the method of the invention with the aid of an industrial robot;

Fig. 11, a plan view of the device of Fig. 10;

Fig. 12, a schematic side view of a device for carrying out the method of the invention with the aid of a portal manipulator;

Fig. 13, a schematic side view of a further embodiment of a device for carrying out the method of the invention, using a manipulator, with a movable transport table;

Figs. 14-20, a schematic detail view of the laying tool of the device of Figs. 10 and 11 showing its association with the



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terminal of a fluorescent lamp choke of the light box of Fig. 1, illustrating various chronologically successive phases in the course of the method of the invention upon connecting the endlessly supplied line to the first terminal;

Figs. 21-29, each in a corresponding view, the arrangement of Figs. 14-20, showing chronologically successive steps of the course of the method after the fixation of the end of the line, during laying of the line to the next terminal, upon contacting, and ensuing clipping of the line at that terminal;

Fig. 30, in a schematic plan view and on a different scale, the light box of Fig. 1 in the wiring state after the conclusion of the segment of the wiring illustrated by Fig. 14-29;

Figs. 31-33, in views similar to Figs. 14-19, the line-laying means of the device of Figs. 10 and 11 in association with a further fluorescent lamp choke of the light box of Fig. 1, illustrating chronologically successive steps in the course of the method of the invention in producing the next wiring segment; and

Fig. 34, the light box of Fig. 30, in the state after the production of the wiring segment produced by the method of Figs. 31-33.

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The method for direct wiring of electrical apparatus elements and circuit components of the apparatus systems will be described below in conjunction with the wiring of a rectangular light box 1, shown in Fig. 1, for two rod-shaped gas discharge tubes eg. fluorescent light bulbs not shown in further detail. For operation the light box is covered with a transparent or translucent acrylic glass hood or reflector, which is clamped in place in mounts or retainers 2 and not shown in further detail.

The light box has already been pre-assembled to the extent that the necessary electrical switch elements for receiving and operating the gas discharge lamps have been secured in the correct positions by a predetermined location plan fixedly to the box bottom 3, for instance being screwed in place. In detail, four lamp sockets 4 of a known construction are provided in the vicinity of the end walls of the box, each in pairs facing one another, and two magnetic fluorescent lamp chokes 5 are assigned to each pair and are locked on approximately the centre line of the box bottom 3, on either side of line introduction openings 6, at equal intervals from the end walls of the box. An insulating material base 7 that carries a capacitor 8 is secured to the box bottom 3, also located on its centre line, next to the line introduction openings 6. Terminals for electric supply lines are provided on each of the lamp sockets 4, ballasts 5 and insulating material base 7; these terminals are identified by reference numeral 9 for the lamp sockets 4, reference numeral 10 for ballasts or chokes, and reference numeral 11 for the base 7 of insulating material of capacitor 8. These terminals 9, 10 11 are all designed by the same basic principle with a contacting zone in accordance with the IDC technique. Their form can be seen in detail from Figs. 2 through 9; it will be described below in particular in terms of the

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terminal 10 of a choke 5, with reference to Figs. 2 through 7:

Each terminal 10 has a housing 12, made of insulating material and of essentially rectangular cross section, which is placed on a base part 13, likewise produced from insulating material, resulting in a unit-type connection clamping terminal that is secured at 14 to a stamped, upward-bent tab of a baseplate 15 of the choke 5. The two side walls 16 of the housing 12, which is open at the top, have on their inside two formed-on ribs 17 opposite one another, which are located approximately in the middle between the two face ends 18 of the housing 12 and between them define a slightly wedge-shaped or parallel-sided introduction slit 19 (Fig. 6), which is widened on its top by means of introduction bevels 20. In its lower region, the introduction slit 21 is locally widened somewhat in a region in the shape of part of a circle.

Two narrow grooves 22 facing one another extend into the ribs 17 from below to approximately the height of the introduction bevels 20; they receive the two legs 24, defining an IDC slit 23 open at the edge, of an IDC contact 25 made from spring steel or spring bronze. The narrow, essentially U-shaped IDC contact 25 in the form of a small plate is embedded on all sides in the insulating material of the housing 12 except for the clipping segments formed at the legs 24 and oriented toward the IDC slit 23; both legs 24 are limitedly movably guided in the grooves 22. In a manner not shown in further detail, one end of the winding of the choke 5 is connected to the IDC contact. Together with the IDC slit 23, the IDC contact forms the contacting zone of the terminal 10.

As can be seen particularly from Figs. 3 through 7, the housing 12 has one groove-like indentation 26 of rectangular cross

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section each on either side of the ribs 17 and hence adjoining the introduction slit 19, each indentation being open toward the top of the housing 12 next to the introduction slit 19. The two groove-like indentations 26 are located in alignment with one another and with the introduction slit 19. They are likewise defined toward the top by an introduction bevel 27. Figs. 5, 7 show that the depth of the groove-like indentations 26 is greater than the depth of the introduction slit 19, and that its width 28 is also substantially greater than the width of the introduction slit 19.

The dimensions of the individual parts are selected such that for an insulated conductor pressed in through the introduction slit 19, the insulation is cut open in the IDC slit 23 by the legs 24 of the IDC contact 25, and at the same time a gas-tight contacting takes place between the IDC contact 25 and the conductor that is deformed at the clamping point. The pressed-in conductor is simultaneously firmly clamped by its insulation in the introduction slit 19 between the two ribs 17, and the widening at 21 serves to assure that the line will lock into place in detent fashion at its insulation upon being pressed into the introduction slit 19. The thus-fixed, connected line extends through one of the groovelike indentations 26, (Fig. 2) while its clipped end is located in the other groovelike indentation 26, as will be described in further detail hereinafter. The width and depth of the groovelike indentations 26 and their axial length are dimensioned such that contact protection is automatically produced for the clipped end of the line. This means that a standardized sensing prong, in the test for shock-hazard protection, cannot penetrate as far as the bared, clipped end at the depth of the associated groovelike indentation 26.

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In the embodiment of the housing 12 described, two groovelike indentations 26 aligned with one another are provided, one on either side of the introduction slit 19, and their width and depth are substantially larger than the diameter of the line to be received. It is also conceivable to leave out one of the groovelike indentations 26, which is particularly worth considering if the line is merely being laid continuously through the terminal, as will also be described in further detail below. In individual instances, both groovelike indentations 26 may even be omitted.

Fig. 4 shows a modified embodiment of the housing 12 in plan view: In this embodiment, only one groovelike indentation 26 is present, which is defined in the housing 12a on both sides by one pair 17 of ribs each with an intervening introduction slit 19 and by a contact element 25 protruding into the slit with its legs 24. The pairs of ribs are each formed on flush at the ends with the side walls 16a in the housing 12a and are aligned by their introduction slits 17 with the longitudinal axis of the groovelike indentation 26.

While in the embodiment of Figs. 2 and 3 a clipped end of a line is located next to the contacting zone formed by the IDC element 25 (see Figs. 27-29, for instance), in the embodiment of Fig. 4 it is assured that the clipped end will be located in the contacting zone defined by the two IDC contacts 25, or in other words inside the housing 12a that is closed on all sides except for the introduction slit.

The terminals 11 located on the insulating material base 7 are fundamentally formed identically to the terminals 10, as can be learned from Fig. 8. Reference is therefore made to Figs. 2-7 in terms of their description. Identical elements are identified

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by the same reference numerals.

A total of three terminals 11 are located on the insulating material base 7; two of them are combined into a connection clamp unit marked 28, which has a unitlike housing 12b. Clamps are indicated at 29 for internal connection to the terminals of the capacitor 8.

The terminals 9 of the lamp sockets 4 are also fundamentally equivalent to the terminals 10 of Figs. 2 and 3 in design. In Fig. 9, identical elements are therefore again provided with the same reference numerals and reference is made to the description of Figs. 2 and 3.

While for the terminals 10, 11 (Figs. 2, 8) the housings 12, 12b are however located with their introduction slits 19 and the groovelike indentations 26 pointing longitudinally of the choke 5 or starter 6 and hence longitudinally of the light box bottom 3 (Fig. 1), the arrangement for the lamp sockets 4 is made such that the housings 12 are secured on a fastening base 30 of the respective lamp socket 4, with introduction slits 19 and groovelike indentations 26 extending transversely to the longitudinal direction of the gas discharge lamps to be used and hence of the lamp box bottom 3. In the lamp sockets 4, lines to be connected must therefore be pressed into the introduction slit 19 in such a way that they extend at right angles to the longitudinal direction of the lamp box 3.

The wiring of the light box 1, described thus far in terms of its circuit elements 4, 5, 7 and their terminals 9, 10, 11, is done with the aid of an industrial robot as shown in Figs. 10, 11 or a manipulator as shown in Figs. 12, 13 that moves the line-laying means, as will be described below in conjunction with Figs. 13 ff:

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The line-laying means, identified overall by reference numeral 31, are seated in the apparatus of Figs. 10, 11 on the two-piece arm 32 of an industrial robot 33, which has a column 36 rotatable about a first stationary vertical axis 34, for instance by a stepping motor drive 35, and the column carries a first arm piece 37, which in the region of its free end is connected, via a swivel bearing 39 that forms a vertical second pivot axis 38 parallel to the first pivot axis 34 and is provided with an incremental rotational drive, to a second arm piece 40, which carries the line-laying means 31 on its outer end. The two drives 35, 39 can move the second pivot axis 38 along a circle 41 about the first pivot axis 34 and in the extended state of the arm 32 can move the line-laying means 31 along an essentially circular path curve 42; a reciprocating drive 43 associated with the drive column 36 enables a controlled vertical raising and lowering motion of the arm 32 and thus of the line-laying means 31. the industrial robot 33 is assigned a stationary work table 44, with a transport mechanism integrated in it as suggested by an arrow 45 (Fig. 10), which mechanism makes it possible, on the horizontal work surface of the work table 44, to move successively preassembled light boxes 1 of Fig. 1 from a remote readiness position at 46 (Fig. 10) to the operating range of the line-laying means outlined by the essentially circular path curve 42, as is indicated at 47 by the working position of the light box 1 shown in Figs. 10, 11. In this working position 47, the light box 1 is firmly clamped to the work table 44 in the correct position. The associated clamping means are of a known type; they are not further shown in Figs. 10, 11. Within its operating range, the line-laying means 31 can be moved by the programmable industrial robot 33 to any arbitrary location inside the light box 1 and can

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be moved along any preprogrammed, defined course inside the light box 1.

The situation is fundamentally the same if the portal manipulator 48 shown in Fig. 12 is used, in which the preassembled light box 1 is firmly fastened in the correct position on a light box receptacle 50 on a stationary work table 49, and the line-laying means 31 are located on a carriage 51 that is supported on a portal 52 in such a way that it can be freely programmably moved both in an X direction represented by a double arrow in the longitudinal direction of the light box and in a Y direction, again represented by a double arrow, extending transversely to it. Moreover, the line-laying means 31 are rotatably supported on the carriage 51 about a vertical pivot axis 53 (c axis). Each of the axes of motion X, Y, c, like the reciprocation axis (z), are assigned their own incremental stepping drives, which being triggered by a freely programmable control unit can move the line-laying means 31 to any arbitrary point along a particular preprogrammed course within the fixedly clamped, preassembled light box 31.

Finally, the relative motion between the line-laying means 31 and the preassembled light box 1 required for line laying, or in other words for laying the terminals 9, 10, 11 of the preassembled light box 1, can also be attained with the apparatus of Fig. 13. Here the preassembled light box 1 is clamped to an XY table 54 by means of the light box receptacle 50; the axes of motion X, Y of this table are each represented by double arrows. The line-laying means 31 are carried by a positioning device 56, located above the XY table 54 on a stationary carrier 55; this device is capable of imparting a reciprocating motion in the Z direction (represented by a double arrow) and a rotational motion

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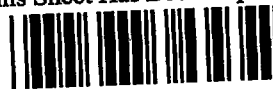


about the vertical axis 53 (c axis) to the line-laying means 31. In this case as well, incremental drives for motion in the XY axis or the zc axis are assigned to the XY table 54 and the positioning device 56 and are triggered by a freely programmable control unit, in such a manner that the line-laying means can be moved to any arbitrary site within the light box 1 along the particular programmed course.

The line-laying means 31 in turn have preferably a so-called line laying tool 57 with an optionally multiple-part housing 58, which is secured to the arm 32 of the industrial robot 33 (Fig. 10) or to the carriage 51 (Fig. 12) or to the positioning device 56 (Fig. 13). A vertical laying prong 59 of substantially rectangular cross section is located on the underside of the housing 58 and includes an L-shaped curved line guide conduit 62, which opens out in the region of a side wall at 60, a short distance from the flat bottom face 61 of the laying prong 59. The line guide conduit 62 (Fig. 14) contained in the laying prong 59 is extended in the housing 57 in the form of a guide tube 65, to which a belt drive for a line suggested at 68 and comprising two pairs 66 of belt rollers (Figs. 12, 13) and endless drive belts 67 wrapped around them, is assigned.

The belts 67, each guided by one side parallel to one another and a slight distance from one another are coupled via the belt rollers 66 to an incremental drive that imparts a controlled drive motion to them that is synchronized with the relative path motion between the preassembled light box 1 and the line-laying means 31; this motion can be generated when the wiring is done by the devices of Figs. 10-13.

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A measurement system preceding the belt drive for the line 68 and comprising a measuring wheel 70 and a drive roller 71 elastically prestressed in the engagement position makes it possible to measure the exact feed motion of the line 68, regardless of the slip that occurs between the endless belts 67 of the belt drive, so that perfect synchronization of the line feeding with the displacement motion of the robot 33, the manipulator 48, or the XY table 54.

The laying prong 59 is as a rule rigidly secured to the housing 57; it may, however, also be supported so as to be raisable and lowerable in the vertical Z axis and provided with a suitably triggerable adjusting device inside the housing 58. This is suggested by a double arrow 72 in Fig. 12.

As can be seen for instance from Fig. 14, a pressure member movable vertically in the Z axis of a displaceable ram 76, which is raisable and lowerable via an associated control drive in the interior of the housing 58, is located laterally spaced apart from the vertical, flat side face 60 of the laying prong 59 that contains the mouth 74 of the line guide conduit 62 - or on the housing 58 itself as in Figs. 12, 13. The motion of the ram 76 is controlled by program by the control unit as a function of the displacement motion of the line-laying means 31. A sensor 77 (Fig. 14) coupled to the ram 76 outputs a check-back signal indicating the position attained by the bottom face, acting as a pressure face 78, of the ram 76 to the control unit, so that an exact adjustment of the height of the bottom face 78 of the ram 76 relative to the mouth 74 of the line guide conduit 62 is possible.

Finally, a clipper knife 79 is supported such that it can be raised and lowered on the vertical side face 60 of the laying prong 59; its associated drive mechanism, accommodated in the

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housing 58, is not shown in further detail. It can be advanced, by the knife edge 80 (Fig. 15) located on its lower end, out of the position of repose shown in Figs. 14, 16, 17 into a working position shown in Fig. 27, in which it has smoothly clipped the end of the line 68 protruding from the mouth 74 of the line guide conduit 62. To that end, the knife edge 80 has overtaken the opening of the mouth 74, with the underside 81 of the edge of the mouth of the line guide conduit 62 acting as a counterpart knife, as can readily be seen from Fig. 27, for example.

In principle, embodiments in which the knife 79 is given its own counterpart knife, separate from the laying prong 59, are also possible.

With the aid of the line-laying means 31 described, which is moved by the industrial robot 33 (Fig. 10, 11), for example, by a program along predetermined paths of movement, a preassembled light box 1, which is provided at predetermined points of the light box bottom 3 with the terminal 9, 10, 11 formed as described, is automatically wired in the following way, the description being made in conjunction with Figs. 14-34:

An insulated line 68, for instance drawn in endless fashion from a supply coil 82 (Fig. 10), is threaded into the laying tool of the line-laying means 31. This line runs between the measuring wheel 70 and the contact roller 71 and between the two endless belts 67 of the belt drive and is fed by the belt drive through the guide tube 65 into the L-shaped line guide conduit 62. The belt drive has moved the forward end of the line 68 so far forward, in the manner that can be seen from Figs. 12-17, that a segment 84 of it (Fig. 17) protrudes from the mouth 74 of the line laying conduit 62, this segment extending to beneath the pressure face 78 of the ram 76.

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A preassembled light box 1 has been moved into the working position 47 of Fig. 10 into the operating range of the industrial robot 33 and firmly clamped there in the correct position on the work table 44 (Fig. 11). The ram 76 is in its raised position of repose shown in Fig. 16; the knife 79 is also in its position of repose above the mouth 74. The belt drive 66, 67 is not moving.

The industrial robot 33, controlled by program accordingly, takes the line-laying means 31 with the laying prong 59 from a remote position of repose into the vicinity of the first terminal, which in this case is a terminal 10 of the left-hand choke 5 of Fig. 1. In the process the laying prong 59 arrives approximately at the position of Fig. 14, in which it is located above and laterally offset from the terminal 10.

In this position of the laying prong 59, position sensing means located on the housing 58 and taking the form of an image processing system 85 are located with the picture taking device 86 of this system above the terminal 10. The image processing system 85 includes means for image evaluation, with the aid of which it calculates the positional deviation of the laying prong 59 from the terminal 10 and generates a suitable compensating control signal. This signal is processed in the control unit in such a way that the industrial robot 33 - or a positioning system located between it and the line-laying means 31, similar to the positioning device 56 of Fig. 13 - performs the requisite positional tolerance compensation and positions the laying prong 59 precisely in the correct position relative to the terminal 10. Once this has been achieved, the laying prong 59 assumes the position of Fig. 16, in which it is aligned accurately above the housing 12 and the groovelike indentations 26 thereof.

The ram 76 now moves to its lower operating position of

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Fig. 17, in which it rests with its pressure face 78, located on the bottom of a longitudinal groove, on the end segment 84 of the line, suitably far advanced out of the mouth 74 of the line guide conduit 92 and positions this segment precisely horizontally. The end segment 84 of the line can then be advanced farther if needed, as far as the end of the pressure face 78.

The laying tool of the line-laying means 31 and in particular their laying prong 59 and the ram 76 are simultaneously moved downward along the vertical Z axis. In the process, the horizontal end segment 84 of the line is pressed through the introduction slit 19 of the housing 12 at the terminal 10 into the IDC slit 23 of the IDC contact 25, until the line segment 84 locks into place in the widened portion 21 of the slit (Fig. 6). In this pressing-in motion, an equally great, uniform pressing-in force is exerted from the top of the line guide channel 62 and the pressure face 78 on both sides of the introduction slit 19 upon the horizontally retained end segment 84 of the line, so that this segment is unable to escape, and satisfactory insertion into the contacting zone of the terminal 10 is assured.

In this introduction and pressing-in motion, the insulation is cut open by the clipper edges on the legs 24 of the IDC element, and satisfactory contacting is produced. At the same time, the end segment 84 of the line is positionally firmly fixed by the two ribs 17 on both sides of the IDC contact 25, with slight deformation of its insulation occurring in the process.

The ram 76 and the laying prong 59 have preferably the same width on their front end at right angles to the plane of the drawing (Fig. 19), which is equivalent to the width of the groovelike indentations 26, so that a satisfactory mutual spatial association between the housing 12 and the laying prong 59 and the

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ram 76 when the line segment 84 is pressed in is assured. The elements now assume the position shown in Fig. 18.

The ram 76 now moves upward into its final position or position of repose and releases the end of the line segment. This situation is shown in Fig. 19.

Since the end of the line segment 84 is received in the groovelike indentation 26 in the immediate vicinity of the guide groove 19, and this indentation has a length, width and height such that the free end of the conductor cannot be accidentally touched from outside, and since the IDC contact 25 is embedded in the insulating material of the housing 12 and is likewise enclosed all-insulated, i.e. protected against accidental contact from outside, satisfactory shock-hazard protection is already attained at the terminal 10.

The control unit now controls the motion of the industrial robot 33 by program such that the laying prong 59 moves from the contacted terminal 10 to the next terminal - terminal 11 - on the insulating material base 7 over the rectilinear laying course that can be seen in Fig. 30, in the process laying the line 8. This is illustrated in Figs. 20, 21.

In the process, the belt drive 66, 67, controlled by the control unit, is actuated in synchronism with this displacement motion of the laying prong 59 such that tension-free laying of the line ensues. Optionally, in this displacement motion a vertical motion in the Z axis may also be imparted to the laying prong 59, for instance in order to place the laid line on the box bottom 3 (Fig. 1) or to compensate for a difference in height between the terminals 10, 11, as suggested in Fig. 22.

In the course of this displacement motion, the laying prong 59 is first merely brought to the vicinity of the terminal 11, to

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the position shown in Fig. 21 and Fig. 22, in which the image processing system 85 is located above the terminal 11 and can detect the spatial position of the terminal, which may certainly also be influenced by unavoidable tolerances in the assembly of the apparatus systems.

The image processing system 85 now, similarly to the process described above for the terminal 10, ascertains the positional deviation of the laying prong 59 from the terminal 11 and via the control unit of the industrial robot 33 brings about the positional tolerance compensation required for exact positioning of the laying prong 59 relative to the terminal 11. Once this operation has been concluded, the elements assume the position shown in Figs. 23 and 24.

The ram 76 is now lowered from its final position or position of repose into the working position, in which it rests with its pressure face 78 on the part of the line 68, guided horizontally here, that is emerging from the mouth 74 of the line guide conduit 62; see Fig. 25.

Next, the laying prong 59 and the ram 76 are lowered simultaneously and in a fixed association both to one another and to the housing 12 of the terminal 11; the line segment 84a extending between the pressure face 78 and the top of the edge of the mouth 74 is pressed, supported at two points on both sides of the contacting zone, into the introduction slit 19 and the IDC slit 23, until it reaches the detent position already described in conjunction with Figs. 18 and 19. The line 68 is thus perfectly contacted at its line segment 84a and is firmly clamped and fixed next to the contact point on both sides of its insulation in the guide slit 19.

In the present wiring process, the line laid in the manner

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described is clipped at the terminal 11. This is done with the knife 79, which moves downward and severs the line 68 directly at the mouth 74 of the line guide conduit 62, with the edge of this mouth acting as a counterpart knife. The elements now assume the situation shown in Fig. 27.

When the line 68 is clipped in this way, the end of the laid segment of line, retained in the guide slit 19 of the terminal 11, is bent downward, as Fig. 27 shows, from the oblique face 86 adjoining the cutting edge 80 of the knife 79. This means that the bare end face of the conductor, at the cut face, is aimed toward the bottom of the surrounding groovelike indentation 26, and consequently the shock-hazard protection is substantially increased. At the same time because of this bend a further mechanical fixation of the end of the line at the terminal 11 is obtained.

This concludes the process of wiring between the two terminals 10 and 11. The knife 79 returns to its final position or position of repose, as shown in Fig. 28.

Next, the ram 76 is returned to its final position or position of repose, and the laying prong 59 is moved upward by the industrial robot 33, whereupon the outset position for the next wiring step in the light box 1 is already reached. This starting position is shown in Fig. 29.

Depending on the wiring to be done, the line 68 may also be through-wired at the terminal 11, as an example. In that case clipping of the line as in Figs. 27 and 28 is not done; instead, following the situation shown in Fig. 26, the ram 76 is returned to its final position or position of repose (see Figs. 19, 20), whereupon the control unit as programmed causes the industrial robot 33, the line-laying means 31 and thus the laying prong 59 to

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move along a preprogrammed defined path to the next terminal. This will be briefly described now in conjunction with Figs. 31-33:

The next following terminal is again a terminal 10, but now that of the right-hand choke 5 in Fig. 1. The line must be moved past the choke 5. The choke 5, as can be seen particularly from Fig. 2, is equipped in the region of both ends, at the top, with two retaining elements 870 for lines 68. Each of the comblike retaining elements 870 is provided with a row of parallel, continuous detent grooves 88 of semicircular cross section, into each of which one line 68 can be pressed via an introduction slit 89.

In the line laying between the terminals 11, 10 (Figs. 26 and 31), the industrial robot 33 therefore, along a preprogrammed path, takes the laying prong 59 first to the vicinity of the respective retaining element 870. Once positioning of the laying prong 59 has been done in the manner already described, by means of the image processing system 85, the ram 76 moves downward and either alone or jointly with the laying prong 59 presses the line into one of the detent grooves 88. Next, the ram 76 is returned to its final position or position of repose; the laying prong 59 moves upward and is moved to the next subsequent retaining element 870, where the same process is repeated.

Following this, the laying prong 59 is moved to the vicinity of the terminal 10 and positioned above it in the manner already described, whereupon the ram 76 is again moved forward until its pressure face 78 rests on the line segment 84a emerging from the mouth 74. The elements assume the situation shown in Fig. 32.

In the now-ensuing lowering motion of the laying prong 49

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of the ram 76, not only is the line segment 84a fixed in the introduction slit 19, horizontally aligned and perfectly supported, in the manner already described and contacted in the IDC slit 23, but at the same time the line 68 is also bent downward to the level of the IDC contact 25. Once the contacting is concluded, the elements assume the position of Fig. 33.

As the next step, the line 68 can either be clipped (as in Fig. 27), or alternatively it is through-wired to the next following terminal, for instance a terminal 9 of a lamp base 4.

Since for the lamp base 4 the introduction slits 19 are aligned with the terminals 9 transversely to the longitudinal direction of the light box, the industrial robot 33 must rotate the line-laying means 31 and here in particular the housing 58 of the laying tool 57 having the laying prong 59 and the ram 76, about the vertical axis (c axis) by 90°, before the then-bent line portion is introduced into the introduction slit 19 in the manner already described.

The direct wiring, carried out by the method steps described, of the preassembled light box 1 is shown in Figs. 33, 34 for the following two cases: First, the line 68 is clipped once it reaches the terminal 11 (Fig. 27), and second, it is through-wired beyond this terminal (Fig. 31).

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The claims defining the invention are as follows:

1. A method for wiring terminals of electrical apparatuses or apparatus systems with the aid of a controlled mechanical line-laying means,
comprising the steps of:
providing a preassembled electric apparatus system which includes the electric apparatuses, said apparatuses having terminals fixedly located thereon;
said terminals comprising a contacting zone including a contact element and a constricted guide region of insulating material;
relatively moving a first one of said terminals and the line-laying means into operating range and correctly relatively positioning the preassembled apparatuses and the line-laying means by means of relatively motion therebetween;
supplying the end of a line from a line supply means to the line-laying means, and introducing said end into the contacting zone of the first terminal to affix said end at that terminal and produce an electrical contact with the contact element;
relatively moving, along a predetermined path, the preassembled electrical apparatuses and the line-laying means, and bringing every other terminal successively into operating range of the line-laying means, thereby laying the line, and positioning the line directly relative to the preassembled apparatuses,
positively supplying, during each of these relative movements, from the line-laying means at least a length of the line that corresponds to the distance between said first terminal and a second successive terminal along a line-laying course;
introducing, by means of the line-laying means, the line at each terminal into the contacting zone of the respective terminal, affixing the line to the respective terminal, and producing an electrical contact; and
then, without further positioning movement of the line-laying means, cutting off the thus-laid line at the end of the line-laying course by said line-laying means, in the



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region of the last terminal to be contacted at a position within said guide region and inwardly of one end surface thereof.

2. The method of claim 1, including the step of:
bringing, a support or retention element into the operating range of the line-laying means;
positioning the line correctly relative to said support or element, and
introducing, by means of the line-laying means, line into a line mount at the support or retention element and securing the line to said support or retention element.

3. The method of claim 1, wherein said moving step comprises:
moving the line-laying means by a multiaxially moveable manipulator or industrial robot, whose movement is programmable in at least one axis; and
wherein the preassembled electric apparatuses are located in a stationary position prior to moving the line-laying means.

4. The method of claim 1, wherein:
the line-laying means are located at a predetermined location, optionally at a positioning device imparting a positioning motion to them; and
wherein the preassembled electrical apparatuses are moved by means of a transport means that is movable relative to the line-laying means.

5. The method of claim 1, comprising the step of:
synchronising the line length supplied during line-laying between two terminals by the line-laying means with the relative motion between the preassembled apparatuses and the line laying means,
whereby since the beginning of the line is fixed at the first terminal at the onset of laying a line, tension relief required in direct laying of the line is attained automatically.



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6. The method of claim 5, wherein the length of the line length supplied by the line-laying means is dimensioned of such length that the line laid between the terminals is completely free of tensile strain.

7. The method of claim 1, wherein said moving step comprises:

controlling the relative motion between the preassembled electrical apparatuses and the line-laying means, such that the line-laying means approaches the vicinity of the respective terminal; and

then positioning the line-laying means precisely in a line inserting position relative to the terminal.

8. The method of claim 7, including the step of ascertaining the positional deviation of the line-laying means from the position of the terminal with the aid of position sensing means after the line-laying means have been brought into the vicinity of the terminal; and

automatically compensating for any positional deviation.

9. The method of claim 8, wherein the step of ascertaining the positional deviation includes:

providing an image processing system, assigned to the line-laying means; and

moving said image processing system for taking an image close to the terminal; and

further including the step of calculating compensation for the positional deviation and providing a corresponding output control signal.

10. The method of claim 1, including after the step of positioning the line-laying means, the step of

imparting an introduction motion of a defined course length to the line in the region of the terminal, with which motion the line is brought into the contacting zone of the terminal.



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11. The method of claim 1, wherein the relative motion between the preassembled electrical apparatuses or apparatus system and the line-laying means is, at least intermittently, substantially rectilinear.

12. The method of claim 1, wherein the contact elements in the contacting zones are IDC (insulation displacement connection) means; and

the line is pressed by the line-laying means into these contact elements; and

including the step of supporting the line, during the cutting operation by said line laying means.

13. The method of claim 12, wherein the line, upon being pressed in the contact means, is subjected to a pressing-in force on both sides of the IDC contact means.

14. The method of claim 12, wherein the line is firmly clamped on at least one side of the IDC contact means.

15. The method of claim 1, including the step of cutting the line directly at the line-laying means.

16. The method of claim 12, including the step of cutting the line at the IDC contact means.

17. The method of claim 12, including the step of cutting the line between spaced IDC contact means of an apparatus, while the line is in the contacting zone.

18. The method of claim 1, including the step of cutting the line such that the end thereof is protected in the guide region,

whereby the end will be automatically shock-hazard-proof protected and no further positional movement of the line-laying means is required.



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19. The method of claim 1, wherein the apparatus system comprises a light fixture.

20. Line-laying means, for carrying out the method of claim 1, comprising:

a line-laying tool having a housing defining a working side;

a guide conduit for the line on the working side of the housing, terminating in a mouth of a laying prong;

controlled feed means for the line;

at least one pressure member located in the vicinity of the mouth of the guide conduit for the line emerging from the mouth, said pressure member being movably supported for movement substantially transversely to the axial direction of the guide conduit in the mouth region;

positioning means on the pressure member for positioning the pressure member between a remote position of repose distant from the mouth and an operating position, in which operating position the pressure member protrudes on one side spaced from and past an edge of a mouth of the guide conduit with a pressure face aligned with the line protruding from the mouth, or substantially flush with the top of the edge of the mouth;

controlled wire cutting means slidably movably located on the housing adjacent the pressure member; and

a slide surface for said wire cutting means formed on the housing; and

wherein said mouth, terminating the guide conduit is located in said slide surface, whereby an end portion of said line projecting from said mouth will be cut cleanly and a bottom side of the edge of the mouth of said guide conduit will form a counterelement of the cutting force of said cutting means whereby said pressure member can insert the line into a contact element and the cutting means can cut the line at a position within a constricted, protected guide region of a terminal without further movement of said line-laying means.



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21. The line-laying means of claim 20, wherein the pressure member is a ram longitudinally displaceably guided on the housing.

22. The line-laying means of claim 21, wherein the line-laying means includes a laying prong; and
the ram is located parallel to and spaced apart from the laying prong.

23. The line-laying means of claim 22, wherein the mouth of the guide conduit is located laterally on the laying prong and on the side toward the pressure member.

24. The line-laying means of claim 22, wherein the pressure member and the laying prong have, at least in part, essentially the same width, measured transversely to the longitudinal direction of the line emerging from the mouth of the guide conduit.

25. The line-laying means of claim 20, wherein the controlled cutting means for cutting the line comprises at least one cutter blade movably located in the region between the mouth of the guide conduit and the pressure member.

26. The line-laying means of claim 23, wherein the cutting means comprises a cutter blade which is operatively supported immediately on the laying prong, and
an edge portion of the mouth of the line guide conduit is formed as a knife counterelement.

27. The line-laying means of one of claims 19-26, wherein the laying prong is movably supported on the housing and is coupled with its own adjusting means.

28. Terminal, for use in the method of one of claims 1-19, using the line-laying means of one of claims 20-27, with clamping terminals containing the contacting zone which terminals have a housing of insulating material with at least one introduction slit, open at the edge, for a line



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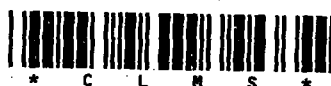
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and at least one IDC contact located in the housing with an IDC slit open at the edge toward the introduction side and aligned with the introduction slit, wherein the preassembled electrical apparatus or apparatus system, the housing of each terminal is provided with an introduction slit accessible to the line-laying means; that the housing on at least one side adjoining the introduction slit has a slitlike or groovelike indentation that receives the line and whose width is greater than the width of the introduction slit; and that the dimensions of the slitlike or groovelike indentation are such that a free end, located in the vicinity of the IDC contact, of a line contacted in the IDC contact is received in shock-hazard-proof fashion in the slitlike or groovelike indentation; and that the slitlike or groovelike indentation forming a constricted guide region and the housing are adapted to the dimensions of the laying prong and of the pressure member of the laying tool of the line-laying means.

29. The terminal of claim 28, wherein the introduction slit has a width that brings about a clamping fixation of a line pressed into it.

30. The terminal of claim 28 or 29, wherein the slitlike or groovelike indentation in the housing is located so as to be defined on both side by IDC contacts.

31. The terminal of one of claims 28-30, wherein the slitlike or groovelike indentation is deeper than the introduction slit.



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PROCESS FOR WIRING CONNECTIONS OF ELECTRICAL APPLIANCES OR
COMPONENT ELEMENTSABSTRACT:

Wiring of terminals of electrical apparatus or apparatus systems (4, 5, 7) is done automatically in the course of the direct wiring. A preassembled electrical apparatus or apparatus system is made available with terminals (9, 10, 11) fixedly located in it, whereupon by means of an automatically guided line-laying tool (59), an endlessly supplied line (68) is moved into the contacting zones of the specially formed terminals, fixed there, and either clipped or through-wired.

(Fig. 14)

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PROCESS FOR WIRING CONNECTIONS OF ELECTRICAL APPLIANCES OR COMPONENT ELEMENTS

The invention relates to a method for wiring of terminals of electrical apparatus or apparatus systems with the aid of controlled mechanical line-laying means, in particular line-laying means arranged for carrying out this method.

The term "wiring" is understood in the industry, in the case of electrical apparatus or apparatus systems, to mean the connecting of terminals to an electric line and the contacting of this line at the applicable terminal, in order to establish an electrical connection, for example with the associated switch element. This kind of wiring is required in the majority of electrical apparatuses operating in the low-current range, including electronic switch control and regulating equipment and in apparatus systems, this latter overall term being understood to include in particular such elements as printed circuit boards, plug-in packages or modules, etc., which as available on the market are designed as units and are intended to be inserted into electrical apparatuses. For the wiring itself, as a rule, switch wires, which are provided with a lacquer coating or a sheath of insulating material, or insulated flexible cables are used as the lines. Connecting the lines, which are insulated at the ends, in the contacting zone of the respective terminal is done using various known connecting techniques (such as screwing, plug-in connection, soldering, insulation displacement connection method of termination, and crimping). The operating steps required for the wiring are even today predominantly done by hand. This is

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time-consuming and frequently requires trained workers; the resultant expense is therefore considerable.

For the sake of more-rational production, particularly in relatively large-scale mass production of identical electrical apparatuses, it is known to prefabricate the lines or to produce partial or complete cable harnesses, or in other words a typical preassembled product, first in a first region, separately from the electrical apparatus. In a second region, the insulation of this preassembled product in the applicable apparatus or end product is then done. This final assembly includes essentially the contacting or connecting of the various lines of the preassembled product to the contacting zones of the terminals and laying and securing the prefabricated lines or cable harnesses in the apparatus. While automated prefabricating devices are already in use for prefabricating the lines, the ensuing further processing of the lines that have been produced, for instance to produce partial or complete cable harnesses, and the operations directly at the wiring site are still virtually without exception done by hand.

A number of methods and apparatuses are already known for automatic production of cable harnesses (US Patent 4,677,734; German Patent Disclosures DE-OS 36 08 243, 36 11 805, 38 20 636, and 38 20 638; and Swiss Patent 598 740), all of which employ what are known as wire-laying boards and the like. However, all these methods require very major technical effort and expense, which can be considered only for relatively large-scale mass-production of equipment. In any case, with this technique the fundamental problem still remains that the final assembly of the prefabricated lines or cable harnesses involves considerable labor, and so the attainable rationalization effect remains limited. Moreover, the

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course of the lines in the apparatus must often be chosen with a view to the prefabrication of the lines or cable harnesses, and this means long laying paths with detours, branches, loops, and bi-directional motions of clamping devices.

The object of the invention is therefore to create a wiring method for electrical apparatus and apparatus systems that makes it possible to substantially rationalize wiring compared with known methods, while at the same time assuring high operating safety while lessening the possibilities for error in the wiring.

To attain this object, the method according to the invention has the characteristics of claim 1.

The new method assures rational complete automation of the wiring of electrical apparatus and apparatus systems. It makes it possible to dispense with prefabricated lines and partial or full cable harnesses, because it performs direct assembly of the lines in the apparatus or apparatus system. It is possible to contact a line in the form of an endless line to be contacted fully automatically to the terminals provided with suitable automation-appropriate contacting zones, lay it in a defined way in the wiring process between the terminals, and finally to cut it off. With this direct assembly of the line, the requisite electrical connections are automatically produced serially and completely. The capability of through-wiring, that is, connecting a plurality of terminals with one line, offers a substantial advantage. It is in fact possible to dispense with the plurality of lines previously needed for that purpose. This not only represents economy in terms of the number of lines but also avoids doubling up at terminals and multiple laying out of the same terminals, since the lines are mounted directly and paid-out from a supply, and since as already noted, it is unnecessary to produce preassembled products,

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or in other words to prefabricate the lines, a very major rationalization effect is attained, while at the same time fewer changes in direction in the laying process itself are required. Branches, loops and the like that were previously needed with a view to the prefabrication of lines or combining lines into partial or full cable harnesses, are largely dispensed with. At the same time, in comparison with the prior art, there are fewer terminals, which increases the wiring safety and reduces the possibilities of error.

When long laying paths are structurally dictated, a support or retention location can also be brought into operating range of the line-laying means and positioned correctly relative to them by means of a relative motion between the preassembled apparatus or apparatus system; in that case, by means of the line-laying means, the line can be inserted into a line mount at the support or retention point and secured there. From this support or retention point, the line is then, in the next direct wiring operation, carried to the next terminal, at whose contacting zone it is again contacted and clipped as needed.

In the new method, both the beginning and the end of the line as well as a continuous line can be contacted at the corresponding successively contracted terminals. Since the beginning of the line is fixed at the terminals at the onset of laying a line, the tensile relief required in direct laying of the line can be attained simply in that the line length paid out during line-laying between two terminals by the line-laying means is automatically synchronized with the relative motion between the preassembled apparatus or apparatus system and its line-laying means. The line length paid out by the line-laying means may be dimensioned as long enough that the line laid between the

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terminals is completely free of tensile strain. If necessary, this line can also readily be laid with an excess line length, for example so that it sags. If it should be desirable in individual cases for the line laid between two terminals to be kept at a certain tensile strain, then this can also be achieved by a simple suitable adaptation of the line-laying means to the aforementioned relative motion between the preassembled apparatus or apparatus system.

For practical performance of the new wiring method it is advantageous if upon the relative motion between the preassembled apparatus or apparatus system in the line-laying means, the line-laying means merely come into the vicinity of the applicable terminal, whereupon next the line-laying means, in a positioning motion, are positioned precisely correctly relatively to the terminal. In this way it is attained that the displacement motion of the line-laying means, taking place along the path corresponding to the predetermined laying course, need not meet overly stringent requirements for accuracy, while at the same time, exact prepositioning of the terminals themselves or of the components carrying them in the electrical apparatus or electrical apparatus system becomes unnecessary. The positioning motion required for exact positioning can be imparted to the line-laying means, which have been brought to the vicinity of the applicable terminal, in direct cooperation between a laying tool of the line-laying means and the suitably designed terminal, or a guide device provided on it, to mention a quite simple possibility. The procedure may also be such, however, that with the line-laying means brought to the vicinity of the terminal, the positional deviation of the line-laying means from the position of the terminal is ascertained with position sensing means, and the

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positional deviation is then automatically compensated for. Sensing means that are intrinsically arbitrary may be used to ascertain the positional deviation. An image processing system assigned to the line-laying means has proved to be especially practical for this purpose; to take pictures, it is moved near the terminal, and it has means for image evaluation, in which the compensation for the positional deviation is calculated, whereupon a corresponding control signal is output that is evaluated for controlling a motion device of the line-laying means.

The relative motions between the preassembled apparatus or apparatus system and the line-laying means that are required in carrying out the new wiring method in the course of the direct wiring can in principle be produced in various ways. For instance, the line-laying means may be moved by a multiaxially movable manipulator or industrial robot, whose motion is programmable in at least one axis. The preassembled apparatus or apparatus system is then located prior to the beginning of the wiring in a stationary position within the operating range of the manipulator or industrial robot. The latter is assigned a suitable control unit, in which the course coordinates required for the laying courses are programmed, such that the line-laying means execute the moving and positioning motions necessary in the operating process, and by means of suitable system components (sensor system, etc.), perform further functions, such as the aforementioned positional tolerance compensation, by means of suitable system components (sensor system, etc.).

Alternatively, however, the procedure may be such that the line-laying means are stationary or located at a positioning device that imparts merely a positioning motion to them, while the preassembled electrical apparatus or apparatus system is moved by

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means of a transport means movable relative to the line-laying means. The transport means is again connected to a programmable control unit, which makes it possible to fully automatically achieve the appropriate laying courses for the directly wired lines. The outcome of the work is therefore the same. Which of these two kinds of procedure will be chosen in a given case depends, among other factors, on the type of apparatus or apparatus system to be wired.

The relative motion between the preassembled apparatus or apparatus system, produced in the manner described for the direct wiring, can intrinsically be chosen arbitrarily as a function of local conditions within the apparatus or apparatus system, and even curved laying courses are possible. As a result, however, it is practical if this relative motion is at least intermittently substantially rectilinear, so that at least intermittently straight laying courses result.

Forming the contacting zones at the various terminals must be done in a way suitable for automation; that is, the line-laying means must be capable, after their positioning at the applicable terminal, of introducing the line into and contacting it in the applicable contacting zone fully automatically. As has been recognized, this requirement can be met especially simply by using contacting zones that have contact means operating by the principle of the insulation displacement connection or contact (IDC) method, or IDC technique; the line is pressed into the contact means by the line-laying means, producing the electrical contact. The IDC technique produces a very high-quality electrical connection of the electric conductor of the line to be connected and the contact means, because it brings about a large-surface area, gas-tight contacting in the manner of a cold weld. Since

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the conductor is contacted immediately after the insulation is cut, oxidation of the conductor surface cannot occur as it does if the line end are first insulated-off or stripped in a separate operation prior to the contacting. For fixation, the line upon being pressed in suitably firmly is clamped on at least one side of the IDC contact means. The pressing-in itself is advantageously done such that a pressing-in force is exerted upon the line on both sides of the IDC contact means, so that upon being pressed in, the line remains perfectly aligned and is reliably both contacted and firmly clamped.

If through-wiring does not occur at the particular terminal, the line is clipped immediately at the line-laying means or, by suitable formation of the IDC contact means, directly at the line-laying means; at the same time, shock-hazard protection for the contacted line end is produced. Since stripping of its own insulation is not provided, there will be savings at each terminal compared with other connection techniques of a small length of line, which over the length of line required for the entire wiring represents a noticeable economy.

As already referred to at the outset, the new fully automatic method of direct wiring can be employed without prefabrication of lines etc. in intrinsically all apparatus and apparatus systems. However, it has been found that a very valuable application is to employ it for automatic wiring of lighting fixtures or parts thereof. Such lighting fixtures in fact have a relatively large light box, whose dimensions are chosen with a view to the luminous bodies to be accommodated in it, such as gas discharge lamps, etc., and also have some standardised associated network elements such as ballasts that are accommodated in the light box. Wiring of the terminal of these network elements is often done entirely manually at present; this is expensive and difficult.

The novel wiring method is carried out with suitably defined line-laying means, which make it possible to carry out the various functions required for the operating

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process. An especially suitable embodiment of such line-laying means for this purpose is the subject of claim 20.

By providing a pressure member, located in the vicinity of the mouth of the guide conduit or guide tube of the line, for the like emerging from the mouth it is attained that the line in this region can be pressed into the contacting zone of the terminal in such a manner that it is aligned and perfectly supported. High wiring safety in the region of the terminals can thus be assured, while at the same time no remachining whatever is needed. The contacting zone of the terminal is as a rule formed by the aforementioned IDC technique, but the new tool can in principle be used for other connection techniques as well where it is crucial for a conductor end or conductor piece to be introduced and in particular pressed in a predetermined orientation exactly into a slit or into a corresponding receptacle of a clamping device

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present at the particular terminal.

In an advantageous embodiment, the pressure member is a ram guided longitudinally displaceably along the housing or along a part of the laying tool connected to it; as a rule, the ram is located parallel to and spaced apart from the so-called laying prong of the laying tool, the prong likewise being formed as a ram, so that the conductor on being pressed into the contacting zone is supported at two points spaced apart from one another by the same distance. The mouth of the guide conduit or tube of the laying tool is suitably located laterally on the laying prong on the side toward the pressure member, and the pressure member and the laying prong may have at least in some regions an essentially equal width, measured transversely to the longitudinal width of the conductor emerging from the mouth of the guide conduit or guide tube. A very simple design of the terminal can thus be achieved.

In order to clip the line at a terminal, an IDC contact may for instance used, which has a clipper edge that becomes operative when the conductor is pressed into the contacting zone. In that case it suffices to provide the aforementioned pressure member on the laying tool. If this kind of clipper edge at the terminal is dispensed with, then it is advantageous if controlled clipper means for the line are provided on the laying tool that have at least one movable clipper blade in the region between the mouth of the guide conduit and the pressure member. This clipper blade may be supported so that it acts directly at the laying finger, with the edge of the mouth of the guide conduit being formed as a counterpart knife. Clipping of the conductor can be done either next to the contacting zone or directly within the contacting zone itself.

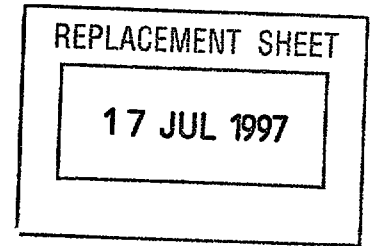
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Finally, the laying prong of the laying tool is as a rule fixedly located on the housing thereof, or on a part connected to it; however, it may also be supported movably and coupled to its own adjusting means.

As already explained, the new method for direct wiring can be carried out especially simply using terminals whose contacting zones are designed in accordance with the so-called IDC technique. This technique is explained, for instance in the journal entitled "Messen + Prüfen/Automatik" [Measurement + Testing/Automatic Systems], July/August 1982, pp. 491, 492; the design of corresponding IDCs or IDC contacts may be learned for instance from German Utility Model DE-GM 88 04 388, published French Patent Application 2 330 159 and U.S. Patent 2,501,187. Based on this prior art, the preferred object is to create a terminal for use in the method referred to above, using the aforementioned line-laying means, that is designed such that in a simple, effective way it assures operationally safe contacting and fixation of the connected line and at the same time does not hinder carrying out the method automatically.

The terminal is formed according to a feature of the invention with a slitlike or groovelike indentation provided on the housing of the clamping terminal means. This assures on the one hand shock-hazard protection of the clipped end of the line, without requiring additional method steps or provisions for that purpose. Secondly, if necessary, it can also provide centering of the laying prong and/or pressure member of the laying tool upon introduction of the line into the contacting zone. The IDC contact itself that is used then upon introduction of the line brings about a certain automatic height compensation, because the



only critical point is that the conductor be received firmly in the IDC seat with a certain height tolerance range.

The introduction slit in the housing at the terminal may have a width that brings about a clamping fixation of a pressed-in line, so that the line is fixed independently of the actual contacting zone. The indentation in the housing may also be defined on both sides of IDC contacts or located on one or both sides of an IDC contact.

DRAWINGS

The method of the invention is described below in terms of an exemplary embodiment, in conjunction with the drawing. Shown in the drawing with respect to an example are:

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Fig. 1 in a perspective schematic view, a preassembled light box of a fluorescent light fixture to be wired by the method of the invention;

Fig. 2, in a fragmentary perspective view on a different scale, the terminals, formed in the according with the invention, of a fluorescent lamp ballast choke for the light box of Fig. 1;

Fig. 3, a fragmentary plan view on a different scale of a terminal of the arrangement of Fig. 2;

Fig. 4, a plan view corresponding to Fig. 3 of a terminal of the arrangement of Fig. 2, in a modified embodiment;

Figs. 5-7, side views in section taken along the line V-V of Fig. 3, and line VI-VI and line VII-VII of Fig. 5, respectively, of a clamping terminal of one of the terminals of the arrangement of Fig. 2;

Fig. 8, a schematic perspective view on a different scale of the terminals, formed according to the invention, of the clamping block of the light box of Fig. 1;

Fig. 9, in a perspective view on a different scale, the terminals formed according to the invention of a lamp socket of the light box of Fig. 1;

Fig. 10, a schematic side view of an apparatus for carrying out the method of the invention with the aid of an industrial robot;

Fig. 11, a plan view of the device of Fig. 10;

Fig. 12, a schematic side view of a device for carrying out the method of the invention with the aid of a portal manipulator;

Fig. 13, a schematic side view of a further embodiment of a device for carrying out the method of the invention, using a manipulator, with a movable transport table;

Figs. 14-20, a schematic detail view of the laying tool of the device of Figs. 10 and 11 showing its association with the

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terminal of a fluorescent lamp choke of the light box of Fig. 1, illustrating various chronologically successive phases in the course of the method of the invention upon connecting the endlessly supplied line to the first terminal;

Figs. 21-29, each in a corresponding view, the arrangement of Figs. 14-20, showing chronologically successive steps of the course of the method after the fixation of the end of the line, during laying of the line to the next terminal, upon contacting, and ensuing clipping of the line at that terminal;

Fig. 30, in a schematic plan view and on a different scale, the light box of Fig. 1 in the wiring state after the conclusion of the segment of the wiring illustrated by Fig. 14-29;

Figs. 31-33, in views similar to Figs. 14-19, the line-laying means of the device of Figs. 10 and 11 in association with a further fluorescent lamp choke of the light box of Fig. 1, illustrating chronologically successive steps in the course of the method of the invention in producing the next wiring segment; and

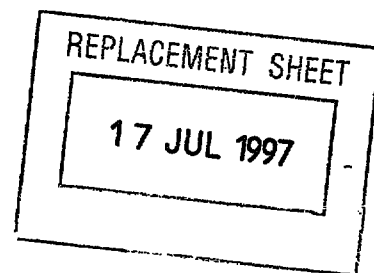
Fig. 34, the light box of Fig. 30, in the state after the production of the wiring segment produced by the method of Figs. 31-33.

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The method for direct wiring of electrical apparatus elements and circuit components of the apparatus systems will be described below in conjunction with the wiring of a rectangular light box 1, shown in Fig. 1, for two rod-shaped gas discharge tubes eg. fluorescent light bulbs not shown in further detail. For operation the light box is covered with a transparent or translucent acrylic glass hood or reflector, which is clamped in place in mounts or retainers 2 and not shown in further detail.

The light box has already been pre-assembled to the extent that the necessary electrical switch elements for receiving and operating the gas discharge lamps have been secured in the correct positions by a predetermined location plan fixedly to the box bottom 3, for instance being screwed in place. In detail, four lamp sockets 4 of a known construction are provided in the vicinity of the end walls of the box, each in pairs facing one another, and two magnetic fluorescent lamp chokes 5 are assigned to each pair and are locked on approximately the centre line of the box bottom 3, on either side of line introduction openings 6, at equal intervals from the end walls of the box. An insulating material base 7 that carries a capacitor 8 is secured to the box bottom 3, also located on its centre line, next to the line introduction openings 6. Terminals for electric supply lines are provided on each of the lamp sockets 4, ballasts 5 and insulating material base 7; these terminals are identified by reference numeral 9 for the lamp sockets 4, reference numeral 10 for ballasts or chokes, and reference numeral 11 for the base 7 of insulating material of capacitor 8. These terminals 9, 10 11 are all designed by the same basic principle with a contacting zone in accordance with the IDC technique. Their form can be seen in detail from Figs. 2 through 9; it will be described below in particular in terms of the

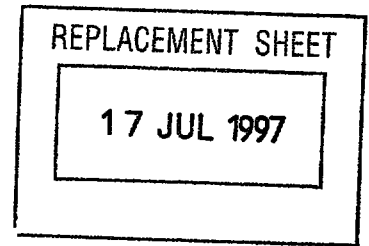


terminal 10 of a choke 5, with reference to Figs. 2 through 7:

Each terminal 10 has a housing 12, made of insulating material and of essentially rectangular cross section, which is placed on a base part 13, likewise produced from insulating material, resulting in a unit-type connection clamping terminal that is secured at 14 to a stamped, upward-bent tab of a baseplate 15 of the choke 5. The two side walls 16 of the housing 12, which is open at the top, have on their inside two formed-on ribs 17 opposite one another, which are located approximately in the middle between the two face ends 18 of the housing 12 and between them define a slightly wedge-shaped or parallel-sided introduction slit 19 (Fig. 6), which is widened on its top by means of introduction bevels 20. In its lower region, the introduction slit 21 is locally widened somewhat in a region in the shape of part of a circle.

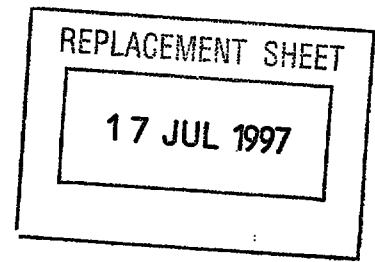
Two narrow grooves 22 facing one another extend into the ribs 17 from below to approximately the height of the introduction bevels 20; they receive the two legs 24, defining an IDC slit 23 open at the edge, of an IDC contact 25 made from spring steel or spring bronze. The narrow, essentially U-shaped IDC contact 25 in the form of a small plate is embedded on all sides in the insulating material of the housing 12 except for the clipping segments formed at the legs 24 and oriented toward the IDC slit 23; both legs 24 are limitedly movably guided in the grooves 22. In a manner not shown in further detail, one end of the winding of the choke 5 is connected to the IDC contact. Together with the IDC slit 23, the IDC contact forms the contacting zone of the terminal 10.

As can be seen particularly from Figs. 3 through 7, the housing 12 has one groove-like indentation 26 of rectangular cross



section each on either side of the ribs 17 and hence adjoining the introduction slit 19, each indentation being open toward the top of the housing 12 next to the introduction slit 19. The two groove-like indentations 26 are located in alignment with one another and with the introduction slit 19. They are likewise defined toward the top by an introduction bevel 27. Figs. 5, 7 show that the depth of the groove-like indentations 26 is greater than the depth of the introduction slit 19, and that its width 28 is also substantially greater than the width of the introduction slit 19.

The dimensions of the individual parts are selected such that for an insulated conductor pressed in through the introduction slit 19, the insulation is cut open in the IDC slit 23 by the legs 24 of the IDC contact 25, and at the same time a gas-tight contacting takes place between the IDC contact 25 and the conductor that is deformed at the clamping point. The pressed-in conductor is simultaneously firmly clamped by its insulation in the introduction slit 19 between the two ribs 17, and the widening at 21 serves to assure that the line will lock into place in detent fashion at its insulation upon being pressed into the introduction slit 19. The thus-fixed, connected line extends through one of the groovelike indentations 26, (Fig. 2) while its clipped end is located in the other groovelike indentation 26, as will be described in further detail hereinafter. The width and depth of the groovelike indentations 26 and their axial length are dimensioned such that contact protection is automatically produced for the clipped end of the line. This means that a standardized sensing prong, in the test for shock-hazard protection, cannot penetrate as far as the bared, clipped end at the depth of the associated groovelike indentation 26.

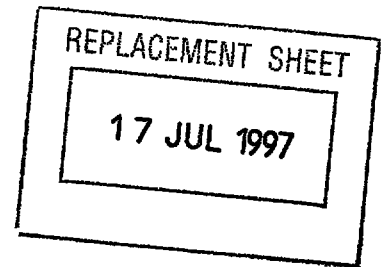


In the embodiment of the housing 12 described, two groovelike indentations 26 aligned with one another are provided, one on either side of the introduction slit 19, and their width and depth are substantially larger than the diameter of the line to be received. It is also conceivable to leave out one of the groovelike indentations 26, which is particularly worth considering if the line is merely being laid continuously through the terminal, as will also be described in further detail below. In individual instances, both groovelike indentations 26 may even be omitted.

Fig. 4 shows a modified embodiment of the housing 12 in plan view: In this embodiment, only one groovelike indentation 26 is present, which is defined in the housing 12a on both sides by one pair 17 of ribs each with an intervening introduction slit 19 and by a contact element 25 protruding into the slit with its legs 24. The pairs of ribs are each formed on flush at the ends with the side walls 16a in the housing 12a and are aligned by their introduction slits 17 with the longitudinal axis of the groovelike indentation 26.

While in the embodiment of Figs. 2 and 3 a clipped end of a line is located next to the contacting zone formed by the IDC element 25 (see Figs. 27-29, for instance), in the embodiment of Fig. 4 it is assured that the clipped end will be located in the contacting zone defined by the two IDC contacts 25, or in other words inside the housing 12a that is closed on all sides except for the introduction slit.

The terminals 11 located on the insulating material base 7 are fundamentally formed identically to the terminals 10, as can be learned from Fig. 8. Reference is therefore made to Figs. 2-7 in terms of their description. Identical elements are identified



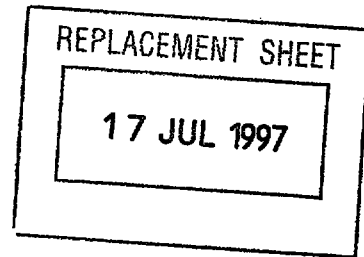
by the same reference numerals.

A total of three terminals 11 are located on the insulating material base 7; two of them are combined into a connection clamp unit marked 28, which has a unitlike housing 12b. Clamps are indicated at 29 for internal connection to the terminals of the capacitor 8.

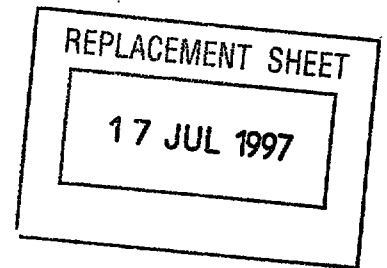
The terminals 9 of the lamp sockets 4 are also fundamentally equivalent to the terminals 10 of Figs. 2 and 3 in design. In Fig. 9, identical elements are therefore again provided with the same reference numerals and reference is made to the description of Figs. 2 and 3.

While for the terminals 10, 11 (Figs. 2, 8) the housings 12, 12b are however located with their introduction slits 19 and the groovelike indentations 26 pointing longitudinally of the choke 5 or starter 6 and hence longitudinally of the light box bottom 3 (Fig. 1), the arrangement for the lamp sockets 4 is made such that the housings 12 are secured on a fastening base 30 of the respective lamp socket 4, with introduction slits 19 and groovelike indentations 26 extending transversely to the longitudinal direction of the gas discharge lamps to be used and hence of the lamp box bottom 3. In the lamp sockets 4, lines to be connected must therefore be pressed into the introduction slit 19 in such a way that they extend at right angles to the longitudinal direction of the lamp box 3.

The wiring of the light box 1, described thus far in terms of its circuit elements 4, 5, 7 and their terminals 9, 10, 11, is done with the aid of an industrial robot as shown in Figs. 10, 11 or a manipulator as shown in Figs. 12, 13 that moves the line-laying means, as will be described below in conjunction with Figs. 13 ff:



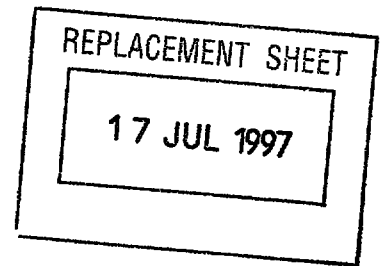
The line-laying means, identified overall by reference numeral 31, are seated in the apparatus of Figs. 10, 11 on the two-piece arm 32 of an industrial robot 33, which has a column 36 rotatable about a first stationary vertical axis 34, for instance by a stepping motor drive 35, and the column carries a first arm piece 37, which in the region of its free end is connected, via a swivel bearing 39 that forms a vertical second pivot axis 38 parallel to the first pivot axis 34 and is provided with an incremental rotational drive, to a second arm piece 40, which carries the line-laying means 31 on its outer end. The two drives 35, 39 can move the second pivot axis 38 along a circle 41 about the first pivot axis 34 and in the extended state of the arm 32 can move the line-laying means 31 along an essentially circular path curve 42; a reciprocating drive 43 associated with the drive column 36 enables a controlled vertical raising and lowering motion of the arm 32 and thus of the line-laying means 31. the industrial robot 33 is assigned a stationary work table 44, with a transport mechanism integrated in it as suggested by an arrow 45 (Fig. 10), which mechanism makes it possible, on the horizontal work surface of the work table 44, to move successively preassembled light boxes 1 of Fig. 1 from a remote readiness position at 46 (Fig. 10) to the operating range of the line-laying means outlined by the essentially circular path curve 42, as is indicated at 47 by the working position of the light box 1 shown in Figs. 10, 11. In this working position 47, the light box 1 is firmly clamped to the work table 44 in the correct position. The associated clamping means are of a known type; they are not further shown in Figs. 10, 11. Within its operating range, the line-laying means 31 can be moved by the programmable industrial robot 33 to any arbitrary location inside the light box 1 and can



be moved along any preprogrammed, defined course inside the light box 1.

The situation is fundamentally the same if the portal manipulator 48 shown in Fig. 12 is used, in which the preassembled light box 1 is firmly fastened in the correct position on a light box receptacle 50 on a stationary work table 49, and the line-laying means 31 are located on a carriage 51 that is supported on a portal 52 in such a way that it can be freely programmably moved both in an X direction represented by a double arrow in the longitudinal direction of the light box and in a Y direction, again represented by a double arrow, extending transversely to it. Moreover, the line-laying means 31 are rotatably supported on the carriage 51 about a vertical pivot axis 53 (c axis). Each of the axes of motion X, Y, c, like the reciprocation axis (z), are assigned their own incremental stepping drives, which being triggered by a freely programmable control unit can move the line-laying means 31 to any arbitrary point along a particular preprogrammed course within the fixedly clamped, preassembled light box 31.

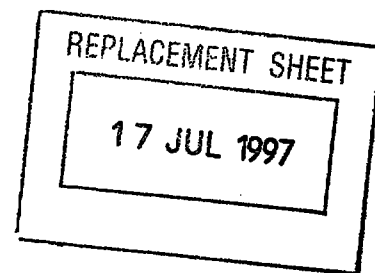
Finally, the relative motion between the line-laying means 31 and the preassembled light box 1 required for line laying, or in other words for laying the terminals 9, 10, 11 of the preassembled light box 1, can also be attained with the apparatus of Fig. 13. Here the preassembled light box 1 is clamped to an XY table 54 by means of the light box receptacle 50; the axes of motion X, Y of this table are each represented by double arrows. The line-laying means 31 are carried by a positioning device 56, located above the XY table 54 on a stationary carrier 55; this device is capable of imparting a reciprocating motion in the Z direction (represented by a double arrow) and a rotational motion



about the vertical axis 53 (c axis) to the line-laying means 31. In this case as well, incremental drives for motion in the XY axis or the zc axis are assigned to the XY table 54 and the positioning device 56 and are triggered by a freely programmable control unit, in such a manner that the line-laying means can be moved to any arbitrary site within the light box 1 along the particular programmed course.

The line-laying means 31 in turn have preferably a so-called line laying tool 57 with an optionally multiple-part housing 58, which is secured to the arm 32 of the industrial robot 33 (Fig. 10) or to the carriage 51 (Fig. 12) or to the positioning device 56 (Fig. 13). A vertical laying prong 59 of substantially rectangular cross section is located on the underside of the housing 58 and includes an L-shaped curved line guide conduit 62, which opens out in the region of a side wall at 60, a short distance from the flat bottom face 61 of the laying prong 59. The line guide conduit 62 (Fig. 14) contained in the laying prong 59 is extended in the housing 57 in the form of a guide tube 65, to which a belt drive for a line suggested at 68 and comprising two pairs ~~66~~ of belt rollers (Figs. 12, 13) and endless drive belts 67 wrapped around them, is assigned.

The belts 67, each guided by one side parallel to one another and a slight distance from one another are coupled via the belt rollers 66 to an incremental drive that imparts a controlled drive motion to them that is synchronized with the relative path motion between the preassembled light box 1 and the line-laying means 31; this motion can be generated when the wiring is done by the devices of Figs. 10-13.

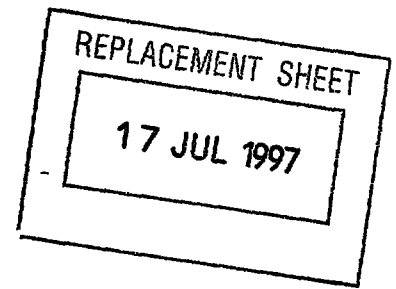


A measurement system preceding the belt drive for the line 68 and comprising a measuring wheel 70 and a drive roller 71 elastically prestressed in the engagement position makes it possible to measure the exact feed motion of the line 68, regardless of the slip that occurs between the endless belts 67 of the belt drive, so that perfect synchronization of the line feeding with the displacement motion of the robot 33, the manipulator 48, or the XY table 54.

The laying prong 59 is as a rule rigidly secured to the housing 57; it may, however, also be supported so as to be raisable and lowerable in the vertical Z axis and provided with a suitably triggerable adjusting device inside the housing 58. This is suggested by a double arrow 72 in Fig. 12.

As can be seen for instance from Fig. 14, a pressure member movable vertically in the Z axis of a displaceable ram 76, which is raisable and lowerable via an associated control drive in the interior of the housing 58, is located laterally spaced apart from the vertical, flat side face 60 of the laying prong 59 that contains the mouth 74 of the line guide conduit 62 - or on the housing 58 itself as in Figs. 12, 13. The motion of the ram 76 is controlled by program by the control unit as a function of the displacement motion of the line-laying means 31. A sensor 77 (Fig. 14) coupled to the ram 76 outputs a check-back signal indicating the position attained by the bottom face, acting as a pressure face 78, of the ram 76 to the control unit, so that an exact adjustment of the height of the bottom face 78 of the ram 76 relative to the mouth 74 of the line guide conduit 62 is possible.

Finally, a clipper knife 79 is supported such that it can be raised and lowered on the vertical side face 60 of the laying prong 59; its associated drive mechanism, accommodated in the

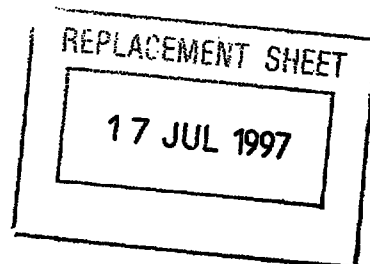


housing 58, is not shown in further detail. It can be advanced, by the knife edge 80 (Fig. 16) located on its lower end, out of the position of repose shown in Figs. 14, 16, 17 into a working position shown in Fig. 27, in which it has smoothly clipped the end of the line 68 protruding from the mouth 74 of the line guide conduit 62. To that end, the knife edge 80 has overtaken the opening of the mouth 74, with the underside 81 of the edge of the mouth of the line guide conduit 62 acting as a counterpart knife, as can readily be seen from Fig. 27, for example.

In principle, embodiments in which the knife 79 is given its own counterpart knife, separate from the laying prong 59, are also possible.

With the aid of the line-laying means 31 described, which is moved by the industrial robot 33 (Fig. 10, 11), for example, by a program along predetermined paths of movement, a preassembled light box 1, which is provided at predetermined points of the light box bottom 3 with the terminal 9, 10, 11 formed as described, is automatically wired in the following way, the description being made in conjunction with Figs. 14-34:

An insulated line 68, for instance drawn in endless fashion from a supply coil 82 (Fig. 10), is threaded into the laying tool of the line-laying means 31. This line runs between the measuring wheel 70 and the contact roller 71 and between the two endless belts 67 of the belt drive and is fed by the belt drive through the guide tube 65 into the L-shaped line guide conduit 62. The belt drive has moved the forward end of the line 68 so far forward, in the manner that can be seen from Figs. 12-17, that a segment 84 of it (Fig. 17) protrudes from the mouth 74 of the line laying conduit 62, this segment extending to beneath the pressure face 78 of the ram 76.



A preassembled light box 1 has been moved into the working position 47 of Fig. 10 into the operating range of the industrial robot 33 and firmly clamped there in the correct position on the work table 44 (Fig. 11). The ram 76 is in its raised position of repose shown in Fig. 16; the knife 79 is also in its position of repose above the mouth 74. The belt drive 66, 67 is not moving.

The industrial robot 33, controlled by program accordingly, takes the line-laying means 31 with the laying prong 59 from a remote position of repose into the vicinity of the first terminal, which in this case is a terminal 10 of the left-hand choke 5 of Fig. 1. In the process the laying prong 59 arrives approximately at the position of Fig. 14, in which it is located above and laterally offset from the terminal 10.

In this position of the laying prong 59, position sensing means located on the housing 58 and taking the form of an image processing system 85 are located with the picture taking device 86 of this system above the terminal 10. The image processing system 85 includes means for image evaluation, with the aid of which it calculates the positional deviation of the laying prong 59 from the terminal 10 and generates a suitable compensating control signal. This signal is processed in the control unit in such a way that the industrial robot 33 - or a positioning system located between it and the line-laying means 31, similar to the positioning device 56 of Fig. 13 - performs the requisite positional tolerance compensation and positions the laying prong 59 precisely in the correct position relative to the terminal 10. Once this has been achieved, the laying prong 59 assumes the position of Fig. 16, in which it is aligned accurately above the housing 12 and the groovelike indentations 26 thereof.

The ram 76 now moves to its lower operating position of

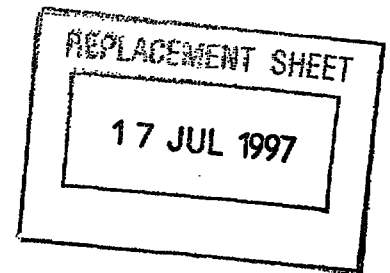
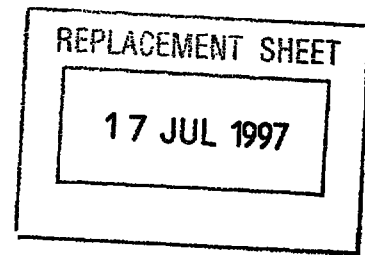


Fig. 17, in which it rests with its pressure face 78, located on the bottom of a longitudinal groove, on the end segment 84 of the line, suitably far advanced out of the mouth 74 of the line guide conduit 92 and positions this segment precisely horizontally. The end segment 84 of the line can then be advanced farther if needed, as far as the end of the pressure face 78.

The laying tool of the line-laying means 31 and in particular their laying prong 59 and the ram 76 are simultaneously moved downward along the vertical Z axis. In the process, the horizontal end segment 84 of the line is pressed through the introduction slit 19 of the housing 12 at the terminal 10 into the IDC slit 23 of the IDC contact 25, until the line segment 84 locks into place in the widened portion 21 of the slit (Fig. 6). In this pressing-in motion, an equally great, uniform pressing-in force is exerted from the top of the line guide channel 62 and the pressure face 78 on both sides of the introduction slit 19 upon the horizontally retained end segment 84 of the line, so that this segment is unable to escape, and satisfactory insertion into the contacting zone of the terminal 10 is assured.

In this introduction and pressing-in motion, the insulation is cut open by the clipper edges on the legs 24 of the IDC element, and satisfactory contacting is produced. At the same time, the end segment 84 of the line is positionally firmly fixed by the two ribs 17 on both sides of the IDC contact 25, with slight deformation of its insulation occurring in the process.

The ram 76 and the laying prong 59 have preferably the same width on their front end at right angles to the plane of the drawing (Fig. 19), which is equivalent to the width of the groovelike indentations 26, so that a satisfactory mutual spatial association between the housing 12 and the laying prong 59 and the



ram 76 when the line segment 84 is pressed in is assured. The elements now assume the position shown in Fig. 18.

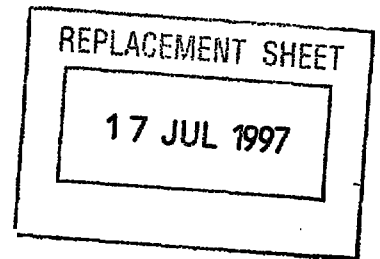
The ram 76 now moves upward into its final position or position of repose and releases the end of the line segment. This situation is shown in Fig. 19.

Since the end of the line segment 84 is received in the groovelike indentation 26 in the immediate vicinity of the guide groove 19, and this indentation has a length, width and height such that the free end of the conductor cannot be accidentally touched from outside, and since the IDC contact 25 is embedded in the insulating material of the housing 12 and is likewise enclosed all-insulated, i.e. protected against accidental contact from outside, satisfactory shock-hazard protection is already attained at the terminal 10.

The control unit now controls the motion of the industrial robot 33 by program such that the laying prong 59 moves from the contacted terminal 10 to the next terminal - terminal 11 - on the insulating material base 7 over the rectilinear laying course that can be seen in Fig. 30, in the process laying the line 8. This is illustrated in Figs. 20, 21.

In the process, the belt drive 66, 67, controlled by the control unit, is actuated in synchronism with this displacement motion of the laying prong 59 such that tension-free laying of the line ensues. Optionally, in this displacement motion a vertical motion in the Z axis may also be imparted to the laying prong 59, for instance in order to place the laid line on the box bottom 3 (Fig. 1) or to compensate for a difference in height between the terminals 10, 11, as suggested in Fig. 22.

In the course of this displacement motion, the laying prong 59 is first merely brought to the vicinity of the terminal 11, to



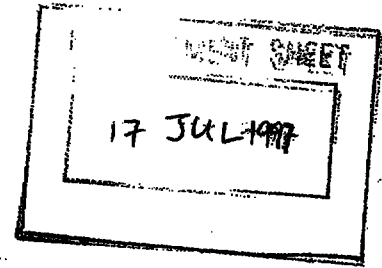
the position shown in Fig. 21 and Fig. 22, in which the image processing system 85 is located above the terminal 11 and can detect the spatial position of the terminal, which may certainly also be influenced by unavoidable tolerances in the assembly of the apparatus systems.

The image processing system 85 now, similarly to the process described above for the terminal 10, ascertains the positional deviation of the laying prong 59 from the terminal 11 and via the control unit of the industrial robot 33 brings about the positional tolerance compensation required for exact positioning of the laying prong 59 relative to the terminal 11. Once this operation has been concluded, the elements assume the position shown in Figs. 23 and 24.

The ram 76 is now lowered from its final position or position of repose into the working position, in which it rests with its pressure face 78 on the part of the line 68, guided horizontally here, that is emerging from the mouth 74 of the line guide conduit 62; see Fig. 25.

Next, the laying prong 59 and the ram 76 are lowered simultaneously and in a fixed association both to one another and to the housing 12 of the terminal 11; the line segment 84a extending between the pressure face 78 and the top of the edge of the mouth 74 is pressed, supported at two points on both sides of the contacting zone, into the introduction slit 19 and the IDC slit 23, until it reaches the detent position already described in conjunction with Figs. 18 and 19. The line 68 is thus perfectly contacted at its line segment 84a and is firmly clamped and fixed next to the contact point on both sides of its insulation in the guide slit 19.

In the present wiring process, the line laid in the manner



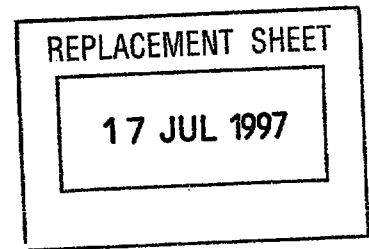
described is clipped at the terminal 11. This is done with the knife 79, which moves downward and severs the line 68 directly at the mouth 74 of the line guide conduit 62, with the edge of this mouth acting as a counterpart knife. The elements now assume the situation shown in Fig. 27.

When the line 68 is clipped in this way, the end of the laid segment of line, retained in the guide slit 19 of the terminal 11, is bent downward, as Fig. 27 shows, from the oblique face 86 adjoining the cutting edge 80 of the knife 79. This means that the bare end face of the conductor, at the cut face, is aimed toward the bottom of the surrounding groovelike indentation 26, and consequently the shock-hazard protection is substantially increased. At the same time because of this bend a further mechanical fixation of the end of the line at the terminal 11 is obtained.

This concludes the process of wiring between the two terminals 10 and 11. The knife 79 returns to its final position or position of repose, as shown in Fig. 28.

Next, the ram 76 is returned to its final position or position of repose, and the laying prong 59 is moved upward by the industrial robot 33, whereupon the outset position for the next wiring step in the light box 1 is already reached. This starting position is shown in Fig. 29.

Depending on the wiring to be done, the line 68 may also be through-wired at the terminal 11, as an example. In that case clipping of the line as in Figs. 27 and 28 is not done; instead, following the situation shown in Fig. 26, the ram 76 is returned to its final position or position of repose (see Figs. 19, 20), whereupon the control unit as programmed causes the industrial robot 33, the line-laying means 31 and thus the laying prong 59 to



move along a preprogrammed defined path to the next terminal. This will be briefly described now in conjunction with Figs. 31-33:

The next following terminal is again a terminal 10, but now that of the right-hand choke 5 in Fig. 1. The line must be moved past the choke 5. The choke 5, as can be seen particularly from Fig. 2, is equipped in the region of both ends, at the top, with two retaining elements 870 for lines 68. Each of the comblike retaining elements 870 is provided with a row of parallel, continuous detent grooves 88 of semicircular cross section, into each of which one line 68 can be pressed via an introduction slit 89.

In the line laying between the terminals 11, 10 (Figs. 26 and 31), the industrial robot 33 therefore, along a preprogrammed path, takes the laying prong 59 first to the vicinity of the respective retaining element 870. Once positioning of the laying prong 59 has been done in the manner already described, by means of the image processing system 85, the ram 76 moves downward and either alone or jointly with the laying prong 59 presses the line into one of the detent grooves 88. Next, the ram 76 is returned to its final position or position of repose; the laying prong 59 moves upward and is moved to the next subsequent retaining element 870, where the same process is repeated.

Following this, the laying prong 59 is moved to the vicinity of the terminal 10 and positioned above it in the manner already described, whereupon the ram 76 is again moved forward until its pressure face 78 rests on the line segment 84a emerging from the mouth 74. The elements assume the situation shown in Fig. 32.

In the now-ensuing lowering motion of the laying prong 49

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of the ram 76, not only is the line segment 84a fixed in the introduction slit 19, horizontally aligned and perfectly supported, in the manner already described and contacted in the IDC slit 23, but at the same time the line 68 is also bent downward to the level of the IDC contact 25. Once the contacting is concluded, the elements assume the position of Fig. 33.

As the next step, the line 68 can either be clipped (as in Fig. 27), or alternatively it is through-wired to the next following terminal, for instance a terminal 9 of a lamp base 4.

Since for the lamp base 4 the introduction slits 19 are aligned with the terminals 9 transversely to the longitudinal direction of the light box, the industrial robot 33 must rotate the line-laying means 31 and here in particular the housing 58 of the laying tool 57 having the laying prong 59 and the ram 76, about the vertical axis (c axis) by 90°, before the then-bent line portion is introduced into the introduction slit 19 in the manner already described.

The direct wiring, carried out by the method steps described, of the preassembled light box 1 is shown in Figs. 33, 34 for the following two cases: First, the line 68 is clipped once it reaches the terminal 11 (Fig. 27), and second, it is through-wired beyond this terminal (Fig. 31).

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The claims defining the invention are as follows:

1. A method for wiring terminals of electrical apparatuses or apparatus systems with the aid of a controlled mechanical line-laying means,
comprising the steps of:
providing a preassembled electric apparatus system which includes the electric apparatuses, said apparatuses having terminals fixedly located thereon;
said terminals comprising a contacting zone including a contact element and a constricted guide region of insulating material;
relatively moving a first one of said terminals and the line-laying means into operating range and correctly relatively positioning the preassembled apparatuses and the line-laying means by means of relatively motion therebetween;
supplying the end of a line from a line supply means to the line-laying means, and introducing said end into the contacting zone of the first terminal to affix said end at that terminal and produce an electrical contact with the contact element;
relatively moving, along a predetermined path, the preassembled electrical apparatuses and the line-laying means, and bringing every other terminal successively into operating range of the line-laying means, thereby laying the line, and positioning the line directly relative to the preassembled apparatuses,
positively supplying, during each of these relative movements, from the line-laying means at least a length of the line that corresponds to the distance between said first terminal and a second successive terminal along a line-laying course;
introducing, by means of the line-laying means, the line at each terminal into the contacting zone of the respective terminal, affixing the line to the respective terminal, and producing an electrical contact; and
then, without further positioning movement of the line-laying means, cutting off the thus-laid line at the end of the line-laying course by said line-laying means, in the



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region of the last terminal to be contacted at a position within said guide region and inwardly of one end surface thereof.

2. The method of claim 1, including the step of:
bringing, a support or retention element into the operating range of the line-laying means;
positioning the line correctly relative to said support or element, and
introducing, by means of the line-laying means, line into a line mount at the support or retention element and securing the line to said support or retention element.

3. The method of claim 1, wherein said moving step comprises:

moving the line-laying means by a multiaxially moveable manipulator or industrial robot, whose movement is programmable in at least one axis; and

wherein the preassembled electric apparatuses are located in a stationary position prior to moving the line-laying means.

4. The method of claim 1, wherein:

the line-laying means are located at a predetermined location, optionally at a positioning device imparting a positioning motion to them; and

wherein the preassembled electrical apparatuses are moved by means of a transport means that is movable relative to the line-laying means.

5. The method of claim 1, comprising the step of:

synchronising the line length supplied during line-laying between two terminals by the line-laying means with the relative motion between the preassembled apparatuses and the line laying means,

whereby since the beginning of the line is fixed at the first terminal at the onset of laying a line, tension relief required in direct laying of the line is attained automatically.



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6. The method of claim 5, wherein the length of the line length supplied by the line-laying means is dimensioned of such length that the line laid between the terminals is completely free of tensile strain.

7. The method of claim 1, wherein said moving step comprises:

controlling the relative motion between the preassembled electrical apparatuses and the line-laying means, such that the line-laying means approaches the vicinity of the respective terminal; and

then positioning the line-laying means precisely in a line inserting position relative to the terminal.

8. The method of claim 7, including the step of ascertaining the positional deviation of the line-laying means from the position of the terminal with the aid of position sensing means after the line-laying means have been brought into the vicinity of the terminal; and

automatically compensating for any positional deviation.

9. The method of claim 8, wherein the step of ascertaining the positional deviation includes:

providing an image processing system, assigned to the line-laying means; and

moving said image processing system for taking an image close to the terminal; and

further including the step of calculating compensation for the positional deviation and providing a corresponding output control signal.

10. The method of claim 1, including after the step of positioning the line-laying means, the step of

imparting an introduction motion of a defined course length to the line in the region of the terminal, with which motion the line is brought into the contacting zone of the terminal.



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11. The method of claim 1, wherein the relative motion between the preassembled electrical apparatuses or apparatus system and the line-laying means is, at least intermittently, substantially rectilinear.

12. The method of claim 1, wherein the contact elements in the contacting zones are IDC (insulation displacement connection) means; and

the line is pressed by the line-laying means into these contact elements; and

including the step of supporting the line, during the cutting operation by said line laying means.

13. The method of claim 12, wherein the line, upon being pressed in the contact means, is subjected to a pressing-in force on both sides of the IDC contact means.

14. The method of claim 12, wherein the line is firmly clamped on at least one side of the IDC contact means.

15. The method of claim 1, including the step of cutting the line directly at the line-laying means.

16. The method of claim 12, including the step of cutting the line at the IDC contact means.

17. The method of claim 12, including the step of cutting the line between spaced IDC contact means of an apparatus, while the line is in the contacting zone.

18. The method of claim 1, including the step of cutting the line such that the end thereof is protected in the guide region,

whereby the end will be automatically shock-hazard-proof protected and no further positional movement of the line-laying means is required.



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19. The method of claim 1, wherein the apparatus system comprises a light fixture.

20. Line-laying means, for carrying out the method of claim 1, comprising:

a line-laying tool having a housing defining a working side;

a guide conduit for the line on the working side of the housing, terminating in a mouth of a laying prong;

controlled feed means for the line;

at least one pressure member located in the vicinity of the mouth of the guide conduit for the line emerging from the mouth, said pressure member being movably supported for movement substantially transversely to the axial direction of the guide conduit in the mouth region;

positioning means on the pressure member for positioning the pressure member between a remote position of repose distant from the mouth and an operating position, in which operating position the pressure member protrudes on one side spaced from and past an edge of a mouth of the guide conduit with a pressure face aligned with the line protruding from the mouth, or substantially flush with the top of the edge of the mouth;

controlled wire cutting means slidably movably located on the housing adjacent the pressure member; and

a slide surface for said wire cutting means formed on the housing; and

wherein said mouth, terminating the guide conduit is located in said slide surface, whereby an end portion of said line projecting from said mouth will be cut cleanly and a bottom side of the edge of the mouth of said guide conduit will form a counterelement of the cutting force of said cutting means whereby said pressure member can insert the line into a contact element and the cutting means can cut the line at a position within a constricted, protected guide region of a terminal without further movement of said line-laying means.



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21. The line-laying means of claim 20, wherein the pressure member is a ram longitudinally displaceably guided on the housing.

22. The line-laying means of claim 21, wherein the line-laying means includes a laying prong; and
the ram is located parallel to and spaced apart from the laying prong.

23. The line-laying means of claim 22, wherein the mouth of the guide conduit is located laterally on the laying prong and on the side toward the pressure member.

24. The line-laying means of claim 22, wherein the pressure member and the laying prong have, at least in part, essentially the same width, measured transversely to the longitudinal direction of the line emerging from the mouth of the guide conduit.

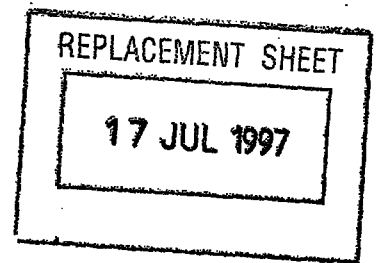
25. The line-laying means of claim 20, wherein the controlled cutting means for cutting the line comprises at least one cutter blade movably located in the region between the mouth of the guide conduit and the pressure member.

26. The line-laying means of claim 23, wherein the cutting means comprises a cutter blade which is operatively supported immediately on the laying prong, and
an edge portion of the mouth of the line guide conduit is formed as a knife counterelement.

27. The line-laying means of one of claims 19-26, wherein the laying prong is movably supported on the housing and is coupled with its own adjusting means.

28. Terminal, for use in the method of one of claims 1-19, using the line-laying means of one of claims 20-27, with clamping terminals containing the contacting zone which terminals have a housing of insulating material with at least one introduction slit, open at the edge, for a line





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and at least one IDC contact located in the housing with an IDC slit open at the edge toward the introduction side and aligned with the introduction slit, wherein the preassembled electrical apparatus or apparatus system, the housing of each terminal is provided with an introduction slit accessible to the line-laying means; that the housing on at least one side adjoining the introduction slit has a slitlike or groovelike indentation that receives the line and whose width is greater than the width of the introduction slit; and that the dimensions of the slitlike or groovelike indentation are such that a free end, located in the vicinity of the IDC contact, of a line contacted in the IDC contact is received in shock-hazard-proof fashion in the slitlike or groovelike indentation; and that the slitlike or groovelike indentation forming a constricted guide region and the housing are adapted to the dimensions of the laying prong and of the pressure member of the laying tool of the line-laying means.

29. The terminal of claim 28, wherein the introduction slit has a width that brings about a clamping fixation of a line pressed into it.

30. The terminal of claim 28 or 29, wherein the slitlike or groovelike indentation in the housing is located so as to be defined on both side by IDC contacts.

31. The terminal of one of claims 28-30, wherein the slitlike or groovelike indentation is deeper than the introduction slit.



REPLACEMENT SHEET

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PROCESS FOR WIRING CONNECTIONS OF ELECTRICAL APPLIANCES OR COMPONENT ELEMENTS

ABSTRACT:

Wiring of terminals of electrical apparatus or apparatus systems (4, 5, 7) is done automatically in the course of the direct wiring. A preassembled electrical apparatus or apparatus system is made available with terminals (9, 10, 11) fixedly located in it, whereupon by means of an automatically guided line-laying tool (59), an endlessly supplied line (68) is moved into the contacting zones of the specially formed terminals, fixed there, and either clipped or through-wired.

(Fig. 14)