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(54) Apparatus for forming tube

(57) An elongate generally cylindrical tube (7) is formed into a generally rectangular section tube having a bend therein. The apparatus for forming the tube comprises first and second tube receiving members (5) substantially aligned with each other and pivotable about substantially parallel axes. Each of the tube receiving members incorporates a channel formed in an upper surface (17) thereof for receiving a generally cylindrical tube to be deformed. Tube deforming means (15) is adapted to be lowered onto the tube so as to urge the tube into the channels and to cause the members (5) to pivot in mutually opposing directions, with adjacent faces of the members being urged in the direction of movement of the tube deforming means (15). In this way at least one bend is formed in the deformed tube. Each channel is formed with a recess (23) in adjacent ends thereof for receiving excess material of the tube (7) in the early stages of deformation.

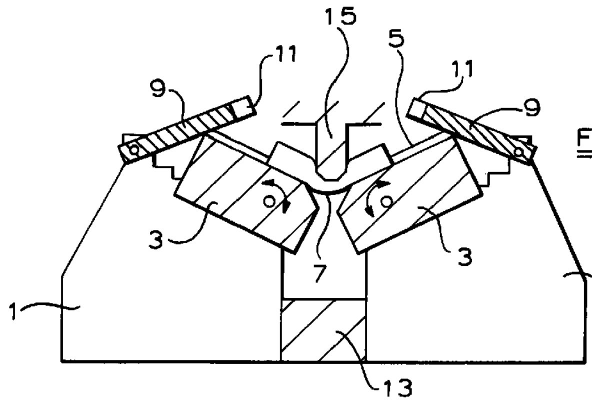

FIG 6

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Description

The present invention is concerned with an apparatus forming a generally rectangular section tube and to the use of such a tube, for example in a transformer with one or more fluid cooled windings.

It is well known to provide cooling ducts in the secondary blade, at least, of a transformer for use with welding apparatus. The transformer may be positioned, for example, at the free end of a robotic arm and may be cooled by water flowing through the cooling ducts.

The secondary blade is conventionally made by providing a tube, for example of stainless steel (EN5BB) and having a substantially circular cross-section, formed into the shape of the secondary blade and by casting copper to form the secondary blade around the tube, the secondary blade having a substantially rectangular cross section with the cooling duct running therethrough. Cool water can then be passed through the cooling duct in the tube, and therefore through the secondary blade, in order to cool the primary winding.

There are several disadvantages in manufacturing a secondary blade in this manner. The manufacturing process is complex and the resulting winding is therefore costly to produce. Additionally, the purity of copper used for casting is not as high as that of copper which is employed, for example, in the manufacture of copper tubes by drawing. The low purity of the copper leads to the generation of undesirable amounts of heat in the secondary winding and to losses in the transformer. It is therefore desirable to be able to manufacture the secondary blade in a more cost-effective manner and to be able to employ copper tube with resulting benefits in transformer operation. However, the primary difficulty in employing copper tube lies in the formation of the necessary bends in the tube without deforming the tube in such as manner as to distort or close the flow path of the cooling duct through the tube.

It is therefore an object of the present invention to provide an apparatus for forming a generally rectangular section tube so that the formed tube can be employed in any suitable application, for example in the secondary blade (winding) of a transformer.

According to the present invention there is provided an apparatus for forming an elongate generally cylindrical tube into a generally rectangular section tube having a bend therein, the apparatus comprising first and second tube receiving members substantially aligned with each other and pivotable about substantially parallel axes, each of which members incorporates a channel formed in an upper surface thereof for receiving a generally cylindrical tube to be deformed; and tube deforming means adapted to be lowered onto the tube so as to urge the tube into the channels and to cause the members to pivot in mutually opposing directions, with adjacent faces of the members being urged in the direction of movement of the tube deforming means, so as to introduce at least one bend into the deformed tube, wherein each channel is formed with a recess in adjacent ends thereof for receiving excess material of the tube in the early stages of deformation.

The depth of the recess may increase towards the adjacent ends of each channel.

The recess may be formed with a constant curvature. For example, the recess may be formed with a part-cylindrical surface. The axis of the cylindrical surface may be arranged at a predetermined angle relative to the remainder of the surface of the channel in which the recess is formed. The predetermined angle may be in the range from 4 degrees to 7 degrees. The preferred predetermined angle may increase with increasing diameter of the cylindrical surface.

For a better understanding of the present invention and to show more clearly how it may be carried into effect reference will now be made, by way of example, to the accompanying drawings in which:

Figure 1 is a cross-sectional view of one embodiment of an apparatus for forming tube in accordance with the present invention, the apparatus being in a first position;

Figure 2 is a plan view, on a different scale, of part of the apparatus shown in Figure 1;

Figure 3 is a cross-sectional view of the part shown in Figure 2;

Figure 4 is an end elevational view of the part shown in Figures 2 and 3;

Figure 5 is a view corresponding to Figure 1 with the apparatus in a second position;

Figure 6 is a view corresponding to Figures 1 and 2 with the apparatus in a position intermediate the first and second positions;

Figure 7 shows a tube deformed in the apparatus of Figures 1 to 6 and prepared for use as a secondary blade of a transformer;

Figure 8 is a cross-sectional view of an apparatus for forming a further tube in a first step;

Figure 9 is a cross-sectional view of a modification of the apparatus of Figure 8 for forming the further tube in a second step;

Figure 10 shows a tube bent by the apparatus of Figures 8 and 9;

Figure 11 is a plan view of part of an apparatus for flattening the bent tube shown in Figure 10;

Figure 12 is a perspective view of a secondary winding of a transformer incorporating the present invention; and

Figure 13 is a cross-sectional view through a welding transformer incorporating a secondary blade and windings according to the present invention.

The apparatus shown in Figure 1 comprises a pair of supports 1 each of which is in the form of two spaced side members. Pivotably mounted between each pair of side members is a block 3 which has secured thereto a channel shaped forming die 5 which is best shown in Figures 2, 3 and 4 and will be described in more detail hereinafter. The forming die 5 may be integral with the pivotable block 3, but a separate forming die is preferred because this permits the use of alternative forming dies adapted, for example, to tubes of different diameters and/or other dimensions.

Adjacent end surfaces of the blocks 3 are spaced apart from each other and a tube 7 of copper or the like having a circular cross section and substantially uniform wall thickness is supported on the two forming dies 5 and extends across the gap between the two blocks.

The tube 7 is initially retained in position by means of an arm 9 pivotably mounted on each of the supports 1. The width of the arm is dimensioned to be greater than the diameter of the tube and the free end of each arm is formed with a rectangular cut-out having a width such as to correspond substantially to the diameter of the tube and a depth such that there is a predetermined distance between the bases of the cut-outs corresponding substantially to the length of the tube 7. The protrusions 11 at each side of the cut-outs can be seen in Figures 1, 5 and 6.

A removable anvil 13 is provided intermediate the two supports 1 and beneath the gap between the two blocks 3 for reasons that will become clear hereinafter.

Positioned above the tube 7 is an arm 15 which is movable towards and away from the anvil 13.

One of the channel shaped forming dies 5 (the left-hand die from Figure 1) is shown in more detail in Figures 2, 3 and 4. The die 5 comprises a channel having a generally planar base 17 having an upright web 19 extending along opposite longitudinal edges of the base. The free end of the die is tapered at 21 from the top of the webs to the lower edge of the base, for example at an angle of 45 degrees. Formed in the base 17 and extending away from the tapered end 21 is a part-circular cut-out 23. The cut-out is formed with constant curvature (that is, it is formed with a cylindrical cutter), but the depth of the cut-out increases towards the tapered end 21 (that is, the cutter is angled with respect to the base). The purpose of the cut-out 23 will be explained in more detail hereinafter.

For deforming a tube having an outer diameter of 25 mm, the spacing between the webs 19 may be 32 mm and the cut-out 23 may be formed with a 30 mm diameter cylindrical cutter arranged at an angle of about 4 degrees 45 minutes (± 15 minutes) (corresponding to a depth of substantially 5 mm at the tapered end and an overall length of about 65 mm). For deforming a tube having an outer diameter of substantially 28.58 mm (1⅛ inches), the spacing between the webs 19 may be 37 mm and the cut-out 23 may be formed with a 36 mm diameter cylindrical cutter arranged at a slightly greater angle of about 6 degrees and 10 minutes (± 15 minutes) (corresponding to a depth of substantially 7 mm at the tapered end and an overall length of about 65 mm).

Figure 5 shows the apparatus of Figure 1 after it has been operated to form a tube 7 from its original cylindrical configuration into a generally rectangular section having two right-angle bends. The blocks 3 have been pivoted by downward movement of the arm 15 towards the blocks such that the end faces in Figure 1 are the lower faces in Figure 5 and the arms 9 have been pivoted upwardly by the rear ends of the blocks 3 as shown in Figure 1.

Figure 6 shows the apparatus of Figure 1 in an intermediate position in which the tube 7 is undergoing deformation by the arm 15, with the blocks 3 in the process of pivoting and the arms 9 being lifted clear of the pipe 7 by the rear ends of the blocks.

Once the tube 7 has been deformed to the configuration shown in Figure 5, it can be removed from the apparatus by any convenient means. One way of removing the tube from the apparatus is to remove the anvil 13 and to place a filler (not shown) in the U of the formed tube. When the arm 15 is subsequently lowered, the formed tube is ejected from between the two blocks 3.

The apparatus can then be returned to the configuration of Figure 1 to repeat the operation.

The problem when deforming a tube in the manner that tube 7 is deformed is to avoid the duct within the tube closing. This is achieved according to the invention by providing the cut-out 23 in each of the channel-shaped members. The cut-outs allow excess material to enter therein during initial deformation with the result that the duct within the tube does not close, while the pivoting motion of the blocks, and therefore of the channel-shaped members, subsequently draws the excess material around the bend of the formed tube.

The ends of the deformed tube can then be trimmed if necessary. When used for a transformer secondary blade, for example in a welding transformer, as will be explained in more detail hereinafter, the ends of the deformed tube are cut at opposing 42 and 43 degree angles as shown in Figure 7, or at any other suitable angle for soldering purposes.

The apparatus shown in Figures 8 and 9 is adapted to bend a further cylindrical tube into a generally rectangular configuration. The apparatus is employed in two steps. The apparatus comprises two spaced side members 25 between which are pivotably mounted two blocks 27, each of which has a channel 29 formed in an upper surface thereof for receiving a tube 31. The tube

31 is deformed in a first step illustrated with reference to Figure 8. The apparatus includes a die 33 in the form of a right-angled triangle having the apex thereof directed downwardly and which is formed with a channel 35 in the inclined sides thereof. The die 33 is lowered onto the tube 31 and deforms the same while the two blocks pivot such that the upper surfaces thereof become aligned with the inclined sides of the die. In this way a right-angle bend is formed in the tube 31.

The triangular die 33 is then raised and is replaced by a generally rectangular die 37 for use in a second step as illustrated with reference to Figure 9. The generally rectangular die 37 has two relatively long sides which are arranged in an upright configuration and two relatively short sides which extend laterally and is formed with a channel 39 in the upright sides and in the bottom face. The die 37 is made in separable rear and front halves to facilitate removal of the bent tube 31. The die 37 is lowered onto the tube 31 and deforms the same simultaneously in spaced locations corresponding to the ends of the lower surface of the die, while the two blocks pivot such that the upper surfaces thereof become aligned with the upright sides of the die. This results in the tube being given a substantially rectangular configuration. The tube is received in the channel 39 and may be removed from the die by separating the front half from the rear half of the die.

Intermediate the first and second steps, the free end of the tube which is to form the upper lateral extension of the rectangular configuration may be cut at an angle of substantially 42 or 43 degrees for co-operating with the deformed tube shown in Figure 7, or at any other angle suitable for soldering.

The bent tube 31 is shown in Figure 10, the uppermost bend in the tube having a smaller radius than the lower bends.

The next stage is to flatten the bent cylindrical tube 31 into a substantially rectangular cross-section and apparatus for effecting this is shown in Figure 11. The apparatus shown in Figure 11 comprises a generally horizontal plate 41 which is mounted on springs shown (not shown). Formed in the upper surface of the plate 41 is a generally rectangular depression 43, having upright side walls and a planar base which is separate from the remainder of the plate 41 and is not sprung, for receiving the bent tube. An upper plate (not shown) is then lowered onto the plate 41 so as to flatten the tube 31 into a substantially rectangular cross-section.

In order to removed the flattened tube from the depression a rectangular frame is positioned around the depression, and optionally a rectangular block is positioned within the flattened tube and the upper plate is lowered once again. This causes the plate 41 to be displaced and the flattened tube to be ejected from the depression.

Two of the flattened tubes can then be secured, for example by silver soldering, to the deformed tube shown in Figure 7 to result in a secondary blade for a transformer, such as a welding transformer, having a duct for cooling fluid extending therethrough. Such a secondary pair of blades is shown in perspective view in Figure 12.

We have found that such a secondary blade can be manufactured in more cost-effective manner and allows copper tube to be employed with resulting benefits in transformer operation.

Figure 13 is a cross-sectional view through one embodiment of a welding transformer incorporating a secondary blade as described above. The transformer incorporates a primary winding in the form of a plurality of copper plates 45 (referred to as windings) electrically insulated from each other except where they are joined and a secondary blade 47 formed with an integral cooling duct and being insulated from the primary winding. The primary windings and the secondary blade are encased in a resin material and positioned within laminations 48.

Claims

1. An apparatus for forming an elongate generally cylindrical tube (7) into a generally rectangular section tube having a bend therein, characterised in that the apparatus comprises first and second tube receiving members (5) substantially aligned with each other and pivotable about substantially parallel axes, each of which members incorporates a channel formed in an upper surface (17) thereof for receiving a generally cylindrical tube to be deformed; and tube deforming means (15) is adapted to be lowered onto the tube so as to urge the tube into the channels and to cause the members (5) to pivot in mutually opposing directions, with adjacent faces of the members being urged in the direction of movement of the tube deforming means (15), so as to introduce at least one bend into the deformed tube, wherein each channel is formed with a recess (23) in adjacent ends thereof for receiving excess material of the tube (7) in the early stages of deformation.

2. An apparatus as claimed in claim 1, characterised in that the depth of the recess (23) increases towards the adjacent ends of each channel.

3. An apparatus as claimed in claim 1 or 2, characterised in that the recess (23) is formed with a constant curvature.

4. An apparatus as claimed in claim 3, characterised in that the recess (23) is formed with a part-cylindrical surface.

5. An apparatus as claimed in claim 4, characterised in that the axis of the cylindrical surface is arranged at a predetermined angle relative to the remainder

of the surface of the channel in which the recess (23) is formed.

6. An apparatus as claimed in claim 5, characterised in that the predetermined angle is in the range from 4 degrees to 7 degrees.

7. An apparatus as claimed in claim 6, characterised in that the predetermined angle increases with increasing diameter of the cylindrical surface.

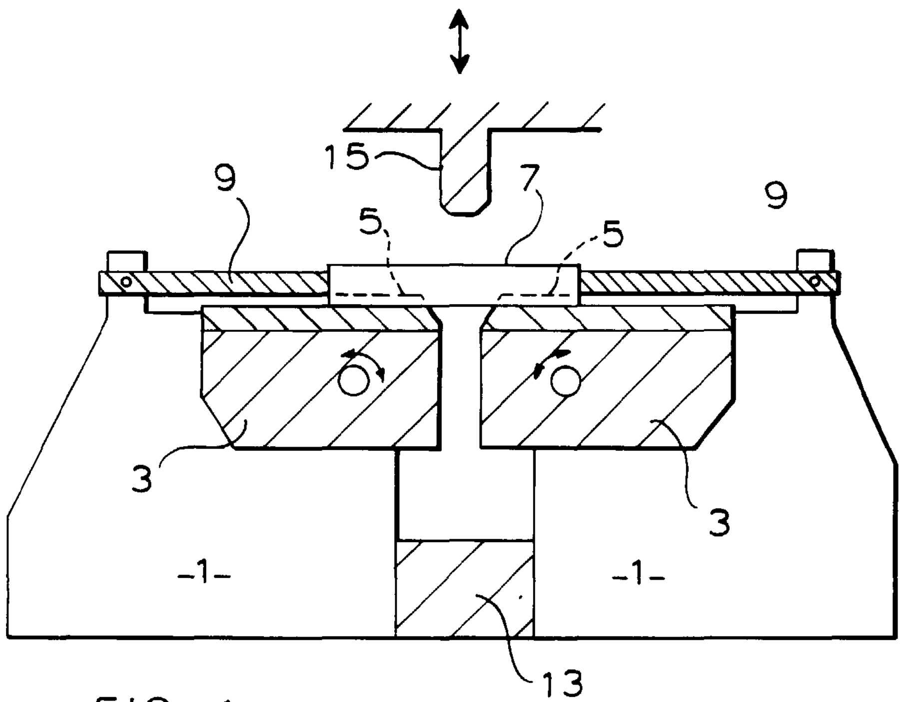

FIG 1

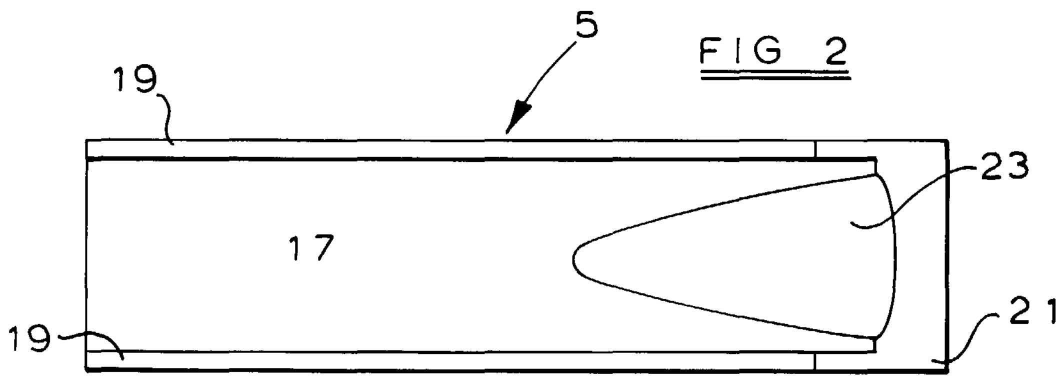

FIG 2

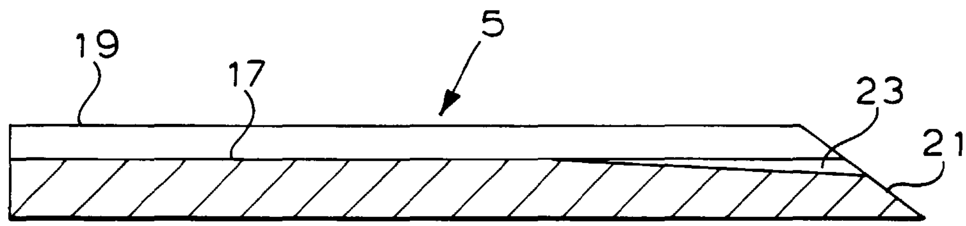

FIG 3

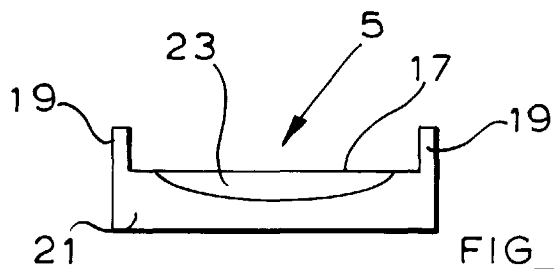

FIG 4

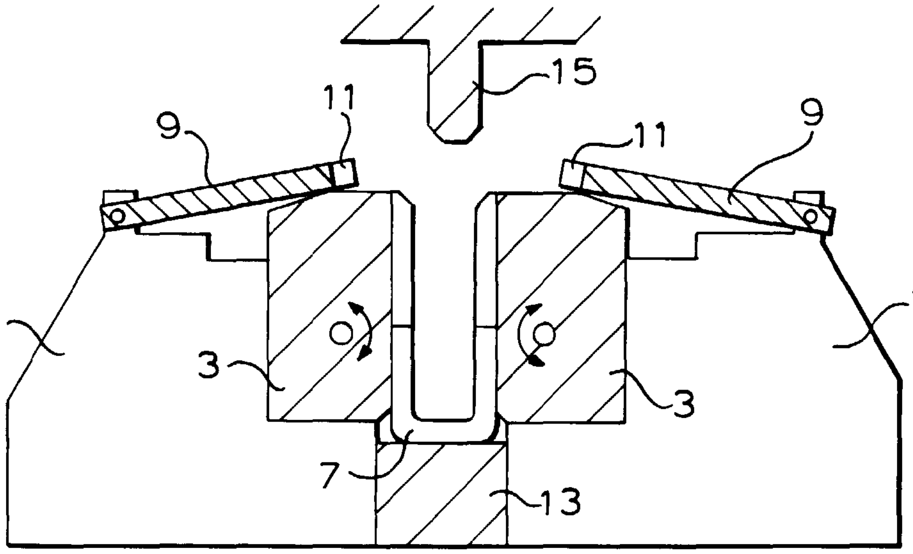

FIG 5

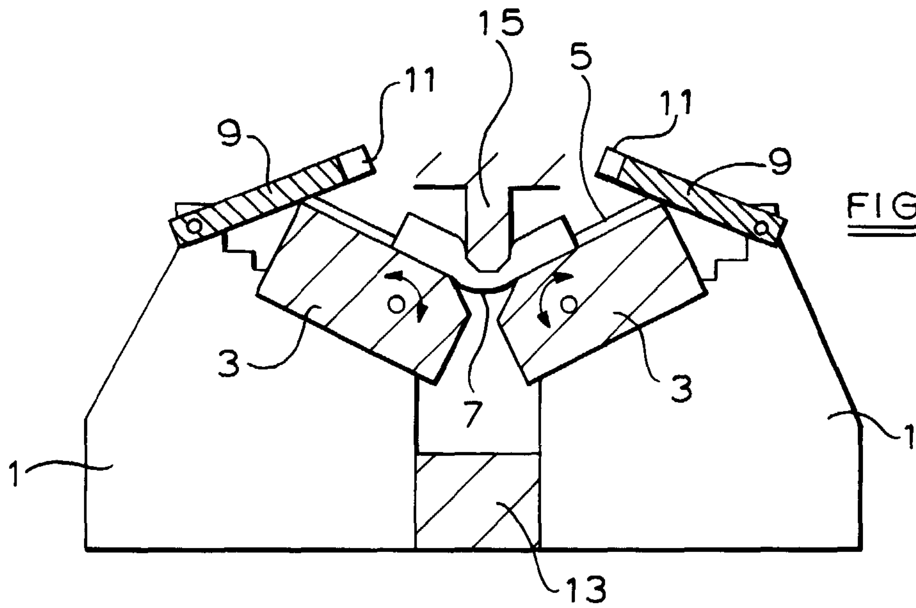

FIG 6

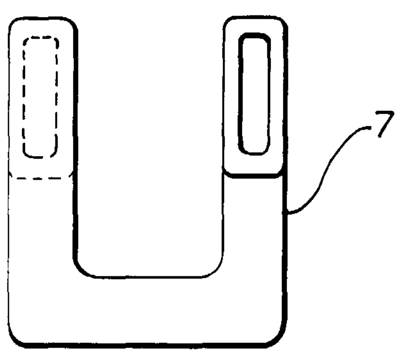

FIG 7

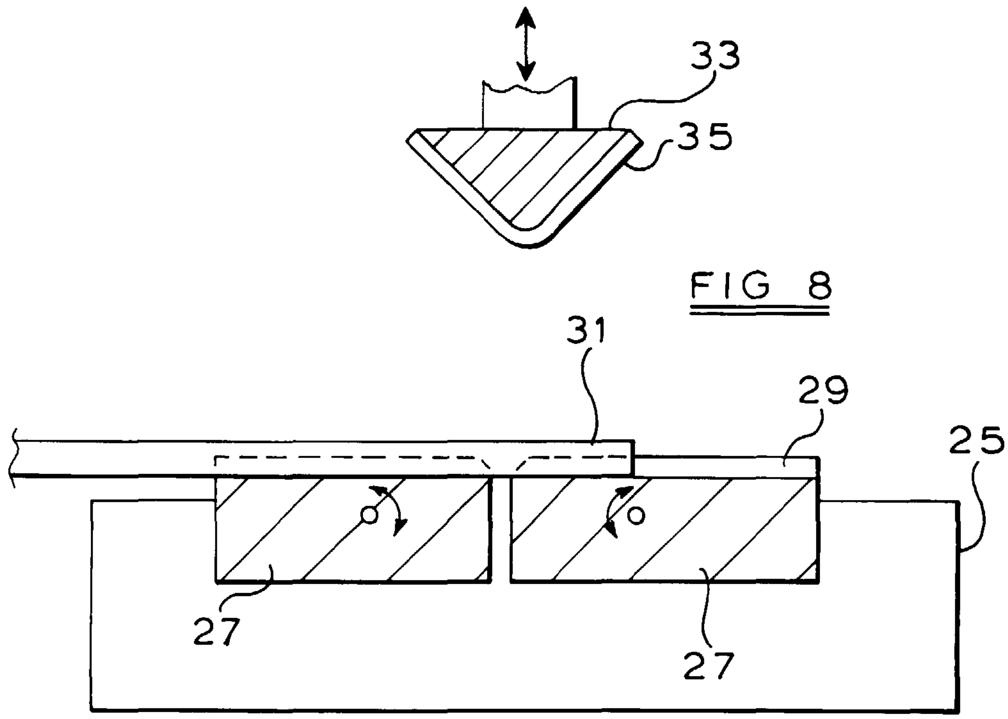

FIG 8

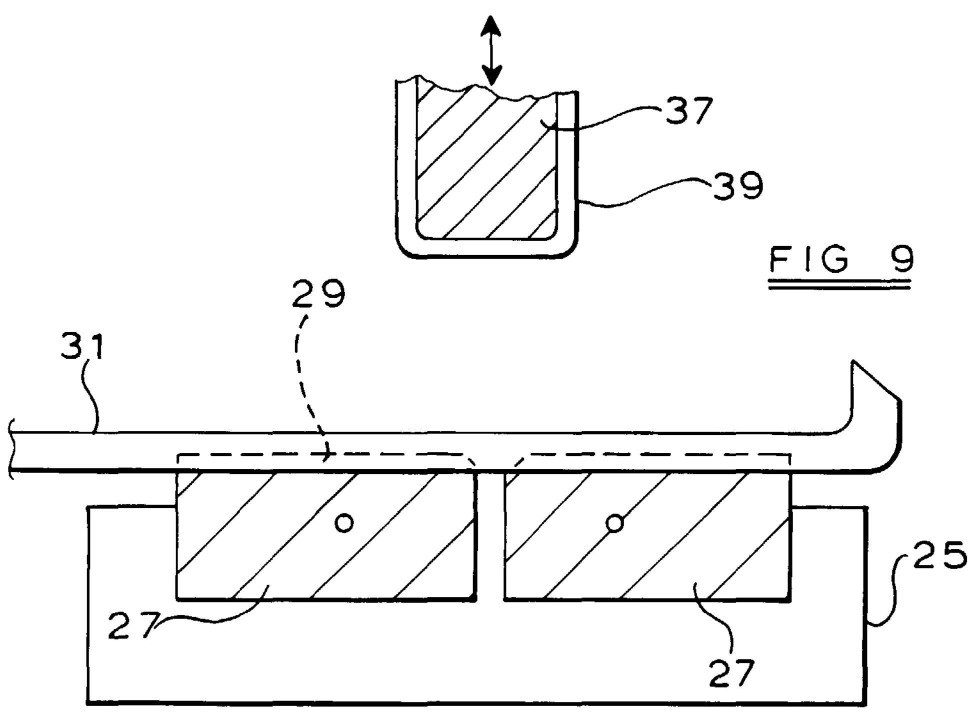

FIG 9

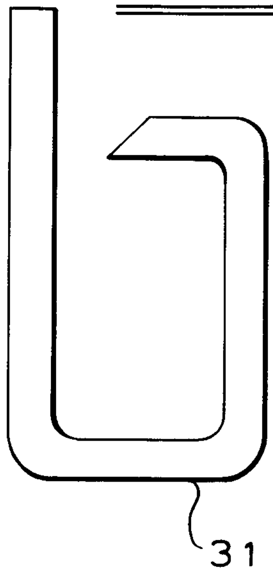

FIG 10

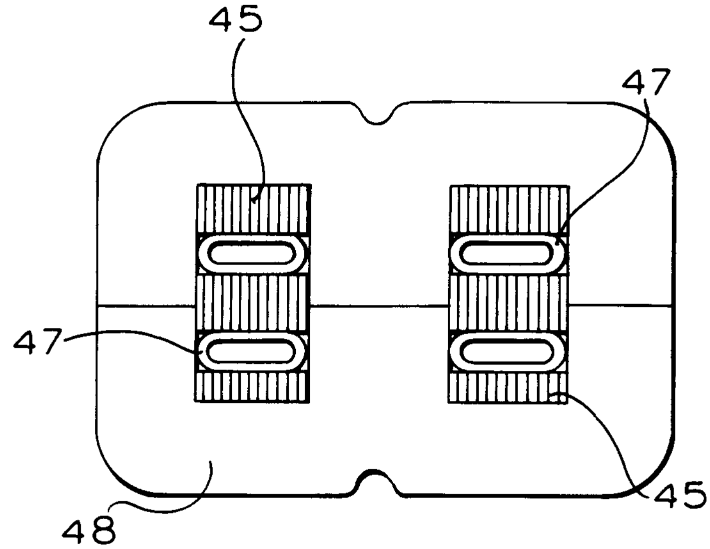

FIG 13

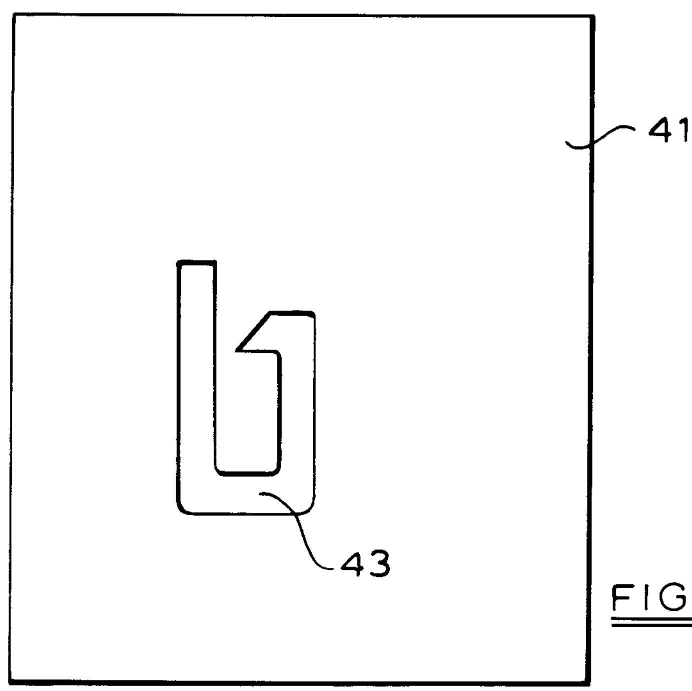

FIG 11

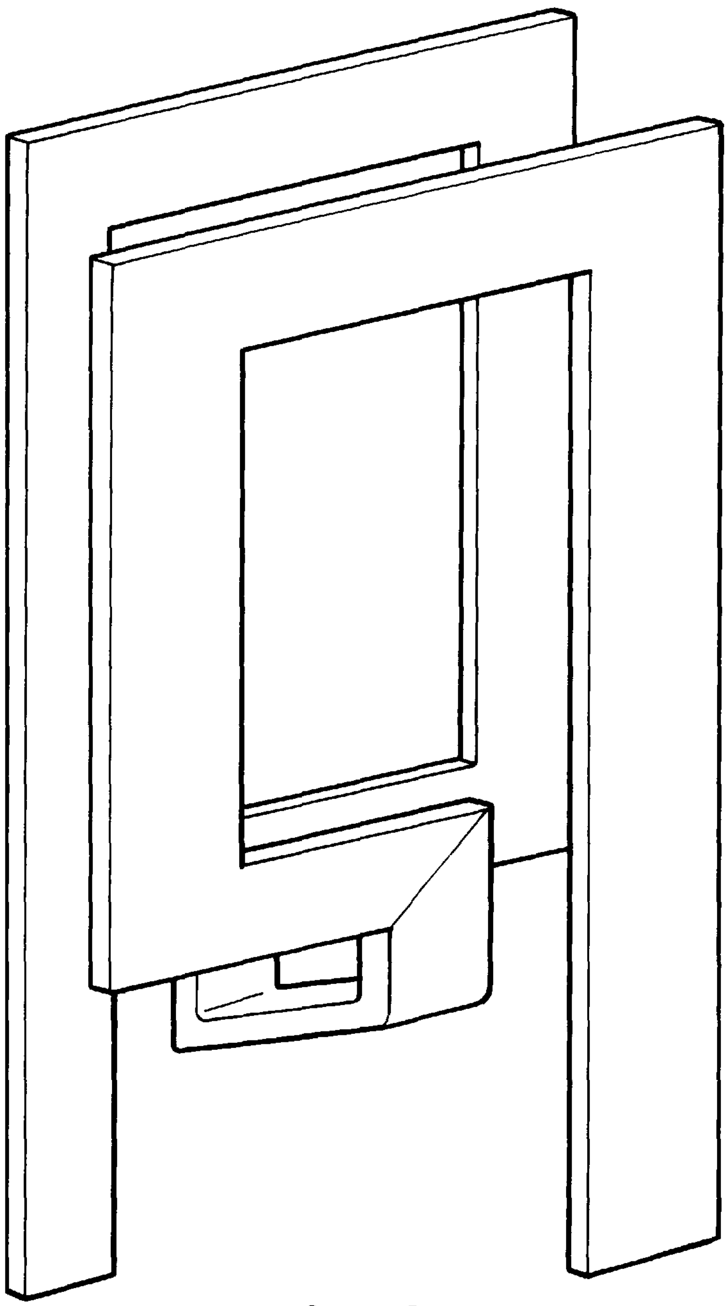

FIG 12

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 30 5397

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	GB 2 122 521 A (NEWMAN-TONKS HARDWARE LTD) * column 3, line 11-17; claim 3; figures 1-3,5,6 * ---	1-7	B21D7/06
A	US 2 983 995 A (GRESSÉ) * figures 5,6 * -----	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
B21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	11 March 1998	Ash, R

CATEGORY OF CITED DOCUMENTS

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