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(54) Electrical contact terminal and multi-contact connector.

(57) An electrical contact terminal (2) of the type contained in a connector housing (46) comprises a yoke portion (4) having extending therefrom, a contact arm (6) and a spring arm (8). The contact arm (6) has an electrical contact portion (34) on one side thereof and a bearing portion (32) on the other side which bears against a bearing portion (44) on the spring arm (8). When the contact arm (6) is flexed toward the spring arm (8) by a mating part, such as a circuit board (24), the contact force is developed in the spring arm (8) and the contact arm (6) serves primarily as a conductor. The terminal (2) and the contact arm 6 serves primarily as a conductor. The terminal 2 is produced by stamping sheet metal without subsequent bending, so that all parts of the terminal lie in the plane of the sheet metal from which it was produced. Terminals of the type described are used in electrical connectors for printed circuit boards which are also described.

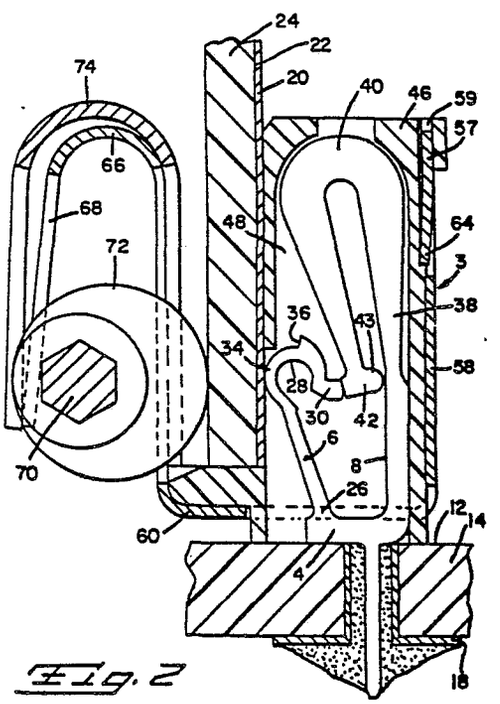

Fig. 2

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Electrical contact terminal and multi-contact connector

This invention relates to sheet metal electrical contact terminals and to multi-contact electrical connectors which contain sheet metal terminals.

U.S. Patent 4,188,085, U.S. Patent 3,871,736, and U.S. Patent 4,176,895, all describe sheet metal electrical contact terminals which have all of the parts of the terminal lying in a single plane, which is the plane of the metal stock from which the terminal was formed. Terminals of this flat type are extremely thin and can be placed on closely spaced centers in a multi-contact electrical connector. Flat terminals of the type described in the above identified U.S. Patents are, therefore, extremely useful when electrical connections must be made with closely spaced terminal pads on a circuit board and under similar circumstances where close spacing is required in an electrical connector.

A flat terminal which has all of its parts lying in the plane of the sheet metal stock from which it was formed is comparatively stiff, or rigid, as compared with a terminal manufactured by forming the sheet metal normally or at right angles to the sheet metal stock. The latter type of contact terminal, which is more widely used than flat terminals, can be provided with flexible contact members having a high degree of flexibility. A flat terminal which has all of its parts lying in the plane of the sheet metal stock will have relatively stiff flexible contact members which are capable of only limited movement when they are flexed. This problem may be overcome to some extent by designing the flat terminal with an extremely long contact arm, as shown in U.S. Patent 4,176,895. The use of a long contact arm, however, is undesirable under many circumstances. The terminal itself must be relatively large because of the length of the contact arm

and the connector in which the terminal is used must, therefore, have a relatively large housing. Furthermore, the use of an extremely long contact arm which carries the electrical current when the terminal is put to use causes self-inductance effects which are intolerable under many circumstances. Some telephone equipment, for example, has switching times of the order 10^{-9} seconds and under current conditions such as these, the rate of change of the current with time is extremely high notwithstanding the fact that the actual magnitude of the current may be relatively low. The high rate of change of the current gives rise to the self-inductance effects which may hamper the operation of the equipment on which on which the connector is being used.

The present invention in accordance with one aspect thereof, is directed to the achievement of a flat terminal having all of its parts lying in the plane of the metal from which the terminal was produced and which has minimal self-inductance effects when it is used under circuimstances of rapid switching. In accordance with a further aspect, the invention is directed to the achievement of a flat terminal capable of developing relatively high contact forces when desired, and which has a flexible contact arm capable of flexure to the extent required in an electrical connector. In accordance with a further aspect, the invention is directed to the achievement of a multi-contact electrical connector having flat extremely thin contact terminals therein on closely spaced centers.

An electrical terminal in accordance with the invention is formed from sheet metal stock by stamping or etching and has all of its parts in a single flat plane which is defined by the thickness of the metal from which the terminal was produced. The terminal has a contact arm having a fixed end and a free end, a

portion of the edge adjacent to the free end being a contact portion of the terminal which engages a complementary terminal device. The terminal is characterized in that it has a yoke section from which the contact arm extends and which has a spring arm extending from the yoke section beside the contact arm. The contact arm and the spring arm have opposed bearing edge portions which are against each other when the contact arm is flexed towards the spring arm so that the spring arm supports the contact arm. The contact force which is developed when the terminal is put to use is imposed by the spring arm which is flexed by the contact arm. The current passing through the terminal passes from the contact portion of the contact arm to the yoke portion through the contact arm and not through the relatively long spring arm.

A terminal in accordance with the invention can be used in a multi-contact electrical connector having a housing in which there are provided a plurality of side-by-side cavities each of which has a contact terminal therein. The contact portions of the spring arms project through openings in the housing past one surface of the housing so that a circuit board clamped against that surface is engaged by the contact portions of the terminals. A channel-shaped frame assembly is provided in which the housing is positioned and which also receives a circuit board. A clamp is provided on this frame assembly for clamping the circuit board against the one surface of the housing thereby to engage the conductors on the circuit board with the contact portions of the terminals in the housing.

FIGURE 1 is a cross-sectional view of a multi-contact electrical connector having contact terminals in accordance with the invention contained therein, this view showing the positions of the parts when the connector is not mated with a complementary circuit board.

FIGURE 2 is a view similar to Figure 1, showing the positions of the parts when the connector is mated with a circuit board.

FIGURE 3 is a perspective view of a terminal in the as-stamped condition.

FIGURES 4 - 6 illustrate the essential steps involved in the operations of severing individual terminals from a carrier strip and inserting the terminals into a connector housing.

FIGURE 7 is a diagram which illustrates the deflection of the contact arm of the terminal.

FIGURE 8 is a force/deflection diagram illustrating the functioning of the contact arm of the terminal.

FIGURES 9 and 10 are perspective views of the connector, the connector shown in assembled condition in Figure 9 and with the parts exploded from each other in Figure 10.

Referring first to Figures 1 and 2, a terminal 2, in accordance with the invention, serves to connect conductors 18 on the underside of one printed circuit board 14 to conductors 20 on a surface 22 of a smaller printed circuit board 24. The terminal is contained in a housing 46 of a connector 3 mounted on the upper surface 12 of circuit board 14 and the terminal has a solder post 10 which extends through an opening 16 in the circuit board and is soldered to the conductor 18, as shown. It will be understood that the connector 3 contains a plurality of terminals on closely spaced centers.

The terminal 2 comprises a yoke section 4 having extending therefrom a contact arm 6 and a spring arm 8 in side-by-side spaced-apart relationship. These arms extend from the upper edge of the yoke and the previously identified solder tab or post 10 extends from the the lower edge of the yoke. The contact arm has a

fixed end 26 which is integral with the yoke and extends obliquely away from the spring arm to a generally circular free end portion 28. At the end of this circular portion, there is provided an extension 30 which is directed towards the spring arm and edge 32 of this extension serves as a bearing portion for cooperation with a bearing portion 44 on the spring arm 8. The edge of the circular portion which is outwardly directed, as shown at 34, serves as a contact portion of the terminal and engages the conductor 20 on the circuit board 24. An ear 36 is provided on the circular portion 28 and has an edge which bears against the inside surface of the housing cavity 48 so that the contact arm cannot move leftwardly in a counter-clockwise direction from the position shown in Figure 1.

The spring arm 8 has a lower portion which is of substantially uniform width and which extends normally of the yoke 4 of the terminal. This lower portion merges with a spring portion 38 which is reversely curved, as shown at 40, and which merges with a depending portion 41. The free end 42 of the spring arm is adjacent to the extension 30 of the contact arm 6. The rightwardly facing edge 43 of the free end of the spring arm serves as a stop to prevent overstressing. The leftwardly facing edge 44 is normally against the bearing surface edge 32 of the contact arm 6.

The connector 3, Figures 9 and 10, comprises an insulating housing 46 having a plurality of side-by-side cavities 48 therein extending upwardly from the lower end of the connector as viewed in the drawing. These cavities are dimensioned snugly to receive the terminals as shown, and the lefthand wall 50 of the housing 46 has an opening therein 52, through which parts of the circular free end portion 28 of the contact arm project. The insulating housing has a leftwardly extending flange 54 which serves as a support

for the circuit board 24, as shown in Figure 2, and this flange also supports, in part, a frame assembly 56 which is assembled to the housing.

The frame assembly is of stamped and formed sheet metal, preferably steel, and is generally channel-shaped having sidewalls 58, 62 and a base 60. The sidewall 58 is disposed against the rightwardly facing surface of the housing as viewed in Figure 1, and has a lance 64 struck from its upper end portion which is received in a recess in the housing. The frame assembly is also retained on the housing by ears 57 on the frame which are received in openings 59 in the housing.

The sidewall 62 is reversely bent, as shown at 66, at its upper end to provide a depending arm as shown at 68, which is spaced from the sidewall 62. A cam shaft 70 is supported between the arm 68 and the sidewall 62 and has spaced-apart eccentric cams 72 mounted thereon. Openings are provided in the sidewall 62, the depending arm 68, and in a U-shaped spring member 74 to provide clearance for these cams. The housing 46 has an extension 69 on its lefthand end as viewed in Figure 10, and a recess 67 in this housing receives the end portion of the U-shaped spring member 74 and the end portion of the shaft 70. The channel-shaped spring member 74 has an integral biasing spring 71 thereon which bears against the lefthand end of the shaft 70 and stabilizes it in the frame assembly 56. Shaft 70 is supported adjacent to its righthand end between ears 73, 75 on the sidewall 62 and on the depending portion 68 of the frame assembly 56. The shaft 70 is movable in a horizontal direction towards the wall 50 so that circuit boards of varying thicknesses can be received in the trough 76 defined by the sidewall 62 and the housing wall 50.

In order to firmly clamp the circuit board against the contact surfaces 34 of the contact arms 6

of the terminals, the U-shaped spring 74 is mounted on the sidewall 62 and the depending arm 68 of the frame 56. This spring 74 may not be required under all the circumstances but can be used when it is desired to have extremely high forces at the electrical interfaces between the contact portions 34 of the terminals and the terminal pads on the circuit board 24.

In use, edge portions of the circuit board are inserted into the trough 76 as shown in Figure 2, and the shaft 70 is thereafter rotated through an angle of substantially 190° to the position shown in Figure 2. During such rotation of the shaft, the cams 72 will progressively push the circuit board 24 against the contact terminals 2 and the spring 74 will be flexed as shown, so that it will develop the required clamping force. The contact arm 6 is flexed in a generally clockwise direction as the cam is rotated so that the contact arm pushes the spring arm 8 to the position in Figure 2. The manner in which the contact arm is flexed and the spring arm 8 is stressed when the parts are in the positions of Figure 2 is discussed more fully below.

Terminals in accordance with the invention can be produced of any suitable material by simply removing material from flat stock metal. The removal of the material will ordinarily be carried out by a simple stamping operation to produce terminals in strip form, as shown in Figure 3, however, such terminals might under some circumstances, be manufactured by chemical etching of the strip. In any event, the finished terminal will have all of its parts lying in the plane of the original stock metal so that the cantilever beams, the contact arm, and the spring arm, are relatively stiff, although they are flexible.

Referring now to Figures 3 - 6, the terminals as stamped are integral with a continuous carrier strip 78 and in the as-stamped condition, differ from the

terminals as installed in the housing in that each terminal has an extension 84 of the yoke 4 and an additional solder post 86. Also, the end of the contact arm is integral with the end of the spring arm, as shown at 80, and the short lower portion on the end of the contact arm extends through a complete circle, as shown at 82. The material indicated at 80 and 82 is removed prior to insertion of the terminal into the housing cavity 48 as shown at 80', 82' Figure 4. The yoke extension 84 and the second solder post 86 may also be removed, as indicated in Figure 4. Alternatively, the yoke extension and second solder leg may remain on the terminal and the tab 10 may be removed. When the terminals are provided on closely spaced centers, alternate terminals may thus have the leg 10 removed and the remaining terminals have the leg 86 removed so that a grid hole pattern in the circuit board can be provided for more convenient spacing and location of the conductors on the circuit board.

Terminals 2 are installed in the housing 46 in the general manner shown in Figures 4 - 6, and preferably by means of insertion machinery having the elements described below for guiding and inserting the terminals. The housing 46 is supported in a housing support 88 that has a recess 90 in which the housing is supported with the open lower end of a cavity 48 disposed above the leading terminal on the strip 78. At the insertion station, a contact arm flexing and guiding tool 92 moves against the contact portion 34 of the contact arm 6 and an inserter 94 moves into surrounding relationship with the solder tab 10 of the terminal. The upper surface 95 of this inserter thus bears against the lower edge of the yoke portion 4 of the terminal so that when the inserter 94 moves upwardly, the terminal will be pushed into the cavity 48. Prior to upward movement of the inserter, the flexing

and guiding tool 92 moves rightwardly from the position of Figure 4 to the position of Figure 5, in which the righthand surface 91 of this tool is coplanar with the adjacent internal surface 97 of the housing 46.

When the flexing tool 92 moves from the position of Figure 4 to the position of Figure 5, it moves the contact arm 6 rightwardly to the position shown in Figure 5. During this movement of the contact arm 6, the edge 32 of the contact arm moves against the bearing portion 44 at the end of the depending section 41 of the spring arm 8. The section 41 of the spring arm is also flexed as shown in Figure 5. As will be explained below, the spring arm 6 is overstressed when it is initially flexed as shown in Figures 4 and 5 and after overstressing, the contact arm is supported by the spring arm when the terminal is placed in service as shown in Figures 1 and 2.

When the terminal 2 is held in the insertion tooling as shown in Figure 5, the terminal is sheared from the carrier strip 78 by a shearing means and thereafter the inserter 94 moves upwardly from the position of Figure 6. A guide means 96 is provided against the righthand edge of the terminal and in alignment with the surface 99 of the cavity so that the terminal will move smoothly into the cavity 48. When the tooling is then removed from beneath the terminal and the housing is removed from the housing support 88, the contact arm 6 will move leftwardly until the ear 36 is against the internal surface of the cavity, as shown in Figure 1.

It will be apparent from the foregoing description that the electrical function of the terminal is performed primarily by the contact arm 6 in that the current will flow from the contact portion 34 along this arm to the yoke 4 and through the solder post 10 to the conductor 18. The contact arm is substantially straight and extremely short, so that inductance

effects will be minimized. Current will not tend to flow across the bearing portions 32, 44 and through the spring arm because of the fact that this current path would present would present a higher resistance. The contact arm is flexed when the circuit board 24 positioned against the surface of the wall 50 of the housing 46 but its flexure makes only a minor contribution to the contact force developed in the electrical interface of the terminal and the circuit board in Figure 2. Most of the contact force is developed in the spring arm 8 and is transmitted to the contact arm 6 through the upper portion 28 of the contact arm directly to the terminal pad on the circuit board 24. Thus, the intermediate shank portion of this contact arm 6 is not subjected to the contact force which is present at the electrical interface. The spring arm can, of course, be designed to provide optimum properties and characteristics for the particular use to which the connector will be put. If extremely high contact forces are desired, this spring arm 8 can be made relatively stiff so that it will develop such high forces. Alternatively, if a contact force of limited magnitude is desired, the contact force can be reduced by redesigning the spring arm of the terminal.

While the principles of the invention will be apparent from the foregoing discussion, the following discussion of the performance of a specific terminal in accordance with the invention will provide a deeper understanding of the invention and the manner in which terminals can be designed specifically for particular applications. The following discussion is based on studies of a terminal produced from phosphor bronze stock metal having a thickness of 0.25mm. and in a relatively hard temper. The terminal had an overall height of 14.8mm and a width of about 4.99mm. The dimensions of the parts in the terminal were selected to

produce a contact force of about 600 gms.

Figure 7 is a diagram which shows the relative positions of the upper end of the contact arm at different stages of the assembly operation in which the terminal is inserted into the cavity 48. In this view, the line 98 indicates the position of the contact arm 6 prior to flexing of this arm inwardly towards the spring arm, in other words, the position of the arm, as it appears in Figure 4 of the drawing. The line 100 denotes the position of the contact arm when the parts are in the position of Figure 6 or Figure 2, that is, when the contact arm is flexed rightwardly to its extreme position. When this arm 6 is flexed by the flexing tool 94, the material in the arm yields and plastically flows so that the arm has a tendency to return only to the position indicated by the line 102 as the result of springback. However, when the connector housing is removed from the housing support 88, the spring arm 8 pushes the contact arm leftwardly beyond its normal position 102 to the position 104. The spring arm is of course flexed rightwardly when the parts are moved to the position of Figure 5 and it has a tendency to return to its normal position, and it is this tendency of the spring arm to return to its normal position that pushes the contact arm to the position indicated by the line 104.

Figure 8 is a force travel diagram showing the position of the upper end of the contact arm during the assembly process. The reference numerals 98, 100, 102, 104 have been applied to Figure 8, with prime marks, so that the curve shown in Figure 8 can be correlated with the arm positions shown in Figure 7. As shown in Figure 8, the upper end of the arm 6 is moved a total of 0.97mm when it is flexed from the position of Figure 4 to the position of Figure 5 and during such flexure, the load remains substantially

constant after it has risen to a plateau value. When the connector is removed from the connector support 88, the upper end of the contact arm 6 moves leftwardly past the condition of no load, as shown at 102', and is flexed in a manner such that it is loaded in the opposite direction, as indicated at 104'.

The significance of the diagram of Figure 8 is that the contact arm is flexed leftwardly from its normal position in the assembled connector so that when the circuit board is inserted into the trough 76 and clamped against the surface 50, the initial portion of the travel of the contact arm merely has the effect of unloading the stresses in the arm 6 and returning it to its unstressed position, as indicated by the line 102 in Figure 7. Thereafter, the arm is flexed rightwardly to the position indicated by the line 100 in Figure 7.

The fact that the contact arm and the spring arm are both in a flexed condition and are resiliently biased towards each other results in the capability in the contact arm for an increased amount of travel in normal usage, as compared in the amount which would be obtainable if the contact arm were not flexed leftwardly when it is in its Figure 1 position and, therefore preloaded against the lower end of the spring arm. The spring arm can, of course, withstand the flexure which it must undergo in the ordinary use of the connector by virtue of its substantial mass and its dimensions.

The specific terminal in accordance with the invention which has been described above has a circular free end 28 on the contact arm 6 which is capable of rotation relative to the shank portion of the contact arm when the load, the contact force, is applied against the contact portion 34 and the reaction force is applied against the bearing portion 32 by the spring arm. The capability for this rotation increases the

overall range of movement of the contact area 34 rightwardly, as viewed in the drawing, when the circuit board is mated with the connector. In other words, the shank portion of the contact arm 6 which extends from the base portion 26 to the free end undergoes flexure when the contact arm is stressed and this flexure of the arm results in some movement of the contact zone 34 rightwardly from the position of Figure 1. In addition, the rotation of the circular upper end 28 of the contact arm also results in some rightward movement of the contact portion 34 from the position of Figure 1 and the total amount of movement of the contact portion 34 is therefore the sum of the movement contributed by the shank portion of the contact arm and the portion contributed as the result of the rotation of the circular upper portion of the contact arm.

This characteristic of the disclosed embodiment is highly advantageous in that it permits the designer of a specific terminal to achieve a greater amount of movement of the contact portion 34 than would be obtainable if all of the movement were simply a result of flexure of the shank portion of the contact arm. Additionally, the rotation of the circular upper portion 28 of the contact arm contributes to the achievement of a wiping motion on the contact surfaces since the actual zone of contact moves relatively over the zone of contact on the circuit board 24 as the circuit board is clamped in the connector.

Terminals in accordance with the invention can be plated with a conductive metal as desired and as indicated by the environment of the intended use. Tin plating or plating with a tin-lead alloy may be satisfactory under many circumstances, particularly in view of the fact that high contact forces can be obtained from the terminal if desired. Gold plating may be used

if an extremely low resistance is required. If terminals in accordance with the invention are used under cryogenic conditions, a plating of indium or pure tin may be used.

Claims

1. An electrical terminal (2) of the type which has substantially all of its parts in a flat plane, the plane being defined by the thickness of the metal of the terminal (2), the terminal having a contact arm (6) which is flexible in the plane of the terminal, the contact arm having a fixed end (26), a portion (34) of the edge of the contact arm which is spaced from the fixed end (26) being a contact portion of the terminal, the terminal (2) being characterized in that:

the terminal has a yoke section (4), the fixed end (26) of the contact arm (6) being on the yoke section,

a spring arm (8) extends from the yoke section, the spring arm being beside the contact arm (6),

the contact arm (6) and the spring arm (8) have opposed bearing edge portions (32, 34) which are against each other when the contact arm (6) is flexed towards the spring arm (8) whereby the contact force developed in the terminal is produced by the spring arm.

2. An electrical terminal (2) as set forth in claim 1, the terminal being a stamped sheet metal member.

3. An electrical terminal (2) as set forth in claim 2 having an integral solder post (10) extending from the yoke (4) section for soldering to a conductor on a circuit board (14).

4. An electrical terminal (2) as set forth in claim 3, the contact arm (6) having an extension (30) which extends towards the spring arm (8), the bearing edge portion (32) of the contact arm being on the extension.

5. An electrical terminal (2) as set forth in either of claims 1 or 4, the spring arm (8) extending

from the yoke portion (4) past the free end (28) of the contact arm and then extending in a reverse direction (40, 41) back towards the free end of the contact arm.

6. An electrical terminal (2) as set forth in claim 5, the terminal being contained in a terminal-receiving cavity (48) of an electrical connector housing (46), the cavity having an opening (52) therein adjacent to the free end (28) of the contact arm (6), a portion of the free end (28) of the contact arm including the contact portion (34) extending through the opening (52) whereby upon placement of a circuit board (24) against the housing (46), the contact portion (34)of the contact arm (6) will contact a conductor (20) on the circuit board (24).

7. An electrical terminal (2) contained in a housing (46) as set forth in claim 6, the housing (46) having a plurality of identical terminals (2) therein in side-by-side spaced-apart relationship.

8. An electrical terminal (2) contained in a housing (46) as set forth in claim 7, the housing (46) having a clamp (72) for clamping a circuit board (24) against the housing (46) thereby to engage conductors (20) on the circuit board (24) with the contact portions (34) of contact terminals (2) in the housing.

9. An electrical contact terminal (2) contained in a housing (46) having a clamp (72) as set forth in claim 8, the clamp being a stamped and formed sheet metal frame (56) having a channel-shaped cross-section, the housing (46) being between the sidewalls (58, 62) of the channel-shaped member (56) and against one of the sidewalls (58), a clamping member (70) being mounted on the other sidewall (62).

10. An electrical contact terminal (2) contained in a housing (46) having a clamp (72) as set forth in claim 9, the clamping member (70) being a shaft having a plurality of spaced-apart circular cams (72) eccentrically mounted on the shaft.

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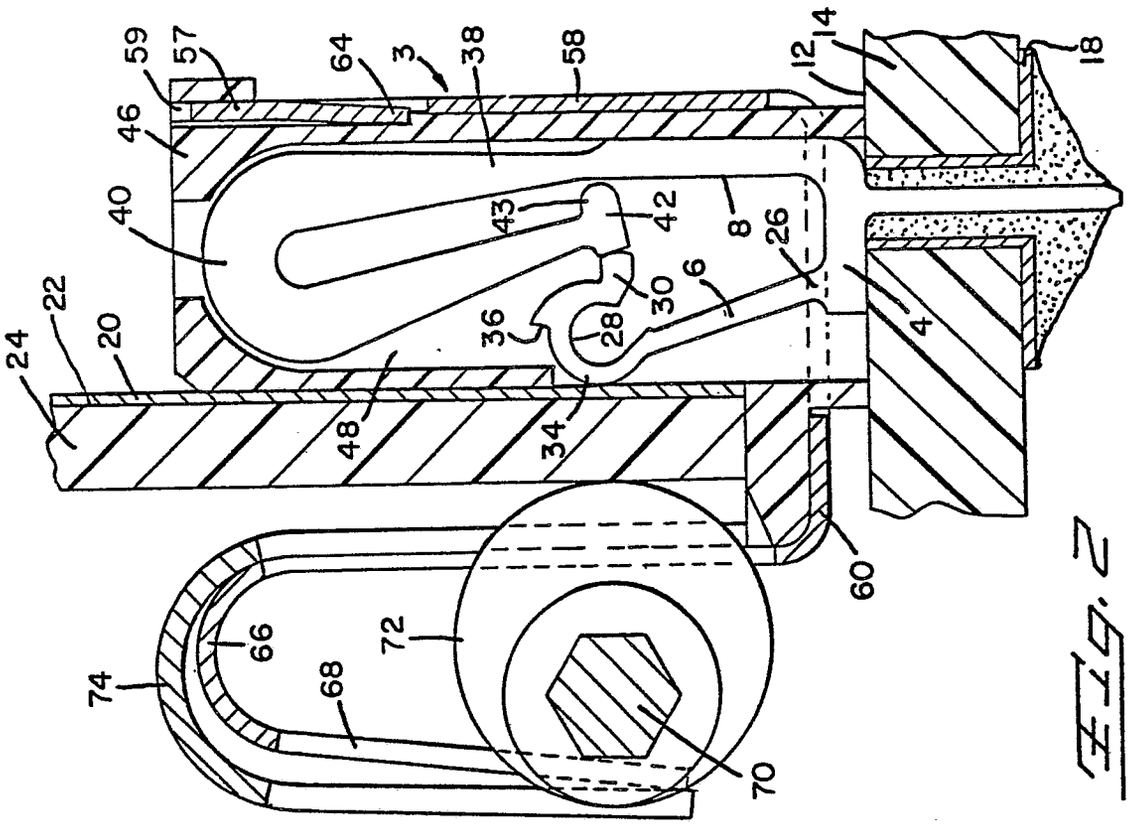

FIG. 2

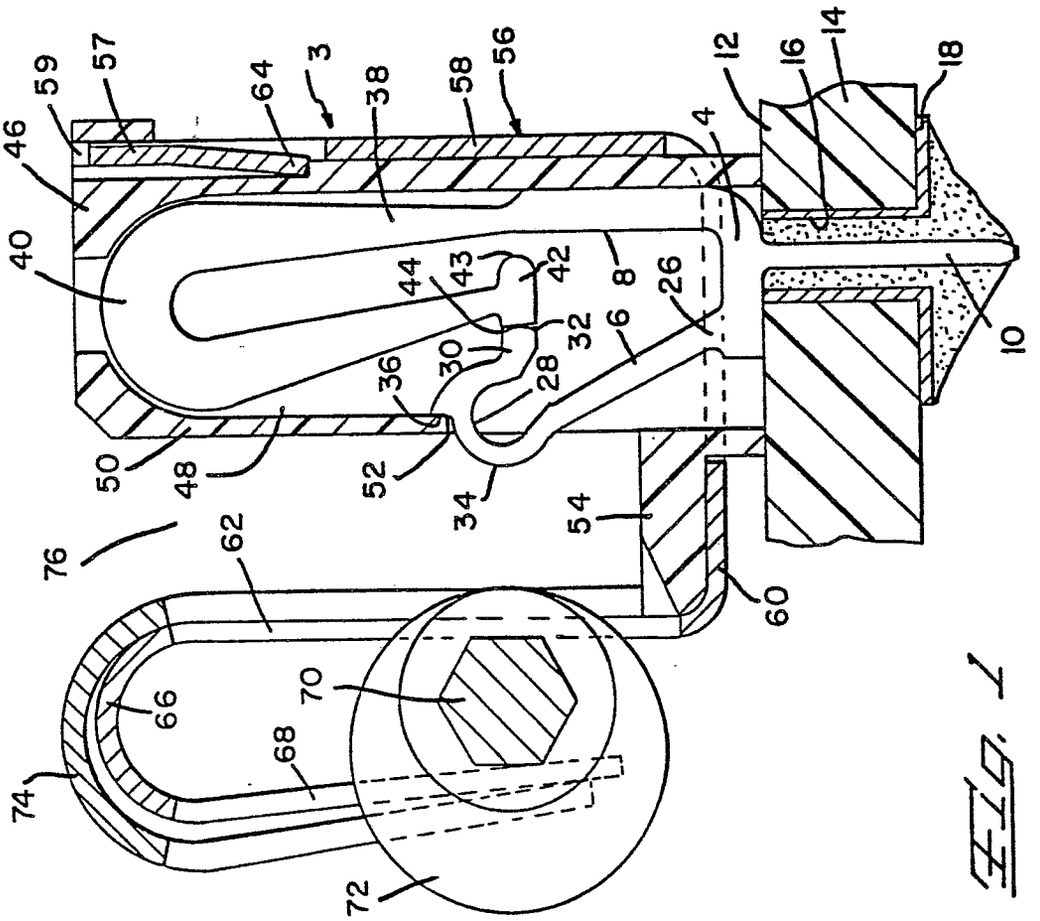

FIG. 1

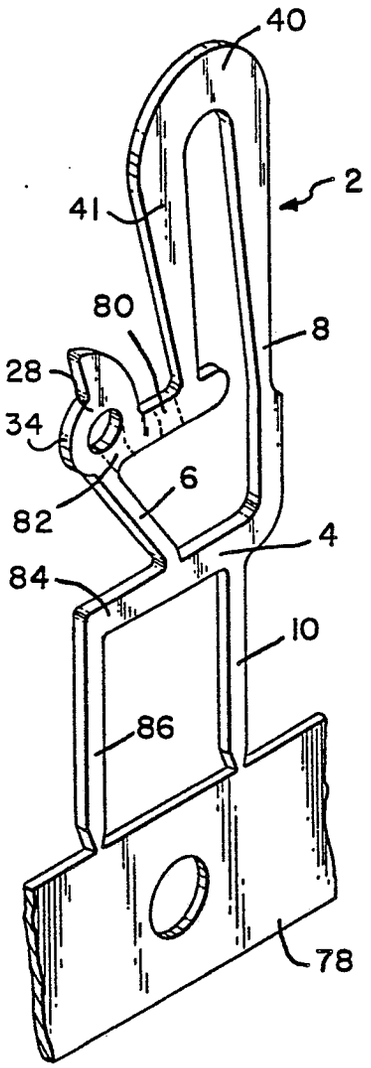
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Fig. 3

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Fig. 4

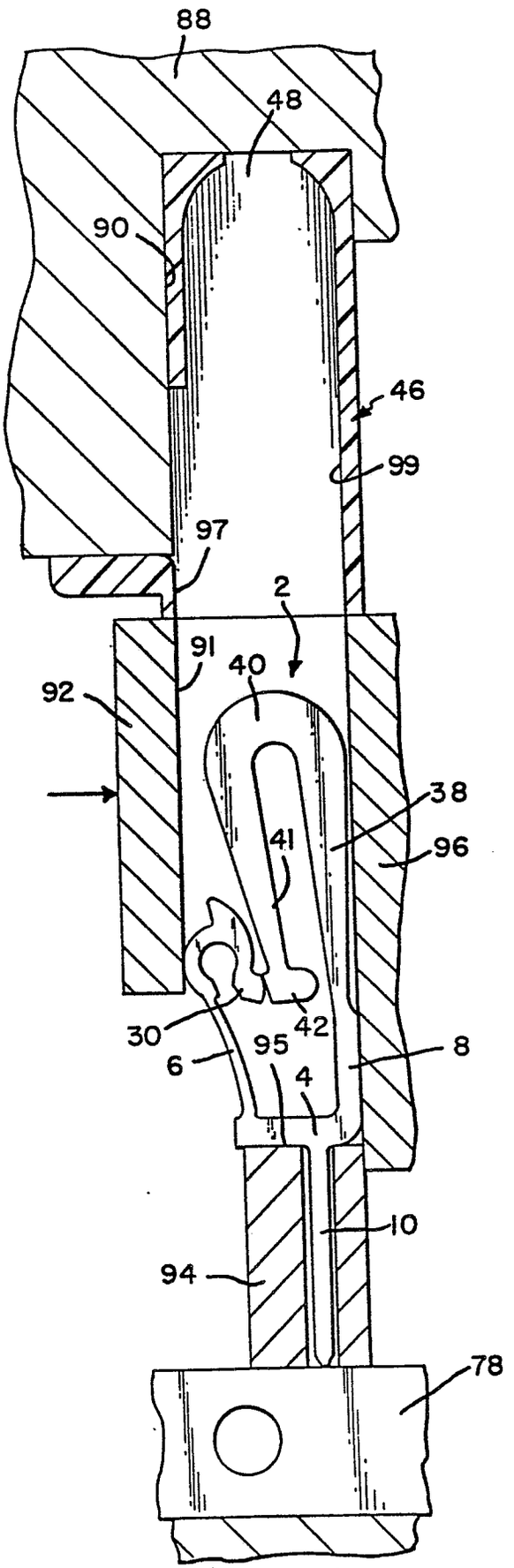
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Fig. 5

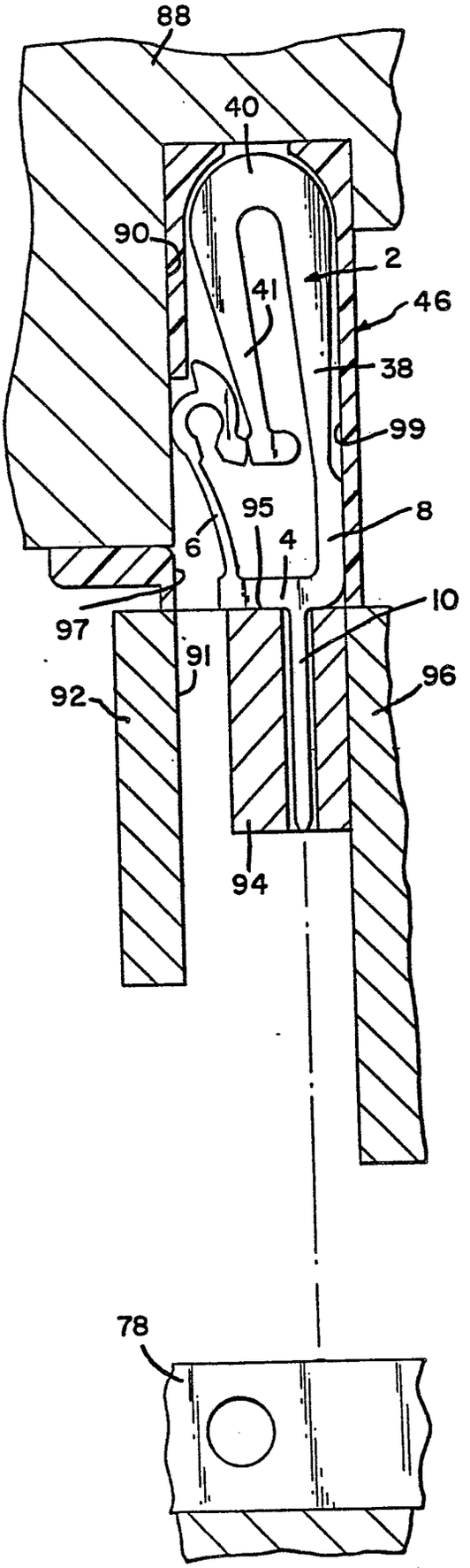
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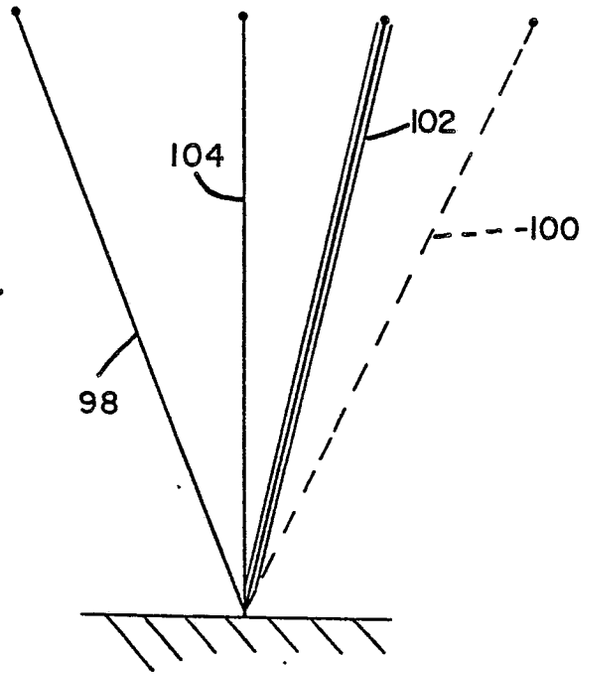
Fig. 6

Fig. 7



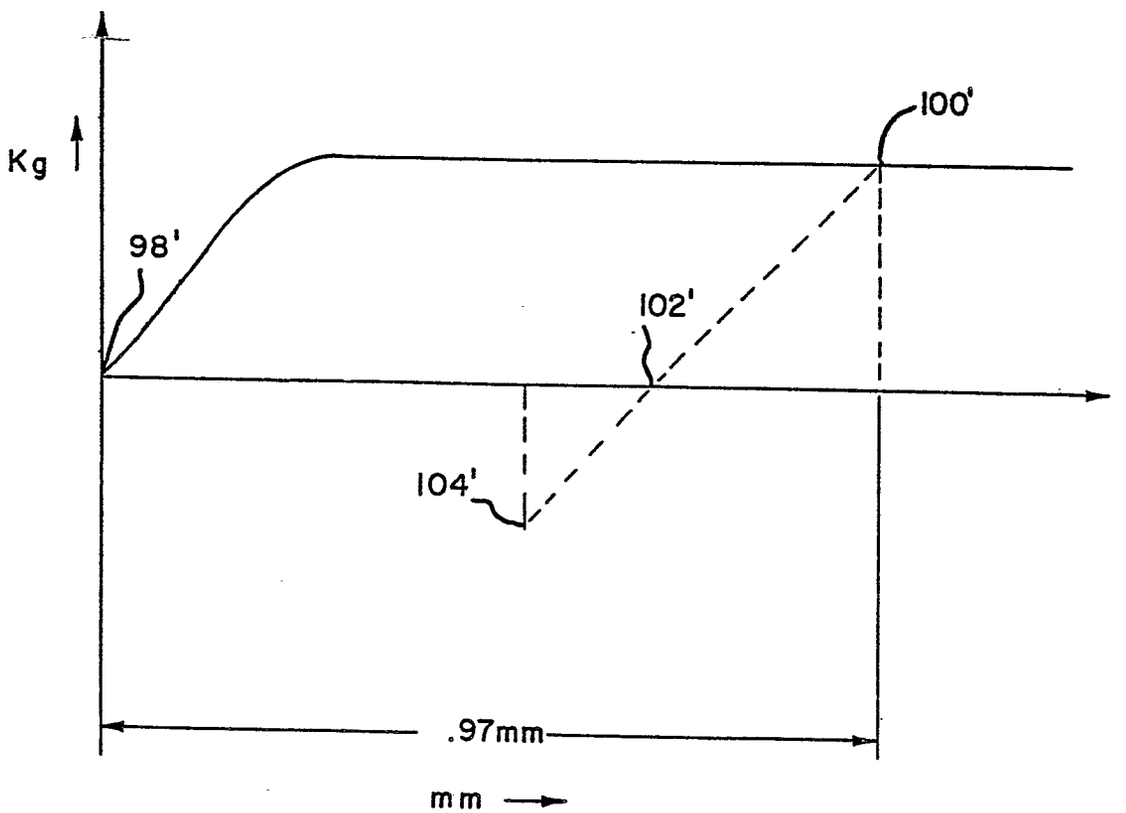


Fig. 8

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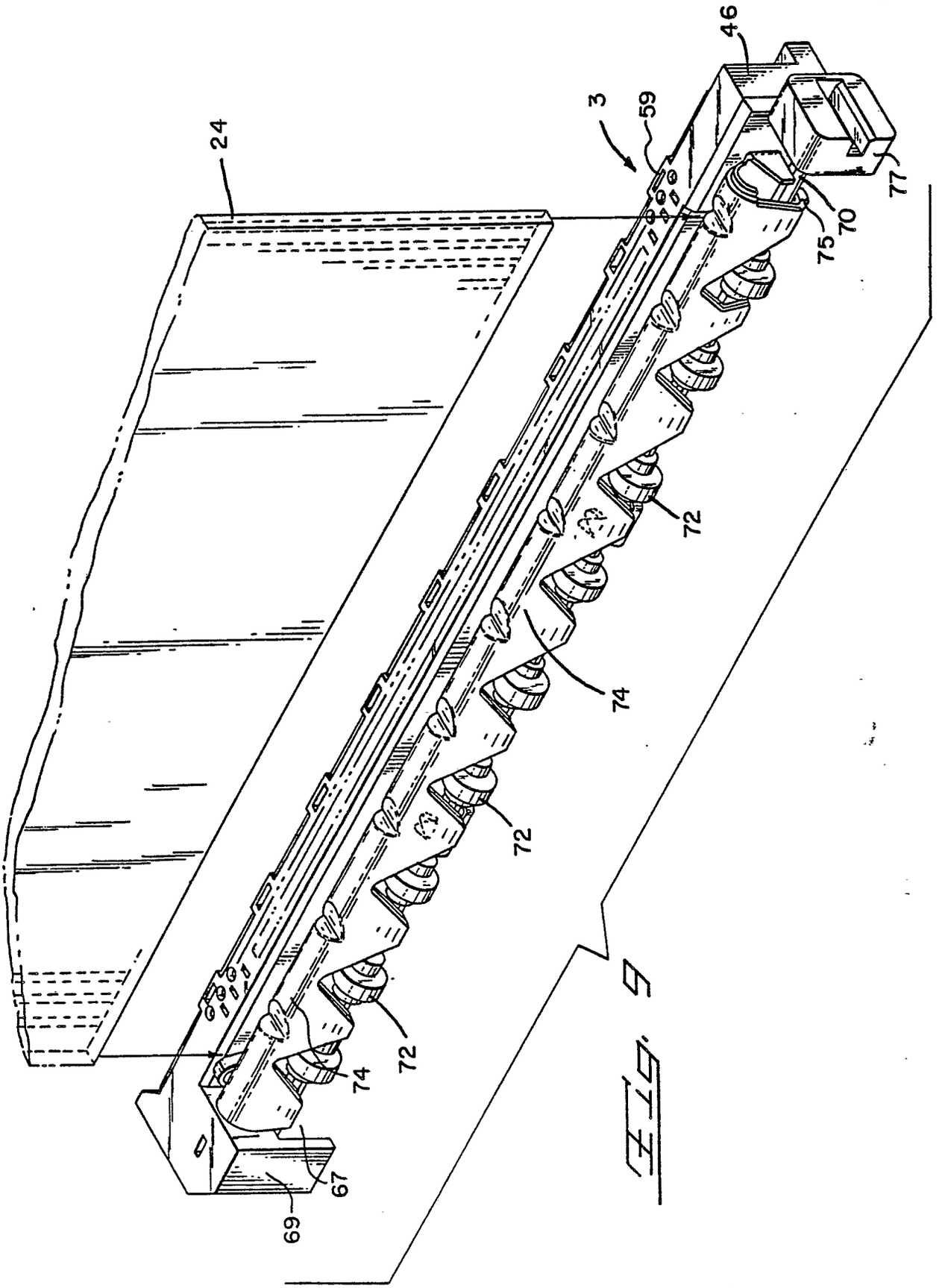

FIG. 5

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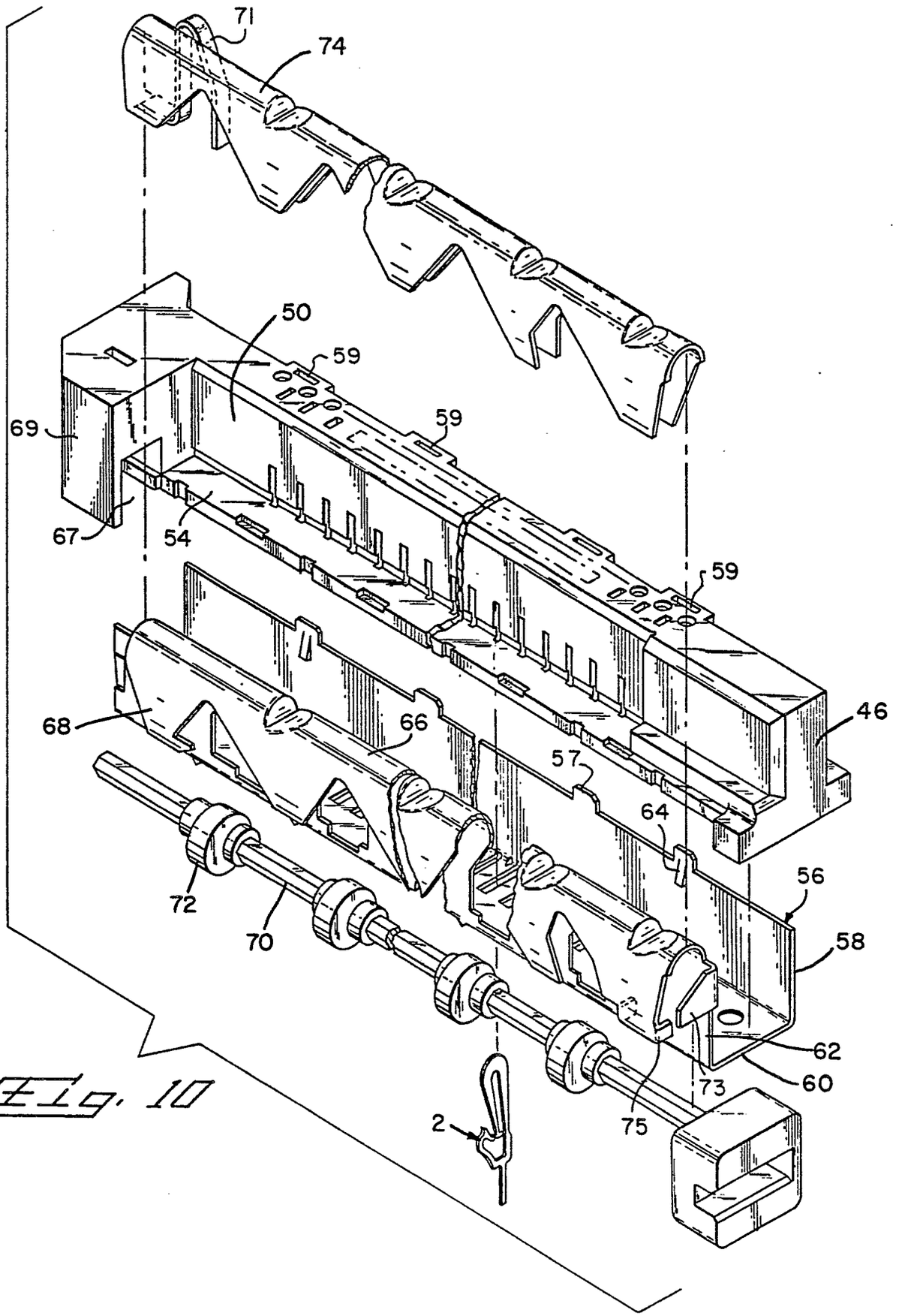

Fig. 10