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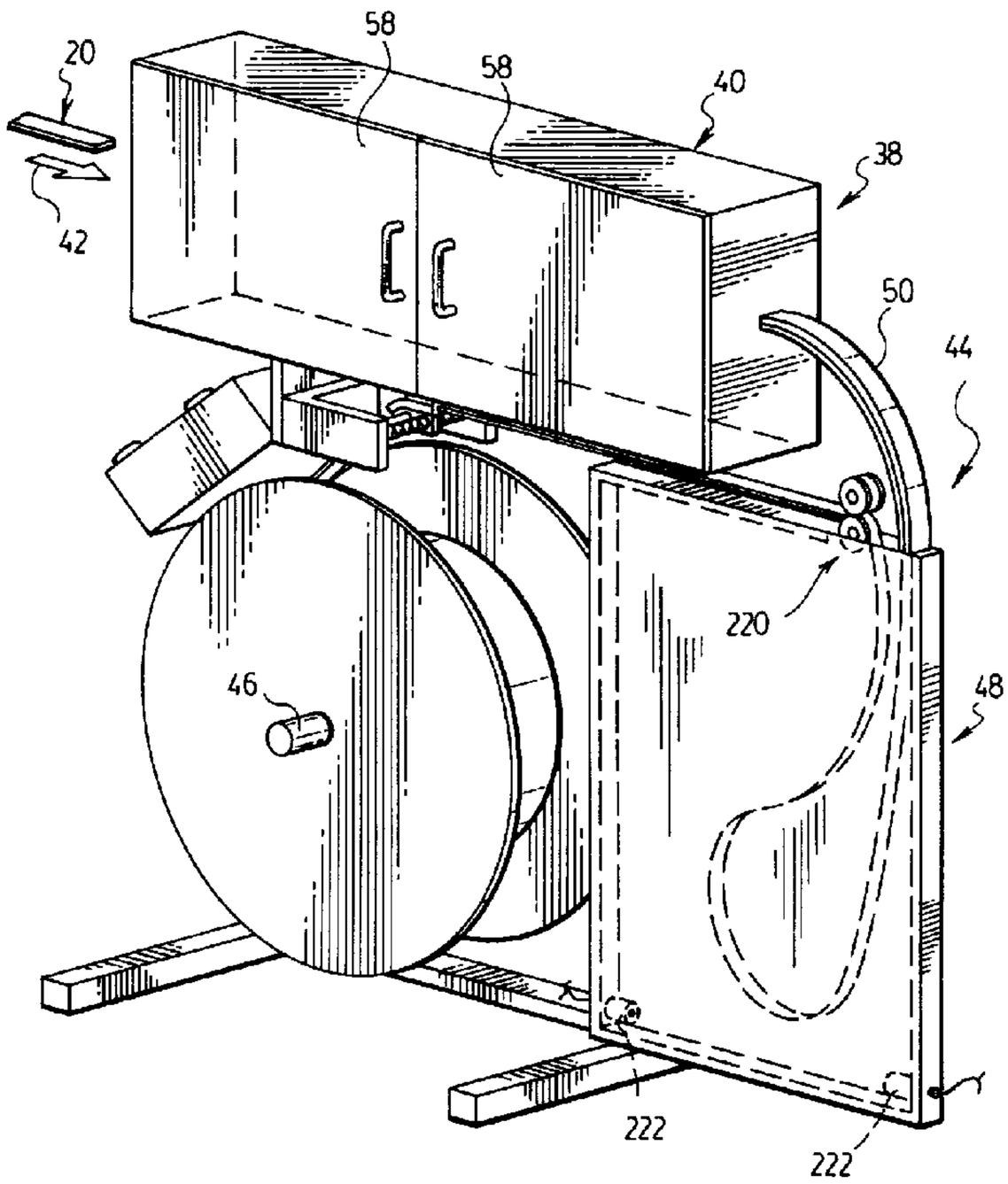
(54) **METHODE ET DISPOSITIF DE RECYCLAGE DE BANDEROLAGE**

(54) **METHOD AND APPARATUS FOR RECYCLING STRAPPING**



(57) Used plastic strapping is recycled by feeding successive lengths of strapping to a cutter station that cuts off leading and trailing end portions of the strapping to provide "clean" ends, and cuts out any old lap-joints. The resulting sections of strapping are heat-sealed together to form "new" continuous strapping that is wound onto a spool for re-use. A single cutter head having upstream and downstream cutters is used to perform all cutting operations. The two cutters move downwardly together and either cut out a lap-joint or a leading or trailing end portion of a length of strapping, depending on what portion of strapping is positioned below the cutter head.

ABSTRACT OF THE DISCLOSURE

Used plastic strapping is recycled by feeding successive lengths of strapping to a cutter station that cuts off leading and trailing end portions of the strapping to provide "clean" ends, and cuts out any old lap-joints. The resulting sections of strapping are heat-sealed together to form "new" continuous strapping that is wound onto a spool for re-use. A single cutter head having upstream and downstream cutters is used to perform all cutting operations. The two cutters move downwardly together and either cut out a lap-joint or a leading or trailing end portion of a length of strapping, depending on what portion of strapping is positioned below the cutter head.

Title: METHOD AND APPARATUS FOR RECYCLING STRAPPING

FIELD OF THE INVENTION

This invention relates generally to a method and apparatus for recycling used plastic strapping or other material in strip form (hereinafter called "strapping").

BACKGROUND OF THE INVENTION

Plastic strapping is widely used to bundle together stacks or other groupings of articles for shipping. For example, stacks of corrugated cardboard stock are bundled together using flat section polypropylene or polyethylene strapping. The strapping may be applied by a paper stock supplier prior to shipping the stock to a corrugated container manufacturer; the manufacturer will then cut, print and otherwise form the stock into blanks or finished containers. When the stock is to be used, the strapping is simply cut with a knife at random locations, pulled away from the stack and discarded.

Typically, the strapping comprises lengths of polypropylene or polyethylene strapping, each of which is looped around a stack of cardboard stock and secured in place by heat sealing together overlapping end portions of the length of strapping, forming a double-thickness lap joint. A single stack may be encircled by two loops of strapping in a crossed configuration. When the strapping is cut, the cut is almost always made at a location remote from the heat seal. As such, each discarded length of strapping usually includes a heat seal that may be at almost any location along the length of the strapping.

These used lengths of strapping not only are difficult to handle locally, but represent a significant disposal cost. Often, the discarded lengths of strapping are simply loaded into waste disposal containers and shipped to a landfill site. Sometimes, the strapping will first be chopped up into small fragments. This tends to make handling and disposal somewhat easier but involves cost in terms of equipment and an operator to feed in the discarded lengths of strapping.

At the very least, the container manufacturer is forced to incur significant costs in dealing with the waste strapping. Not only that, but finished container blanks that have been made from the cardboard stock usually must later be rebundled for shipping to the end user. A container manufacturer must accordingly purchase new strapping for that purpose.

In summary, significant costs are involved in disposing of the old strapping and buying new strapping. There is also a negative environmental impact that results from dumping of plastic strapping into landfill sites.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method and apparatus that addresses this problem by providing for recycling or reuse of discarded lengths of strapping, some or all of which may include heat-sealed lap joints.

In a method aspect of the invention, successive lengths of strapping, at least some of which include lap joints, are advanced along a defined path from an input station to a take-up station, and a number of steps are performed on the lengths of strapping as they are advanced along the path. First, at a cutter station downstream from the input station, leading and trailing end portions of each successive length of strapping are cut off to provide "clean" leading and trailing ends. Any lap joints are cut out of the lengths of strapping, thereby forming respective upstream and downstream strapping sections having "clean" leading and trailing ends. A first one of the strapping sections is advanced to a position in which a trailing end portion thereof is located at a joining station. A leading end portion of the next succeeding strapping section is then advanced into overlapping relationship with the trailing end portion of the first section and the two overlapping portions are sealed together to join the two sections end-to-end. The joined sections are wound or otherwise taken up at the take-up station downstream of the joining station as continuous strapping. This process is continued with successive strapping sections.

In other words, the old discarded lengths of strapping are in effect "cleaned up" by making fresh clean cuts at the leading and trailing end of each section and cutting out any old lap joints. The resulting strapping sections are then joined together end-to-end by forming new lap joints and the resulting continuous strapping is taken up, for example, by a winding unit or mandrel. The recycled strapping can then be used in the same manner as new strapping in a binding machine or other equipment.

Preferably, the cutter station includes a cutter head having upstream and downstream cutters that are spaced a predetermined distance along the path in which the strapping is advanced. The spacing between the cutters is selected as appropriate to cut out a portion of the strapping that includes a heat seal. The upstream cutter of the cutter head can also be used to trim a leading end portion from the length of strapping and the downstream cutter can be used to trim a trailing end portion of a length of strapping.

In this embodiment, the method also includes the step of detecting a leading end of a strapping length at a detection station upstream from the cutter station, and advancing the strapping length to the cutter station and into a predetermined to position with the leading end of the strapping between the upstream and downstream cutters. Similarly, the trailing end of a length of strapping can be detected at the detection station and the strapping advanced through essentially the same distance to position the trailing end of the length of strapping between the upstream and downstream cutters of the cutter head.

A lap joint in a length of strapping provides a double-thickness of strapping that can be detected at the detection station. The strapping can then be advanced through an amount selected to position the lap joint between the upstream and downstream cutters so that the lap joint will be cut out when the cutter head is operated.

In another aspect, the invention also provides an apparatus for recycling strapping that includes an input station, a take-up station and a strapping guide extending from the input station to the take-up station,

and along which can be advanced successive lengths of strapping at least some of which include lap joints. The apparatus also includes drive means for advancing the strapping along the guide, and a cutter station for cutting off leading and trailing end portions of each successive length of strapping to provide "clean" leading and trailing ends, and for cutting out any lap joints, thereby forming respective upstream and downstream strapping sections having "clean" leading and trailing ends.

The apparatus also includes a joining station downstream of the cutter station, to which a first one of the strapping sections can be advanced so that a trailing end portion of that section is at the joining station. A leading end portion of the next succeeding strapping section is then advanced into overlapping relationship with the trailing end portion of the first strapping section and the overlapping portions of strapping are sealed together to join the sections end-to-end. The sequence is repeated with successive strapping sections while the take-up station accumulates the continuous strapping that is formed from the individual strapping sections.

Typically, the joining station will be designed to heat-seal the strapping sections together, although other joining methods may be used, such as gluing or crimping. Typically, heat sealing will be used for plastic strappings, gluing might be more appropriate for other strapping materials. Crimping may be used where the strapping is metal.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings which illustrate a particular preferred embodiment of the invention by way of example, and in which:

Fig. 1 comprises six sequential views denoted (a) to (f) which illustrate successive steps in the method of the invention;

Fig. 2 is a front perspective view showing the overall apparatus for performing the method;

Fig. 3 is a front elevational view illustrating the principal

components of the apparatus of Fig. 2;

Fig. 4 is a perspective view of part of the input station that is visible at the left hand end of Fig. 3;

Fig. 5 is a perspective view of a further downstream part of the input station;

Fig. 6 is a perspective view of a lap joint detection station of the apparatus;

Fig. 7 is a perspective view of a strapping guide that is immediately downstream of the station shown in Fig. 6;

Fig. 8 is a perspective view of a cutter head of the apparatus;

Fig. 9 is an elevational view from the left in Fig. 8;

Fig. 10 is a perspective view of a strapping joining (heat-sealing) station of the apparatus;

Fig. 11 is a perspective view of a strapping take-up station;

Fig. 12 comprises views denoted (a), (b) and (c) that illustrate removal of a lap joint from a length of strapping;

Fig. 13 comprises views denoted (a) to (f) that illustrates heat-sealing of two sections of strapping;

Fig. 14 comprises views denoted (a) to (f) that illustrate a sequence of operation that follows on from the sequence of Fig. 12;

Fig. 15 comprises views denoted (a) to (d) that illustrate a subsequent heat-sealing step; and,

Fig. 16 comprises views denoted (a) to (c) that illustrate trimming of a trailing end portion of a length of strapping.

DESCRIPTION OF PREFERRED EMBODIMENT

The drawings illustrate a method and an apparatus that was devised primarily in the context of recycling polypropylene or polyethylene strapping that had been used for bundling corrugated cardboard stock. Typically, a length of strapping is looped around a stack of cardboard and the ends of the length of strapping are joined together by heat sealing to form a lap joint. When the stock is to be used, the strapping is simply cut at a random location, usually remote from the heat seal.

Fig. 1(a) shows a cut length of strapping such as might have been used for bundling a stack of cardboard stock. In the drawing, the strapping is denoted by reference numeral 20 and is shown laid flap and as having opposite end portions 22 and 24 that were formed by cutting a loop of strapping. An "old" lap joint is indicated at 26. In order to be able to recycle the strapping in accordance with the method of the invention, it is necessary to cut out the lap joint 26 and "clean up" each end of the length of strapping by cutting off an end portion of the strapping.

As will be described in detail later, the method of the invention involves feeding successive lengths of strapping lengthwise into a machine that cuts the strapping in this fashion and then forms a new lap joint between the cut sections of strapping.

It is irrelevant which end of the length of strapping is fed first into the machine, but if it is end portion 22 (the leading end portion) the first step in the method is to cut off the leading end portion of the length of strapping, sufficiently far back from the old cut that any frayed area is removed. A typical cut line is indicated at 28.

The next step is to cut out the lap joint 26 by making a pair of cuts 30 and 32 that are spaced in the direction of travel of the length of strapping sufficient to ensure that the lap joint is completely removed. This forms upstream and downstream strapping sections 20a and 20b which are then joined by advancing the upstream section 20b to bring its leading end portion into overlapping relationship with the trailing end portion of the downstream section 20a (Fig. 1(d)) and then heat-sealing the overlapping portions together to form a new lap joint 34 as shown in Fig. 1(e).

Finally, the trailing end portion of the length of strapping is removed, for example, by making a cut along the line indicated at 36 in Fig. 1(e). Fig. 1(f) shows the completed "new" length of strapping. Additional strapping sections can then be added to the "trailing" end portion of the new length of strapping by repeating the step shown in Fig. 1(a), heat-sealing the leading end portion of that length of strapping to the

trailing end portion of the length shown in Fig. 1(f) and then repeating the steps shown in Fig. 1(b) to 1(e).

Referring now to Figs. 2 and 3, an apparatus for carrying out the method of the invention is generally indicated by reference numeral 38 and includes the cabinet 40 which houses the components shown in Fig. 3. The apparatus includes the input station (not visible in Fig. 2) at which successive lengths of strapping are fed into the housing, as indicated by the arrow 42 and a take-up station generally indicated at 44 at which a continuous "new" strapping is wound onto a mandrel 46. An accumulator 48 is provided upstream of the mandrel so that rotation of the mandrel does not have to be timed to travel of strapping through the apparatus. A strapping guide is shown at 50 for directing strapping from cabinet 40 to accumulator 48.

For safety reasons, doors 52 are provided on cabinet 40. The doors may be transparent so that operation of the components within the cabinet can be visually monitored. However, for convenience of illustration, the components within the cabinet have not been shown in Fig. 2.

Referring now to Fig. 3, the input station referred to previously is generally denoted 60 and receives strapping fed into the apparatus (by hand) in the direction of arrow 42. The apparatus also includes, in sequence from the input station 60 to the take-up station 44, a detection station 64, a cutter station 66, a joining (heat-sealing) station 68 and a downstream detection station 70. These stations together define a path for strapping from the input station 60 to the take-up station 44. The two detection stations 64 and 70 include respective pairs of rollers 74, 76 and 78, 80. Each pair of rollers defines a nip for receiving strapping and the rollers are driven to convey the strapping through the apparatus.

Cutter station 66 includes a cutter head 82 that has upstream and downstream cutters 84 and 86 spaced in the direction of travel of strapping through the apparatus by an amount corresponding to the spacing between the two cut lines 30 and 32 indicated in Fig. 1(b) for cutting

an old lap joint out of a length of strapping. The two cutters 84 and 86 move up and down together when the cutter head is actuated (as will be described). In addition to cutting out old lap joints, the upstream cutter 84 is used to trim off a leading end portion of a length of strapping, while the downstream cutter 86 is used to cut a trailing end portion from a length of strapping.

The heat-sealing station 86 includes a heated blade 88 that can be advanced and retracted horizontally between overlapping end portions of sections of strapping to be sealed together as shown in Fig. 1(d), and a pair of anvils or jaws 90 and 92 that can be moved vertically towards and away from one another to respectively clamp the strapping against knife 88 and release the strapping.

Briefly, the leading end portion of an in-coming length of strapping is advanced to a position approximately mid-way between the two cutters 84 and 86 and the cutter head is actuated to cut off the leading end portion of the strapping (Fig. 1(a)). Strapping advance is then continued until the detector station 64 detects a lap joint. The strapping is then advanced to bring the lap joint to a position mid-way between the two cutters 84 and 86 and the cutter head is operated to cut out the lap joint. Next, the section of strapping downstream of the cut is advanced until its trailing end portion is at the heat-sealing station 68. The section of the strapping upstream of the cut is advanced to bring its leading end portion into overlapping relationship with the trailing end of the downstream portion, and the two portions are sealed together. Strapping advance then continues. The sequence of operation is essentially repeated on successive lengths of strapping that are fed into the apparatus forming continuous "new" strapping.

In more detail, Fig. 4 shows an input guide or "horn" 94 that opens to the exterior of the cabinet at the input station, as best seen in Fig. 3. The horn presents a relatively large "target" opening 94a to an operator feeding lengths of strapping into the apparatus and in effect guides the in-coming strapping to a relatively narrow slot 94b that is sized to relatively

closely match the size of the strapping. Thus, the operator does not have to be overly careful about precisely feeding the strapping into the apparatus, and can work quite rapidly. A photo-electric cell set 96 is incorporated in the horn to provide a signal indicating the presence of strapping at the input station.

Immediately downstream of the horn opening 96 is a device 98 that is designed to precisely locate the strapping both vertically and laterally as the strapping begins to travel through the apparatus. The strapping locating device 98 includes a base plate 100 which carries on its upper face a fixed guide element 102. Element 102 is of inverted L-shape and defines with the base plate 100 an opening 104 that is sized to relatively closely match the thickness of the strapping. Element 102 defines at the left hand side of opening 104 as drawn, a fixed guide face 102a for the left hand edge of strapping 20.

A corresponding opposite edge of opening 104 is defined by an edge of a guide element 106 which can move laterally with respect to opening 104 within limits defined by a pair of parallel links 108 that are pivotally coupled between element 106 and base plate 100. One of those links has an extension 108a to which is coupled one end of a tension spring 110 that extends to a fixed pin 112 on base plate 100. Spring 110 biasses guide element 106 inwardly with respect to opening 104. This has the effect of urging the strapping 20 against the left hand guide surface 102a of guide 102, positively locating the strapping in the lateral direction.

Immediately downstream of the locating device 98 is the first detection station 64; this is shown in detail in Fig. 6. Device 98 has been omitted for clarity of illustration. For the same reason, also omitted from Fig. 6 is a fixed guide 114 shown in Fig. 7. Like device 98, guide 114 has an opening 116 through which the strapping 20 passes; however, in this case, the opening 116 is of fixed dimensions selected to allow smooth passage of strapping 20 through the guide, while laterally and vertically constraining the strapping fairly precisely. Fig. 3 shows the locations of device 98 and guide 114 relative to the roller pair 74 and 76.

Reverting to Fig. 6, a length of strapping 20 having a lap joint 26 is shown positioned immediately before it enters the nip between the two rollers 74 and 76. It will be seen that the rollers have respective smooth surface portions 76a and 78a, on which the strapping 20 rides as it passes through the detection station 64. Inwardly of the smooth surface portions 76a and 78a, the two rollers have respective sets of teeth 76b and 78b that mesh with one another as the rollers turn. The teeth 76b, 78b are relatively deep so that the rollers can move apart slightly while remaining in driving engagement (see later). In fact, roller 76 is mounted on a rotary shaft 118 that is fixed, while roller 74 is mounted on a corresponding shaft 120 carried by a lever arm 122 that can pivot about a pivot pin 124. Arm 122 is part of a double arm lever, the second arm 126 of which is generally horizontal. This arrangement allows roller 74 to move away from roller 76 in response to entry of a length of strapping 20 into the nip between the two rollers. The distal end 126a of arm 126 then moves upwardly as indicated in ghost outline in Fig. 6. Roller 74 is biassed downwardly towards roller 76 by a spring 127.

Since a lap joint 26 in strapping 20 represents a double-strapping thickness, the distal end 26a of arm 126 will in fact move to one of two elevated positions depending on whether only a single or a double-thickness of strapping is present in the nip between the two rollers 74 and 76. A pair of proximity detectors 128 are provided adjacent arm end 126a for detecting the respective positions. In other words, the lower one of the two detectors 128 will respond when only a single thickness of strapping is present between the rollers, while the upper detector will respond to the presence of a lap joint 26.

Fig. 6 also shows part of a generally vertically disposed base plate 130, on which are mounted all of the components of the apparatus that can be seen in Fig. 3. In Fig. 6, it can be seen that shaft 118 carrying roller 76 is in fact a drive shaft that extends through base plate 130 and is provided, at the rear side of base plate 130, with a toothed pulley 132 by which roller 76, and hence roller 74 are driven. A drive motor for the

rollers is also mounted at the rear side of base plate 130 and is indicated at 134. A drive shaft 136 from motor 134 drives a further toothed pulley 138 that in turn drives pulley 132 by way of a toothed belt 140.

Motor 134 is an electric servo-motor that is capable of very precise control so that the rotational distance through which rollers 74 and 76 are turned can be determined with some precision. This means that a length of strapping 28 in the nip between the rollers can be advanced through a very precise distance to accurately position the leading end of the strapping, for example, in relation to the two cutters 84 and 86 (Fig. 3). Sophisticated control circuitry is provided for the entire apparatus and includes a programmable logic controller (PLC) that can be set to precisely control all of the various components of the apparatus and their sequence of operation. The control circuitry is designed in accordance with known programmable control principles and does not form part of the invention. Accordingly, details of the control circuitry have not been given.

Immediately downstream of detection station 64 is the cutter station 66; this is shown in detail in Fig. 8. As indicated previously, the cutter station includes a cutter head 82 that is provided with upstream and downstream cutters (knives) 84 and 86 respectively. Cutter head 82 is mounted for vertical sliding movement on a T-section slide 142 that is received in a complementary slide-away (not visible) in head 82. Slide 142 is fixed with respect to the base plate 130 (Fig. 3). At its lower end, slide 142 carries an inverted channel member 144 that overlies a plate 146 to define a passageway 148 for guiding strapping through the cutter station. This passageway precisely positions the strapping with respect to the cutters at opposite ends of the cutter station. A similar, but fixed guide 150 is provided immediately downstream of cutter 84 for conveying the strapping to the sealing station 68 (Fig. 3).

In the case of guide 148, however, the bottom plate 146 is retractable as indicated by the arrow 152 in Fig. 8, and as best seen in Fig. 9. Plate 146 normally occupies the advanced position in which it shown in Fig. 8. However, immediately after the cutter head has been operated,

plate 146 is retracted so that a cut off section of strapping within passageway 148 can fall away as indicated by the arrow 154 in Fig. 9. It will be recalled that this piece of strapping will either be a waste leading or trailing end portion of strapping, or a piece of strapping that includes an old lap joint 26 (Fig. 1(a)).

Reverting to Fig. 9, it will be seen that plate 146 is retractable through a slot 156 in the base plate 130. A pneumatic cylinder and ram unit 158 is mounted by a bracket 160 to the rear face of base plate 130 for advancing and retracting plate 146. Cylinder and ram unit 158 is also shown in Fig. 8. A further, but vertically mounted cylinder and ram unit 162 is carried by a bracket 164 on the front face of base plate 130 and is coupled to the cutter head 82 for vertically displacing the cutter head between the inoperative upper position in which it is shown in Fig. 8, and a lower position, for cutting the strapping in passageway 148. The stroke of movement of the cutter head between these two positions is relatively small.

Downstream of the cutter station 66 is the heat-sealing station 68, and that is shown in detail in Fig. 10. Again, a length of strapping 20 is shown approaching the heat-sealing station 68 but the guide 150 through which the strapping travels is not shown. The principal components of the heat sealing station are upper and lower jaws 90 and 92 respectively, and heated blade 88 (see also Fig. 3). The various arrows that appear in Fig. 10 indicate that the two jaws 90 and 92 are vertically movable towards and away from one another and that the heated blade 88 can be extended or retracted in a generally horizontal plane through an opening (not shown) in base plate 130. In Fig. 10, the blade 88 is shown in its advanced position and the two jaws are shown in their retracted positions clear of the blade.

In order to form a heat seal between the leading end of one section of strapping and the trailing end of another section of strapping, the end portions of the two strapping sections are initially positioned respectively above and below blade 88 with the blade and the jaws 90 and 92 in the positions in which they are shown in Fig. 10. The two jaws are

then closed onto the strapping sections and press the strapping sections against the blade 88. The strapping sections are held in this position for a pre-determined period of time sufficient to partially melt the surfaces of the strapping sections that are in contact with blade 88. The jaws 90 92 are then opened, and blade 88 is retracted. The jaws are then closed again to press the two strapping sections directly against one another for a period of time sufficient to finalize formation of the heat seal. The jaws are then retracted again and the strapping can now be advanced and continue on through the apparatus.

Fig. 10 shows a cylinder and ram device 172 that is mounted horizontally behind base plate 130 and connected to blade 88 so that the blade can be advanced and retracted by actuating the device 172 in the appropriate direction. Support structure for cylinder and ram unit 172 is indicated at 174. Wires for supplying power to the blade 88 for heating are indicated at 176.

On the front face of base plate 130 a second cylinder and ram unit 178 is mounted in a vertical position and coupled to a slide block 180 that carries the upper jaw 90. Block 180 slides on a fixed slideway 182 so that the upper jaw 90 can be advanced and retracted in the vertical direction by appropriate operation of cylinder and ram unit 178.

A similar slide block 184 carries the lower jaw 92 and is mounted on a slide 186. Immediately below slide 186 a rocker 188 is pivoted to base plate 130 about a pivot pin 190. Vertical links 192 and 194 at respectively opposite ends of rocker 188 extend vertically, one to the upper slide block 180 and the other to the lower slide block 184. This arrangement causes movement of jaw 92 that is equal and opposite to the movement of the upper jaw 90 that takes place when cylinder and ram unit 178 is actuated.

Immediately downstream of blade 88 as seen in Fig. 10 is a strapping guide 196 comprising respective upper and lower plates 198 and 200, of which the upper plate 198 has a recess (not visible) forming a passageway for the strapping similar to the passageway 148 shown in Fig. 8.

At its end adjacent the upper jaw 90, the upper plate 198 is angled upwardly as indicated at 198a and fitted with an air nozzle 202 that, accordingly, is angled downwardly somewhat obliquely with respect to the heated blade 88, as best seen in Fig. 3. Fig. 3 also shows that a second, similar nozzle 204 is angled upwardly and oppositely to nozzle 202 from the strapping guide 150 at the upstream side of the heat sealing station. As best shown in Fig. 13(a) (to be described), air jets that issue from the respective nozzles 202 and 204 serve to separate the two portions of strapping that are to be sealed together at the heat-sealing station, and ensure that one is positioned above and one below the heated blade 88.

Reverting again to Fig. 3, it will be seen that the second pair of rollers (78, 80) are positioned immediately downstream of the strapping guide 196. Strapping travels from the heat-sealing station towards the take-up station 44 through the nip between these rollers. The rollers and the take-up station 44 are illustrated in Fig. 11.

Rollers 78, 80 are essentially the same as the rollers 74, 76 described previously in connection with Fig. 6, and are driven in the same way, from their own electric servo-motor 206 through a belt drive generally indicated at 208. Again, roller 80 drives roller 78 and roller 78 is carried by a two armed lever generally indicated at 210 and pivotally mounted on a pin 211. In this case, only a single proximity detector (212) is provided adjacent the distal end of the upper arm of lever 210. This responds to the presence of lever 210 as indicating that strapping is passing between the two rollers 78, 80. When the strapping leaves the nip between the rollers, arm 210 is no longer detected and a signal is given indicating that the strapping has run out.

A curved strapping guide 50 (Fig. 2) extends outwardly and then downwardly from a location adjacent the nip between the two rollers 78 and 80 and delivers the strapping into an accumulator 48, which is best seen in Fig. 2; Fig. 11 merely shows the path of the strapping through the accumulator. Referring to Fig. 2, it will be seen that the accumulator is essentially a thin and flat receptacle or box having a transparent front face

216 so that the strapping can be visually observed within the accumulator. Strapping enters through guide 50 at the top right corner of the accumulator as shown in Fig. 2 and is allowed to adopt a random looped configuration within the accumulator. The strapping is then led out of the accumulator adjacent guide 50 through the nip between a pair of idler spools 220, and forward towards the take-up mandrel 46.

A photo-electric detector set 222 detects when the loop or loops of strapping within the accumulator reach the bottom of the enclosure and provide a signal to indicate that the mandrel should be actuated to wind up strapping from the accumulator. In other words, the mandrel is operated only intermittently when the photo-electric detector set 222 determines that the accumulator is filling up with strapping.

Reverting to Fig. 11, strapping mandrel 46 carries a strapping spool 224 which is keyed to the mandrel 46 (key not shown) but removable so that a full spool of strapping can be removed as a unit and transported elsewhere for reuse or storage.

From the idler spools 220, the strapping passes through a strapping guide 226 which is designed to traverse laterally parallel to mandrel 46 to guide the strapping axially of the spool 224 so that the strapping is wound uniformly onto the spool. Thus, guide 226 has an internally screw-threaded lower portion that receives a screw-threaded shaft 228 driven by a belt 230 from the mandrel 46. A main mandrel drive motor 232 drives mandrel 46 through a gear box 234 and a further belt drive 236.

To summarize, when the photo-electric detector set 222 detects that the accumulator is filling up, a signal is sent to motor 232 to start the mandrel. As the mandrel rotates, the strapping guide 226 progressively traverse in the axial direction of the mandrel to lay the strapping in a consistent spiral onto the spool 224. After a predetermined time interval, motor 232 stops until another signal is received from the photo-electric detector set. When the spool 224 is full, strapping can be allowed to accumulate in accumulator 48 while the spool is changed.

Figs. 12 to 16 are schematic sequence drawings illustrating operation of the apparatus.

Referring first to Fig. 12(a), a first length of strapping 20' is assumed to have been advanced to a position in which its trailing end portion is at the heat-sealing station 68. An in-coming length of "old" strapping 20" is detected by upward movement of roller 74 at the detection station 64. This provides a timing signal to the programmable logic controller (PLC) of the control circuitry. The PLC then "directs" the rollers 74, 76 to advance the strapping by a rotational amount that is sufficient to bring the leading end of the strapping to approximately mid-way between the two cutters 84, 86 of the cutter station 66. Cylinder and ram unit 162 is then actuated to cut off the leading end portion of strapping length 20", as shown in Fig. 12(b). As soon as the cut has been made, the bottom plate 146 of the strapping guide 144, 146 is retracted so that the cut off piece of strapping can fall down and be discarded as shown in Fig. 12(c). The PLC then "directs" the rollers 74 and 76 to advance the strapping section 20" to bring the leading end portion thereof to the heat-sealing station.

Fig. 13 shows the heat-sealing operation in principle. Jets of air from the nozzles 202, 204 separate the end portions of the respective sections of strapping and allow the heated blade 88 to be advanced between the jaws 90 and 92. The jaws then close as shown in Fig. 13(b) and remain closed for a time sufficient to allow the heated blade to partially melt the opposing faces of the strapping sections.

The two jaws 90, 92 are then retracted as shown in Fig. 13(c), blade 88 is withdrawn, and the jaws are again closed, pressing the two overlapping portions of strapping against one another. The jaws remain closed for a time sufficient to ensure bonding (Fig. 13(d)).

The jaws then open and the strapping is advanced by operation of the rollers 78 and 80 under the control of the PLC, as shown in Figs. 13(e) and (f).

The strapping continues along its path driven by the two sets of drive rollers 74, 76 and 78, 80 as shown in Fig. 14(a). When an "old"

heat seal approaches the rollers 74, 76, roller 74 is lifted to a greater extent that before, triggering the upper one of the two proximity detectors and providing a specific indicator signal to the PLC (Fig. 14(b)).

The PLC then directs the rollers 74, 76 to advance the strapping to bring the "old" heat seal 26 to a position mid-way between the two cutters 84, 86 of the station 66. This is shown in Fig. 14(c). The following two views show the cutter head 82 being actuated to cut out the portion of the strapping that includes the old heat seal, and the lower strapping guide plate 146 being retracted as the cutter head returns upwardly, so that the portion of strapping containing the old heat seal can fall away.

The strapping is then advanced by the rollers 74, 76 to bring the "new" leading end portion of the strapping to the heat-sealing station 68 as shown in Fig. 14(f).

Figs. 15(a) to (d) show formation of a heat seal in generally the same fashion as in Fig. 13.

Finally, Figs. 16(a) to (c) show that, when the trailing end of the last length of strapping leaves the nip between the two drive rollers 74, 76, neither of the two proximity detectors 128 is actuated. The PLC then "knows" that there is no strapping between the rollers. The rollers 78, 80 upstream of the heat-sealing station 68 are "directed" to advance the strapping through a sufficient distance to bring the trailing end of the strapping section to a position between the two cutters 84, 86 of the cutter station. The cutter head is then operated and the trailing end portion of the strapping discarded as described previously. The rollers 78, 80 are then directed to advance the strapping to bring the trailing end portion to the heat-sealing station 68, and then stop, until a new incoming length of strapping is detected at station 64.

In summary, the method and apparatus provided by the invention allows strapping such as plastic strapping that would otherwise be discarded and represent a disposal cost and possible environmental hazard to be reused simply by feeding lengths of strapping successively

into the apparatus. The ends of the lengths of strapping are automatically trimmed, old heat seals cut out and the resulting sections heat-sealed together to form new, continuous strapping.

It will of course be appreciated that the preceding description relates to a particular preferred embodiment of the invention and that many modifications are possible. Some of those have been indicated previously and others will be apparent to a person skilled in the art.

In particular, it is to be noted that, while reference has been made specifically to plastic strapping, the invention is not limited in this respect, and may be applied to other material in strip form, e.g. strips of metal, irrespective of whether or not the strips are intended to be used for bundling articles. Also, while heat sealing has been referred to as a particular example of a joining method, the invention is not limited to heat sealing and could be practised using other sealing techniques, such, for example, as gluing or crimping. For example, crimping might be appropriate for metal strips.

Alternative forms of cutter station may include co-operating vertically movable and stationary cutters at each end of the cutter station; and a separate cutter (e.g. at the input station) for trimming leading and trailing end portions of a length of strapping. In the former case it may be possible to omit the strapping guide (144, 146) between the cutters.

The heat-sealing station 68 as shown, for example, in Fig. 10 may be simplified by making the lower heat-sealing jaw 92 stationary and moving the upper jaw 90 only, towards and away from the lower jaw. In that event, the lower jaw 92 would be positioned somewhat higher than shown in Fig. 10. It might also be desirable to allow for some flexibility in the position of the blade 88, for example, by pivoting the blade at its inner end about a horizontal axis parallel to the path of strapping through the heat-sealing station.

A further modification in the area of the heat-sealing station may be to replace one or both of the air nozzles 202, 204 with a mechanical lever arranged to physically engage and mechanically displace the

strapping to ensure that the respective portions of the strapping are disposed above and below the blade 88. For example, a lever may be used in place of the upstream nozzle 204 and the downstream nozzle 202 may be retained. The lever may be pivotally mounted adjacent blade 88 so that an operative end of the lever can be moved between an elevated position in engagement with the strapping, and a depressed position clear of the strapping. The lever may be spring-biassed to its depressed position and movable under the control of an air cylinder to its strapping deflecting position.

WE CLAIM:

1. A method of recycling strapping comprising:

advancing along a defined path from an input station to a take-up station, successive lengths of strapping, at least some of which include lap joints, and performing the following steps on said strapping lengths as they are advanced along said path:

(a) at a cutter station downstream from said input station, cutting off leading and trailing end portions of each successive strapping length to provide "clean" leading and trailing ends, and cutting out of said length, any lap joint, thereby forming respective upstream and downstream strapping sections having "clean" leading and trailing ends;

(b) advancing a first one of said strapping sections to position a trailing end portion thereof at a joining station downstream of said cutter station;

(c) advancing a leading end portion of a next succeeding strapping section into overlapping relationship with said trailing end portion of said first strapping section;

(d) sealing said overlapping portions together to join said strapping sections end-to-end;

(e) taking up said joined sections at said take-up station downstream of said sealing station as continuous strapping; and,

(f) repeating steps (b), (c) and (d) with successive said strapping sections while continuing to perform step (e).

2. A method as claimed in claim 1, wherein step (a) is performed by providing at said cutter station, a cutter head having upstream and downstream cutters spaced along said path by a distance sufficient to cut a lap joint out of a said length of strapping, and wherein said upstream cutter is used to cut off a leading end portion of a strapping length and said downstream cutter is used to cut off a trailing end portion

of a strapping length.

3. A method as claimed in claim 2, comprising the further step of detecting at a detection station upstream of said cutter station, a leading or trailing end of a length of strapping or a lap joint in a strapping length, and advancing the strapping length to the cutter station and into a predetermined position with the said end or lap joint between the upstream and downstream cutters, and then operating the cutter.

4. A method as claimed in claim 1, wherein step (d) comprises heat-sealing said overlapping portions of strapping together by heating opposed surfaces of said overlapping portions, and pressing said portions together to form a heat seal.

5. A method as claimed in claim 1, wherein step (e) comprises delivering said continuous strapping to a strapping accumulator and periodically withdrawing strapping from said accumulator and winding the strapping onto a spool.

6. A method of recycling strapping comprising:

advancing along a defined path, successive lengths of strapping at least some of which include a lap joint;

in respect of each said strapping length:

(a) at a first station along said path, detecting a leading end of said strapping length;

(b) advancing said strapping length along said path to a second station having upstream and downstream cutters spaced a predetermined distance along said path, and positioning said leading end of said strapping length between said upstream and downstream cutters;

(c) cutting a leading end portion from said strapping length to provide a "clean" leading end cut, using said downstream cutter;

(d) while continuing to advance said strapping length along

said path, detecting at said first station any lap joint in said strapping length;

(e) positioning a strapping length that includes a detected lap joint with the joint between said upstream and downstream cutters at said second station;

(f) operating said cutters to cut out a portion of said strapping that includes the lap joint, and form a new "clean" leading end cut on a portion of strapping downstream of said cutter station, and a "clean" trailing end cut on a portion of strapping upstream of said cutter station;

(g) at said first station detecting a trailing end of said strapping length;

(h) advancing said strapping length to bring said trailing end to a position between said upstream and downstream cutters at said second station;

(i) cutting a trailing end portion from said strapping length to provide a "clean" trailing end on said strapping length;

(j) positioning a first one of said lengths of strapping with a trailing end portion thereof at a joining station downstream of said cutter station;

(k) advancing a leading end portion of an immediately downstream section of strapping into overlapping relationship with said trailing end portion of the first section of strapping;

(l) sealing said overlapping portions together to join said strapping sections end-to-end;

(m) taking up said joined sections at a take-up station downstream of said sealing station; and,

(n) repeating steps (k), (l) and (m) using succeeding sections of strapping, to form continuous recycled strapping.

7. Apparatus for recycling strapping comprising:

an input station, a take-up station and strapping guide means extending from the input station to the take-up station and along which

can be advanced successive lengths of strapping, at least some of which include lap-joints;

strapping drive means for advancing the strapping along the guide means;

a cutter station downstream of said input station for cutting off leading and trailing end portions of each successive length of strapping to provide "clean" leading and trailing ends, and for cutting out any lap-joints, thereby forming respective upstream and downstream strapping sections having "clean" leading and trailing ends;

a joining station downstream of the cutter station;

said drive means being adapted to advance a first one of said strapping sections to bring a trailing end portion of that section to said joining station, and to advance a leading end portion of a next succeeding strapping section into overlapping relationship with the trailing end portion of the first strapping section;

said joining station being adapted to join together said overlapping portions of the strapping, whereby continuous strapping is formed by joining together successive strapping sections.

8. An apparatus as claimed in claim 7, wherein said cutter station includes a cutter head including upstream and downstream cutters spaced along said strapping guide means by a distance sufficient to cut a lap joint out of a said length of strapping, wherein said upstream cutter is used to cut off a leading end portion of a strapping length, and said downstream cutter is used to cut off a trailing end portion of a strapping length.

9. An apparatus as claimed in claim 8, wherein said cutter head, together with said upstream and downstream cutters is vertically movable between an upper, inoperative position clear of said strapping guide means, and a lower cutting position, and wherein the strapping guide means includes a strapping guide extending between said cutters and having a bottom wall that is retractable to allow a cut-out portion of the

strapping to fall away.

10. An apparatus as claimed in claim 7, wherein said strapping drive means includes a first pair of driving rollers adjacent said input station, and a second pair of driving rollers downstream of said joining station, each pair of rollers defining a nip that is co-incident with the path of strapping along said strapping guide means so that strapping is advanced along said guide means by passing through the nip between said pairs of rollers.

11. An apparatus as claimed in claim 10, further comprising, in association with each said pair of rollers, an electric servo-motor drivably coupled to a first roller in said pair, and means for driving said second roller from the first roller.

12. An apparatus as claimed in claim 10, further comprising means for supporting the rollers in each pair, for movement between a first position in which the rollers are in contact with one another, and a second position in which the rollers have moved apart in response to advance of a length of strapping into the nip between the rollers, and means for detecting when the rollers are in said second position, as indicating the presence of strapping between the rollers.

13. An apparatus as claimed in claim 12, wherein said detection means includes first and second detectors positioned to discriminate between movement of the rollers apart a first distance in response to the presence of a single thickness of strapping between the rollers, and a second distance in response to the presence of a lap-joint in said nip, represented by a double-thickness of strapping, the detectors providing corresponding signals to control circuitry of the apparatus.

14. An apparatus as claimed in claim 7, wherein said joining

station comprises a heat-sealing station, included a heated blade that can be advanced between said overlapping portions of strapping for heating opposed surfaces of said overlapping portions or retracted clear of the strapping, and a pair of jaws adapted to press together said heated overlapping portions of strapping to form a heat seal.

15. An apparatus as claimed in claim 14, wherein said strapping guide means includes respective guides upstream and downstream of said heat-sealing station, said guides being provided with means for separating said overlapping portions of strapping to accept said heated blade.

16. An apparatus as claimed in claim 7, wherein said input station comprises an input guide having a first end presenting a relatively large "target" opening into which incoming lengths of strapping can be introduced, and tapering to an outlet opening that conforms relatively closely to the profile of the strapping, and wherein said strapping guide means includes a first guide immediately downstream of said outlet opening adapted to locate the strapping in both the horizontal and vertical directions for delivery to said cutter station.

17. An apparatus as claimed in claim 7, wherein said take-up station comprises an accumulator for receiving said continuous strapping from said joining station, and winding means downstream of said accumulator for drawing strapping from said accumulator and winding up the strapping into a form in which can be reused.

18. An apparatus as claimed in claim 17, wherein said strapping winding means includes a mandrel, a spool removably coupled to the mandrel and onto which the strapping is wound, and a motor for driving the mandrel to wind a strapping onto the spool.

19. An apparatus as claimed in claim 18, where said accumulator

includes a receptacle for receiving said continuous strapping from the joining station and in which the strapping is allowed to accumulate in a random loop configuration, and means for detecting when sufficient strapping has accumulated that strapping should be wound from the accumulator, said detecting means providing a signal to said mandrel drive motor to command winding of strapping onto said spool.

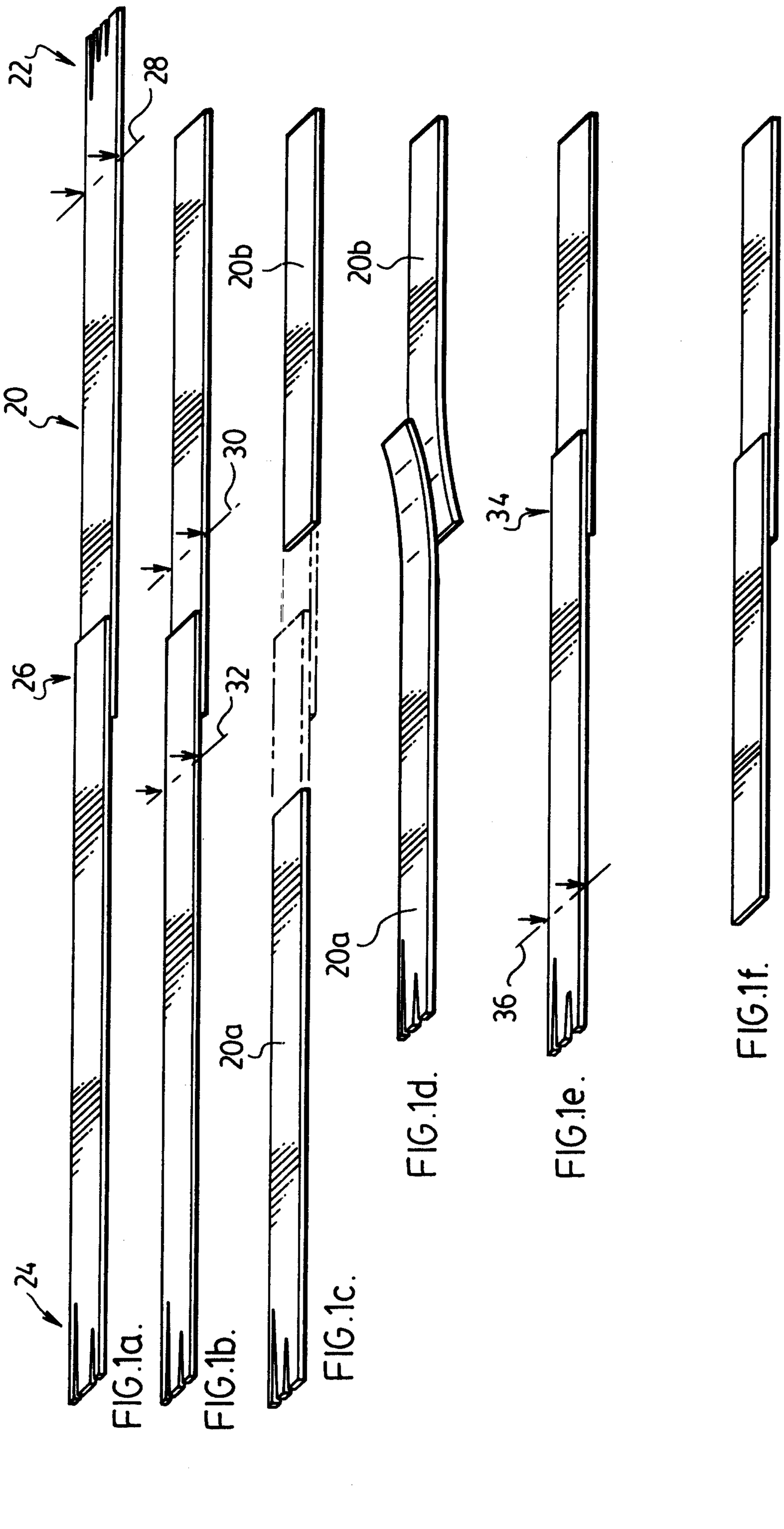
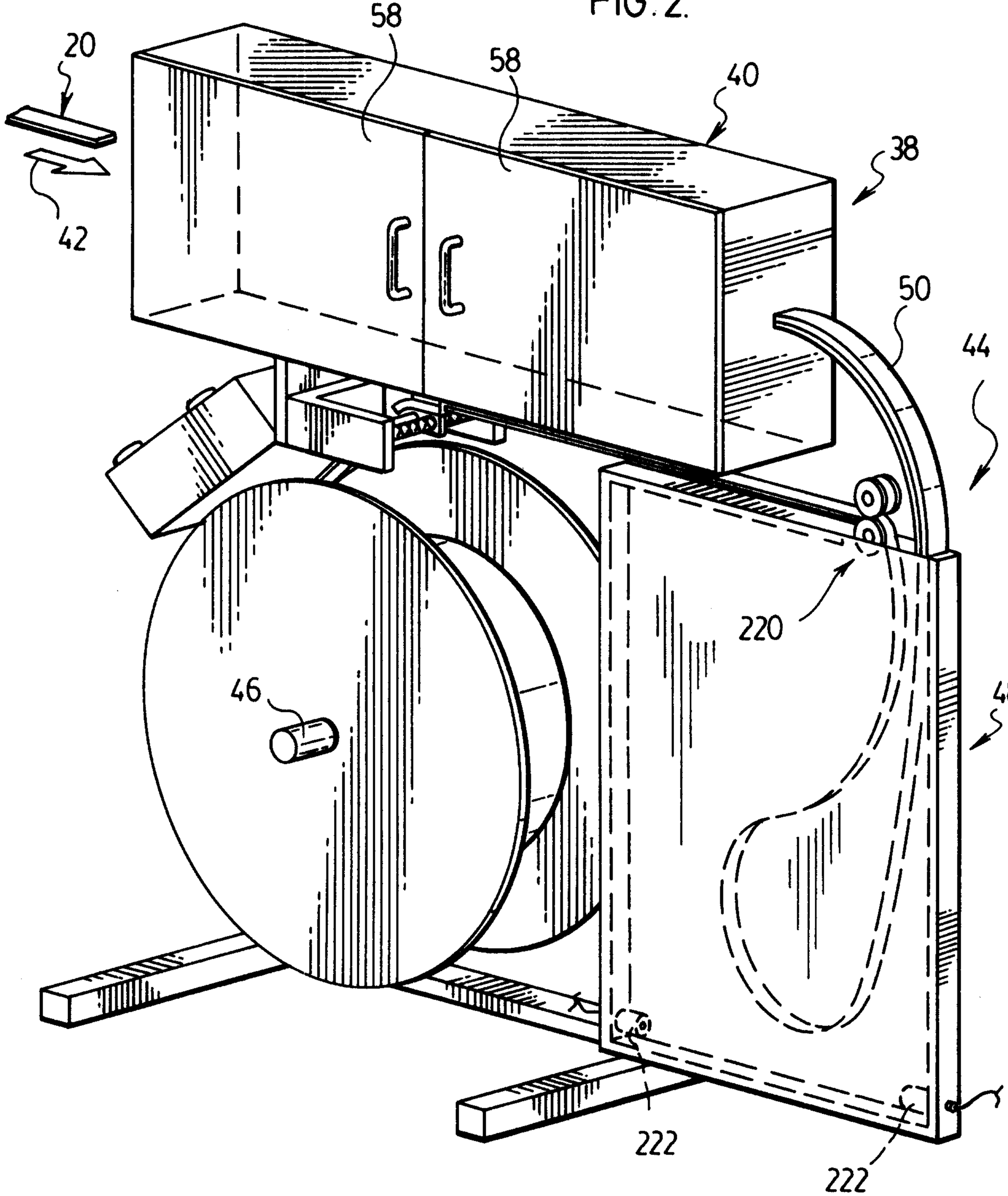


FIG.1a. FIG.1b. FIG.1c. FIG.1d. FIG.1e. FIG.1f.

FIG. 2.



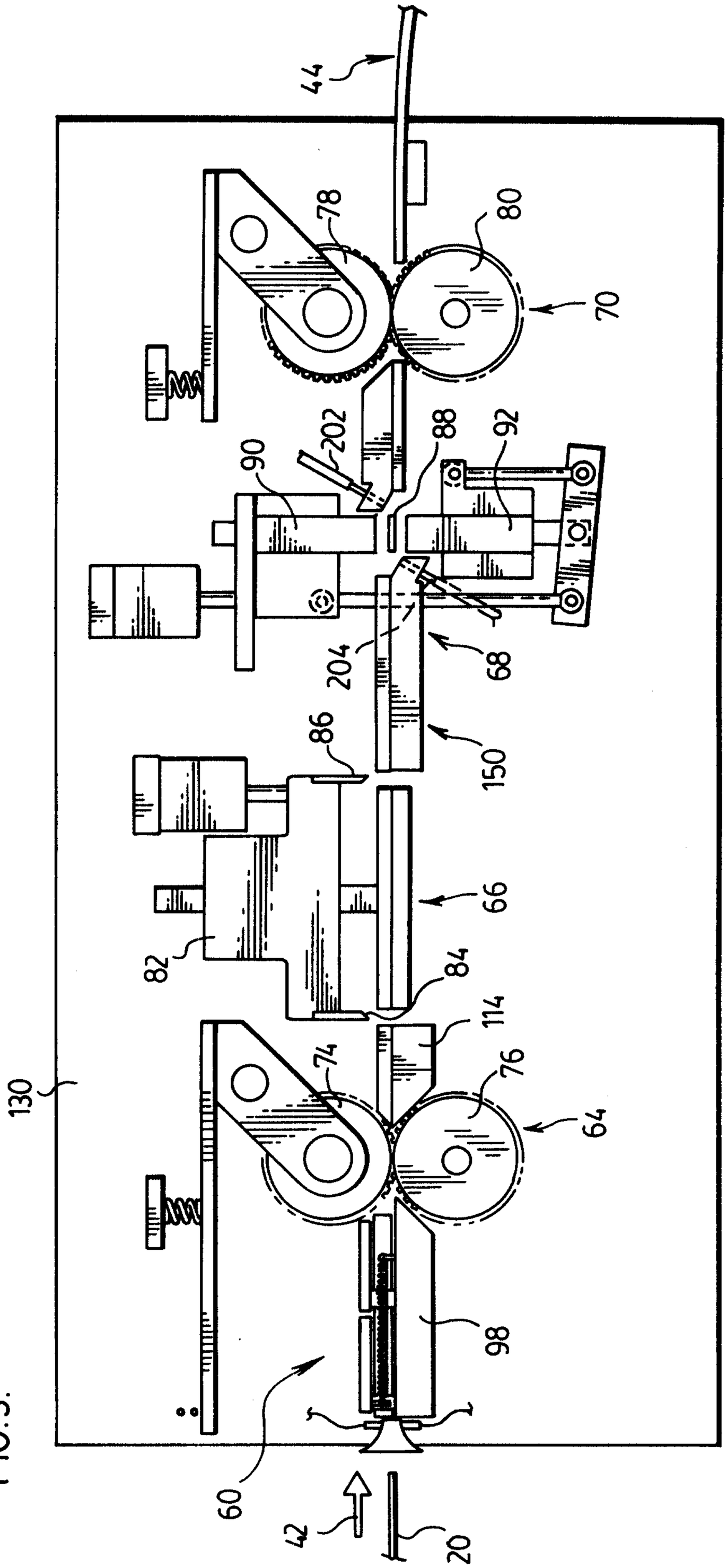

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FIG.3.

FIG.4.

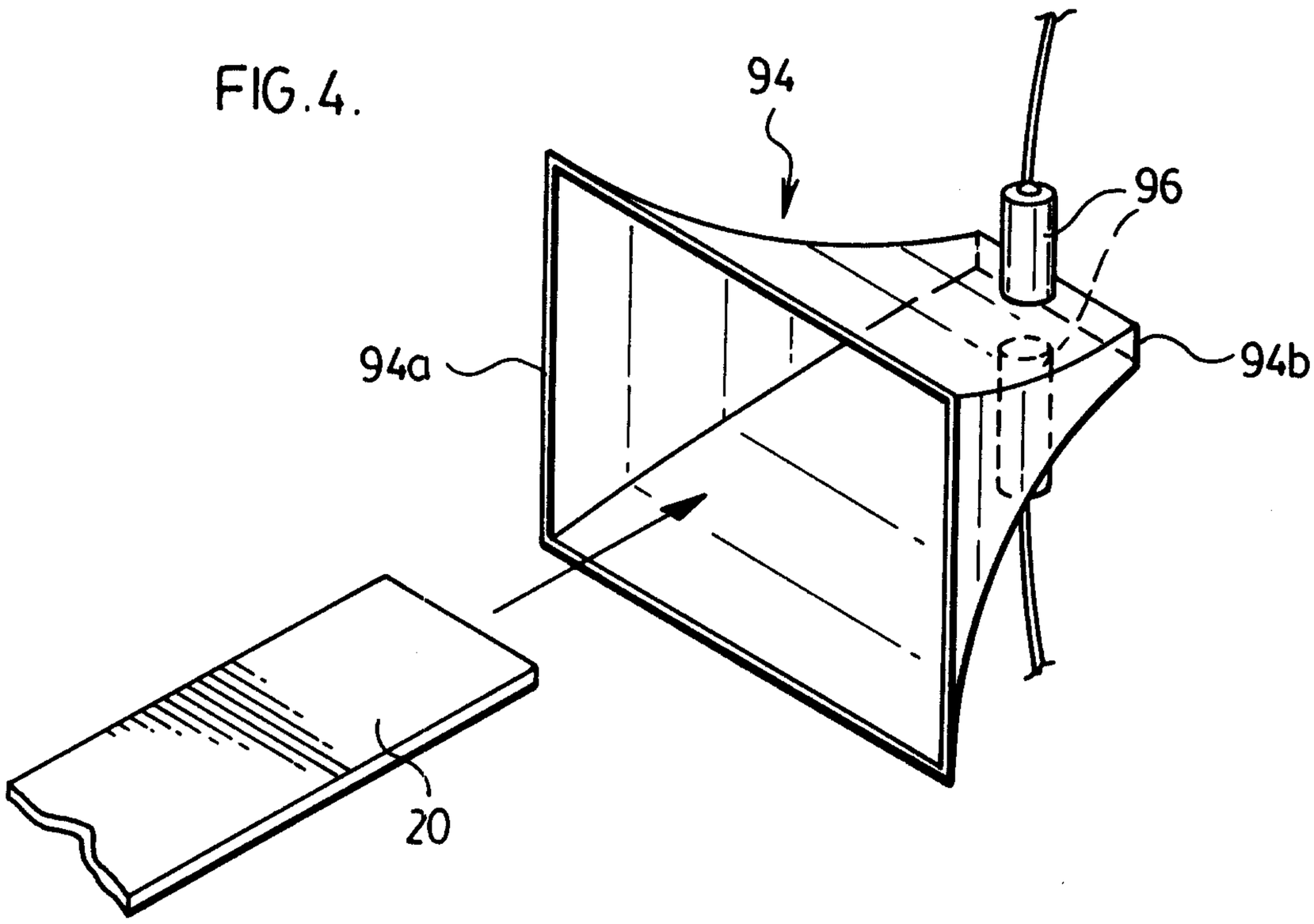

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FIG.5.

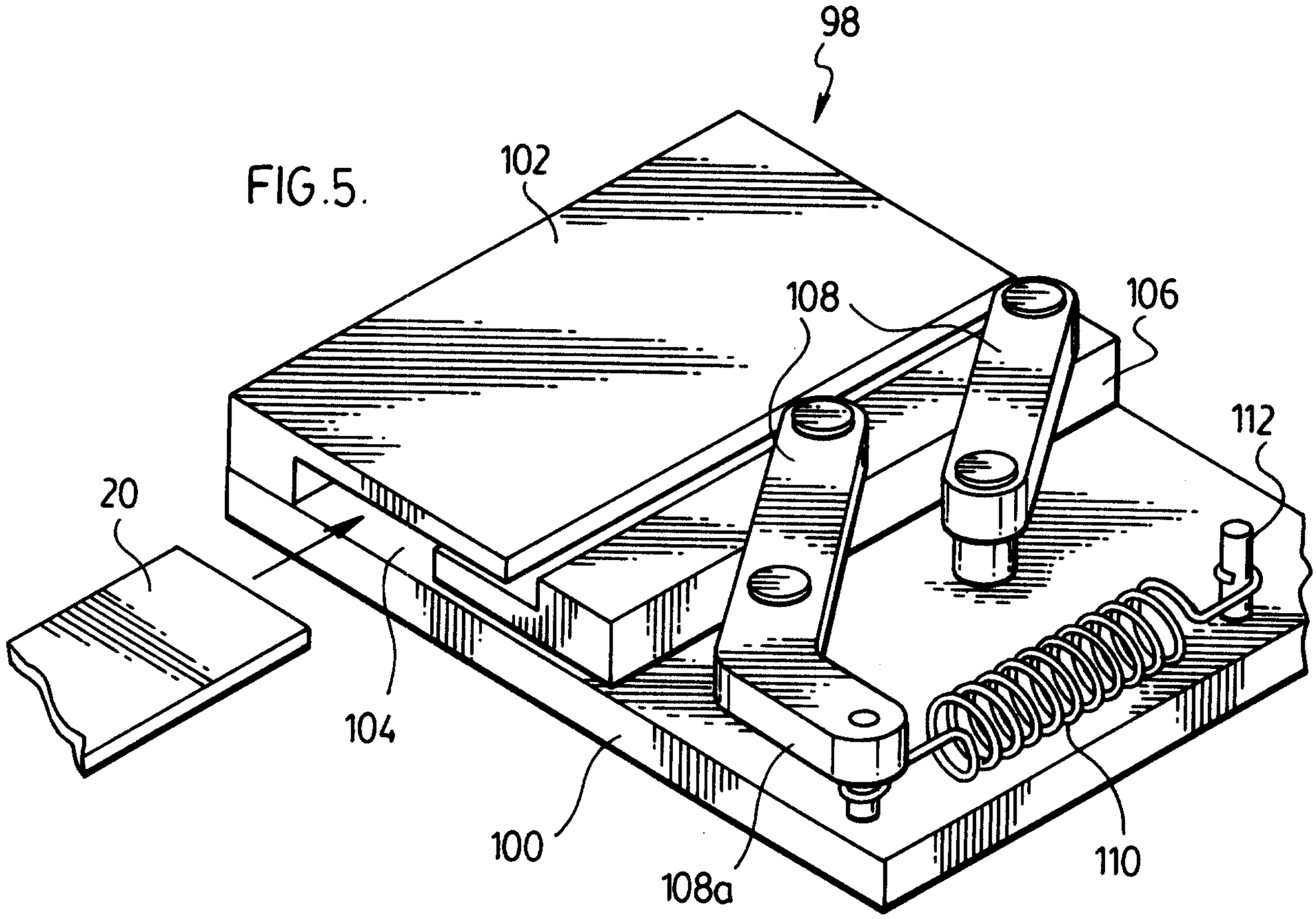
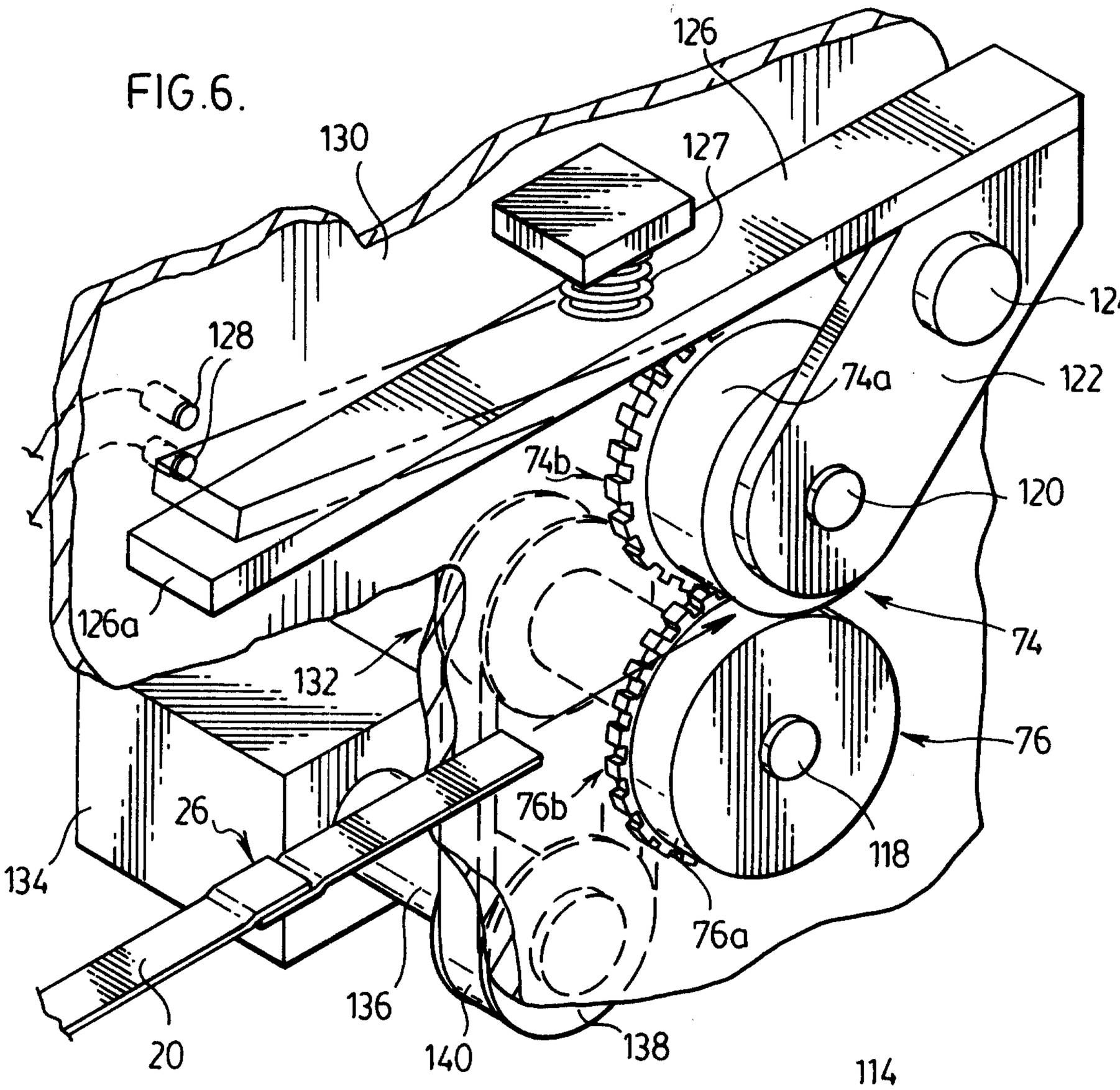


FIG.6.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76b
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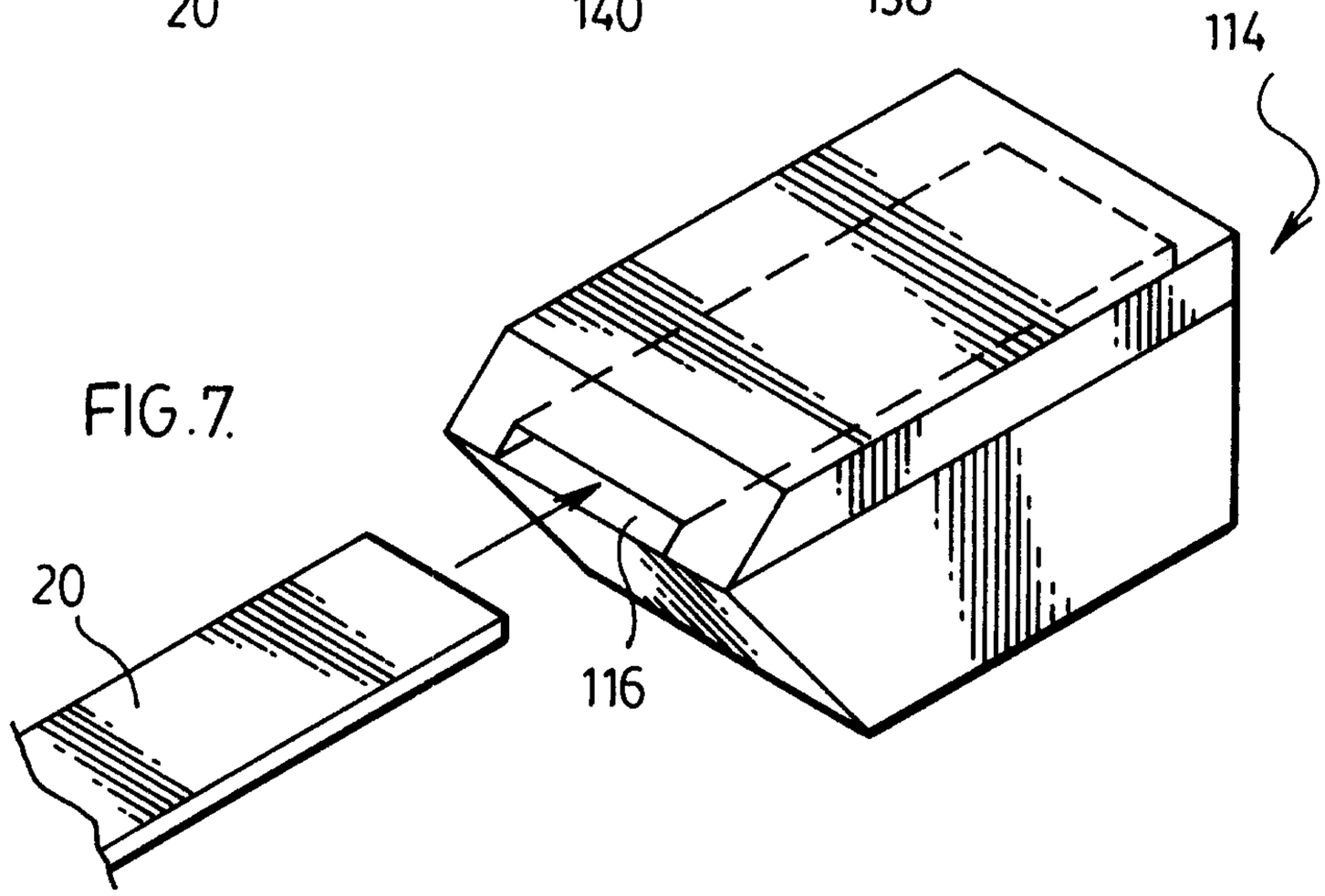
FIG.7.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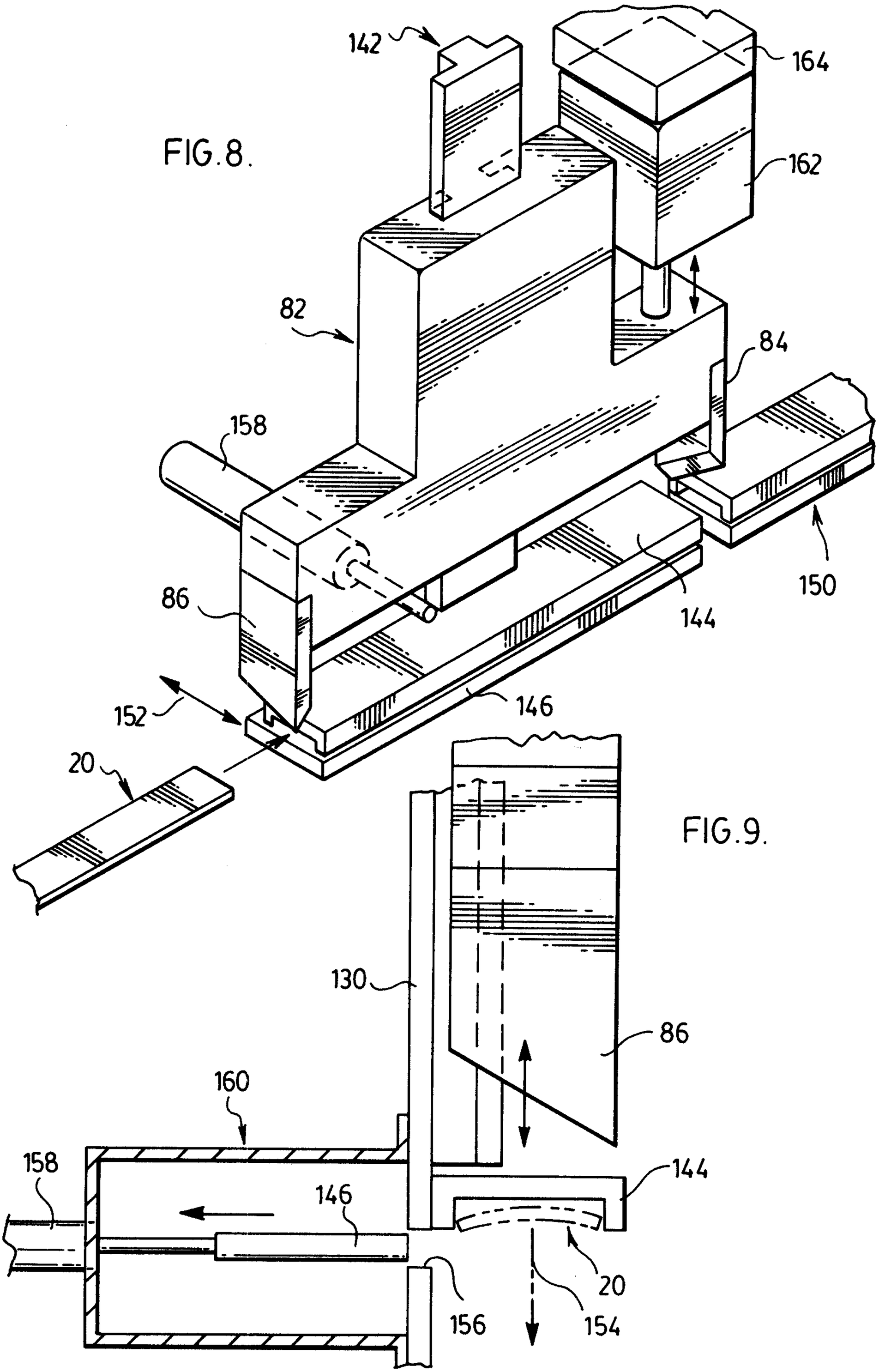
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FIG.8.

FIG.9.

FIG.10.

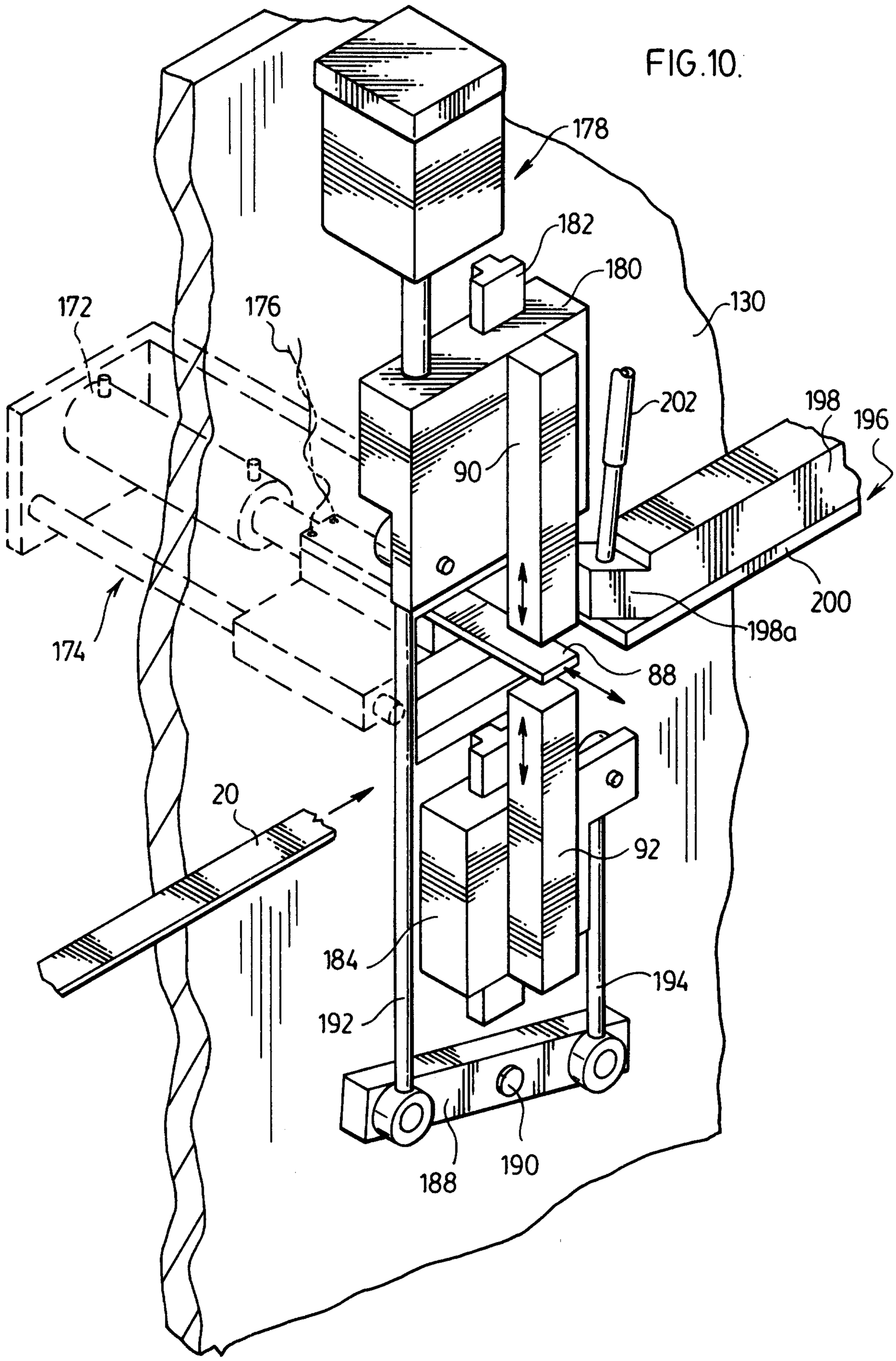
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FIG. 11.

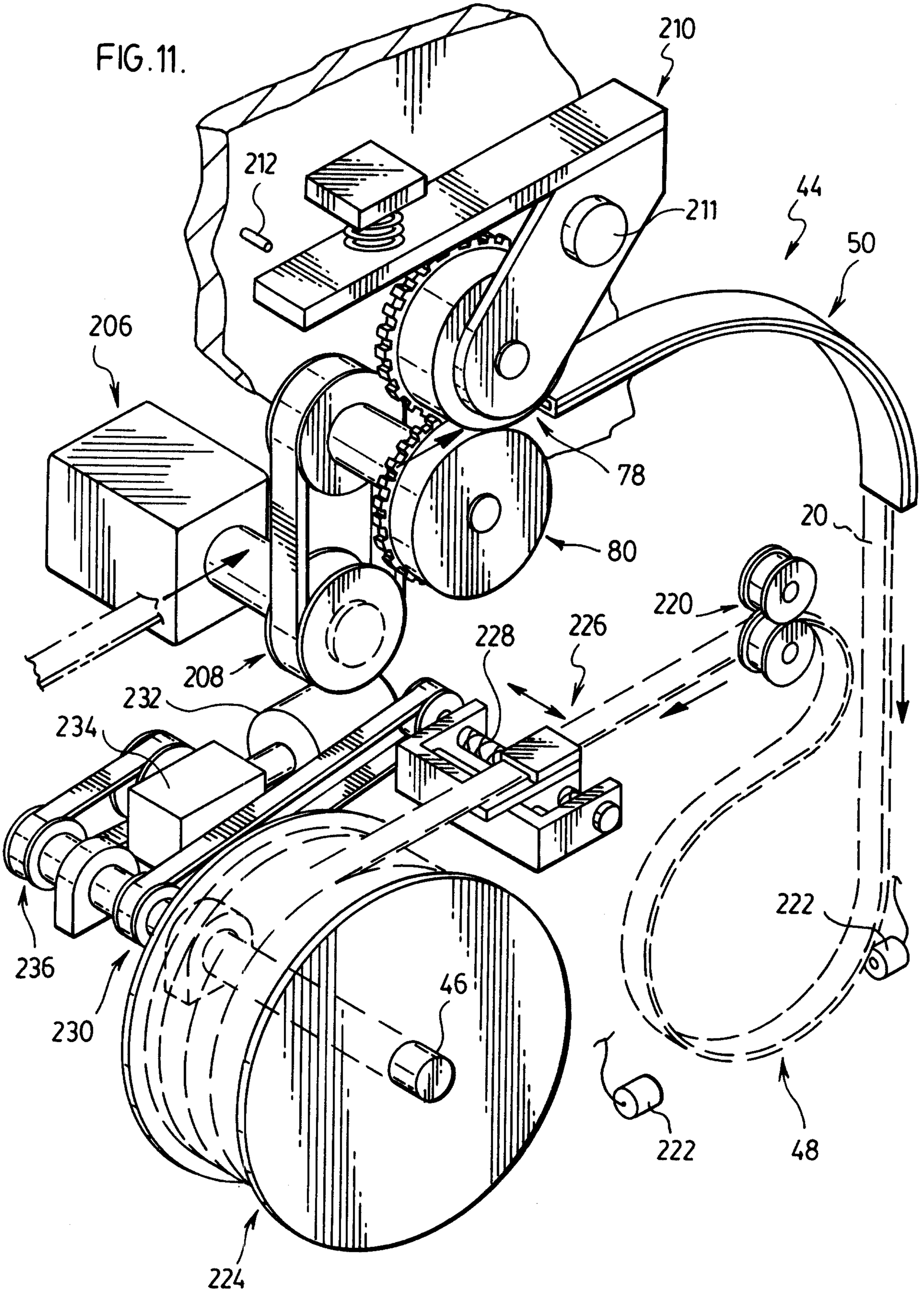
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FIG.12a.

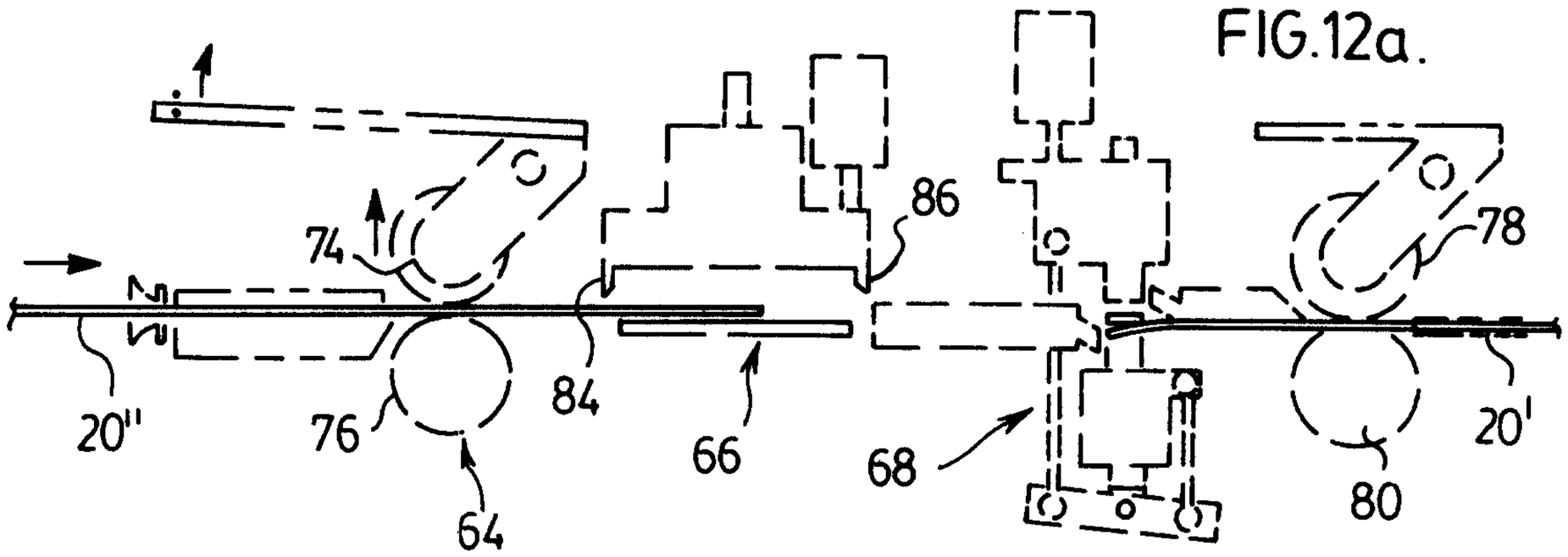


FIG.12b.

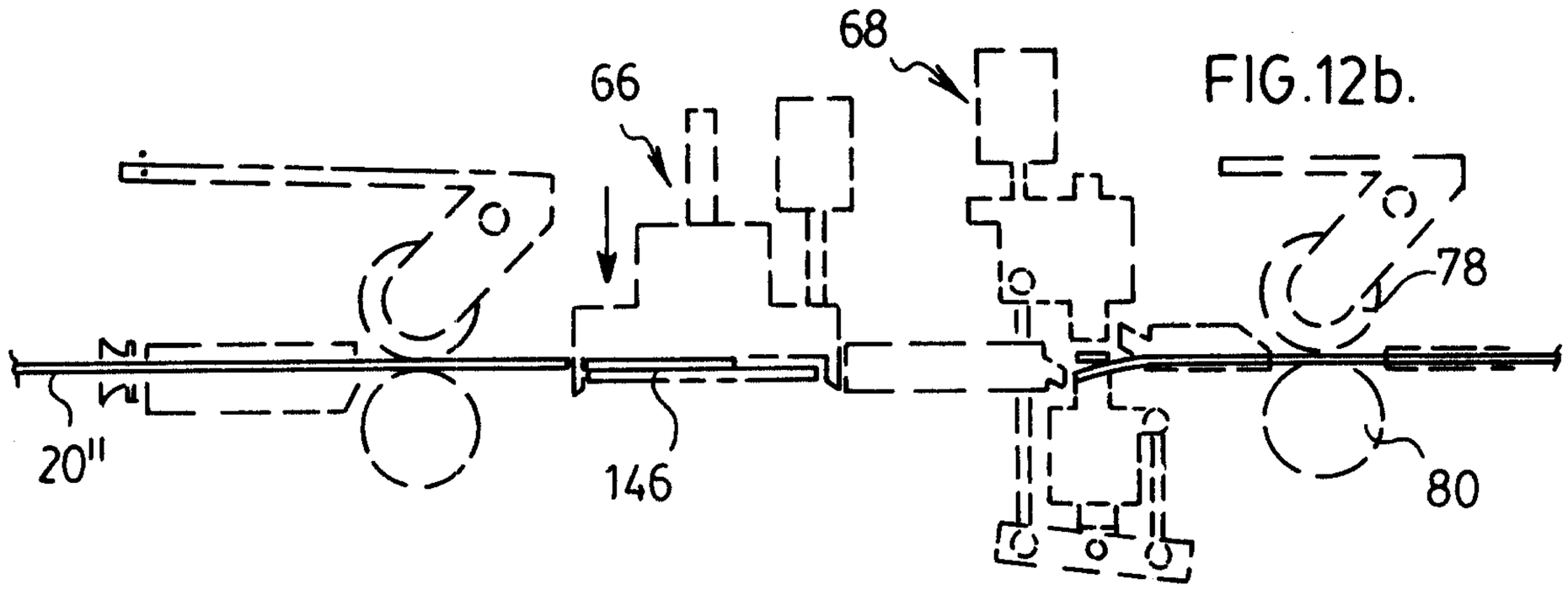


FIG.12c.

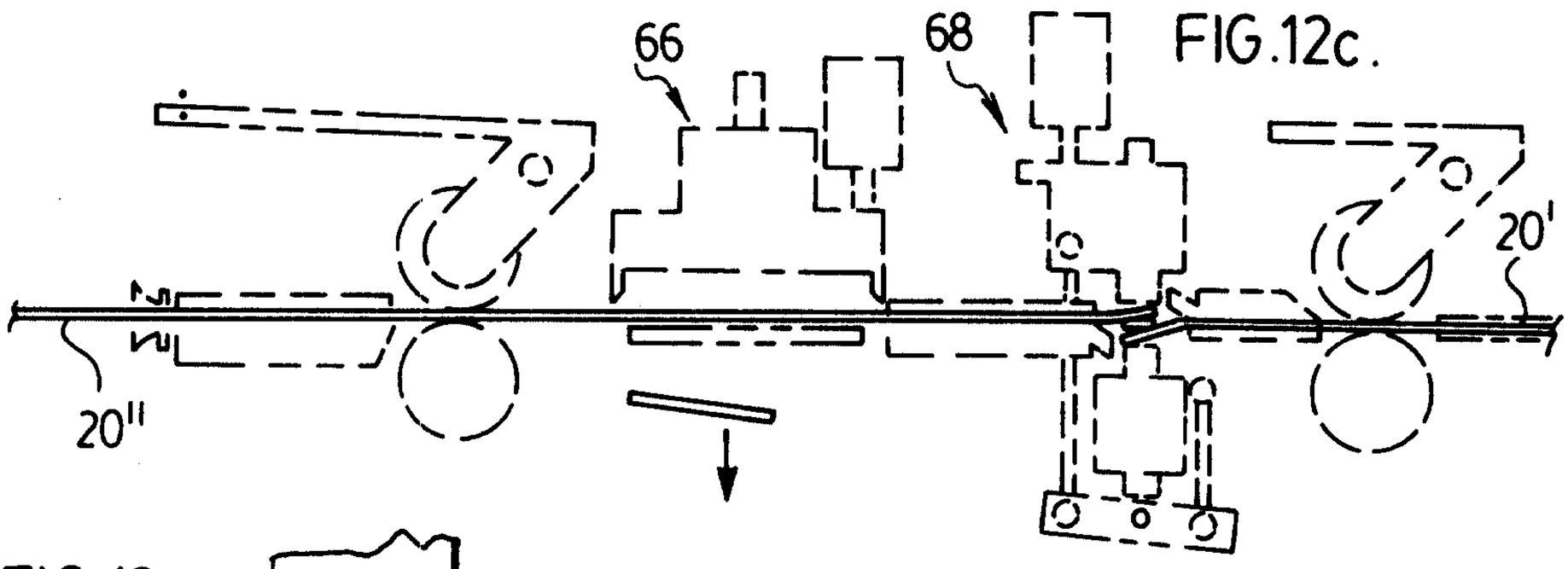


FIG.13a.

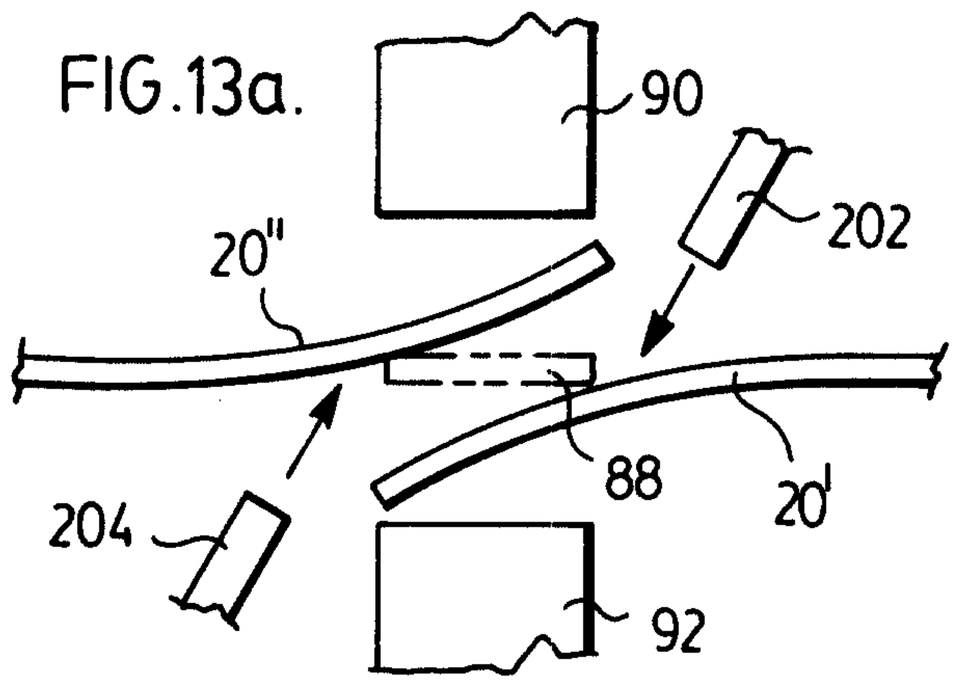


FIG.13b.

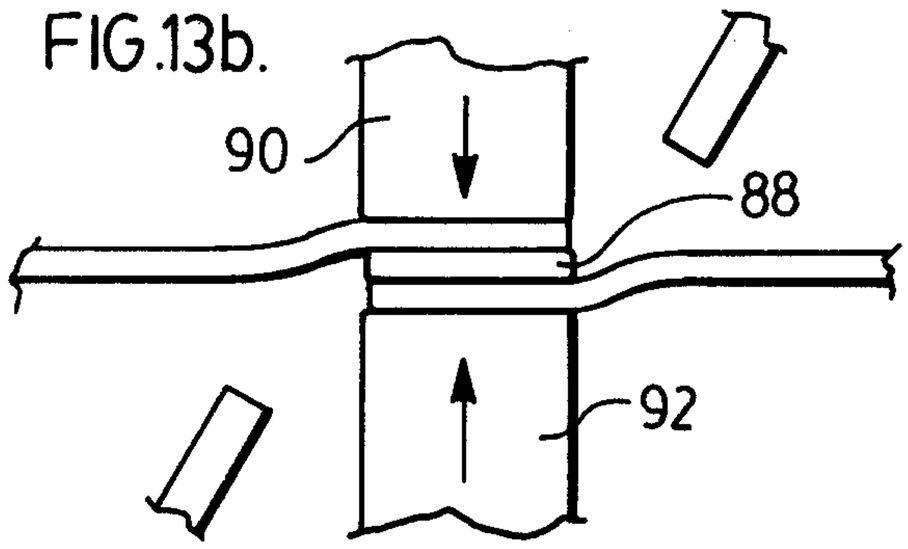


FIG.13c.

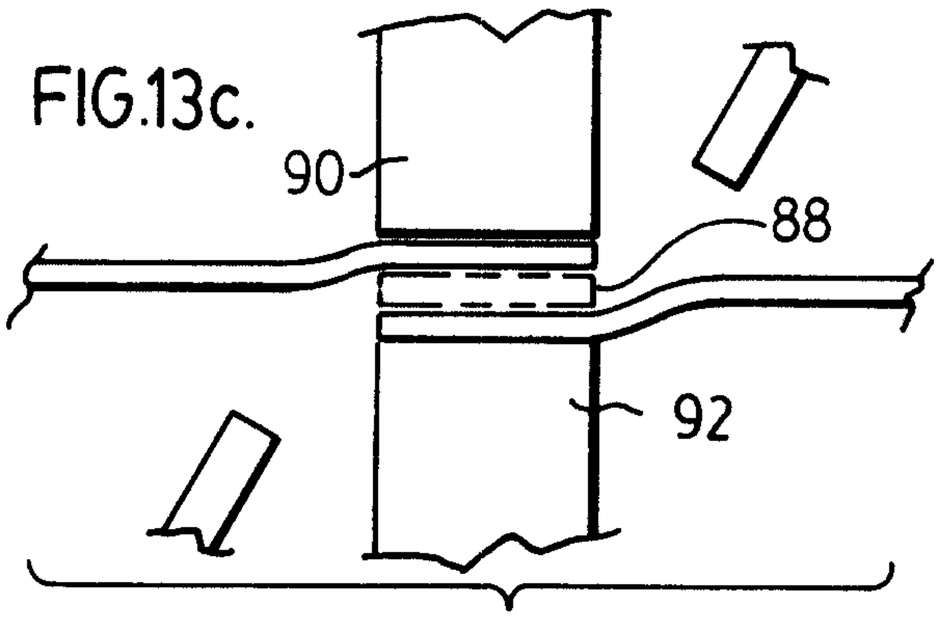


FIG.13d.

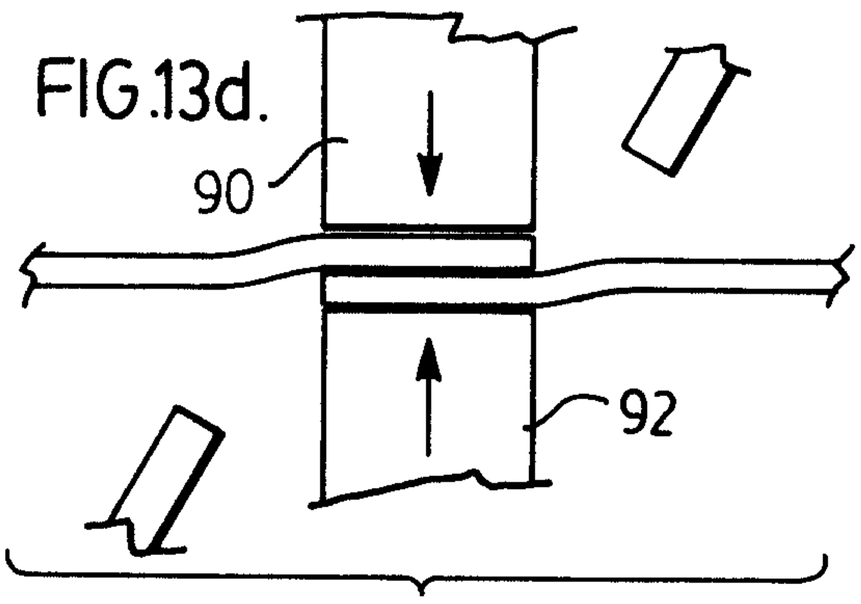


FIG.13e.

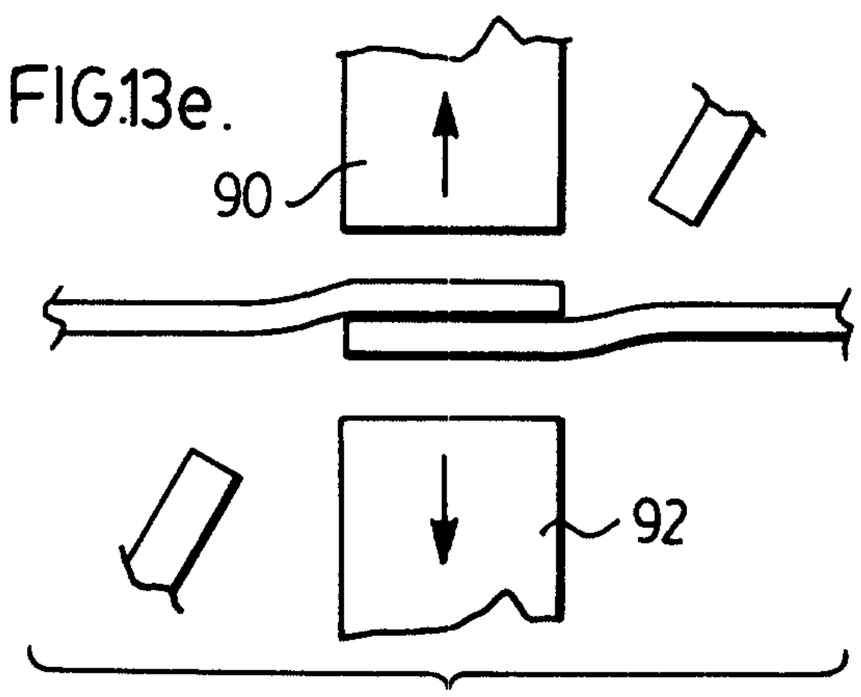


FIG.13f.

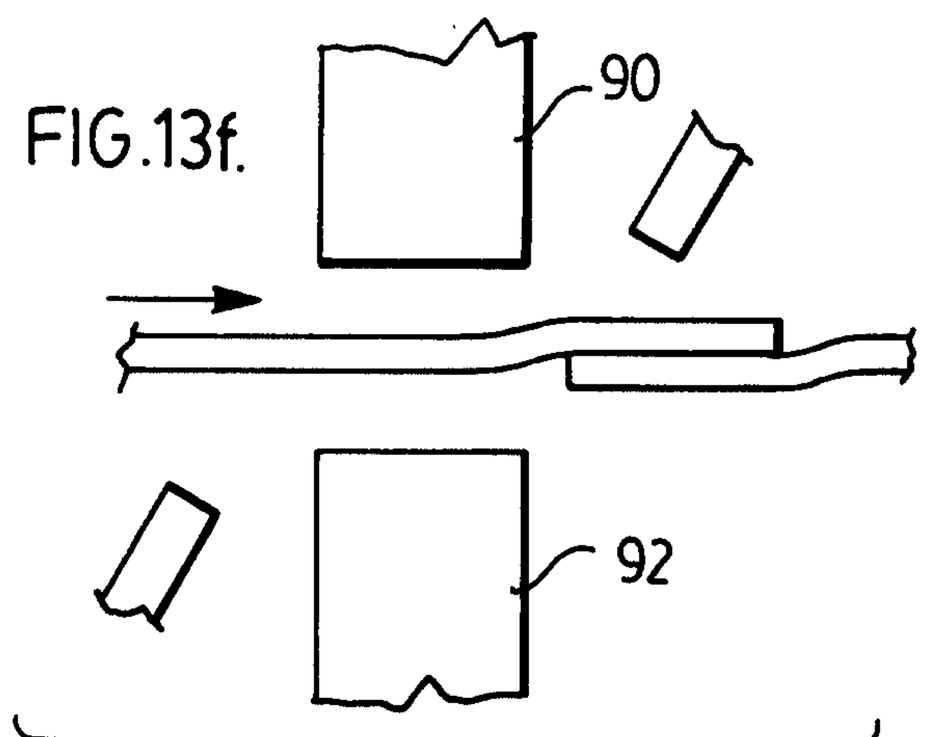


FIG.14a.

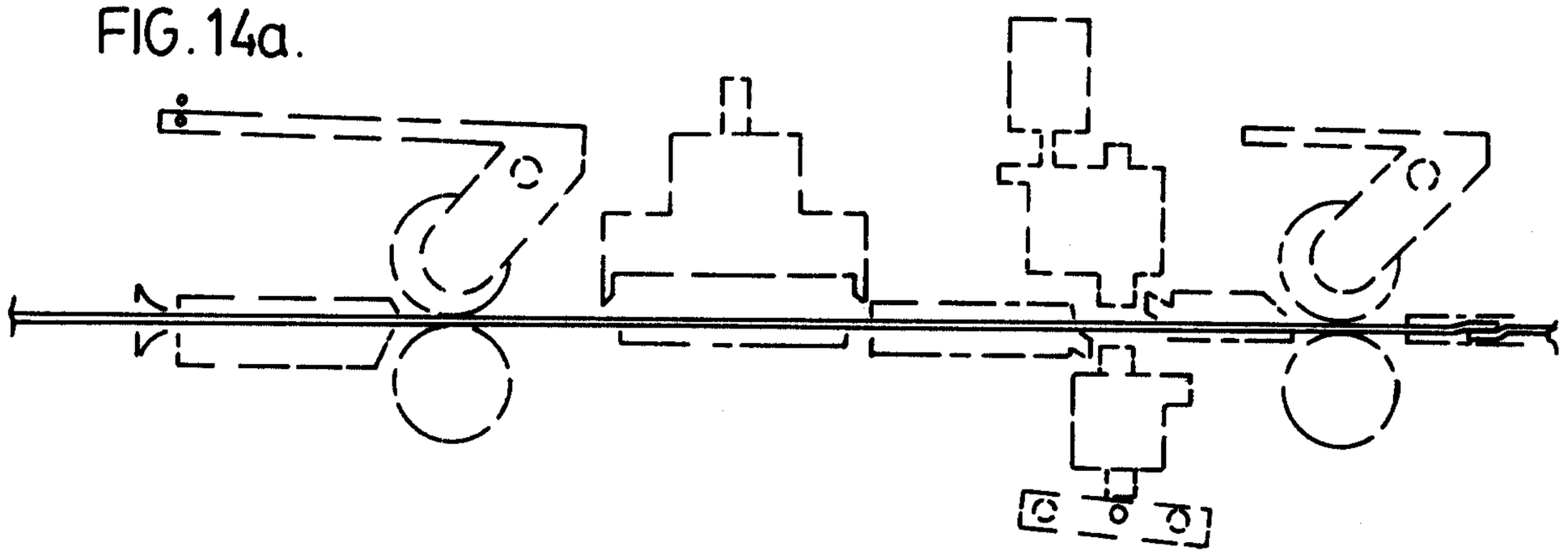


FIG.14b.

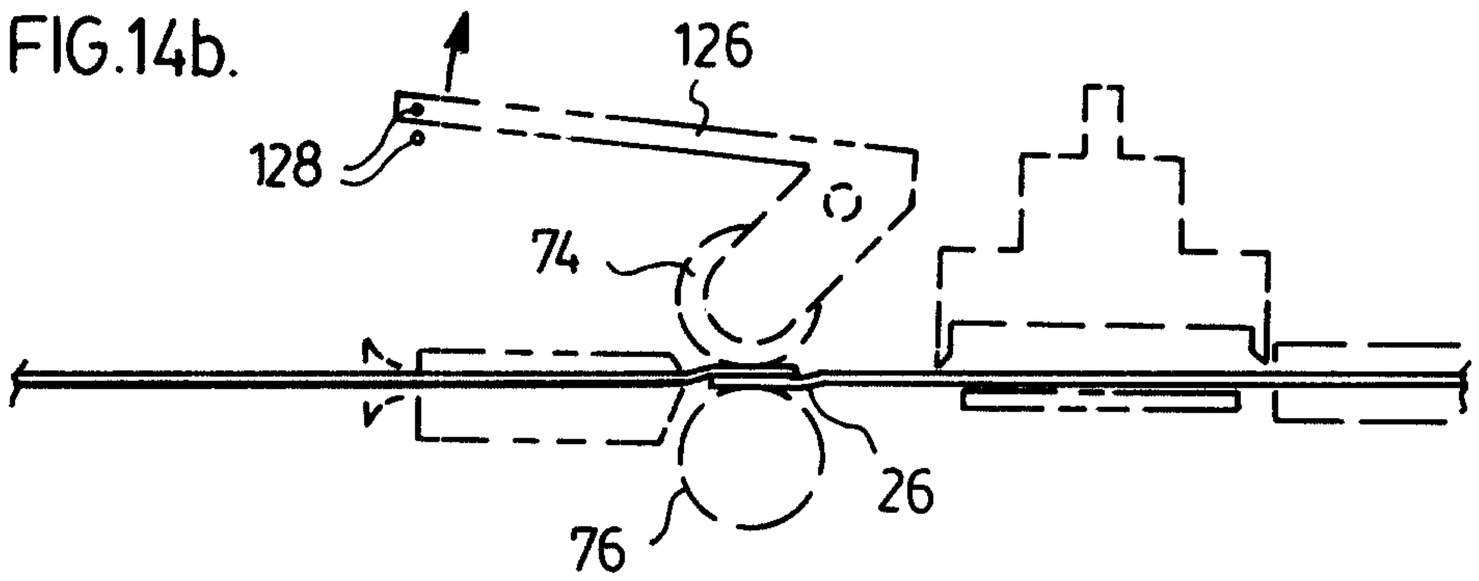


FIG. 14c.

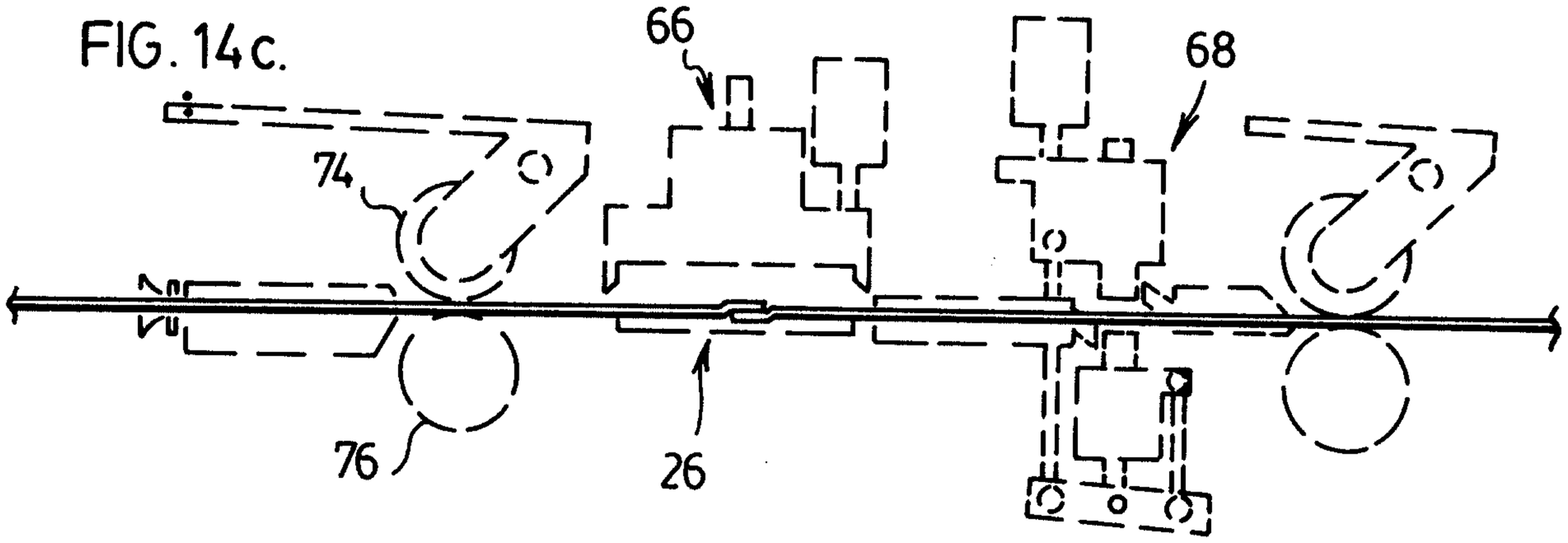


FIG. 14d.

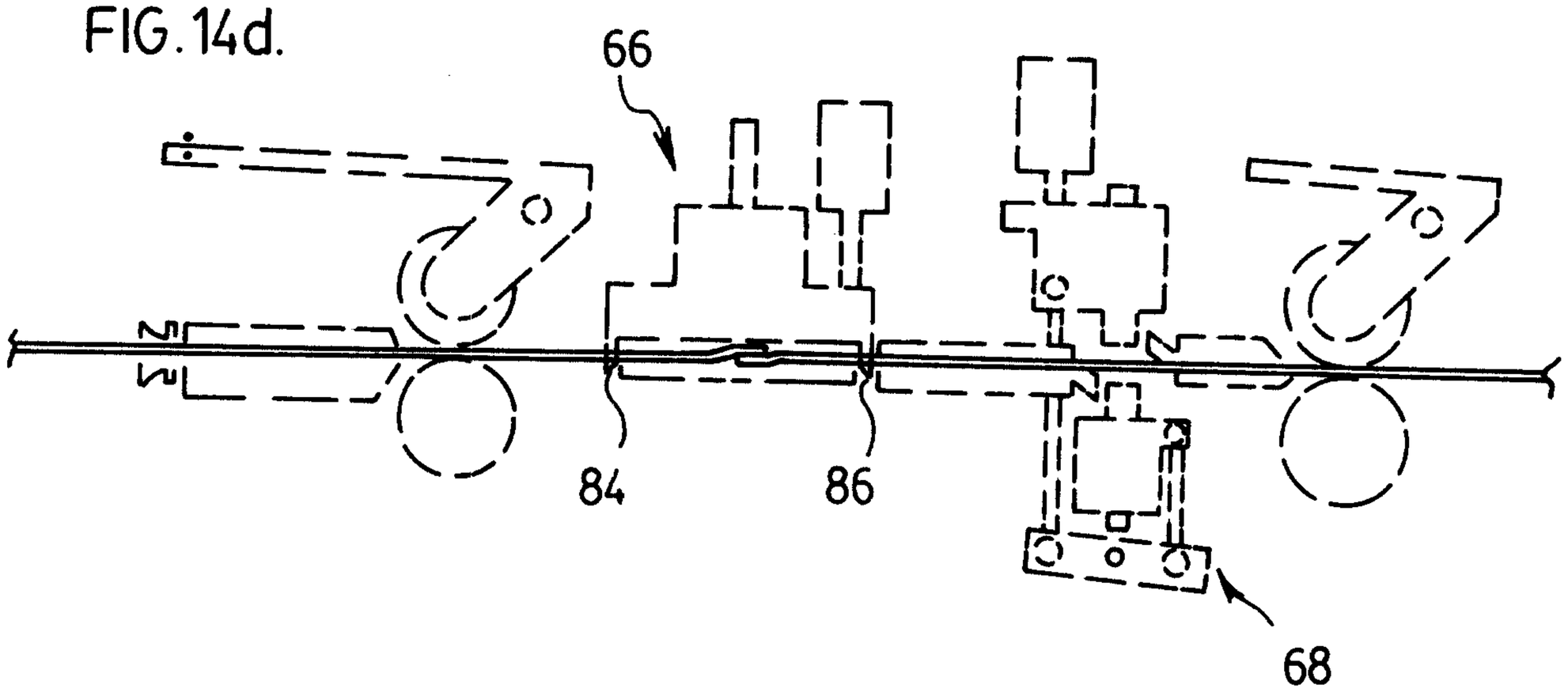


FIG. 14e.

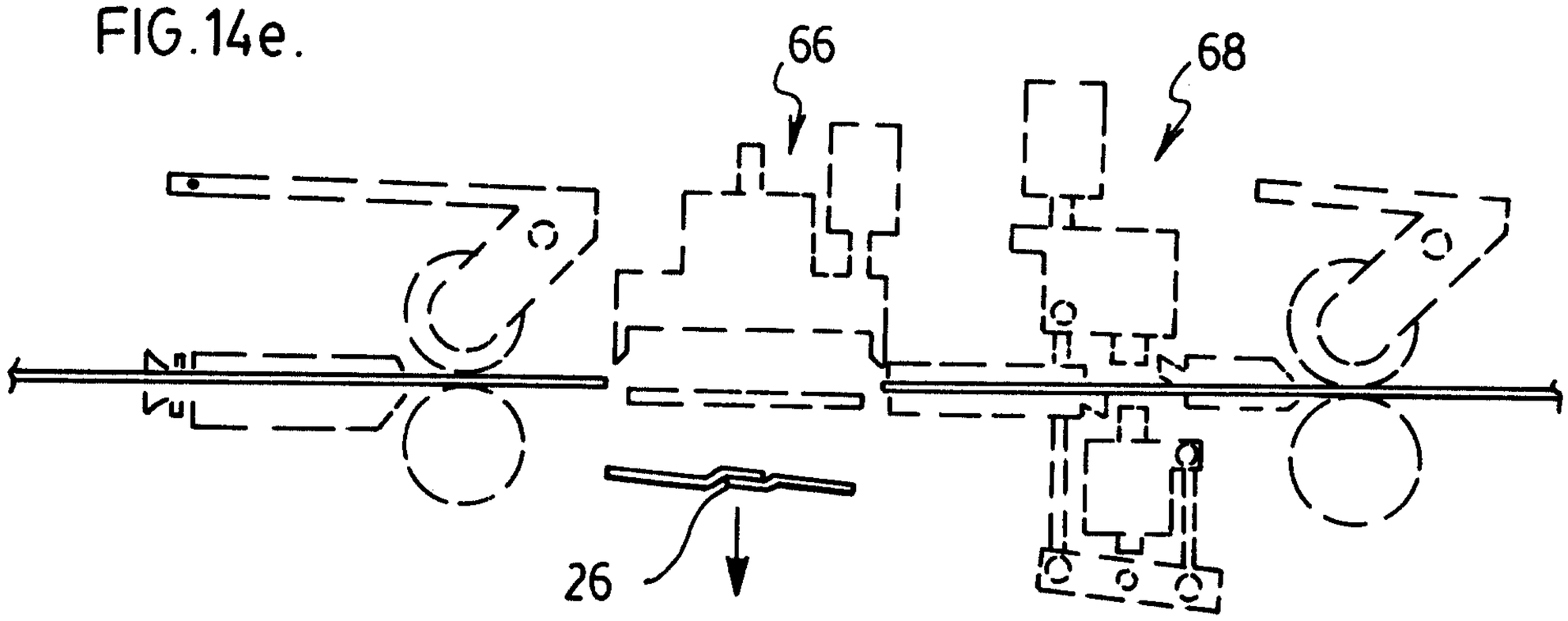
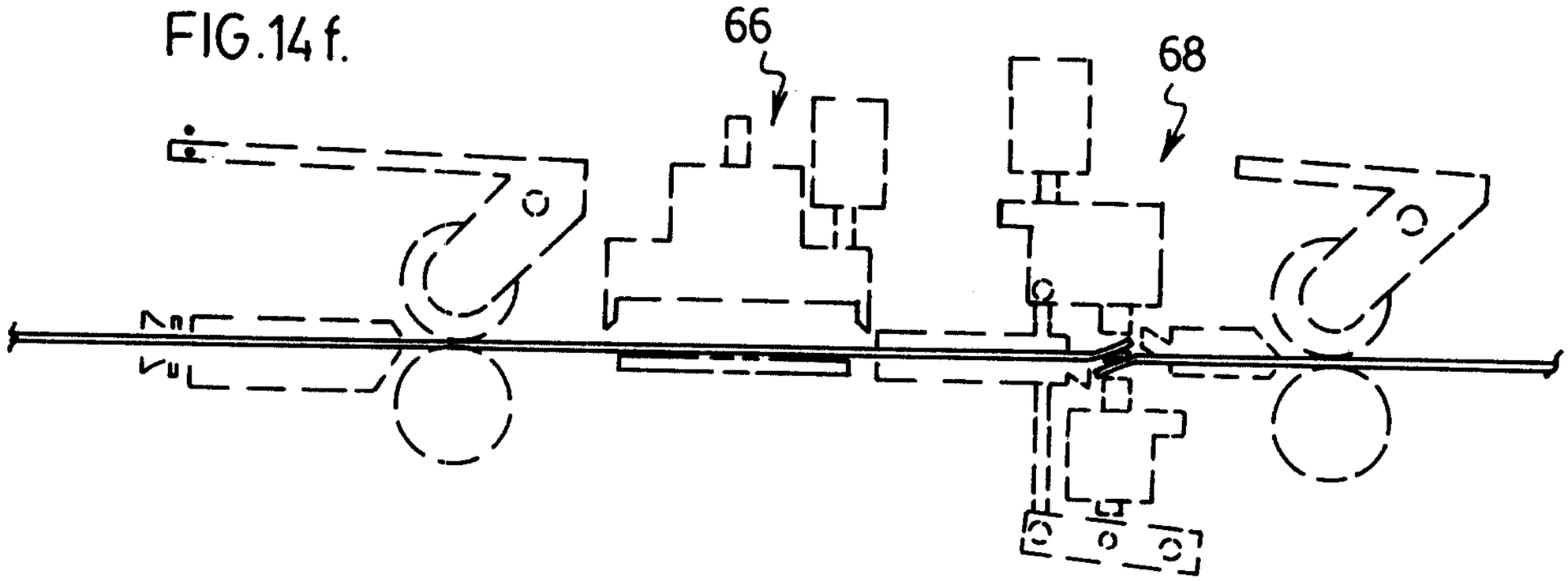


FIG.14f.



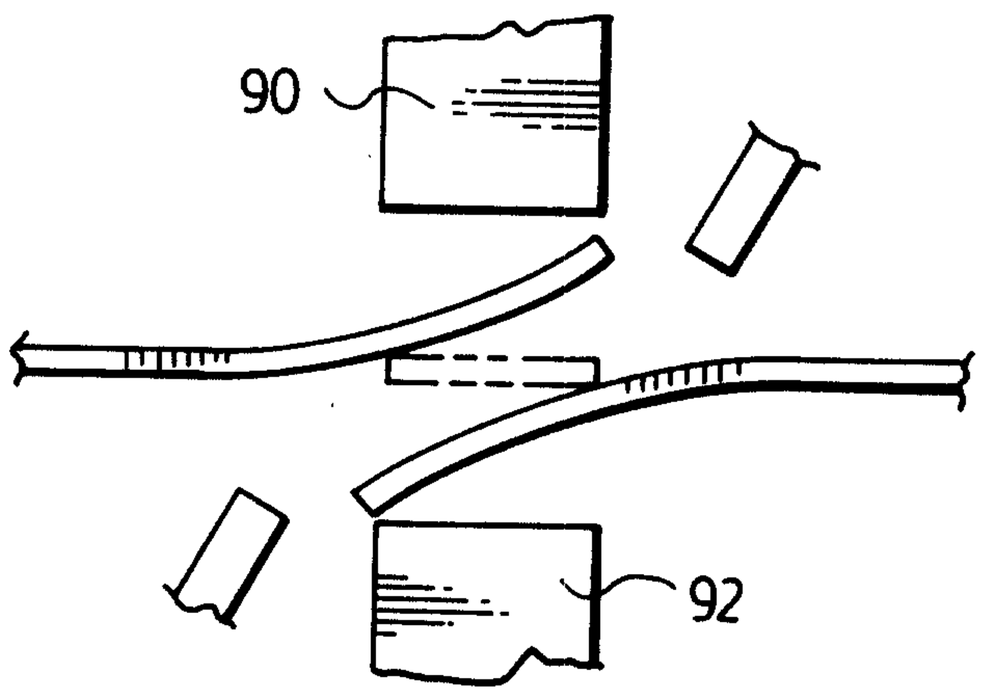


FIG.15a.

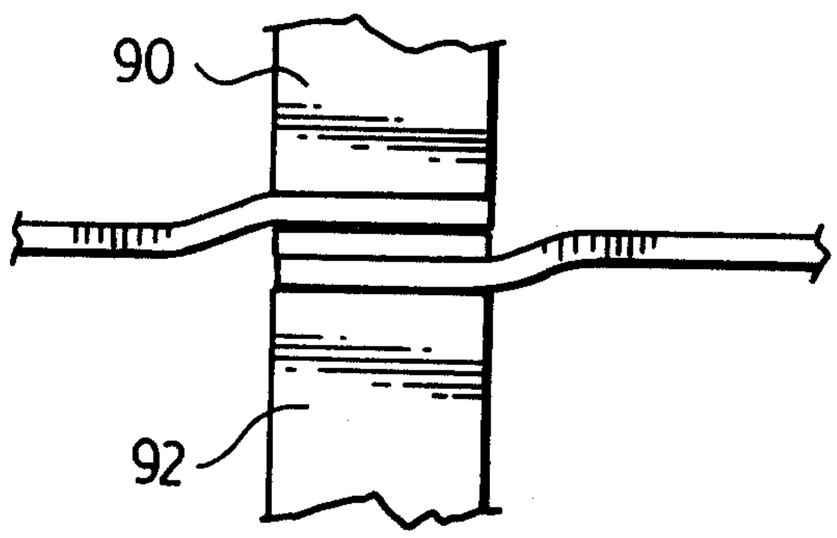


FIG.15b.

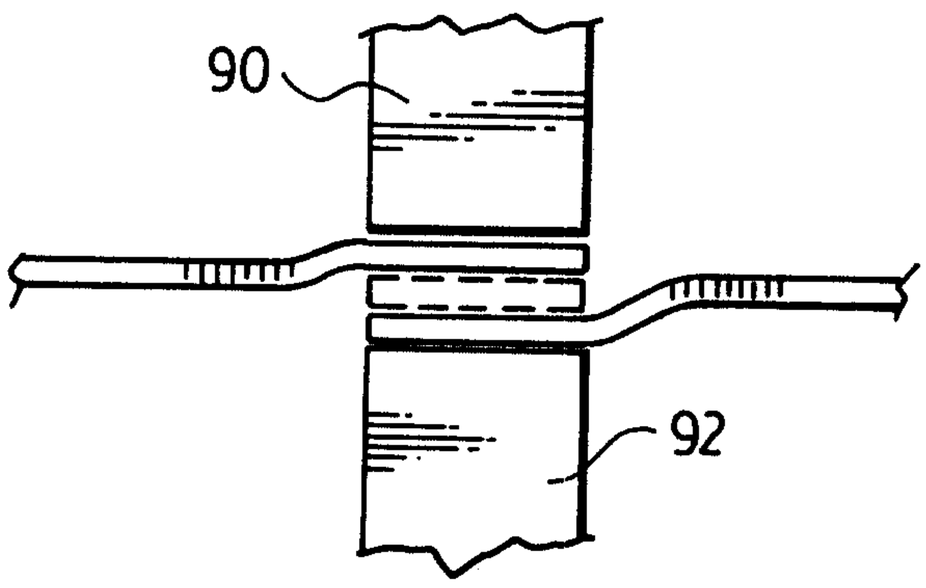


FIG.15c.

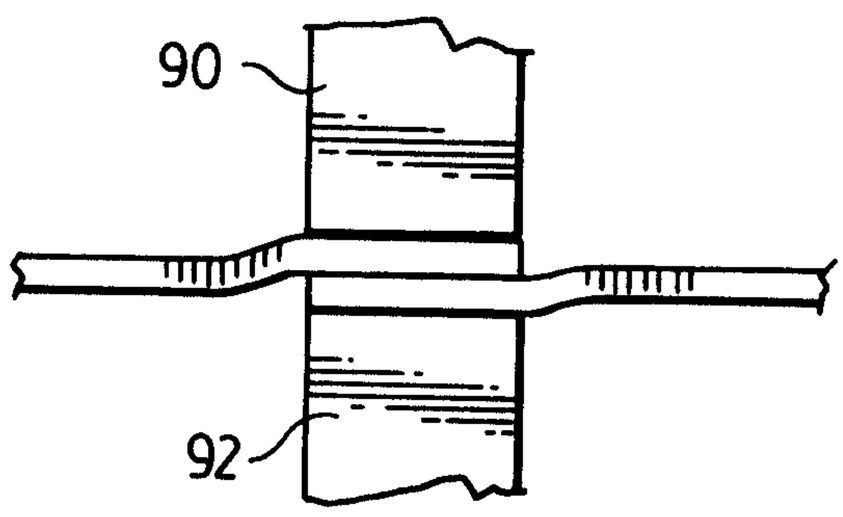


FIG.15d.

FIG.16a.

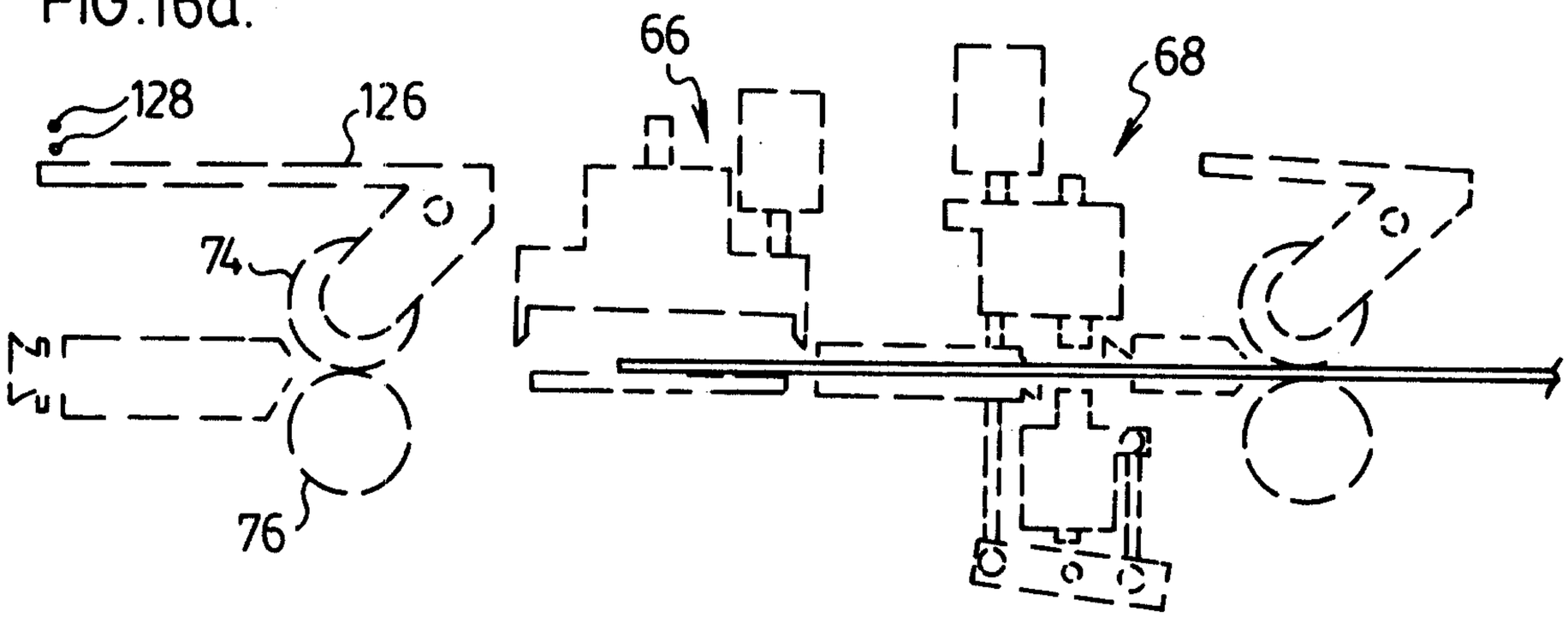


FIG.16b.

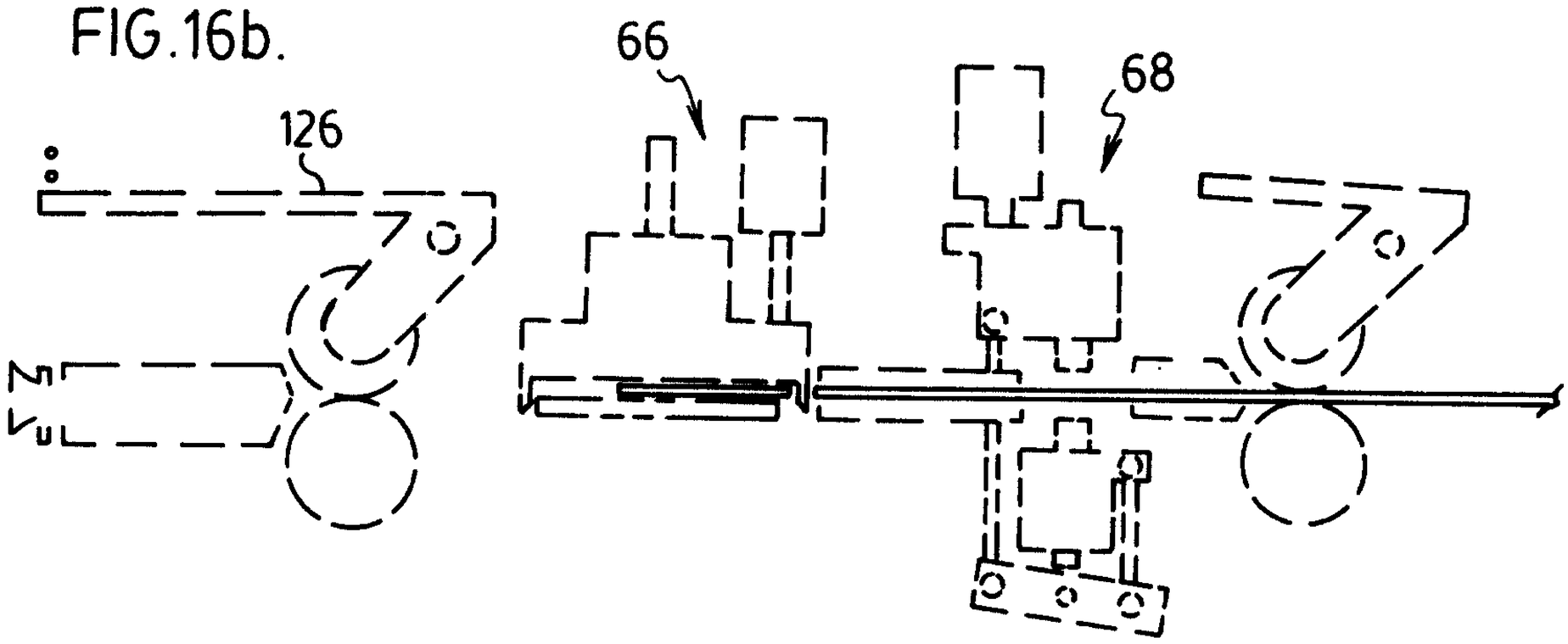


FIG.16c.