United States Patent

[11] **3,621,884**

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New York, N.Y.
[32] Priorities **Oct. 17, 1968**
[33] **Australia**
[31] **44936/68;**
May 12, 1969, Australia, No. 54863/69

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[54] **HELICALLY WOUND TUBING**
6 Claims, 20 Drawing Figs.

[52] **U.S. Cl.** **138/154,** 72/49
[51] **Int. Cl.** **F16l 11/16**
[50] **Field of Search** 138/154, 150, 135, 136, 144; 72/49

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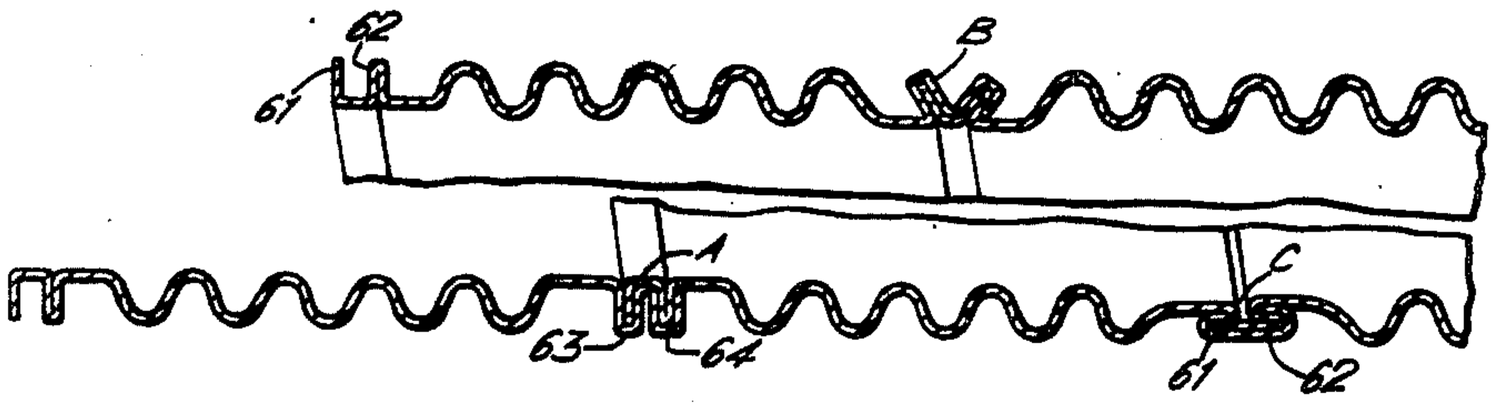
Primary Examiner—Laverne D. Geiger
Assistant Examiner—Richard J. Sher
Attorney—Silverman & Cass

ABSTRACT: A locked seam is formed in ducting formed by convoluted metal strip and seam locking adjacent edges of adjacent convolutions, in which one edge is folded to form a pair of inwardly facing channels and the other is folded to form a generally T-shaped flange and the arms of the T-shaped flange are locked within the channels. The seam may be formed by folding the edges of the strip before it is convoluted to provide along one edge an open U-shaped element facing out of the plane of the strip. A complementary flange is formed along the other edge, generally of similar U-shape or L-shape and after the strip is convoluted and the edges are mated the U-shape is deformed to form the seam. Apparatus for forming the seam comprises a mandrel removably mounted on a frame and two pairs of forming means disposed about the mandrel, one pair being fixed in its location relative to the frame and the other pair being movable with the mandrel, whereby the mandrel can be changed without requiring adjustment of the forming means.



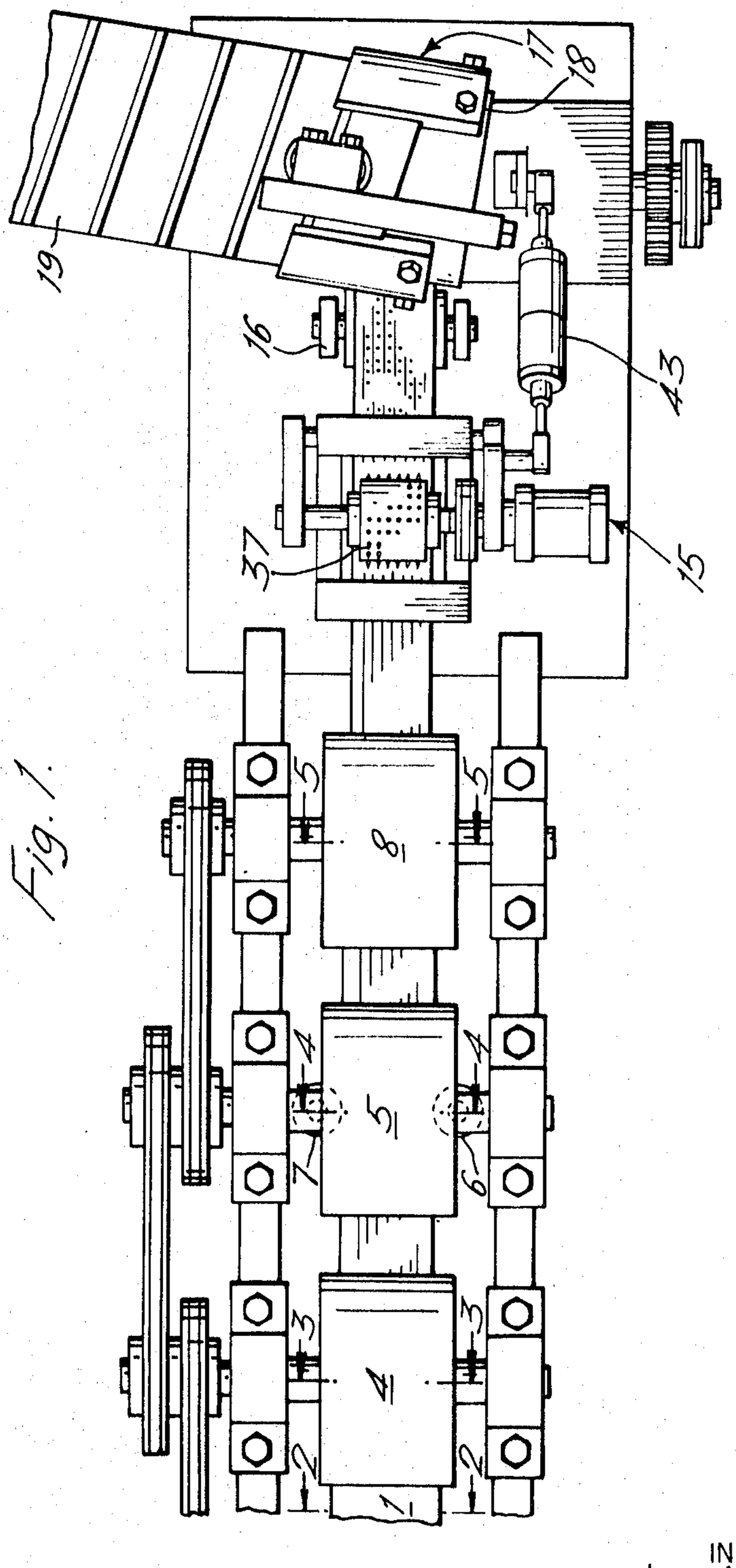


Fig. 1.

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Fig. 2.

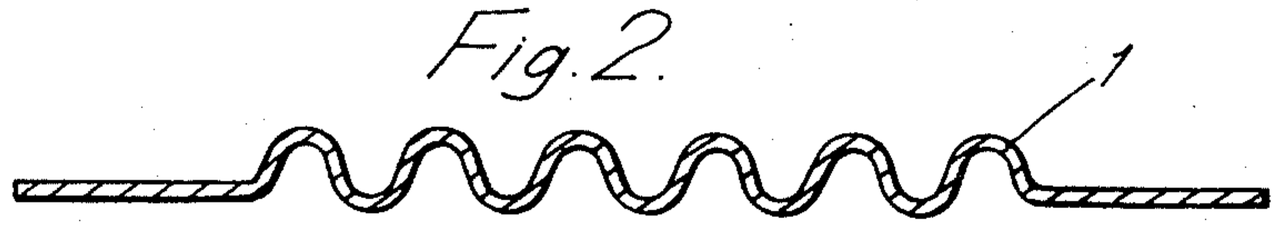
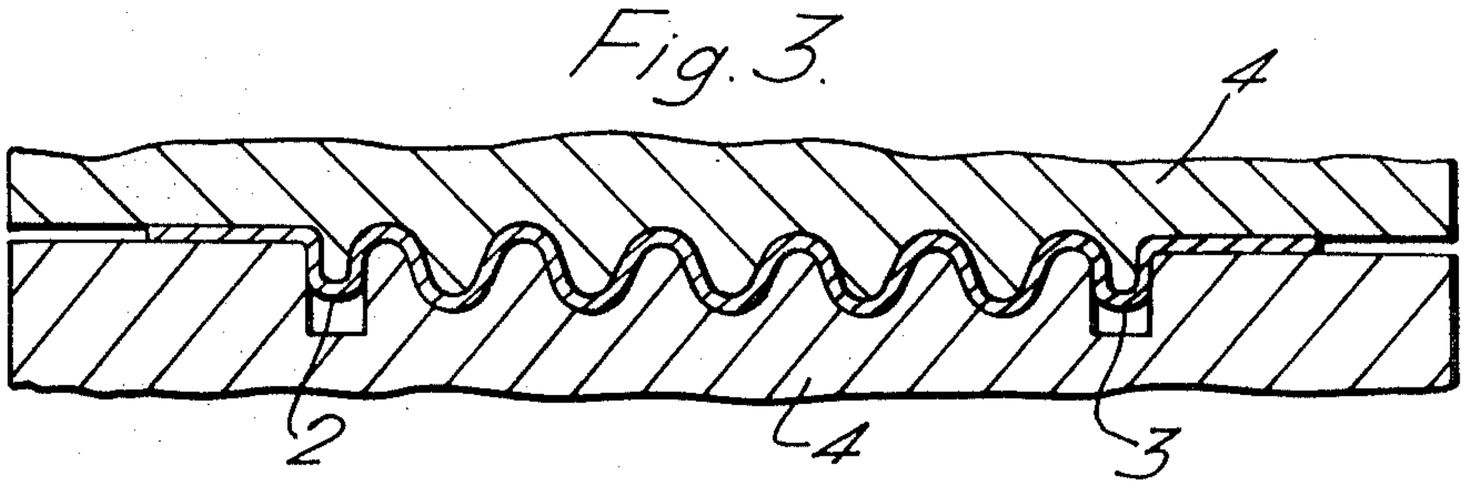


Fig. 3.



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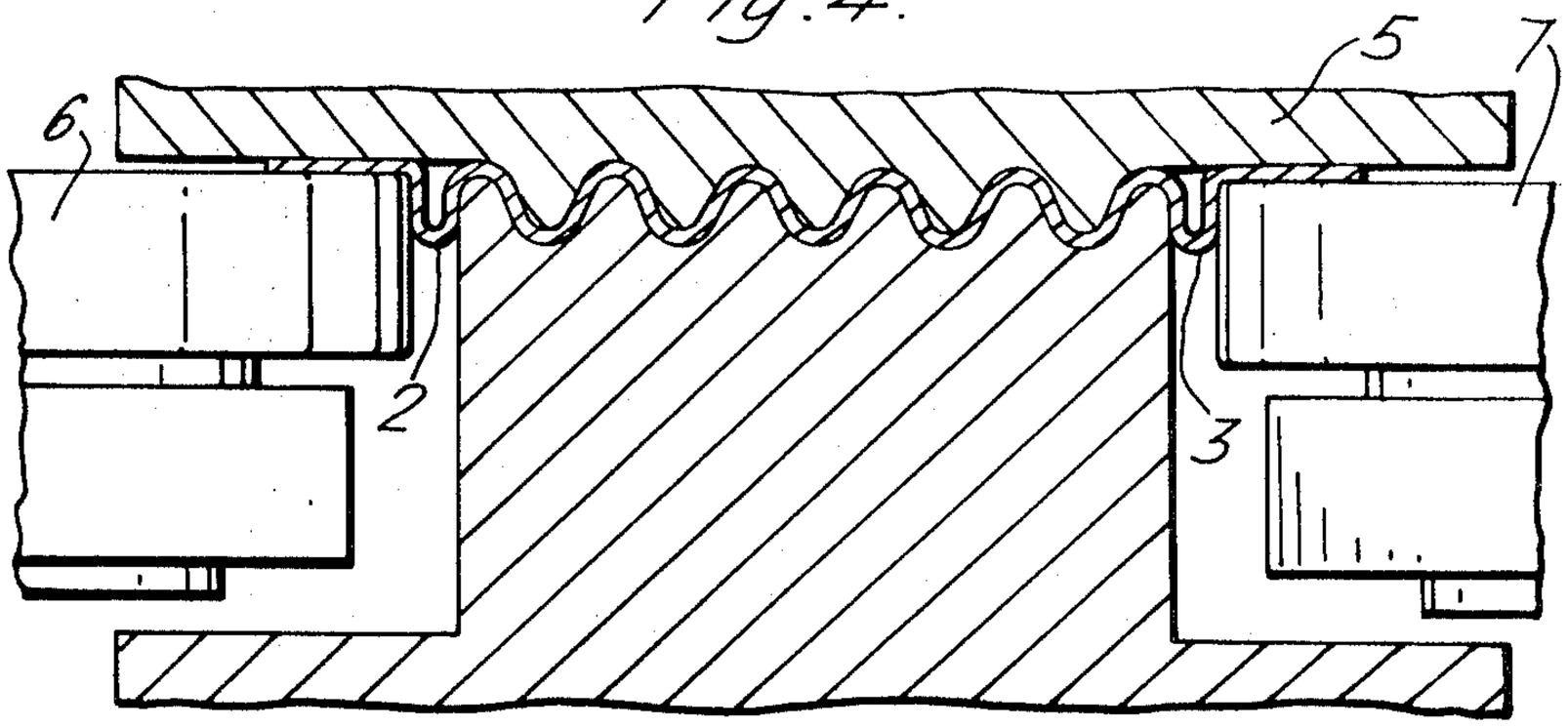

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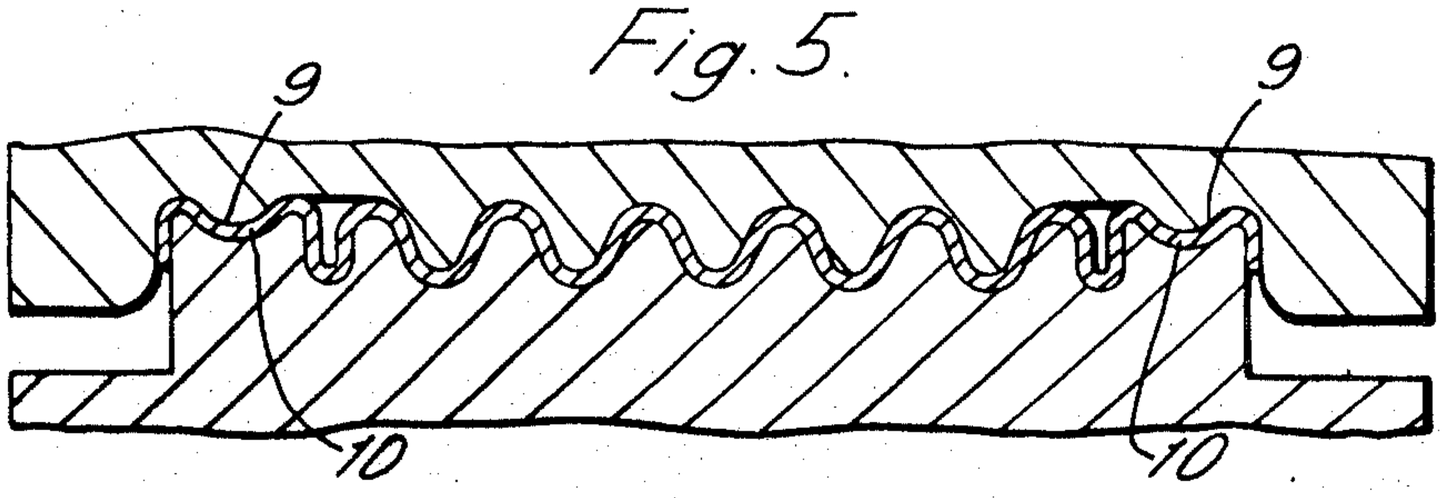

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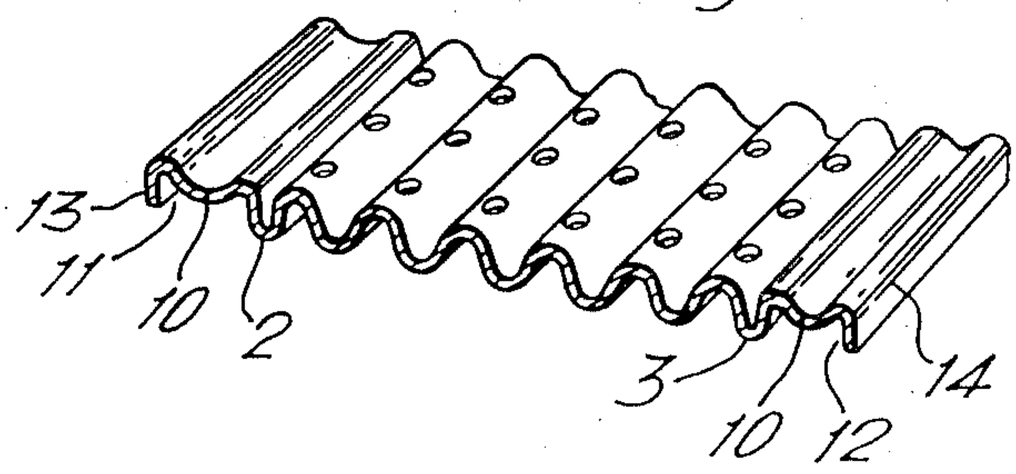
Fig. 6.



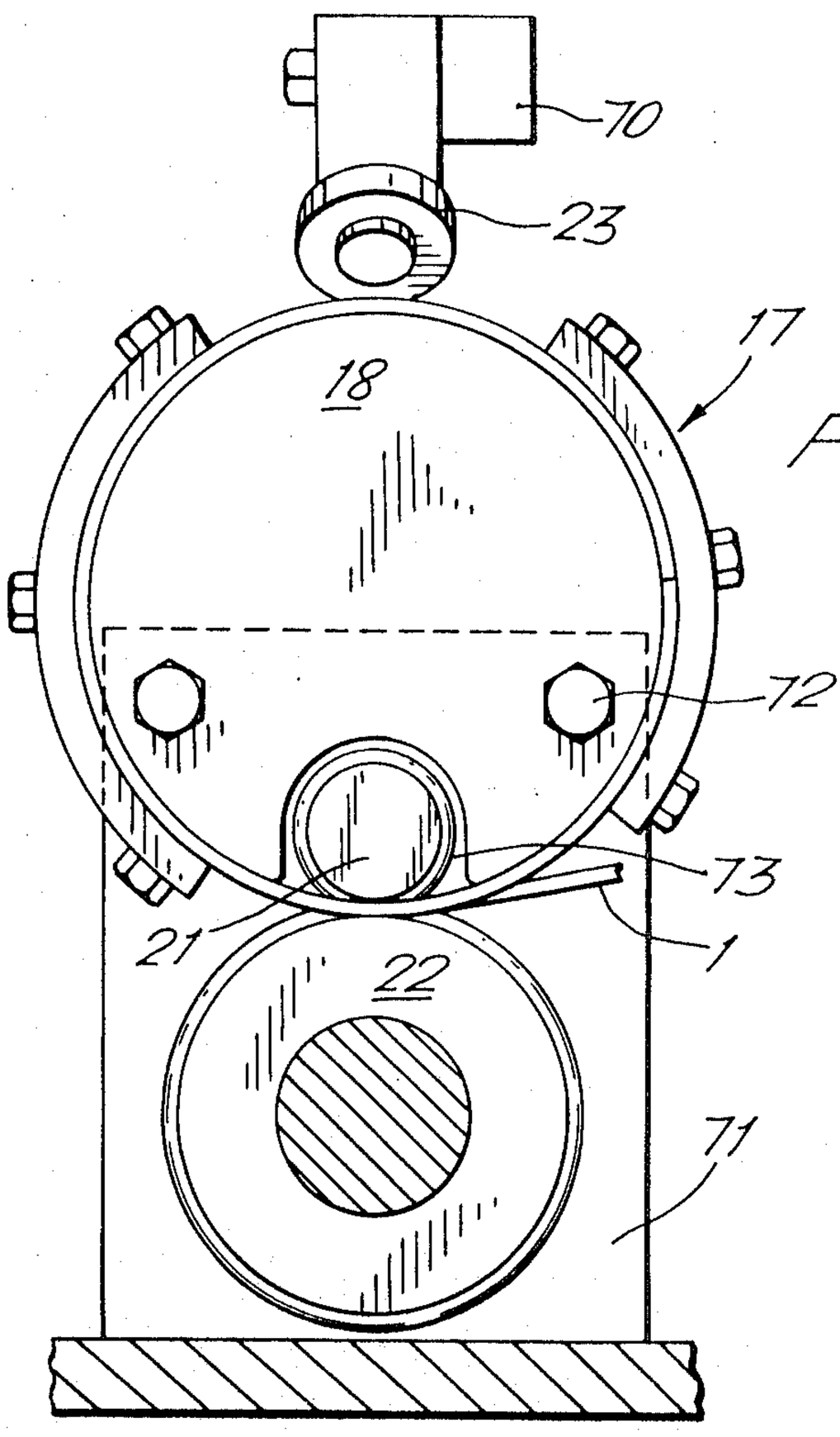


Fig. 7.

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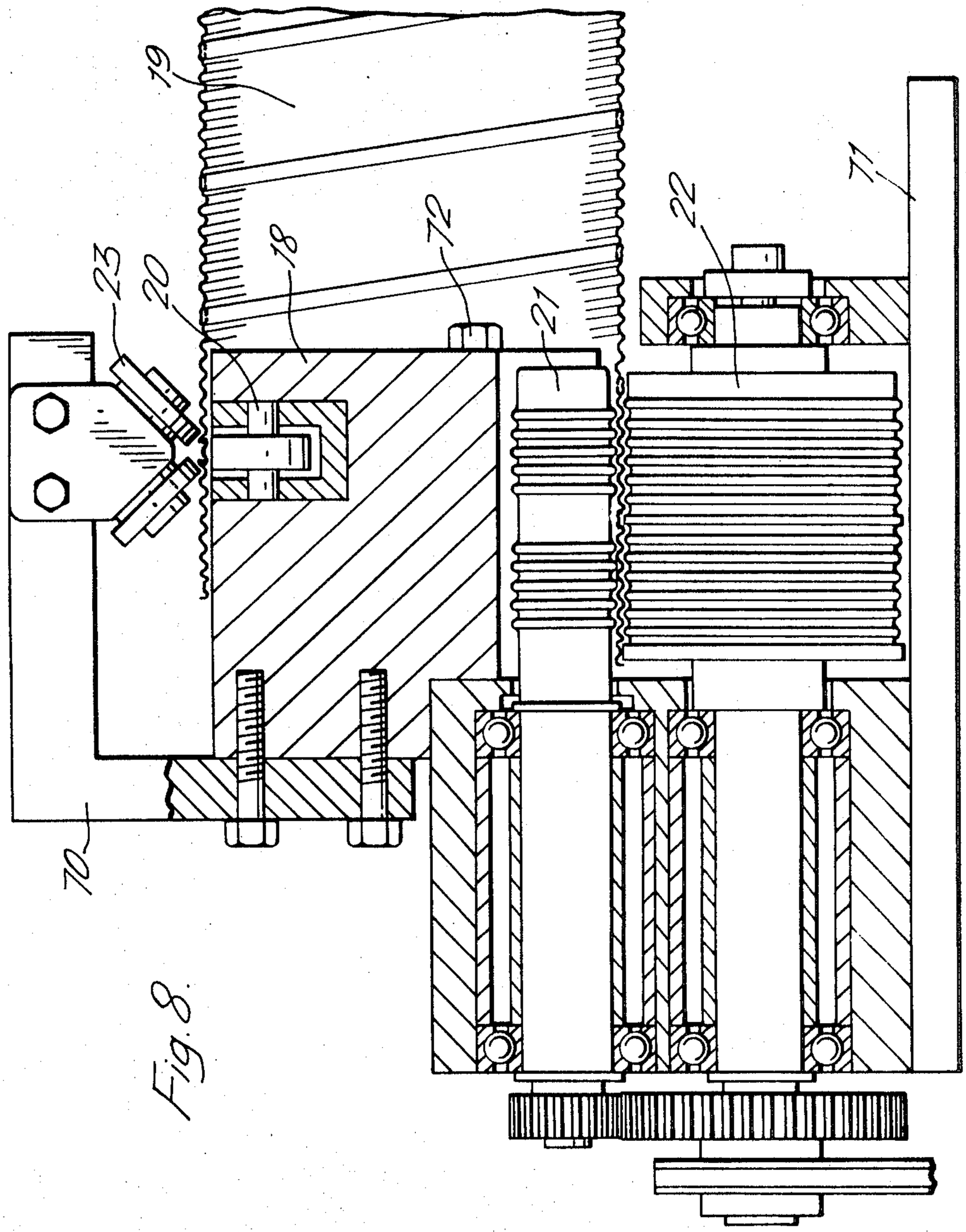

Fig. 8.

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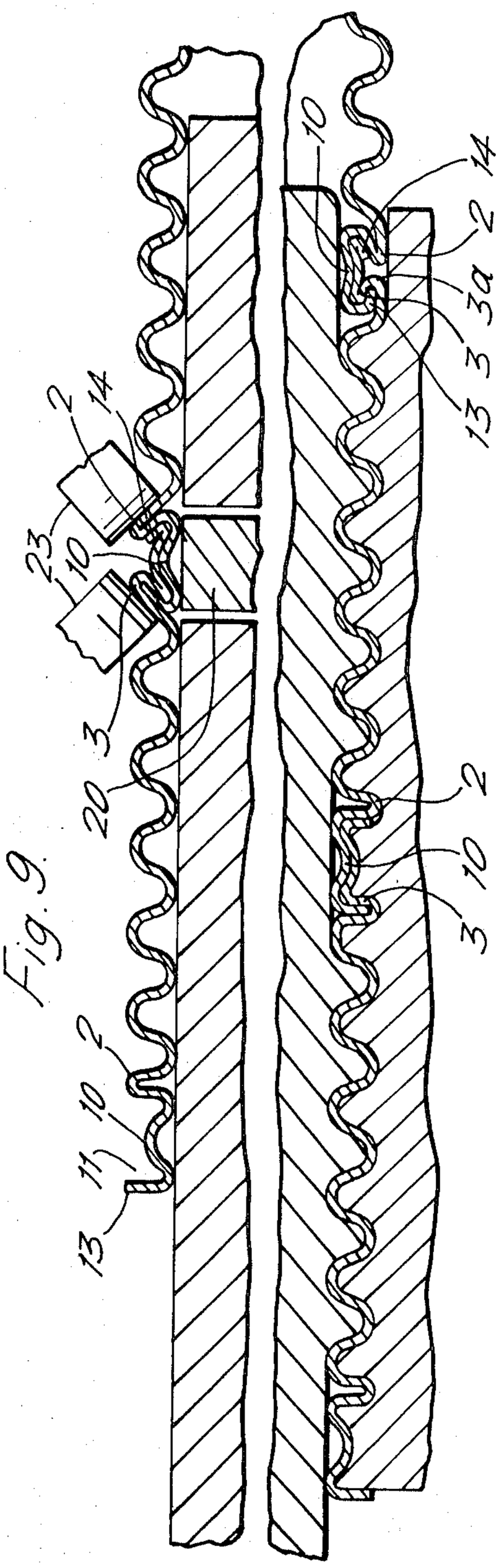

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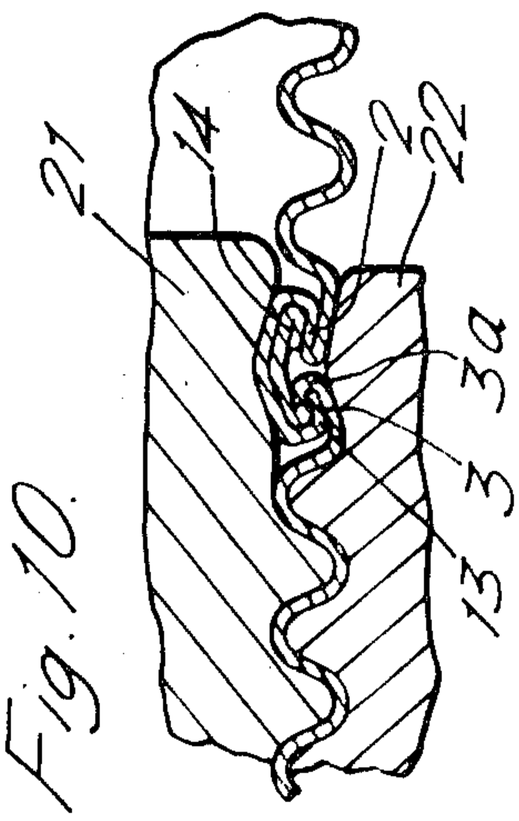

Fig. 10.

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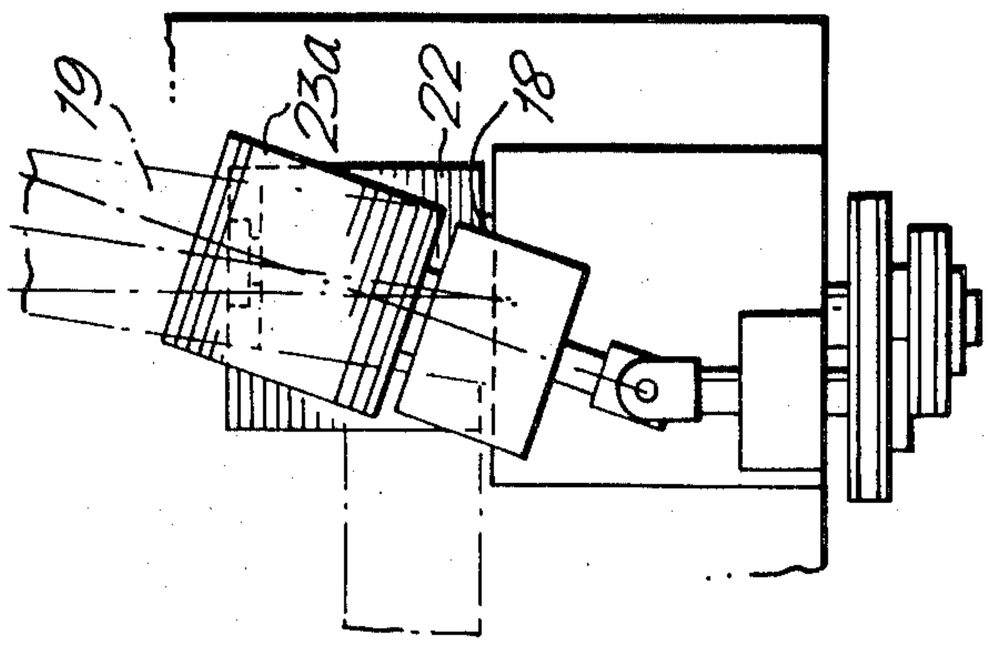

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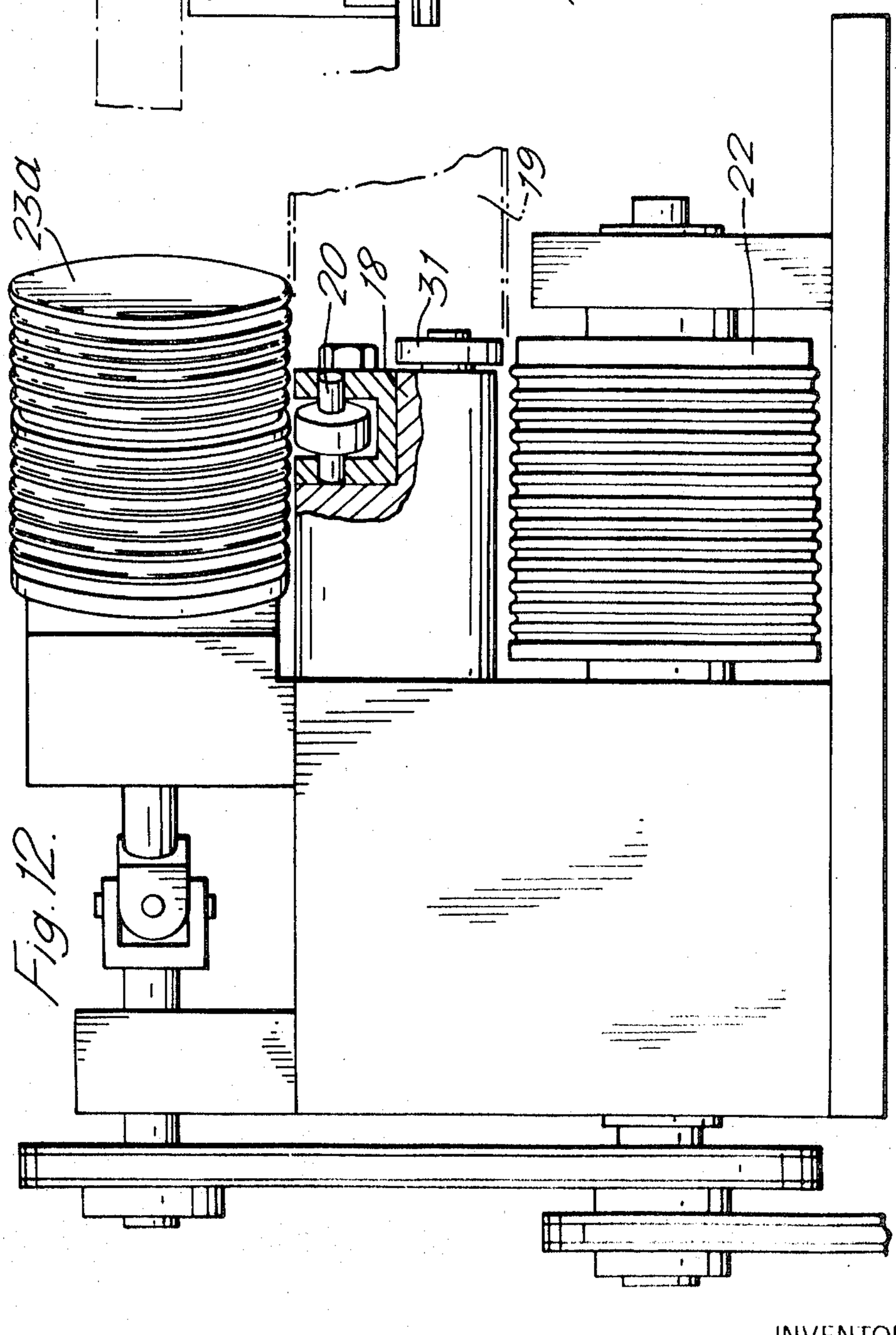

Fig. 12.

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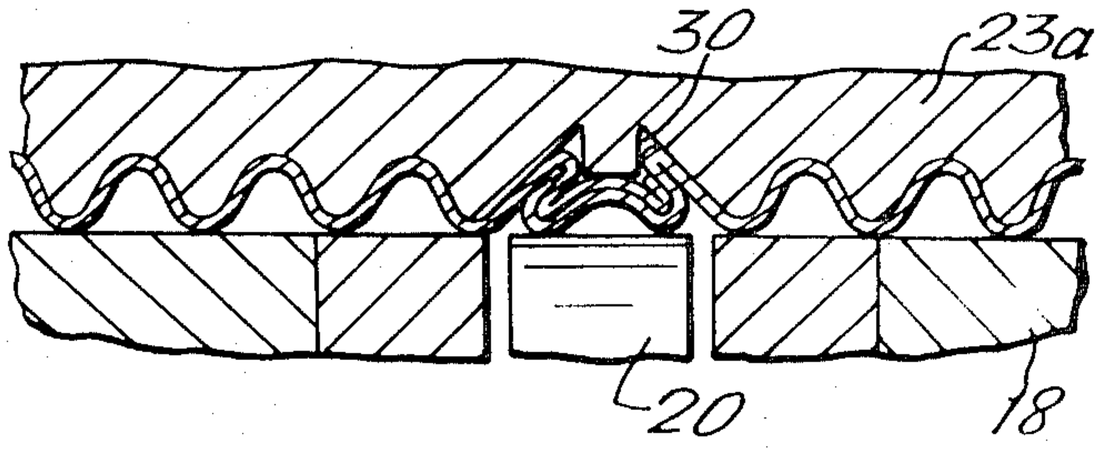
Fig. 13.



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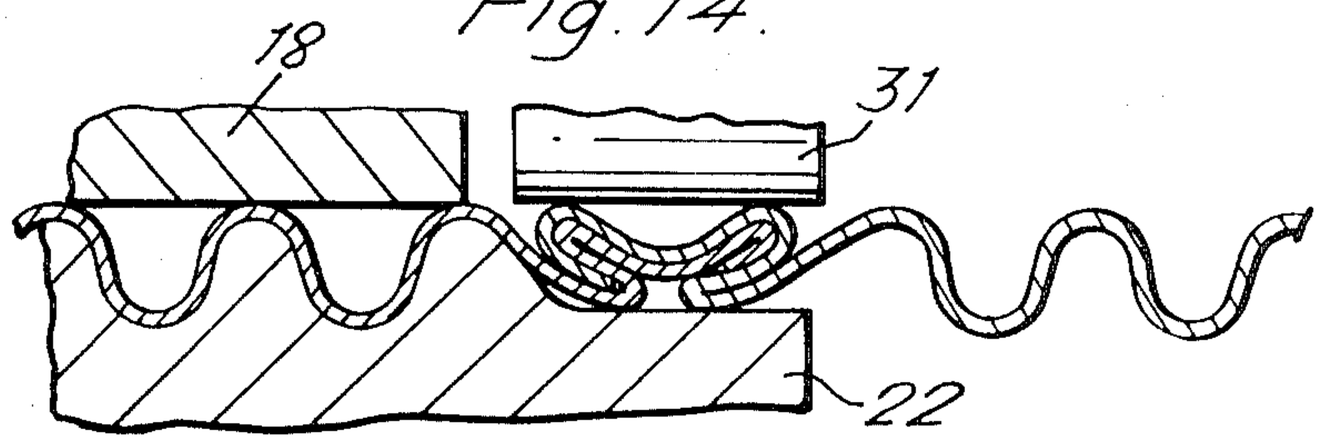

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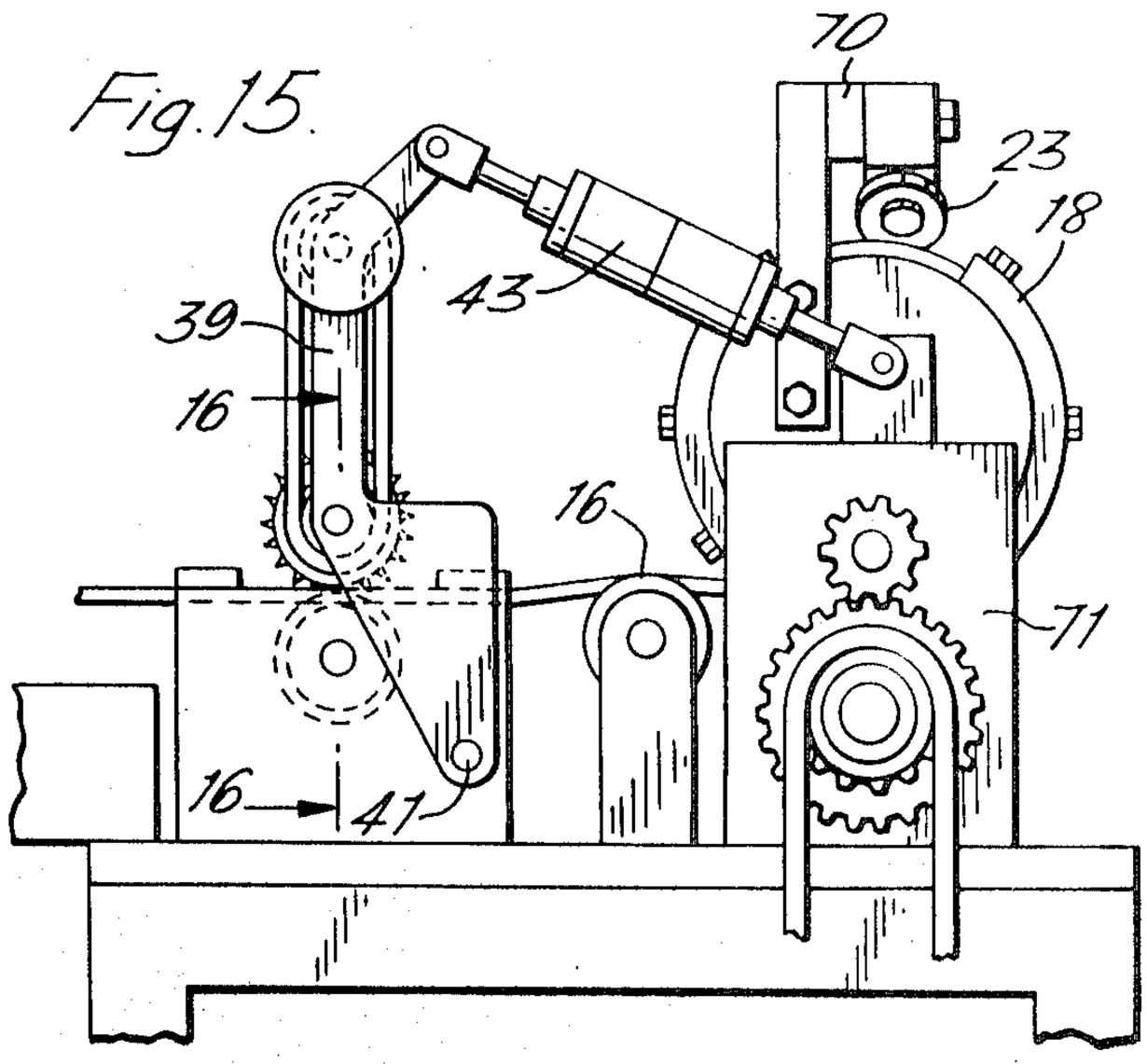

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Fig. 16.

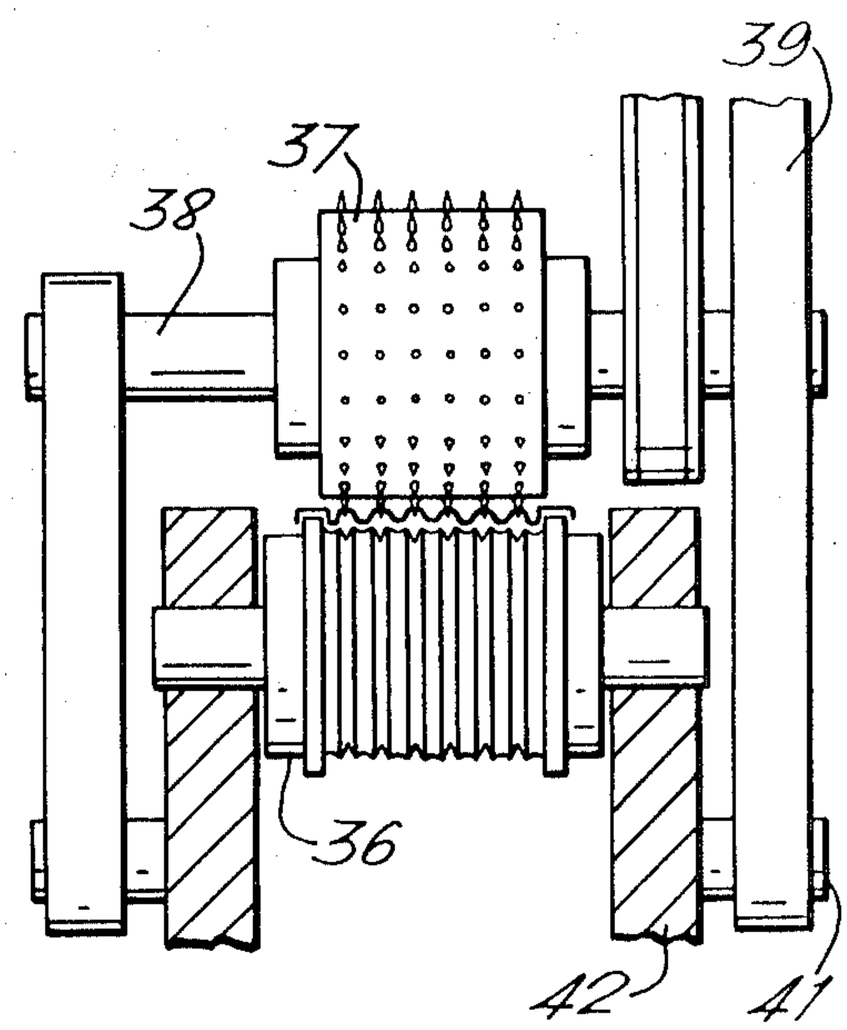
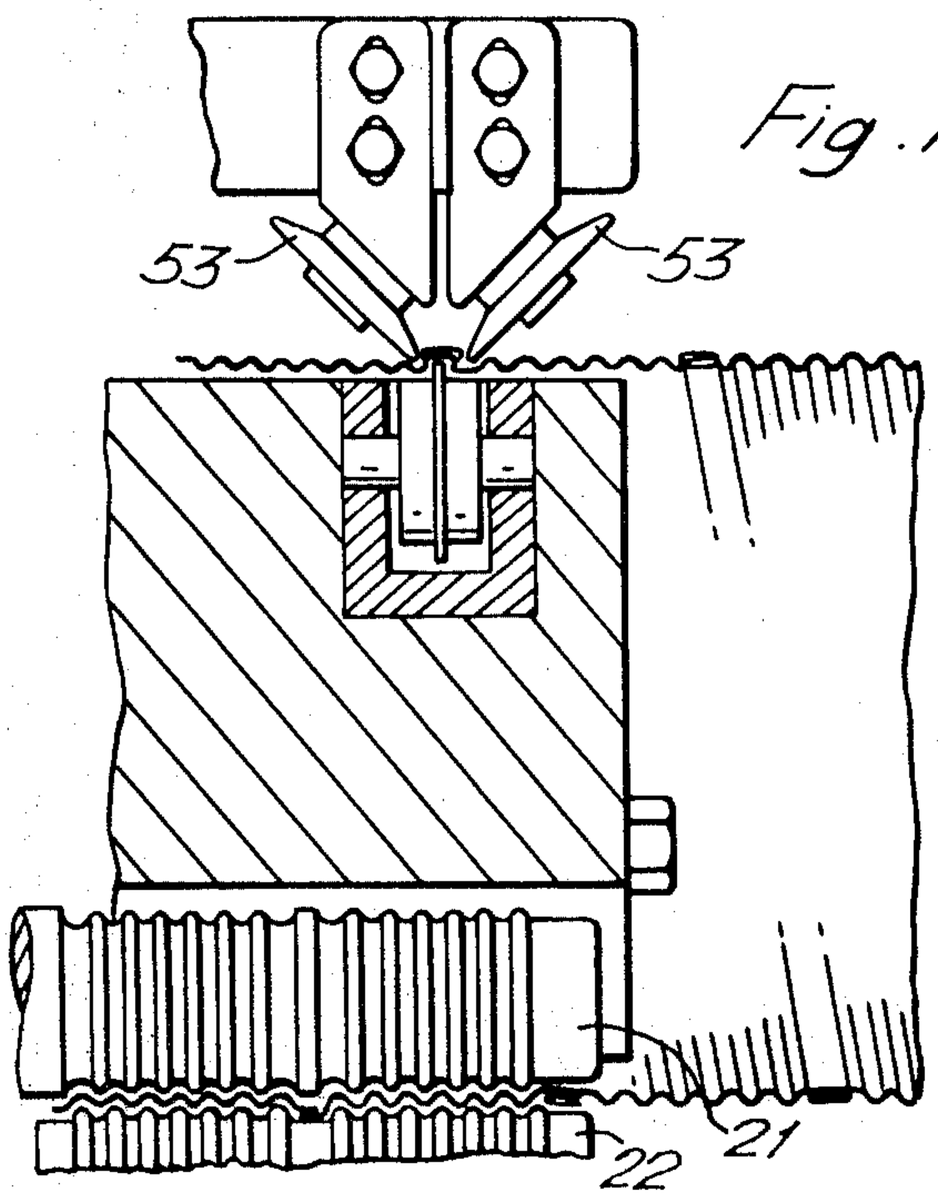


Fig. 17.



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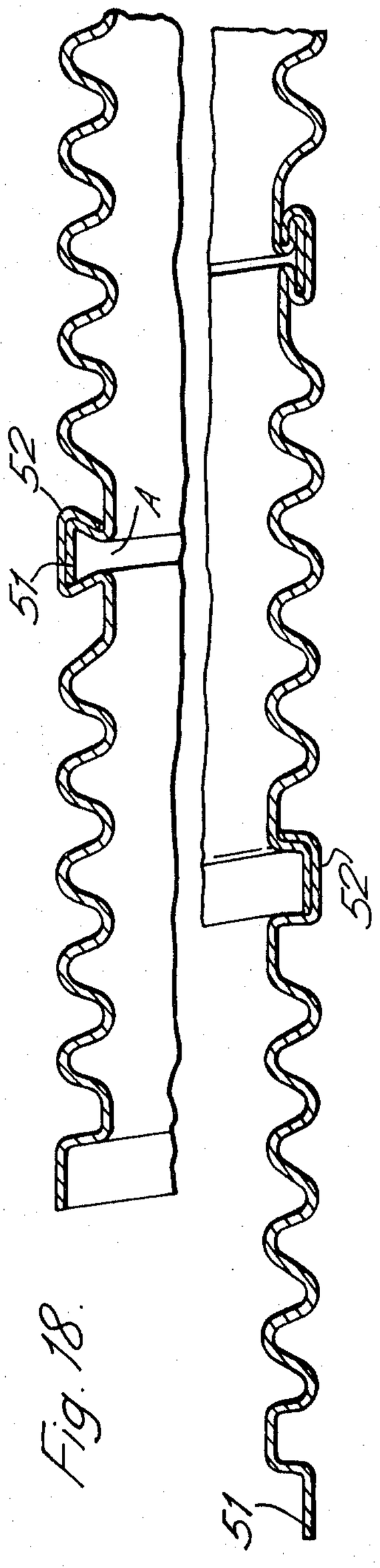

Fig. 18.

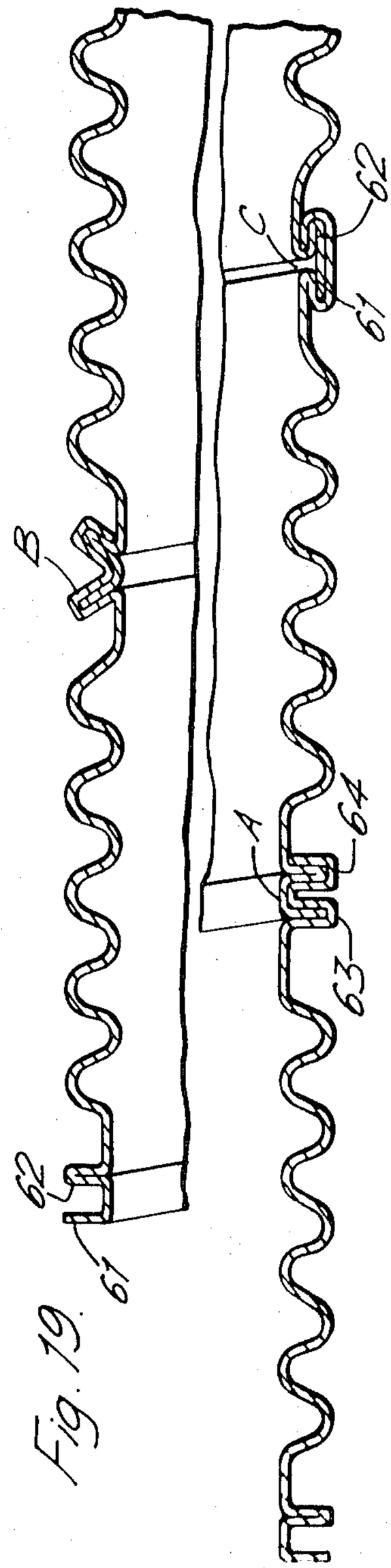

Fig. 19.

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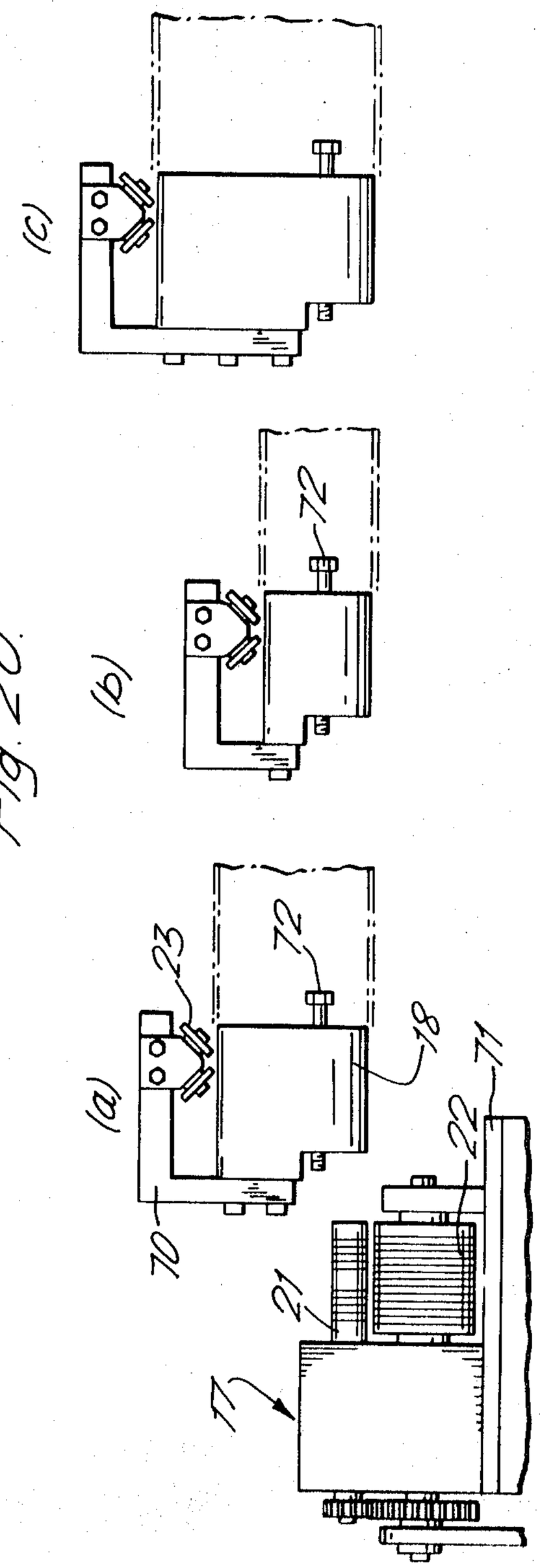

Fig. 20.

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HELICALLY WOUND TUBING

BACKGROUND OF INVENTION

1. Field of Invention

The invention relates to the formation of helically wound locked seamed ducting of the general type described in prior U.S. Pat. No. 3,435,852.

2. Prior Art

The ducting described in our said prior patent has proved most satisfactory in use but, by virtue of its construction relatively complex machinery has been required to form the locked seam. Apparatus for the production of the ducting is described in our prior U.S. Pat. application No. 638,393 and this apparatus comprises a mandrel having a number of forming and driving rollers arranged about its circumference, which apparatus operates to form the locked seam. This requires very accurate setting of the rollers and a further disadvantage of this construction is that since each mandrel can be used to form one diameter of duct only, to change from one duct size to another necessitates the changing of the mandrel and the adjusting of the positions of the many forming rollers. In practice therefore we have found it necessary to change the whole forming head when changing to a new duct size. Furthermore, the construction of the double locked seam according to our prior application requires that in the initial stages of construction, the flange and channel from which the seam is formed having a substantial depth and accordingly they are considerably stretched in bending about the mandrel. This creates particular problems if the material is not sufficiently ductile.

SUMMARY

The primary object of this invention is to provide a new form of locked seam construction which may lead to the simplification of the apparatus necessary for its formation. A further object is to provide a method of forming a locked seam in which the major part of the formation of the seam can be carried out on the material in strip form before the edges are brought together. In particular, it is the object to provide such a method for use in the formation of helically wound ducting in which a substantial part of the seam-forming operation can be carried out before the material is convoluted in the coiling head. The preferred form of the invention allows the formation and closing of the seam to be performed almost entirely by the use of simple bending and pressing operations avoiding any substantial drawing operation during the process. The preferred form of the invention also substantially eliminates buckling or wrinkling of the metal at the seam.

According to this invention there is provided a tube formed from helically wound ductile strip material with adjacent edges of the strip joined together by a locked seam wherein said locked seam comprises a pair of generally oppositely directly channels formed in one edge and disposed on opposite sides of the longitudinal medial plane of the seam with their mouths facing, and a complementary flange of generally T-shaped cross section formed in the other edge with its arms disposed one within each of the said channels.

According to one form of the invention the channels are directly facing one another and the arms of the flange are substantially coplanar. In another form of the invention the channels are disposed so that their directions of facing intersect at an angle slightly less than 180° and the arms of the flange are correspondingly angled. In this construction the channels are disposed to face slightly outwardly of the tube.

The invention further provides a method of forming helically wound seam-locked tubing from ductile strip material comprising the steps of forming in one edge of the strip at least one element of U-shaped cross section and in the other edge at least one complementary flange, convoluting the strip and mating the adjacent edges of the convolutions so that the flange lies within the U-shaped element, folding the or each U-shaped element and the flange to form a pair of generally oppositely directed channels and a pair of generally oppositely directed flange arms lying within the channels, and flattening the channels to grip the flange arms within them and form a locked seam.

A preferred method of forming the seam according to this invention comprises the steps of forming in one edge of the strip a U-shaped element which is formed with an open mouth directed at right angles to the general plane of the strip and outwardly of the formed tube, said U-shaped element having an outer wall and an inner wall, the inner wall being formed by a deep corrugation or rib formed by folding the strip; forming in the other edge of the strip a similar deep corrugation or rib displaced from the edge of the strip to leave an edge flange; convoluting the strip, and mating the adjacent edges of the convoluted strip so that the flange lies within the U-shaped element and the outer wall of said element lies within the rib of the flanged edge of the strip, and bending the ribs inwardly towards each other to form the U-shaped element into a pair of inwardly facing channels and the flange in a flange of T-shaped cross section with the arms of the T lying within the channels and flattening the channels so that the arms of the flange are locked within the channels and the outer wall of the channel is locked within the rib of the flanged edge.

In an alternative form of the invention the locked seam is formed by first folding one edge of the strip to form a U-shaped element with an open mouth directed at right angles to the general plane of the strip and forming a complementary flange element in the other edge mating the edges, inwardly deforming the sidewalls of the U-shaped element to close the mouth thereof so that the sidewalls of the element form with the web thereof two inwardly facing channels and the flange element is bent over on itself to a T-shaped configuration, and flattening the seam to lock the arms of the flange within the channels.

The invention provides a still further method of forming the seam comprising the steps of first forming in one of the edges of the strip a pair of parallel U-shaped elements arranged side by side and in the other edge a pair of parallel flange elements arranged side by side, mating the flange elements within the U-shaped and spreading the channels apart by bending them in opposite directions about the longitudinal medial plane of the seam so that the U-shaped elements form two inwardly facing channels and the flange elements are substantially coplanar and form the arms of a flange of generally T-shaped cross section with the arms lying within the channels, and flattening the channels to lock the arms of the flange within the channels.

The invention also provides apparatus for forming helically wound tubing from ductile strip material comprising a frame, a mandrel mounted on the frame but removable therefrom and forming means located about the periphery of the mandrel for seaming together adjacent edges of strip material convoluted about the mandrel characterized in that the forming means comprise two cooperating pairs of forming means one pair being mounted on the frame and the other pair being mounted so as to be removable on removal of the mandrel whereby on substitution of one size of mandrel for another only one of the pairs of forming means needs to be adjusted to accommodate the new mandrel. Preferably the mandrel is a fixed substantially cylindrical mandrel and at least one of the forming means comprises a rotatable roller located in a cavity formed in the mandrel.

The reference above to a "flange" being formed on one edge of the strip is not to be understood as limiting the invention to the provision of a plan flanged edge. The expression "-flange" and "channel" have been used largely for convenience of description and as will be apparent from the description of the embodiments of the invention the flanged edge of the strip may be in fact constituted by a channel and be substantially similar to the edge which is referred to as terminating in a channel.

In order that the invention may be better understood the preferred embodiment and a number of alternative constructions will now be described by way of example and with reference to the accompanying drawings:

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a plan view of part of apparatus for forming convoluted corrugated tubing by the method of this invention;

FIGS. 2 to 5 are cross-sectional views on the lines 2—2, 3—3, 4—4, 5—5 respectively of FIG. 1 and illustrate the steps in the formation of the strip for use according to this invention;

FIG. 6 is a perspective view of a section of strip according to the invention;

FIG. 7 is a side elevation partly in cross section of the forming head shown in FIG. 1;

FIG. 8 is an end elevation partly in cross section of the forming head;

FIG. 9 is an enlarged cross-sectional view of the forming mandrel (broken away to reduce space);

FIG. 10 is a fragmental cross-sectional view of modification of the construction shown in FIG. 9;

FIG. 11 is a plan view to a small scale of a modification of the apparatus for producing small diameter ducting;

FIG. 12 is a cross-sectional view to a larger scale of the apparatus of FIG. 11;

FIGS. 13 and 14 are enlarged fragmental views showing the stages in the formation of the seam in the apparatus of FIGS. 11 and 12;

FIG. 15 is a side elevation (from the opposite side to FIG. 7) of the forming head showing the arrangement of the tube spiking mechanism;

FIG. 16 is a cross-sectional view (on an enlarged scale) on the line 16—16 in FIG. 15;

FIG. 17 is a fragmentary cross-sectional view showing a mandrel and forming mechanism for forming the seam by an alternative method;

FIG. 18 shows diagrammatically the stages in the formation of a seam by the method employing the forming head of FIG. 17;

FIG. 19 shows diagrammatically yet another method of forming the seam of this invention; and

FIG. 20 shows diagrammatically how, using the method and apparatus of this invention mandrels of different size may readily be substituted one for another on the one machine.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to FIGS. 1 to 5, ductile strip material, such as aluminum, 1 is formed to a corrugated configuration (see FIG. 2) by corrugating rollers (not shown) and in the last stages of its formation narrow edge ribs 2, 3 are formed by forming rollers 4. The strip then passes to another set of forming rollers 5 and the ribs 2 and 3 are pushed in by crushing rolls 6, 7 to make the ribs deeper and narrower.

The strip then passes to the next set of rolls 8 where the edge margins of the strip are turned down so that channels 11, 12 are formed in each edge, bounded respectively by downturned edge margins 13 and rib 2 and rib 3 and downturned edge margin 14. At the same time the bases of the channels are indented by the forms 9, to form convexities 10.

The strip is then perforated by perforating head 15 and is passed over an initial forming roller 16 to the forming head 17 where it is convoluted about mandrel 18 to form a tube 19.

As the strip is fed to the forming head 17 it passes between forming rolls 21, 22 and is coiled about mandrel 18 to a helical configuration with the edges of the strip in mating relationship.

For convenience of description the channel 11 will be referred to as a channel element and the channel 12 which is narrower and fits within the channel 11 will be referred to as a flange. As the strip is coiled about the mandrel with the flange 12 lying in the channel element 11 it passes beneath deforming rollers 23 which deform the ribs 2, 3 inwardly to partly close the mouth of the channel 11. A small backing roller 20 is let into the mandrel below the deforming rollers 23 to reduce friction. As the seam thus partly formed continues around the mandrel it again passes between the forming rolls 21, 22 at a position where the rolls are shaped to complete the inward deformation of the ribs and to crush the seam flat as shown in FIG. 9.

The final operation of closing the seam forms the flange to a generally T-shaped configuration with the edge 14 squashed down to form one arm of the T and the rib 3 squashed in to form the other arm of the T and with the shank of the T formed by the portion 3*a* of the rib 3. The two arms of the T are gripped in the inwardly facing channels formed by bending over the edge margin 13 and the rib 2, and are held within these channels (see FIGS. 9 and 10).

The formation of the seam in the the operation described above was carried out partly by the corrugating rolls and the crushing rolls 6, 7 and thereafter the seam was completed by mating the edges of the strip and bending the ribs 2, 3 by means of the deforming rolls 23 and the forming rolls 21, 22. Thus it will be seen that all of the initial steps in the formation of the seam are carried out before the two edges are brought together and that after mating of the edges, only the steps of bending in the ribs to form the two oppositely directed channels and pressing them down, are required to be performed. It will be observed also that the double locked seam is formed from channels which are only half the height of that which would be necessary for the formation of the double locked seam of our prior application No. 5,601/66. Thus there is substantially less stressing of the material in forming it about the coiling head. Furthermore, in view of the fact that only two operations have to be performed after the edges of the strip are brought together, these operations can be carried out with only two sets of forming rollers. Thus is is not necessary, as in the prior construction, to provide a large number of rollers positioned about the circumference of the forming mandrel. Because of the very much simpler construction of the forming head it becomes a relatively simple matter to substitute one forming head for another when it is desired to change from one tube size to another. This feature of the invention will be more fully described hereinafter.

The provision of the convexities 10 in the bases of the channels has the effect of eliminating wrinkling or buckling of the seam when the strip is convoluted about the mandrel. Without the convexity such wrinkling is likely to occur because of the distance of the mass of metal in the base of the seam from the neutral axis of curvature. The provision of the convexities reduces this effect. A further advantage derives from the fact that, as is best seen from FIG. 14, the flattening of the seam causes the ribs to tend to straighten out the convexity and, due to its elasticity, the convexity tends to spring back thereby forming a tighter seam.

A slight modification of the seam above described is shown in FIG. 10 of the drawings. In that FIGURE convexities 10 in the channels are not formed and the end portions of the forming rolls 21, 22 are shaped so that the final seam instead of being crushed flat is slightly bent about its longitudinal medial plane. This slight deformation of the seam alters the line of action of forces tending to open the seam and consequently leads to a somewhat stronger joint.

A further modification of the apparatus is shown in FIGS. 11 to 14. This modification is designed primarily for use in the manufacture of small diameter pipes say, of the order of 2 1/2 inches to 3 inches diameter. For such pipes it is not possible to inset the forming roller 21 into the bottom of the mandrel and also because of increased resistance to bending over the small diameter it is desirable for the deforming rollers 23 to be driven to help clear the tube from the mandrel. In this modification the forming roll 21 is omitted and the deforming rollers 23 are placed by a driven grooved forming roll 23A provided with a V-groove 30 to inwardly deform the ribs 2 and 3. Flattening down of the seam is done by a plain roller 31 provided at the end of the mandrel. As will be seen from FIG. 11, the roller 22, the mandrel 18 and the roller 23A are each arranged with respect to one another at an angle equal to the helix angle of the tube. The flattening roller 31 is however mounted on an axis parallel to that of the roller 22 with which it cooperates.

In another modification the mandrel 18 may be rotatable.

FIGS. 15 and 16 show in some detail the spiking mechanism of the apparatus of this invention. As in the construction shown in our previous application No. 5,601/66 the spiking

mechanism comprises a spiked roller and a backing roller. However, in this case instead of being arranged to spike the strip after the tube is formed, as in the preferred embodiment shown in our prior application, the mechanism is here arranged to spike the strip before it is convoluted about the mandrel. The backing roller **36** is mounted on the machine frame in front of the initial forming roller **16** and the spiking roller **37** is mounted above it on an axle **38** carried by a bracket **39** pivoted on a pivot pin **41** of the frame section **42** which carries the backing roller **36**. The bracket **39** is connected at its upper end to a ram and cylinder mechanism **43** which can be operated to pivot the bracket about the pivot **41** and thereby move the spiking roller **37** toward or away from the strip to render it operative or inoperative or to vary the degree of penetration of the spikes thereby varying the sizes of the holes formed.

FIG. **17** shows a modification of the forming head for forming the seam by the first of the above-mentioned alternative methods. FIG. **18** shows the steps in the formation of the seam by this method. In this method the strip is formed at one edge with a L-shaped flange **51** and in the other edge with a U-shaped channel element **52** the channel element in this case being formed such that its open mouth is inwardly directed with respect to the formed tube. As the strip is fed to the mandrel the L-shaped flange **51** is mated with the channel element **52** and as the strip passes around the mandrel it passes between nipping-in rollers **53** which nip-in the base of the channel to partially close its mouth as shown at A in FIG. **18**. As the seam passes further around the mandrel it is finally flattened by the forming rollers **21, 22** as in the previous construction. The steps in the formation of the seam by the second alternative method are shown diagrammatically in FIG. **19**. In this method the edges of the strip are formed so that in one edge there is a pair of ribs **61, 62** which are outwardly directed with respect to the tube and in the other edge there is a pair of channels **63, 64** formed with their mouths facing inwardly with respect to the tube. As the strip is convoluted about the mandrel the ribs **61, 62** are first mated with the channels **63, 64** as shown at A in FIG. **19**. The channels are next spread apart as shown at B in FIG. **19** and finally they are flattened down to form oppositely directed channels with the arms of the flange **61, 62** locked within them as shown at C in FIG. **19**.

It will be seen with the resultant seam formed by either of the methods of FIGS. **18** and **19** is the same and also that the seam is substantially the same as that formed by the method illustrated with reference to FIG. **9** of the drawings except that in the latter case the body of the seam lies within the tube whereas in the two former cases the body of the seam lies on the outside of the tube. Also in the construction shown in FIG. **9** each arm of the flange is of double thickness since it is formed from an element which is originally channel shaped whereas in the constructions shown in FIGS. **18–19** the free arm of the flange is of single thickness the flange having been formed from an original L-shaped element. It would be readily apparent however that the double thickness portion can easily be omitted from the construction shown in FIG. **9** and likewise that the free arm of the flange shown in FIGS. **18** and **19** can be of double thickness rather than single thickness.

The seam according to this invention and its method of formation have enabled us to produce apparatus in which the substitution of one mandrel for another when a different-sized tube is to be produced can be carried out relatively simply. This is illustrated in FIG. **20** of the drawings where illustrations (*a*), (*b*) and (*c*) show medium-sized, small-sized and large-sized mandrels respectively which can all be secured to the same basic forming head **17** in a simple operation. That this can be done is due to the fact that the formation of the seam is carried out at only two locations about the periphery of the mandrel. At the first location a pair of forming rollers

(such as those shown as **21** and **22** in FIGS. **7** and **8**) are mounted on the machine frame and are common to all sizes of mandrel. The forming means at the second location comprise the angled deforming rollers **23** and the surface of the mandrel itself or alternatively the backing roller **20** (see FIG. **8**). The deforming rollers **23** are carried on the bracket **70** which is bolted to the mandrel **18** and the mandrel **18** itself is secured to the frame **71** of the coiling head by means of bolts **72**.

It will thus be seen, particularly by reference to FIG. **20**, that to change from one sized mandrel to another all that is necessary is to undo the bolts **72**, remove the existing head and substitute a new one. Since the roller **21** is located within the cavity **73** in the mandrel but is not attached to the mandrel it, and its cooperating roller **22**, will not be disturbed by this changeover operation. It is thus possible in the construction according to this invention to change from one mandrel size to another merely by changing the mandrel and its associated forming rollers (such as **23**) without the necessity for any adjustment of the other forming means **21, 22**.

The seam and the method of apparatus for its construction provided by this invention provides a strong and reliable seam and one which can be made on apparatus in which the substitution of one forming head for another can readily and rapidly be carried out without the complicated and delicate adjustment of the forming means which was necessary in the construction according to our prior application No. 5,601/66. It will also be seen that according to this invention the major proportion of the seam-forming operation is carried out before the strip reaches the mandrel. The apparatus is accordingly more easily and readily controlled and adjusted than was the case in the previous construction.

We have described above a number of alternative methods for the formation of the seam according to this invention and also a number of modifications which may be made to the apparatus for the construction of the seam. It will be appreciated however that other variations and modifications could be made to the method and apparatus within the scope of the invention as defined by the following claims.

I claim:

1. A tube formed from helically wound ductile strip material with adjacent edges of the strip joined together by a locked seam wherein said locked seam comprises a pair of generally oppositely directed channels formed in one edge of said strip and disposed on opposite sides of a longitudinal medial plane of the seam with their mouths facing, and a complementary flange of generally T-shaped cross section formed in the other edge of said strip with its arms disposed one within each of the said channels.

2. A tube as claimed in claim **1**, wherein the channels are directly facing one another and the arms of the flange are substantially coplanar.

3. A tube as claimed in claim **1**, wherein the channels are disposed to face slightly outwardly of the tube and their directions of facing intersect at an included angle slightly less than 180°, the arms of the flanges being correspondingly angled.

4. A tube as claimed in claim **1** wherein the shank of the flange lies approximately on a longitudinal medial plane of the seam and is disposed transverse of the elongate dimension of the tube.

5. A tube as claimed in claim **2** wherein the shank of the flange lies approximately on a longitudinal medial plane of the seam and is disposed transverse of the elongate dimension of the tube.

6. A tube as claimed in claim **3** wherein the shank of the flange lies approximately on a longitudinal medial plane of the seam and is disposed transverse of the elongate dimension of the tube.

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