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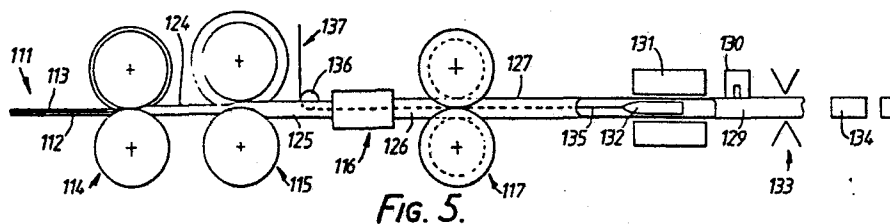
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London WC1N 2DD(GB)(54) **Method and apparatus for manufacturing plain bearings.**

(57) A method and apparatus for forming plain bearings from a bearing strip consisting of a metal backing and a lining of bearing material. The apparatus comprises a series of tube forming rolling mills (114, 115, 116 and 117) arranged to roll the strip (111) to a part cylindrical form; a closed pass forming die (131) having an internal mandrel (132) arranged

to form the rolled strip (127) to a final tube configuration (129); a drawing mechanism arranged to draw the strip/tube through the rolling mills and die; and a severing mechanism (133) arranged to cut the formed tube (129) in to lengths (134).

**Fig. 5.**

METHOD AND APPARATUS FOR MANUFACTURINGPLAIN BEARINGS.

5. The present invention relates to the manufacture of plain bearings, particularly semi-cylindrical shells and cylindrical bushes.

10. Some of the known methods of forming semi-cylindrical bearing shells include coining or bend punching. These methods suffer the disadvantage that it is often difficult to avoid an increased thickness along the axial edges. Furthermore, if an overlay is required, this can only be applied in practice after the forming operation and therefore requires a relatively complicated jigging and plating operation.

15. If cylindrical bushes are required this generally necessitates wrapping a blank, either from flat or from a part cylindrical form around a mandrel. Again, it is difficult to avoid increased wall thickness at the joint line.

20. In all these known methods, the forming operations are generally performed on individual blanks. Thus, the production rates of which these methods are capable are limited and are generally subject to problems with the precise location of the individual blanks for the forming operations.

25. In another known method, blanks are partially severed from a strip and progressively formed in successive stages prior to final severing. While this method simplifies precise location, the progressive machine tooling is expensive.

30.

It is an object of the present invention to provide a simple and inexpensive method of producing plain bearings with constant thicknesses and one in which plating can be carried out prior to forming.

5. It is a further object to provide a method of producing bearing blanks at a higher rate of production than previously attained.

- According to one aspect of the invention, there is provided a method of manufacturing plain bearings
10. from a bearing strip (11) in the form of a metal backing (12) having a lining (13) of bearing material, the method comprising forming the strip into a cylindrical tube or part-cylindrical form (29) and subsequently cutting formed strip (29) to the required lengths,
15. characterised in that the forming step comprises drawing the strip (11) through a forming die (14).

- The leading end of the strip may be preformed to allow it to enter the die and the die and strip may be subjected to ultrasonic vibration in order to assist
20. its passing through the die, though this is not essential. However, if high reductions are required, 50% ultrasonic vibration could be used to reduce the load and hence reduce the possibility of the tube fracturing. For small dies, the length of the die may be relatively
25. short, for example from 2 to 5 times the diameter of the finished tube, but for larger sizes the length may be as little as $\frac{1}{4}$ the diameter.

- In a preferred method according to the invention, the method comprises passing the strip through a
30. tube rolling apparatus and subsequently drawing the rolled strip through a die. The formed strip is then

cut to the required lengths.

Such methods may be capable of producing very large quantities of bearings at a very high rate to an accuracy which is expected to be higher than that normally achieved by coined bushes and without the need to resort to expensive progressive machine tooling. Thus the strip may be finished to size on the internal and external diameter.

5. The backing may be steel, copper, bronze, aluminium or an alloy of aluminium. The lining may be a soft metal alloy such as aluminium/tin, aluminium/lead, copper/lead, aluminium/silicon/tin, aluminium/silicon/zinc or may be a plastics material such as polytetrafluoroethylene (PTFE), polyphenylene sulphide (PPS), polyetheretherketone (PEEK), or alloys of these materials e.g. PTFE/PEEK/graphite/
10. bronze. Other materials may of course be used for the backing and for the lining and the lining may be coated with an overlay.

- The formed strip may be fully cylindrical or partly cylindrical, in particular semi-cylindrical. In the case of semi-cylindrical form, two sections are preferably drawn through the die together to form a cylindrical tube. A major advantage of drawing two halves together as a tube is that it allows simple circular tooling and the possibility of finishing to wall and peripheral length in one operation.
20. 25.

Thus, the method may produce close wall tolerance half bearings to finished wall thickness without creating joint face swell, thus allowing for thinner linings and may be capable of operating at high production rates.

30. Another advantage of this method may be the elimination of jigging and plating of the half bearings since the option of strip plating or casting on an overlay is viable.

The rolling apparatus preferably comprises a series of tube forming mill stands. There may be as few as three or as many as fifteen or more, particularly in the case of relatively thick-walled, fully cylindrical bushes. Not all of the rollers in the roll stands need be driven and so some or all may be idler rolls, though these may have a shaping function.

The apparatus may also include a device for attaching a tab or other protrusion to the outside of the formed strip which can serve, in the finished bearing, as a means for accurately locating the bearing in its housing. The tab may be attached by any suitable means such as stud-welding, spot welding, electron beam or laser beam welding, or by an adhesive. The attachment operation can be carried out simply and at accurate spacings as the formed strip leaves the forming apparatus prior to severance. Such an operation is easier to perform than the presently generally used operation in which a nick is punched from the inner surface of formed bearings, and lends itself to the process of the invention since separate formed bearings do not need to be accurately positioned individually for the operation to be performed. Furthermore, the bearing surface of the formed bearing remains unaffected.

25.

The strip may be drawn to form the finally formed tube in a closed pass, in which the final sizing/shaping die includes an internal mandrel, or in an open pass, in which the die has no internal mandrel. The strip may be lubricated prior to drawing.

5.

However, the die is preferably a cylindrical carbide die with a conical inlet form over an internal plug. Constraining both inner and outer surface whilst carrying out cold work, may be the means by which high wall thickness tolerances can be achieved.

10.

With such a system, the initial and replacement tooling cost can be quite low and since wear of the carbide die is slow it tends to have a long life. As the die reaches top limit it can be refurbished for the next larger size so increasing its useful life further.

15.

Preferably, the finished blanks are severed by means of cutting rollers having helical cutting edges, which are caused to rotate about the formed tube thus pulling the tube past the cutting rollers and progressively severing the finished blanks. Alternatively, parting off the tube could be achieved by bar feed autos.

20.

In an alternative drawing operation, the tube may first pass through a die in an open pass that causes the outside diameter of the tube to be reduced, though the bore may still be larger than that of the final bush.

25.

The tube may then be drawn through a second die in a closed pass, i.e. with an internal mandrel. The outside diameter may thus be reduced further and the bore constrained by the mandrel.

5. The tube may be drawn by a system of two continuously reciprocating jaws which grip the tube alternately; these may be driven by hydraulic rams to give continuous motion.

- With such a system, the tube may be cut into lengths by means of a flying saw. These may be accelerated away
10. and transferred to a run-out table. Subsequently they may be formed into bushes of the required length.

The invention also extends to apparatus for carrying out a method in accordance with the invention.

- The invention may be carried into practice in
15. various ways and some embodiments will now be described by way of example with reference to the accompanying drawings, in which:-

20. FIGURE 1 is a simplified schematic axial vertical section through forming apparatus in accordance with the invention;

FIGURE 2 is a simplified schematic side view of one embodiment of drawing apparatus;

25. FIGURE 3 is an end elevation of another embodiment of apparatus for drawing and severing mechanism for the blanks;

FIGURE 4 is a section on the line IV-IV in FIGURE 3 with some parts omitted for clarity;

30. FIGURE 5 is a simplified schematic axial vertical section through forming apparatus in accordance with another embodiment of the invention;

FIGURES 6 to 9 are transverse vertical sections through four successive rolling stands in which the vertical separation of the rollers is exaggerated for the sake of clarity;

5. FIGURE 10 is a simplified vertical section through an alternative die arrangement, and

FIGURES 11 to 15 are schematic views showing sequential stages in the operation of an alternative form of drawing apparatus.

10.

- Referring firstly to Figure 1, a bearing strip 11, comprising a steel backing 12 and a lining 13 of copper/lead is introduced to a carbide die 14 located in a steel housing (not shown) and drawn through by means to be discussed in more detail below.
- 15.

- The die 14 has a tapered entry portion 15 which tapers down to a cylindrical final forming surface 16. An elongate plug or mandrel 17 is located in the bore thus defined and is fixed relative to the die 14. Although shown as extending beyond the upstream end of the die 14, the mandrel 17 may begin within the die 14. The die 14 and plug 17 are polished to a high finish. Ultrasonic vibration apparatus 18 is located around the die which may optionally be used to assist in the passage of the strip 11 through the die 14.
- 20.
- 25.

- As the strip 11 enters the die 14 it is progressively wrapped around the plug 17 until the fully cylindrical tube form 29 is achieved as the formed strip leaves the die.
- 30.

One way in which the strip 11 can be drawn through the die 14 is shown schematically in Figure 2.

In the embodiment of Figure 2, the die 14 is mounted on a draw bench 21. A gripper unit 22 having self-gripping jaws shown diagrammatically at 23 grips the end of the tube form 29 and is pulled along the draw bench 21 by suitable means such as a hook 24 the gripper unit 22 engaging a draw chain 25 in the draw bench 21. Drawing speeds of perhaps 5 to about 30 metres per minute may be achieved with such an arrangement. A tab attachment device 130 may be provided.

After a length of strip 11 has been drawn, the tube 29 so produced is cut to the desired length to give finished bushes. Using a drawing rate of 5.5m/min it should be possible to produce 15,000 bushes per hour of 20mm nominal length with 5% allowance for parting off etc. There is no indication, however, that this is the maximum drawing speed attainable.

It will be appreciated that this particular embodiment is not ideally suited to continuous operation. The embodiment shown in Figures 3 and 4 however is intended for continuous operation and makes use of a mechanism for both drawing the tube 29 and severing finished bushes 34.

The mechanism comprises a cylindrical frame 41 which houses three equi-spaced cutting rollers 42. The frame 41 is rotatably mounted about its axis on idle wheels 43 and the cutting rollers 42 are rotatable mounted in the frame 41 about axes generally parallel to that of the frame 41 in bearings 44.

The cutting rollers 42 are each formed with a helical cutting edge 45 whose pitch is equal to the desired length of the finished bushes 34. The depth of each cutting edge 45 gradually increases along its length until it is slightly greater than the thickness

of the strip 11.

- In operation the finished tube in its final cylindrical form 29 is introduced along the axis of the frame 41 and between the three cutting rollers 42 until it encounters the cutting edges 45. At the same time, the frame 41 is rotated on the idle wheels 43 by means of a toothed belt (not shown) co-operating with a rack 46 extending around the perimeter of the frame 41. This causes the cutting rollers to travel around the tube 29 and to rotate about their axes thus drawing the tube 29 in the direction of arrow A in Figure 4. At first, the tube encounters the shallowest part of the cutting edges 45 and as it progresses through the frame 41 the cutting edges 45 bite deeper until a finished blank 34 is severed.

- It will be understood that the relative positions of the three cutting edges 45 will be synchronised so that all three contribute to each single cut in the tube 29. The radial (with respect to the frame 41) positions of the cutting rollers 42, and hence their proximity to the tube 29 are adjustable by means of hand wheels 47 which are connected to the bearings 44 and are threaded through the frame 41.

- In an alternative construction, the cutting edges 45 may be of constant depth but the cutting rollers may be inclined with respect to the axis of the frame 41 so that the extent of their penetration increases as the tube is drawn through the frame 41.

- In another alternative construction, a pair of preforming rollers may be employed upstream of the die 14 to give a small amount of curvature to the strip 11 to aid drawing.

Where half-cylindrical bushes are to be manufactured the finished tube or bushes may be split. More preferably, however a pair of half strips are fed to the die 14, one on either side of the plug 17. These are then

5. drawn together to form effectively a cylindrical tube in two halves which can then be cut to length as required.

This embodiment of the invention will now be further illustrated by the following non-limiting examples.

EXAMPLE 1.

10. This example illustrates the production of fully cylindrical bushes using the apparatus of Figures 1 and 2.

- A strip of bimetal 1.5mm thick comprising a steel backing lined with an alloy of copper 70% and lead
15. 30% was slit to a width of 62mm. The end was swaged and was then inserted into a highly polished carbide die located in a steel housing, the die having a tapering entry portion followed by a cylindrical final form. The diameter of the die was 19.44mm and
20. a polished steel plug having a diameter of 16.74mm was located in the die, around which the swaged strip was located.

- The strip was gripped on the far side of the die by a self-gripping device in a gripper unit mounted
25. on a draw bench. The gripper unit was pulled by a chain driven by an electric motor at 5.5m/min and the passage of the strip through the die was assisted by an EP lubricating oil. Individual bushes were cut from the tube produced.

30. A visual inspection revealed a high finish on both internal and external surfaces.

EXAMPLE II

This example illustrates the production of half bushes using the apparatus of Figures 1 and 2.

- In this case, the procedure of Example 1 was
5. repeated but two similar strips 31mm wide were swaged and introduced into the die. After drawing, individual half-bushes were cut off and again both internal and external surfaces exhibited a high finish.

- Another embodiment of the invention is shown
10. in Figures 5 to 9.

- Referring firstly to Figure 5, a bearing strip 111, comprising a steel backing 112 and a lining 113 of copper/lead is passed through successive roll stands 114, 115, 116, 117. As shown in Figures 6 to
15. 9, the strip is formed in four corresponding stages 124, 125, 126, 127 to a cylindrical form 127 which is practically closed, having only a small gap 128.

- In the first roll stand 114, the upper roll engages the lining surface 113 and the lower roll acts on
20. the backing 112 to bend particularly the outer edges of the strip 111 to form the curved section shown as 124. In the second roll stand 115, the upper roll again engages the lining surface 113 and the lower roll on the backing 112, but in this case,
25. the upper roll bends the centre of the bent strip 124, forming it further to the section 125.

- In the third roll stand 116, the rolls are arranged horizontally and both act on the backing surface 112, thus bending the strip 111 to the near cylindrical
30. section 126. Finally, in the fourth roll stand 117 the two rolls combine to close the section 126 into the almost fully cylindrical form 127, leaving only a small gap 128.

- Referring back to Figure 5, the final forming and sizing stage comprises a die 131 having an internal mandrel 132. The almost cylindrical form 127 is passed through the die 131 while the mandrel 132 effectively
5. passes along the inside of the almost cylindrical form 127, though of course, the mandrel 132 is maintained stationary with respect to the die 131, by means of a wire or chain 135 which is secured to the apparatus, possibly via a pulley 136 or the like, located somewhere
10. between the second roll stand 115 and the fourth roll stand 117 as shown diagrammatically at 137. This gives the final cylindrical form 129. Alternatively, the mandrel 132 is secured to a bar which is attached to the apparatus via a screw thread connecton for adjustability.
15. This is then cut at 133 to the required lengths, given the finished bushes 134.

- Although this embodiment is shown as having four roll passes, it will be appreciated that a greater number may be provided and any or all or none of the
20. rollers may be driven. Furthermore, the mandrel 132 may be omitted.

The severing mechanism may be similar to that described with reference to Figures 3 and 4.

- An alternative arrangement for the die-forming
25. operation is shown in Figure 10, in which the tube 211 moves in the direction of the arrow B.

- The apparatus comprises a sinking die 212, a drawing die 213 and a mandrel 214 supported by a shaft 215 so that it is operatively located within the drawing
30. die 213.

In operation, the partly-formed tube 211 passes through the sinking die 212 which causes the outside

diameter to be reduced, though the internal diameter is still larger than the required bore of the finished bushes. The tube 211 is then drawn through the drawing die 213 and over the mandrel 214. The outside diameter is reduced still further but the internal diameter is constrained by the mandrel 214. This leads to cold work being performed on the tube enabling closer tolerances to be maintained.

5. The tube 211 may be drawn by an alternative form of drawing apparatus illustrated schematically in Figures 10. 11 to 15 in which motion of the tube 211 is in the direction of the arrow C in Figure 11.

- The apparatus comprises a pair of crossheads fitted with clamping jaws 221,222 arranged to grip 15. the formed tube 211. The crossheads and jaws 221,222 are driven reciprocally by a pair of hydraulic rams (not shown). The gripping and releasing of the tube by the jaws 221,222 are synchronised with respect to their motion to produce continuous linear movement 20. of the tube 211.

- In figure 11 the tube 211 is gripped by the jaw 221 as it is moving to the right. At the same time, jaw 222 has released the tube 211. The jaw 221 pulls the tube 211 to the right as shown in Figure 12 while 25. the jaw 222 moves to the left. The jaw 222 then reverses its direction and grips the tube 211 as shown in Figure 13, and the jaw 221 releases the tube 211. The jaw 222 continues to pull the tube 211 to the right while the jaw 221 moves to the left as shown in Figure 14. 30. Finally, as shown in Figure 15, the jaw 221 reverses its direction and grips the tube 211, and the jaw 222 releases the tube 211.

This cycle is repeated continuously.

- With such an arrangement a flying saw 223 is provided as shown schematically in Figure 13. The saw 223 is mounted on a linear bearing slide 224 and
5. is arranged to cut the tube 211 into lengths of for example 3 metres on the fly. Saw jaws 225, 226 are arranged to grip the tube 211 on each side of the saw 223 causing the saw unit to travel with the tube whereupon the saw 223 cuts the tube 211. A pair of
10. accelerator rolls (not shown) move the cut lengths away onto a run-out table. In the meantime, the saw 223 resets and returns to its start position.

This system can produce tube at a rate of 15m/min with a wall thickness tolerance of 0.025mm or better.

15. In order to start up this operation for example when a new strip is to be formed, the strip is first tapered to a point and a drawbar is welded to this end. The drawbar is inched through the machine by the second jaws 222 until the formed tube 211 has
20. passed the first jaw 221. The first jaw 221 is then made to grip the tube 211 and the tube 211 is inched forward, while the second jaw 222 is inched back, until the drawbar has passed the saw 223. The operator can then cut off the drawbar and the leading end of
25. the tube 211 and begin normal operation.

CLAIMS.

1. A method of manufacturing plain bearings from a bearing strip (11) in the form of a metal backing (12) having a lining (13) of bearing material, the method comprising forming the strip into a cylindrical tube or part-cylindrical form (29) and subsequently cutting formed strip (29) to the required lengths, characterised in that the forming step comprises drawing the strip (11) through a forming die (14).
2. A method as claimed in Claim 1 characterised in that on starting up, the leading end of the strip is preformed to allow it to enter the die (14) and the die (14) and the strip (11) are then subjected to ultrasonic vibration during forming in order to assist the passage of the strip (11) through the die (14).
3. A method as claimed in Claim 1 or Claim 2 characterised in that, prior to passing through the die (131), the strip (111) is passed through a tube rolling apparatus in the form of a series of tube forming mill stands (114,115,116,117).
4. A method as claimed in any preceding claim characterised in that the strip conveyed to the die is in two parts whereby two sections are drawn through the die together to form a cylindrical tube in two halves.

5. A method as claimed in any preceding claim characterised in that the die forming operation comprises passing the tube through a first die (212) in an open pass and subsequently passing the tube through a second die (213) in a closed pass.

10. 6. A method as claimed in any preceding claim characterised in that the tube (211) is drawn by a system of two continuously reciprocating jaws (221,222) which grip the tube (211) alternately.

15. 7. A method as claimed in Claim 6 characterised in that the tube (211) is cut into lengths by means of a flying saw (223).

20. 8. A method as claimed in any of Claims 1 to 4 characterised in that the finished blanks (34) are severed by means of cutting rollers (42) having helical cutting edges (45) which are caused to rotate about the formed tube (29) thus pulling the tube (29) past the cutting rollers (42) and progressively severing the finished blanks (34).

25. 9. Apparatus for forming plain bearings (134) from a bearing strip (111) consisting of a metal backing (112) and a lining (113) of bearing material, which comprises a forming mechanism arranged to form the tube into a cylindrical or part-cylindrical form and a severing mechanism (133) arranged to cut the formed
30. tube (129) into lengths (134) characterised in that the forming mechanism includes a tube rolling station (114,115,116,117) arranged to roll the strip to a part-cylindrical form (127); a die forming station (131) arranged to form the rolled strip (127) to a final

drawn configuration (129); and a drawing mechanism arranged to draw the strip through the tube rolling and die forming stations.

5. 10. Apparatus as claimed in Claim 9 characterised in that the tube rolling station comprises a plurality of tube forming mill stands (114,115,116,117).

10. 11. Apparatus as claimed in Claim 9 or Claim 10 characterised in that the die forming station comprises an open-pass die (212) and a subsequent closed-pass die (213).

15. 12. Apparatus as claimed in any of Claims 9 to 11 characterised in that the drawing mechanism comprises a pair of continuously reciprocating jaw members (221,222) arranged to grip the drawn strip (211) alternately.

20. 13. Apparatus as claimed in any of Claims 9 to 12 characterised in that the severing mechanism is a flying saw (223) arranged to move in synchronism with the drawn strip (211) during its severing operation.

25. 14. Apparatus as claimed in any of Claims 9 to 13 characterised by accelerator rolls arranged to convey the severed lengths of formed strip on to a run-out table.

30. 15. Apparatus as claimed in any of Claim 9 to 14 characterised by a device for attaching a tab to the outside of the formed strip.

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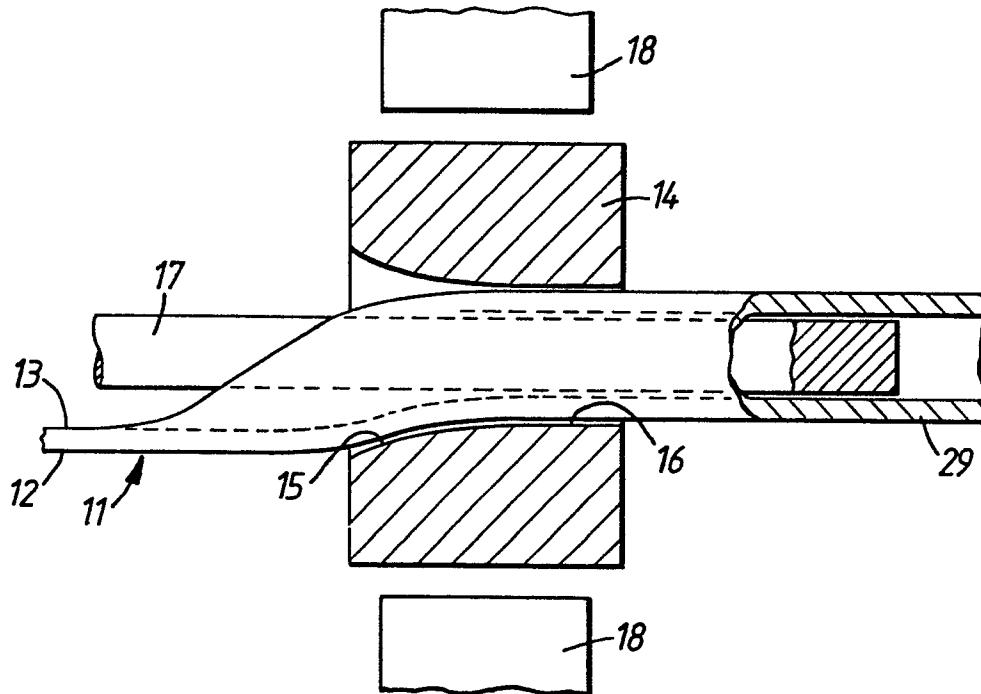


FIG. 1.

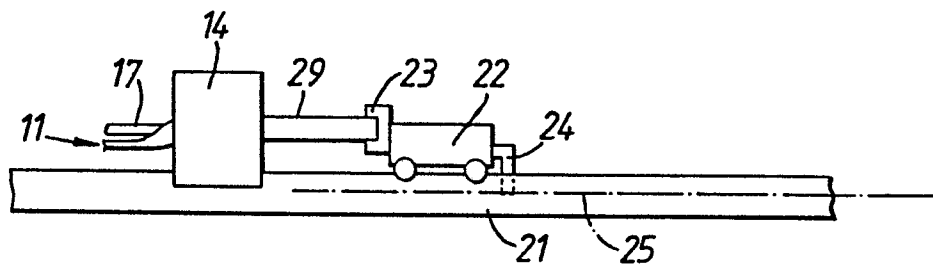


FIG. 2.

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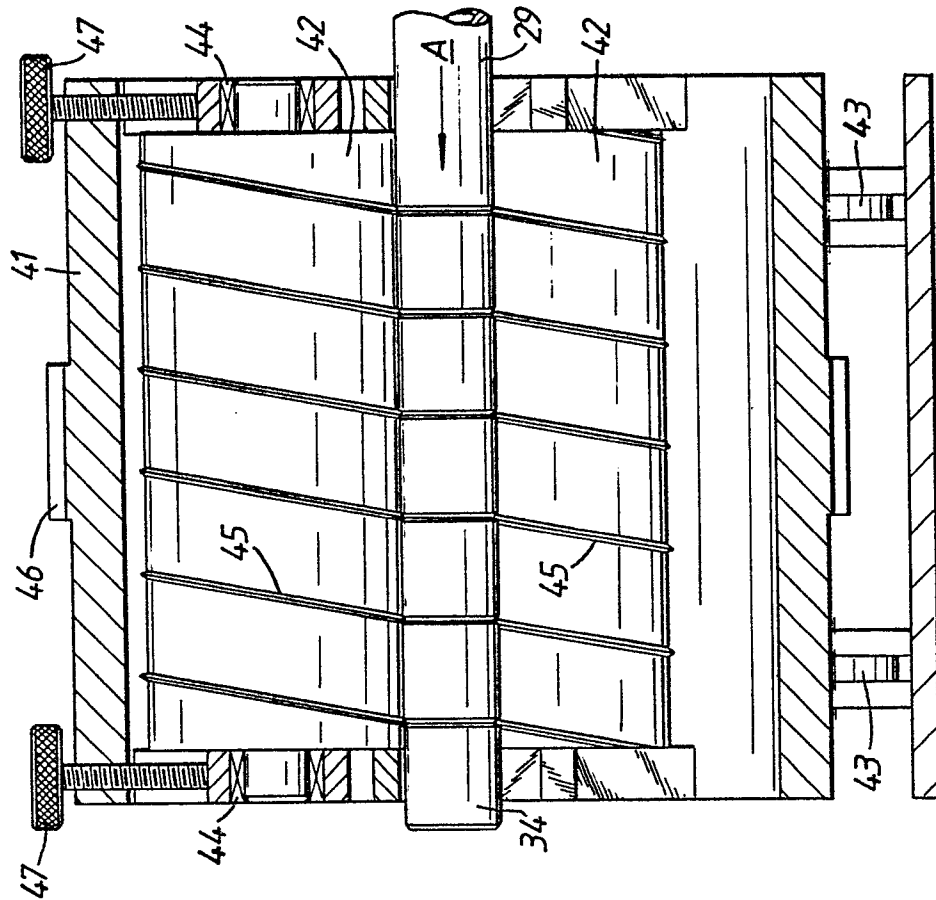


FIG. 4.

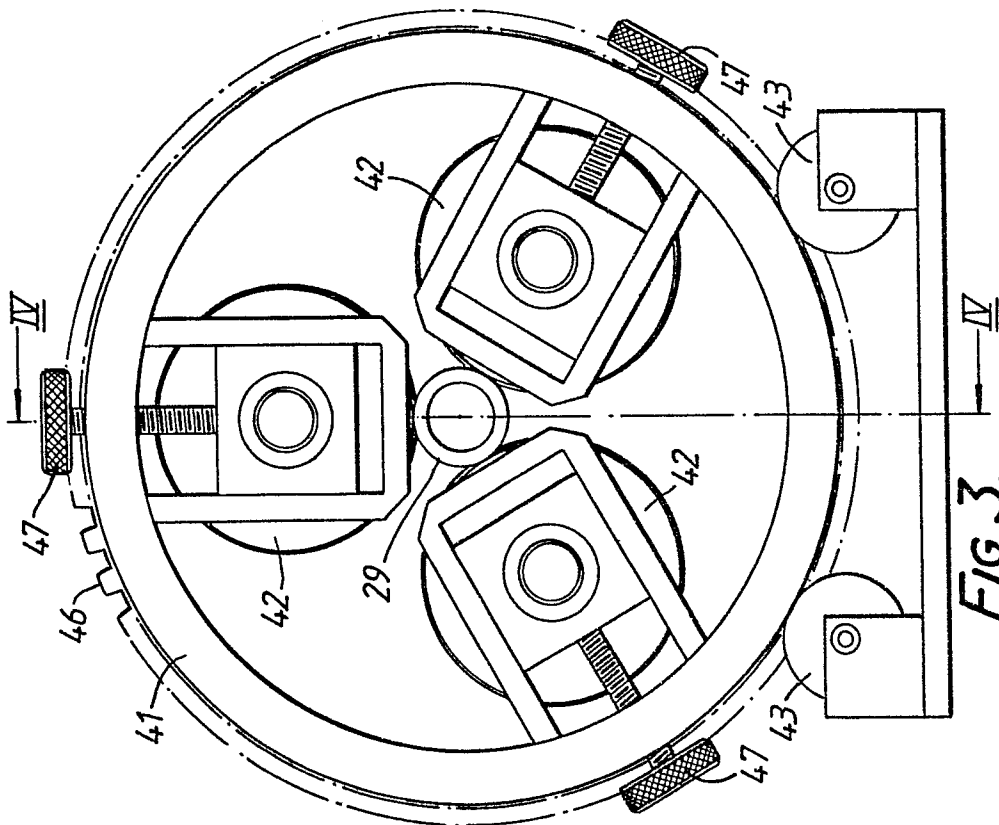
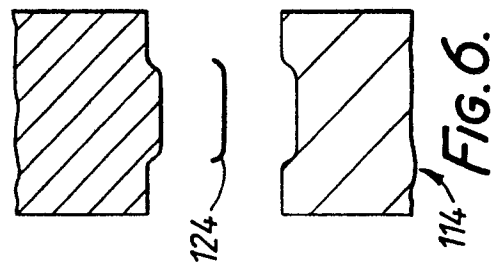
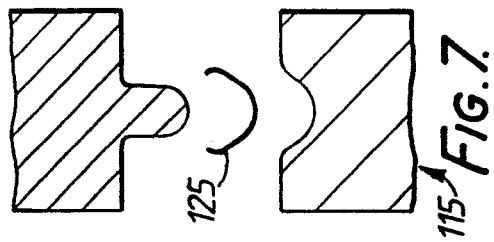
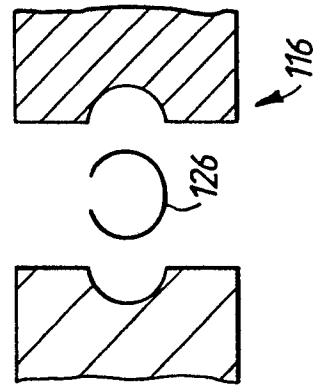
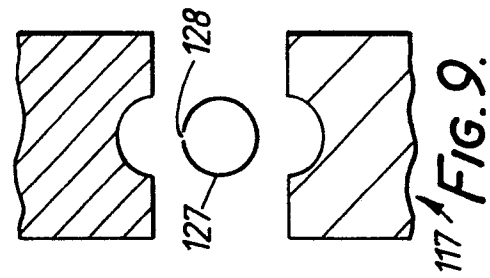
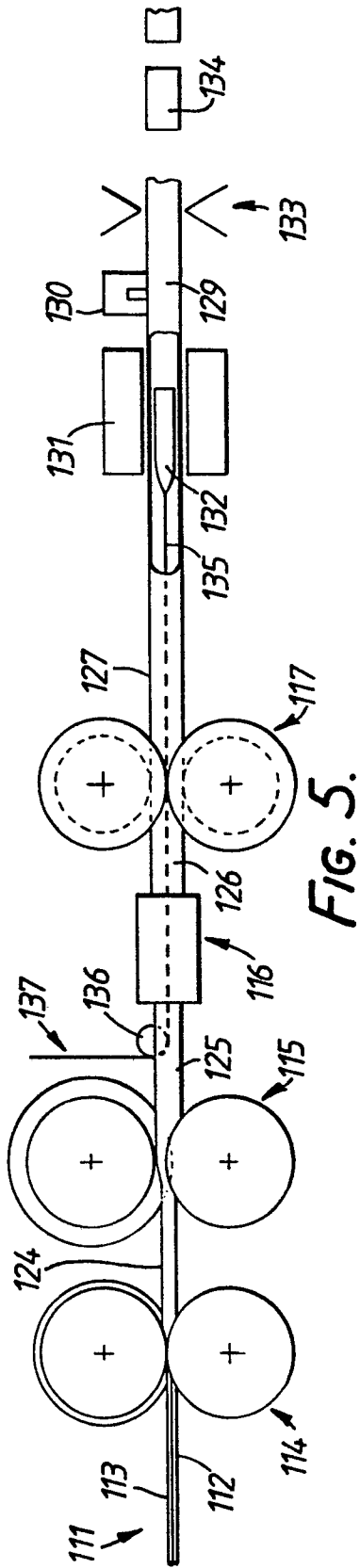


FIG. 3.

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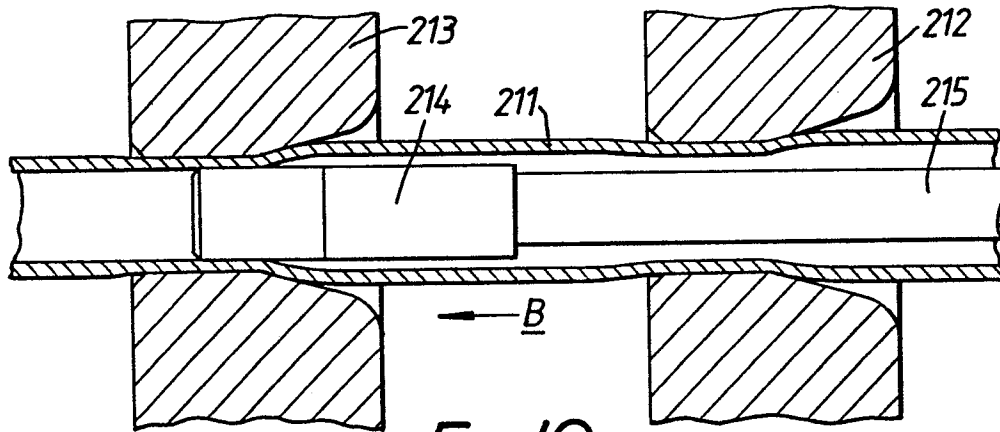


Fig. 10.

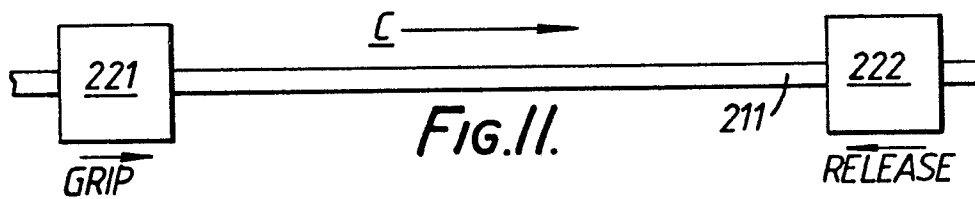


Fig. 11.

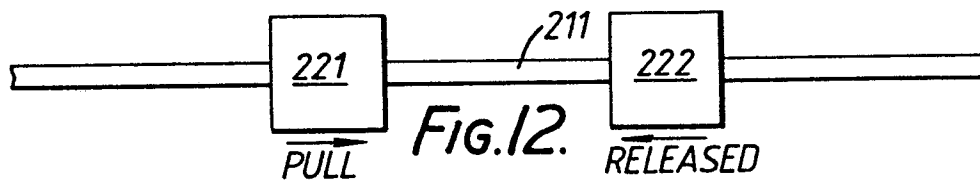


Fig. 12.

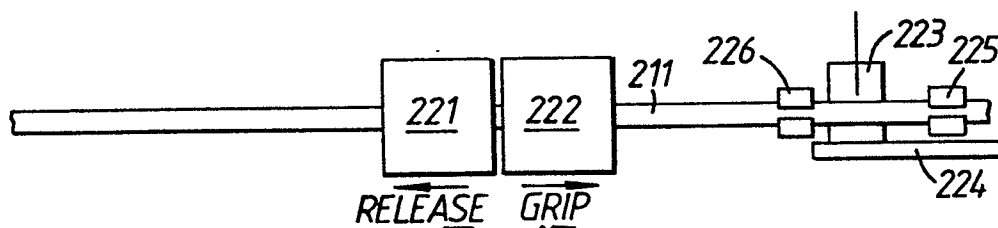


Fig. 13.

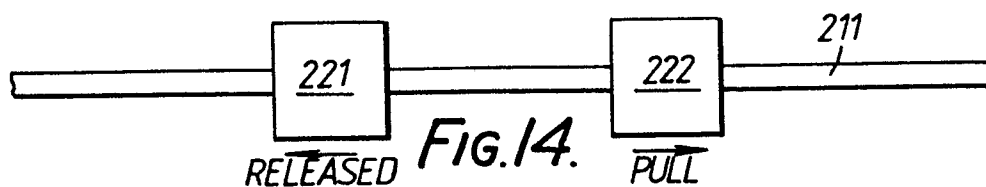


Fig. 14.

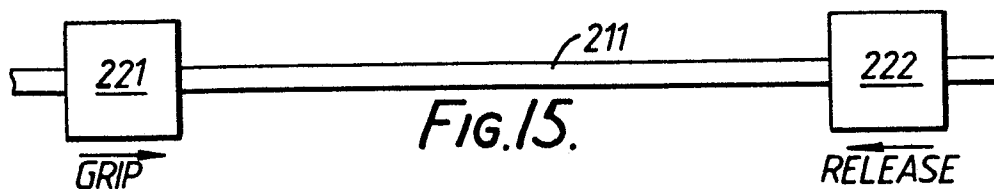


Fig. 15.