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(54) Wire straightening apparatus

(57) A rotary member (12) for apparatus for straightening elongate material such as wire has an elongate housing (34; 234) and a plurality of deflection members (37-39, 112, 114; 237, 238, 312, 314) for engaging wire being fed through the housing. This engagement displaces the wire radially with respect to the housing axis so that the feeding of the wire through the housing while the latter is rotating helps to straighten the wire. The member is characterised in that the housing is hollow and contains the deflection members, and in that the member includes retaining means (160, 162; 360, 362) for retaining the deflection members in the housing. The advantage of such a rotary member is that deflection members can be removed simply by removing the retaining means, ie without dismantling the housing. Preferably, the rotary members directly engage the housing so that the housing can angularly and axially locate the members therein. This is particularly advantageous since it facilities the provision of means of providing radial adjustment of the radial members. Wire straightening apparatus comprising a pair of such rotary members and drive means for counter-rotating the rotary members is also shown, as is a wire bending machine having the wire straightening apparatus and feed means for feeding the wire through the apparatus and to a bending head (1).

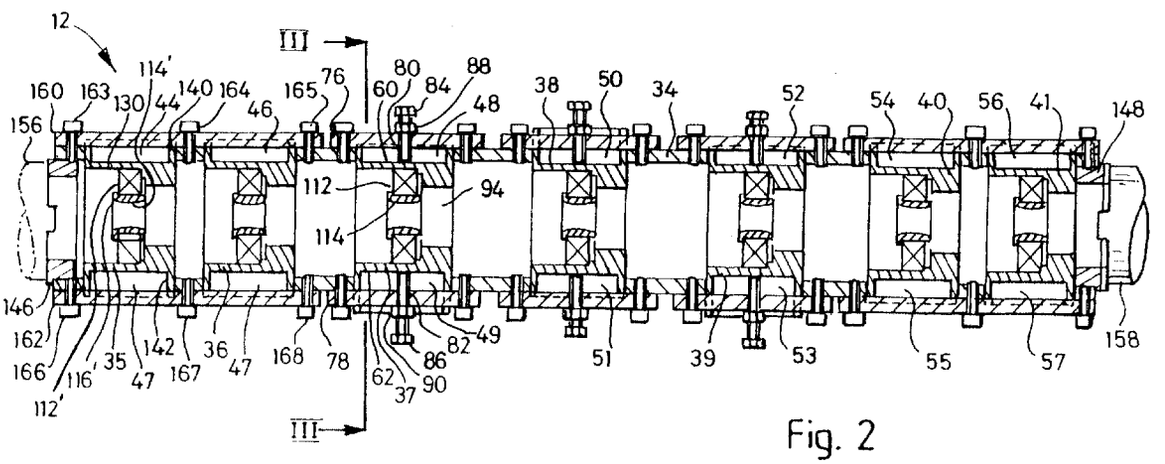

Fig. 2

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Description

Field of the Invention

This invention relates to apparatus for straightening elongate material, for example wire or tubing, to a rotary member for such apparatus, and to a wire bending machine fitted with such apparatus.

Background to the Invention

There are various different types of wire bending machine in which wire is fed through a bending head from a coiled or rolled stock. Such machines also incorporate wire straightening apparatus, interposed between the coiled stock and the bending head, for straightening the wire from the wire stock so that the bending head can bend the wire into the desired shape. Other types of wire bending machines have one or more bending heads which are supplied with pre-cut lengths of wire, and do not therefore include wire straightening apparatus. However, if the wire is initially stored on a coiled or rolled stock, it has to be passed through wire straightening apparatus before the pre-cut lengths can be formed.

One known type of wire straightening apparatus is used in the CNC-8 Omni-Forming Centre produced by Pave Automation Design and Development Limited. That apparatus comprises a pair of counter-rotating rotary members (or "spinners") through which the wire is passed. The rotary members cause radial deflection of the wire as it passes therethrough, resulting in the wire travelling along a generally helical path through each rotary member.

Each rotary member is formed from a number of annular sections which are bolted together by a number of bolts extending through all the sections. Consequently, the removal of one of the sections, for repair or replacement, can involve releasing some or all of the other sections from the bolts, and thus, in effect, can result in the dismantling of the entire rotary member.

Summary of the Invention

According to a first aspect of the invention, there is provided a rotary member for apparatus for straightening elongate material, the member comprising a hollow elongate housing, a plurality of deflection members for engaging wire being fed through the housing so as to displace the wire radially with respect to the housing axis, and retaining means for retaining the deflection means in the housing.

By providing a housing which is separate from the deflection members, the deflection members can be removed simply by removing the retaining means, i.e. without dismantling the housing. In addition, since the housing is hollow, it can have a relatively low weight, and hence moment of inertia, compared with a rotary member formed from annular sections. The low moment of inertia facilitates the angular acceleration and braking of the rotary member in use, and hence reduces the wear and tear on the member resulting from the acceleration and braking.

Preferably, the housing includes a plurality of axially spaced apertures, each of which is in registry with a respective deflection member, and is so dimensioned as to allow the respective deflection member to be inserted into or removed from the housing therethrough.

Consequently, each deflection member can, on removal of the retaining means, be removed from or inserted into the housing independently of the other deflection members.

Preferably, adjacent deflection members are axially spaced within the housing. The space in the housing between adjacent deflection members can accept, for example, dirt or debris which results from the engagement of the deflection members with the wire, and which would otherwise impair the performance of the deflection members.

Preferably, the housing is cylindrical.

Preferably, each said aperture is one of a respective pair of diametrically opposed apertures.

Preferably, the retaining means comprises bar means releasably attachable to the exterior of the housing so as to extend across the apertures, and the deflection members are so shaped that they matingly engage the bar means so as to be angularly located relative to the housing.

Preferably, the retaining means includes adjustment means for adjusting the radial positions of the deflection members.

Preferably, the adjustment means comprises a plurality of screw-threaded shafts, each of which extends through a respective screw-threaded aperture in the bar means to engage a respective deflection member.

Preferably, each deflection member engages the housing so as to be axially and/or angularly located thereby.

The use of the housing and the bar means to provide direct angular and axial location is particularly advantageous where screw threaded shafts are used, since the shafts need only bear against the deflection member, as they do not need to extend into the deflection member to help to secure the latter.

Preferably, each deflection member comprises a sub-assembly having a body in which a sleeve is mounted, the arrangement being such that, in use, the wire passes through and is engaged by the sleeve, thereby causing said deflection of the wire.

The sleeve is preferably mounted on the body through a deep-groove ball bearing so that the sleeve is rotatable relative to the body.

Preferably, the sleeve is releasably retained on the body by, for example, circlips.

Preferably, the bar means comprises at least two bars for engaging portions of each body at opposite end

regions thereof, said portions being such as to allow radial movement of the body, relative to the housing between two limits, each defined by engagement with a respective bar. In this case, the sub-assembly is preferably asymmetric in such a way that the sleeve is closer to one of said bars than to the other, at the corresponding limits.

This facilitates the setting up of the rotary member so that the wire is deflected towards alternating sides of the housing axis, relative to the housing. To that end, the bodies are arranged so that adjacent bodies are displaced by 180° relative to each other.

According to a second aspect of the invention, there is provided wire straightening apparatus comprising a pair of axially spaced aligned rotary members, each in accordance with the first aspect of the invention, and drive means for counter-rotating the rotary members.

The invention also lies in a wire bending machine having wire straightening apparatus in accordance with the first aspect of the invention, and feed means for feeding wire through the wire straightening apparatus and to a bending head.

Preferably, the machine includes control means for controlling the rate at which wire is fed through the machine by the feed means and the speed of rotation of the rotary members, wherein the control means is so arranged as to increase or decrease said speed or rotation in response to corresponding variations in the rate at which wire is fed through the members.

Preferably, the control means is so arranged that there is substantially no rotation of the rotary members while the wire is stationary relative to those members.

Thus, the control means prevents the rotary members from damaging the wire (for example by work hardening) while the wire is stationary relative to the rotary members (for example during bending of the wire).

Preferably, the control means is so arranged that the speed of rotation of the rotary members is proportional to the rate at which wire is fed through them, the ratio of rotational speed to feed rate thus being substantially constant (for non-zero feed rates).

Preferably, the control means is operable to cause the drive means to rotate the rotary members by between one half and six (preferably five) revolutions for every inch (2.54 cm) of wire fed therethrough.

Thus if, for example, the wire is being fed through the rotary members at a rate of 1 metre per second, the control means will cause the rotary members to rotate at around 2,360 rpm if the members are to rotate once for every inch of wire fed therethrough, around 11,800 rpm in order to achieve five revolutions per inch of wire, or around 14,160 rpm if a rate of six revolutions per inch is required.

Brief Description of the Drawings

Two embodiments of wire straightening apparatus, in accordance with the invention, will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic isometric view of a wire bending machine fitted with wire straightening apparatus in accordance with the invention;

Figure 2 is a sectional side view of a rotary member of one embodiment of the wire straightening apparatus;

Figure 3 is a cross-sectional view taken along the line III-III of Figure 2;

Figure 4 is a sectional side view of one of a number of deflection members forming part of the rotary member;

Figure 5 is a more detailed sectional side view of one of the components shown in Figure 4;

Figure 6 is a partially exploded perspective view of a region of the rotary member between its two ends;

Figure 7 is an exploded sectional view of an end region of the rotary member;

Figure 8 is a sectional side view of part of the rotary member, showing wire passing therethrough;

Figure 9 is a sectional side view, corresponding to Figure 2, of the rotary member of the second embodiment of wire straightening apparatus;

Figure 10 is a longitudinal sectional view of a housing forming part of that rotary member;

Figure 11 is an end view of the housing;

Figure 12 is a front view of one of the components housed in the housing;

Figure 13 is a sectional side view of that component;

Figure 14 is a sectional view along the line XIV-XIV of Figure 12;

Figure 15 is an end view of one of two end fittings for the housing (of either embodiment);

Figure 16 is a sectional side view of that end fitting; and

Figure 17 is a plan view of another component of the rotary member of the second embodiment.

Detailed Description

Figure 1 shows a bending machine having a bending head 1 to which a wire 2 is fed by a feed mechanism 4 from a coiled stock 6. The machine includes a rotatable gripper mechanism 8 for rotating the wire 2 about its own axis, and wire straightening apparatus 10 which is interposed between the feed mechanism 4 and the stock 6.

The straightening apparatus 10 comprises a pair of co-axial cylindrical rotary members, referred to as spinners, 12 and 14 which are arranged in series and connected to a motor 16 through a pulley and belt transmission 18 and a gear box 20.

The motor 16 is operable to rotate the spinners 12 and 14 respectively in a clockwise and an anticlockwise direction as viewed in Figure 1 at an angular speed which is controlled by a control unit 22.

The spinners 12 and 14 are identical, and only the components of the spinner 12 will be described in detail.

Referring to Figure 2, the spinner 12 comprises a hollow cylindrical housing 34 which contains seven axially-spaced cylindrical bodies 35-41.

The axis of each cylindrical body is substantially perpendicular to the elongate axis of the housing 34, and the ends of each housing extend into a respective pair of diametrically opposed circular apertures in the housing 34. Those apertures are indicated by the reference numerals 44-57 (apertures 48 and 44 being more clearly shown in Figures 6 and 7 respectively), and are of a slightly larger diameter than that of the cylindrical bodies 35-41 so that the bodies 35-41 can be inserted into and removed from the housing 34 through the apertures, and the ends of the bodies are accessible through the apertures when the bodies are in position in the housing 34.

The bodies 37-39 are identical with each other, and only the body 37 will therefore be described in detail.

With reference to Figures 3-6, the body 37 is formed with two flat end faces 60 and 62, each of which is surrounded by a respective one of two cylindrical peripheral walls 64 and 66 which are formed as extensions to the sides of the body 37. The walls 64 and 66 have part circular portions formed at their outboard ends, and each of the walls includes a pair of opposed slots. The slots in the wall 64 are denoted by the reference numerals 68 and 70, whilst reference numerals 72 and 74 denote the slots in the wall 66.

As can be seen from the drawings, particularly Figure 4, the face 60 is closer to the inboard ends of the slots 68 and 70 than is the face 62 to the inboard ends of the slots 72 and 74.

With the body 37 in place in the housing 34, the slots 68 and 70 matingly engage a bar 76 which extends, in the direction of the axis of the housing 34, across the aperture 48, and which is screwed at either end to the housing 34. The slots 72 and 74 matingly engage a similar bar 78 which extends across the aperture 49. The engagement of the slots with the bars 76 and 78 provides angular location of the body 37 in the housing 34, and also prevents the body 37 from dropping out of the housing 34 through either of the apertures 48 and 49.

The bars are partially accommodated in two opposed recesses 79 and 81 (Figure 7) running along the length of the housing 34.

The bars 76 and 78 include central screw-threaded bores through which two screw-threaded adjustment shafts, respectively referenced 80 and 82, extend. The ends of the shafts 80 and 82 external to the housing 34 are terminated in heads 84 and 86 for facilitating the rotating of the shafts so as to vary the distance by which they extend radially into the housing 34.

The opposite ends of each shaft engages a respective one of the faces 60 and 62, so that the shafts provide radial location for the body 37 relative to the housing 34. The external portions of the shafts also carry locking nuts 88 and 90 which define (adjustable) limits of movement of the shafts into the body 34.

With reference to Figure 4, the body 37 has a central passage 92 which includes a reduced diameter exit 94, and which is stepped so as to define two annular shoulders 96 and 98. The shoulders 96 and 98 are situated between the exit 94 and an annular groove 100 which accommodates a removable circlip 110.

The circlip 110 helps to hold a deep-groove ball bearing 112 against the shoulder 98. The deep-groove ball bearing 112 provides rotatable mounting for a cylindrical sleeve 114 which extends through the bearing 112, and which includes a radial outer flange 116 at one end, and an annular groove 118 in the region of its other end.

The flange 116 is of a larger diameter than the inner periphery of the bearing 112, whilst the annular groove 118 accommodates a circlip 120 which is also of a larger diameter than the inner periphery of the bearing 112. Thus, the sleeve 114 is retained in position in the bearing 112 by the engagement of the flange 116 and circlip 120 with the bearing 112.

The sleeve 140 is shown to an enlarged scale in Figure 5, from which it can be seen that the inner surface of the sleeve has two curved end portions 122 and 124 disposed one on either side of a central, untapered cylindrical portion 126.

The components shown in Figure 4 can all be inserted into or removed from the housing 34 as a single sub-assembly. The bodies 38 and 39 contain identical bearings, sleeves and circlips, those components forming identical sub-assemblies to that shown in Figure 4, and are retained in position by identical arrangements of bars, screws and adjustment shafts, to those used for the body 37.

The body 35 is shown in more detail in Figure 7, and forms part of another sub-assembly which is identical to the sub-assembly shown in Figure 4 in all features other than the shape of the body. In this case, the body 35 is, in the section shown in Figure 2, symmetrical about the

axis of the housing 34. Thus, the body has two end faces 130 and 132 which are spaced by the same distance from the inboard end (for example 134 and 138) of the slots in the peripheral walls 140 and 142 which surround the faces 130 and 134. Since the components housed within the body 35 are identical to those in the body 37, they have been indicated in Figure 7 by identical reference numbers followed by the symbol '.

The spinner 12 also includes identical end pieces 146 and 148. The end piece 146 is shown in more detail in Figure 15 and 16, and takes the form of a cylinder which includes a radial outer end flange 150 and two diametrically opposed slots 152 and 154 which provide rotational key to a complementary cylindrical inlet guide 156.

(Figure 1). The corresponding slots in the end piece 148 provide a rotational key to a complementary cylindrical connector 158 which connects the member 12 to the output of the gearbox 20.

Each of the bodies 36, 40 and 41 is identical to the body 35 and contain identical components to those contained in that body.

Bodies 35 and 36 are held in position by two bars 160 and 162 which engage in the slots in the ends of the bodies 35 and 36. The bar 160 extends across the apertures 44 and 46, whilst the bar 162 extends across the apertures 45 and 47. Both bars are screwed to the body 34 by the fixing screws 163-168 as shown in Figure 2. A similar arrangement of bars and fixing screws retains the bodies 40 and 41 in position. When so retained, the bodies 35, 36, 40 and 41 are so positioned that their central passages, and hence the sleeves therein, are co-axial with the axis of the body 34.

The body 38 is inverted relative to the bodies 37 and 39 so that the end face of the body 38 which is closer to the inboard end of its corresponding slot is downwardly facing when the bodies are orientated as shown in Figure 2. With the rotary member set up as shown in Figure 2, the screw-threaded adjustment shafts have been so positioned that the sleeves within the bodies 37-39 are co-axial with the axis of the housing 34. When in this position, the body 38 is at the top of its range of allowable motion (when orientated as shown in Figure 2) whilst the bodies 37 and 39 are at the bottom of theirs.

When the bodies are so positioned, the wire 2 may be readily "threaded" through the rotary member (the tapered entrances to the sleeves facilitate the threading process). Once the wire 2 has been threaded through the rotary member, the adjustment shafts for the members 37-40 are altered until the members are in positions such as are shown in Figure 8, in which the sleeves in the members 37 and 40 are radially displaced in one direction relative to the axis of the housing 34, whilst the sleeve in the body 38 is radially displaced in the opposite direction.

On its passage through the spinner 12, the wire 2 is deflected by the sleeve in the rotary member 37 along a path which has an initial curved portion 170 followed by a second portion 172 which is substantially parallel with the axis (denoted by 174) of the housing 34 before the wire reaches a third curved portion 176. Each of the sleeves in the bodies 38 and 39 deflects the wire along a path which has a respective set of three similar portions. The co-axial sleeves in the pairs of bodies 35, 36 and 40, 41 cause the path of the wire 2 to be co-axial (with the spinner axis) respectively before and after the radial displacement by the sleeves shown in Figure 8 occurs.

Since the spinner 12 rotates as the wire is fed therethrough, the radial displacement caused by the sleeves shown in Figure 8 results in the wire travelling along a generally helical path.

Figure 9 shows a spinner of an alternative embodiment of wire straightening apparatus. That spinner is identical to the spinner 12 (and hence the spinner 14) in all respects apart from the arrangement of sleeves at the entrance and exit of the spinner (and apertures in the body for accommodating the associated cylindrical bodies) and the means of retaining the cylindrical bodies within the housing. Accordingly, features corresponding to those of the spinner 12 are indicated by the same reference numerals raised by 200.

Instead of having four axial end sleeves contained in corresponding bodies (35, 36,40 and 41) the spinner of the second embodiment has two axial end sleeves 400 and 402 of extended length. Those sleeves are mounted by deep-groove ball bearings 404 and 406 in cylindrical bodies 408 and 410 of enlarged diameter compared with the bodies 237-239. Apart from their dimensions, the bodies 408 and 410 and bearings 404 and 406 are identical to the other bodies and bearings of the spinner. The shape of the body 408 (and hence the body 410) is indicated in greater detail in Figures 12-14. The body 234 has correspondingly enlarged apertures 409 and 411 for accommodating the ends of the bodies 408 and 410.

Each of the other bodies of the second embodiment, unlike those of the first embodiment, is not held in place by a respective pair of bars. Instead, all three bodies 237, 238 and 239 are retained and angularly located in the housing 234 by a single pair of opposed common bars 412 and 414. Each bar is held in position by a respective set of four screws which extend into screw-threaded holes (some of which are visible in Figure 10) in the body 234. The bar 412 is shown in more detail in Figure 17, from which it will be seen that the bar includes four large diameter apertures for accepting the screws for fixing to the body 234 and three smaller dimension apertures, arranged in alternating relationship with the large diameter apertures which accommodate the screw-threaded radial adjustment shafts for the bodies 237-239.

Referring back to Figure 1, the control unit 22 is connected to, and controls the speed of operation of a motor 24 on the feed mechanism 4. The motor 24 is, in turn, connected to a screw-threaded shaft 26 through a belt

and pulley transmission 28.

The shaft 26 extends through a screw-threaded passage in a block 30. The screw-threads on the shaft 26 and in the passage complement each other so that rotation of the shaft 26 moves the block 30 therealong. The block 30, in turn, carries a pneumatic clamp 32 through which the wire 2 extends.

The control unit 22 also controls the operation of a fixed pneumatic clamp 420 which forms part of the feed means 4 and is situated downstream of the reciprocating clamp 32.

The clamp 420 holds the wire 2 during the return strokes of the reciprocating clamp 32, but is released from the wire 2 when the latter is being held by the clamp 32 during its advance strokes (which feed the wire 2 through the apparatus).

The control unit 22 so controls the speed of operation of the motors 16 and 24 that each of the spinners 12 and 14 undergoes one complete revolution for each inch of wire 2 drawn therethrough. Thus, if the wire 2 is drawn through the spinners 12 and 14 at a speed of 1 metre per second during advance strokes of the clamp 32, the rotary members 12 and 14 are rotated at a speed of 2,362 rpm. However, at the end of the advance stroke of the clamp 32, and during its subsequent return stroke, there is no feed of the wire 2 through the spinners 12 and 14. During this time, therefore, there is correspondingly no rotation of the spinners 12 and 14.

The clamps 32 and 420 can be operated to feed the wire through the machine in a reverse direction, which enables certain shapes of wire to be formed by the head 1. However, it is undesirable to feed the wire through the spinners 12 and 14 in a reverse direction, and to avoid this the wire straightening apparatus 10 is mounted on a carriage (not shown) for moving the apparatus in a reverse direction during such reverse feed of the wire.

The wire twisting apparatus 8 comprises a motor 422 connected to a releasable clamp 424 via an intermediate gear wheel 426. When the wire 2 is not being fed through the machine (in either direction) the clamp 424 is operable to grip the wire 2 and the motor 422 to rotate the clamp 424 to twist the wire 2 about its own axis to enable the bending head 1 to form wire products which are bent in more than one plane.

The bending head 1 is similar to the bending head used on the CNC-8 Omni-Forming Centre produced by Pave Automation Design and Development Limited, and comprises a pair of opposed guide projections 428 and 430 through which the wire 2 passes, and a finger 432 mounted on a rotatable support 434. The support 434 is, in turn, connected to a motor 436 through gear wheels 438 and 440, and is, in use, rotated by the motor 436, thus causing the finger 432 to bend the wire 2 against either of the projections 430 and 428. The bending head 1 is connected to pneumatic cylinder 442 which is operable to move the bending head in a direction perpendicular to the wire axis. This enables the finger 432 to be moved clear of the wire 2 so that subsequent rotation of the support 434 can move the finger 432 to either side of the wire 2. Wire products which have been bent at the bending head 1 are subsequently severed from the rest of the wire by a guillotine 444 situated downstream of the head 1.

Claims

1. A rotary member (12) for apparatus for straightening elongate material, the member comprising an elongate housing (34; 234), a plurality of deflection members (37-39, 112, 114; 237, 278, 312, 314) for engaging material being fed through the housing (34; 234) so as to displace the material radially with respect to the housing axis (174), characterised in that the housing (34; 234) is hollow, and contains the deflection members (37-39, 112, 114; 237, 238, 312, 314) and in that the member includes retaining means (160, 162; 360, 362) for retaining the deflection members (37-39, 112, 114; 237, 238, 312, 314) in the housing.

2. A rotary member according to claim 1 further characterised in that each deflection member engages the housing (34; 234) to be axially and/or radially located thereby.

3. A rotary member according to claim 2, in which the housing (34; 234) includes a plurality of axially spaced apertures (48, 50, 52; 248, 250, 252), each of which is in registry with a respective deflection member, and is so dimensioned as to allow the respective deflection member to be inserted into or removed from the housing therethrough, wherein each deflection member engages the part of the housing which defines its respective aperture.

4. A rotary member according to claim 3, in which adjacent deflection members are axially spaced from each other within the housing (34; 234)

5. A rotary member according to any of the preceding claims, in which the housing (34; 234) is cylindrical.

6. A rotary member according to claim 3, in which each said aperture in the housing (34; 234) is one of a respective pair of diametrically opposed apertures.

7. A rotary member according to any of the preceding claims, in which the retaining means comprises bar means (160, 76, 162, 78; 360, 362) releasably attachable to the exterior of the housing (34; 234) so as to extend across the apertures in the housing (34; 234), and the deflection members are so recessed that they matingly engage the bar means.

8. A rotary member according to any of the preceding

claims, in which the retaining means includes adjustment means for adjusting the radial positions of the deflection members.

9. A rotary member according to claim 8 when appended to claim 7, in which the adjustment means comprises a plurality of screw-threaded shafts (80, 82; 280, 282), each of which extends through a respective screw-threaded aperture in the bar means to engage a respective deflection member (37; 237).

10. A rotary member according to any of the preceding claims, in which at least one of the deflection members (37; 237) comprises a sub-assembly having a generally cylindrical body (37) in which a sleeve (114; 314) is mounted, the arrangement being such that, in use, the material passes through and is engaged by the sleeve, thereby causing said deflection of the material.

11. A rotary member according to claim 10, in which the axis of the body (37) of the sub-assembly is substantially perpendicular to the axis about which the housing (34; 234) rotates in use.

12. A rotary member according to claim 10 or claim 11, in which the sleeve is mounted on the body through a deep-groove ball bearing (112; 312) so that the sleeve is rotatable relative to the body.

13. A rotary member according to any of claims 10 to 12, in which the sleeve is releasably retained on the body by at least one circlip.

14. A rotary member according to claim 10 when appended to claim 7, in which the bar means comprises at least two bars (76, 78; 412, 414) for engaging portions of each body at opposite end regions thereof, said portions being such as to allow radial movement of the body, relative to the housing between two limits, each defined by engagement with a respective bar.

15. A rotary member according to claim 14, in which the sub-assembly is asymmetric in such a way that the sleeve is closer to one of said bars than to the other, at the corresponding limits.

16. Wire straightening apparatus comprising a pair of axially spaced aligned rotary members, each in accordance with any of the preceding claims, and drive means for counter-rotating the rotary members.

17. A wire bending machine having wire straightening apparatus in accordance with claim 16, and feed means for feeding wire through the wire straightening apparatus and to a bending head.

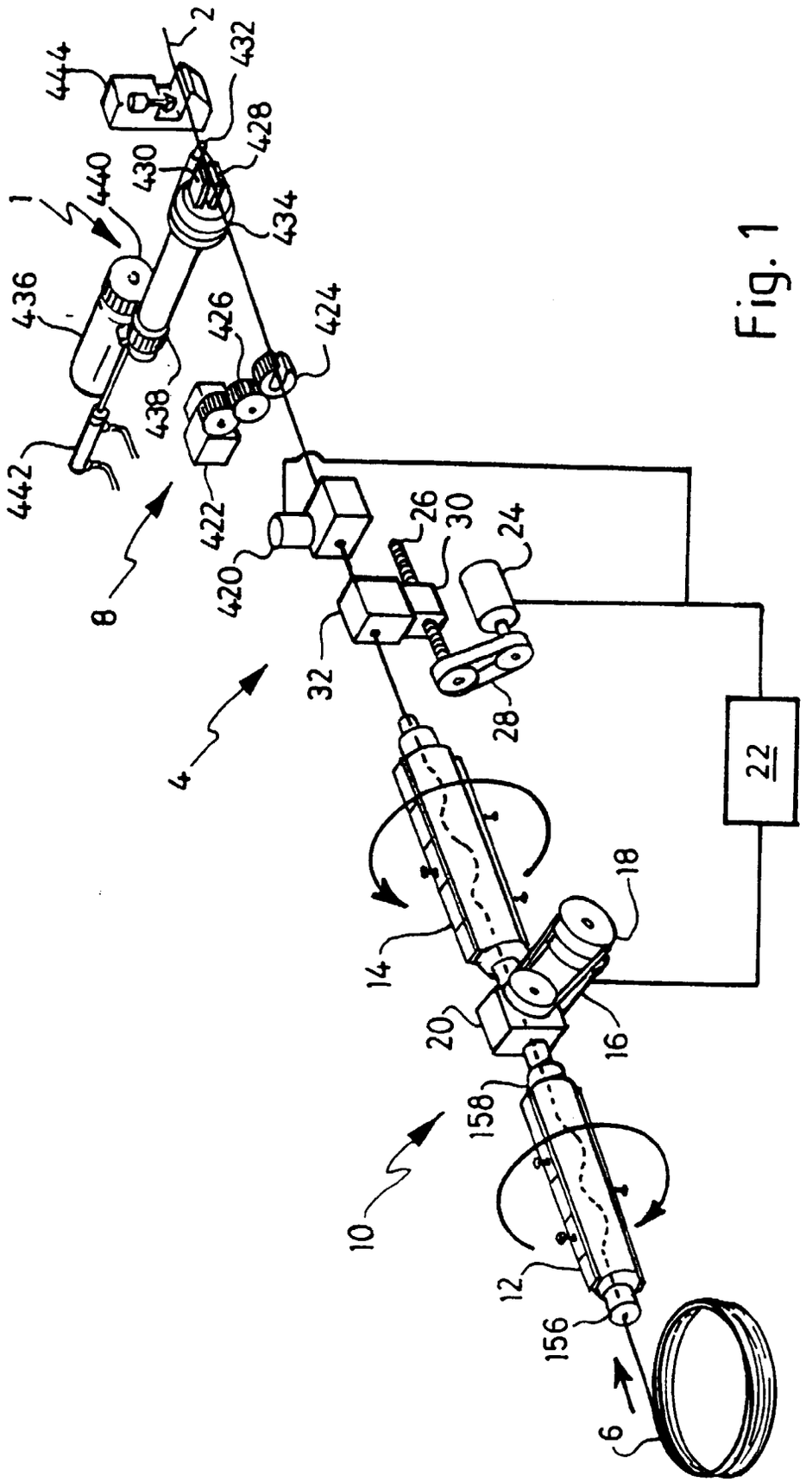
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Fig. 1

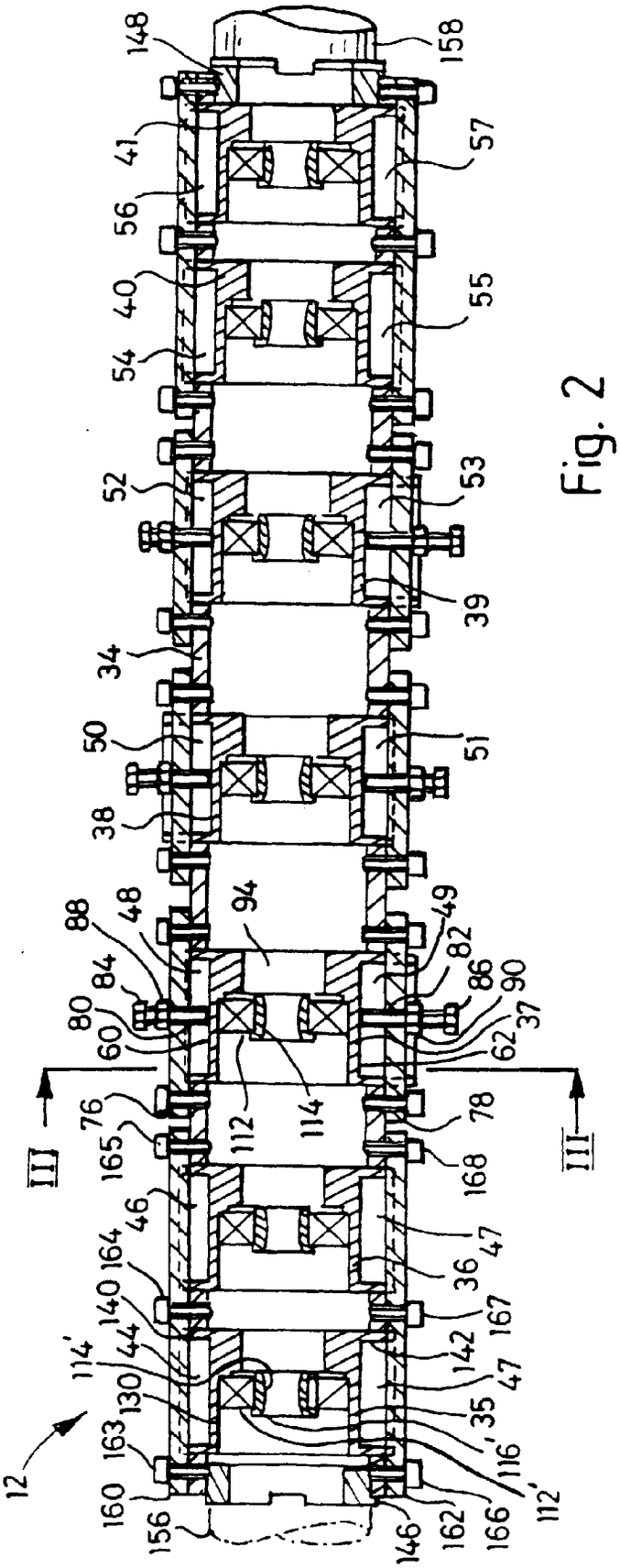
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Fig. 2

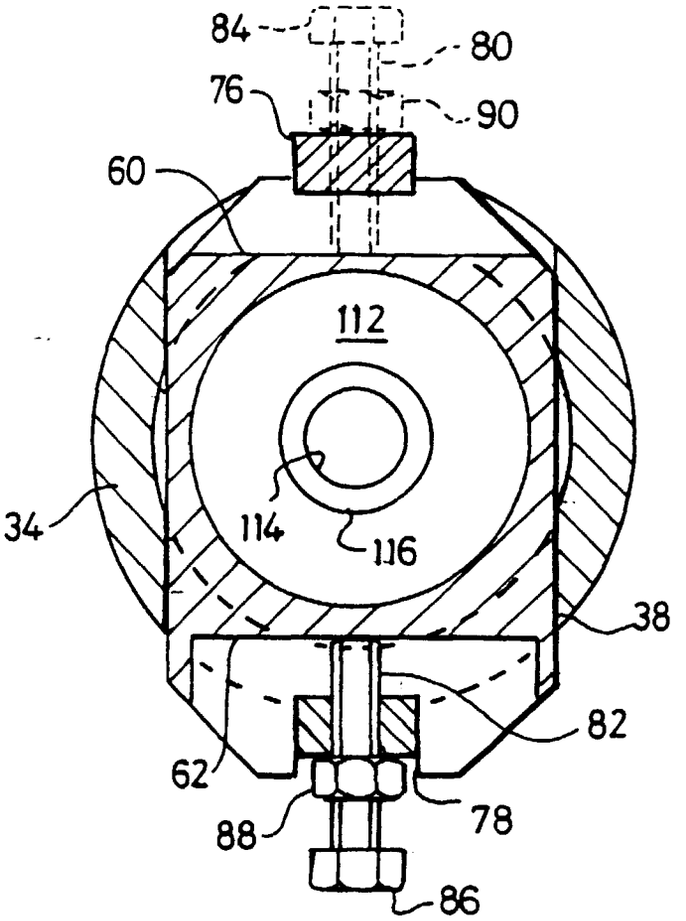

Fig. 3

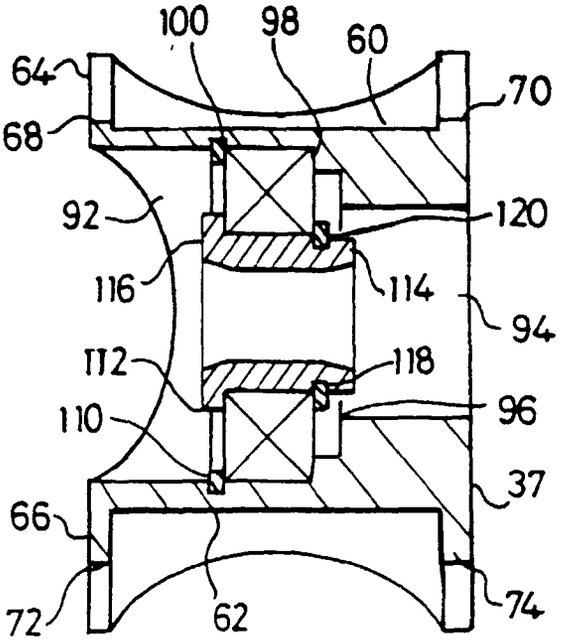

Fig. 4

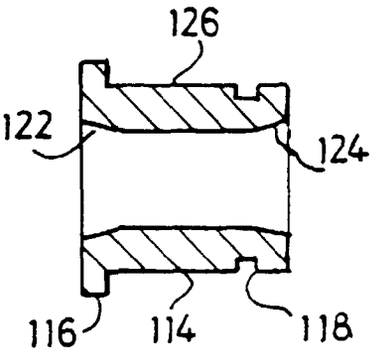

Fig. 5

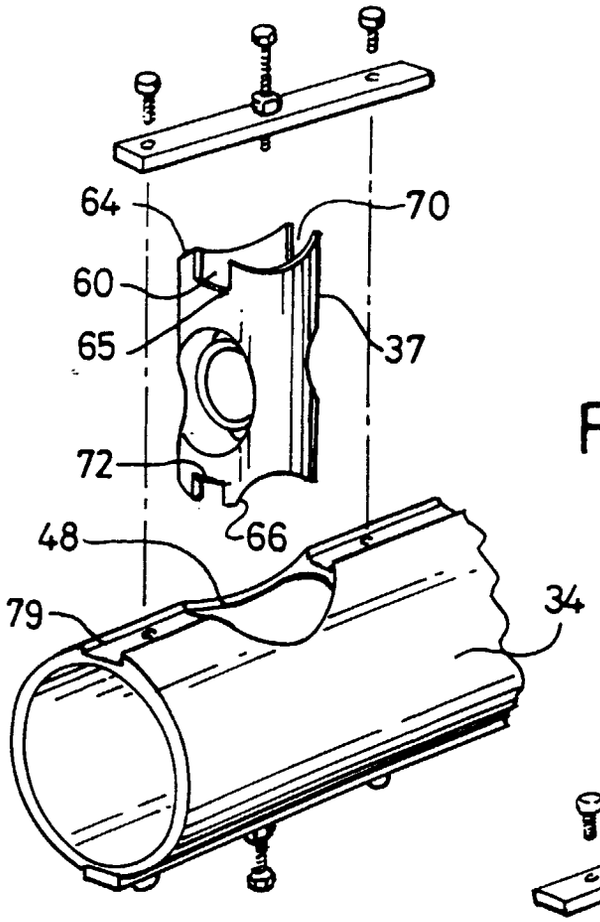
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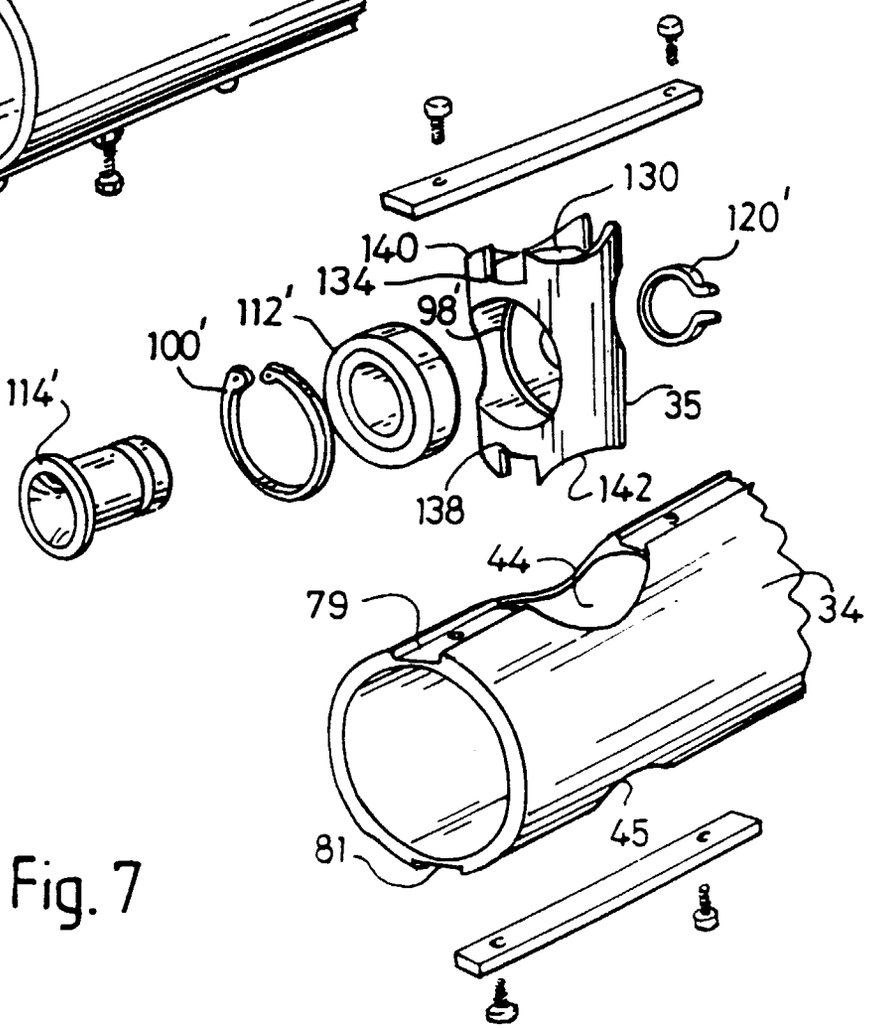
Fig. 6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134
112'
98'
100'
114'
35
138
142
44
79
34
81
45

Fig. 7

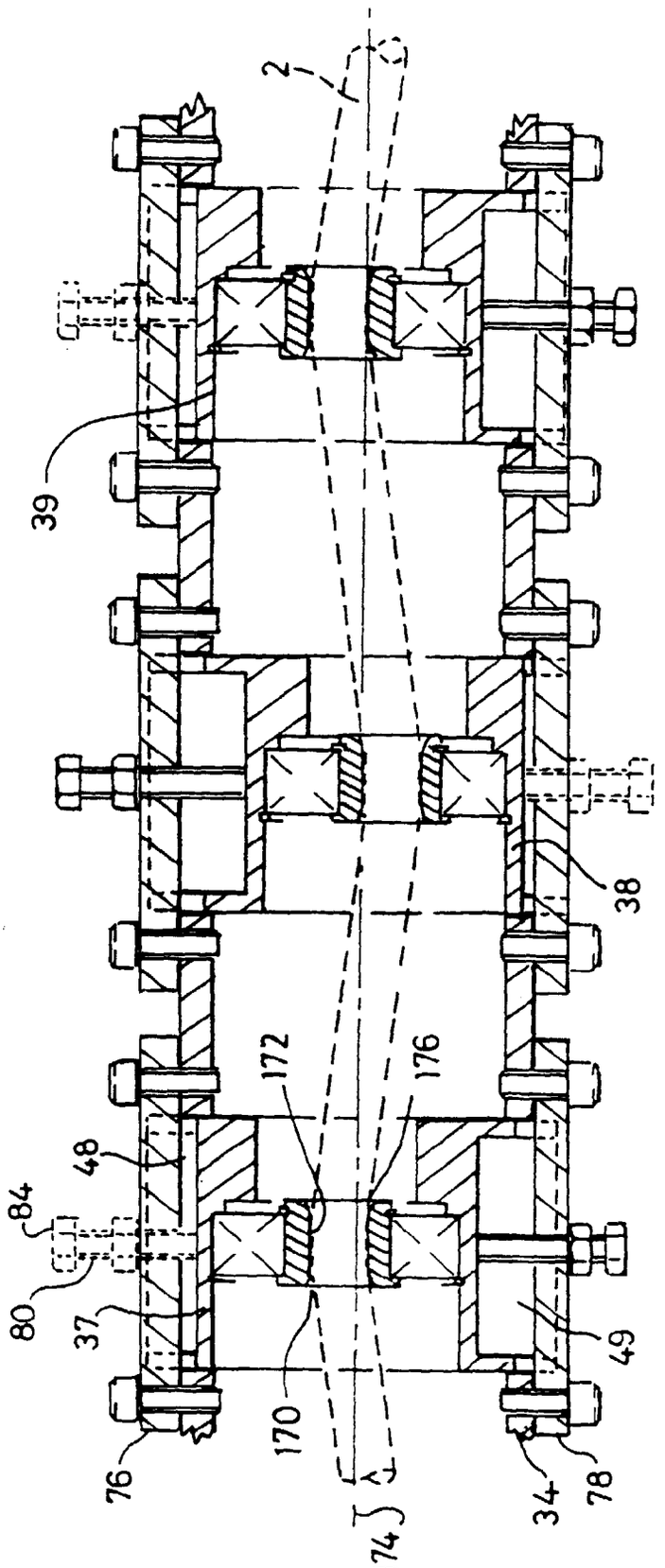
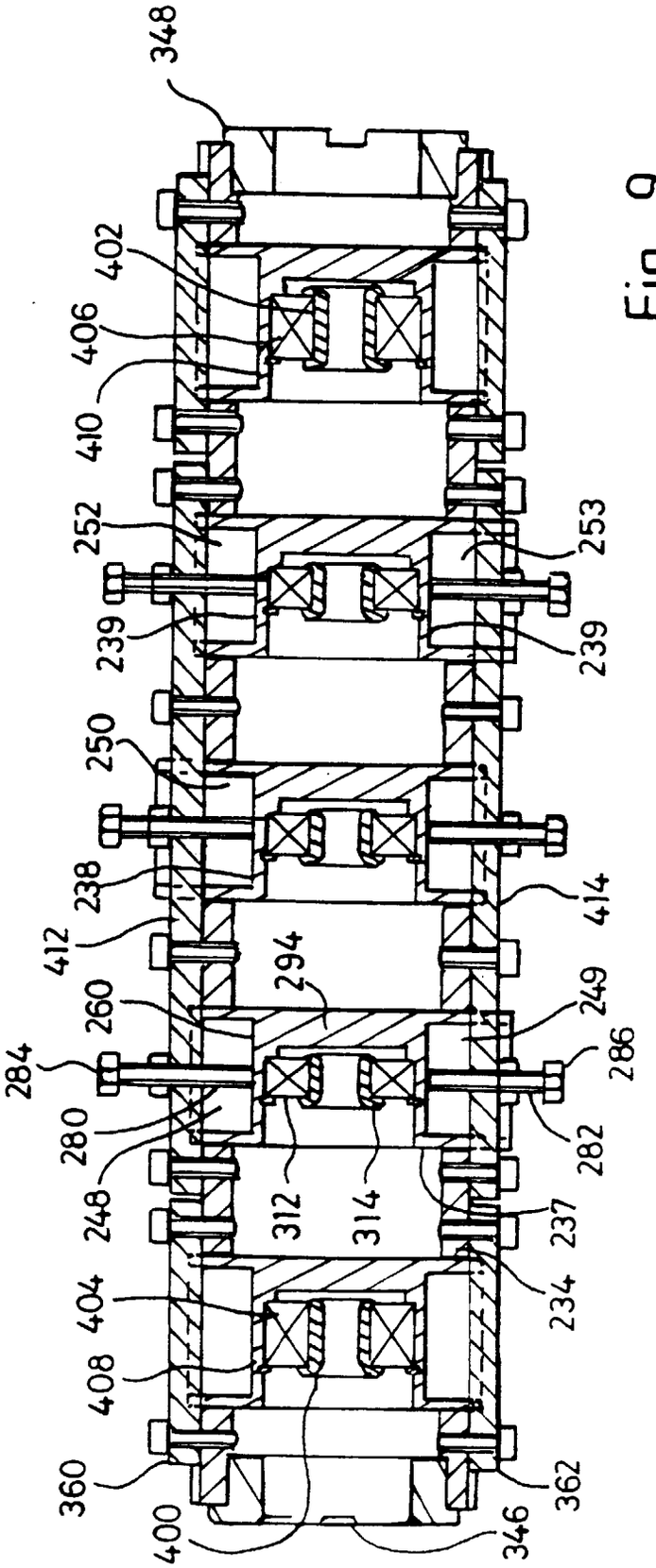


Fig. 8


348
402
406
410
252
253
239
239
250
238
414
412
294
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284
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280
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248
312
314
237
404
234
408
360
362
400
346

Fig. 9

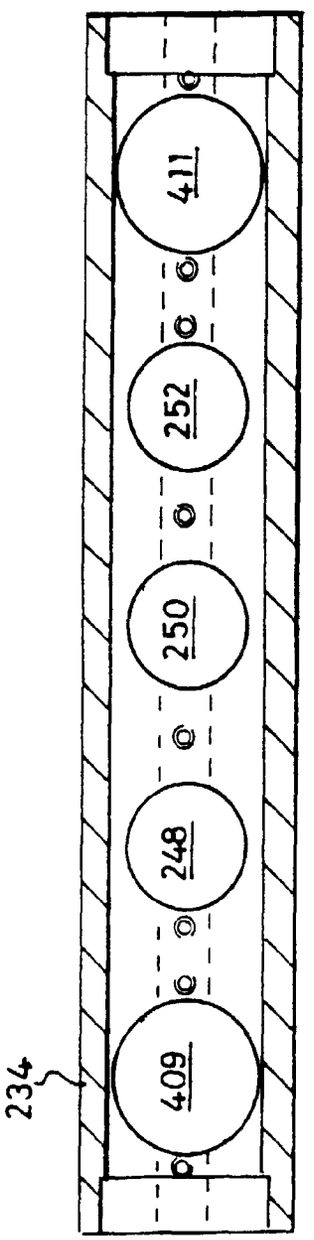

Fig. 10

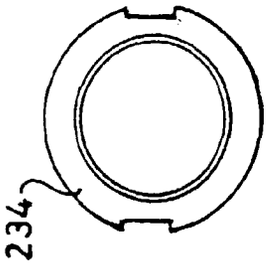

Fig.11

Fig.12

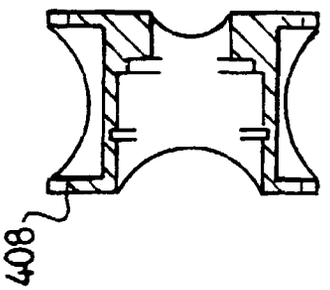

Fig.13

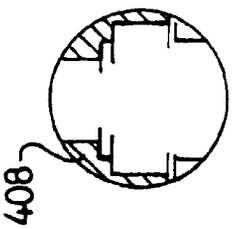

Fig.14

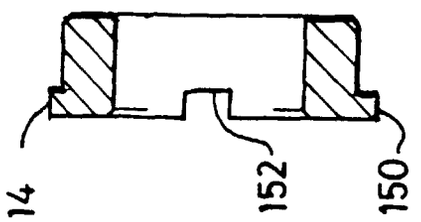

Fig.16

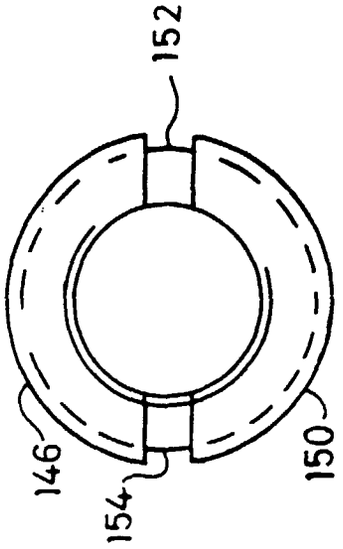

Fig.15

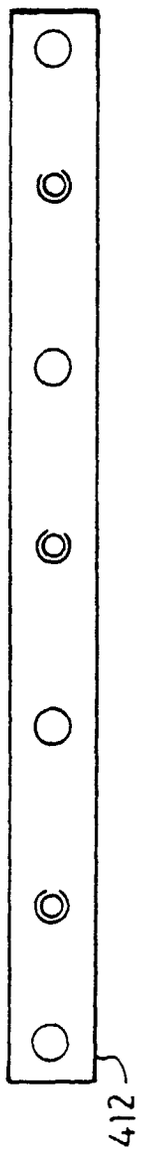

Fig.17