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(54) **Wire-forming machine**

(57) Machine for forming metal wire comprising a wire forward-feeding and coiling unit (2) and a plurality of forming plates (40) arranged downstream of said unit (2), in which these plates support a respective plurality of forming heads (100), and in which said wire forward-feeding and coiling unit (2) is provided with a plurality of pairs of mutually opposing rollers (3,3A,18,19) revolving about respective parallel axes (11,12,18A,18B,19A,19B) as driven by an assembly of kinematical mecha-

nisms with a driving wheel associated to each one of said rollers; to each one of said pairs of rollers there is associated a pair of said driving wheels, the axes of rotation of which are parallel, and which are engaged via a gear coupling with a driving shaft that is orthogonal to the plane defined by the parallel axes of rotation of said pairs of driving wheels.

Said gear coupling is of the inclined-teeth type, preferably with cylindrical helical gears.

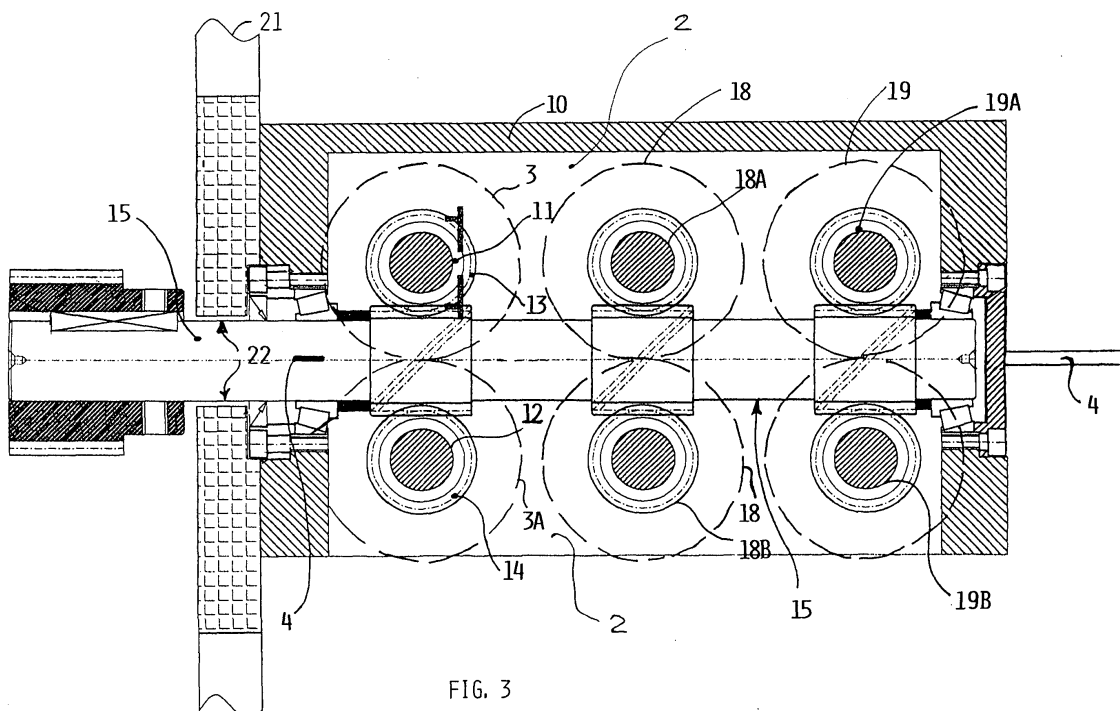


FIG. 3

Description

[0001] The present invention refers to an improved type of machine for forming metal wire, adapted to allow for a greater productivity and throughput through an increase of the travelling speed of the wire in the appropriate wire forward-feeding and coiling units.

[0002] Wire-forming machines, in which metal wire is processed in special forming units in view of being converted into corresponding finished parts or items, in particular wire springs and the like, are variously known in the art.

[0003] In view of appropriately reaching said forming units, the wire must in the first place be unwound from the related coil-stock in which it has been wound for storage after wire-making; it must then be properly straightened and pushed, with the aid of such gripping and pushing means as largely known in the art, into said forming units; in particular, said wire gripping and pushing means are formed by the so-called and well-known "gear-cases ". As illustrated in the prior patent EP 0 682 997, these gear-cases are constituted by assemblies comprising a plurality of pairs of synchronously rotating rollers, these pairs being arranged in a sequence and in a proper alignment, in such a manner as to enable the wire to be successively gripped by successive pairs of rollers provided so as to be matching with each other along a generatrix thereof, and pushed in an orderly manner, and with an adequate force, towards said forming units.

[0004] Also largely known in the art is the fact that there are a number of applications in which the wire, before being formed in said forming units, must also undergo a twisting or coiling operation. For example, this occurs when forming special springs, or similar items, which have substantially a three-dimensional expansion.

[0005] In this case, it is a largely known fact that said gear-case does not remain spatially stable with respect to the coil-stock from which the wire is being unwound, and therefore with respect to the environment, but rather is caused to rotate in a continuous manner, as the wire is unwound and fed forward, about an axis coinciding with the feeding axis of the wire.

[0006] With reference to the accompanying Figure 1, which is a perspective schematic view of a wire forming machine provided with such a gear-case as described above, it can be noticed that said gear-case 1 is firmly and rotatably joined to a rotating plate 21, which is appropriately engaging rotatably driving means that are adapted to substantially impart the desired rotary motion to said gear-case 1, and the related rollers 3, in which said rotary motion can be easily graduated, i.e. adjusted and synchronized with the forward-feeding motion and speed of the metal wire 4.

[0007] This solution is largely used in the art without encountering any particular problem, except for the fact that the productivity of the machine may undergo con-

siderable limitations.

[0008] As a matter of fact, owing to the gear-case being an inherently heavy member and, above all, featuring a considerable inertia with respect to the afore-cited axis of rotation, if abrupt speed variations or reversals in the direction of rotation are to be brought about, it is quite clear and obvious that the highest possible angular acceleration will in these cases be the one produced by said driving motor, and imparted to said rotating plate 21, compatibly with the resisting inertia of said gear-case.

[0009] It practically ensues that, if the wire is to be twisted or coiled according to a very close pattern, so that said rotating plate must therefore rotate at a correspondingly high speed, owing to the latter being actually limited - as explained above - by the inertia of the gear-case, the need arises for also the feed-forward speed of the metal wire to be reduced accordingly, in order to obtain the desired twisting or coiling pattern.

[0010] Considering that it is actually the feed-forward speed of the wire through the machine that contributes in a decisive manner to the overall productivity of the machine, it can be most readily appreciated that the inertia of said gear-case ultimately plays a key-role in determining the productivity of the machine and, as a result, the economic import thereof.

[0011] It would therefore be desirable, and it is actually an object of the present invention to provide a wire forming machine with a gear-case rotating in a controlled and variable manner about the axis of the wire, in which said gear-case has an inertia that is sensibly lower than the inertia typically featured by prior-art gear-cases.

[0012] Such a machine shall further be easy to manufacture using existing, readily available techniques, tools and materials, and shall be competitive in its construction and easy to use; preferably, its implementation shall be such as to basically involve such modifications as are compatible with currently available and produced machines, while the newly introduced features shall by no means affect the overall reliability of the machine itself.

[0013] According to the present invention, these aims, along with further ones that will be apparent in the following description, are reached in a particular kind of wire forming machine that is provided with such operation and control means as described below by way of non-limiting example with reference to the accompanying drawings, in which:

- Figure 2 is a vertical and cross-sectional plan view of a first arrangement according to the present invention;
- Figure 3 is a longitudinal cross-sectional plan view showing symbolically the arrangement illustrated in Figure 2;

- Figure 4 is a symbolical front view of the geometry of a second embodiment of the arrangement according to the present invention;
- Figures 4A and 4B are a side view and a perspective view, respectively, of an arrangement according to the present invention, the geometry of which is illustrated in Figure 4 above;
- Figure 5 is a symbolic perspective view of an improved embodiment of a machine according to the present invention;
- Figure 6 is a plan view of the arrangements illustrated in Figure 5, as seen from a distant position along the axis of the metal wire;
- Figure 7 is a view of a symbolically illustrated variant in the number and the related arrangement of the gear-cases of a machine according to the present invention;
- Figure 8 is a perspective view of a further arrangement of a machine according to the present invention;
- Figure 9 is a top plan view of the arrangement illustrated in Figure 8;
- Figure 10 and Figure 11 are views of two different operating set-ups of the machine illustrated in Figures 8 and 9;
- Figure 12 is a perspective view of a different embodiment of the arrangement illustrated in Figure 8;
- Figure 13 is a front elevational plan view of the arrangement illustrated in Figure 12.

[0014] With reference to the above-cited Figures 2 and 3, the gear-case, which shall be referred to as the wire forward-feeding and coiling unit 2 from now on in this description, is comprised by an outer casing 10, preferably of the load-bearing or structural kind, at least a pair of mutually opposing pull-in, i.e. feed-forward rollers 3, 3A, in which there is provided a symmetrical groove 5 adapted to receive the wire 4 and tightly grip it with a combined pincers-like effect, so that the synchronous rotation of said rollers causes the wire to move forwards at the desired rate or speed.

[0015] Said two rollers 3 and 3A are shrink-fitted on or similarly attached to respective driving axles 11, 12 jutting into said outer casing 10, inside which they are rotatably supported and held in position in a stable manner with the aid of means that are commonly known in the art.

[0016] On each one of said axles 11, 12, inside said outer casing 10, there are shrink-fitted, or anyway press-

fitted, respective motion transmission members 13, 14, which are adapted to transmit the rotary motion of a driving shaft 15, which is also provided inside said outer casing 10, to said driving axles 11, 12.

[0017] According to the present invention, in view of reducing as much as possible the moment of inertia of said driving shaft 15 with respect to the wire 4, said driving shaft 15 is oriented in the manner shown in the two Figures being considered here as a reference, where it can be noticed that the axis "O" of said shaft is substantially orthogonal (in the sense that it lies on an orthogonal plane) to said two driving axles 11 and 12 and, in particular, it is parallel to the feed-forward direction of the metal wire 4.

[0018] In view of ensuring a most perfect functionality, i.e. ability to perform its duty, of the rotary coupling of said motion transmission members 13, 14 with said driving shaft 15, all of which having axes of rotation that are orthogonal with respect to each other, said rotary coupling may be advantageously implemented by means of inclined-teeth gears, in particular by means of cylindrical helical gears. Since such devices are well-known in the art, they shall not be described here any further for the sake of brevity.

[0019] As compared with the usual prior-art configuration, according to which said driving shaft 15 was held parallel to said two driving axles 11 and 12, it can be readily appreciated that the configuration according to the present invention - all other conditions being equal - enables a wire forward-feeding and coiling unit 1 to be provided, which has a remarkably lower moment of inertia with respect to the axis of rotation (axis of the wire 4), owing to said drive shaft 15 not being oriented orthogonally to the wire, but rather parallel to the latter.

[0020] The above described solution, anyway, still allows for a number of advantageous improvements. A first one of such improvements, which is illustrated symbolically in Figure 3 itself, provides for both driving axles 11, 12 of a same pair of rollers to be coupled to a same drive shaft, in which an additional gear is used to transmit motion in a synchronous manner.

[0021] As a further improvement, said motion transmission members 13, 14 may also feature following characteristics, i.e.:

- they are mutually aligned, in the sense that they are at the same distance from the wire 4, and further
- they are spaced from each other by an appropriate separating gap adapted to accommodate said shaft 15.

[0022] It can actually be readily appreciated that, in this manner, such a further improvement enables both the size, and the resulting space requirements, and the weight of the shaft itself to be further reduced, with the result that the advantageous effects that can be attained with the invention can be additionally boosted.

[0023] A further improvement that stands as matter of course lies in the fact that, if there are provided various pairs 18, 19, ... of feed-forward rollers, all of them having their respective driving axles 18A, 18B, 19A, 19B, ..., as well as their respective motion transmission members, all such devices and members will then be sized and arranged in such a manner as to be able to be rotatably driven by a single drive shaft 15, as this is clearly illustrated in the same Figure 3 in a manner that anyone skilled in the art is fully capable of readily understanding and implementing.

[0024] As far as the transmission of the motion to such a drive shaft 15 is concerned, a fact that should be taken into due consideration in the first place is that this shaft must of course rotate about its own axis, along an axis extending parallel to the feed-forward direction of the wire. However, owing to the same shaft being an integral part of the rotary wire forward-feeding and coiling unit, it must at the same time rotate about the wire itself, and shall of course do this jointly with the rotary motion of said wire forward-feeding and coiling unit 2.

[0025] To this purpose, and with reference to Figures 3 and 4, the unit itself is provided with a rotating plate 21, on a face of which said wire forward-feeding and coiling unit is fitted rotatably, and in which there is provided a suitable through-hole 22; said drive shaft 15, upon jutting out of said wire forward-feeding and coiling unit, is inserted rotatably in said through-hole 22 so as to come out on the other side of it.

[0026] On to the portion of said shaft protruding from said plate on said other side thereof there is attached, by shrink-fitting or other similar technique, a driving gearwheel 23, which is coupled peripherally with an appropriate centering gearwheel 24, the axis of which is coincident with the axis of rotation "R" of said rotating plate 21; said two wheels, i.e. the driving wheel and the centering one, may be co-planar and have parallel axes, so that the mutual coupling thereof can be brought about with the aid of simple straight-toothed gears.

[0027] Said centering gearwheel is firmly joined to and coaxial with a pulley 25, on which there is fitted a driving belt 26 that is driven by other members of the machine with the aid of means that are commonly known in the art.

[0028] Furthermore, this centering gearwheel, jointly with the pulley, is able to rotate freely relative to said rotating plate 21, although they are co-axial.

[0029] Those skilled in the art should at this point be fully capable of understanding the way in which the above-mentioned arrangements actually work: in fact, said drive shaft 15, which carries said wire forward-feeding and coiling unit 2, is caused to rotate owing to the effect of its eccentric position in relation to said rotating plate 21, whereby the rotation of the wire forward-feeding and coiling unit 2 about the wire 4 is ensured. At the same time, however, the rotation of this shaft 15, and therefore the rotation of said rollers 3 and 3A, is ensured regardless of the position in which the shaft may also

be (and, therefore, even during motion), owing to the fact that the driving gearwheel 23 connected thereto is constantly engaged with the corresponding centering gearwheel 24, which in turn is driven by the pulley and the associated driving belt; and, since these mechanical relations are constantly established, the desired effect of a double continuous motion of the pairs of feed-forward rollers is attained.

[0030] Moreover, this solution has a quite important advantage in that the two motions can be imparted at rotating speeds that are fully independent of, i.e. fully unrelated with each other, thereby dramatically improving the application scope and the flexibility of the above described machine.

[0031] However, a machine that is made as illustrated above may still have a drawback in that, owing to said wire forward-feeding and coiling unit 2 being arranged in a half-space lying on a single side with respect to the plane that passes through the metal wire and extends orthogonally to said pairs of rollers, as this is best illustrated both in Figure 1 and in Figure 2, it ensues a condition of total unbalance with respect to the wire itself due to the effect of the rotation of said rotating plate 21, thereby giving rise to continuous vibrations being generated, with a resulting greater extent of wear-down of the related support members and, in general, an easily understandable higher degree of criticalness not only in the design, but also in the construction and the use of the machine.

[0032] In view of doing away with or at least minimizing such a drawback, following improvement is advantageously implemented: with reference to Figures 5 and 6, the plurality of pairs of feed-forward rollers 3, 3A, ... etc. is subdivided into two distinct assemblies and the pairs of rollers of a same assembly are associated to a same wire forward-feeding and coiling unit 30 having the characteristics as described above: Similarly, the same occurs with the pairs of rollers of the other assembly, forming the wire forward-feeding and coiling unit 31.

[0033] Two distinct wire forward-feeding and coiling units are in this way provided, which are arranged and applied in a sequence, but preferably contiguously, so that a general point of the wire will first pass through one of said units and then through the second one.

[0034] In addition, said units are mutually oriented so as to be arranged exactly in opposition with respect to the wire, as this can be clearly inferred from the illustration appearing in Figure 6, in which said units are sighted from a distance along the axis of the wire 4. In this manner, the centre of gravity of the totality of said wire forward-feeding and coiling units is shifted sensibly towards the wire itself, thereby markedly reducing the unbalance and the vibrations induced by it, under beneficial effects on the operation of the entire machine, although the moment of inertia is not modified to any sensible extent.

[0035] This improvement may be embodied in various, differently organized and more articulate manners.

For instance, the pairs of feed-forward rollers may be subdivided in more than simply two sub-assemblies 33, 34, 35, each one of which then constitutes a distinct wire forward-feeding and coiling unit.

[0036] In an advantageous manner, these distinct wire forward-feeding and coiling units may be provided in a radial arrangement, as spaced from each other by an equal angle "s", as this is illustrated symbolically in Figure 7 representing the same view as the one of Figure 6, however with reference to the case in which there are three of said distinct and successive wire forward-feeding and coiling units.

[0037] As a matter of fact, the subdivision of the pairs of feed-forward rollers into a larger number of wire forward-feeding and coiling units allows for their unbalance, as taken individually, to be more effectively brought into equipoise; it further makes it possible for the overall moment of inertia to be reduced.

[0038] The drive and rotation devices and parts of each one of said several wire forward-feeding and coiling units so provided are the same as the ones used in the afore-described case in which use is made of just a single one of such units. Therefore, their implementation and adaptation may well be considered as being fully within the capabilities of those skilled in the art, so that they shall not be described here any further.

[0039] Anyway, a machine that is made as illustrated above offers the possibility for further advantageous improvements to be implemented. In fact, and again with reference to Figure 1, it should be noticed that wire forming is performed by a plurality of forming heads that are arranged in a various manner, but preferably according to a radial pattern, on respective variously combinable plates 40 that are provided downstream of said wire forward-feeding and coiling units.

[0040] Each such forming head is largely known to be designed in view of performing a specific task, so that, when complex forming operations are to be carried out, the need generally arises for several forming heads to be used.

[0041] Now, such a need involves an undesired increase in the number of forming heads to be used, and this in turn leads to an increased complexity from a construction point of view, as well as a resulting increase in overall costs.

[0042] In view of doing away with, or at least reducing the extent of such a drawback, a kind of multipurpose forming head is disclosed and proposed here, which is able to perform at least two types of forming operations having different characteristics.

[0043] It is a largely known fact that a forming process generally requires the use of a tool that is capable of deforming the metal wire at a predetermined angle under utilization of opposition or contrasting means having definite characteristics; a process involving several forming operations will therefore require the use of tools with contrasting means that are suitable to ensure deformation of the wire at respectively different angles.

[0044] With reference to Figures 8 and 9, a forming unit is therefore illustrated, which comprises a bending head 100 that is provided with contrasting means on a side thereof, and with a moving bending tool 103 provided with a respective working stud 104 on the other side thereof, in which said tool is capable of moving relative to said bending head 100. Said contrasting or opposition means are comprised of a first opposition stud 105 that is applied in a firmly joined manner on to said bending head, and a second opposition stud 106 that is applied in a firmly joined manner on to said first stud 105, as this is best illustrated in the above-cited Figures.

[0045] The outer surfaces of said first and second studs have different radiuses of curvature, so as to be able to bring about differing bending extents.

[0046] The selection of the stud to be used for bending is determined by the positioning of the wire 4 relative to such studs and, namely, by the height or distance of said wire in relation to the head 100, in such a manner that the rotary motion of the working stud 104 will push the wire 4 exactly against that contrasting or opposition stud, the radius of curvature of which is to be used to the actually intended purpose, while at the same time preventing said wire 4 from possibly engaging against studs that are not desired or required.

[0047] The actual operation of the above-illustrated arrangement is as follows: according to the kind or extent of deformation to be imparted to the wire, and therefore the tool to be used, the wire is lifted, using generally known means (not shown), from the shown side of the bending head in such a manner as to enable it to be set either aligned with said first contrasting stud 105, as this is illustrated symbolically in Figure 10, or aligned with said second contrasting stud 106, as this is illustrated symbolically in Figure 11, these Figures being both an elevational plan view of the bending head as seen from a distance along the axis of the wire.

[0048] Depending on the selected set-up, i.e. alignment of the wire, the latter is intercepted by the working stud 104 and then bent by the motion performed by the latter in relation to one of the two contrasting or opposition studs 105 and 106; depending on which one of said contrasting or opposition studs is engaged, the wire itself is deformed according to the related outer geometrical characteristics thereof. As a result, the need only arises for the characteristics of said contrasting or opposition studs to be defined and the suitable alignment to be selected accordingly in order to ultimately obtain the desired bending or deformation curvature of the wire.

[0049] A further improvement of the above-described machine can be obtained, as best illustrated in Figures 12 and 13, if said bending head is provided on said side thereof with an open groove 107 for the wire 4 to be able to slide therethrough before eventually coming out of the body of said bending head through an appropriate aperture 112. In a corresponding manner, said moving bending tool 103 is provided along its side border 109

with a cutting edge 110. The configuration of the above-described devices and arrangements is such that, owing to the motion of said moving tool 103, said cutting edge 110 moves along to pass by said aperture 112 from which said metal wire is coming out, so that the wire itself, being in this manner subject to a shearing stress between said cutting edge 110 and the opposite resisting wall of said aperture 112, is of course severed.

Claims

1. Machine for forming metal wire comprising:

- a wire forward-feeding and coiling unit (2),
- a rotating plate (21) adapted to rotatably drive said wire forward-feeding and coiling unit (2),
- a plurality of forming plates (40) arranged downstream of said wire forward-feeding and coiling unit (2) and adapted to support a respective plurality of forming heads (100),

in which said wire forward-feeding and coiling unit is provided with a plurality of pairs of mutually opposing feed-forward rollers (3, 3A, 18, 19) revolving about respective parallel driving axles (11, 12; 18A, 18B; 19A, 19B), as driven by an assembly of kinematical mechanisms,

characterized in that:

- said assembly of kinematical mechanisms comprises rotary motion-transmission means (13, 14), each one of which is associated to a respective one of said parallel driving axles (11, 12),
- there is provided a rotary drive shaft (15) adapted to transmit the rotary motion thereof to said rotary motion-transmission means (13, 14) via appropriate couplings,
- and said drive shaft revolves about its own axis of rotation, which is orthogonal to the plane defined by the axes of rotation of said parallel driving axles (11, 12).

2. Wire forming machine according to claim 1, **characterized in that** a plurality of pairs of feed-forward rollers have respective axes that are parallel to each other so as to define respective planes; **in that** said planes are parallel to each other; and **in that** said drive shaft (15) is orthogonal to said parallel planes and coupled to the parallel driving axles (11, 12; 18A, 18B; 19A, 19B) of respective feed-forward rollers (3, 3A, 18, 19).

3. Wire forming machine according to claim 1 or 2, **characterized in that** said parallel driving axles (11, 12; 18A, 18B; 19A, 19B) of a same pair of rollers are spaced from each other by a separation gap

within which there is arranged said drive shaft.

4. Wire forming machine according to any of the preceding claims, **characterized in that** said couplings between said rotary motion-transmission means (13, 14) and said drive shaft (15) are of the inclined-teeth gear type, preferably cylindrical helical gears.

5. Wire forming machine according to any of the preceding claims, **characterized in that:**

- in said rotating plate (21) there is provided a suitable boring, preferably a through-hole (22),
- said drive shaft (15) juts out of said wire forward-feeding and coiling unit and is inserted rotatably in said through-hole (22) provided in said rotating plate (21),
- on to the portion of said shaft protruding from said plate there is attached, by shrink-fitting or other similar technique, a driving gearwheel (23), which is coupled peripherally with an appropriate centering gearwheel (24), the axis of which is coincident with the axis of rotation "R" of said rotating plate,
- said centering gearwheel is firmly joined to a co-axial circular member for the transmission of motion.

6. Wire forming machine according to claim 5, **characterized in that** said circular motion-transmission member is a pulley (25) adapted to engage an appropriate drive belt (26).

7. Wire forming machine according to any of the preceding claims, **characterized in that:**

- there is provided a plurality of pairs of said wire feed-forward rollers,
- said plurality of said pairs of rollers is subdivided into two distinct sub-assemblies (30, 31) arranged in successive positions with respect to the feed-forward motion of the wire, so that a general point of the wire will first pass through one of said sub-assemblies and then through the second one,
- and said two sub-assemblies are oriented in a mutually opposing manner.

8. Wire forming machine according to any of the preceding claims 1 to 6, **characterized in that:**

- there is provided a plurality of pairs of said wire feed-forward rollers,
- said plurality of said pairs of rollers is subdivided into at least three distinct sub-assemblies (33, 34, 35) arranged in successive positions with respect to the feed-forward motion of the

wire, so that a general point of the wire will first pass through one of said sub-assemblies and then successively through the other ones,

- and said at least three distinct sub-assemblies are arranged in a radial arrangement in relation to each other and are preferably so distributed as to feature an equal angular distance between successive sub-assemblies.

9. Wire forming machine according to the preamble of claim 1, **characterized in that** said wire end-product forming unit comprises:

- a bending head (100) provided with at least a contrasting or opposition means on a side (101) thereof,
- a moving bending tool (103) provided with a respective working stud (104), said tool being capable of moving relative to said bending head (100),

in which said contrasting or opposition means is comprised of a first opposing stud (105) that is applied in a firmly joined manner on to said bending head, and a second opposing stud (106) that is applied in a firmly joined manner on to said first stud (105).

10. Wire forming machine according to claim 9, **characterized in that** said first opposing stud (105) and said second opposing stud (106) have outer surfaces featuring different radiuses of curvature at least in the zone at which they come into contact with said metal wire (4).

11. Wire forming machine according to the preamble of claim 8, **characterized in that** said wire end-product forming unit comprises:

- a bending head (100) provided on a side thereof with at least a contrasting or opposition means,
- a moving bending tool (103) provided with a respective working stud (104), said tool being capable of moving relative to said bending head (100),

in which said bending head is provided on said side thereof with at least an open groove (107) which is adapted to accommodate said metal wire sliding therethrough, and which debouches on the other side of said bending head through an appropriate aperture (112),

and in which said moving bending tool (103) is provided on a side border (109) thereof with a cutting edge (110) adapted to be caused to pass by said aperture (112).

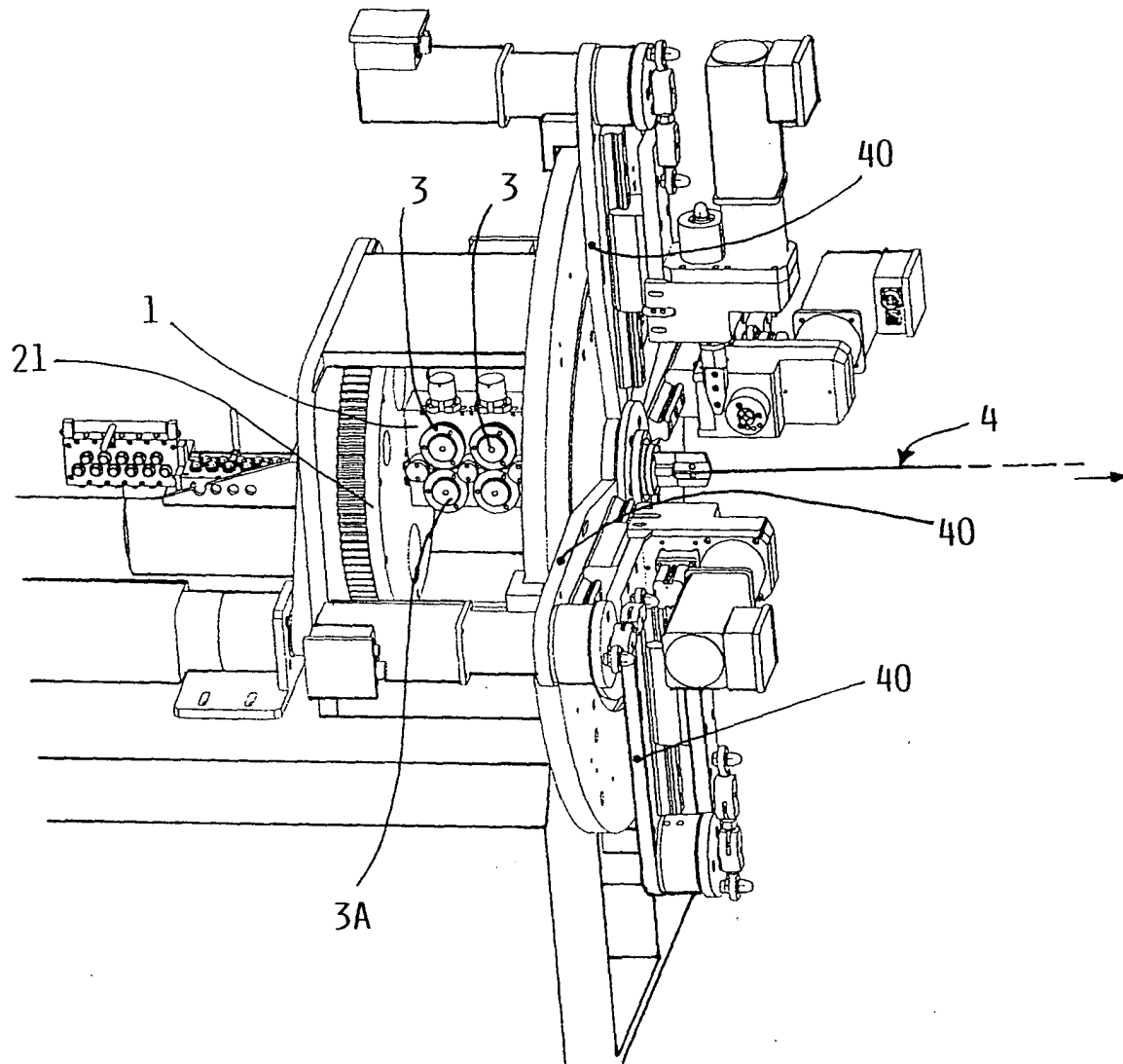
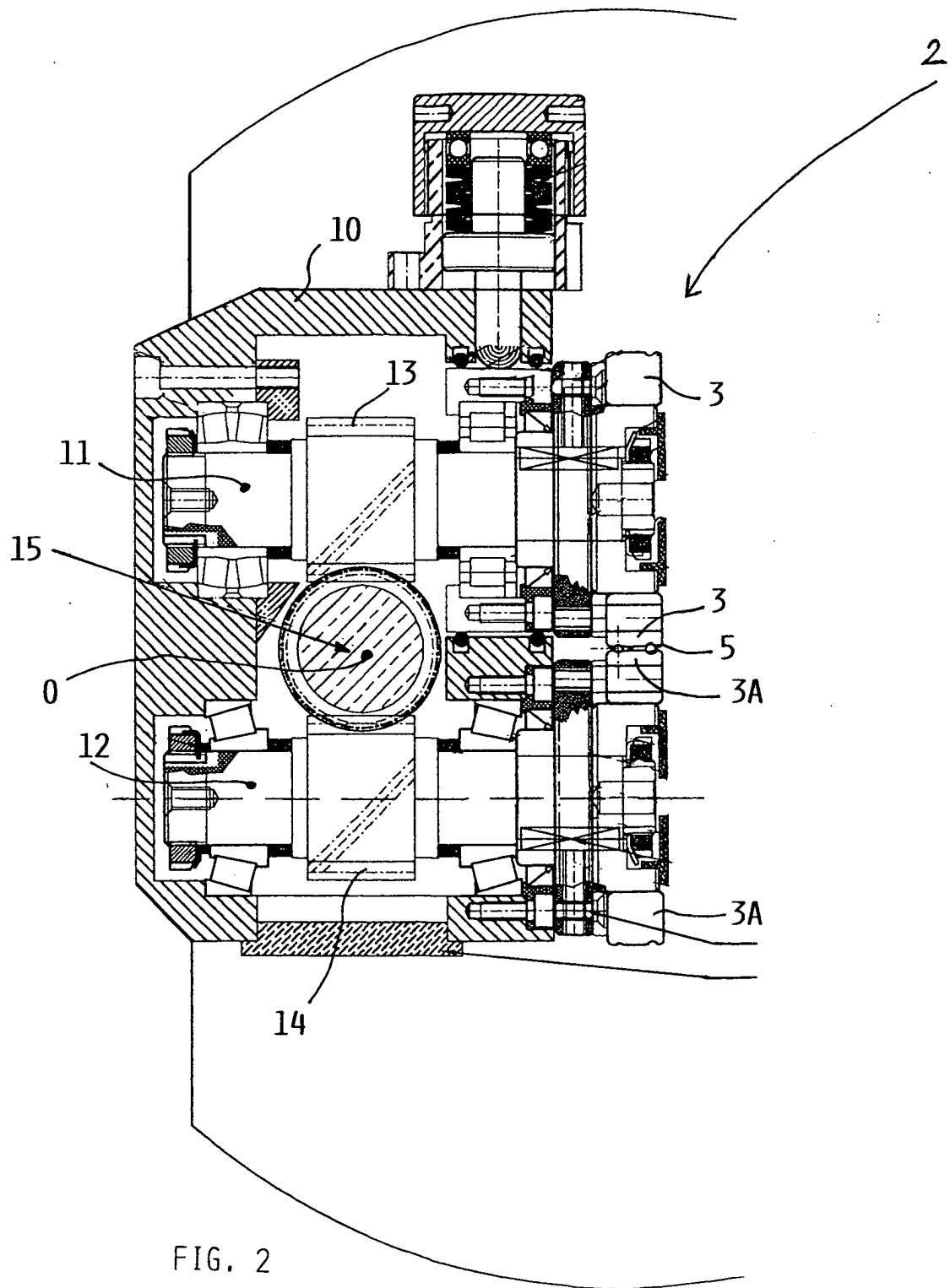


FIG. 1



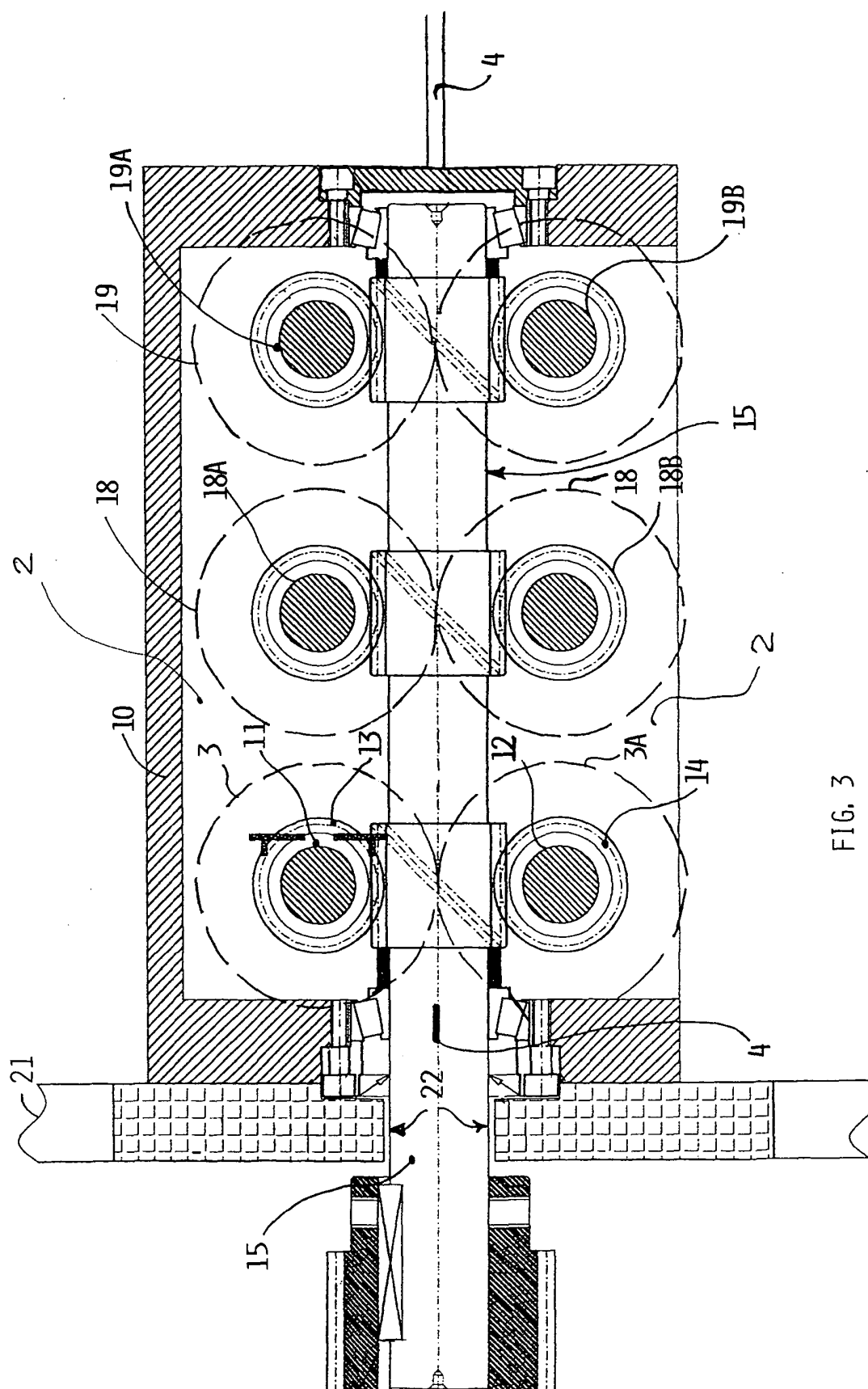


FIG. 3

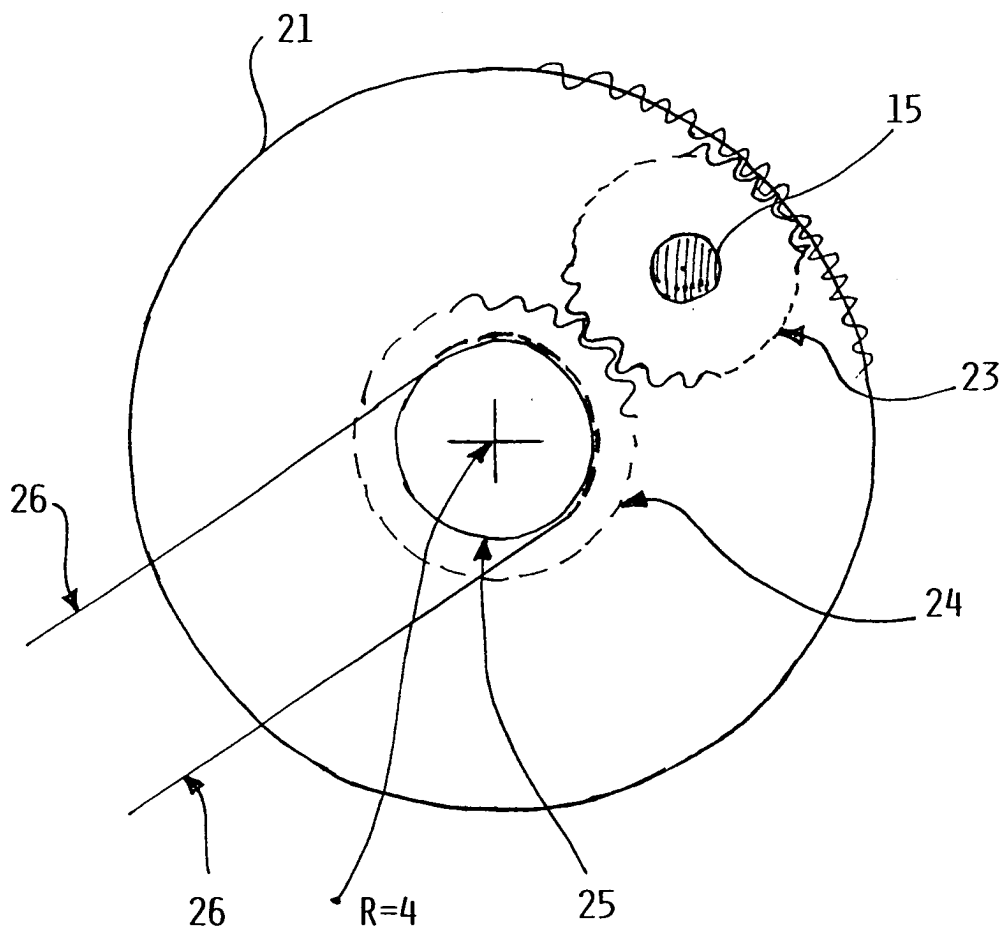


FIG. 4

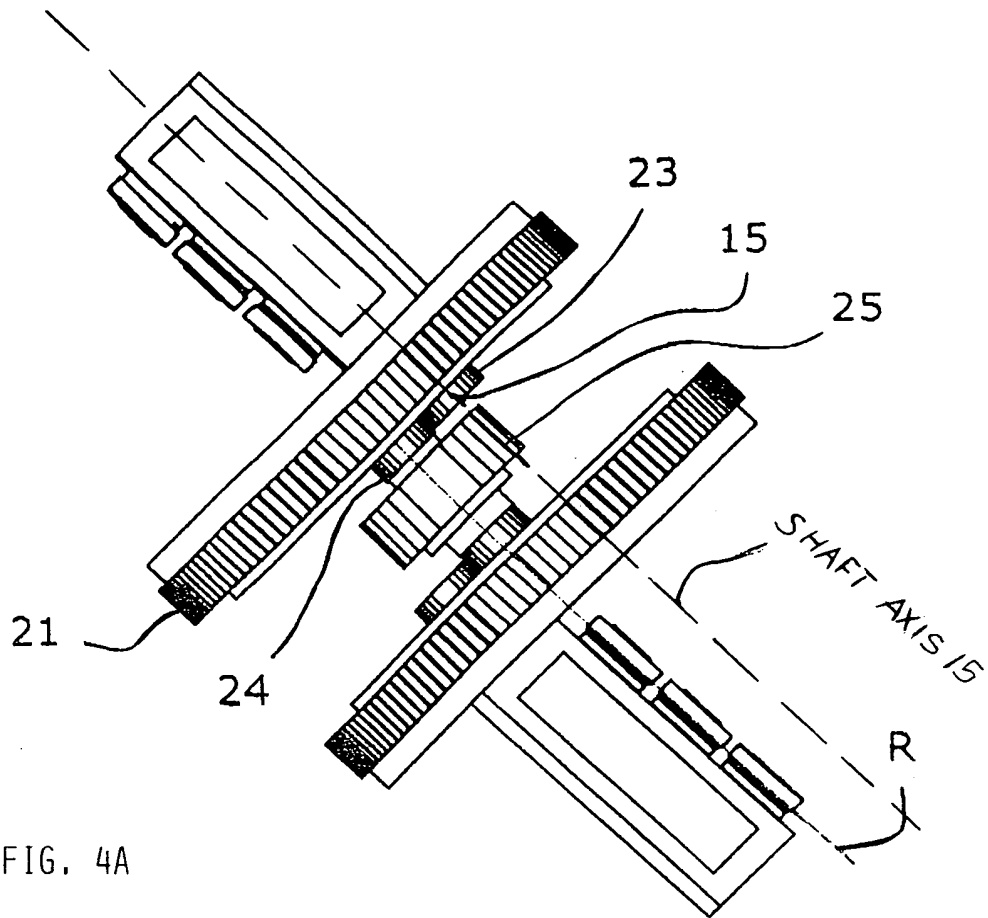


FIG. 4A

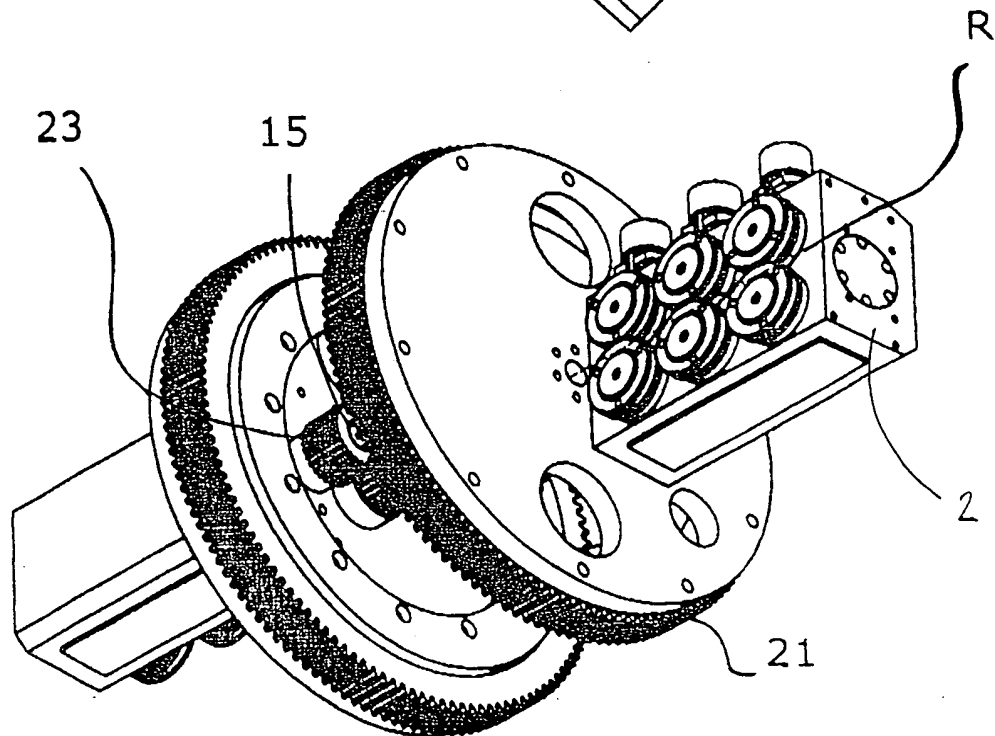
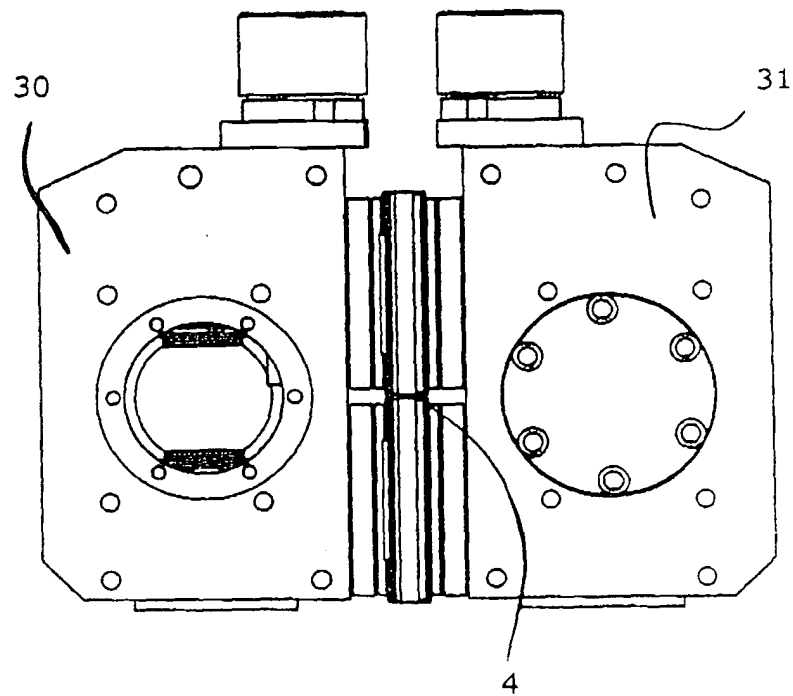
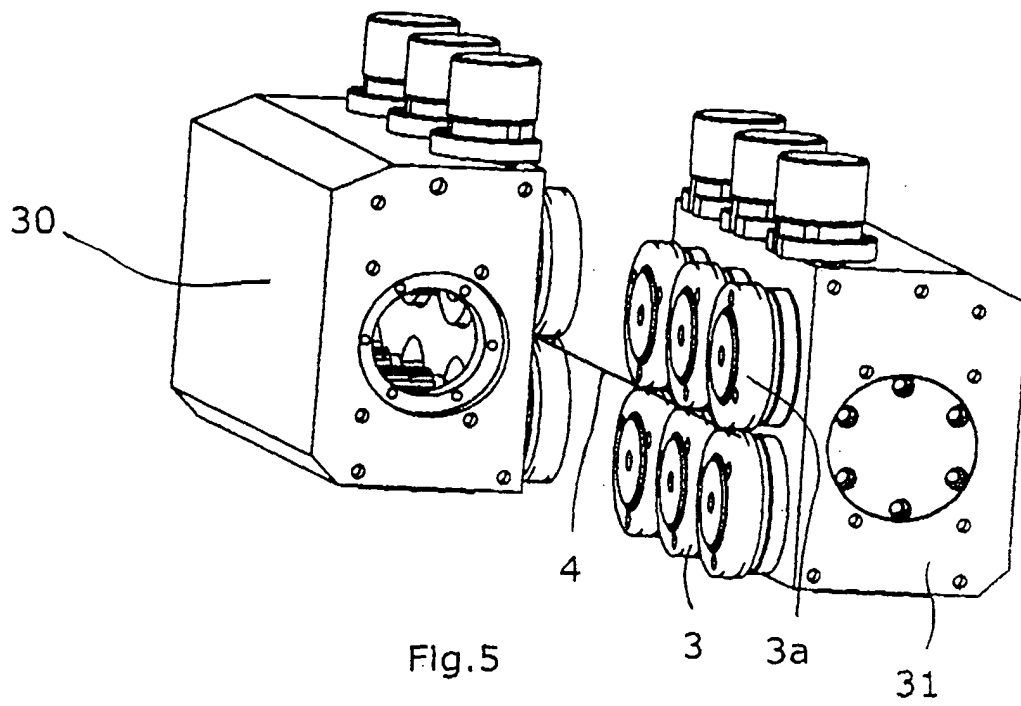


FIG. 4B



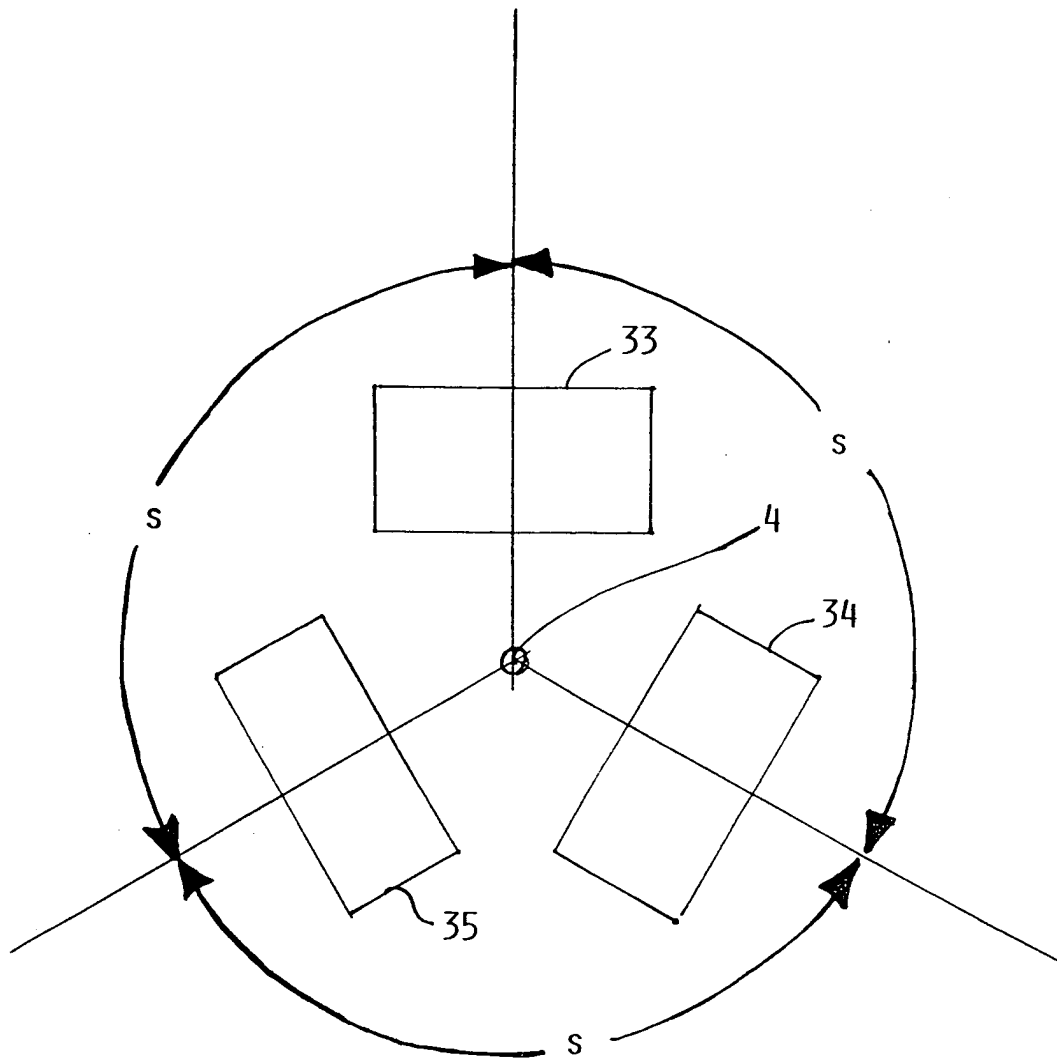


FIG. 7

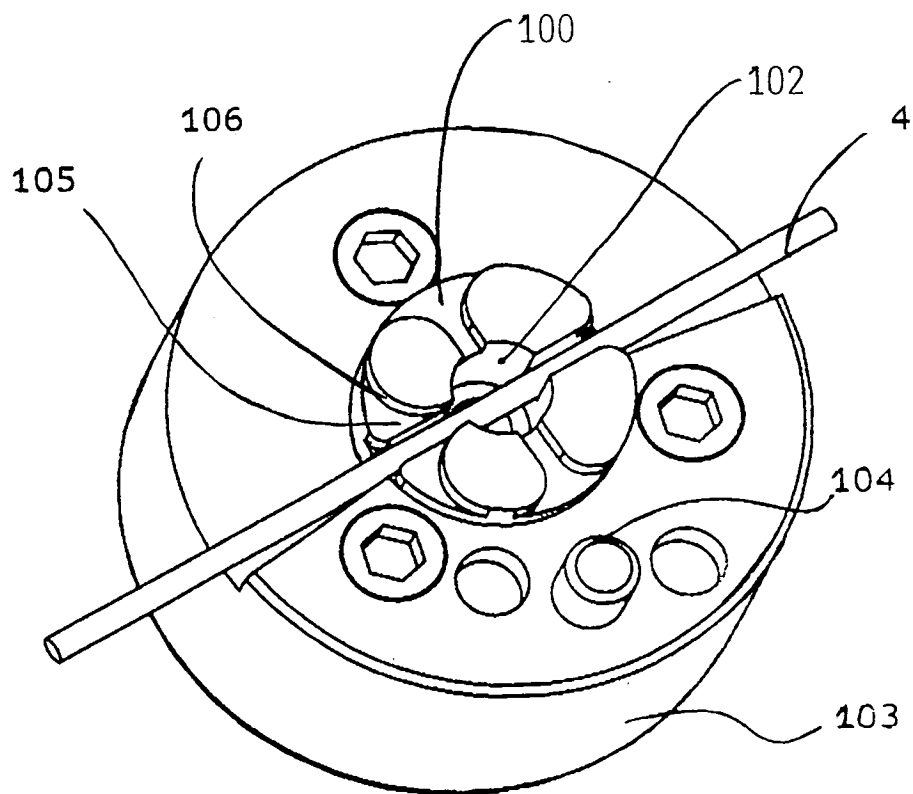


Fig. 8

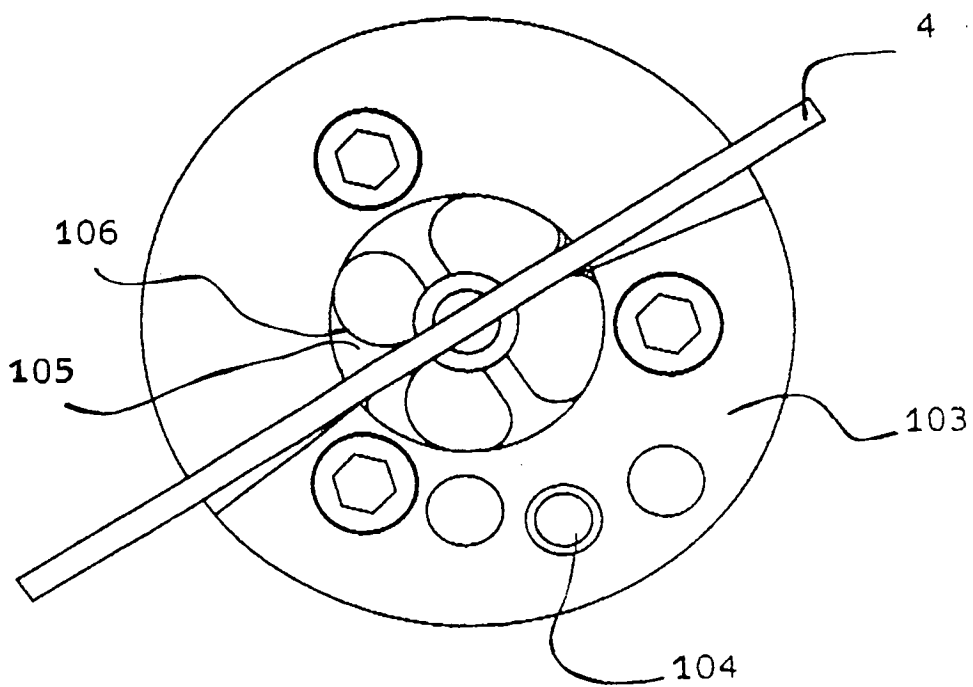


Fig. 9

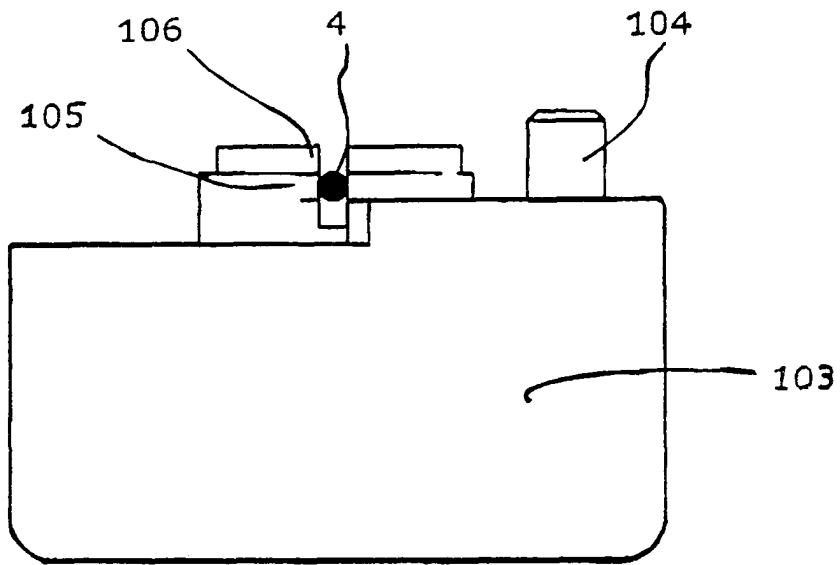


Fig.10

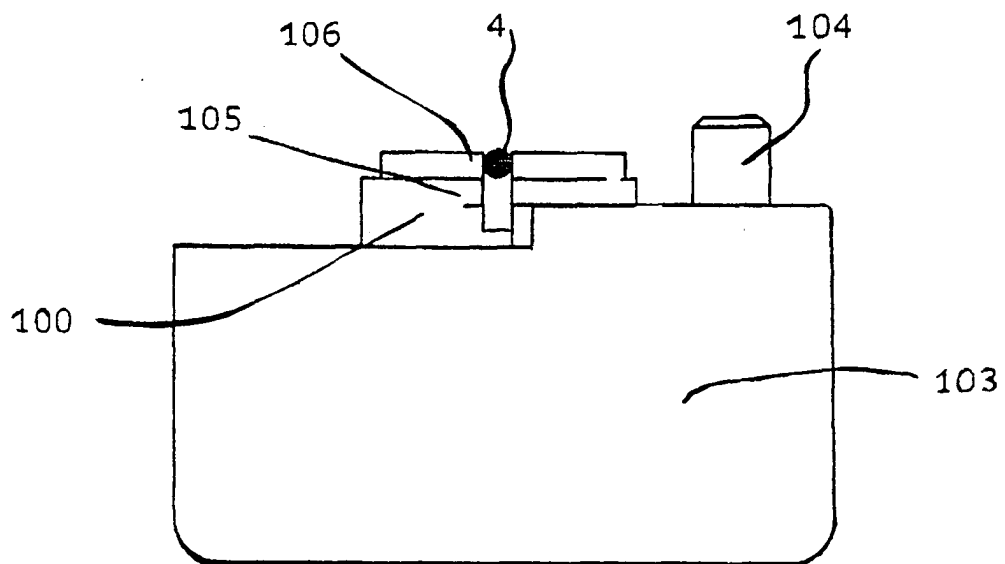


Fig.11

