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(71) Applicant: **Bobbio S.R.L.**
I-22069 Rovellasca (Como) (IT)

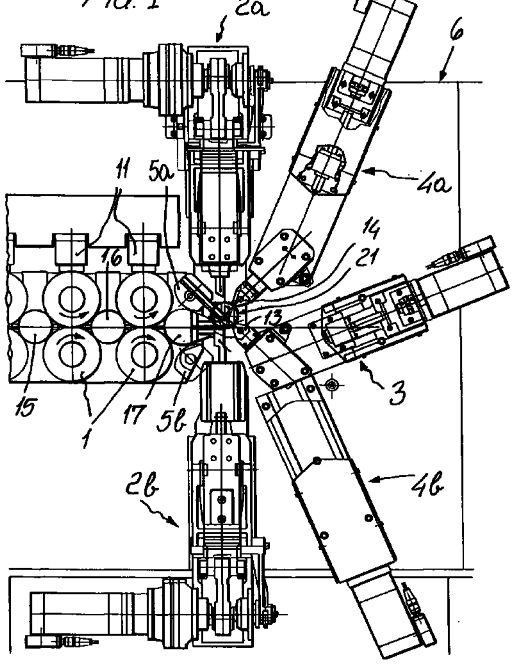
(72) Inventor: **Moltrasio, Gianni**
22069 Rovellasca (Como) (IT)

(74) Representative: **Cicogna, Franco**
Ufficio Internazionale Brevetti
Dott.Prof. Franco Cicogna
Via Visconti di Modrone, 14/A
20122 Milano (IT)

(54) Apparatus and method for making coil springs

(57) An apparatus for making coil springs comprises a wire feeding assembly (1), a supporting assembly (6) for supporting at least a forming foot element (3) for forming the spring turns, a coil spring axial pitch forming tool, and a cutting assembly (2a,2b). The main feature of the invention is that the foot element supporting assembly (6) comprises a plurality of slides, driven by respective driving servomotors, controlled by a digitally controlled processor, and which can be oriented according to directions adapted to provide a proper geometrical configuration of the turns of the spring, to arrange the foot elements opposite to the wire feeding direction in order to cause the coil wire to yield depending on the technological properties thereof.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an apparatus for making coil or helical springs.

[0002] The invention further relates to a method for making said coil or helical springs.

[0003] More specifically the present invention relates to an apparatus and method for bending metal wires, for example for making spiral coils having a revolution solid configuration the generatrix line of which can comprise any combinations of algebraic lines; the revolution solid also having a comparatively high conicity and a turn variable pitch.

[0004] As is known, conventional coil spring making machines comprise several main features or operating functions.

[0005] The first of this operating function is that of feeding the wire metal, which is obtained by opposite rollers which, by pressing on the wire and rotating with the same peripheral turning speed, cause the wire to be driven in an axial direction thereof, while subjecting the wire to a pushing force depending on the stress the wire must be subjected to.

[0006] A second operating function is that of bending the wire, which is obtained by bending tools adapted to offset the wire rectilinear path and to cause the wire to yield according to a set bending radius.

[0007] A third operating function is that of moving the coil spring turns away from one another which is obtained by tools arranged transversely of the spring coil turns and engaged between the turns so as to move away the first turn from its bending plane, thereby providing a set pitch between the adjoining turns.

[0008] A fourth operating function is that of cutting the wire, which is obtained by two cutting tools, of which one is movable with respect to the other in the cutting plane, said tools having a suitable stiffness and being driven on an accurate driving path, said tools being moreover subjected to a comparatively high force for overcoming the breaking limit of the wire.

[0009] To the above main functions, it is possible to add further functions, both of an auxiliary type and specifically designed for improving the performance and operating rate of the basic devices.

[0010] In order to perform satisfactorily, however, prior coil spring making machines must be subjected to a lot of adjusting operations and, very frequently, a good coil spring making result is achieved only after a lot of complex and fatiguing empirical tests; moreover, a given making pattern cannot be always precisely reproduced in time since the number of independent operating variables is very high.

[0011] In this connection, it should be also pointed out that the coil spring making machines must also be designed depending on the conditions imposed by the geometry of the spring coil turns as well as by the driving pattern of the turn forming feet, both depending on the technological process thereon the machine is based, and on the dynamic construction of said machine.

[0012] The above mentioned requirements generate great problems in identifying a proper mathematical model for meeting the designing requirements and properly controlling the kinematic performance of the several mechanisms processing the coil wire as the spring is made. Moreover, several technological parameters are related to the wire material nature, the bending the wire must be subjected to, which parameters require a further series of mathematic models specifically designed for matching the resilient-plastic features of the wire through the overall making process.

[0013] In particular the operating path of the forming foot elements must fit as far as possible the homothety theory of the turns, both considering the variation of the coil spring geometric pattern (for example in the presence of a possible tapering or pitch variation), and in changing a set diameter in order to match the resilient return effects of the wire material (in fact, as the coil spring diameter varies, the amount of the correction to be performed must be correspondingly changed, and this parameter, as is known, being not linearly related to the geometrical parameters).

[0014] Several attempts and empirical processes have been designed for defining a quick and consistent manner for making a given spring, based on set designing data. However, the high number of possible adjustments and alternating devices to be used for achieving a same result, has made a proper designing of such a process very complex.

[0015] Even the numerically or digitally controlled apparatus which are at present available on the market have not been found as suitable to fully solve the problem of a full automatisation of the coil spring making process, because of lacking of proper mathematic and technologic supports frequently related to not fully satisfactory mathematical models as at present used as well as to a not satisfactory information related to the resilient-plastic features of the wire forming material.

[0016] In this connection it should be moreover considered that the cutting procedures conventionally based on the related motion between a movable cutting tool and a fixed cutting tool (also called counter-cutting pin) are frequently conditioned by the operating stroke amount and the resilient properties of the rectilinear motion guides: the comparatively great displacement of the cutting tool, on the other hand, mainly depends on the need of not interfering against the largest diameter turns in the case of tapering springs; these drawbacks would cause a very quick wearing-out of the cutting edge and yet other drawbacks. Moreover, this processing manner of the cutting mechanisms compels to supply a very great installed power while causing deleterious impact effects on the cutting devices.

[0017] A further problem is that the use of a pre-hardened steel material wire, which is at present broadly diffused, would generate cutting problems for cutting the end portions of each individual made spring, as well as very burr formation problems.

SUMMARY OF THE INVENTION

[0018] Accordingly, the aim of the present invention is to overcome the above mentioned problems of prior coil spring making machines or apparatus, by providing an improved coil spring making apparatus which can properly operate starting from a simple information related to the data directly contained in the spring configuration or design.

[0019] Within the scope of the above mentioned aim, a main object of the present invention is to provide such a coil spring making apparatus which also allows tapering or conical coil springs to be easily made.

[0020] The above aim and object, as well as yet other objects, which will become more apparent hereinafter, are achieved, according to one aspect of the present invention, by an apparatus for making coil springs, said apparatus comprising a wire feeding assembly, and being characterized in that it further comprises a supporting assembly for supporting at least a coil spring turn forming foot element, a tool for defining an axial pitch of said coil spring as well as a cutting assembly, said foot element supporting assembly comprising a plurality of slides, driven by respective driving servomotors controlled by a digitally controlled processor, said slides being adapted to be oriented according to directions adapted to provide a proper geometrical pattern of the turns of said coil spring, by arranging said foot elements opposite to the wire feeding direction in order to cause said wire to be yielded and deformed, depending on the technological features of said wire.

[0021] The invention also relates to a method for making coil springs, starting from a wire supplied by the inventive apparatus, characterized in that said method comprises a step of detecting the technological properties of said wire, said detecting step being carried out by providing technological data related to the spring coil wire by using said apparatus, a processing step for processing said data in order to provide a correlation curve representative of the elastic-plastic performance of the wire, and an adjusting step for adjusting the tool assemblies of said apparatus in order to properly make the coil spring.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Further advantages and characteristics of the present invention will become more apparent hereinafter from the following detailed disclosure, given by way of an illustrative but not limitative example, with reference to the accompanying drawings, where:

Figure 1 is a schematic perspective view illustrating the apparatus according to the invention specifically designed for making a right pattern coil spring;

Figure 2 is a schematic perspective view illustrating the apparatus according to the invention specifically designed for making a left pattern coil spring;

Figure 3 is a further schematic perspective view illustrating the inventive apparatus specifically designed for making twisting or torsion springs;

Figure 4 is yet another schematic perspective view illustrating a cutting unit as partially cross-sectioned;

Figure 5 is a further side schematic view illustrating the mentioned cutting unit;

Figure 6 illustrates the forming geometry of a circular turn of a coil spring; and

Figure 7 illustrates a stress-strain diagram related to the material of the spiral coil forming wire.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023] In the following disclosure reference will be made to some preferred embodiments of the invention, which have been illustrated as an example of several possible not limitative variations of the invention.

[0024] In order to properly understand the invention, it should be pointed out that the present invention intends to solve the geometrical problems related to the coil spring making processes, while relating said problem to the related kinematic problem to be properly solved in all of the spring making apparatus.

[0025] In fact, in order to provide a proper coil spring making process all of the operating parameters must be properly digitally controlled independently from possible subjective interpretations by the operators.

[0026] To that end two basic theorems at the base of a proper designing of coil spring making apparatus will be at first considered: the first being a geometrical theorem and the second being a technological problem.

[0027] More specifically, the first of said theorems specifically relates to the geometrical pattern of the circular turn of a coil spring: in fact, it is known that the winding circumference c of a coil spring turn, made by suitable tools or foot elements, P_1 and P_2, tangent to said circumference and the first of which is arranged at $-\alpha$ (for example - 45°) and the second of which is arranged at $+\alpha$ (+45°) with respect to a straight line passing through the center O (see Figure 6) is characterized by the following features:

a) by holding at a set condition the tangency point A of the half-line r (which represents the path of the wire before its deformation) for any circumferences of radius R, and by holding the orienting angles of the foot elements unchanged, the point O will be displaced along the vertical line passing through A;

b) the half-lines s and t, having an origin A and respectively passing through P_1 and P_2 (oriented at 1/2 α and 3/2 α with respect to a horizontal line) represent a locus of the homothetic points of the circumferences passing through three points, of which both the fixed point A and the vertically aligned points P_1 and P_2 are arranged on the half-lines s and t having a preset orientation. This means that all of the circumferences will have their centers arranged on the same vertical line passing through A.

[0028] The second theorem relates to the wire deforming technology or method; actually, the deforming wire condition, the wire being considered as an originally rectilinear beam having a constant cross-section, is that overcoming the yield limit or point Q (see Figure 7) and causing the wire to plastically yield by properly calibrating the yielding amount depending on a unit yielding deformation e_{sn} and depending on the elastic-plastic module E_1.

[0029] The actual deformation of the wire is related to its cross section and to the deforming force application lever arm, according to a well known mathematical relationship which, in the case of a circular cross-section, is as follows:

$$y_m = 1/3\ e_{sn} L^2 / r_f$$

[0030] Thus, the deformation or strain y_m must be related to the material type and the processing thereof, to the square of the straining force application arm L and to the reverse of the radius r_f of the circular cross-section.

[0031] After straining, the wire will recover its resilient characteristics starting from the size of a circular turn different from that set for the straining: this is conventionally called resilient recovery and constitutes the subject matter of very complex evaluations.

[0032] The thus made turn must coincide with the final turn of the spring being made and its precision will reflect the good amount of the product as well as the meeting of its operating requirements.

[0033] Making now specific reference to the figures of the accompanying drawings and, more specifically, to the number references of said figures, the coil spring making apparatus according to the present invention comprises a wire roller feeding assembly 1, two cutting units 2a and 2b, and a first-foot element assembly 3, as well as two discrete second-foot element assemblies, i.e. an assembly 4a for a right spring and an assembly 4b for a left spring (see the figure). The bed 6 supports, in addition to the mentioned assemblies, also the axial pitch defining or forming devices 5a and 5b.

[0034] The driving or entraining means 1 comprise several pairs of opposite rollers which can be clamped against one another by any known methods (for example by using oleodynamic jacks 11), for clamping against the wire 12; in particular, said rollers are rotatively driven about their rotary axis by one or more electric motors coupled by known driving elements. The clamping force, and consequent friction component, associated with the rotary movement of the rollers will be transmitted to the wire thereby causing said wire to be fed toward the forming foot elements 13 and 14; as shown, along the wire path a plurality of wire guiding elements 15, 16 and 17 for properly guiding the wire while preventing it from being deflected under peak loads are provided. The first foot element 13 can be interposed on the wire path thereby causing a first bending step by exceeding or overcoming the wire yielding point in the section arranged at the end of the wire guiding element 17.

[0035] The second wire bending step is carried out by affecting the wire path by the second foot element 14: the latter, in particular, will further strain the wire so as to provide the end radius of the spring before the resilient recovery.

[0036] Along the following curved path, the wire is processed by the axial pitch forming device 5a, specifically designed for straining the coil spring turn in a direction perpendicular to its laying plane. Instead of the device 5a, it would be also possible to use a device 18, the so-called vertical pitch forming device, also adapted to offset the trajectory of the turn being formed, by straining the wire under a twisting force.

[0037] The cutting unit of Figures 4 and 5 comprises two tools, i.e. the counter-cutting pin 19 and the cutting tool 20, on which the turn 21 is entrained upon formation. At the end of the spring forming process, the spring wire must be properly cut and, to that end, the cutting tool 20 is driven transversely of the wire 21a in order to cut it by the counter-cutting pin 19. If the spring is a cylindrical type of spring, then the spring turn diameter will be held constant, and the trajectory of the wire to be cut will always pass through the position 21a; on the contrary, as the spring is a conical or tapering type of spring, the diameter of the spring will change and its trajectory could be extended up to the position 21b. In this case, however, the necessary space would interfere against the cutting tool 20a.

[0038] In order to overcome this problem, the present invention provides a novel solution of causing the cutting tool to be rearwardly displaced to the position 20b up to the end of the making of the spring. As the spring has been made, the cutting tool will be recovered to the cutting position 20a in order to perform a cutting movement in a cross direction of the wire axis.

[0039] The combination of the two cutting movements is carried out by holding the supporting construction 27 stationary and displacing the slide 24 in two direction, i.e. the cutting vertical direction by the connecting rod 22-crank mechanism 23, the connecting rod 28 foot end of which is vertically guided, while being pivoted to the slide 24; and the swinging direction about the pin 28, as controlled by the rocking element 26 of the cam 25 rigid with the crank shaft 23. In the illustrated case, the cutting is carried out by using an electric motor 29 coupled, through the reduction gear unit 30, to the crankshaft 23: for each full revolution of this shaft, a cutting cycle will be performed corresponding to the following operating steps: feeding of the cutting tool to the position 20a; downward displacement of said cutting tool against the counter-cutting pin 19, and cutting of the wire arranged at 21a; upwardly recovering and withdrawing to the position 20b.

[0040] With respect to a left spring (see Figure 2) it should be pointed out that, differently from a right spring, the apparatus must change the arrangement of the turn forming foot elements. The first foot element 13 is still driven by the unit 3, the orienting of which represents the sole variation. The second foot element 14, on the contrary, is driven from the unit 4a to the unit 4b, already positioned but not used for the right spring. Thus the cutting unit will be transformed into the unit 2b by only changing the cutting tool 20 and counter-cutting pin 19, and the axial pitch formation will be provided by the axial pitch forming device mounted at the position 5b; a possible vertical pitch, on the other hand, could be formed by the same forming tool 18 displaced to the unit 2a.

[0041] Thus, it will be possible to provide a general purpose setting of the operating units, which can be used both for right and for left springs, without requiring specifically designed or customized units which must be frequently removed and replaced.

[0042] The apparatus according to the invention can also be used for making torsion or twisting springs (see Figure 3).

[0043] In this connection it should be pointed out that the wording "torsion or twisting springs" is used for indicating a lot of variously formed springs having spring turns both of leftward and rightward type. In order to make these springs, a single forming foot element 31 is used, the movement of which would be related to two coordinates which, in the not limitative embodiment being disclosed, would be orthogonal cartesian coordinates.

[0044] A main feature of the invention is that of providing the above mentioned two movements or displacements by the already positioned units 3 and 4a, of which only the unit 3 must be turned to assume a horizontal orienting (x coordinate), on said unit 3 being mounted a device 33 (which, accordingly, is rigid with the slide of the unit 3) supporting the vertical slide 32 to which the general purpose foot element 31 is coupled.

[0045] The movement according to the vertical coordinate y is transmitted by the unit 4a through the supporting element 34 engaged in the guide 35 rigid with the slide of the unit 4a.

[0046] The dynamic straining of the wire is carried out by pushing said wire against the rollers 1 and using the wire guiding elements 15, 16 and 17, while properly displacing the axis thereof by the foot element 31, while the end cutting operation will be performed by the cutting unit 2a.

[0047] The apparatus of the present invention is specifically designed for timing its operating steps by servomotors directly coupled to each of the driving axes (the operating units), without any mechanical connections between said axes. Thus, motion laws and mathematical relationships controlling said operating steps would be imposed by proper software algorithms to provide any desired types of spring without any mechanical limitations. In other words, this novel technical solution would allow to pass from a type of spring to another without performing complex adjustment mechanical operations.

[0048] In order to simplify the driving diagram of the wire feeding rollers, which, in general, will require the use of a mechanical speed transmission, a servomotor having a double speed range is used: in the first of said ranges, it will operate under a constant torque (this being the low speed range), whereas in the secondof said ranges it will operate with a constant power (this being the high speed range).

[0049] The servomotor (or a plurality of servomotors arranged with a mechanical and electrical parallel relationship) is driven by a digital controlling device, in cooperation with other servomotors forming the other driving axes of the diameter, pitch forming devices as well as of the cutting devices.

[0050] The turn diameter forming axes comprise, as stated, three individual slides each of which is controlled or driven by its servomotor, the slides being fixedly mounted on the machine both as a right coil spring is made and as a left coil spring is made.

[0051] The displacement or driving axes will be perfectly directed according to the theoretically proper directions, as required by the turn geometry theorem.

[0052] The axis of the first foot element is constituted by the same slide which can be oriented to the two positions required by the right and left coil, in addition to a horizontal position in order to provide displacements according to cartesian axes as used for making torsion springs, clamping ring elements or other constructions of springs and related articles.

[0053] The axis of the second foot element is provided with two separated or discrete slides, each arranged in a proper geometrical direction according to the oriented rectilinear trajectories: one at +66.5° in the first quadrant for right coil spring, and another at -66.5° in the fourth quadrant for left coil springs.

[0054] Instead of using the prior mechanical coupling systems for coupling the first and second foot elements, the apparatus according to the invention specifically provides for using a software approach, based on algorithms controlled by the digitally controlling device, which has been specifically designed for controlling all of the displacement axes. This will allow to switch from a right spring to a left spring without requiring complex replacing operations for replacing machine parts with consequent pre-adjustments of the apparatus.

[0055] With respect to the wire cutting assembly, it should be pointed out that on a vertically movable unit (for arrangement in an ideal working region according to the spring diameter) all the main devices of the cutting system are concentrated, said devices being rigidly coupled to one another, both for overcoming coupling clearances and the like, allowing, by a single operation, a proper positioning of the system.

[0056] In order to overcome inevitable drawbacks of like devices, a withdrawing movement of the cutting tool from the turn winding plane has been specifically designed, thereby preventing the coil wire from interfering against the tool, while eliminating the further drawback of an excessively long displacement of the tool, as in a case of a vertical withdrawing provided to the same end on the most part of prior coil spring making machines. Thus, the withdrawal of the cutting plane, timed with the upward and downward movement is automatized by a specifically designed mechanism, thereby reducing to a minimum the cutting stroke, and the related working of the system, even in the presence of comparatively high cutting forces, thereby drastically reducing the impact speed between the cutting tools and wire during the cutting operation.

[0057] The system constitutes and axis of the apparatus and is so related to the other drives as to properly combine the cutting operation with a set wire length for completing the spring. This system comprises a servomotor and mechanical amplifier mechanisms for amplifying the forces with an optimum ratio of the installed power and the operating efficiency.

[0058] The present invention also comprises a method for obviating a lacking of proper data on the technological characteristics of the wire, by using the same winding apparatus as an instrument for properly detecting said data, by a statistic type of measurement and processing routine, for example according to the following procedure:

a diameter of the spring is set on the control panel (CNC), and some turns of the spring are coiled;
by a shop gauge the effectively made diameter is measured and the value thereof is transmitted to the CNC unit by keying it on a keypad;
the setting, winding and measuring operations are repeated for a set number of times, by changing the diameter of the sample, by always choosing the diameters within the value range required for that wire diameter.

[0059] Upon achieving the above data, said data is processed together with the following obtained data. The program will provide a statistic correction of the reading errors, a calculation of the regression curve representing the elastic-plastic properties of the wire, and will supply to the apparatus the precise characteristic of the wire material under examination, as required by the curving process and with a very accurate relationship with the desired result: i.e. the making of a patterned spring without any subjective interventions of the operator and without the need of performing in a technological laboratory expensive measurement operations.

[0060] Actually, it will be sufficient to set on the control panel the two diameter variation limit values, to allow the controller to divide into n steps the diameter range, thereby easily making a spring small length constituted by the n steps. The operator will carry out the mentioned n measurements and will key the measured values for allowing them to be acquired by the CNC.

[0061] Likewise are performed the detecting operations for detecting the spring pitch in order to obtain precise data on the elastic-plastic performance of the wire under the combined flexure-twisting straining. With a like procedure, the pitch routine would provide the operator with a small spring piece with some regions thereof for detecting the made pitches, measuring said pitches and sending their values to the controller.

[0062] Then, a correlation curve would be processed for the intended pitch, said curve representing the performance of the wire under this type of resilient-plastic strain.

[0063] Thus, the programming unit would be provided, also for the pitch, with real values for properly adjusting the apparatus tools to precisely make the spring.

[0064] The wire material can have different characteristics, the evaluation thereof being performed by an in-machine test thereby allowing the functional performance to be automatically preset.

Claims

1. An apparatus for making coil springs, comprising a wire feeding assembly, characterized in that said apparatus comprises moreover a supporting assembly for supporting at least a spring coil turn forming foot element, a forming tool for forming an axial pitch of said spring and a cutting assembly, said foot element supporting assembly comprising a plurality of slides, driven by respective servomotors controlled by a digitally controlled processor, and adapted to be oriented according to set directions providing a set geometry of the turns of said spring, to arrange said at least forming foot element in a direction opposite to a wire feeding direction for yielding and straining said wire to be yielded based on set technological properties of said wire.

2. An apparatus according to Claim 1, characterized in that said foot element supporting assembly comprises a first slide for supporting a first turn forming foot element and a pair of slides, arranged symmetrically with respect to an axis parallel to the wire feeding direction, each of said slides being designed for supporting a second coil spring turn forming foot element depending on a right or left direction of the turn of the spring being formed.

3. An apparatus according to Claim 2, characterized in that said first slide can be so oriented that said first foot element provides a right or left turn of said spring, said second foot element being arranged on the slide pertaining to said slide pair opposite to the working direction of said first foot element.

4. An apparatus according to Claim 1, characterized in that said spring coil turn forming foot element supporting assembly comprises a first slide provided with a general purpose foot element and oriented in a direction substantially parallel to the wire feeding direction, said first slide being coupled to a second slide and including driving means for transmitting movement in a direction substantially perpendicular to said wire feeding direction.

5. An apparatus according to Claim 4, characterized in that said first slide is driven by driving means comprising a support element engaged in a guide rigid with said second slide.

6. An apparatus according to one or more of the preceding claims, characterized in that said coil spring axial pitch forming tool is coupled to the wire feeding assembly supporting unit and operates to strain the coil turns in a direction perpendicular to the plane of said coil turns.

7. An apparatus according to one or more of claims 1 to 5, characterized in that said coil spring turn axial pitch forming tool comprises a tool element coupled to said cutting assembly and adapted to twist-strain the wire.

8. An apparatus according to one or more of the preceding claims, characterized in that said cutting assembly comprises a cutting tool and a counter-cutting pin, therebetween the turn of said spring is caused to pass upon forming, wherein said cutting tool is driven transversely of said wire to cut through said wire in cooperation with said counter-cutting pin.

9. An apparatus according to one or more of the preceding claims, characterized in that said cutting assembly comprises a connecting rod-crank assembly, driven by a driving motor coupled through a reducing gear unit to the shaft of said crank.

10. An apparatus according to one or more of the preceding claims, characterized in that said cutting assembly comprises, for making tapering type of springs, a withdrawing cutting tool designed to be withdrawn to a first position for allowing the spring coil turn to pass therethrough, said cutting tool being brought, for a cutting operation, to a second position allowing said cutting tool to perform its cutting movement in a direction transversal of the wire axis.

11. An apparatus according to Claim 10, characterized in that said cutting tools is driven from the first position to the second position thereof by a driving cam rigid with the shaft of said crank and provided with a rocker assembly swingably operating said cutting tool.

12. An apparatus according to one or more of the preceding claims, characterized in that said wire feeding assembly comprises a double speed range servomotor, which operates with a constant torque operation mode or, alternately, with a constant power operation mode.

13. An apparatus according to Claim 12, characterized in that said servomotor is controlled by a digital control device, also controlling further servomotors forming further driving axes for driving said assemblies for making said coil turns, and defining said pitch and cutting.

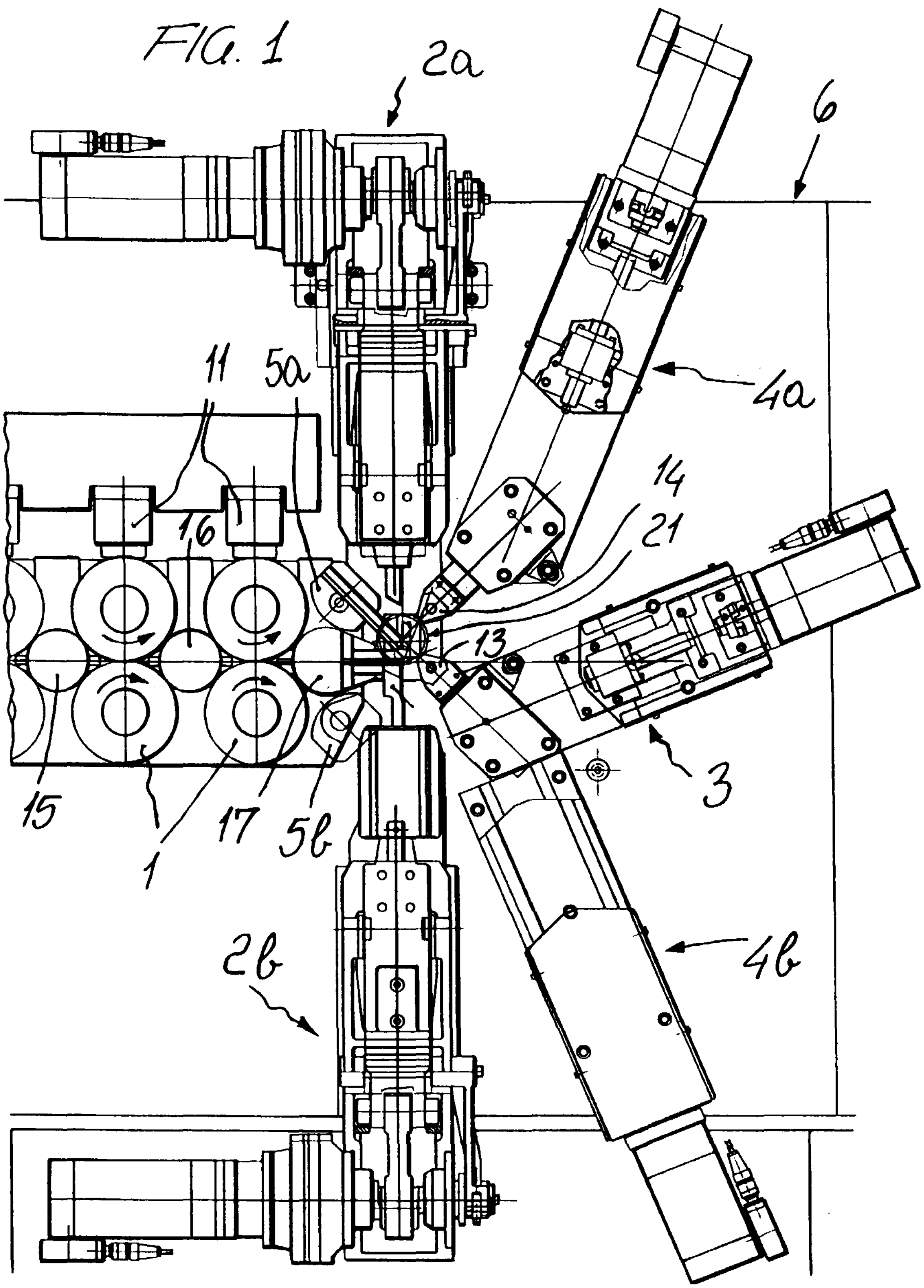
14. A method for making coil springs, starting from a wire supplied by an apparatus according to the preceding claims, characterized in that said method comprises a detecting step for detecting the technological properties of said wire, said detecting step being performed by acquiring from said apparatus technological data related to said wire, a data processing step for providing a correlation curve representative of the elastic-plastic performance of said wire, and a setting step for adjusting the tool assemblies of said apparatus.

15. A method according to Claim 14, characterized in that said detecting step comprises adjusting a diameter of a spring sample to be made and winding some turns of said spring sample; measuring an actually made diameter and sending this diameter value to control units controlling said apparatus, said steps being repeated several times, by changing the diameter of the spring sample, said diameters being changed within a variation range of set values required for said diameter of said wire.

16. A method according to Claims 14 and 15, characterized in that said data processing step provides a statistical correction of read-out errors of said apparatus and a calculation of a regressive curve representing an elastic-plastic performance of said wire, to provide the precise properties of the wire material, as required by the wire bending process and depending on the accuracy of the desired result.

17. A method according to Claims 14 to 16, characterized in that said data detecting and processing steps are designed for providing data related to the elastic-plastic properties of said wire under combined bending twisting straining of said wire.

FIG. 1



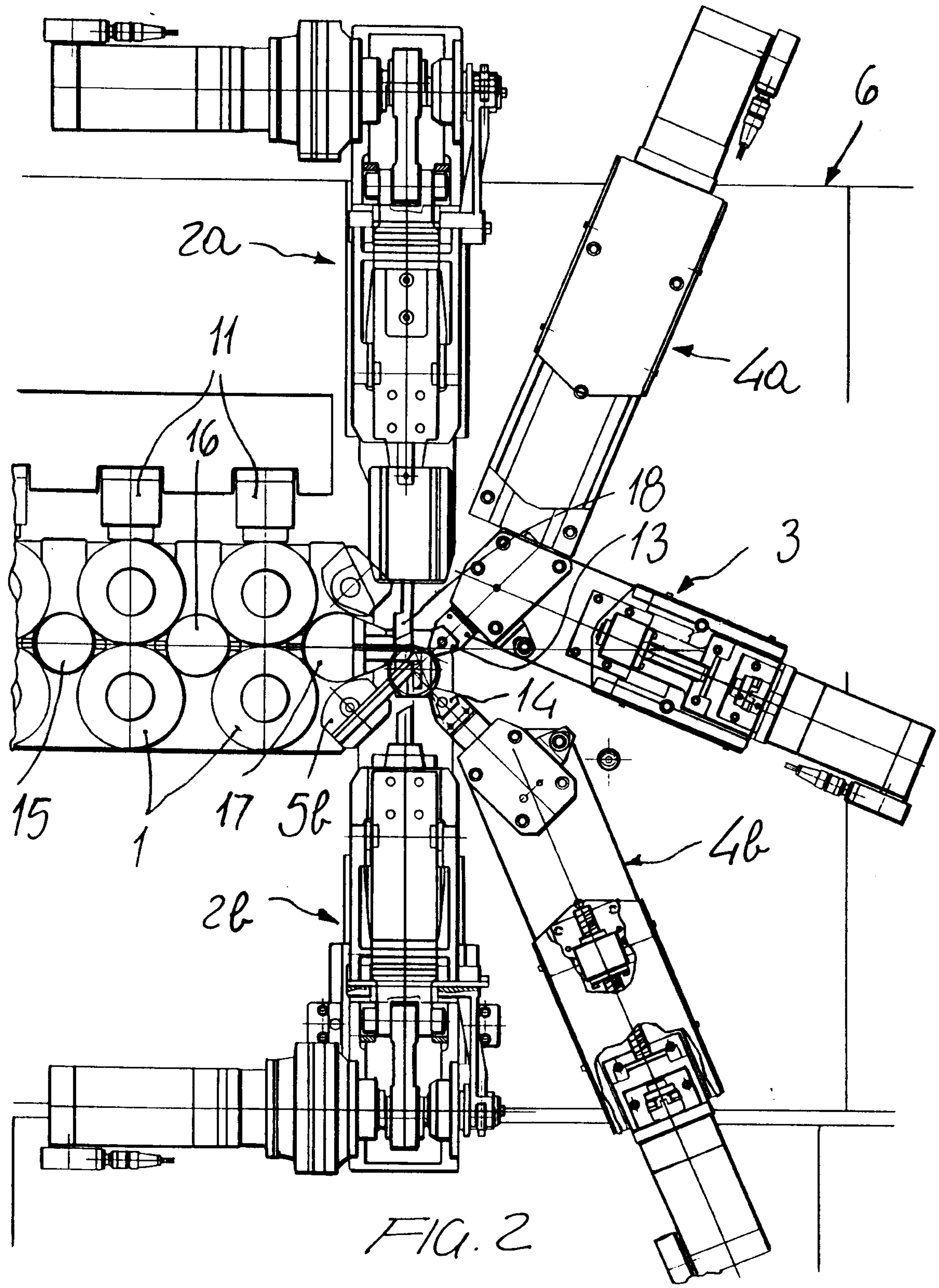


FIG. 2

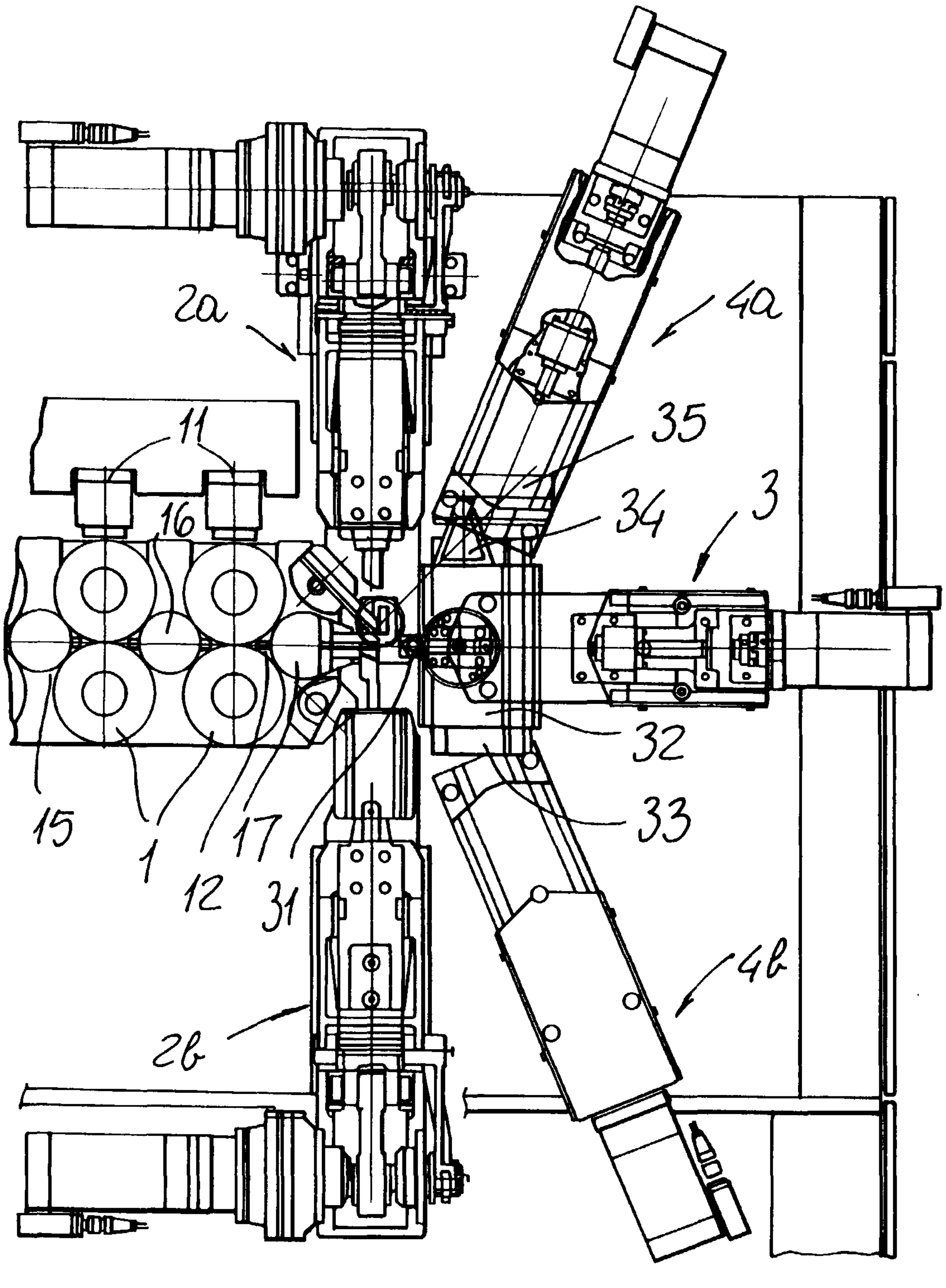


FIG. 3

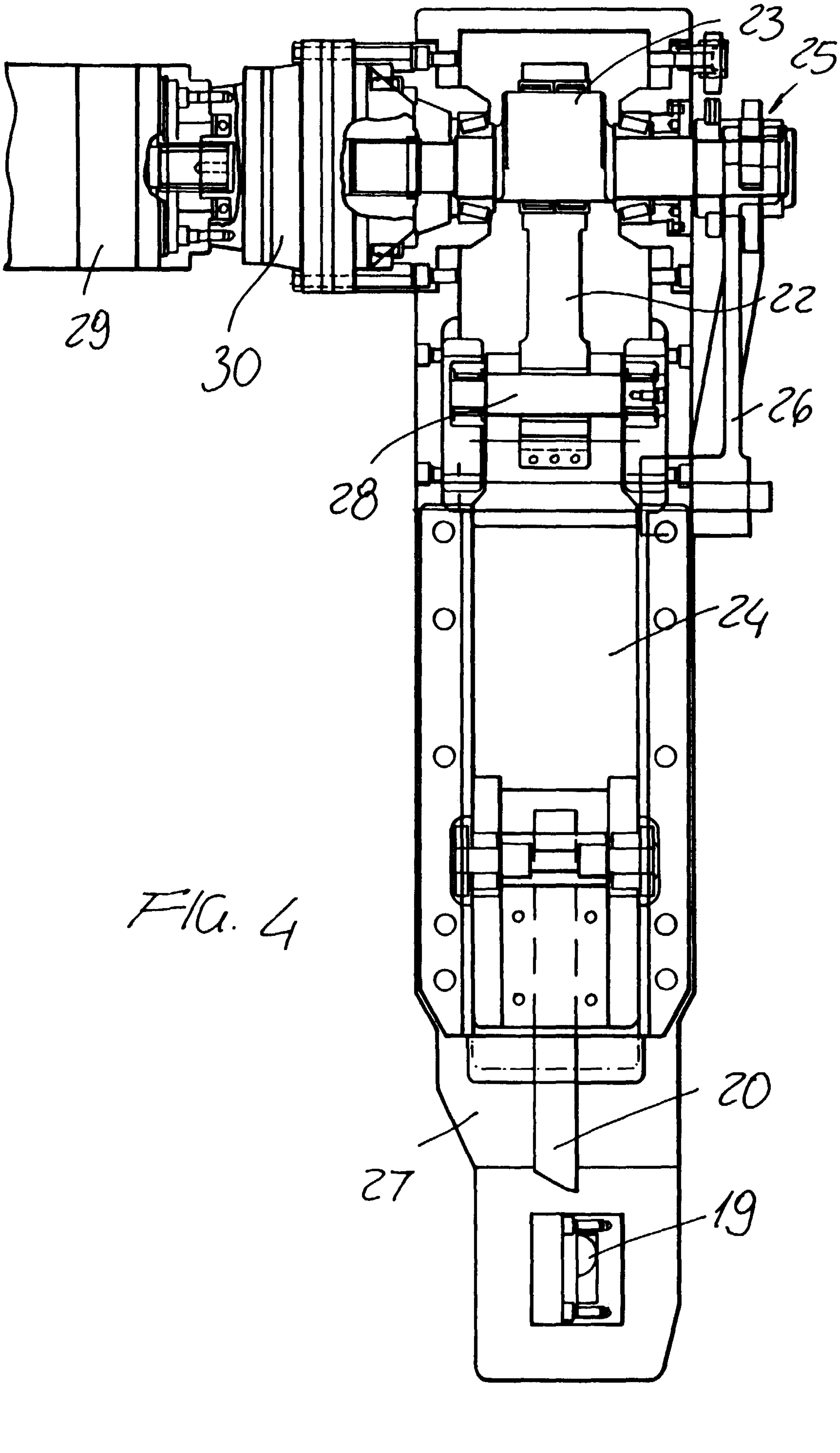


FIG. 4

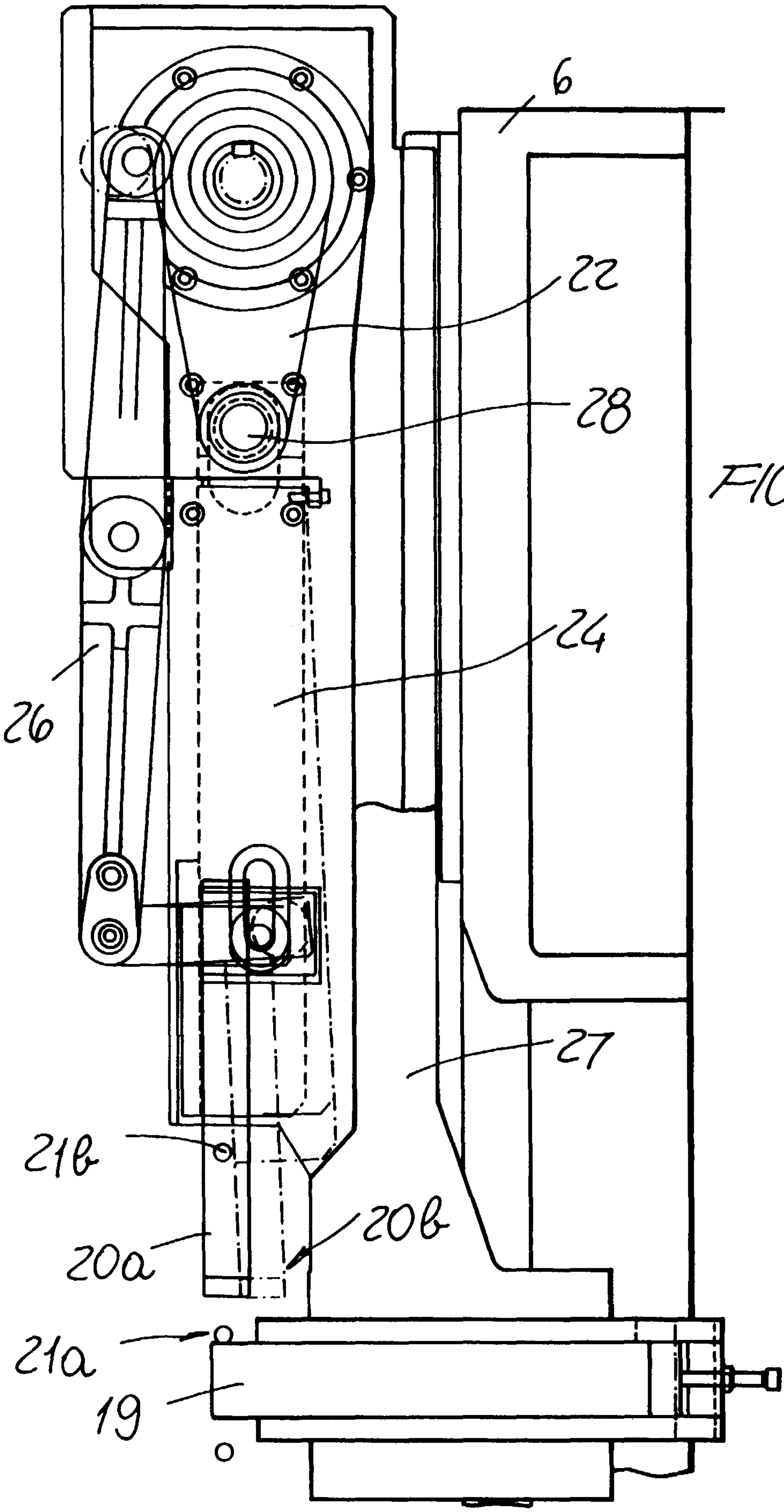


FIG. 5

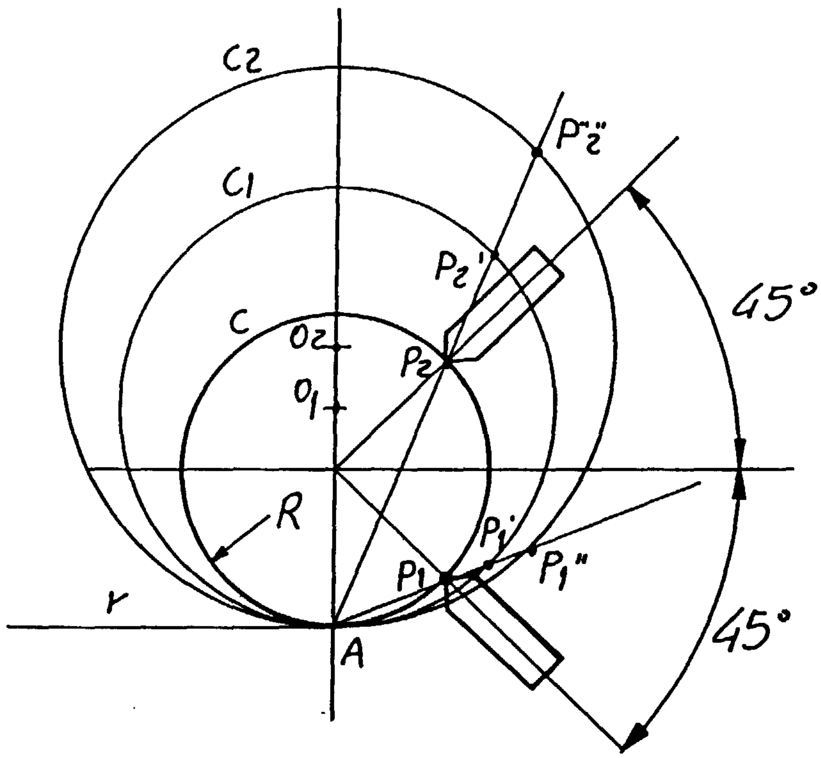


FIG. 6

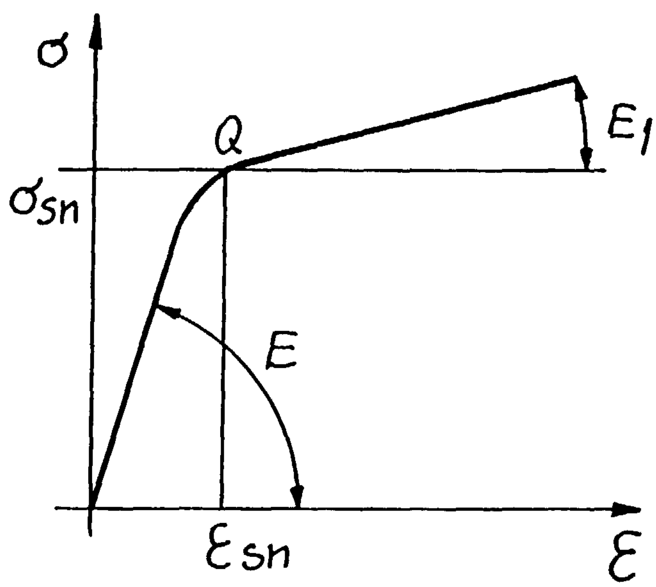


FIG. 7