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(54) **METHOD AND AN APPARATUS FOR
TWISTING AND TIGHTENING A WIRE**

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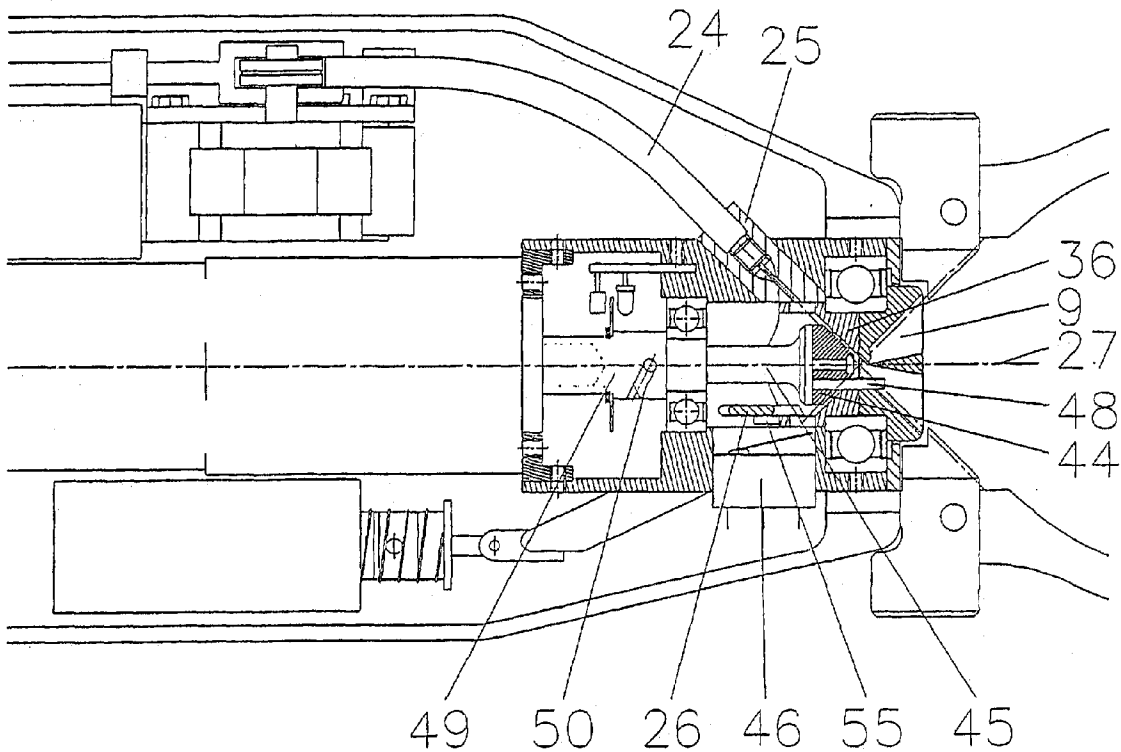
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(57) **ABSTRACT**

A method and apparatus for twisting and tightening a wire with a free end portion around at least two objects, e.g. iron bars for reinforced concrete, for binding the objects together. The method and apparatus enables a tighter and stronger binding to be performed even by means of a portable device and with the use of less binding wire than required by conventional devices.



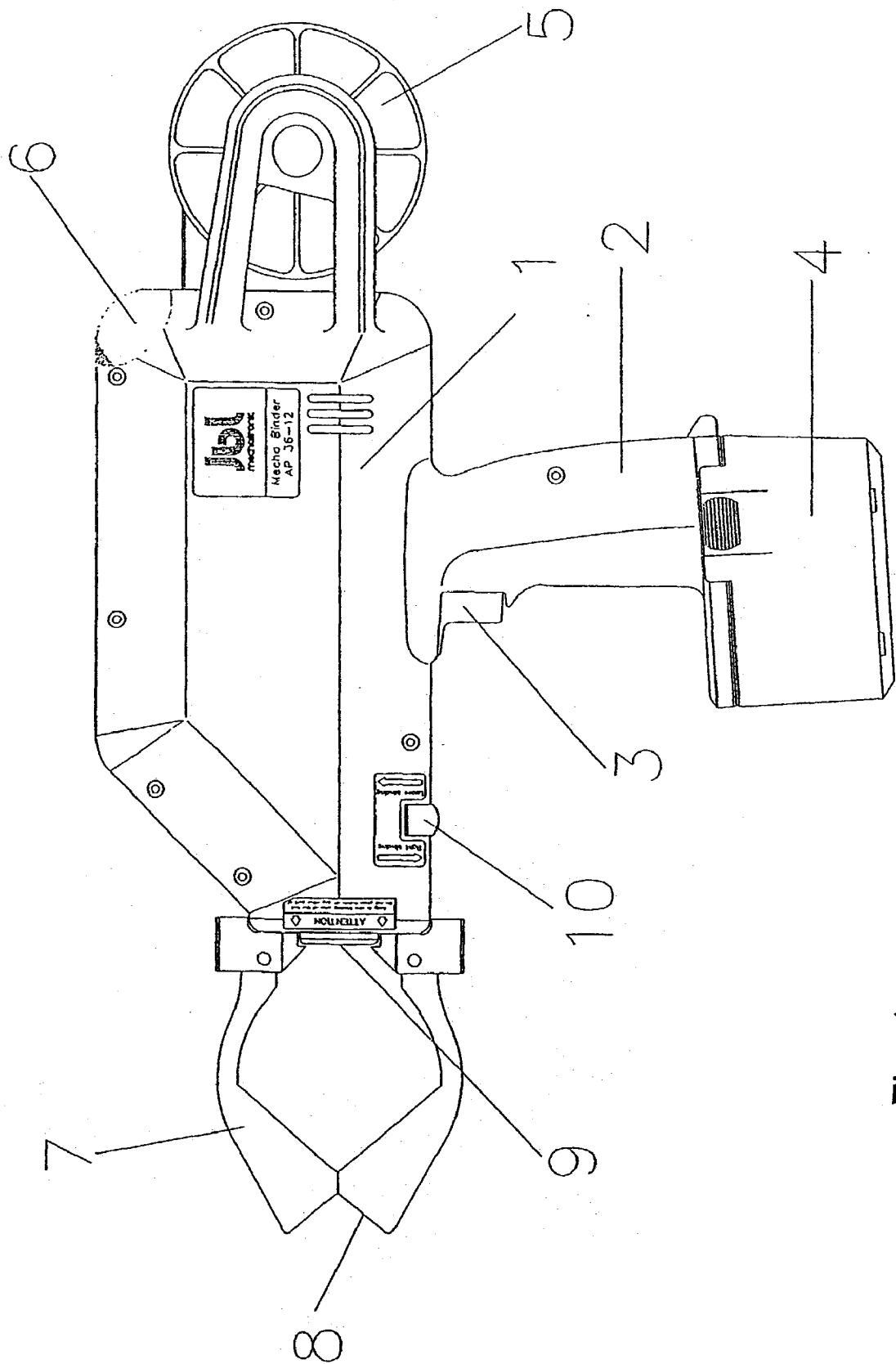


Fig. 1

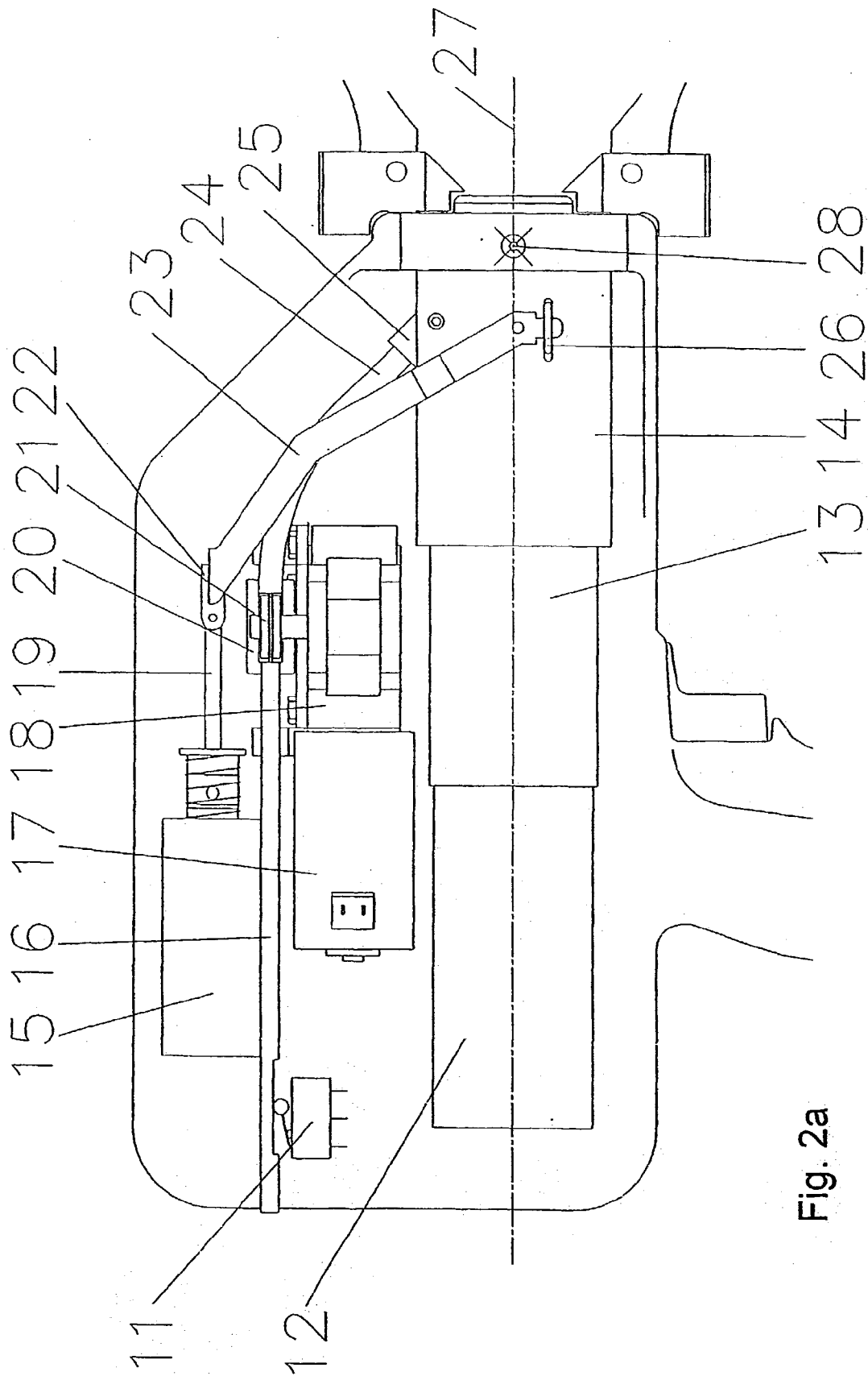


Fig. 2a

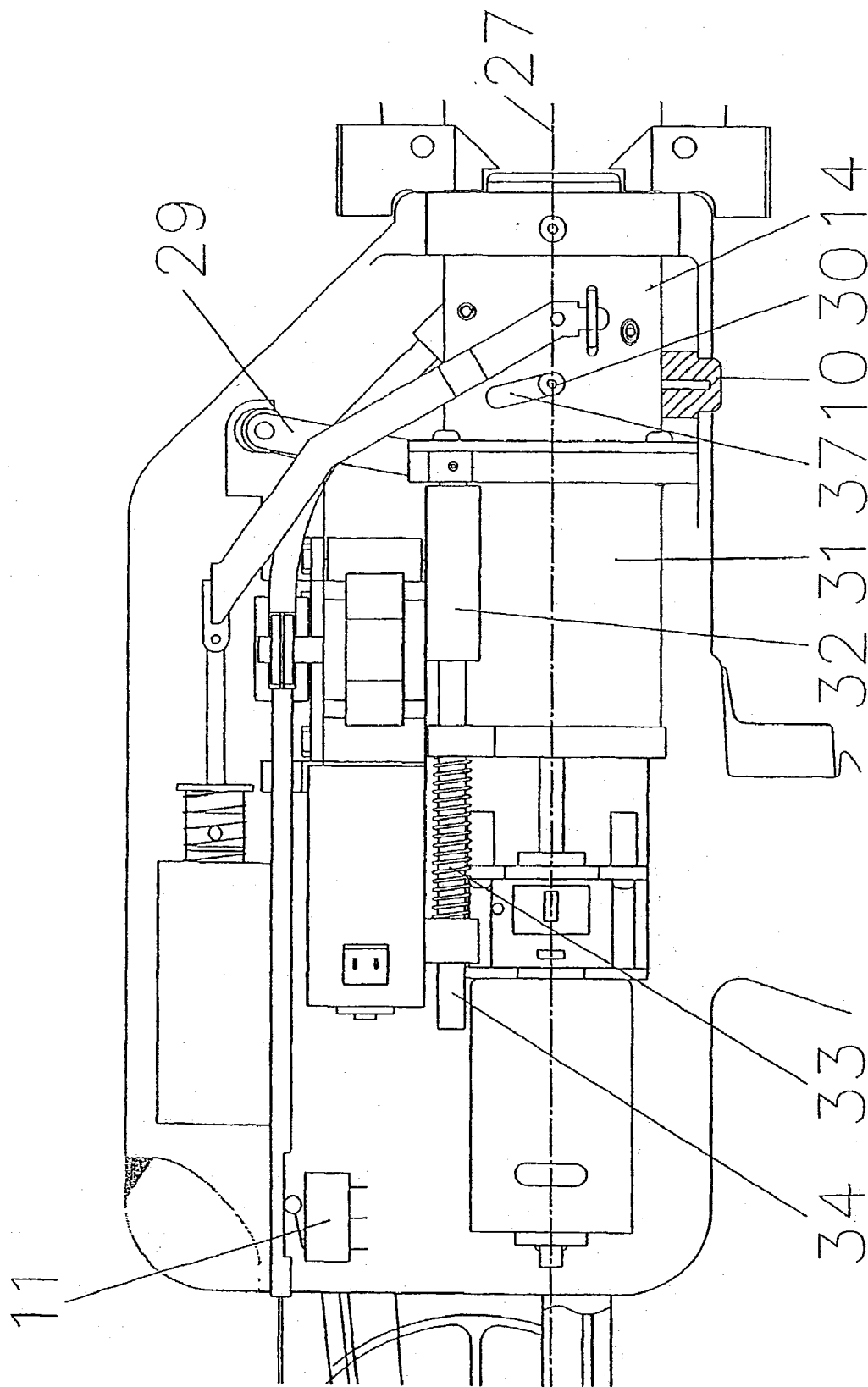


Fig. 2b

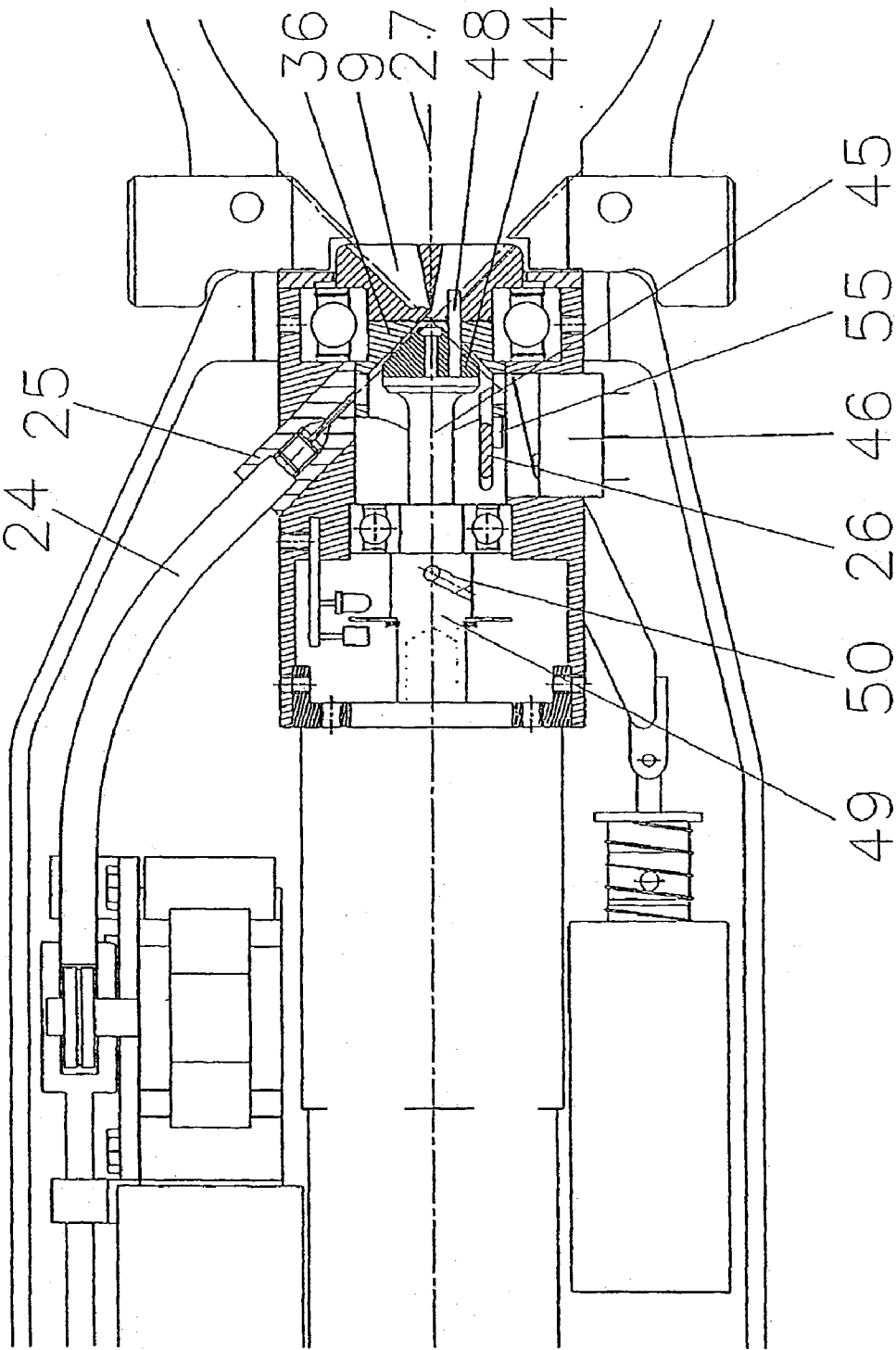


Fig. 3

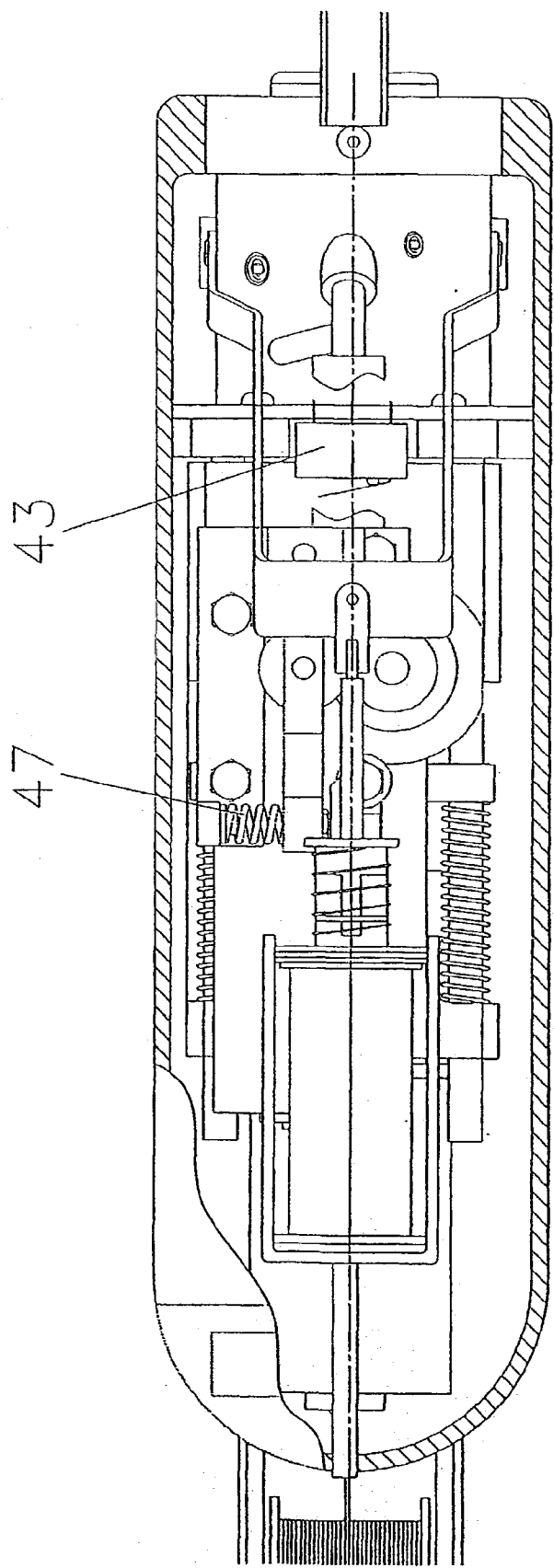


Fig. 4

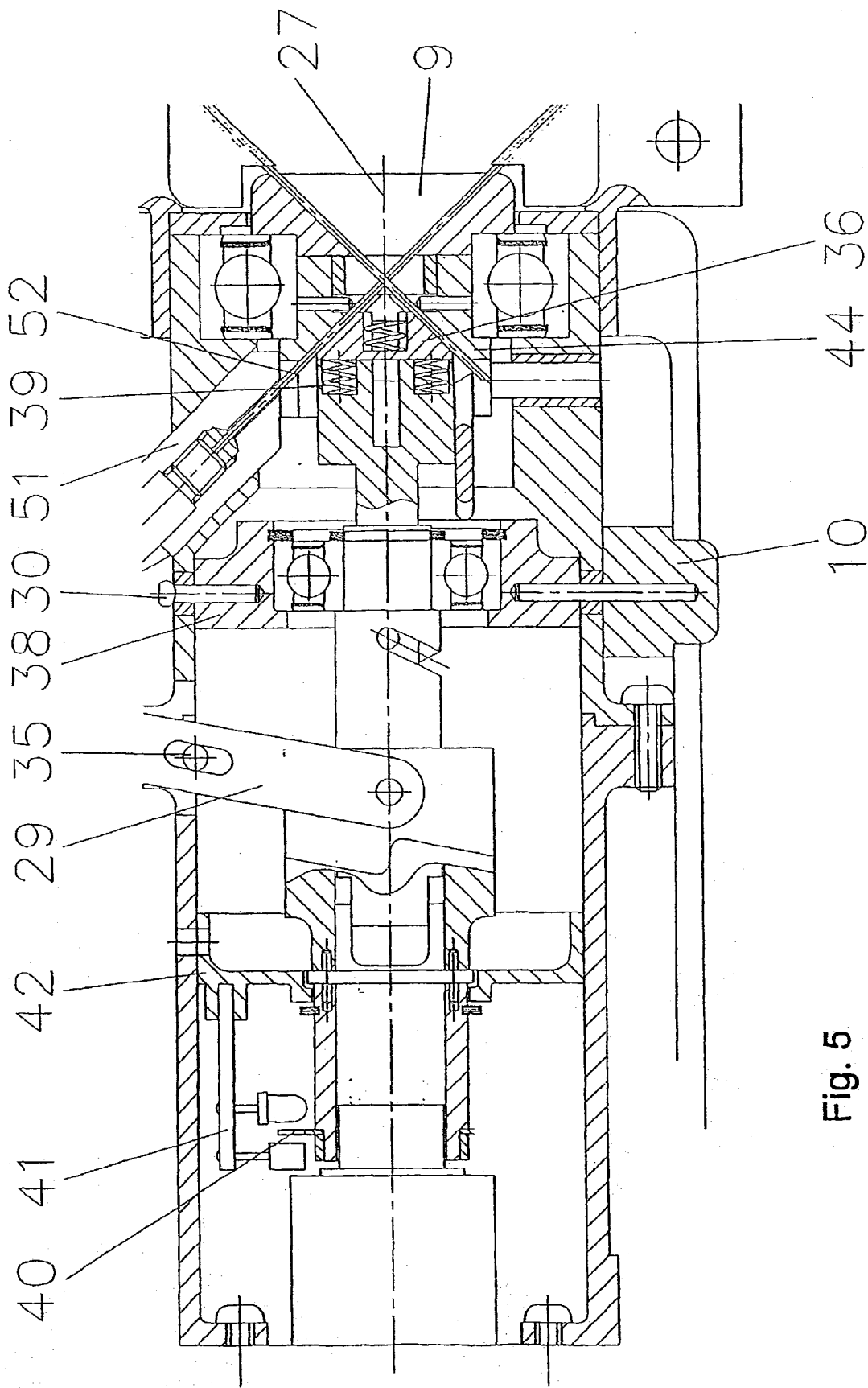


Fig. 5

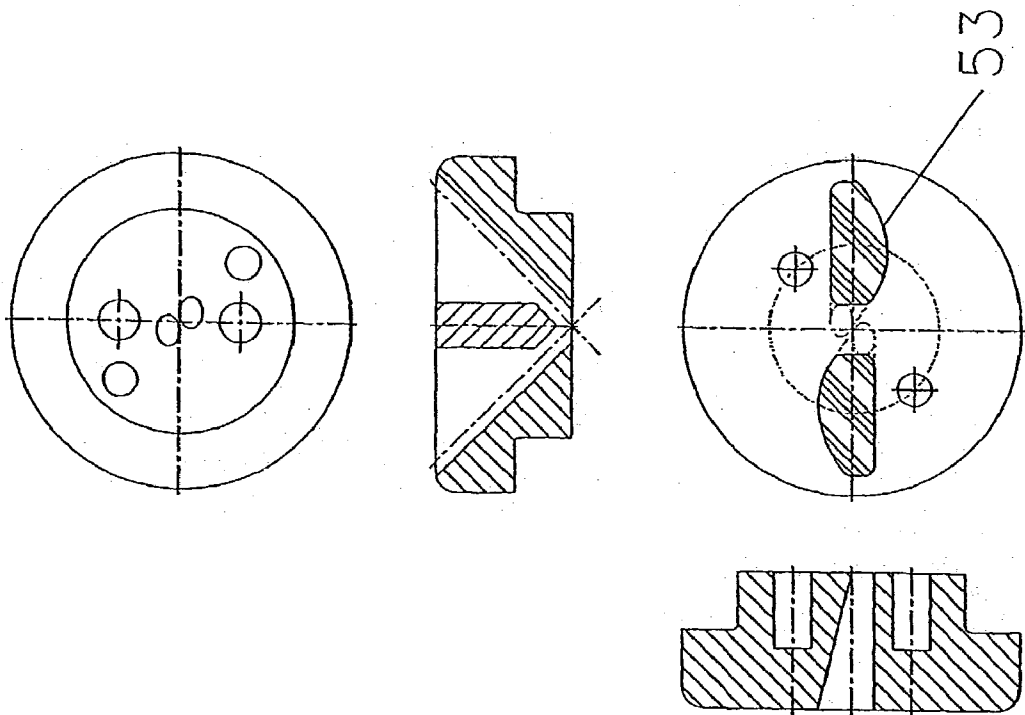


Fig. 6

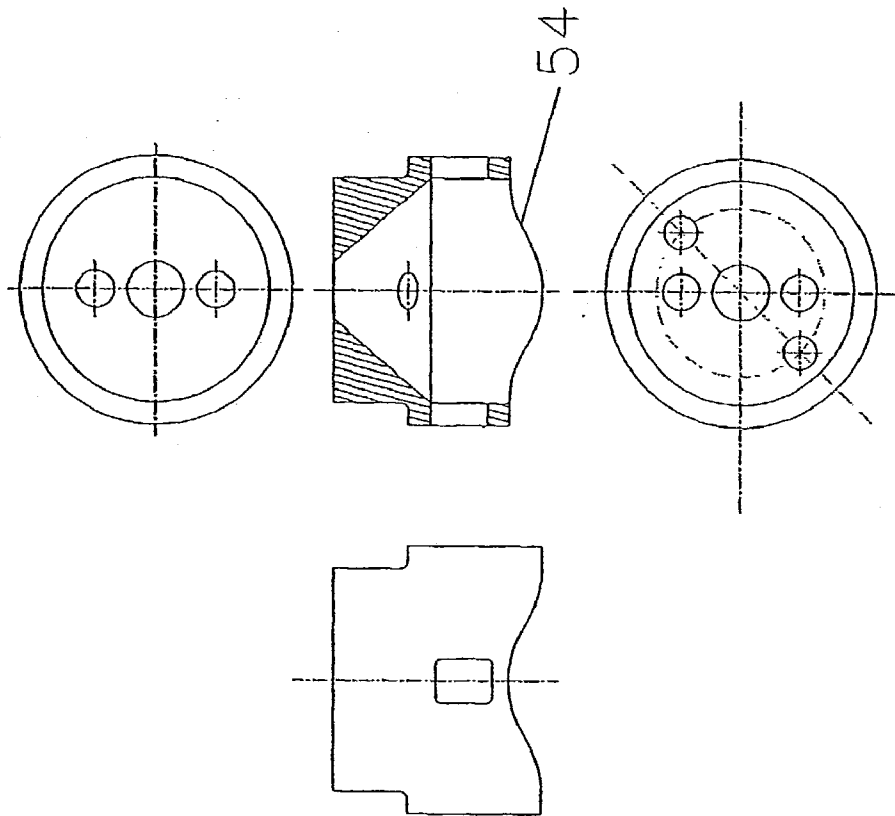


Fig. 7

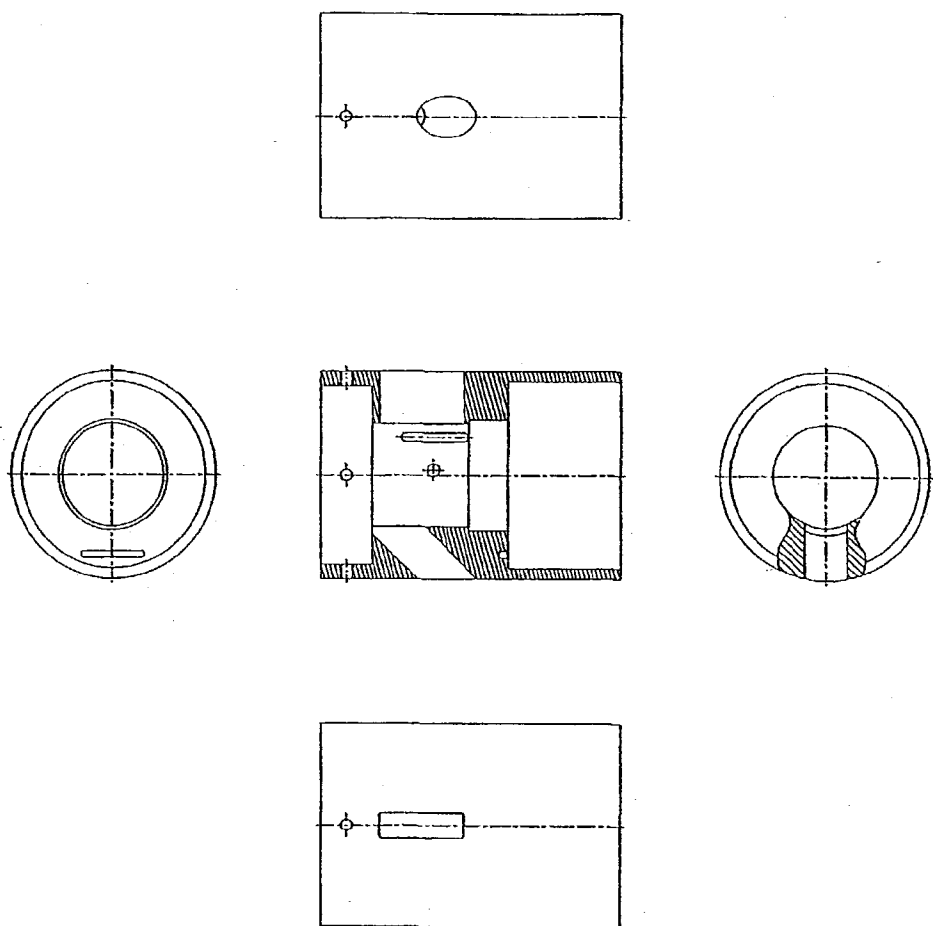


Fig. 9

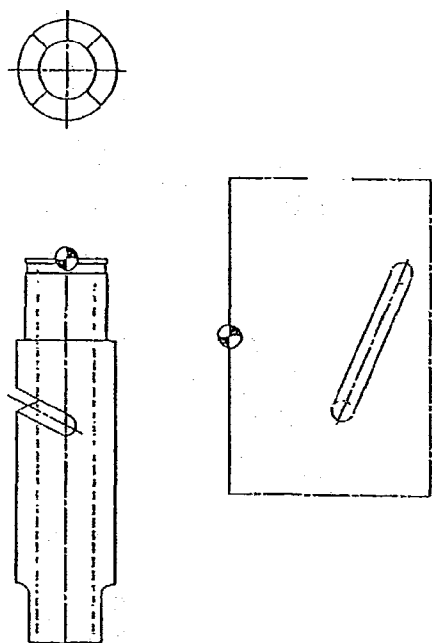


Fig. 8

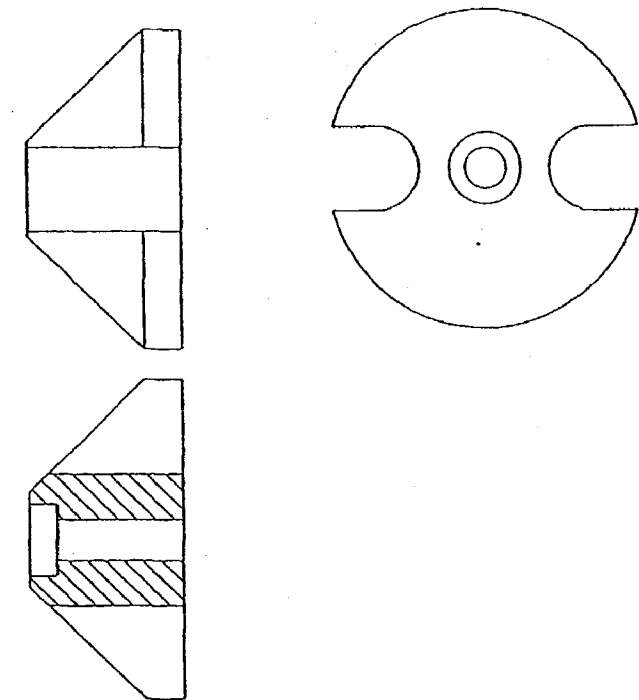


Fig. 10

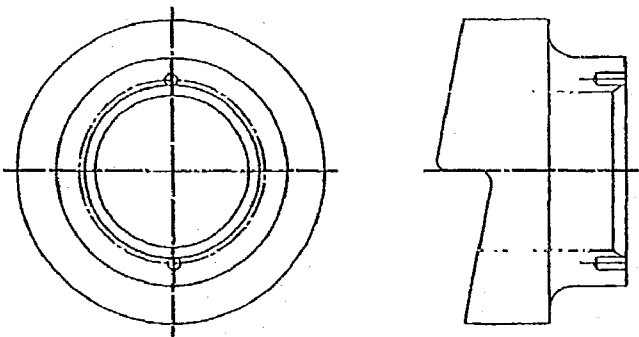


Fig. 11

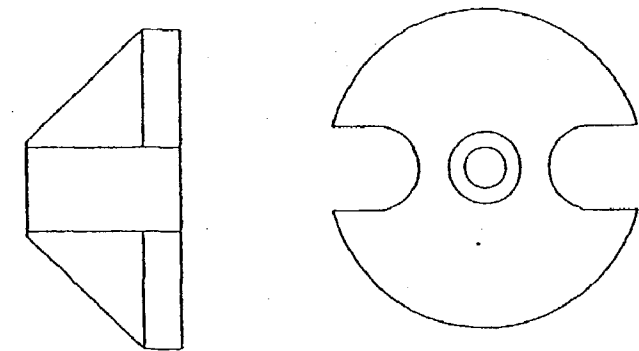


Fig. 12

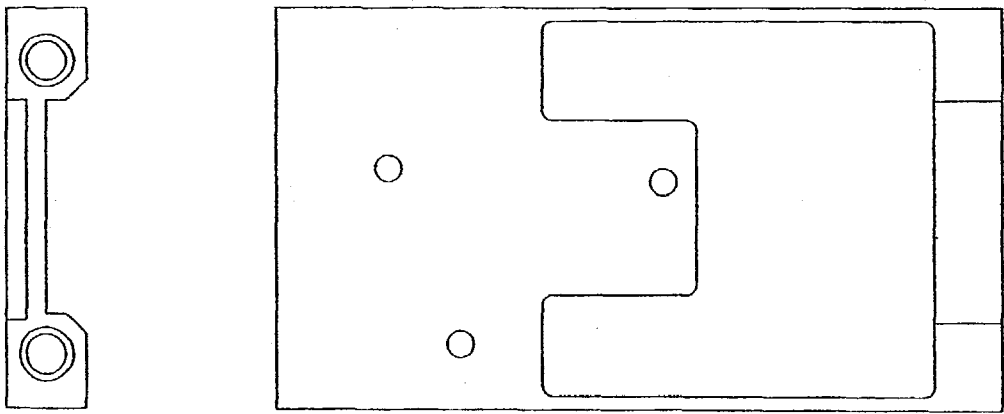


Fig. 14

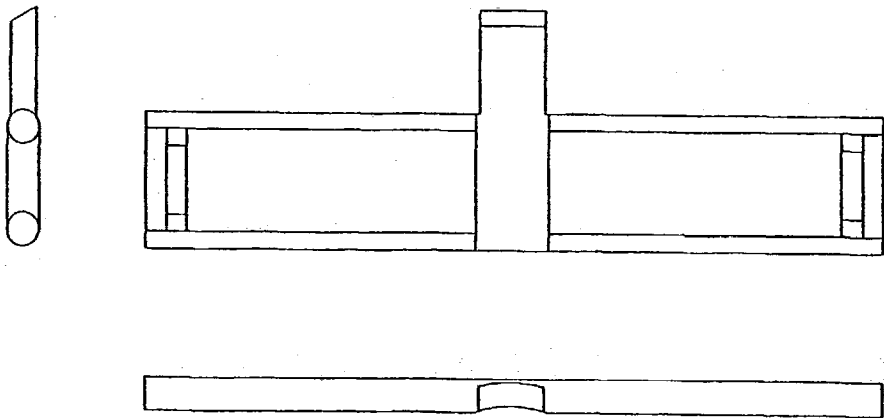


Fig. 13

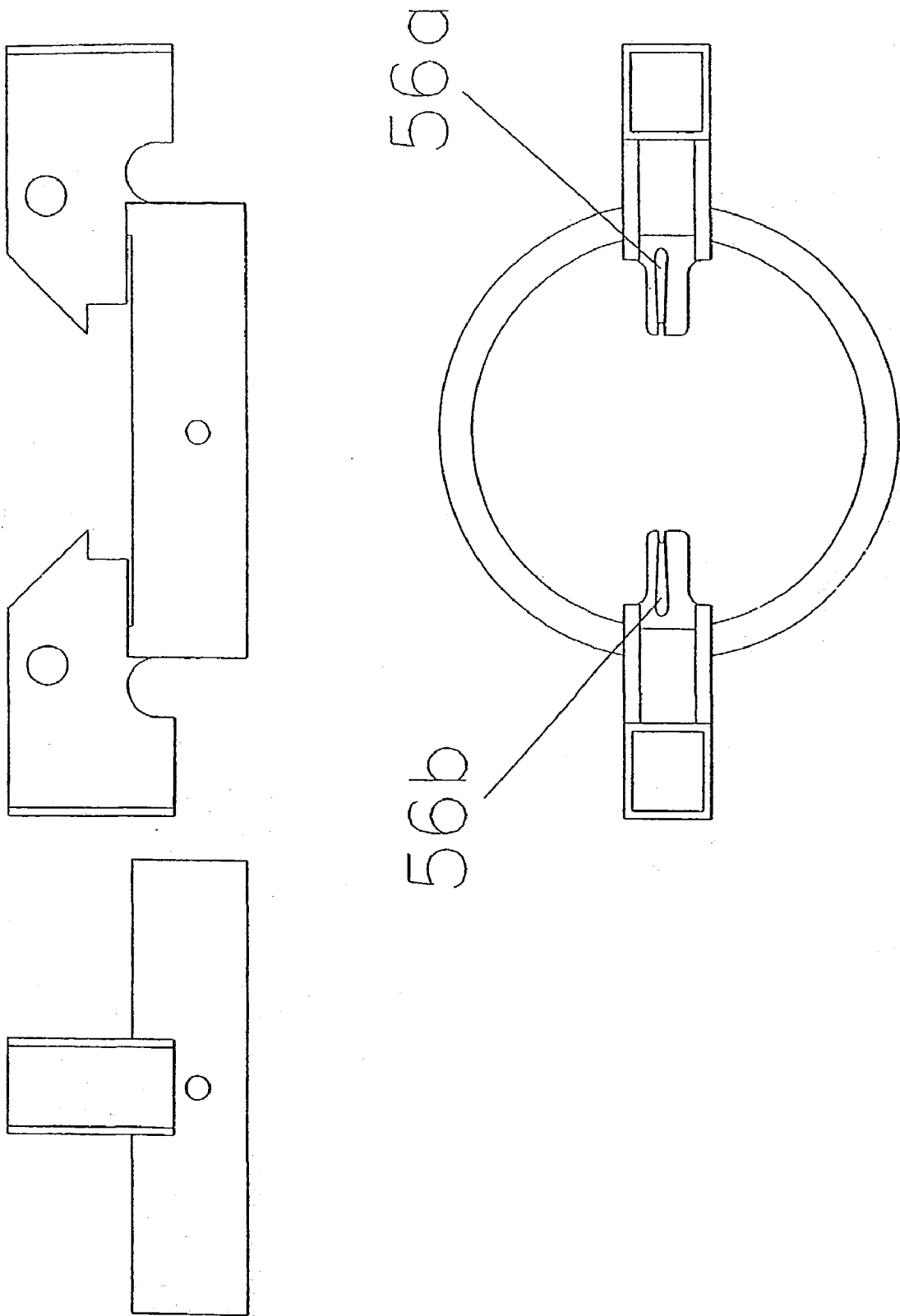


Fig. 15

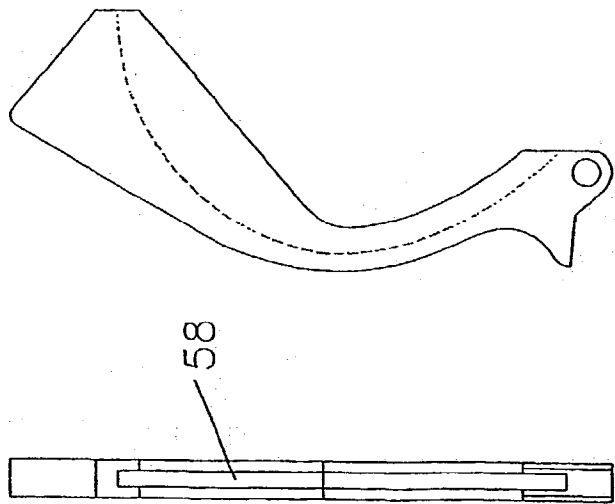


Fig. 16

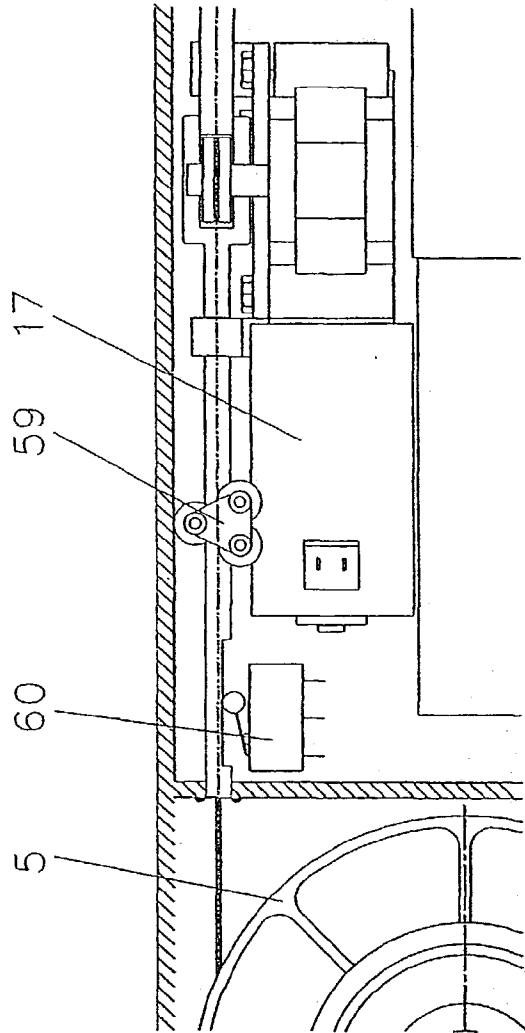


Fig. 17

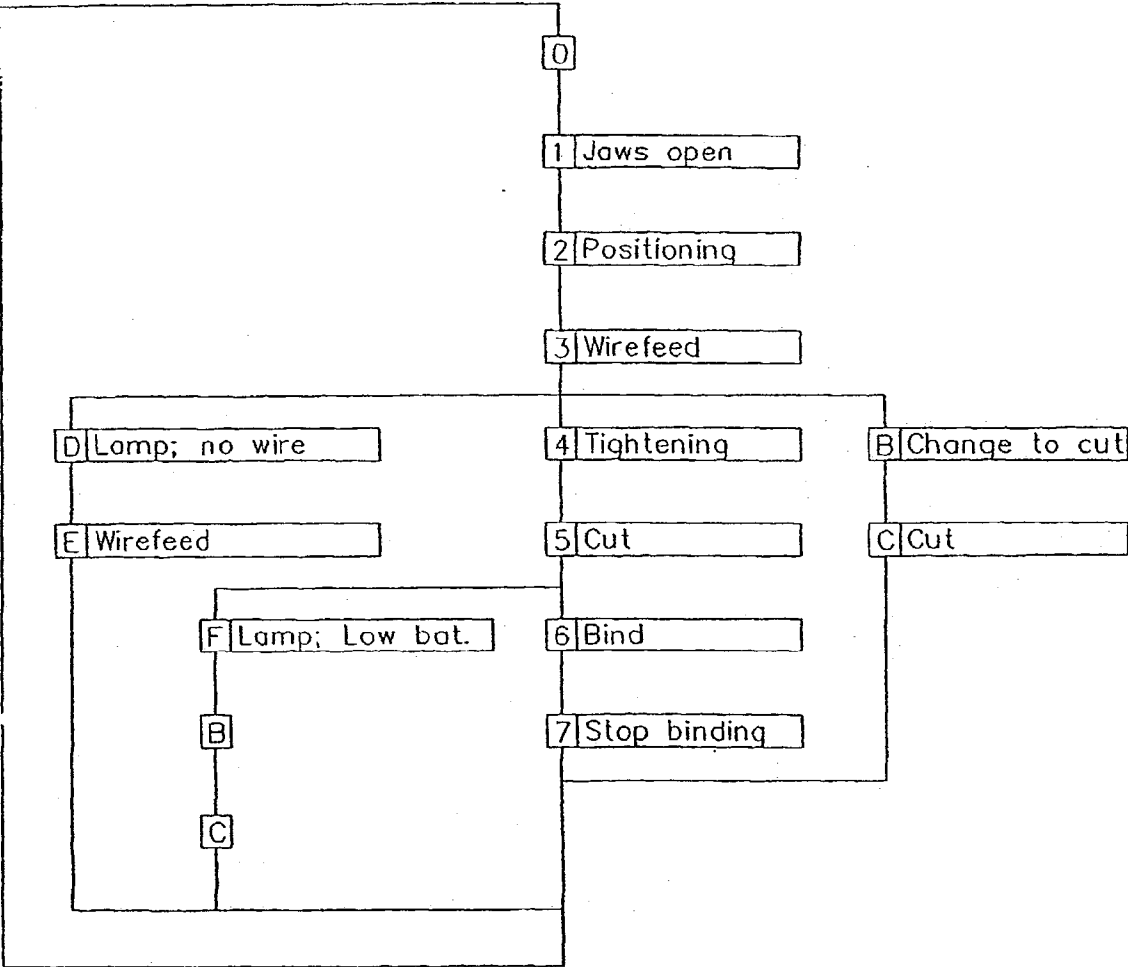
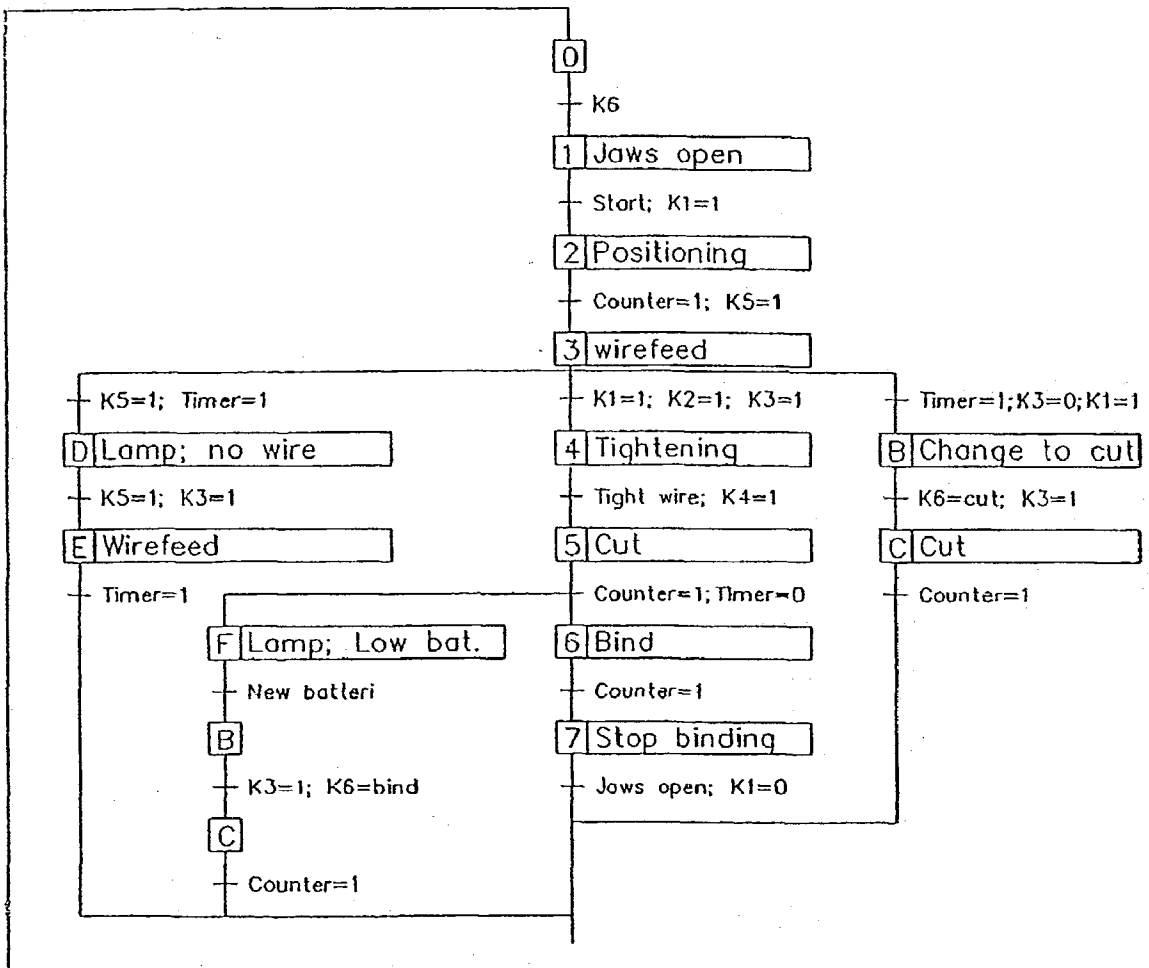


Fig. 18a



K1=Contact, jaws
 K2=Stop wirefeed
 K3=Start-stop
 K4=Wire tight
 K5=Wire censor
 K6=Change
 cut/bind

Tal = Primer drift
 B-C: K3=no touch
 and wire to far
 out
 D-E: No wire or
 not enough wire
 F : Not enough
 power

Fig. 18b

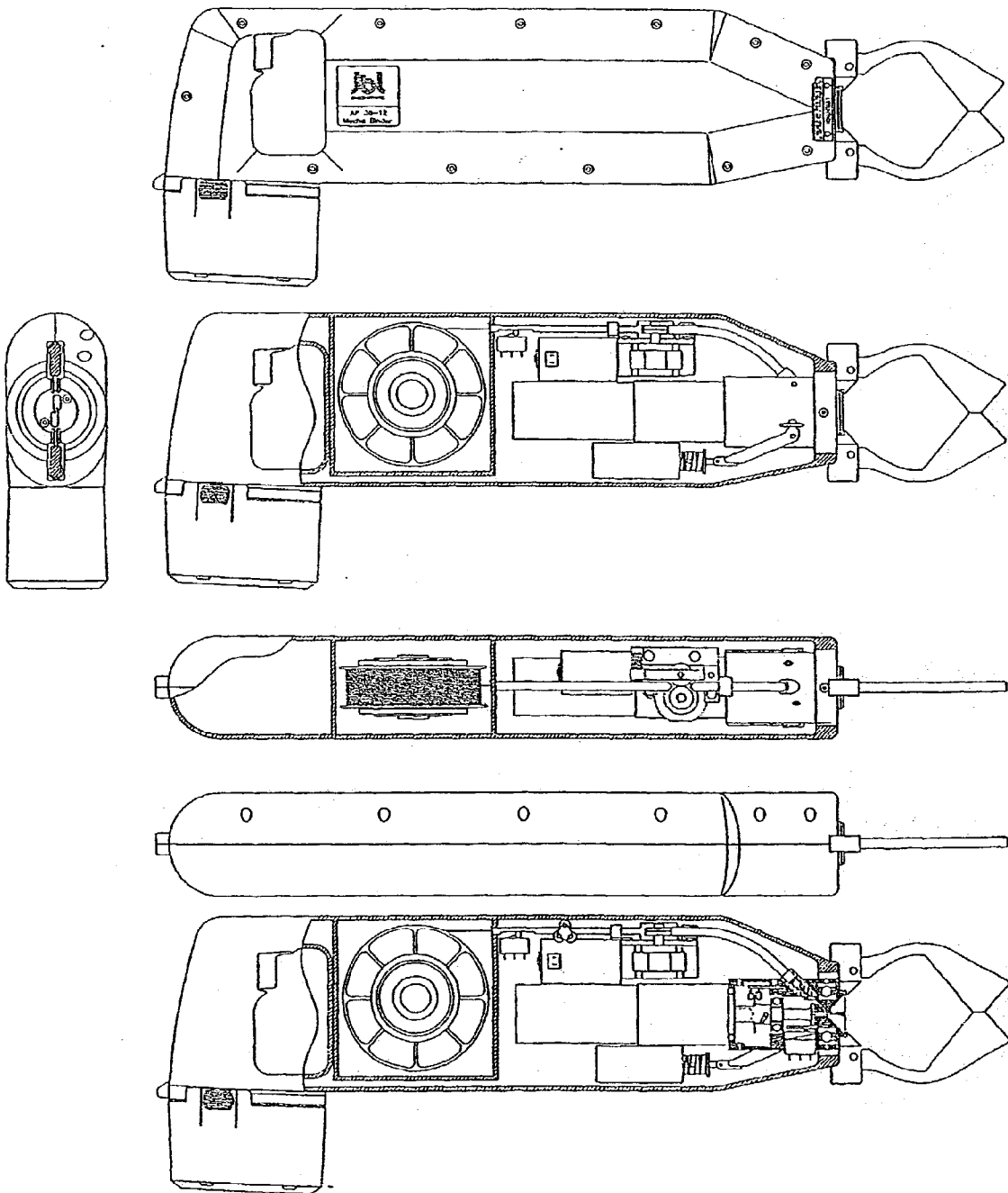


Fig. 19

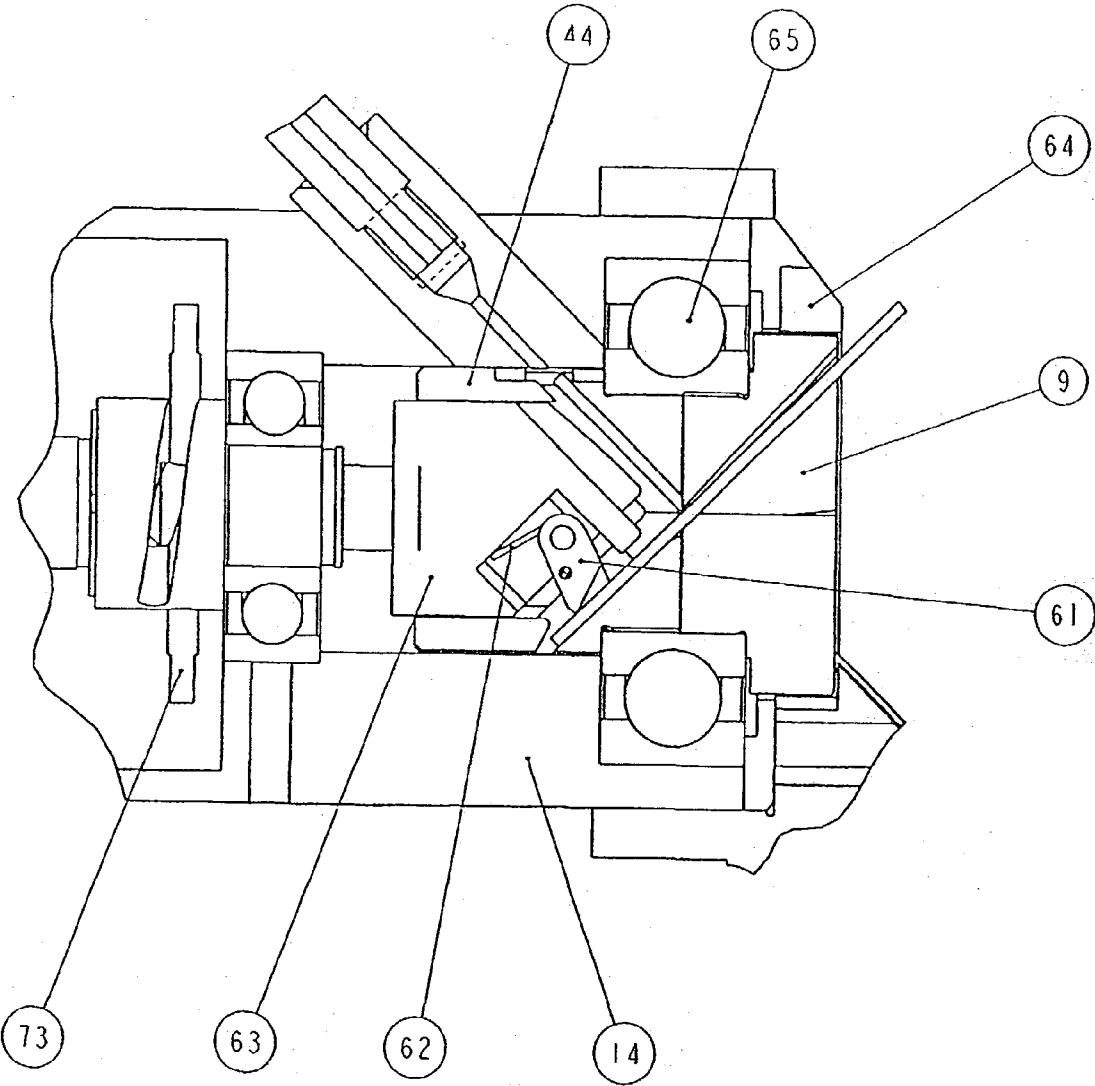


Fig. 20

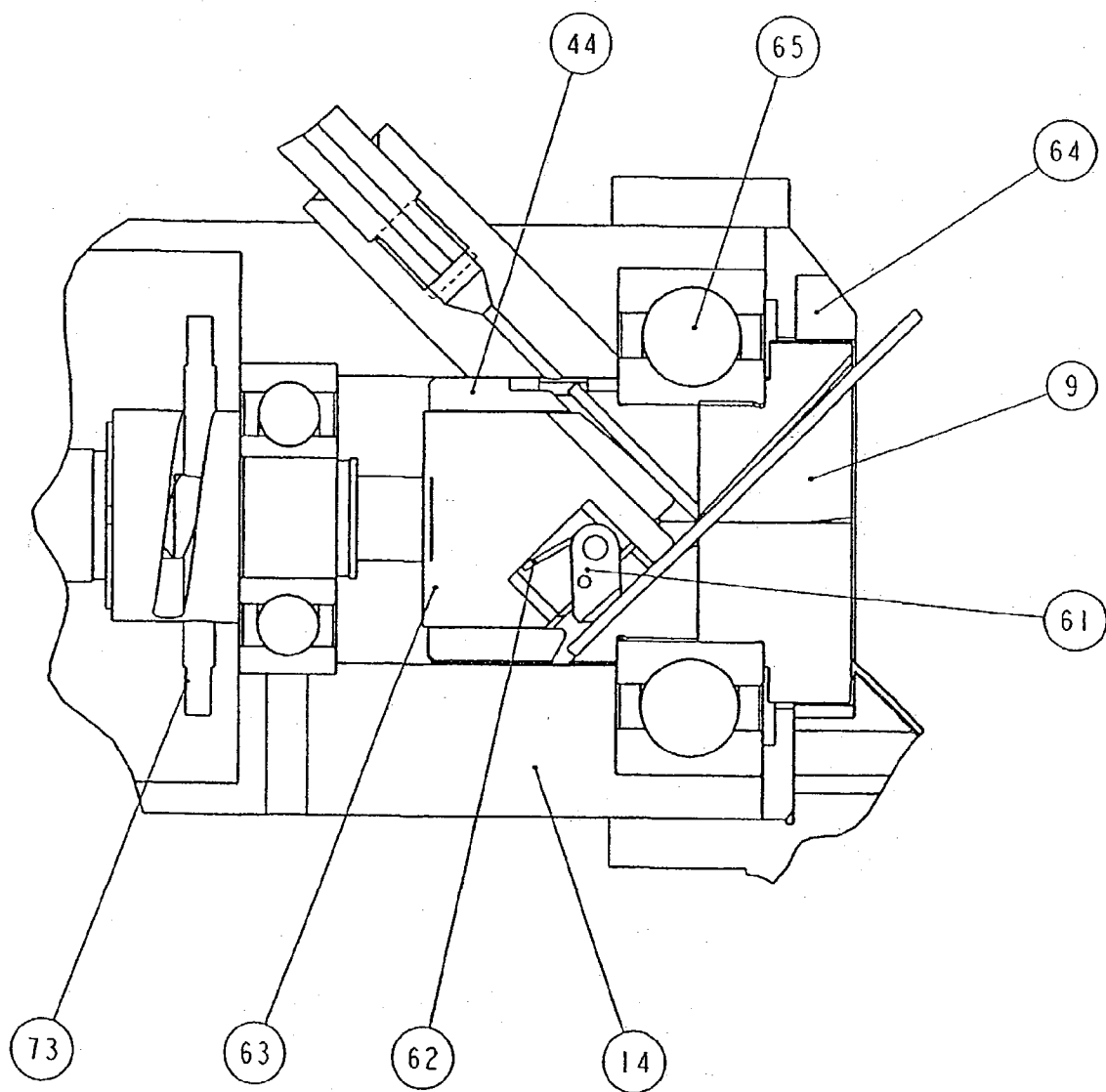


Fig. 21

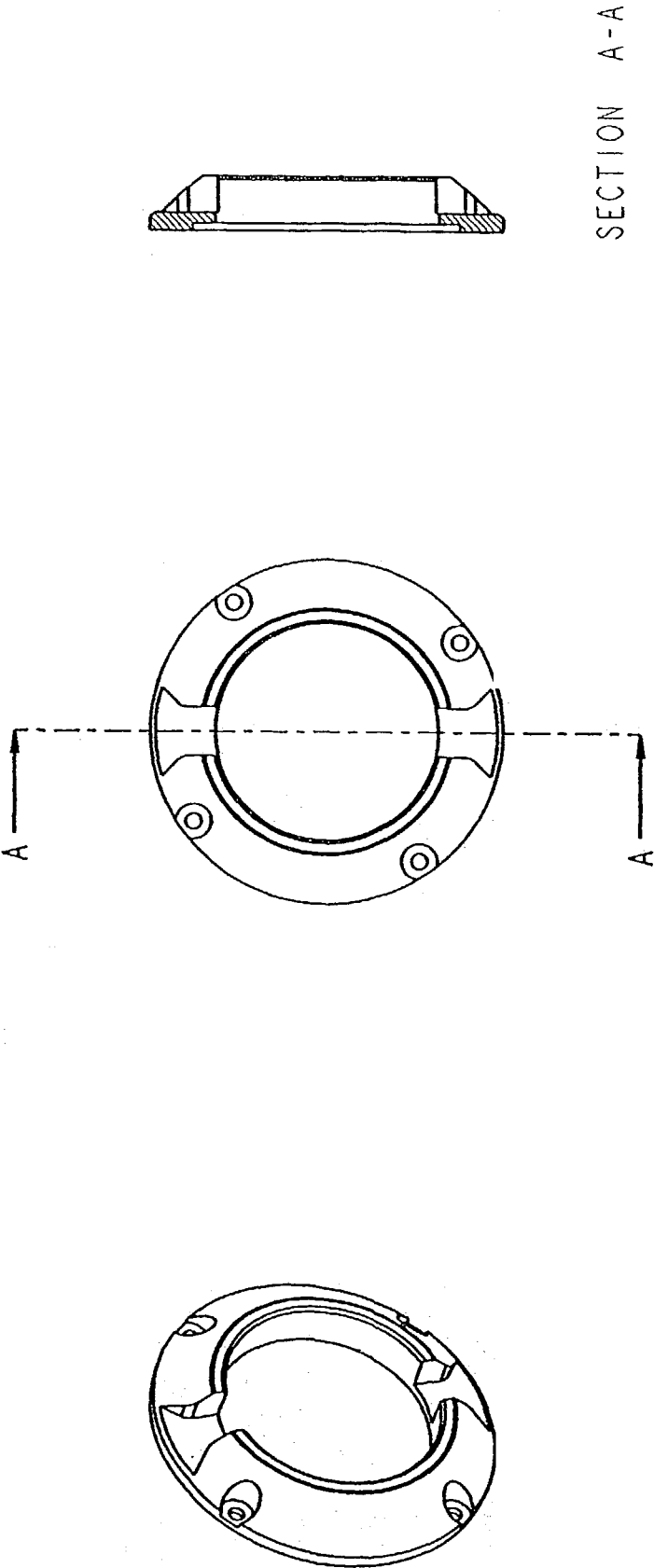


Fig. 22

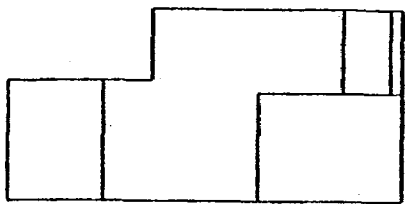
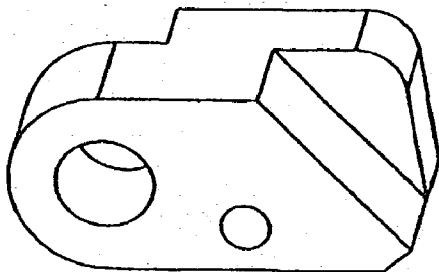
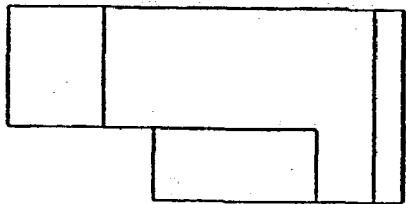
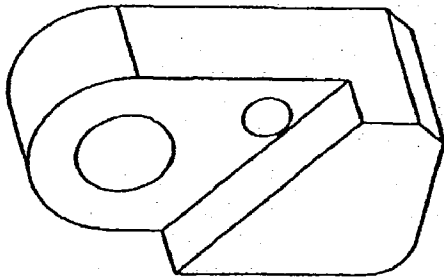
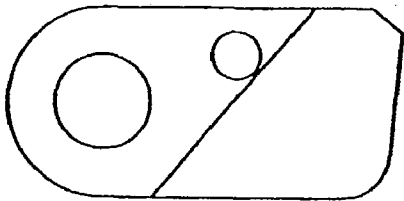


Fig. 23



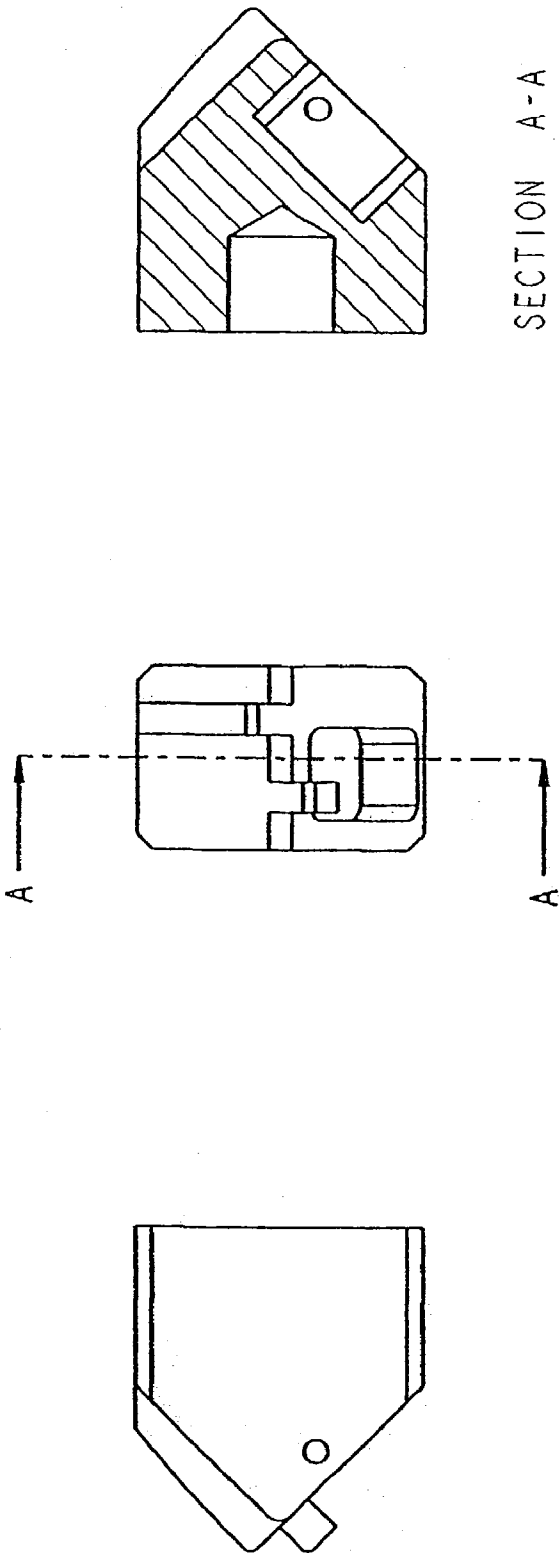


Fig. 24

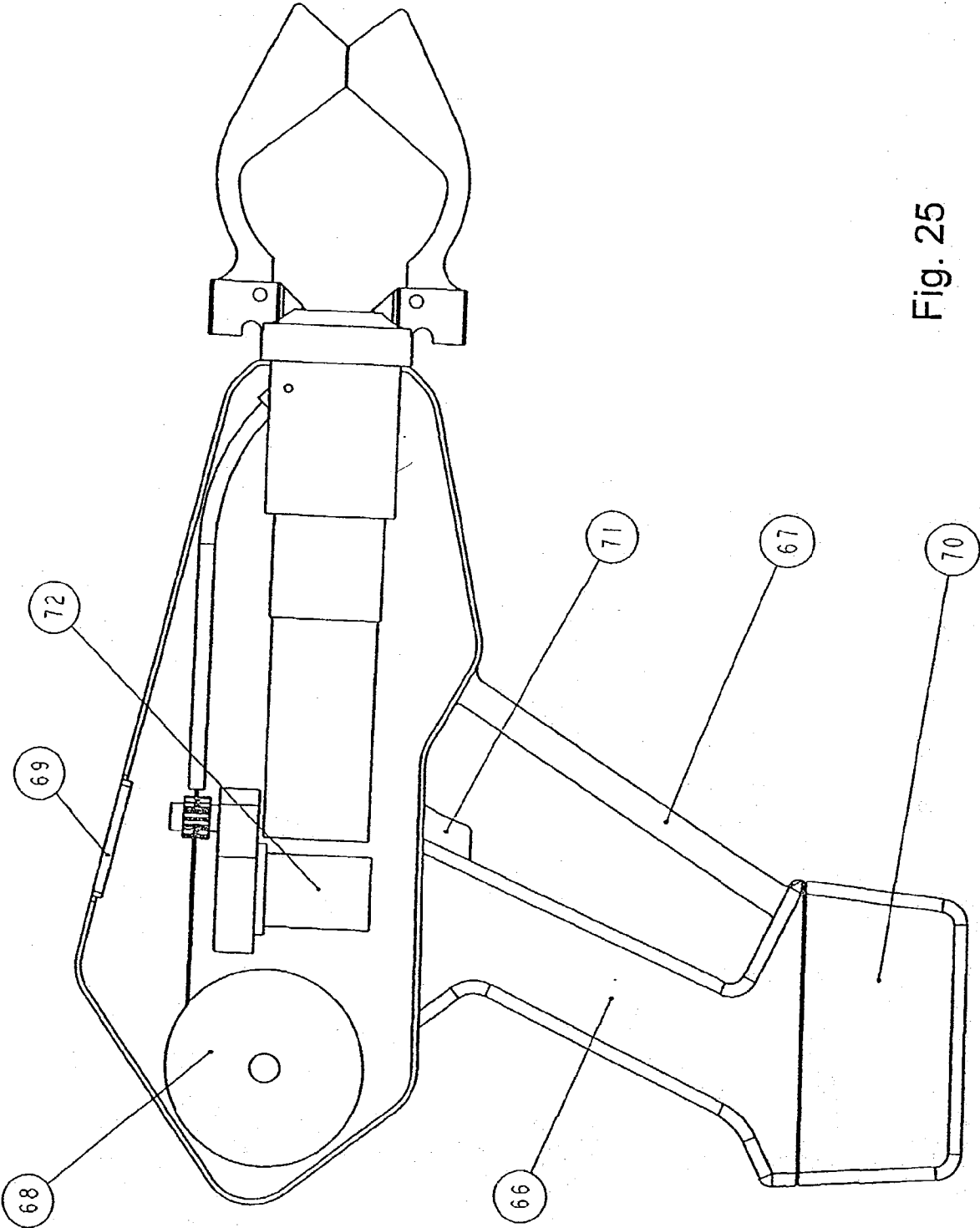


Fig. 25

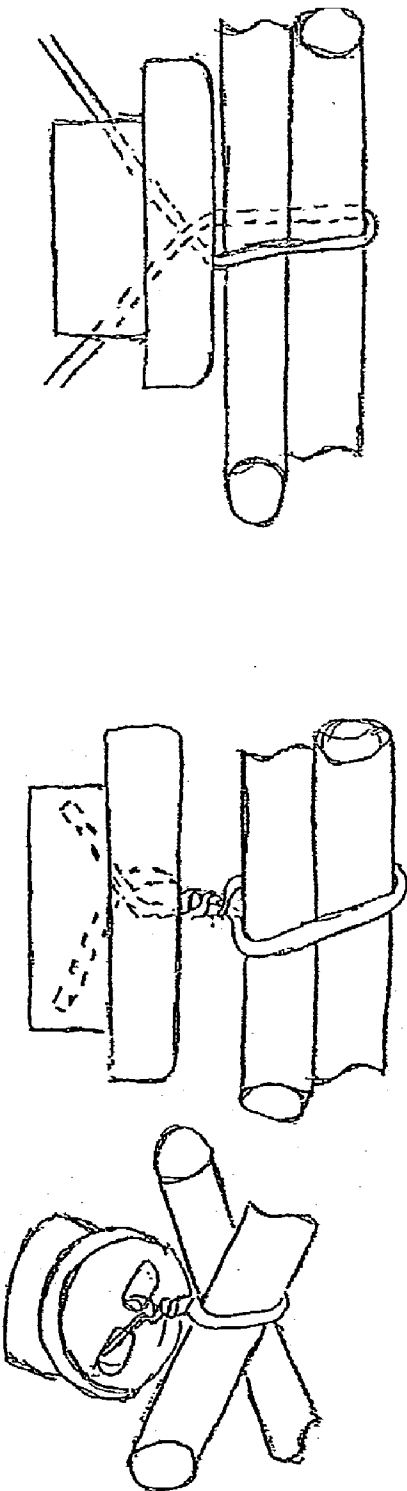


Fig. 26

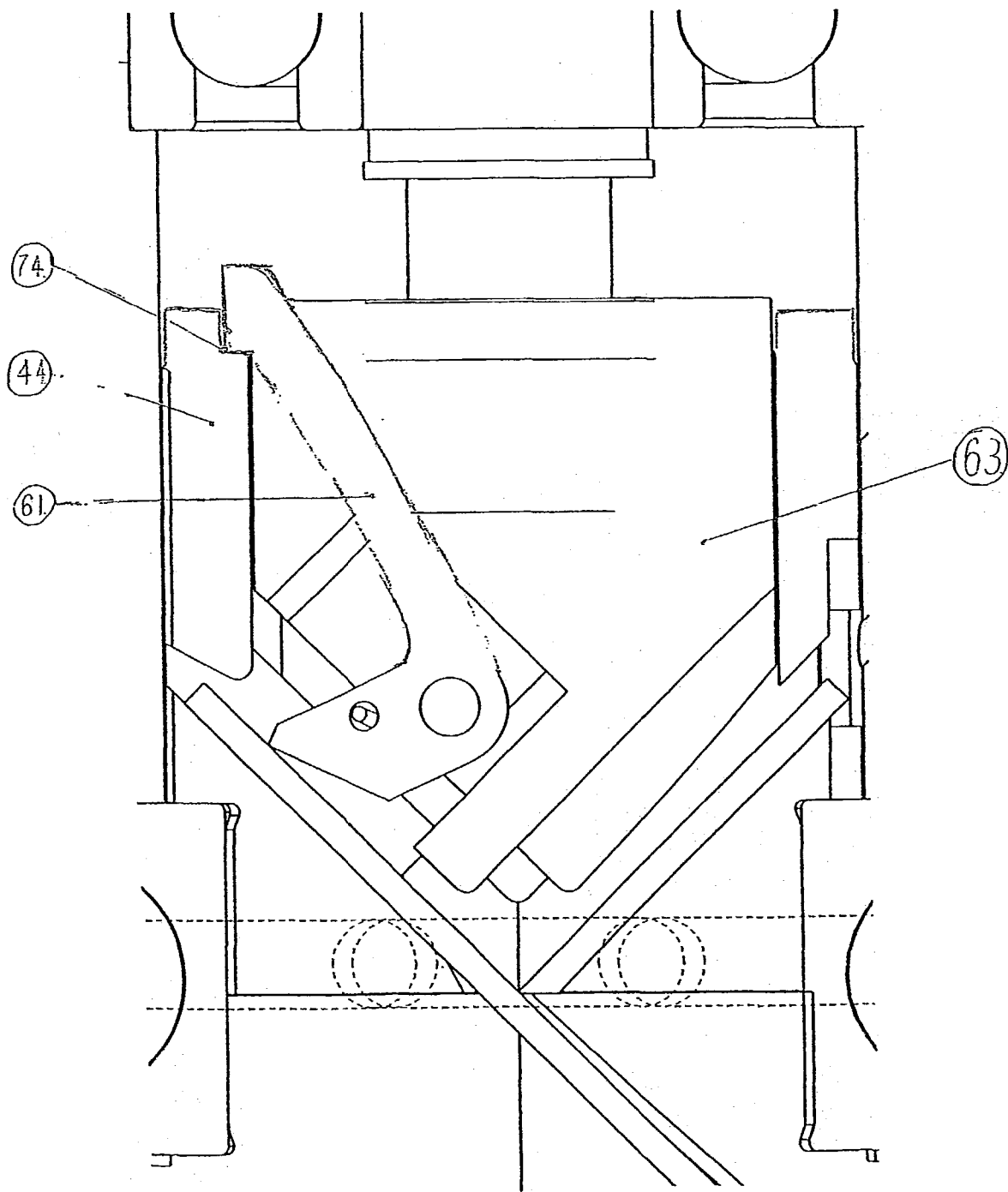


Fig. 27

METHOD AND AN APPARATUS FOR TWISTING AND TIGHTENING A WIRE

FIELD OF THE INVENTION

[0001] The present invention relates to a method and an apparatus for binding objects such as iron bars for reinforced concrete or for binding branches on trees or for binding any items together e.g. for the purpose of packing or securing items. More specifically the invention relates to an improved method and an apparatus for twisting and tightening a wire, the method and apparatus enables a tighter and stronger binding to be performed even by means of a portable device and with the use of less binding wire.

DESCRIPTION OF THE PRIOR ART

[0002] Binding reinforcement bars in concrete constructions is known to be a costly operation. By manual processes a wire is curled around the iron bars and by means of a wire cutter, the free ends of the wire is twisted. Resent considerations not only related to the costs of binding the bars but also related to the working environment, has lead to the development of hand held, portable devices for binding.

[0003] EP 0751270 shows a device for binding reinforcement bars for concrete constructions. The device operates by twisting a wire in a loop by a guide arm. A hook thereby binds the reinforcement bars together by twisting the wire loop.

[0004] U.S. Pat. No. 4,252,157 shows a device for binding reinforcement bars and comprising a differential gear for transferring torque from a motor, respectively to a binding head and a cutting device.

[0005] Both of the above mentioned documents disclose binders having jaws encircling the objects and which are adapted to guide a binding wire in a wire loop around the objects to be tied together. The binders further have twisting means for twisting the wire loop so as to tighten the wire loop around the objects and thus to tighten the objects together.

[0006] The existing binders generally have circular jaws for guiding the wire in circular loops. This is in contrast to the cross sectional shape of the objects to be tied together which objects typically form an oval shape, e.g. when binding two circular iron rods for reinforcing concrete constructions. The result of the circular shaped jaws is typically an excessive overuse of binding wire.

[0007] The existing binders further have twisting means arranged to twist the wire loop by gripping the wire loop, e.g. with a rotating hook without foregoing tightening of the wire in the wire loop. Thereby the tightening force of the wire loop increases as the loop is being twisted and thereby a satisfactory binding force is difficult to achieve.

GENERAL DESCRIPTION OF THE INVENTION

[0008] It is an object of the present invention to provide an improved method and apparatus for binding objects with a reduced amount of wire and an increased binding force.

[0009] Accordingly, a first aspect of the present invention relates to a method for twisting and tightening a wire with a free end portion around at least two objects for binding the objects together, the method comprising:

[0010] arranging the two objects in close contact,

[0011] placing a twisting member in a position next to the objects, the twisting member having a surface facing the objects,

[0012] guiding the free end portion through a hole or groove in the twisting member,

[0013] guiding the free end portion in a path at least one time around the objects, so as to wind a wire portion in at least one loop around the objects,

[0014] guiding the free end portion through or into the twisting member whereby the wire forms a closed loop and defines an intersection of two wire portions, so that said surface of the twisting member is between the intersection and the objects,

[0015] gripping the end of the free end portion of the wire,

[0016] tightening the wire by pulling, and

[0017] turning the twisting member, so as to twist the wire.

[0018] The wording "free end portion of a wire" refers to a coil of wire, from which coil, the free end of wire is transferred through the machine and around the objects to be tied together. Instead of a coil of wire, the machine could use pre-cut wire strips and the free end of wire is in this case just one of the wire ends.

[0019] The surface of the twisting member could be the surface of a disc with two guiding holes, the disc being rotationally mounted to the front end of a binding machine. The binding machine could be provided with guiding jaws to guide the wire from one of the holes around the object to be tied and back through the other hole.

[0020] Generally, the tightening force of a wire loop increases as the wire loop is being twisted. Thereby a satisfactory binding force is difficult to achieve. A feature of the present invention is that the wire forms a closed loop, so that the surface of the twisting member is between the intersection of the wire and the object. When the wire forms such a closed loop with the surface between the intersection of the wire and the objects, the tightening force will be provided already by the first rotation of the twisting member and it is easy to achieve a satisfactory binding force. Selection of a suitable distance between the points where the wire enters and exits the wire loop through the surface of the twisting member is an important issue. It has been found that a distance between the holes in the surface of at least 2 mm. such as between 2 mm. and 10 mm. or between 2 mm. and 6 mm. will provide a significantly improved tightening of the wire without stressing the wire too much. The larger the distance is between the holes, the more the wire is tightened during the first round of the twisting member.

[0021] According to a preferred embodiment, the present invention relates to a method wherein the wire has one end connected to a wire source and wherein the wire is being cut prior to the twisting. The wire source could be a coil of wire and the cutting of the wire could preferably be done after tightening the wire. That results in less wire consumption and compared to using pre-cut wire strips, a better way of binding, in that the strip will have exactly the right length -

not too long and not too short. The tightening of the wire prior to the cutting and twisting, further minimises the overuse of wire.

[0022] The cutting sequence can preferably be executed as a part of the twisting sequence, e.g. by cutting the wire between the disc with the fixation holes and a cutting edge. When the disc starts to rotate the wire is cut and twisted simultaneously. It should though be clear that the cutting of the wire also may be performed either before and/or after the twisting of the wire.

[0023] According to a second aspect the present invention relates to an apparatus for twisting and tightening a wire around two objects and comprising:

[0024] a twisting member having a surface facing the objects, the twisting member having a first hole and a second hole for guiding the wire, the twisting member being mounted in such a way that said surface may contact or be in close contact to the two objects,

[0025] two jaws adapted to encircle the two objects, the jaws being arranged opposite to each other and facing each other in a loop-shaped configuration, each of the jaws having one free end portion and one end pivotally mounted near the twisting member,

[0026] power-driven means for feeding a wire through the first hole or groove in the twisting member and along guiding means in a first one of the two jaws to the free end portion of that jaw and further to the free end portion of the second jaw and therefrom along guiding means in the second jaw and further through the second hole of the twisting member, so as to wind a portion of the wire at least one time around the objects, whereby the wire forms a loop and define an intersection of two wire portions, so that said surface of the twisting member is between the intersection and the objects,

[0027] gripping means for gripping a free end portion of the wire when the wire has been fed around the objects,

[0028] tightening means for tightening the wire when gripped by the gripping means,

[0029] power-driven means for rotating the twisting member, so as to twist two portions of the tightened wire around each other.

[0030] The apparatus could preferably be provided with a twisting member having at least one cutting edge which is adapted to cut the wire as the twisting member is being rotated. The first hole and the second hole in the twisting member are adapted to guide the wire to and from the jaws. The holes should be provided through going from the rear side of the twisting member to the surface facing the objects. The holes should preferably be provided with a mutual distance of 2-10 mm. such as 2-6 mm. when measured on the surface facing the object. Preferably the holes are non parallelly provided though the twisting member, so that the first hole and the second hole crosses over each other at a certain distance inside the twisting member and whereby the free end of the wire is forced to cross over or even intersect the other part of the wire in a certain distance as the free end is guided through the second hole. Thereby a strong tight-

ening of the wire will be provided by the first round of the twisting member as the member is rotated. Preferably, the twisting member is detachably mounted to the binder as will be described in more details later. The user of the binder may then select a twisting member having a distance between the first and the second hole which matches a specific need for tightening force or the user may change the twisting member when the cutting edge needs replacement.

[0031] The two jaws adapted to encircle the two objects, is being arranged opposite to each other and facing each other in a loop-shaped configuration. Since an often occurring situation is to have two reinforcement bars which are to be tied together, it is an important aspect of the present invention to provide the jaws in a non circular, e.g. polar circular configuration. A polar circular shape of the jaws will provide a close contact between the jaws and two reinforcement bars so that an optimally short length of the wire around two reinforcement bars may be achieved. It will be preferred that the jaws of the binder may easily be replaced so that user may select jaws having a size which fits a specific task or which fits specific sizes of the reinforcement bars.

[0032] The jaws should be provided with groves guiding the wire in the loop. Preferably the groves should be open in a radially inward direction, so that the wire, after having been guided around the objects without being bound to the jaws. In order to allow the wire to follow the groves of the jaws even though the groves are open in a radially inward direction, it will be necessary to use a wire having a modulus of elasticity which seeks to straighten out the wire as the wire is guided along the groves in the jaws.

[0033] A wire having a modulus of elasticity of at least 50.000 MPa, such as in the range of 80.000-160.000 MPa. or in the range of 90.000-150.000 MPa. will provide sufficient elasticity for the functioning of the jaws.

[0034] The wire can be provided coiled on wire coils comprising enough wire for several hundred bindings. Elastic wire having been coiled in a circular wire coil, will typically seek back to a curved shape when released from the coil. If the wire is provided in wire coils, it will therefore be preferred to mount the coil and to guide the wire in an arrangement which supports the wire in being guided by the groves of the jaws. This is shown in FIG. 25 wherein the wire is guided so that the curved shape of the wire will support that the wire follows the grove even though the grove is open in a radially inward direction.

[0035] The rotation of the twisting member and the cutting edge could preferably be activated by means of an electrically driven motor. Likewise the feeding of the wire, e.g. from a coil of wire or from a cassette or magazine containing pre-cut wire strips could be activated by means of an electrically driven motor. According to a preferred embodiment the apparatus is adapted for portable use, e.g. in a construction site without power outlets. It is therefore an object to adapt motors that can be operated via a battery, such as the lithium batteries already known for power tools.

[0036] The apparatus may further have a transformer for transformation e.g. of a 220 voltage or a 110 voltage electric current into a low voltage electric current to be used in the electrically driven motor or motors. In that way the appa-

ratus can be operated without a battery, if power outlets are present on the construction site.

[0037] According to a preferred embodiment either the means for feeding the wire or the means for twisting the twisting member may be driven pneumatically by pneumatically driven motors such as the motors known from pneumatic drills, sanders etc.

[0038] The pneumatically driven apparatus could preferably be provided with a gas container for driving the pneumatically driven means.

[0039] According to another preferred embodiment either the means for feeding the wire or the means for twisting the twisting member may be driven hydraulically driven by hydraulically driven motors such as the motors known from hydraulic heavy duty power tools etc.

[0040] The motors used for feeding the wire and for rotating the twisting member could also be any combination between electrically, pneumatically or hydraulically driven motors.

[0041] No matter if the wire is fed and the twisting member is rotated electrically, pneumatically or hydraulically, the motor may be the same motor adapted both for feeding the wire and for rotating the twisting member. E.g. by application of a transmission with one rotational power inlet from the motor and with two rotational power outlets for the wire feeding mechanism and for the rotation of the twisting member.

[0042] The wire feeding mechanism may preferably be provided so that the wire in one operation is both straightened out and fed, e.g. by providing a set of three rotating wire feeding wheels, two being provided on one side of the wire and one on the other side of the wire.

[0043] According to a preferred embodiment of the invention, the gripping means comprises an electromagnet. The gripping means could also be operated pneumatically or hydraulically or by means of any mechanical or electromechanical means.

[0044] Preferably the operation of the first and/or the second electrically, pneumatically or hydraulically driven motor is controlled by a control system. The control system could be adapted to control the speed of the wire feeding, the speed of the rotation of the twisting member, the force applied to the wire feeding mechanism e.g. before a fault signal is indicated, e.g. in case a wire is jammed in the wire feeding mechanism. The control system could further be adapted to indicate the remaining length of the wire on the wire coil—e.g. by tracking the total duration of the wire feeding with a certain speed. The control system may further be adapted to apply a pre-specified tightening force, e.g. by means of varying the rotational force applied to the twisting member. The control system could also be adapted to indicate remaining power level e.g. in a battery for electrically driven motors or in a container with pressurised gas for pneumatically driven motors.

[0045] Preferably the control system operates with means for electronically processing such as a CPU or a PLC. The control system could be comprised in a program for execution in the CPU, and the program could be stored e.g. in an e-prompt or similar means for electronically storing programs. A display for displaying information relevant for the

user of the apparatus may be connected to the control system. Such information could relate to the before mentioned targets of the control system, such as displaying to the user the remaining length of wire on the wire coil, the applied tightening pressure etc. A digital indication of the applied tightening pressure is of particular interest e.g. to a nurseryman using the machine to bind plants, e.g. to posts, where some plants may be destroyed by a too high tightening pressure. It may also be of interest for an electrician or plumber who may use the binder for binding cables, pipes, fittings etc.

[0046] The control system could also be adapted to communicate with an external processor e.g. a PC. By means of such communication capabilities, data related to the binding performed by the apparatus could be uploaded to the PC and used e.g. for quality assurance or for statistical purpose. The data could relate to how many bindings one worker can perform per day, how much wire each binding requires, the average tightening force applied to each binding, number of faults etc. The communication capabilities may also be used to program the apparatus by means of a programming interface to the PC.

[0047] The twisting member that faces the objects could preferably be made of a hardened steel alloy such as titanium alloys or similar metallic or ceramic materials. Since the member easily could get into contact with the objects during the rotation of the member it is important that it is made from a material resistant to the wear and tear.

[0048] Preferably each of the free end portions of the jaws are formed so that funnel-shaped openings extends away from the contact between the free end portions of the two jaws. The openings are used to guide the wire through the jaws.

[0049] The jaws may preferably be spring-biased towards a closed position or could be opened and closed mechanically or electro-mechanically e.g. by hydraulic, pneumatic or electrically driven means and controlled by a CPU or a PLC.

[0050] According to a preferred embodiment, the invention relates to an apparatus wherein a carrying support arm can be attached to the housing of the apparatus for carrying the weight of the apparatus and to enable the apparatus to be used in a distance from the hands of the operator. The carrying arm is practical e.g. for overhead operation of the apparatus or for reaching objects in narrow spaces. The arm may furthermore allow for a more ergonomically correct handling of the apparatus, e.g. by transferring the forces needed for carrying the apparatus to the shoulders and/or the bag of the operator.

[0051] Preferably the apparatus is provided with a contact face for supporting the apparatus against the objects as the tightening means tightens the wire and thereby pulls the objects tight against the apparatus. The contact face may preferably be provided on a non rotating part of the apparatus such as on the binder housing e.g. encircling the twisting member. When the wire has been tightened and the twisting member starts rotating, the contact face will keep a distance between the rotating twisting member and the objects. This is highly advantageous since it reduces wear on the twisting member and since the rotating force thereby will not be transferred to the binding apparatus. The contact face

may alternatively be provided attached to the twisting member. In order still not to transfer the rotating forces occurring as the rotating twisting member touches the objects, the contact face may be provided in a low frictional material such as nylon or Teflon™. The contact face should be interchangeable arranged so as to allow periodically replacement. Alternatively the contact face could be attached to the twisting member over bearing allowing the contact face to stand still against the objects while the twisting member rotates.

[0052] According to a third aspect, the present invention relates to a method for twisting and tightening a resilient wire with a free end portion around at least two objects for binding the objects together using a device comprising two jaws adapted to encircle the two objects, the jaws being arranged opposite to each other and facing each other in a loop-shaped configuration, each of the jaws having a surface facing the objects and a groove in said surface, the method comprising:

- [0053] arranging the two objects in close contact,
- [0054] placing a twisting member in a position next to the objects, the twisting member having a surface facing the objects,
- [0055] guiding the free end portion through a hole or groove in the twisting member,
- [0056] guiding the free end portion in a path at least one time around the objects, so as to wind a wire portion in at least one loop around the objects, whereby the resiliency of the wire ensures that the wire is following the groove in the surface of the jaws in close contact with the jaws,
- [0057] guiding the free end portion through or into the twisting member whereby the wire forms a closed loop and defines an intersection of two wire portions, so that said surface of the twisting member is between the intersection and the objects, gripping the end of the free end portion of the wire,
- [0058] tightening the wire by pulling,
- [0059] turning the twisting member, so as to twist the wire.

[0060] The resiliency of the wire provides a pressure of the wire against the jaws of the binder and thus enables a reliable functioning of the binder with non-circular jaws being open in a radially inward direction. It has been found that a wire which is so elastic that it seeks back to a specific shape when released may advantageously be used for the binding. A modulus of elasticity above 50.000 MPa. gives a desirable flexibility and thus the desired pressure against the jaws. As an example, a coiled wire may either straighten out when released from the coil or may seek into a curved shape when released from the coil. As the free end of the wire is guided through the hole in the twisting member and into the groove in the jaws, the flexibility of the wire will ensure that the wire follows the groove and that the wire thus encircles the objects.

[0061] According to a fourth aspect the present invention relates to the use of a wire having a flexibility which enables the wire to stay in firm contact with the grooves in the jaws of a binder during the binding of object. The wire may as an

example be made from an iron alloy comprises in the range of 1.2-2.0% manganese (Mg), 0.8-1.2% silicon (Si) and 0.06-0.15% carbon (C). Such wires may be purchased on the market, e.g. from vendors of welding wire.

[0062] According to a fifth aspect, the present invention relates to an apparatus for twisting and tightening a wire around two objects and comprising:

- [0063] a twisting member having a surface facing the objects, the twisting member being mounted in such a way that said surface may contact or be in close contact with the two objects,
- [0064] two jaws adapted to encircle the two objects, the jaws being arranged opposite to each other and facing each other in a non-circular loop-shaped configuration, each of the jaws having one free end portion and one end pivotally mounted near the twisting member,
- [0065] power-driven means for feeding a wire through a hole or groove in the twisting member and along guiding means in a first one of the two jaws to the free end portion of that jaw and further to the free end portion of the second jaw and therefrom along guiding means in the second jaw and further through the twisting member, so as to wind a portion of the wire at least one time around the objects, whereby the wire forms a loop and defines an intersection of two wire portions,
- [0066] the wire having an elasticity which is sufficient to press the wire against the guiding means of the jaws,
- [0067] gripping means for gripping a free end portion of the wire when the wire has been fed around the objects,
- [0068] tightening means for tightening the wire when gripped by the gripping means,
- [0069] power-driven means for rotating the twisting member, so as to twist two portions of the tightened wire around each other.

[0070] An elasticity which is sufficient to press the wire against the guiding means of the jaws means that the wire will seek into a predetermined shape, e.g. into a linear shape or into a curved shape. By appropriate arrangement of the wire in relation to the guiding means of the jaws, it may be provided that the wire seeks radially outwardly while the wire is guided by the guiding means. Accordingly, the wire may be guided around the objects by the jaws even though the jaws are non-circular and open in a radially inward direction.

DESCRIPTION OF A PREFERRED EMBODIMENT

[0071] A preferred embodiment of the invention will now be described in details with reference to the drawing in which:

[0072] FIG. 1 shows a binder according to the present invention, seen from the side,

[0073] FIG. 2a shows the binder of FIG. 1 with the outer casing removed,

[0074] FIG. 2b shows details of a binder according to an alternative embodiment,

[0075] FIG. 3 shows details of the binder of FIGS. 1 and 2,

[0076] FIG. 4 shows the binder seen from above,

[0077] FIG. 5 shows an alternative embodiment of the binding arrangement,

[0078] FIG. 6 shows a preferred embodiment a polar head,

[0079] FIG. 7 shows a binding head,

[0080] FIG. 8 shows a spindle,

[0081] FIG. 9 shows a binder housing,

[0082] FIG. 10 shows a wire nozzle,

[0083] FIG. 11 shows an axial tightening device,

[0084] FIG. 12 shows a wire spindle lock,

[0085] FIG. 13 shows a wire lock,

[0086] FIG. 14 shows a sliding platform,

[0087] FIG. 15 shows the jaw attachment base,

[0088] FIG. 16 shows a jaw,

[0089] FIG. 17 shows a wire aligning device,

[0090] FIG. 18a and FIG. 18b are functional diagrams of a control system for the binder,

[0091] FIG. 19 shows different embodiments of the casing for the binder,

[0092] FIG. 20: shows an alternative embodiment of the invention,

[0093] FIG. 21: shows the embodiment of FIG. 20 in another state of the binding sequence,

[0094] FIG. 22 shows a preferred embodiment of the contact face,

[0095] FIG. 23 shows details of the gripping means with the locking pawl,

[0096] FIG. 24 shows details of the spindle lock according to the embodiment of the gripping means shown in FIG. 20,

[0097] FIG. 25 shows an overview of the binder with motor,

[0098] FIG. 26 shows the binding sequence of a binder according to the present invention, and

[0099] FIG. 27 shows a specific embodiment of the locking pawl.

[0100] Referring to FIG. 1 the binder 1 has a handle 2 with and a switch 3 for actuating the binder. The power pack 4 provides an electrical current for driving the binder. The binder may be provided with other means of power such as pressurised gas, a hydraulic pressure or it may be driven electrically directly from the net.

[0101] The binder has a wire coil 5 for feeding the machine with wire. Instead of a wire coil the binder could be provided with a cassette with pre-cut wires. The display 6 is adapted to show status of the binder such as faults, battery

level, number of cuts, remaining length of wire on the wire coil or number of remaining cuts as well as the adjustment of the binder such as the binding force.

[0102] The display 6 is connected to a control system not shown. The control system could preferably be adapted to receive login indicia from the user of the binder which indicia identifies the user towards the control system. The control system then selects pre-specified setting according to the identified user. The pre-specified setting may relate e.g. to the binding force, the binding speed or it may relate to the functioning of the switch 3.

[0103] The switch 3 could be adapted for different modes. One mode could be that the binder binds upon activation of the switch. Another mode could be that the switch is activated once and that the binder then binds upon activation of the jaws or upon indication that the objects to be tied together are located between the jaws. The switch may further comprise means for reversing the binder in case of faults. In one mode the reversing could be activated automatically upon detection of a fault. In another mode releasing the switch before the binding sequence is ended may activate the reversing. The fault that may be detected automatically by the control system could as an example be detection of a too high resistance in the wire feeding mechanism, occurring if the wire is jammed or it could be if a binding sequence is initiated with insufficient remaining wire on the wire coil. In that case a switch 11 seen in FIG. 2 indicates a fault, and the control system responds according to the selected fault mode.

[0104] Further referring to FIG. 1 the binder has jaws 7 for catching the objects. The front end of the jaws is provided with an inclination 8 guiding the objects through the opening between the jaws. The jaws could preferably be pressed together by means of springs, and opened by means of the force of the objects being pressed through the opening between the jaws. The jaws could also be respectively opened and closed by mechanical or electro-mechanical means such as hydraulic, pneumatic or electric actuators.

[0105] The polar head 9 has a combined wire guiding and wire twisting function to be described later.

[0106] By means of the tightening adjustment mechanism 10, the user can adjust the tightening force. The tightening force can be given in three ways. One is by fixing the wire and pulling the wire feeding mechanism rearward. One is by locking the wire with a tightening arm and by means of a tightening device pushing a spindle lock forward to lock the wire meanwhile a sliding platform with the wire feeding mechanism is pressed rearward. Finally the wire may be tightened by means of the twisting of the wire, which according to the present invention is proved by a polar head. The mentioned parts will later be described in details.

[0107] Referring to FIG. 2a binding motor 12 is connected to a binding gear 13. The binding gear changes the driving ratio of the motor so that the binding mechanisms rotates with a speed adapted for the wire, such between 100-1000 rpm. The gear 13 is connected to the polar head 9 through a mechanism to be described later.

[0108] The binder housing 14 is shown in details in FIG. 9 whereas the detailed mechanism of the housing is best seen in FIGS. 3 and 5.

[0109] The electromagnet 15 activates the wire lock 26 through the pinion 19, the fish joint 22 and the pivotally connected arm 23.

[0110] The wire feeding pipe 16 feeds the wire from the wire coil to the polar head 9 and the jaws 7 through the wire feeding mechanism 20 comprising the wire feeding rolls 21 and further through the wire pipe 24 and the wire nozzle 25. The wire feeding mechanism is of a type known e.g. from welding machines and comprises means for adjustment of the gap between the wire feeding rolls so as to enable the use of wires of various diameters. The wire feeding rolls 21 is rotated by means of a wire feeding motor 17 connected to a wire feeding gear 18. The wire feeding rolls 21 could preferably be provided with projections like a gear or sprocket wheel. The projections will avoid that the wire slips between the rolls. According to a preferred embodiment, three wheels are provided so that the wire, in one operation is both fed forward and straightened out - combined aligning means 59 as shown in FIG. 17 and feeding means.

[0111] The numeral 27 indicates the centre line of rotation of the polar head 9 and numeral 28 indicates the intersection point wherein the wire intersects the centre line of rotation.

[0112] Referring to FIG. 2b the tightening arm 29 is connected to axial tightening devices shown in FIG. 11 and best seen in the context in FIG. 5 when the axial tightening devices are activated by rotation around the centre line 27 the tightening arm 29 tilts around the hinge 35 and thus presses the wire feeding mechanism 20 in a rearward direction along the centre line 27. When the wire feeding rolls 21 are locked this will effect a tightening of the wire.

[0113] The tightening adjustment mechanism 10 is connected to the adjustment pin 30 so that the adjustment pin 30 is displacing the wire spindle lock 36 upon rotation of the adjustment mechanism 10 around the centre line 27. The movement of the pin 30 in the slot 37 effects the displacement. The pin 30 is attached to the movable bearing pedestal 38 which presses the spring 39 against the wire spindle lock 36.

[0114] The opto-house 31 is attached to the binding housing 14. The opto-house comprises the axial tightening devices and is connected to the binding gear 13 so that the rotation of the binding gear is transferred to the axial tightening devices. As seen in FIG. 5 the opto house 31 further comprises a opto-disc 40 which by means of the opto-circuit board 41 indicates the angular or axial position of the drive shaft of the binding gear and thus the axial position of the polar head. The opto-circuit board 41 is connected to the control system. The opto-circuit board 41 is fixed to the binder through the attachment ring 42. As an alternative to the opto circuit, the position of the polar head may be determined by magnetic switches or by pure mechanical switches or by a combination between magnetic, mechanical or opto switches or by any other means of sensors capable of indicating the position of the polar head.

[0115] Further referring to FIG. 2b the sliding platform 32 is connected with bars 34. The spring 33 is provided between the sliding platform 32 and the opto-house 31. When the wire feeding rolls are reversed so as to tighten the wire, the sliding platform is pulled in a forward direction along the centre line 27 until the sliding platform reaches the switch 43, FIG. 4. The activation of the switch activates the binding

motor 12 that rotates the polar head 9 so as to twist the wire. The twisting of the wire further tightens the wire.

[0116] Referring to FIG. 3 the binding head 44 is connected to the polar head 9 with driving pins 48 attached to the pressure transferring axle 45 of the wire spindle lock. The pressure transferring axle 45 is axially movably attached to the spindle 49. The spindle 49 is adapted to transfer rotational force to the pressure transferring axle 45 and by means of the slot 50, the pressure transferring axle 45 is pressed forward along the centre line 27.

[0117] After the wire—through the jaws—has been guided in a loop around the objects to be tied together, the free end of the wire returns through the polar head and the binding head and activates the switch 46. Activation of the switch causes activation of the electromagnet 15 which activates the wire lock 26 and further activates the wire feeding motor 17 to reverse so that the wire is tightened. The switch 46 may be omitted and the electromagnet 15 and the wire feeding motor 17 respectively may be activated by means of a timer counting the time from when the binding sequence is started, and using knowledge about the wire feeding speed.

[0118] Referring to FIG. 4 the spring 47 is adapted to enable adjustment of the pressure on the wire between the wire feeding rolls 21 in the wire feeding mechanism 20.

[0119] Referring to FIG. 5 the wire is cut by the binding head 44 and the wire nozzle 51 in the point 52—the wire nozzle 51 is also shown in FIG. 10.

[0120] Referring to FIG. 6 the polar head is provided with two holes 53 where through the wire respectively enters and leaves the jaws. The polar curved shape of the holes provides a constant support of the wire during the entire twisting operation.

[0121] Referring to FIG. 7 the binding head 44 has a curved surface 54. The curved surface provides by rotation of the binding head 44 a pressure on the wheel 55 seen in FIG. 3. The wheel presses the wire lock 26 rearward in order to release the wire lock after the spindle lock 36 has fixed the wire.

[0122] FIGS. 8 and 9 shows details of the spindle and the binder housing.

[0123] FIG. 10 shows details of the wire nozzle.

[0124] FIG. 11 shows details of the axial tightening device.

[0125] FIG. 12 shows details of the wire spindle lock 36. The spindle lock may have two functions. One function is to fixate the wire completely. The function is actuated when the spindle lock is in a forward position whereby the wire is locked between the spindle lock and the binding head. According to another embodiment of the invention another function may be provided wherein an equal release of the wire in both ends of the wire is provided by the wire spindle lock. The retaining force in the wire is provided by an appropriate pressure between the wire spindle lock 36 and the binding head 44 but the wire is not completely locked so that it may slip and thus form an equal release.

[0126] FIG. 13 shows details of the wire lock.

[0127] FIG. 14 shows details of the sliding platform.

[0128] Referring to **FIG. 15** the jaw attachment base comprises a guiding track **56a** for guiding the wire into the jaws and a guiding track **56b** for guiding the wire out of the jaws. The guiding tracks **56a** and **56b** are asymmetrically provided. Fastening means **57** are provided for attaching the jaws opening and closing means such as springs, hydraulic, pneumatic or electric motors or actuators etc.

[0129] Referring to **FIG. 16** the jaws comprises a guiding track **58** for guiding the wire through the jaws and around the objects to be tied together. The jaws of the binder may preferably be detachably mounted so that the jaws easily can be renewed or so that jaws of different size can be attached. Jaws of different size may be necessary depending on the size of the objects that are to be tied together. Preferably the jaws **7**, the jaw attachment base, the polar head **9** and the binding head **44** may be assembled to one unit which can be detachably mounted to the binder. By detaching this unit the user may gain access to cleaning of the internal parts of the binder and the jaws, the jaw attachment base, the polar head and the binding head can easily be renewed when worn-out etc.

[0130] Referring to **FIG. 17** the binder may further be provided with wire aligning means **59** in order to de-curl the wire before the wire enters the binding housing.

[0131] **FIG. 18** shows a functional diagram of the control system.

[0132] **FIG. 19** shows a different embodiment of the casing for the binder. The wire coil has in this example been placed between the handle and the mechanics of the binder. The embodiment provides a long binder adapted for reaching into narrow spaces etc.

[0133] **FIG. 20** shows an alternative embodiment of the invention wherein the gripping means comprises a spring loaded pawl **61** mounted pivotally to the spindle lock. The spindle lock for this embodiment is shown with numeral **63**. As the free end of the wire passes the pawl, the pawl is lifted by the wire. As the spring **62** presses the pawl against the wire, the wire is locked in the reverse direction. As the wire is stopped by the binder housing **14**, the voltage over the wire feed motor will raise. When the raise in the voltage is detected, the wire feeding is stopped and the feeding direction is reversed. As the wire is prevented from going back through binding head **44** and the polar head (the twisting member), the wire is being tightened. As the polar head starts to rotate, the wire is being cut between the wire nozzle **25** and the binding head **44**. In order to obtain enough inertia in the motor axle to perform the wire cut, the motor is allowed to perform between 135 degrees and 200 degrees turning before the spindle lock **63** is being rotated by the motor and thus before the wire is cut.

[0134] According to this embodiment, the pin **73** of the spindle **49** is used for positioning the polar head so that the wire nozzle is positioned correctly in relation to the polar head, allowing the wire to pass through the holes **53**. The pin **73** may be connected to mechanical, magnetic or opto-electric sensors or to any other kind of system capable of sensing the angular position of the pin and thus the polar head.

[0135] **FIG. 21** shows the embodiment of **FIG. 20** after the wire has been tightened. As shown, the spindle lock **63** is pressed forward against the wire and wire is now fixated

between the spindle lock and the binding head **44** along the engagement lines **65**. As the spindle lock is pressed forward, the pawl will be released from its engagement wire.

[0136] Preferably the jaws **7**, the jaws attachment base (**FIG. 15**), the contact face **64**, the polar head **9**, the binding head **44** and the bearing **65** are all detachably connected to the binder for easy repair and service. It will be preferred that all of the above mentioned parts may be detached without the use of tools. As an example the parts may all be kept in place by the contact face **64**.

[0137] **FIG. 22** shows a preferred embodiment of the contact face. The contact face is provided in the form of a circular disc whereby the contact face may be thus be arranged in close vicinity to the polar head **9** and thus provide support for the binder against the objects being tied together.

[0138] **FIG. 23** shows details of the gripping means with the locking pawl.

[0139] **FIG. 24** shows details of the spindle lock according to the embodiment of the gripping means shown in **FIG. 20**.

[0140] **FIG. 25** shows an overview of the binder with motor. **FIG. 25** shows a binder in according with the embodiment of **FIG. 20**. As seen in **FIG. 25**, the binder has a handle **66** and a shield **67** for protecting the user of the binder from hazardous impact with the objects being tied together. Furthermore, the binder has a wire spool **68**, a display **69**, a battery **70**, a trigger **71** and a wire feed motor **72**.

[0141] **FIG. 26** shows two different stages of the binding sequence. In the first sequence the wire has been curled around the objects to be tied together. In the second sequence the binding head has rotated and thus locked the wire with a binding force.

[0142] **FIG. 27** shows an embodiment of the locking pawl **61** of **FIG. 20**. By its engagement with the binding head **44**, the locking pawl is held in the shown position wherein the pawl locks the wire. As the binding head starts to rotate, the engagement between the binding head and the pawl is released whereby the wire is released. At this moment the wire is held by the spindle lock **63**.

[0143] Preferably the wire is provided with a resiliency or flexibility so that a coiled wire automatically straightens out when released from the coil. Thereby it will be achieved that the wire follows the guiding means of the jaws in firm contact with the jaws. In order not to have the wire de-coiling on the wire spool, the wire spool may be provided as a closed magazine. Inside the magazine the wire is coiled with a diameter in the range of 50 mm to 100 mm. or even bigger. The wire is released from the magazine e.g. through a small hole in the magazine. As the wire is release from the magazine, it automatically seeks into a straight configuration.

1. A method for twisting and tightening a wire with a free end portion around at least two objects for binding the objects together, the method comprising:

arranging the two objects in close contact,
 placing a twisting member in a position next to the objects, the twisting member having a surface facing the objects,
 guiding the free end portion through a hole or groove in the twisting member,
 guiding the free end portion in a path at least one time around the objects, so as to wind a wire portion in at least one loop around the objects,
 guiding the free end portion through or into the twisting member whereby the wire forms a closed loop and defines an intersection of two wire portions, so that said surface of the twisting member is between the intersection and the objects,
 gripping the end of the free end portion of the wire,
 tightening the wire by pulling,
 turning the twisting member, so as to twist the wire, characterised in that the wire is cut by a cutting edge of the twisting member.

2. An apparatus (1) for twisting and tightening a wire around two objects and comprising:

a twisting member (9)(44) having a surface (64) facing the objects, the twisting member being mounted in such a way that said surface may contact or be in close contact with the two objects,

two jaws (7) adapted to encircle the two objects, the jaws being arranged opposite to each other and facing each other in a loop-shaped configuration, each of the jaws having one free end portion and one end pivotally mounted near the twisting member,

power-driven means (17) for feeding a wire through a first hole (53) in the twisting member and along guiding means (56a,58) in a first one of the two jaws to the free end portion of that jaw and further to the free end portion of the second jaw and therefrom along guiding means (56b,58) in the second jaw and further through a second hole (53) in the twisting member, so as to wind a portion of the wire at least one time around the objects; whereby the wire forms a loop and defines an intersection (28) of two wire portions, so that said surface of the twisting member is between the intersection and the objects,

gripping means (36, 61) for gripping a free end portion of the wire when the wire has been fed around the objects,

tightening means (29) for tightening the wire when gripped by the gripping means,

power-driven means (12) for rotating the twisting member, so as to twist two portions of the tightened wire around each other, characterised in that the twisting member defines a cutting edge which is adapted to cut the wire when the twisting member is rotated.

3. An apparatus according to claim 2, wherein the jaws are provided with a non-circular shape.

4. An apparatus according to claim 2-3, wherein the means for feeding the wire comprises an electrically driven motor.

5. An apparatus according to any of claims 2-4, wherein the means for rotating the twisting member comprises an electrically driven motor.

6. An apparatus according to any of claims 2-3 or 5, wherein the means for feeding the wire comprises pneumatically driven means.

7. An apparatus according to any of claims 2-4 or 9, wherein the means for rotating the twisting member comprises pneumatically driven means.

8. An apparatus according to any of claims 2-3 or 5 or 7, wherein the means for feeding the wire comprises hydraulically driven means.

9. An apparatus according to any of claims 2-3 or 6 or 8, wherein the means for rotating the twisting member comprises hydraulically driven means.

10. An apparatus according to any of claims 2-11, wherein the same electrically driven motor is used for twisting and feeding.

11. An apparatus according to any of claims 2-3 or 6-7, wherein the same pneumatically driven motor is used for twisting and feeding.

12. An apparatus according to any of claims 2-3 or 8-9, wherein the same hydraulically driven motor is used for twisting and feeding.

13. An apparatus according to any of claims 2-12, wherein the gripping means comprises mechanical or electromechanical actuation means and wherein the mechanical or electromechanical actuation means is selected from a group comprising:

electromagnets,

hydraulic actuators,

pneumatic actuators.

14. An apparatus according to any of claims 2-13, wherein the operation of the first and/or the second electrically, pneumatically or hydraulically driven motor is being controlled by a control system.

15. An apparatus according to claim 14, wherein the control system is comprised in means or electronically processing such as a CPU.

16. An apparatus according to claim 15, further comprising a display connected to the CPU for displaying information to the user.

17. An apparatus according to claim 15 or 16, further comprising an interface for communication between the CPU and external processing means.

18. An apparatus, according to claim 15-17, wherein the means for electronically processing are adapted to vary the tightening force in correspondence to a user-selectidn.

19. An apparatus according to any of claims 2-1-8, wherein at least the part of the twisting member which faces the objects is made of a hardened steel alloy such as titanium alloys or similar metallic or ceramic materials.

20. A apparatus according to any of claims 2-19, wherein each of the free end portions of the jaws forms a funnel-shaped opening extending away from the contact between the free end portions of the two jaws.

21. An apparatus according to any of claims 2-20, wherein the jaws are spring-biased towards a closed position.

22. An apparatus according to any of claims 2-20, wherein the jaws are closed by hydraulic, pneumatic or electrically driven means.

23. An apparatus according to claim 22, wherein the closing by hydraulic, pneumatic or electrically driven means is controlled by the CPU.

24. An apparatus according to any of claims **2-23**, wherein a carrying support arm can be attached to the housing of the apparatus for carrying the weight of the apparatus and to enable the apparatus to be used in a distance from the hands of the operator.

25. An apparatus according to any of claims **2-24**, further comprising a contact face for supporting the apparatus against the objects.

26. An apparatus according to any of claims **2-25**, wherein the wire is an elastic wire for binding an object, said wire having an elasticity of at least 50,000 MPa.

27. An apparatus according to claim 26, wherein the wire is made from an iron alloy comprises in the range of 1.2-2.0% manganese (Mg), 0.8-1.2% silicon (Si) and 0.06-0, 15% carbon (C).

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