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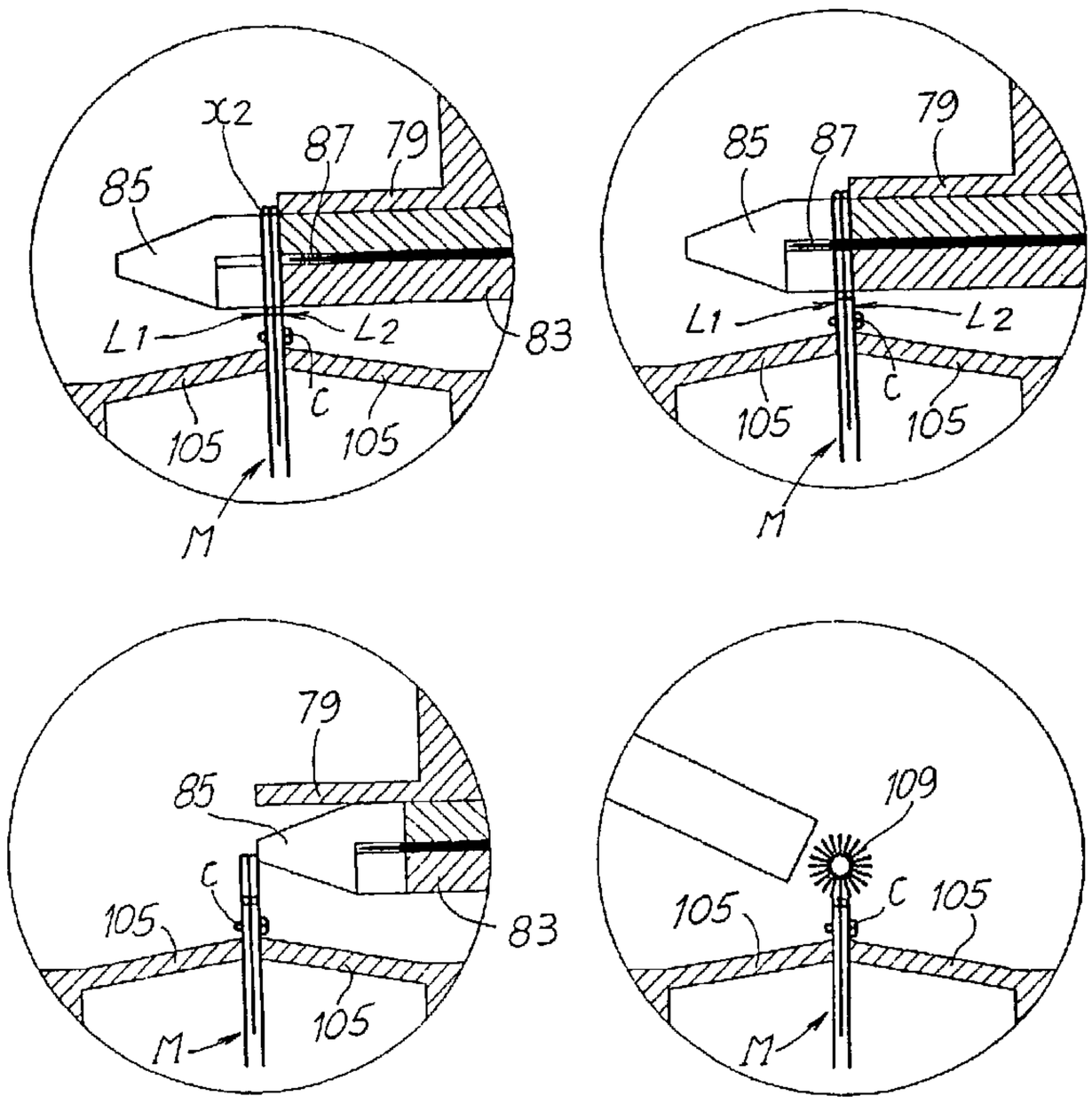
(54) Title: METHOD AND DEVICE FOR THE PRODUCTION OF TUBULAR KNITTED ARTICLES AND IN PARTICULAR FOR CLOSING THE TOE



(57) Abrégé/Abstract:
Described herein is a method for forming a closed toe in a tubular knitted article, for example a sock, comprising the steps of: setting two end flaps (L1, L2) of the article (M) alongside one another; inserting, inside the loops of at least one first row (X2) of stitches of the flaps set alongside one another, a comb-like structure comprising a plurality of teeth (85); sewing (C) together the loops of at least one second row of stitches, which is set between the first row of stitches (X2) and the body of the tubular article (M); and opening the loops of the first row of stitches.

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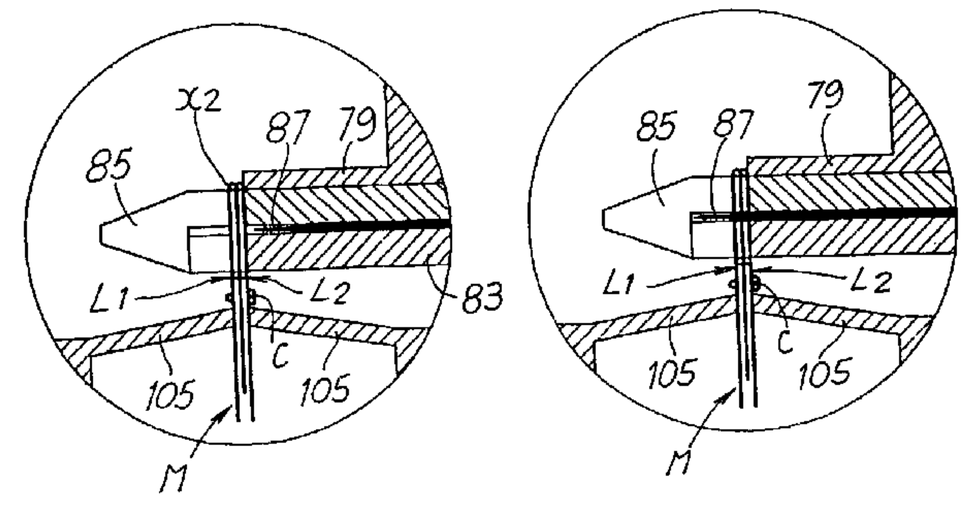
(54) Title: METHOD AND DEVICE FOR THE PRODUCTION OF TUBULAR KNITTED ARTICLES AND IN PARTICULAR FOR CLOSING THE TOE



(57) Abstract: Described herein is a method for forming a closed toe in a tubular knitted article, for example a sock, comprising the steps of: setting two end flaps (L1, L2) of the article (M) alongside one another; inserting, inside the loops of at least one first row (X2) of stitches of the flaps set alongside one another, a comb-like structure comprising a plurality of teeth (85); sewing (C) together the loops of at least one second row of stitches, which is set between the first row of stitches (X2) and the body of the tubular article (M); and opening the loops of the first row of stitches.

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"Method and device for the production of tubular knitted articles and in particular for closing the toe"

DESCRIPTION

Technical field

The present invention relates to a method for producing tubular knitted articles, such as socks and stockings, and in particular for closing the toe of the article by joining the two flaps of the toe.

State of the art

In the production of tubular knitted articles, in particular stockings and socks for men, for sportswear and the like, the product is knitted on a knitting machine, in particular but not exclusively of a circular type, which is a machine equipped with a needle cylinder. The article thus produced has an initial edge and an end edge. The end edge must be closed to form the toe of the article. For this purpose, up to now a linking process has been used, which is carried out on so-called linking machines. Said process involves a high incidence in terms of labour. According to this process, the flaps of the end edge of the article are tensioned and set alongside one another, and are then hooked onto hooks of a linking machine. In carrying out this operation, it is essential to hook each stitch or loop of a given row of stitches onto a respective hook. In greater detail, on each hook there are hooked two corresponding stitches or loops, of the same row, belonging to the two flaps set alongside one another of the end edge of the article. Once the article has been applied on the hooks, linking proper is carried out automatically, with the formation of a particular seam by means of a thread of yarn that forms a row of sewing loops or stitches that intersect the stitches or loops that are set on the hooks. To each pair of loops present on a hook there corresponds a stitch of the seam that joins the flaps. Next, the stitches or loops that are set externally to the seam are cut, namely the stitches of the row of stitches adjacent to the hooks on the side opposite to the one where the tubular article is set. Finally, the latter is removed from the hooks.

Linking enables a practically faultless and particularly smooth closed toe to be obtained. However, as is known to persons skilled in the art and as may

be understood from the foregoing brief description, the process involves a marked incidence in terms of labour for hooking the individual loops or stitches of the row that is to be sewn on the hooks of the linking machine. The operation must be carried out by staff with particularly sharp eyesight, and consequently can, in general, be performed only by young people.

The cost and difficulty in finding staff suitable for carrying out these operations renders recourse to the linking operation increasingly less frequent. As an alternative to linking, the toes of tubular articles are closed by means of seams obtained in a completely mechanized way, or in any case with a low incidence in terms of labour. The quality of the finished product is, however, inferior, in so far as mechanized seams involve the execution of a plurality of stitches distributed in an altogether random way, which generate a seam with a large thickness. A device and a process for closing the toe using a sewing machine associated to a knitting machine are described in WO-A-00/01869.

EP-A-0 635 593 and EP-A-0 592 376 describe a method and a device for joining two flaps of a knitted fabric of a tubular article for forming the closed toe of the finished article. In this case, closing is carried out directly on the circular knitting machine. The seam is obtained automatically, but requires a substantial modification of the knitting machine.

Objects and summary of the invention

A purpose of the present invention is to provide a method and a process for closing the toe of a tubular knitted article, which can be easily automated and which ensures a high-quality product.

According to another aspect, a further object of the present invention is to provide a method for the production of a tubular knitted article which enables manufacture of a tubular knitted article with a toe closed with a high-quality seam, without the drawbacks of the known linking processes.

According to a different aspect, yet a further object of the present invention is to provide a device which will enable closing of the toe of a tubular knitted article with a high-quality seam, without a high incidence in terms of labour, and which will enable high levels of output to be achieved.

In order to obtain closing of the tubular knitted article, the method according to the invention envisages setting two flaps of the end edge of the article alongside one another, in particular by gripping, for example, two roughly diametrically opposite points of the edge itself and tensioning the fabric. Into the stitches or loops of at least one row of the end edge there are then inserted the teeth of a comb-like structure, and the loops are thus aligned for subsequent sewing. Then a seam is made for joining the flaps of woven fabric, at the stitches or loops of a row adjacent to the one in which the teeth of the comb-like structure are inserted; more in particular, the row of stitches on which sewing is performed is the one located between the comb-like structure and the body of the tubular article. Next, once sewing of the loops of this second row has been performed, the loops into which the comb-like structure has been inserted are opened. According to a preferred embodiment of the invention, opening of the loops into which the comb-like structure is inserted is done by cutting the yarn. However, the possibility is not ruled out of performing this opening in a different way. For example, it is possible to form the row of stitches that is to receive the teeth of the comb-like structure using a thread of yarn that melts at a relatively high temperature, for example at the temperature of the dyeing liquid. In this way, once joining of the flaps of the tubular article for closing the toe has been performed, the article is discharged and sent on to subsequent processing stages. One of these involves dipping of the article into a bath at a relatively high temperature, for example, a dye bath, in which the meltable thread is destroyed, with consequent opening of the stitches formed thereby. This results in detachment of the rows outside the seam that joins the flaps. In what follows, reference will be normally made to an operation of cutting of the stitches, but it must be understood that this operation may be replaced by a different operation that leads to the same result, namely, opening of the stitches or interruption of the fabric with consequent separation of the tubular article from the end edge outside the seam.

When opening of the stitches is performed by cutting, it is advantageous to envisage an operation of extraction of the residue of the stitches that have

been cut, for example using a brush or some other removing member. This operation is not necessary when a meltable thread is used, in so far as the latter is completely eliminated by heating.

As compared to a normal linking process, both sewing and the subsequent cutting or opening of the loops are carried out on rows of stitches other than those that are sewn and cut according to the prior art.

As will emerge clearly from the ensuing description, the method described above can be conveniently carried out in an automatic and entirely mechanized way. This is particularly facilitated if the stitches of the row into which the teeth of the comb-like structure are inserted have a greater length than the remaining stitches of the article. In this way, insertion of the comb-like structure into the loops or stitches of the aforesaid row is extremely facilitated and can be carried out by a mechanical hand without any difficulty. Preferably, also the stitches on which sewing is carried out are longer than the remaining stitches of the tubular article, even though they are preferably shorter than the stitches of the row into which the teeth of the comb-like structure are inserted.

The method can advantageously be entirely automated, but this does not rule out the possibility of carrying it out also in a manual or semi-manual way, as will be described hereinafter by way of example on the basis of a series of examples of embodiment.

In practice, with the method of the present invention it is possible to obtain a seam for joining the flaps of the tubular article that is equivalent to a linking seam proper, in so far as the sewing thread produces a chain of stitches or loops which intersect individual pairs of stitches of the two flaps set alongside one another of the tubular article, in a way similar to what happens in linking machines, but with much simpler and automatable procedures.

In order to guarantee that all the stitches or loops of the row adjacent to the one where the teeth of the comb-like structure are inserted will be engaged with corresponding stitches of the seam for closing the toe, even in the case where insertion of the teeth into the loops were not perfectly regular (for example, if a tooth engages two adjacent loops of the same flap), it may

advantageously be envisaged that the pitch of the seam joining the flaps of the article will be smaller than the pitch of the comb-like structure or of the stitches or loops. For example, the pitch of the knitted seam may be a submultiple, for instance one half or one third, of the pitch of the loops of the row of fabric that is to be sewn, or of the pitch of the comb-like structure.

In practice, the method according to the invention envisages the following steps:

- gripping two roughly diametrically opposite points of the tubular article, in positions corresponding to said end flaps;
- tensioning transversely said tubular article in order to bring said end flaps alongside one another;
- tensioning said tubular article longitudinally;
- inserting said comb-like structure into said first row of loops in such a way that each tooth of said comb-like structure inserts into a loop of one first flap and into a corresponding loop of the second flap;
- sewing together the loops of said at least one second row adjacent to the first row; and
- cutting the loops of said first row and sliding out the half-loops that have been cut, or else opening the loops in some other way.

As is known, normally the structure of a knitted fabric is helical, in the sense that if the yarn is fed continuously, a continuous helical sequence of stitches is generated. If the tubular article has a structure of this type, the teeth of the comb-like structure may end up inserting into adjacent rows, and likewise the loops formed by sewing may end up joining corresponding stitches of the two flaps set alongside one another which belong to different rows. This does not affect in a substantial way the final result, thanks to the deformability of the structure of the fabric.

However, according to a preferred embodiment of the invention, the row into which the teeth of the comb-like structure insert and the row on which sewing is performed, as well as possibly some of the rows immediately before and immediately after, may be obtained by interrupting the thread of yarn, in such a way that at these rows there will be entry and exit of the thread of yarn

that forms the stitches. This results in circular rows instead of helical ones and facilitates insertion of the comb-like structure, as well as the sewing or linking operation, which will be performed at the level of a single row without any overlapping. The detailed description of an example of embodiment will clarify further this particular feature.

The method according to the invention for closing the toe of a tubular knitted article may be carried out at a moment and/or in an area different from the moment and/or area of knitting of the tubular article, as currently occurs for the linking process, which is carried out separately from and independently of the process of knitting of tubular articles.

Alternatively, and advantageously, the method for closing the toe may be implemented directly on the machine, or in a position adjacent to the machine, on which said article is manufactured. In this case, the sewing method is integrated in a method for knitting the tubular article. The method will thus involve the following steps:

- knitting the tubular article starting from an initial edge as far as an end edge;
- setting the two end flaps of said end edge alongside one another;
- inserting, inside the loops of at least one first row of stitches of said end flaps, a comb-like structure comprising a plurality of teeth;
- sewing together the loops of at least one second row of stitches, which is set between said first row of stitches and the body of the tubular article; and
- opening (for example by cutting) the loops of the first row of stitches into which the teeth of said comb-like structure have been inserted.

In any case, the process for knitting the article may envisage, according to a preferred embodiment of the invention, the formation of a row of stitches or loops of a larger size or length in order to facilitate insertion of the teeth of the comb-like structure.

According to a further aspect of the invention, a device is provided for sewing two end flaps of a tubular knitted article, said device comprising in combination:

- a comb-like structure with a plurality of teeth for engaging the loops of a first row of said tubular article; and
- possibly a gripping member for gripping said tubular article at an end edge of the article in two approximately diametrically opposite points, in order to tension the end edge and to bring two end flaps of said tubular article alongside one another; and
- sewing means with at least one needle for sewing together the flaps set alongside one another underneath the comb-like structure.

The gripping member for gripping and tensioning the article may even be omitted, in which case said operation may be carried out manually, for example by inserting the edge of the article with the flaps brought up to one another into a so-called guillotine made up of two bars set alongside one another.

Advantageously, also a cutting member may be provided for cutting the loops engaged by said comb-like structure, as well as, preferably, means for removal of the half-loops cut by the cutting member. However, as mentioned previously, opening of the loops adjacent to the seam may be carried out also in a way other than by cutting. In this case, the cutting member and the means for removal of the residual yarn of the half-loops that have been cut may not be present.

In a particular advantageous embodiment of the invention, the device is also provided with a pair of substantially rectilinear bars associated to the comb-like structure and parallel to the latter, between which the tubular article is pressed and engages with the end flaps set alongside one another for insertion of the comb-like structure. The latter may be independent of the pair of bars, or else may be advantageously carried by one of the bars and be mobile with respect to the latter.

In order to facilitate the operations of cutting of the loops of the row inside which the comb-like structure has been inserted, according to a particularly advantageous embodiment of the invention the cutting device is incorporated in the comb-like structure. Said cutting device may comprise a blade housed in a slidable way within a seat made in the teeth of the comb-

like structure. For an efficient cut, movement of the blade may have a component that is parallel and a component that is orthogonal to the development of the teeth of the comb-like structure. The possibility is not ruled out of making and setting the cutting member in a different way, instead of incorporating it in the comb-like structure, although the latter solution presents advantages from the constructional standpoint.

Further advantageous characteristics of the device and method according to the invention are specified in the attached claims.

Described in what follows is an apparatus comprising the device according to the invention, which has also the function of extracting the tubular article from the circular knitting machine and taking it to the area where the sewing device proper for sewing the toe is provided. It must be understood that the ensuing description only refers to one of the possible uses of the device and the method according to the present invention, which may be implemented also in different machines and equipment. For example, it is possible to envisage use of the device and method according to the invention also in combination with an apparatus of the type described in WO-A-00/01869, instead of in combination with the sewing machine described herein, or else in combination with one of the devices described in EP-A-0 679 746, or in combination with other suitable apparatus. The device and method according to the present invention can also be used, for instance, in combination with a machine of the type described in the co-pending European patent application No. 00830020.4 of January 18, 2000 or in the corresponding international patent application PCT/IT01/00009 of January 12, 2001.

In general, the invention may be adopted also in isolation, instead of in combination with a knitting machine with the corresponding means for extracting and handling the tubular article. It is in fact possible to envisage picking-up of the tubular articles from a container where they have been set pell-mell after they have been manufactured in an independent production department. In this case, the step of preparation of the tubular article for the subsequent sewing step may be entirely mechanized or mechanized only in

part by envisaging, for instance, intervention of an operator who sets the tubular articles that are to be sewn on an appropriate support, for example consisting of the end part of a tubular duct. The remaining operations of tensioning, positioning, sewing and discharging may be mechanized.

Brief description of the drawings

A better understanding of the present invention will be provided by the ensuing description and by the attached drawings, which illustrate a non-limiting example of embodiment of the invention. In greater detail, in the drawings:

Fig. 1 is a perspective view of a device for picking up a tubular knitted article from a cylinder of a circular knitting machine and of a device for sewing the toe of the article;

Fig. 2 is a side view according to the line II-II of Fig. 1;

Fig. 3 is a view according to the line III-III of Fig. 2;

Fig. 4 is a perspective view of the devices combined with a circular knitting machine;

Fig. 5 is a perspective view of one part of the sewing area, with elements removed for reasons of greater clarity of the drawing;

Fig. 6 is similar to Fig. 5 and shows the same members from a different observation point;

Fig. 7 is a perspective view of the sewing machine for closing the toes of tubular articles picked up by the pick-up device;

Fig. 8 is a perspective view of an intermediate separator set along a suction pipe of the pick-up device;

Fig. 9 shows the internal members of the intermediate separator of Fig. 8;

Fig. 10 is a longitudinal cross-sectional view of the intermediate separator;

Fig. 11 shows a mobile axial unit that carries the widening members and the members for turning the tubular article inside out for preparing it for sewing of the toe;

Fig. 12 shows the same unit as Fig. 11 with parts removed;

Fig. 13 is a longitudinal cross-sectional view of the unit of Figs. 11 and 12;

Fig. 14 is a view from below according to the line XIV-XIV of Fig. 13;

Fig. 15 shows a pair of bars for retention of the article during the initial steps of sewing of the toe;

Fig. 16 shows a comb-like structure for engagement of the article during sewing and a cutting member housed inside the comb-like structure;

Figs. 17 to 28 show, in a cross-sectional plane passing through the axis of the suction pipe, the device for picking up the article (or part of the device), as well as the widening members and the members for turning the article inside out in order to prepare it for sewing of the toe, Fig. 17A being an enlargement of the output area of the suction pipe;

Fig. 29 is a cross-sectional view according to the line XXIX-XXIX of Fig. 28;

Fig. 29A is an enlargement of the central area of Fig. 29;

Figs. 30 to 32 are cross-sectional views, according to the line XXX-XXX of Fig. 29, of the pair of bars for retention of the article and of the comb-like structure in the step of engagement of the article and insertion of the comb-like structure into the respective row of stitches, as a preliminary step to sewing of the toe;

Fig. 33 shows the sewing machine and the comb-like structure inserted in the article during sewing;

Fig. 34 is an enlargement of a detail of Fig. 33;

Fig. 35 is a schematic illustration of the action of the needle of the sewing machine during the sewing operation;

Figs. 36 to 39 show the steps for cutting the loops of the row of the tubular article inside which the comb-like structure has been inserted;

Fig. 40 shows the step of removal of the residue of yarn after cutting of the loops adjacent to the sewing row;

Fig. 41 illustrates a detail of Fig. 40;

Fig. 42 is a perspective view illustrating a possible embodiment of the system for removal of the residue of yarn;

Fig. 43 is an axial sectional view of the end portion of the suction pipe in the step of removal of the tubular article after the sewing operation;

Figs. 44 to 46 are schematic representations of the weaving operations performed on the article during sewing of the toe;

Fig. 47 is a schematic representation of the rows involved in sewing in an improved embodiment of the invention;

Figs. 48 and 49 are perspective views of a semi-automatic sewing device according to the invention, in two different operating positions;

Fig. 49A illustrates an enlarged detail of Fig. 49;

Fig. 50 is a perspective view of the sewing machine combined with the device of Figs. 48 and 49, with parts removed;

Figs. 51 to 53 show details of the sewing and cutting area of the device of Figs. 48 and 49; and

Fig. 54 is a perspective view illustrating another semi-automatic device according to the invention.

Detailed description of the preferred embodiment of the invention

The devices for picking up and sewing tubular articles are shown in Fig. 4 in combination with a circular knitting machine, and in isolation from the knitting machine in Figs. 1 to 3. The internal structure of the pick-up device may be seen in Figs. 17 to 28. In some of the figures, parts of the devices have been removed for greater clarity of representation. In what follows generic reference will frequently be made to the ensemble made up of the pick-up device and sewing device as to a single device for picking up the article and closing the toe, it being, however, understood that the pick-up device may be combined with a different device for closing the toe and vice versa.

In the attached drawings, the device for picking up the tubular article and closing the toe is designated, as a whole, by 1, whilst 3 designates, as a whole, the circular knitting machine that produces the tubular article. Of the circular knitting machine 3, only the essential components are indicated, which may be seen in particular in Figs. 17 to 19, which show the cylinder 5 of the needles 7 that form a circular needle bed, in a way in itself known. The

needle cylinder 5 is supported, in such a way that it can turn about its own axis, by means of a support, designated by 9, and is set in rotation by means of members (not illustrated) which mesh with a crown gear 11. The members for controlling the needles 7 of the circular bed are not shown, but are in themselves known, as are also all the other members of the circular knitting machine 3, which consequently will not be described in any further detail herein.

The device 1 comprises a suction pipe 13, which is substantially U-shaped, and one end of which, designated by 13A, will hereinafter be referred to as intake end, whilst one end, designated by 13B, will hereinafter be referred to as output end. The intake end 13A is set underneath the cylinder 5 of the needles 7 of the knitting machine 3. In this way, the suction pipe 13 may have any diameter whatsoever, which is independent of the internal diameter of the cylinder 5.

Inside the suction pipe 13 there develops a guide element, designated as a whole by 15. Said guide element 15 (which in the example illustrated has a substantially tubular conformation with a circular cross section) extends outside the suction pipe 13 from the intake end 13A as far as inside the cylinder 5 of the needles 7 of the knitting machine 3. The top end of the guide element 15 approximately reaches the plane of formation of the knitted fabric of the knitting machine 3.

The guide element 15 is made up of two parts, one of which is designated by 15A and the other by 15B. These two parts are hinged about an axis of trace 17 (see in particular Fig. 17) orthogonal to the axis (namely, to the median line) of the suction pipe 13 and of the guide element 15 itself. The reason for this configuration will appear more clearly from the ensuing description of the operation of discharge of the article with the toe closed.

The guide element 15 is supported, inside the suction pipe 13, by means of an intermediate separator, which is designated as a whole by 19, and the parts of which are illustrated in detail in Figs. 8 to 10. The intermediate separator 19 also performs the function of dividing the suction pipe 13 into two consecutive parts, the first of which develops between the intake end 13A and

the intermediate separator 19, and the second between the latter and the output end 13B.

As may be seen in detail in Figs. 8 to 10, the intermediate separator 19 is made up of a pair of jaws 21 and 22 operated by respective actuators 23 and 24, which, in the example illustrated, consist of cylinder-piston systems. The jaws 21 and 22 are fixed to the stems of the cylinder-piston actuators 23 and 24 and have V-shaped front profiles, designated by 21V and 22V. The jaw 21 has a slot, inside which the front portion of the jaw 22 penetrates in such a way as to grip, between the two profiles 21V and 22V, the guide element 15, withholding it in a coaxial position, namely centred with respect to the suction pipe 13.

The jaws 21 and 22 slide in a guide frame 25 which is fixed to the suction pipe 13.

As may be seen in Figs. 9 and 10 (in the latter figure the jaws 21 and 22 being shown in the closed condition), the jaw 22 has an internal duct, designated by 27, which opens onto the profile 22V and onto the top portion of the jaw itself (see in particular Fig. 9). The frame 25 has a slotted opening 29 in a position corresponding to the outlet area of the internal duct 27 to enable application of a flexible pipe or hose that connects the internal duct 27 to a source of air under pressure (not shown) for the purposes that will be clarified in what follows.

As may be seen in particular in Figs. 17, 18 and 19, the guide element 15 has (in its part 15B) a hollow structure inside which a stem 15C is housed that terminates with a head 15E (see in particular Fig. 17A), said stem constituting a telescopically extensible portion of the guide element itself. The reference number 15D designates a extension spring that forces the stem 15C to return into the hollow tubular part of the guide element. The air under pressure, which can be supplied through the internal duct 27 of the jaw 22, has the function of pressurizing the internal area of the hollow part 15B of the guide element 15 to overcome the force of the extension spring 15D and to extract the stem 15C until it reaches the position illustrated in Figs. 17 to 19, whilst in Fig. 20 the stem 15C is shown in a retracted position inside the

hollow part of the guide element 15.

Since the jaws 21 and 22 of the intermediate separator 19 can open, thus releasing the guide element 15 in order to enable passage of the tubular article which must pass along the suction pipe 13 (as will be clarified in what follows), along the suction pipe 13 there are provided further systems for temporary support of the guide element 15 inside the suction pipe 13. These supporting means are clearly visible in Figs. 1, 2 and 3 and are represented in a simplified way in the remaining figures. They are made up of three sets of sliders 31, 32, 33 positioned in respective three sections set at distances apart along the development of the suction pipe 13. In greater detail, two sets of three sliders, namely the sets of three sliders 31 and 32, are positioned on planes orthogonal to the axis of the suction pipe between the intake end 13A of the suction pipe and the intermediate separator 19. The last set of sliders 33 is positioned on a plane between the intermediate separator 19 and the output end 13B of the suction pipe 13. The sets of sliders 31, 32 and 33 can be brought back or retracted in such a way that they do not project inside the suction pipe 13, so as to leave completely free the space between the inner wall of the suction pipe 13 and the guide element 15. Alternatively, the sliders of each set can be displaced radially inwards in such a way that they engage the guide element 15, supporting it inside the suction pipe 13. Synchronized actuation of the sets of sliders 31, 32, 33 enables (in the way that will be clarified hereinafter) transit of the tubular article discharged from the circular needle bed 37 along the suction pipe 13 towards the output end 13B of the latter.

The suction pipe 13 has an end part 13C which is angularly mobile about its own axis with respect to the remaining part of the suction pipe. The movement of rotation of the end part 13C of the suction pipe 13 is imparted by an actuator 35, for example a stepper motor. The latter enables adjustment of the angular position of the part 13C of the suction pipe 13 with respect to the remaining part (which is fixed on the supporting structure) of the pipe, in order to orient appropriately the tubular article before sewing of the toe of the latter, as will emerge clearly from the detailed description of the modes of operation

of the entire device.

At the output end 13B of the suction pipe 13 there is provided a sewing area, designated as a whole by 37. Located in this area are the members that have the function of extracting the tubular article, turning it inside out, from inside the suction pipe 13, of closing the toe of said article by sewing and re-inserting the article into the suction pipe 13 so as to discharge it finally from the device.

Set in the sewing area 37 is a unit 39 which surrounds the suction pipe 13, and more precisely the portion 13C of the latter. The unit 39 carries, in a way that will be described in detail with reference to Figs. 11 to 14, the widening members and the members for turning the tubular article inside out before it is sewn. The unit 39 is axially mobile, in the direction indicated by the arrow f39, along the end part 13C of the suction pipe 13. For this purpose, there are provided a slide guide 41 and an actuator 43 which controls movement of the unit 39.

The unit 39 is illustrated in detail in a perspective view in Figs. 11 and 12, in a cross-sectional view in Fig. 13, and in a view from below in Fig. 14. Fig. 11 shows a ring 45 which forms part of the unit 39 and which is coaxial with the axis of the part 13C of the suction pipe 13. The ring 45 supports a plurality of radial pushers 47 constituting the members for turning the tubular article inside out before sewing of the toe. Each pusher 47 is provided with a radial movement controlled by a corresponding actuator 49, for example a small cylinder-piston actuator. Beneath the ring 45, the unit 39 has a wall 51 which delimits an internal suction chamber 53. The latter is connected, through an opening 55, to a suction line, the connection of which to the suction chamber 53 is designated by 57.

Set inside the suction chamber 53 present in the unit 39 are five shaped plates 59 supported by rotating spindles 61. Each shaped plate 59 carries, in a position at a distance from the corresponding supporting spindle 61, a stem 63 parallel to the spindle 61 itself. The conformation of the shaped plates 59 is such that (see in particular Fig. 12, in which the overlying pushers 47, their actuators 49 and the ring 45 have been removed for clarity of representation),

in a first angular position of the spindles 61, they form a substantially continuous wall orthogonal to the axis of the suction pipe 13, or more exactly to the end part 13C of the suction pipe 13. The wall formed by the shaped plates 59 has a central hole 65 for the purposes that will be clarified hereinafter.

The shaped plates 59 are controlled in such a way that they open simultaneously by means of an oscillation of each spindle 61 about its own axis. For this purpose, a mechanism is provided, which is shown in Figs. 13 and 14 and which comprises pinions 67 fixed to the bottom end of each spindle 61 and meshing with an internal-toothing crown gear 69, the rotation of which causes spontaneous rotation of the pinions 67 and thus of the spindles 61. Rotation of the toothed crown gear 69 is obtained by means of a pinion 70 fitted on a shaft 72 which is driven in rotation about its own axis by means of a cylinder-piston actuator 74.

Set above the unit 39, and approximately aligned with the end part 13C of the suction pipe 13, is a gripping member, designated as a whole by 71, for gripping the tubular article that is to be sewn. The gripping member comprises a pair of brackets 73 (see in particular Figs. 1 to 3 and 5 and 6) which are mobile with respect to one another with a movement of approach and recession represented by the double-headed arrow f73 (see in particular Figs. 5 and 6). Movement in the direction indicated by the arrow f73 is obtained by a pair of cylinder-piston actuators associated to the brackets 73 and carried by a structure which is in turn provided with movements according to a horizontal axis X and a vertical axis Y (see again in particular Figs. 5 and 6). As will emerge clearly hereinafter, the brackets 73 can be brought up to one another for penetrating inside the suction pipe 13 and gripping the end edge of the tubular article, and then tensioning it and carrying it to the sewing machine for the subsequent sewing operation.

The structure that carries the member 71 for gripping the tubular article is supported by a base structure 75, which is in turn constrained to a fixed frame, for example the frame itself of the knitting machine 3. The base structure 75 carries a pair of bars 77 and 79 which are roughly rectilinear. The

bar 77 is fixed to a portion of metal section 81 which is mobile, as indicated by the double-headed arrow f81, by means of cylinder-piston actuators (not shown). In this way, the bar 77 can move away from and up to the bar 79, which is, instead, fixed with respect to the base plate 75.

Underneath the fixed rectilinear bar 79, a comb-like structure 83 is provided, which is illustrated in isolation and in detail in Fig. 16. The comb-like structure 83 has a plurality of teeth 85 and is made up of two portions 83A and 83B, which are connected together and define an intermediate seat for sliding of a cutting blade 87. The comb-like structure 83 is mobile as indicated by the double-headed arrow f83 (see in particular Fig. 6) in a direction orthogonal to the longitudinal development of the fixed rectilinear bar 79. The cutting blade 87 housed inside the comb-like structure 83 moves together with the comb-like structure 83, following the movement of the latter as indicated by the arrow f83. The movement is obtained by cylinder-piston actuators or equivalent actuators, designated by 89 in Fig. 6.

As may be seen in particular in Fig. 16, the cutting blade 87 is provided with a plurality of slots 87A which are inclined with respect to the cutting edge 87B of the blade 87. Into the slots 87A there insert pins 83C which are fixed to the portion 83B of the comb-like structure 83. At one of its ends, the blade 87 extends to form an appendage 87C in which a slot 87D orthogonal to the cutting edge 87B of the blade itself is made. In said slot 87D there engages a slider 91 provided with a movement, parallel to the cutting edge 87B, imparted by a cylinder-piston actuator or equivalent actuator 93. The actuator 93 is carried by the base plate 75, as may be seen in particular in Fig. 6. Thanks to the slot 87D, the cutting blade 87 can move in a direction orthogonal to the cutting edge 87B to follow the movement indicated by the double-headed arrow f83 of the comb-like structure 83, all the time maintaining mechanical connection with the actuator 93. Operation of the actuator 93 causes a thrust in the direction indicated by the arrow f87 (Fig. 16) on the blade 87, which consequently (thanks to the arrangement of the pins 83C and of the inclined slots 87A) will perform a movement with one component that is parallel and one component that is orthogonal to the longitudinal development of the

comb-like structure 83. The function of this movement is, as will be clarified in what follows, that of cutting the loops of the row of stitches inside which the comb-like structure 83 is inserted for carrying out sewing of the toe of the tubular article.

In the sewing area 37 there is moreover provided a sewing machine, designated as a whole by 95, and illustrated in isolation from the other mechanical members in Fig. 7. The sewing machine 95 has been omitted for reasons of clarity of representation in Figs. 1, 2 and 3. The sewing machine has a sewing needle 96 and a mouth for suction of the sewing thread 99. The reference number 101 designates the so-called "crochet", which imparts the raising and lowering movement on the sewing thread for the latter, fed by the thread bobbin, to be appropriately picked up by the sewing needle 96. The shape of the crochet 101 is provided purely by way of example. The crochet may, for instance, also be of the rotating or oscillating type. Likewise, the shape of the needle co-operating with it may be different. The structure of the sewing machine 95 is of a type in itself known to persons skilled in the art, and consequently will not be described in greater detail herein. The type of sewing performed by the needle 96 will in any case be described in greater detail with reference to the operation of the device.

The sewing machine 95 is provided with a sewing movement, indicated by the arrow f95 in Fig. 4, imparted by an actuator, designated as a whole by 97 again in Fig. 4.

Associated to the sewing machine 95 is a retention member for withholding the tubular article after sewing of the toe in order to carry out cutting of the part of fabric external to the seam. The retention member is designated as a whole by 103, and its position with respect to the other members of the device is illustrated in Fig. 4, whilst its structure is illustrated in detail in the perspective representation of Fig. 15.

The retention member 103 comprises a pair of bars 105, which are substantially parallel to the movement of the sewing machine 95 and to the fixed bar 77 and mobile bar 79. The retention bars 105 are provided with a movement orthogonal to their own development in the direction indicated by

the double-headed arrow f105 in Fig. 15. In this way, they can be brought up to one another for withholding the article, or moved away from one another for releasing it. The movement is imparted by cylinder-piston actuators (not shown) housed in the structure of the retention member 103 fixed to the sewing machine 95. Since the retention member 103 is fixed to the sewing machine 95, it is also translated integrally with the sewing machine when the latter performs the sewing movement in the direction of the arrow f95. This enables the bars 105 to be brought into alignment with the tubular article that is being sewn.

Finally, fixed to the sewing machine 95 is a system for removal of the residue of yarn after the cutting operation has been performed by the blade 87, said system being designated as a whole by 107, and its position with respect to the other members of the device being shown in Fig. 4. The structure of the removal system 107 in a possible embodiment is illustrated in the perspective representation of Fig. 42. The removal system 107 is provided with one or more brush members 109 which rotate about the axis of a vertical shaft which is inserted into a suction mouth 111 through which the residue of yarn separated from the tubular article by the brush 109 is sucked in and removed.

Operation of the device so far described is illustrated in what follows with particular reference to Figs. 17 to 43.

Fig. 17 shows the end step of knittingof a tubular article M by the needles 7 of the circular bed of needles of the circular knitting machine 3. The tubular article is knitted starting from an edge B1, which in Fig. 17 is in the bottom part and which in the finished article will remain open. When the tubular article M is a sock, said edge constitutes the elastic border of the sock. The final knitting step envisages formation of an edge B2 which is designed to be sewn to form the closed toe of the finished product.

During formation, the tubular article M comes to set itself in the space between the cylinder 5 of the needles 7 and the guide element 15, and more precisely the part of said guide element that projects with respect to the intake end 13A of the suction pipe 13. In this step, the intermediate separator 19 set

along the suction pipe 13 is closed, and hence the jaws 21 and 22 grip the guide element 15, holding it in position inside the suction pipe 13. Preferably, at least one of the sets of sliders 31 and 32 is also gripped, with the sliders engaging the guide element. The portion of suction pipe between the intake end 13A and the intermediate separator 19 is kept at a negative pressure through a suction mouth 14 set adjacent to the intermediate separator 19, on the intake side of the suction pipe 13. The mouth 14 is connected to a suction fan or the like (not shown).

The stem 15C which can be extracted from the guide element 15 has been previously pushed into its extracted position by means of the air under pressure fed through the jaws of the separator member 19. In this extracted position, the head 15E of the stem 15C comes to be above the plane of the plates 59, which are opened to enable passage of the head itself. Closing of the shaped plates 59 results in the stem 15C remaining engaged, through the hole 65 between the shaped plates 59, with the head 15E above the plates themselves. This means that the stem 15C will remain in the extracted position even in the absence of pressure inside the guide element 15, and hence even when the jaws of the separator member 19 open. In this configuration, the stems 63 fixed to the plates 59 are up against the axis of the stem 15C and are at least partially housed in a seat made in the stem below the head 15E of the latter, in such a way as to reduce the radial encumbrance of the stems 63 for the reasons that will be clarified in what follows.

When the tubular article M has been completed by the circular bed of needles 7 of the circular knitting machine 3, it is unloaded from the needles and, as a result of the negative pressure inside the suction pipe 13, is sucked in along the suction pipe 13 until it assumes the position shown in Fig. 18; i.e., until it comes up against the intermediate separator 19. Movement of the article M along the suction pipe 13 is guided by the guide element 15, the article M sliding in the free space between the inner wall of the suction pipe 13 and the guide element 15. In order to enable passage of the article M beyond the transverse surfaces on which the sliders 31 and 32 act, the latter are

closed and opened in an alternating way, so that, during passage of the article M, only one of the sets of sliders, either 31 or 32, is engaged with the guide element 15. In this way, the tubular article M can pass beyond the sections in which the sliders are set and can reach the position illustrated in Fig. 18.

In order to cause the tubular article M to reach the output end 13B of the suction pipe 13, in such a way that it bears upon the wall formed by the shaped plates 59 in the position illustrated in Fig. 19, the intermediate separator 19 is opened by moving the jaws 21 and 22 away from one another. Suction through the mouth 14 can now be interrupted, whereas suction is activated through the suction line connected, by means of the connection 57, to the chamber 53 inside the mobile unit 39. This latter suction can be activated also in the previous step, i.e., the one represented in Fig. 18.

In this way, the tubular article M reaches the position represented in Fig. 19, in which it bears upon the wall formed by the shaped plates 59 in their closed configuration. Also in this case, movement of the tubular article M is guided by the guide element 15, which extends as far as the shaped plates 59. The sliders 33, which were previously closed for supporting the guide element 15 during opening of the jaws of the intermediate separator 19, are opened to enable passage of the article. Opening of the sliders 33 can be synchronized with a new movement of closure of the intermediate separator 19, in such a way that the guide element 15 will be all the time properly withheld in a substantially central position inside the suction pipe 13. Alternatively, lateral support of the guide element may be obtained, even at least in part, by means of engagement with the hole in the wall defined by the plates 59.

The function of the subsequent steps is to extract the tubular article M from the suction pipe 13 and turn it inside out to carry out the closing operation whereby the end edge B2 of the article is sewn to form the closed toe thereof.

For this purpose, as may be seen in Fig. 20 (which represents the end area alone of the suction pipe 13), the plates 59 are displaced by means of

the rotating spindles 61 so as to displace radially outwards the stems 63 fixed to the plates 59.

Since both the plates 59 and the stems 63 are above the output end 13B and hence outside the suction pipe 13, the movement of divarication of the stems 63 can be extended up to the point where the latter are brought into an external radial position (shown in Fig. 20) outside the encumbrance defined by the edge of the suction pipe 13. In this position, the portion of fabric of the article M close to the edge B1 is tensioned in such a way that it is substantially outside the encumbrance of the suction pipe 13.

Once the stems 63 have engaged the tubular article M, the telescopically extensible stem 15C of the guide element 15 can be retracted inside the portion 15B of the latter, thus reducing the pressure inside the part 15B of the guide element 15. Retraction of the stem is obtained by means of the effect of the extension spring 15D. In Fig. 20 the stem 15C is illustrated in its retracted position.

By means of a vertical movement downwards, as indicated by the arrow f39, of the unit 39, the stems 63 are brought into a position where they are set alongside one another externally and laterally with respect to the output end 13B of the suction pipe 13. The tubular article is still engaged by the stems 63 and has thus followed the latter, enveloping externally the suction pipe 13 in the area that surrounds the output end 13B of the latter. The lowering movement of the unit 39 proceeds until the stems 63 have been completely released from the tubular article M (Fig. 22).

In order to extract the tubular article M completely from inside the suction pipe 13 and turn it inside out by bringing it onto the outer surface of the suction pipe 13, the pushers 47 are pressed against the tubular article M (Fig. 23), and the unit 39 is at this point further displaced downwards, as indicated by the arrow f39 (Fig. 24). In this way, the further movement downwards, as indicated by the arrow f39, of the mobile unit 39 causes the tubular article M to be drawn along the outer surface of the suction pipe 13 until the unit 39 reaches the position illustrated in Fig. 24. In this position, the tubular article M is completely on the outside of the suction pipe 13. It is also turned inside out

with respect to the configuration in which it was knitted by the circular knitting machine 3. The pushers 47 can be divaricated again to release the tubular article M, which remains in the position illustrated in Fig. 25 thanks to the elasticity of the article itself (and in particular of its initial edge B1), which grips on the outer surface of the suction pipe 13. If the tubular article M is particularly long, the stroke downwards of the unit 39 with the pushers 47 in the closed position can be repeated a number of times, bringing the unit 39 each time back upwards after prior opening of the pushers 47 to prevent the latter from drawing the tubular article upwards again during the stroke upwards of the unit 39.

As may be seen in Fig. 24, the suction pipe 13 has two slits 13D which start from the output end 13B, i.e., from the edge of the suction pipe 13, and which extend in a direction parallel to the axis of the suction pipe for a certain stretch. The function of these slits is to enable the brackets 73 to grip the tubular article M and to slide it partially out of the suction pipe 13 for closing the toe of the article by sewing. Before this operation is carried out, however, the tubular article M may require angular positioning.

In fact, the sewing line which is designed to close the toe of the article must have a very precise orientation with respect to the article itself, which normally presents pockets, namely portions of fabric designed to form the heel area and the toe area of the foot of the sock or stocking. The sewing line must assume an extremely precise position with respect to these pockets of fabric. In order to orient the tubular article properly before the sewing operation, it is sufficient to provide, during knitting, marking of the article, for instance by means of a few stitches of yarn of a colour different from that of the yarn of the article. The marking thus obtained can be detected by means of a photo-electric cell (not shown) set in the proximity of the output end 13B of the suction pipe 13. Appropriate angular orientation of the tubular article M is at this point obtained by rotating, about its own axis, the portion 13C of the suction pipe 13 by means of the actuator 35. This rotation is the movement that brings the device from the position of Fig. 24 to the position of Fig. 25. The two figures differ, in fact, only as regards the different position of the slits

13D made in the proximity of the output end 13D of the suction pipe 13. The deviation in angular position between the two figures represents the amount by which the portion 13C of the suction pipe 13 is rotated with respect to the remaining part of the pipe itself in order to bring the tubular article into the correct angular position.

During this step of angular positioning, or in any case at an appropriate instant, the unit 39 is brought back upwards until it reaches the position illustrated in Fig. 26, the pushers 47 remaining in their retracted position, i.e., not in contact with the tubular article, during said movement upwards.

Once the unit 39 has reached the top position illustrated in Fig. 26, the pushers are closed again to press the tubular article M against the outer surface of the suction pipe 13 in the proximity of the output end 13B of the latter. Once the tubular article M has been engaged again by pressing it against the outer surface of the portion 13C of the suction pipe 13, the portion 13C can be rotated again so as to bring the slits 13D into their original position, namely on a plane which contains the axis of the portion 13C of the suction pipe and is orthogonal to the plane of Fig. 26. This movement of rotation of the portion 13C of the suction pipe 13, again obtained by means of the actuator 35, does not cause an angular movement of the tubular article M, in so far as the latter is withheld by the pushers 47, which are advantageously coated with a material having a high coefficient of friction. In this way, the portion 13C of the suction pipe 13 rotates inside the tubular article M in a sliding way, i.e., sliding on the inner surface of the latter.

In the configuration of Fig. 26, the tubular article M is in the correct angular position for the subsequent sewing operation, and can therefore be picked up by the brackets 73 of the gripping member 71. The brackets 73, which are brought up to one another are for this purpose lowered until they move inside the suction pipe 13, into the position shown in Fig. 27, which represents a longitudinal cross section of the suction pipe 13 according to a plane orthogonal to the one represented in Fig. 26. The brackets 73 thus lie on a plane containing the axis A of the portion 13C of the suction pipe 13, on which also the slits 13D lie. In this way, divarication of the brackets 73, as

indicated by the arrow f73 of Fig. 27, is enabled for tensioning the edge B2 of the tubular article M and thus bringing the two flaps of the edge to come close to one another. The movement of divarication of the brackets 73 is combined with a movement of lifting-up of the brackets, which thus reach their final position, illustrated in Fig. 28. In the end phase of the raising movement of the brackets 73, the pushers 47 can be brought up to the suction pipe 13 again for withholding the tubular article M and thus causing longitudinal tensioning thereof.

In this position, the edge B2 of the tubular article M has been stretched or tensioned by means of the brackets 73 in such a way that the two flaps of the edge have been aligned to one another. The brackets 73 have been brought into a vertical position such that their bottom ends are slightly above the rectilinear bars 77 and 79. The latter can thus be brought up to one another to grip the tubular article M in an appropriate position of the edge B2. This is schematically represented in Fig. 29, which shows a longitudinal cross section according to a plane orthogonal to that of Fig. 28. The rectilinear bar 77 has been brought up to the fixed bar 79. In Fig. 28, L1 and L2 designate the two flaps of the edge B2 that have been brought close to one another as a result of the tensioning of the edge B2 performed by the brackets 73 of the gripping member 71. The article can be tensioned by means of a slight movement downwards of the unit 39 with the pushers 47.

Fig. 29A is a schematic enlargement of the area in which the flaps of fabric L1 and L2 forming the edge of the tubular article that is to be closed can be seen. As shown in the schematic section of the fabric, the latter presents a series of rows X2 set above the bars 77 and 79, some of these rows being made with a yarn thicker than that of the other rows. Said thicker rows form a portion of fabric of greater thickness, which is brought to bear upon the bars 77, 79 set alongside one another. The bars 77, 79 do not necessarily have to be pressed against the fabric, which, instead, is appropriately left free to slide so as to be tensioned transversely. Retention in the longitudinal direction is guaranteed by the fact that the portion of fabric of greater thickness obtained with the thicker yarn, designated by FG in Fig. 29A, bears upon the bars 77,

79. The portion of the tubular article made up of the rows X2 will be removed in the subsequent cutting operation, and is consequently normally produced with a yarn of poorer quality than the yarn of the remaining part of the tubular article M.

During the sewing operation, the edge formed by the rows X2 may be kept raised by means of suction through a suction mouth associated to the sewing machine 95 and designated, as a whole, by 102 in Figs. 33 and 34.

With a movement in the direction indicated by the arrow f83, the comb-like structure 83 is at this point pushed towards the tubular article M until the teeth 85 of the comb-like structure 83 penetrate inside the stitches or loops of the row that is set facing the comb-like structure 83, namely the row that is directly beneath the rectilinear bars 77 and 79. As will be described in greater detail with reference to the diagrams of Fig. 44 and of the following figures, and as may be seen in the diagram of Fig. 29A, the loops of this row (designated by X1) have a greater length than the remaining loops of the article in order to enable convenient insertion of the teeth 85 of the comb-like structure 83.

The movement in the direction indicated by the arrow f83 of the comb-like structure 83 is controlled by the actuators 89 described previously (see Fig. 6) and not illustrated, for reasons of clarity, in Fig. 29. The closing movement of the rectilinear bars 77 and 79 and the subsequent movement of the comb-like structure 83 are represented in the sequence of Figs. 30 to 32, which show the aforesaid movements in schematic plan views.

Once the teeth 85 of the comb-like structure 83 have penetrated the individual loops of the respective row in the tubular article M, the mobile rectilinear bar 77 can be retracted to enable insertion of the members of the sewing machine 95, which performs sewing along the loops of the row of stitches underneath the row inside which the teeth 85 of the comb-like structure 83 have penetrated. The sewing operations are schematically illustrated in Fig. 33.

Fig. 33 shows the needle 96 of the sewing machine 95, the mouth 99, and the crochet 101. Also visible is the comb-like structure 83, which is

inserted inside the corresponding row of stitches or loops of the tubular product M. The sewing area is shown enlarged in Fig. 34. Clearly visible in the latter figure is how the comb-like structure 83 and the corresponding teeth 85 are made up of the two portions 83A and 83B (shown separate from one another in the perspective view of Fig. 16), which are connected together and between which the blade 87 is set, said blade, in this configuration, being in a retracted position, namely a position set back with respect to the teeth 85.

Movement of the members of the sewing machine, and in particular of the needle 96 and the crochet 101 which feeds the sewing thread F, is shown in Fig. 35. In this example of embodiment, the needle 96 is a so-called piston needle, i.e., a needle provided with an opening and closing member 96A. A needle of this kind is in itself known from the state of the art, in particular from the prior patents cited in the introductory part of the present description. It is, however, possible to use also other types of needles and/or crochets. For example latch needles or eye needles may be used. The sequence of the sewing operations may be clearly seen in Fig. 35 and is in itself known for other types of applications; consequently, no detailed description is required herein.

It should however be noted that, for the reasons that will emerge more clearly from the description of Fig. 44 and subsequent figures, the pitch of the seam made by the sewing machine 95 with the needle 96 is smaller than the pitch of the comb-like structure 83 and of its teeth 85, i.e., smaller than the pitch of the loops of the row X1. In particular, it is possible to envisage that the pitch of the seam will be equal to one half or to one third of the pitch of the loops of the row X1, and hence of the teeth 85 of the comb-like structure 83.

Figs. 36, 37 and 38 show the subsequent step of cutting of the loops of the row X2, inside which the teeth 85 of the comb-like structure 83 have been inserted. Before carrying out this cutting operation, the flaps L1 and L2 of the tubular article M, which are by now joined together by the seam designated by C in Figs. 36 to 38, are gripped and withheld by the retention bars 105 of the retention member 103 carried by the sewing machine 95 which has made the seam C. This makes it possible to withhold the tubular article M even after the

cutting operation has been performed. Cutting is performed by moving the blade 87 housed inside the comb-like structure 83 so as to bring it from the position of Fig. 36 to the position of Fig. 37. Thanks to this movement, the blade 87 cuts all the loops of the row X2 inside which the teeth 85 of the comb-like structure 83 were previously inserted.

At this point, the comb-like structure 83 can be moved away from the article to reach the position shown in Fig. 38, whilst the tubular article M is withheld by the retention bars 105 provided for this purpose and previously brought up to one another. The residue of cut yarn above the seam C is removed by the removal system 107, which in Fig. 39 is schematically represented by a brush with a horizontal axis, parallel to the bars 105, but which may actually have the configuration shown in Fig. 40. The enlarged representation of Fig. 41 shows the action mechanism of the brush 109, in this case with a vertical axis, for removal of the residue of yarn, designated by FR in the enlarged representation of Fig. 41.

Once said sewing, cutting and yarn-residue-removal operations have been completed, the article M can be removed from the device, after the article has been turned inside out again to assume its final configuration corresponding to the one in which it was produced by the circular knitting machine 3. For this purpose, reverse operations are performed with respect to the ones previously carried out for turning the article inside out by means of the movement of the unit 39 and the action of the sliders 47. Negative pressure is at this point applied inside the suction pipe 13 through a suction mouth 16 (Fig. 43) in such a way that the article, with its toe closed by the seam C, is sucked through the mouth 16 and is removed from the device.

Removal is facilitated by the movement of the part 15B of the guide element 15 with respect to the part 15A, about the hinge axis 17, so that the part 15B of the guide element comes up against the inner wall of the suction pipe 13 on the opposite side with respect to the one where the suction mouth 16 is set, leaving a wider passage for transit of the sewn tubular article M towards the suction mouth 16.

Once the above operations have been completed, the device returns to

the configuration represented in Fig. 17 for sewing of a subsequent tubular article M, which, in the meantime, has started its formation on the circular knitting machine 3.

Figs. 44, 45 and 46 are detailed illustrations of the textile structure of the edge part B2 of the tubular article M for enabling closing by means of the seam described previously. Fig. 44 illustrates one portion of the edge area B2 of the tubular article. The reference X1 designates the row of stitches or loops BX1 of greater length within which the teeth 85 of the comb-like structure 83 insert. As is clearly shown in Fig. 44, said loops BX1 have a greater length than the remaining loops BX underneath, which are the ones forming the body of the tubular article.

Above the row X1 there is a plurality of rows X2 made with the same yarn – or with a yarn of poorer quality – as the one forming the underlying rows of loops or stitches BX. The loops or stitches of the rows X2 may have the same size as the loops BX.

Once again in Fig. 44, C designates the seam formed by the sewing machine. As may be seen in the figure, the seam C is made in a position corresponding to the row of stitches X3 set beneath the row of stitches X1. In other words, the seam C is made on the row of stitches or loops adjacent to the row where the teeth 85 of the comb-like structure 83 are inserted, which represents a substantial difference as compared to normal seams performed with linking machines.

Furthermore, the pitch of the seam C is greater than the pitch of the loops or stitches of the row X3, and hence of the row X1 and of any other row of the article. Also this constitutes a substantial difference as compared to the normal process of linking of tubular articles, where the seam has exactly the same pitch as that of the stitches or loops that undergo linking. The pitch of the seam C, which is smaller than the pitch of the loops, is chosen in such a way that any possible accidental faulty gripping of the loops by the teeth 85 of the comb-like structure 83 does not have any unfavourable effect on the final result of the sewing operation. In fact, even if two adjacent loops were to be taken up on the same tooth 85 of the comb-like structure 83, the seam C

(which has a smaller pitch) would even so grip the loops, thus enabling perfect sewing of the article to be achieved. Instead, in a traditional linking machine, faulty hooking of the loops to be sewn on the hooks of the machine results in an irreparable defect in the product, which consequently must be rejected.

Basically, the loops of the row X3 are sewn together by joining the loops of the flap L1 to corresponding loops of the flap L2 by means of stitch formed by a sewing thread forming the seam C. Said sewing thread forms a chain of stitches, in which between the stitches that join the two flaps there are interspersed stitches that do not join the two flaps of the tubular article.

Fig. 45 shows two portions of the row of stitches or loops X3 on which sewing is performed. The isolated representation of this individual row of stitches or loops clearly shows the sewing technique, performed with a pitch greater than the pitch of the loops. The references XC1 and XC2 designate the loops formed by the sewing thread. In greater detail, the loops XC1 are the ones that engage the yarn forming the loops of both of the flaps set alongside one another of the edge B1 of the article M, whilst XC2 designates the loops formed by the sewing yarn which do not join the two flaps. The seam is, in this example, a single-chain seam, but different embodiments are not to be ruled out.

Fig. 46 is again a representation of the article in the sewing area, in a way similar to the one represented in Fig. 44, but after the cutting operation has been performed by the blade 47. As mentioned previously, cutting is performed on the row X1, namely on the row inside which the teeth 85 of the comb-like structure are inserted. It is precisely this row of stitches or loops having a greater length that is interrupted by cutting, unlike what happens in traditional linking machines, where the row of stitches hooked on the hooks of the linking machine is the one on which sewing is performed; instead, in the present case, cutting is performed on the adjacent row external to the seam, namely the row set on the opposite side of the row of hooks with respect to the side where the body of the tubular article is set.

Figs. 44 and 46 schematically represent that the first of the rows X2, i.e.,

the one immediately after the row X1, is made with a yarn FG of a larger section, which can possibly be elastic. Instead of the first of the rows X2, the immediately subsequent row can be made with the yarn of larger section; or else, even more than one row may be made with a yarn of larger section. The function of this yarn has been illustrated previously with reference to the step of preparation of the article for the sewing operation.

As mentioned previously, the rows of stitches in a normal tubular article develop helically. In order to obtain even more precise and neat sewing or linking of the toe, according to an improved embodiment of the invention it is possible to envisage that the rows of stitches involved in the seam for joining the flaps forming the toe will be circular, instead of helical. This is obtained by interrupting the yarn that forms the fabric. Fig. 47 is a schematic representation of one portion of the rows X1, X2 and X3 in the area where the yarn is interrupted. In this embodiment, each row is formed by yarn that has a beginning and an end, which are designated (for each row) by I1, I2, I3, and F1, F2 and F3. The perfectly circular rows of stitches X1, X2 and X3 that are thus obtained enable alignment along the comb-like structure 83 without any deformation and convenient insertion of the teeth 85 into the individual loops of the row X1. Likewise, the stitches of the seam C will involve only the loops of the row X3 and will not interfere with the loops of the adjacent rows.

With reference to the above figures, a complex device has been illustrated, which, combined with the knitting machine 3, enables complete automation of the production cycle to obtain at output a complete tubular article with the toe that has been sewn or linked. However, the invention can be implemented also in simpler forms, for example by means of a semi-automatic or almost completely manual device, which, in any case, enables closing of the toe with an operation which is much more convenient than traditional linking, at the same time maintaining a high quality of the finished product.

Figs. 48 to 53 show a possible example of embodiment of a substantially manual device, in which the operator inserts the tubular articles manually for closing the toes. The device comprises an insertion guide, designated as a

whole by 201 and made in the form of a guillotine, with two parallel bars that define a channel for insertion of the tubular articles. The latter are designated by M. The insertion guide 201 is divided into three portions. A first portion 201A is fixed with respect to the load-bearing structure 203 of the device. The second portion 201B is mobile, for example by means of a pedal control by the action of an actuator 205, so as to approach a comb-like structure that performs the same function as the comb-like structure 83 previously described and here designated by 207.

The two positions that the portion 201B of the guide 201 may assume can be seen in Figs. 48 and 49. In Fig. 48, the guide portion 201B is aligned to the guide portion 201A, whilst in Fig. 49 the portion 201B is brought up to the comb-like structure.

The third portion 201C of the guide 201 is fixed with respect to the structure of the device and is in a position whereby it is aligned to the portion 201B when the latter is in the position of Fig. 49.

The comb-like structure 207 in this case is made up of a plurality of rigid components 207A which are joined together in a flexible way and are fixed to a chain 209 to form a comb-like structure in the form of a closed track run over two wheels 211, one of which is motor-driven.

The reference number 213 designates, as a whole, a sewing machine, similar to the sewing machine 95 previously described, which is illustrated in isolation in Fig. 50 and is illustrated, in combination with a portion of the comb-like structure, with one of the wheels 211 in Fig. 51. The sewing machine 213 comprises a needle 215 and a crochet 217 of the oscillating type.

As may be seen in particular in the enlarged detail of Fig. 52, the comb-like structure presents a slit that develops within the teeth 208 of the comb-like structure 207, within which a disk-shaped element 219 may penetrate, said disk-shaped element 219 being supported by a shaft 221 driven in rotation by a motor 223.

At the sewing area, as may be seen in the plan view of Fig. 53, underneath the comb-like structure 207 there is a guide profile 225 with an

initial rectilinear portion 225A and a subsequent curvilinear portion 225B. The latter is roughly parallel to the edge of a wheel 227 which has an axis of rotation orthogonal to the plane of Fig. 53 and is driven by a motor (not illustrated). The wheel 227 is located underneath the disk-shaped blade 219 and has the function of drawing along the tubular article during the cutting operation, as will be explained in greater detail in what follows.

The device so far described operates as illustrated hereinafter. The individual articles are inserted into the portion 201A of the guide 201. They are pushed manually as far as the portion 201B of the guide 201. At this point, the operator tensions the article and, by means of a special control, causes displacement of the guide portion 210B against the comb-like structure in such a way that the teeth 208 of the latter insert into the loops of the article. The article has a textile structure equivalent to the one described previously, with rows X1, X2 and X3 of the sizes described previously and for the same purposes. Once the comb-like structure 207 has engaged the article, it advances in the direction indicated by the arrow f207 and carries the article towards the sewing machine. Here the operations of sewing and cutting by means of the disk-shaped blade 219 are performed. The residue of yarn is then eliminated by means of the brush 231.

Fig. 54 shows a different embodiment of a device, generically designated by 301, for semi-automatic sewing of tubular articles. Said device comprises means for positioning and tensioning tubular articles, generically designated by 303, as well as a sewing assembly, generically designated by 305 and similar to the device of Figs. 48 to 53.

The positioning and tensioning means 303 comprise a circular table 307 which turns on a fixed shaft 309. The circular rotary table 307 carries a plurality of suction pipes 311 connected at the rear (in a way not illustrated) to a suction system. The suction pipes 311 perform a function similar to the one performed by the end part 13C of the suction pipe 13 previously described. They present end slits 311, within which brackets 313, which are equivalent to the brackets 73 described with reference to the first example of embodiment and are associated to the unit 305, insert.

The fixed shaft 309 carries a plurality of guides 315 (four, in the example illustrated) with corresponding actuators 317 which control the movement of translation, parallel to the shaft 309 and to the suction pipes 311, of corresponding rings 319, each of which carries a plurality of pushers 321 equivalent to the pushers 47. The guides 315 with the corresponding rings 319 and the pushers 47 define four stations through which each of the suction pipes 311 passes for proper positioning of the tubular article that is to be sewn.

Operation of the device of Fig. 54 is described in what follows. Each tubular article is inserted with its end edge into the suction pipe 311 which is in the position 311X. The operator inserts the end edge of the article into the suction pipe, leaving the elastic initial edge or border of the article outside the pipe, in such a way that it envelops the pipe. The rotary table 307 rotates by one step to bring the suction pipe on which the tubular article has been fitted into the next station, where by means of an axial movement of the respective ring 319 parallel to the pipe and by operating the pushers 321, the tubular article is turned inside out onto the outside of the suction pipe, in a way similar to what was illustrated with reference to Fig. 24 for the previous example of embodiment.

A subsequent rotation by one step takes the suction pipe into the next station where, with modalities similar to the ones described with reference to Figs. 24 and 26, orientation of the tubular article is performed.

A further rotation by one step brings the suction pipe into alignment with the brackets 313, which pick up the tubular article and insert it into the guillotine-like guide of the unit 305. From this position, operation is similar to the one described for the device of Figs. 48 to 53, with the exception that the tubular article remains engaged with its elastic edge or border outside the suction pipe, which is displaced by one further step by rotation of the rotary table 307 during the sewing operation or at the end thereof.

The last ring 319 with the corresponding pushers 321 is used for turning the tubular article inside out again, said tubular article being then extracted by suction through the pipe, in a way altogether similar to what was described

with reference to the first example of embodiment.

The device of Fig. 54 thus operates in a semi-automatic way, in so far as the only manual operation consists in fitting the tubular articles on the individual suction pipes, whereas the entire subsequent processing cycle is carried out automatically.

The system for turning the article inside out may also present a different configuration. For example, shaped rubber wheels may be used which co-operate with the surfaces of the suction pipes 311, instead of the rings 319 and pushers 311. This applies in particular to the first station, in which the article is turned inside out for the first time onto the outside of the suction pipe.

It is understood that the drawings only illustrate a possible embodiment of the invention given purely to provide a practical demonstration of said invention, which may vary in its embodiments and arrangements without thereby departing from the scope of the underlying idea. The possible presence of reference numbers in the attached claims has the sole purpose of facilitating reading thereof in the light of the foregoing description and of the annexed drawings, and in no way limits the scope of protection defined in the claims.

Claims

1. A method for forming a closed toe in a tubular knitted article, comprising the steps of:

- setting two end flaps of said article alongside one another;
- inserting, inside the loops of at least one first row of stitches of said end flaps, a comb-like structure comprising a plurality of teeth;
- sewing together the loops of at least one second row of stitches, which is set between said first row of stitches and the body of the tubular article; and
- opening the loops of the first row of stitches.

2. The method according to Claim 1, in which the loops of said second row are sewn together by joining each loop of one first of said two flaps to a corresponding loop of one second of said two flaps by means of a stitch formed by a sewing thread.

3. The method according to Claim 2, in which said sewing thread forms at least one chain of loops, in which between the stitches that join the two flaps there are interspersed stitches that do not join the flaps of the tubular article.

4. The method according to one or more of the foregoing claims, in which said loops of the first row are opened by cutting.

5. The method according to Claim 4, further comprising a step of elimination of the residue of yarn generated by cutting of said loops of the first row.

6. The method according to one or more of Claims 1 to 3, in which said loops of the first row are obtained using a destructible yarn.

7. The method according to Claim 6, in which said destructible yarn is a yarn that can be destroyed by heating.

8. The method according to one or more of the foregoing claims, in which the loops of said first row have a greater length than the loops of said second row and than the remaining loops forming the tubular article.

9. The method according to Claim 8, in which the loops of said second row have a length smaller than the loops of the first row but greater than the

length of the loops of the remaining rows of the tubular article.

10. The method according to one or more of the foregoing claims, in which the loops of said at least one second row are sewn with a seam having a pitch smaller than the pitch of said loops.

11. The method according to Claim 10, in which the loops of said at least one second row are sewn with a sewing pitch equal to or smaller than one half of the pitch of said loops.

12. The method according to one or more of the foregoing claims, in which the loops of said at least one second row are sewn with a sewing pitch smaller than the pitch of the teeth of said comb-like structure.

13. The method according to Claim 12, in which the loops of said at least one second row are sewn with a sewing pitch equal to or smaller than one half of the pitch of the teeth of said comb-like structure.

14. The method according to one or more of the foregoing claims, comprising the steps of:

- gripping two roughly diametrically opposite points of the tubular article, in positions corresponding to said end flaps;
- tensioning transversely said tubular article in order to bring said end flaps alongside one another;
- tensioning said tubular article longitudinally;
- inserting said comb-like structure into said first row of loops in such a way that each tooth of said comb-like structure inserts into a loop of one first flap and into a corresponding loop of the second flap;
- sewing together the loops of said at least one second row; and
- opening the loops of said first row.

15. The method according to one or more of the foregoing claims, in which sewing of the loops of the second row is performed by means of a seam of the single-chain type.

16. A method for the production of a tubular article with a closed end toe, comprising the steps of:

- knitting the tubular article starting from an initial edge as far as an end edge;

- setting the two end flaps of said end edge alongside one another;
- inserting, inside the loops of at least one first row of stitches of said end flaps, a comb-like structure comprising a plurality of teeth;
- sewing together the loops of at least one second row of stitches, which is set between said first row of stitches and the body of the tubular article; and
- opening the loops of the first row of stitches.

17. The method according to Claim 16, in which the loops of said second row are sewn together by joining the loops of one first of said two flaps to a corresponding loop of one second of said two flaps by means of a stitch formed by a sewing thread.

18. The method according to Claim 17, in which said sewing thread forms at least one chain of stitches, in which between the stitches that join the two flaps there are interspersed stitches that do not join the two flaps of the tubular article.

19. The method according to one or more of Claims 16 to 18, in which said loops of the first row are opened by cutting.

20. The method according to Claim 19, further comprising a step of elimination of the residue of yarn generated by cutting of said loops of the first row.

21. The method according to one or more of Claims 16 to 18, in which said loops of the first row are obtained using a destructible yarn.

22. The method according to Claim 21, in which said destructible yarn is a yarn that can be destroyed by heating.

23. The method according to one or more of Claims 16 to 22, in which the body of the article is knitted and, at the end of knitting of the body of the article, at least said first row of stitches is formed with loops having a greater length than the loops of the rows that form the body of the article.

24. The method according to Claim 23, in which after said first row of stitches, a band of fabric is formed having a greater thickness than the fabric forming the body of the article.

25. The method according to one or more of Claims 16 to 24, in which

the loops of said at least one second row are sewn with a seam having a pitch smaller than the pitch of said loops.

26. The method according to Claim 25, in which the loops of said at least one second row are sewn with a sewing pitch equal to or smaller than one half of the pitch of said loops.

27. The method according to one or more of Claims 16 to 26, in which the loops of said at least one second row are sewn with a sewing pitch smaller than the pitch of the teeth of said comb-like structure.

28. The method according to Claim 27, in which the loops of said at least one second row are sewn with a sewing pitch equal to or smaller than one half of the pitch of the teeth of said comb-like structure.

29. The method according to one or more of Claims 16 to 28, comprising the steps of:

- gripping two roughly diametrically opposite points of the tubular article, in positions corresponding to said end flaps;
- tensioning transversely said tubular article in order to bring said end flaps alongside one another;
- tensioning said tubular article longitudinally;
- inserting said comb-like structure into said first row of loops in such a way that each tooth of said comb-like structure inserts into a loop of one first flap and into a corresponding loop of the second flap;
- sewing together the loops of said at least one second row; and
- opening the loops of said first row.

30. The method according to one or more of Claims 16 to 29, in which sewing of the loops of the second row is performed by means of a seam of the single-chain type.

31. A device for sewing two end flaps of a tubular knitted article and for forming a closed toe of said article, said device comprising in combination:

- a comb-like structure with a plurality of teeth for engaging the loops of a first row of said tubular article; and
- sewing means with at least one needle, for sewing together the flaps set alongside one another underneath the comb-like structure.

32. The device according to Claim 31, comprising a gripping member for gripping said tubular article at one end edge thereof in two approximately diametrically opposite points, in order to tension the end edge and to bring two end flaps of said tubular article alongside one another.

33. The device according to Claim 31 or Claim 32, comprising a cutting member for cutting the loops engaged by said comb-like structure.

34. The device according to Claim 33, comprising a member for removal of the residue of yarn generated by cutting of the loops.

35. The device according to one or more of Claims 31 to 34, further comprising a pair of substantially rectilinear bars associated to said comb-like structure and parallel to the latter, between which the tubular article is pressed with the end flaps set alongside one another.

36. The device according to Claim 35, in which said comb-like structure is carried by one of said bars and is mobile with respect to the latter.

37. The device according to one or more of Claims 31 to 36, in which within the teeth of said comb-like structure there is formed a seat for said cutting member.

38. The device according to one or more of Claims 31 to 37, in which said cutting member is provided with a cutting movement with a component parallel and a component orthogonal to the longitudinal development of the comb-like structure.

39. The device according to one or more of Claims 31 to 38, comprising a retention member for retaining the tubular article between the comb-like structure and the body of the tubular article during cutting of the stitches engaged by the comb-like structure.

40. The device according to Claim 31, comprising a guillotine in which the end edge of the article is to be inserted, said guillotine and said comb-like structure having a relative movement for enabling insertion of the comb-like structure into the tubular article engaged in said guillotine.

41. The device according to one or more of Claims 31 to 40, in which said comb-like structure is a flexible structure.

42. A knitting machine for the production of tubular knitting articles,

comprising a device according to one or more of Claims 31 to 41.

Fig.1

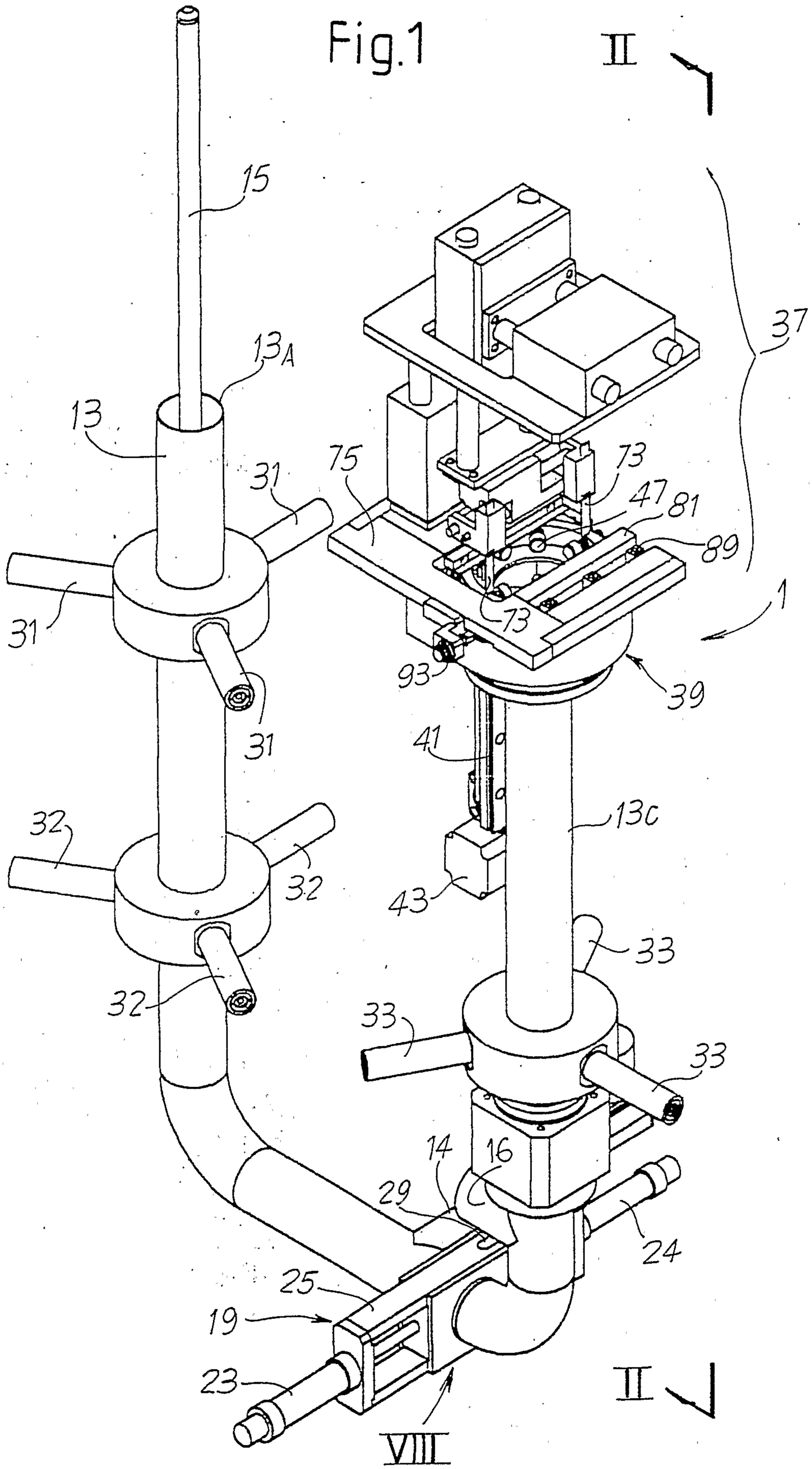
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Fig.2

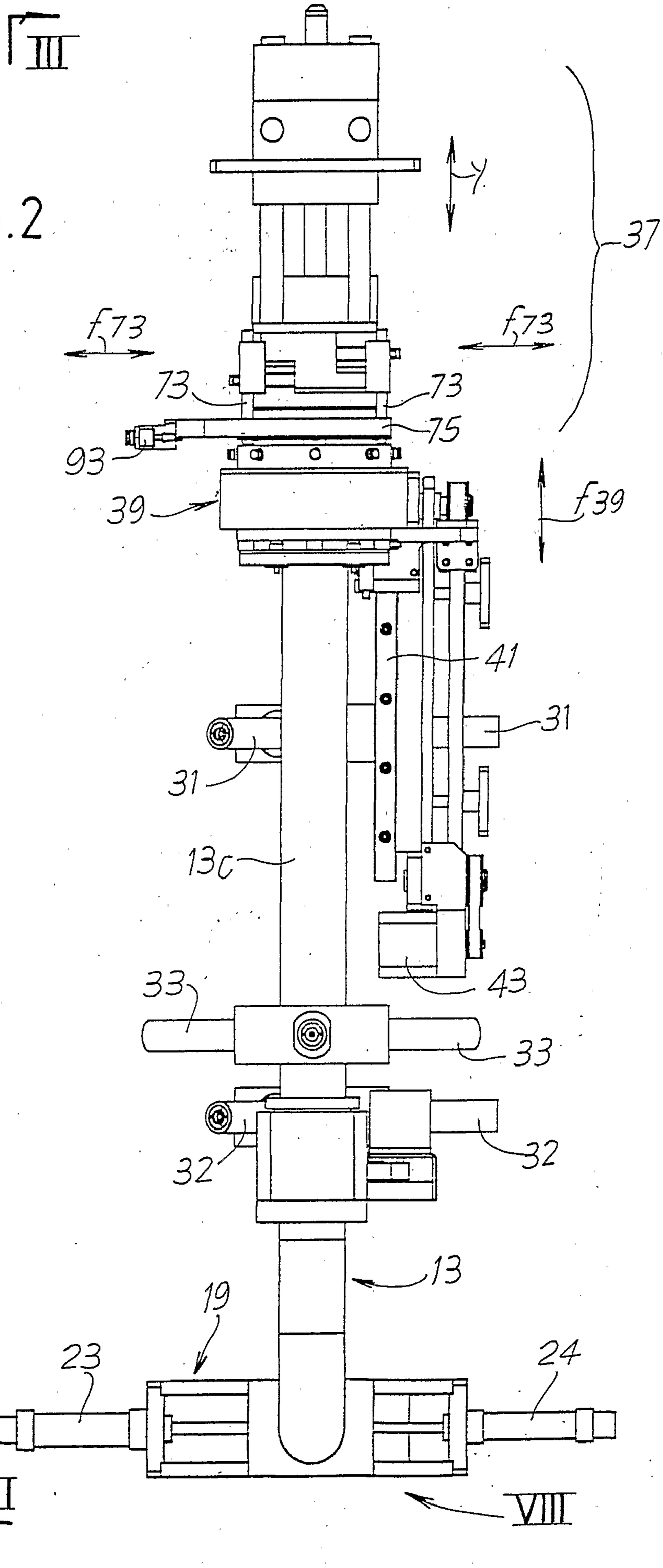
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Fig.3

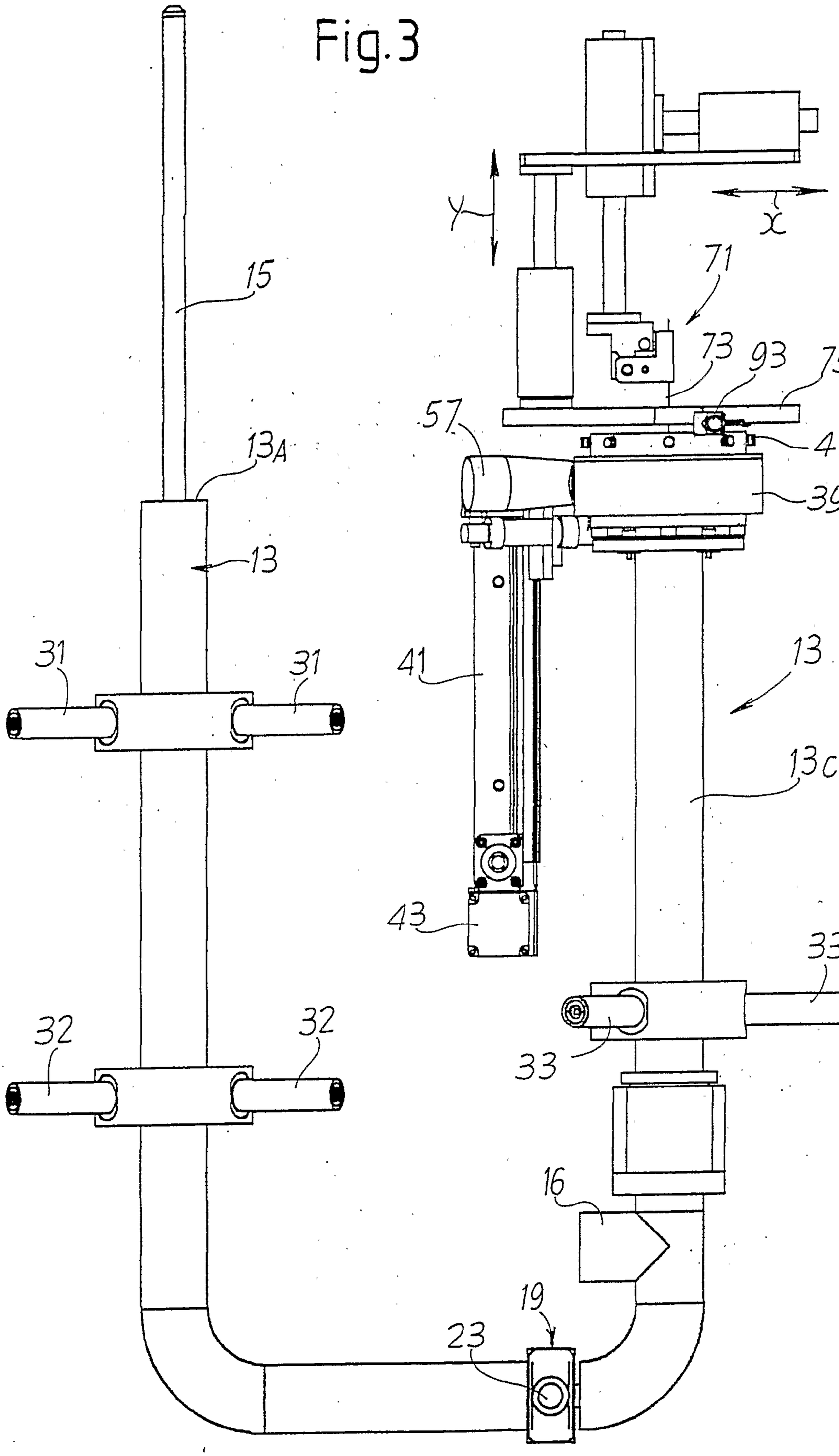
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Fig. 4

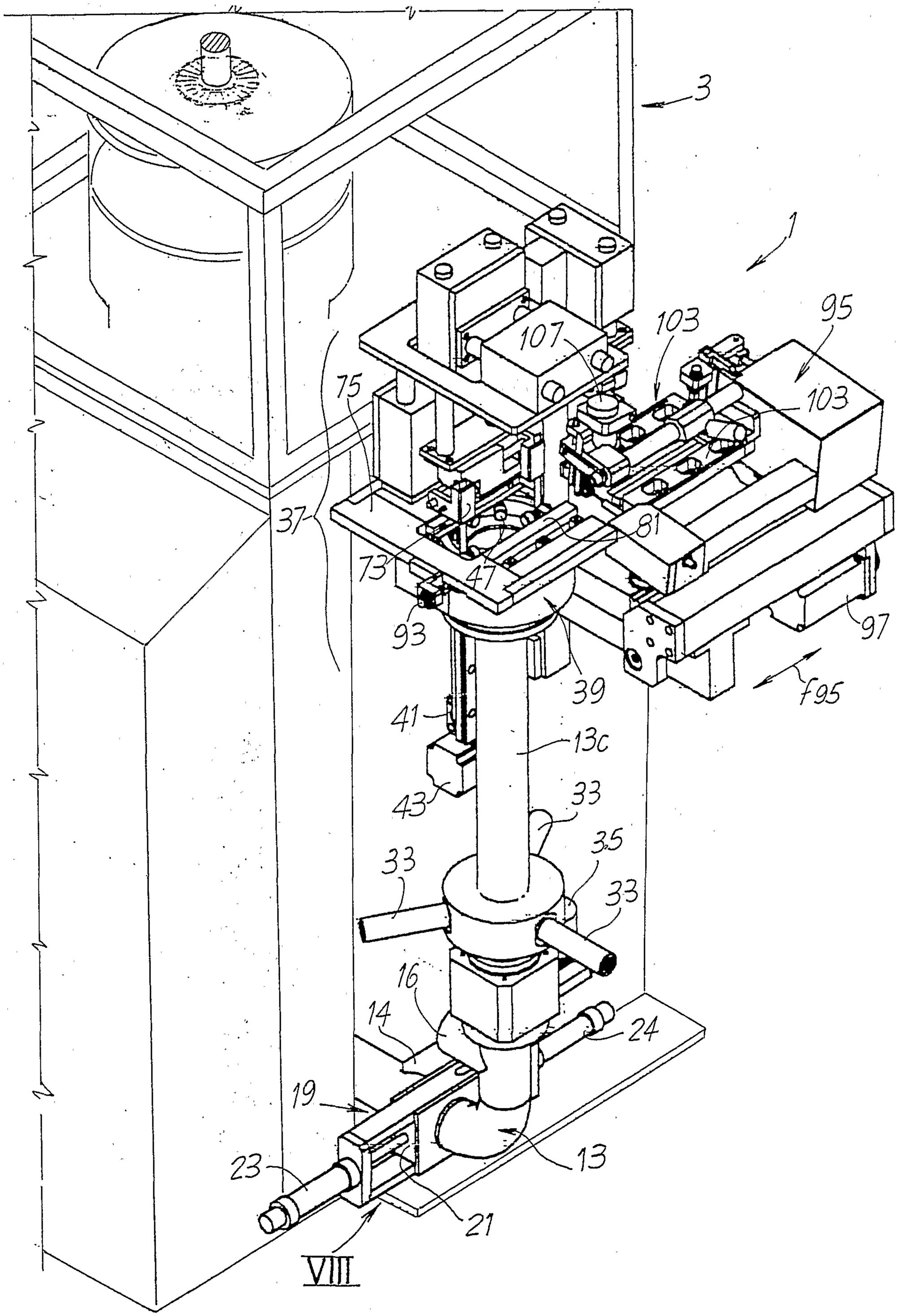
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Fig.5

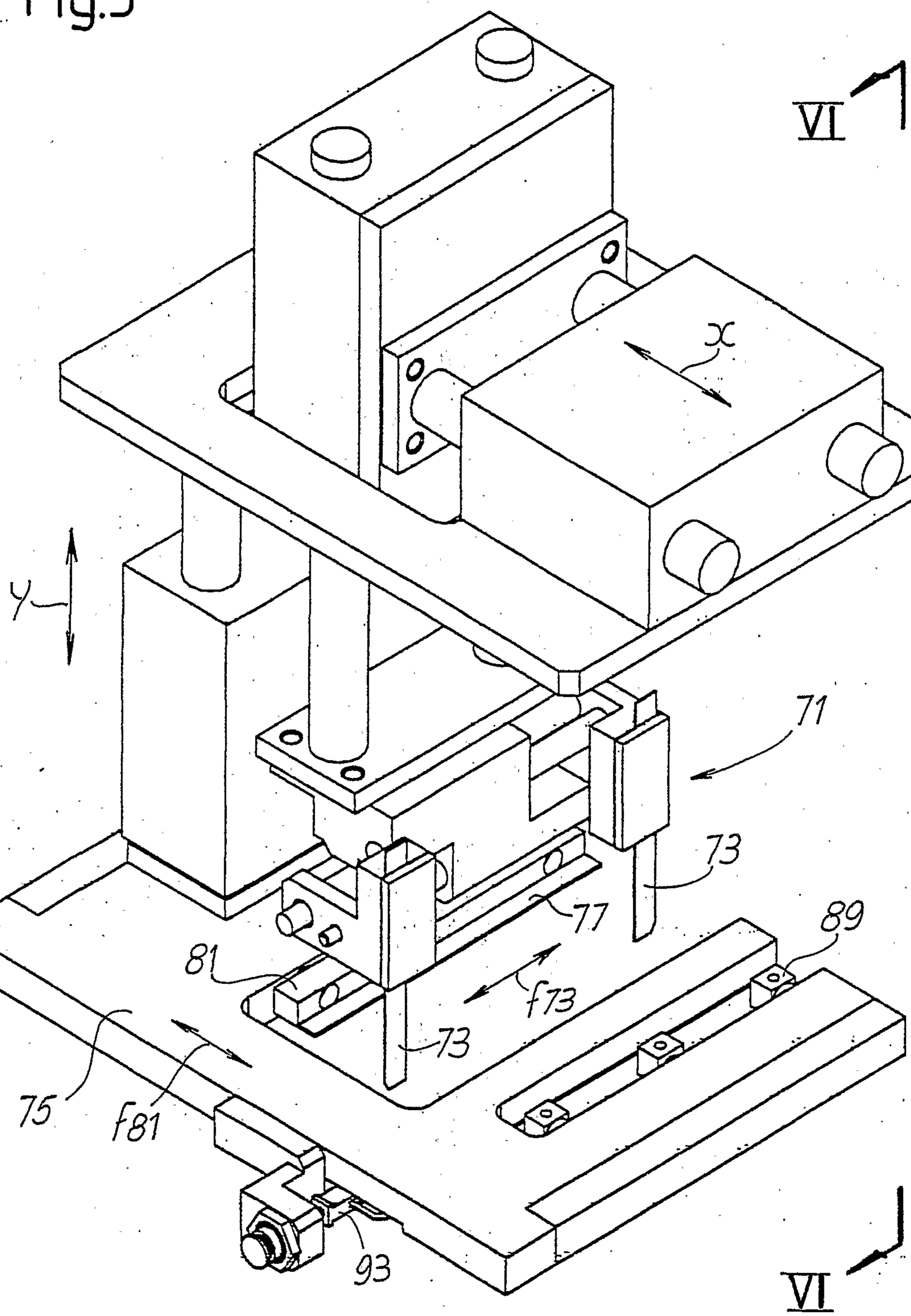


Fig. 6

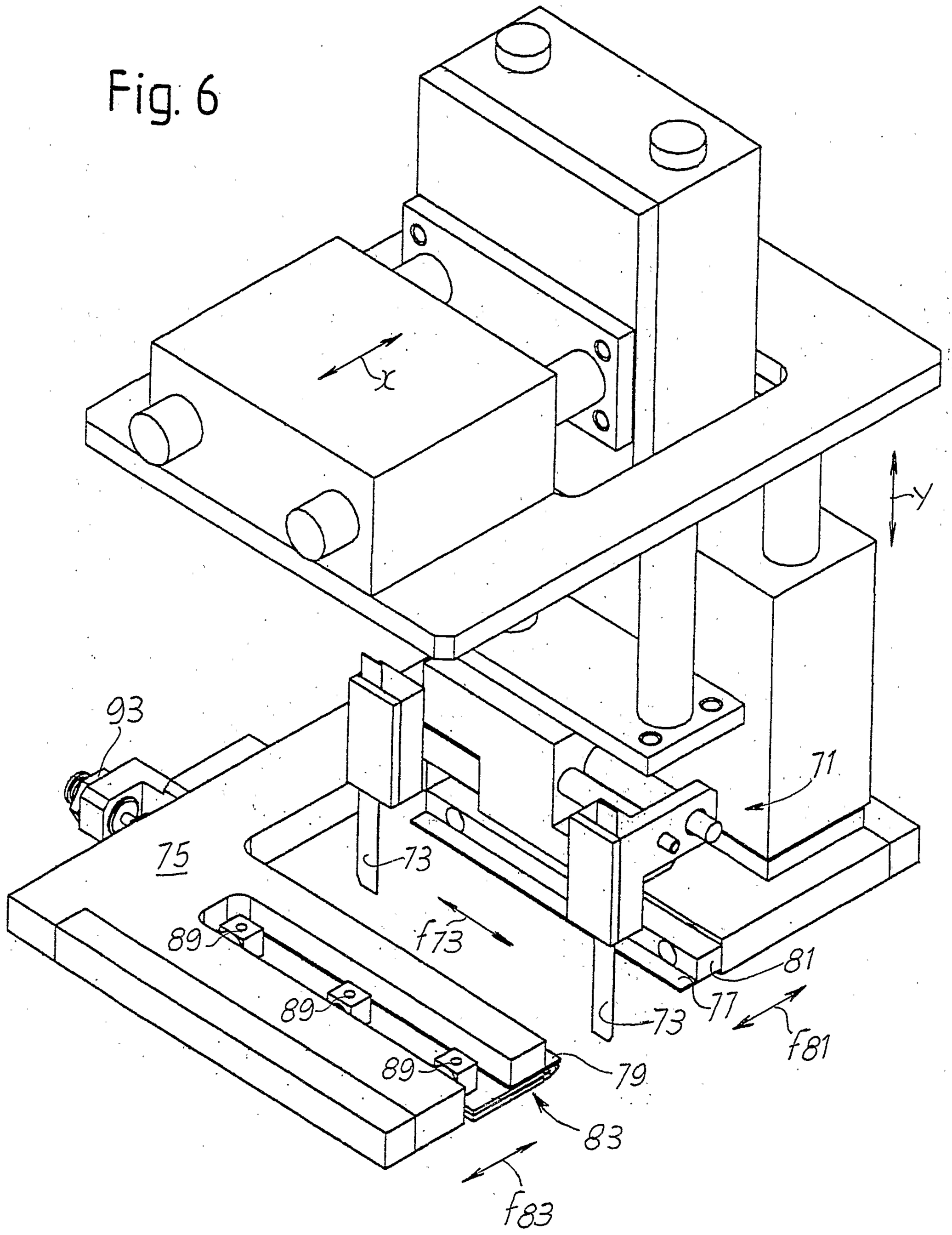
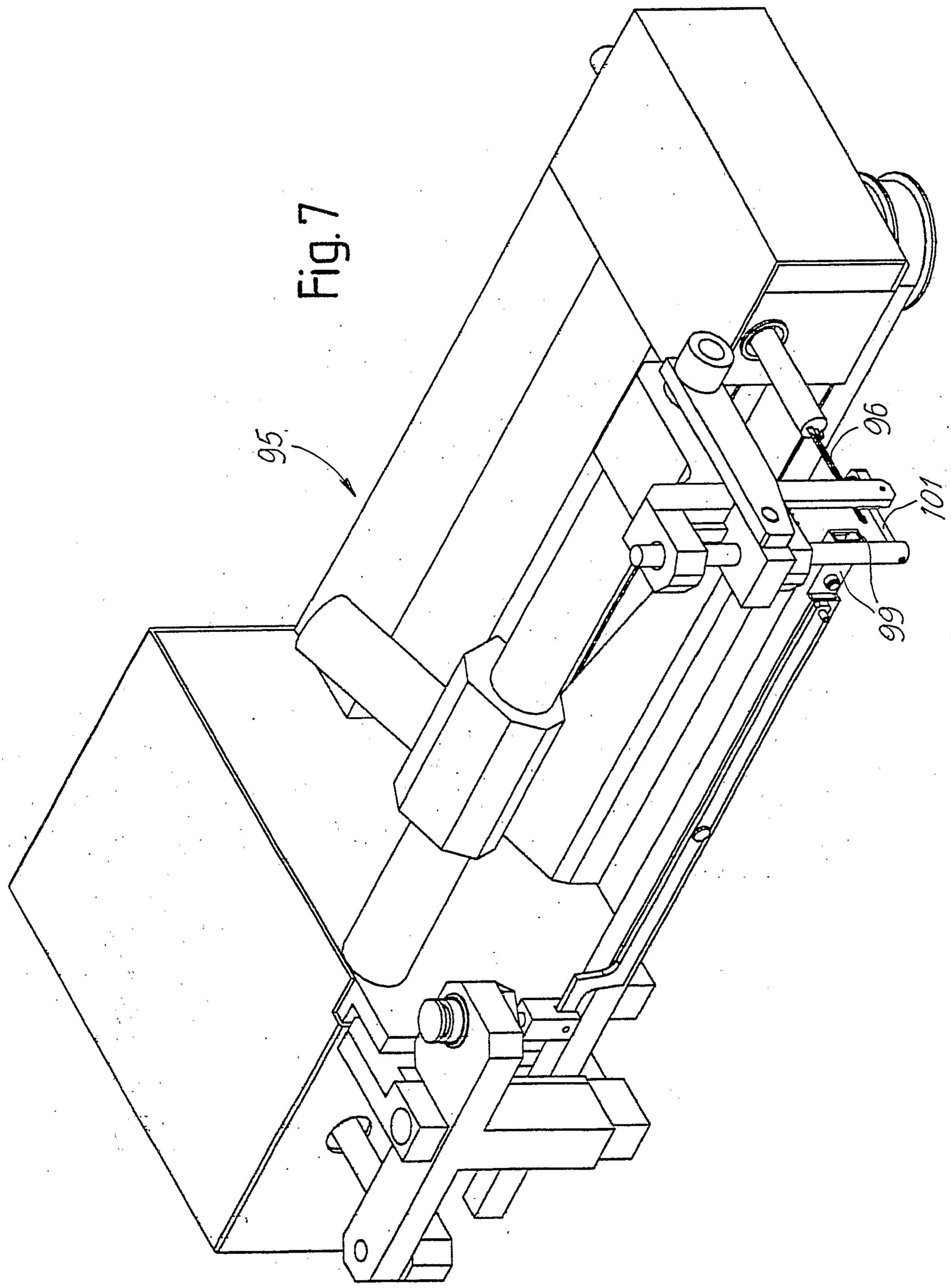


Fig.7



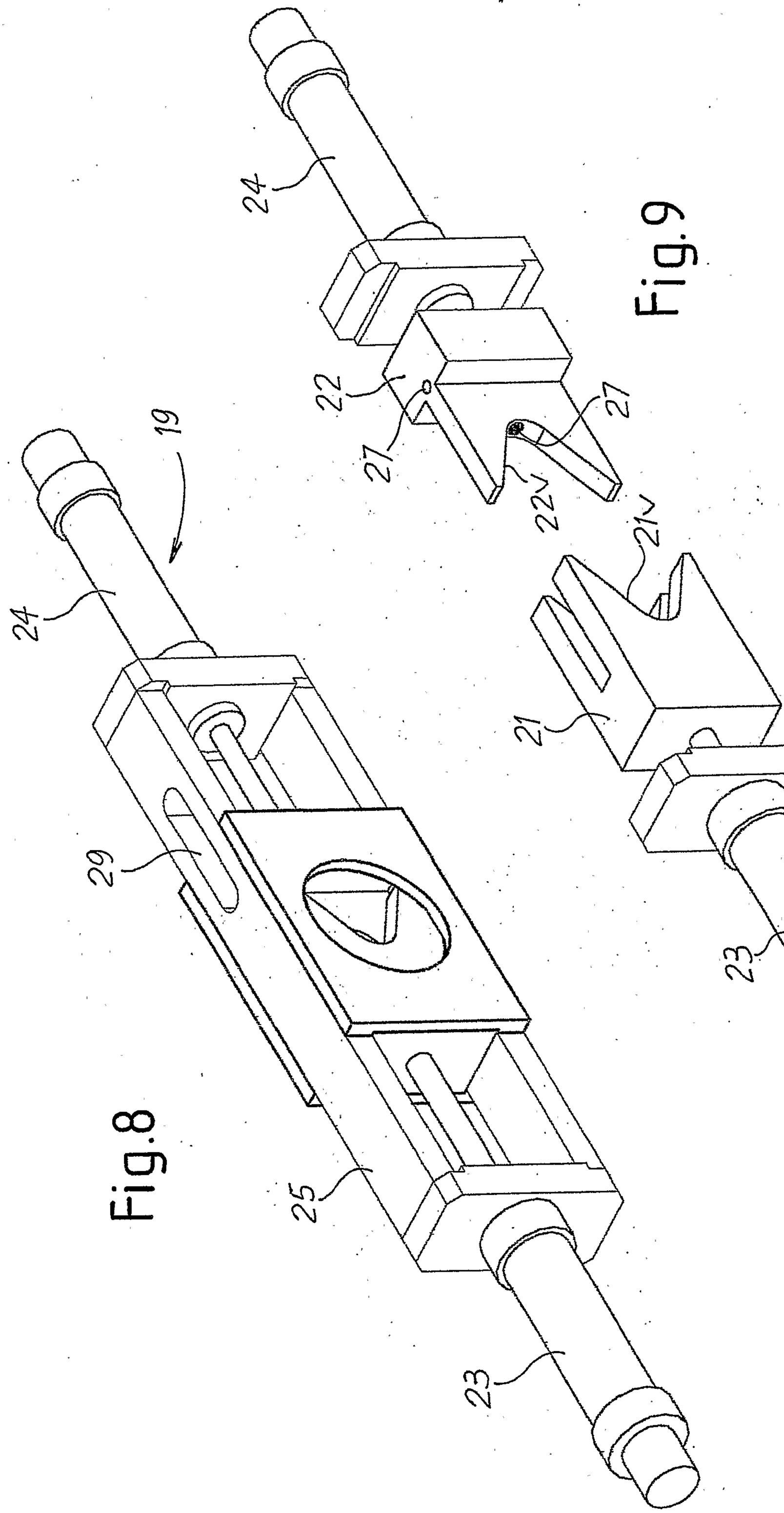


Fig.8

Fig.9

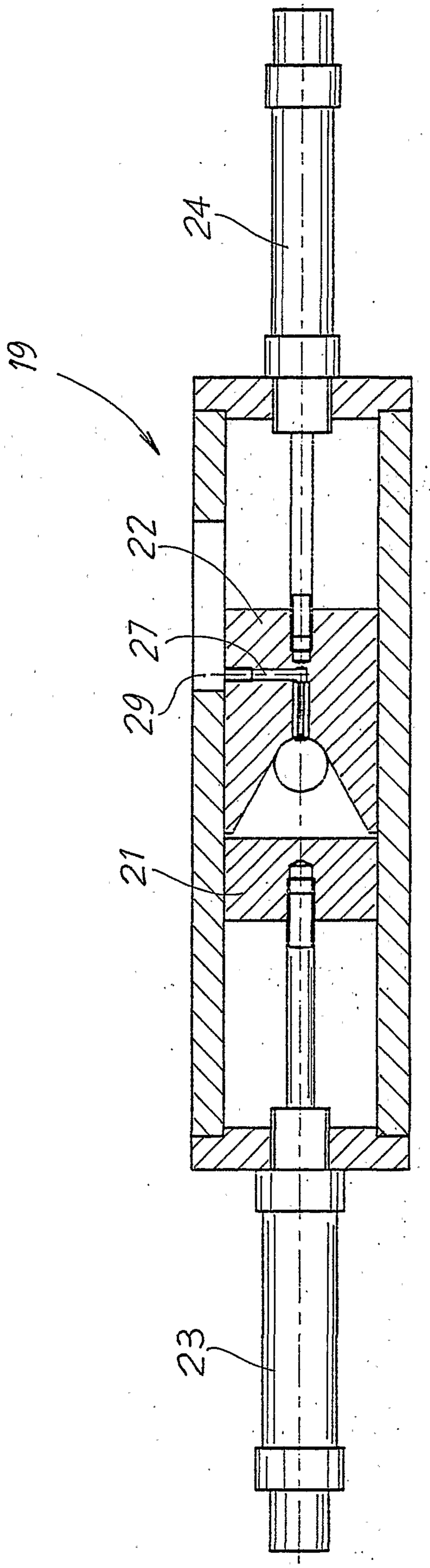


Fig.10

Fig.11

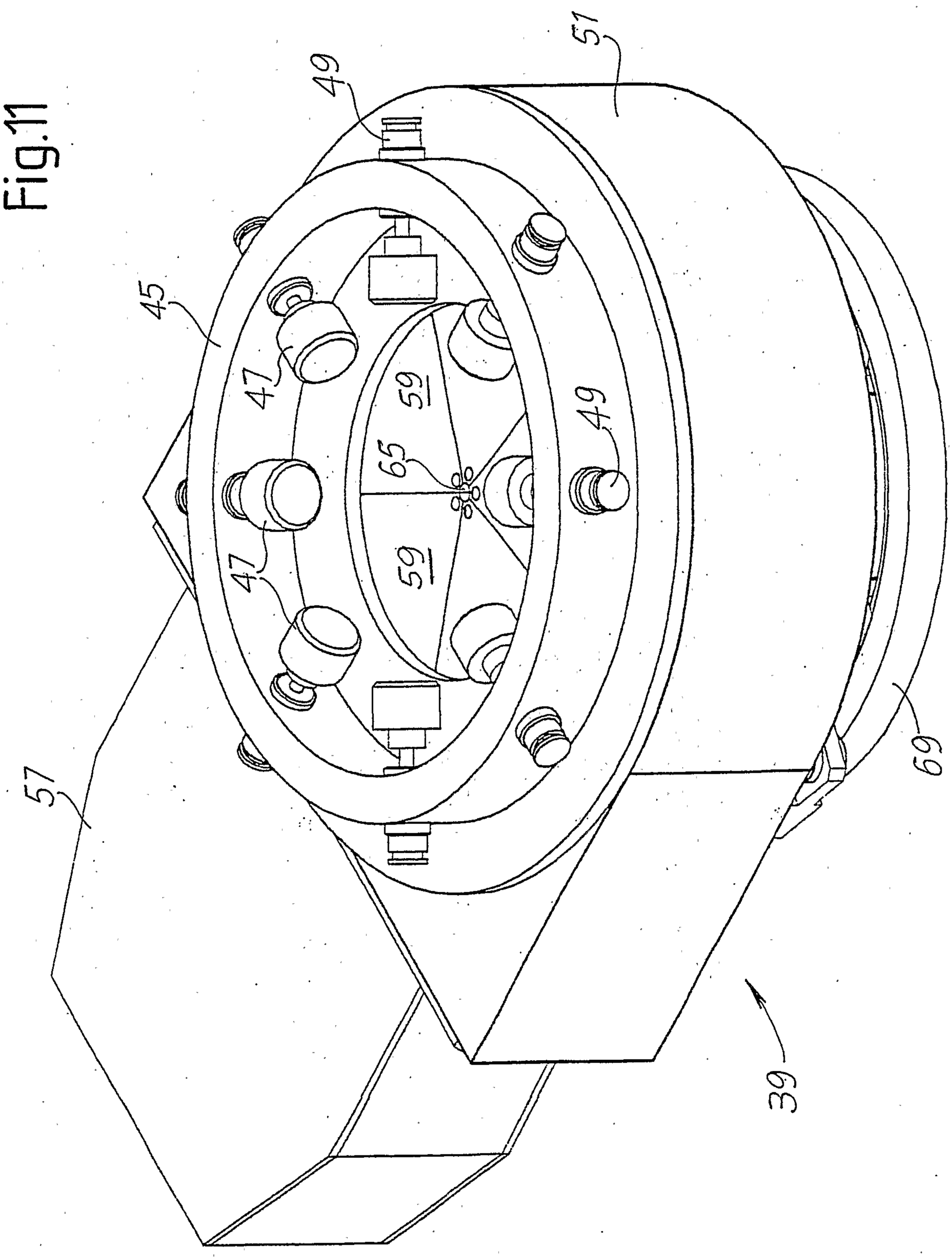
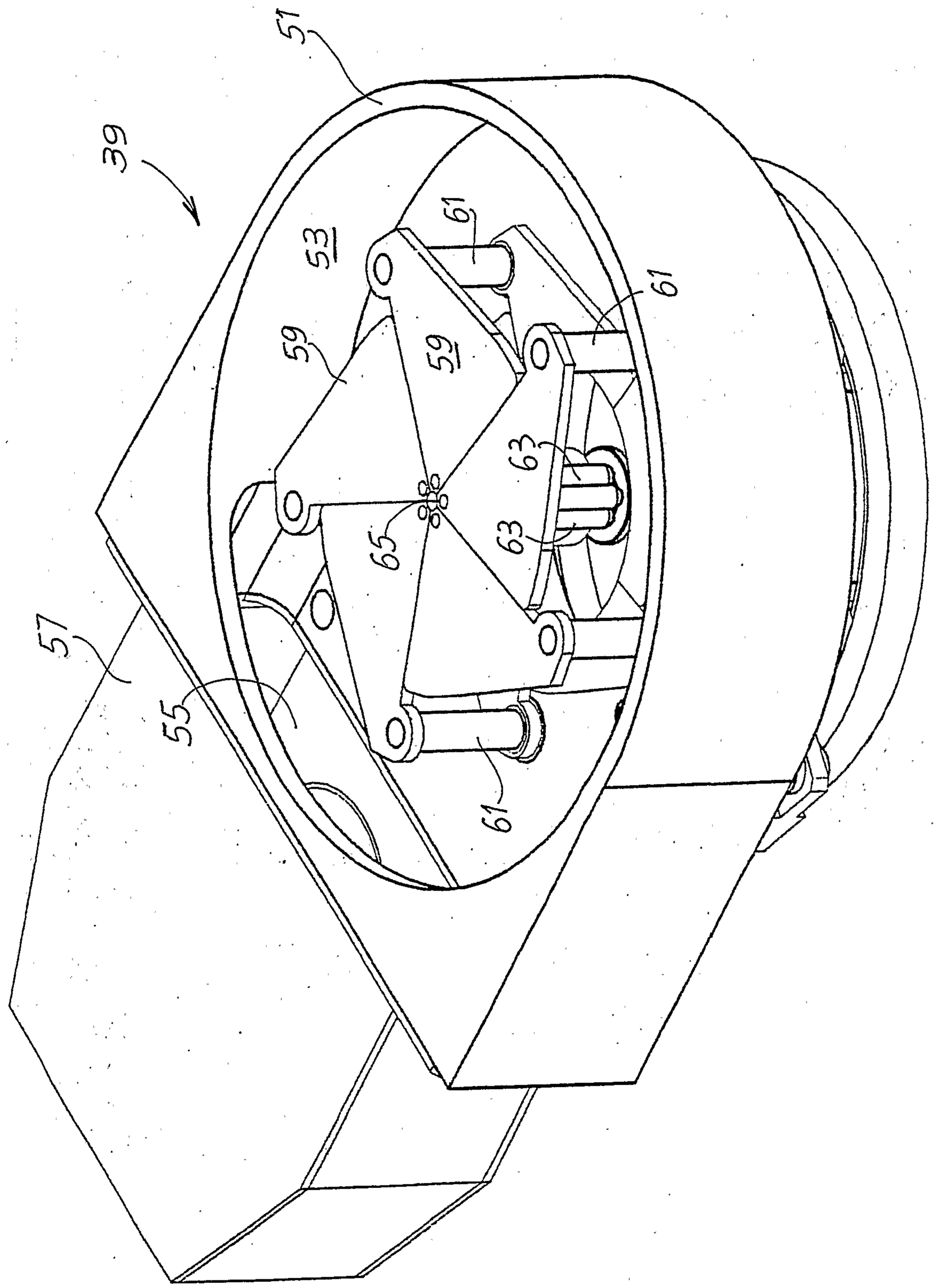


Fig.12



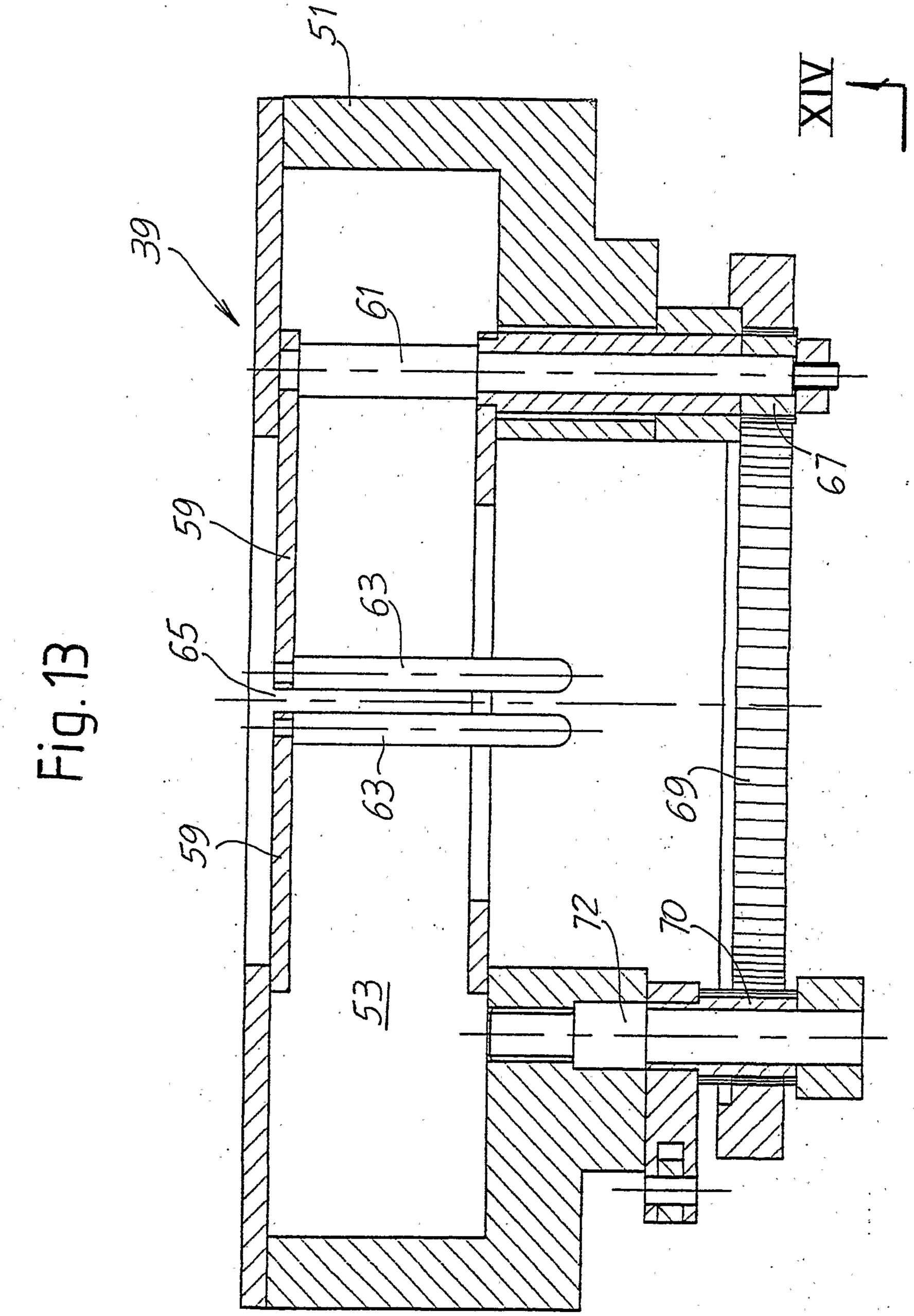


Fig. 13

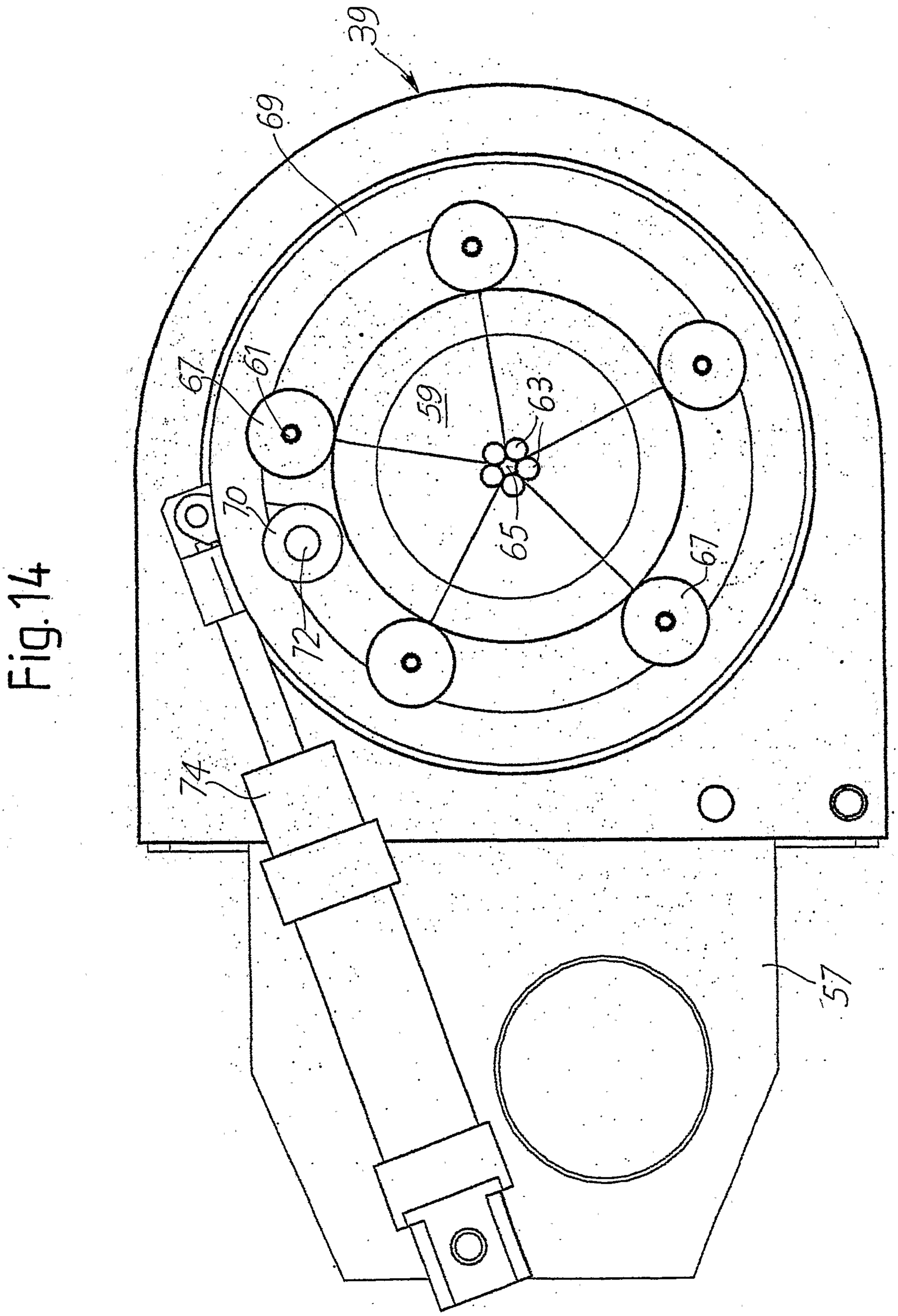


Fig.14

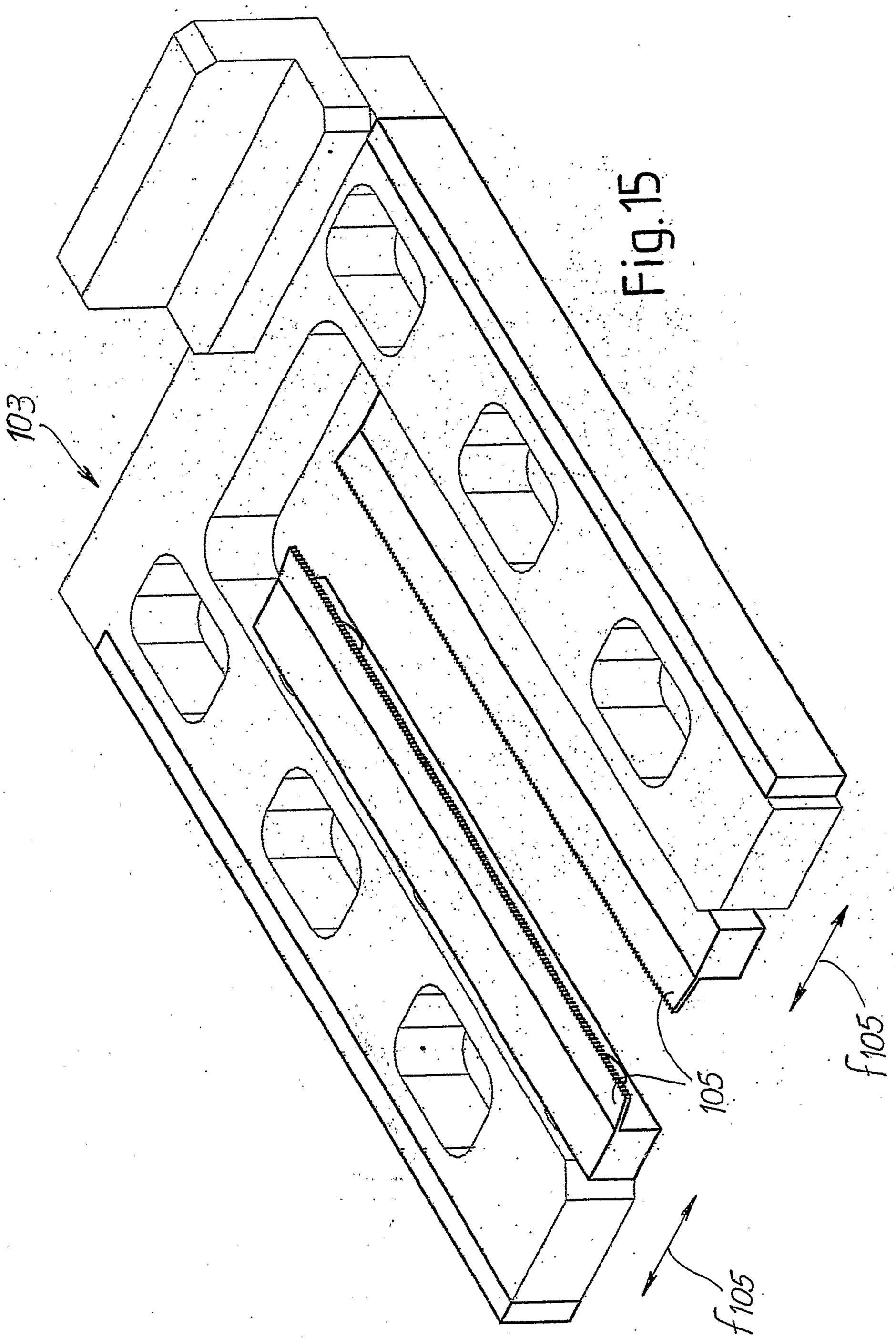


Fig.15

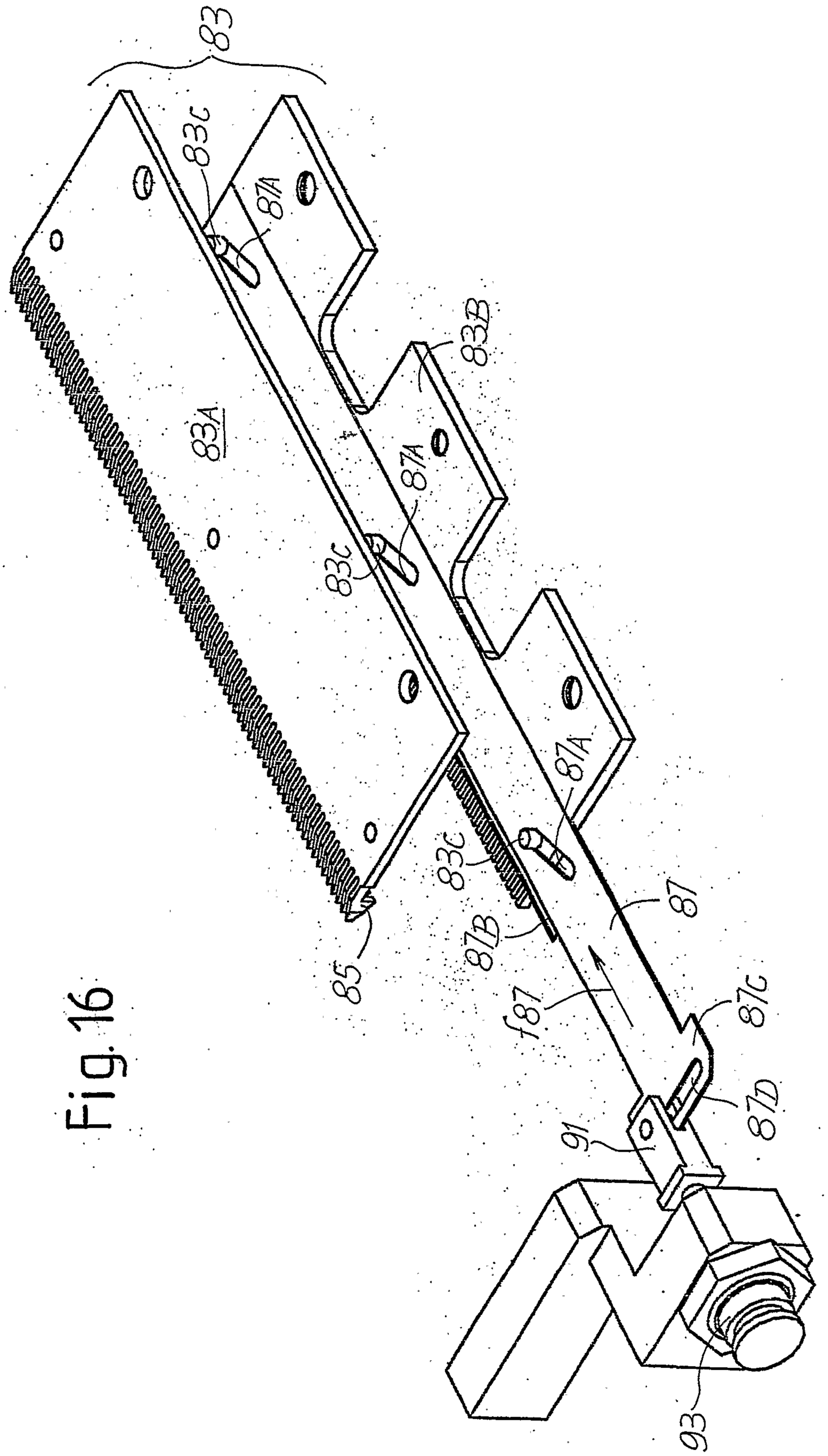


Fig. 16

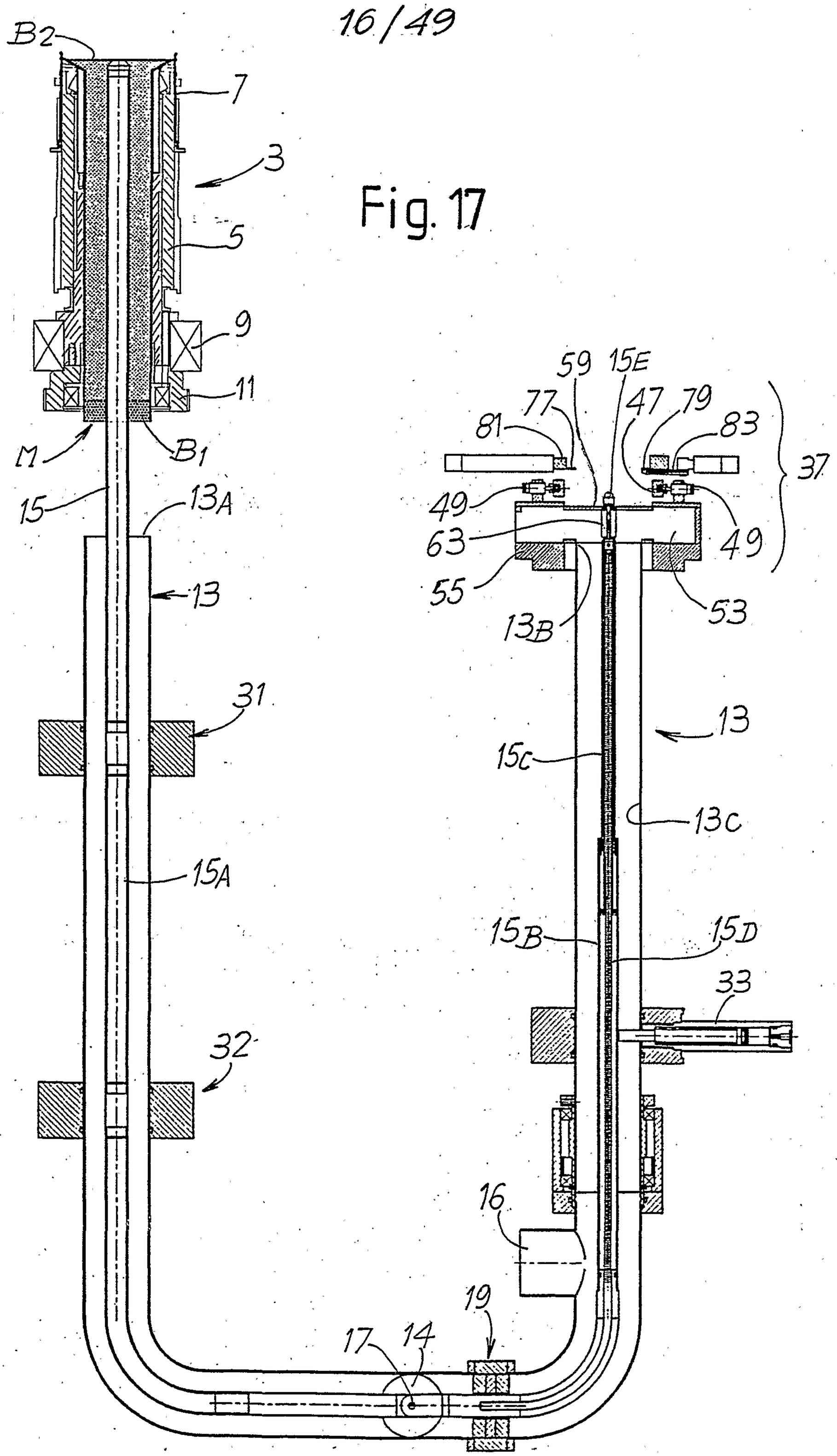

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Fig. 17

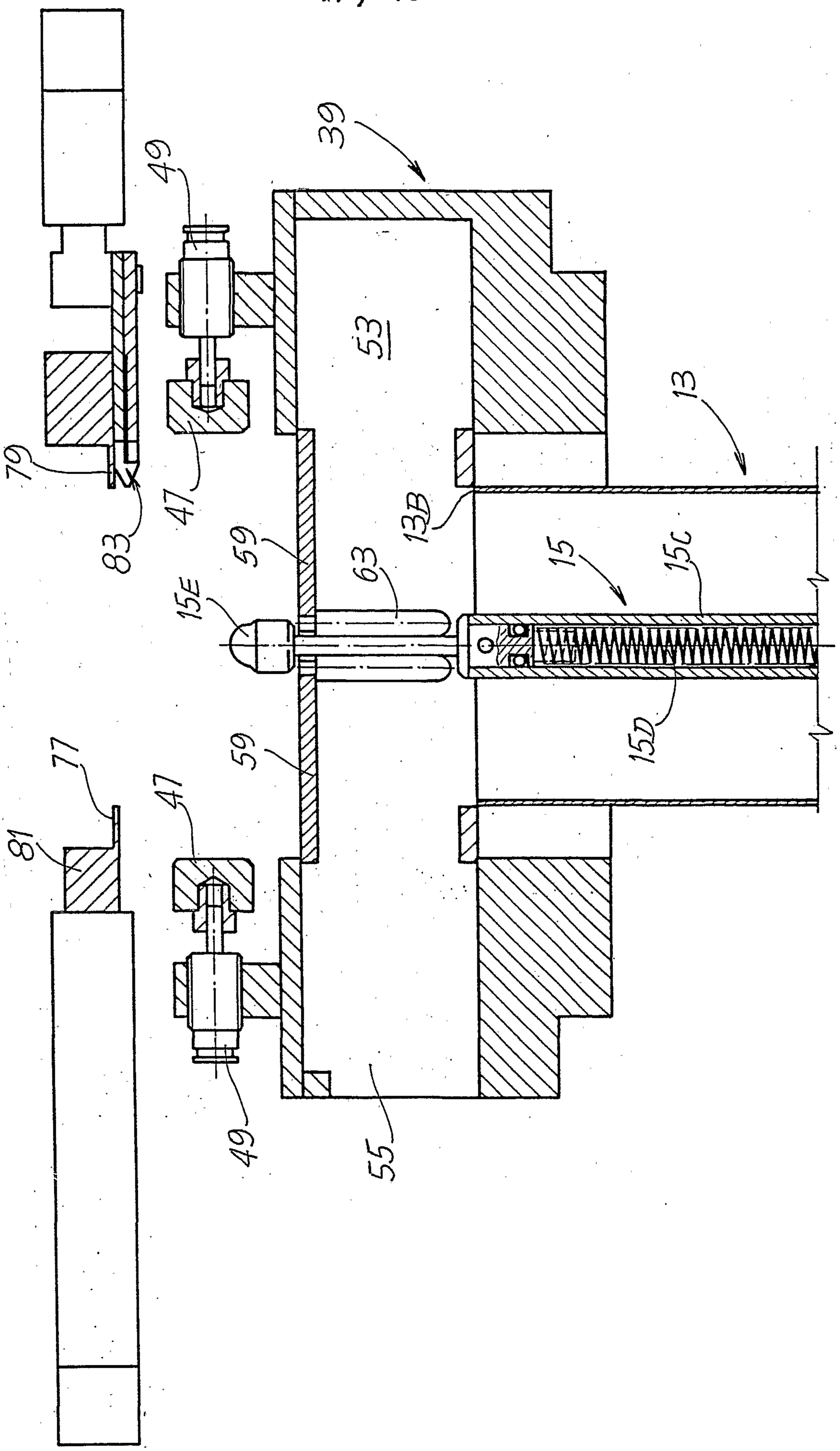

Fig. 17A

18/49

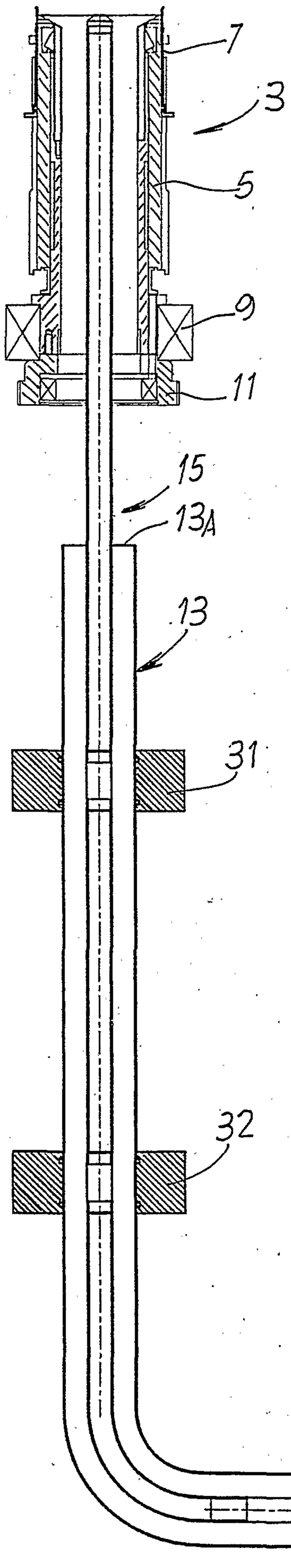
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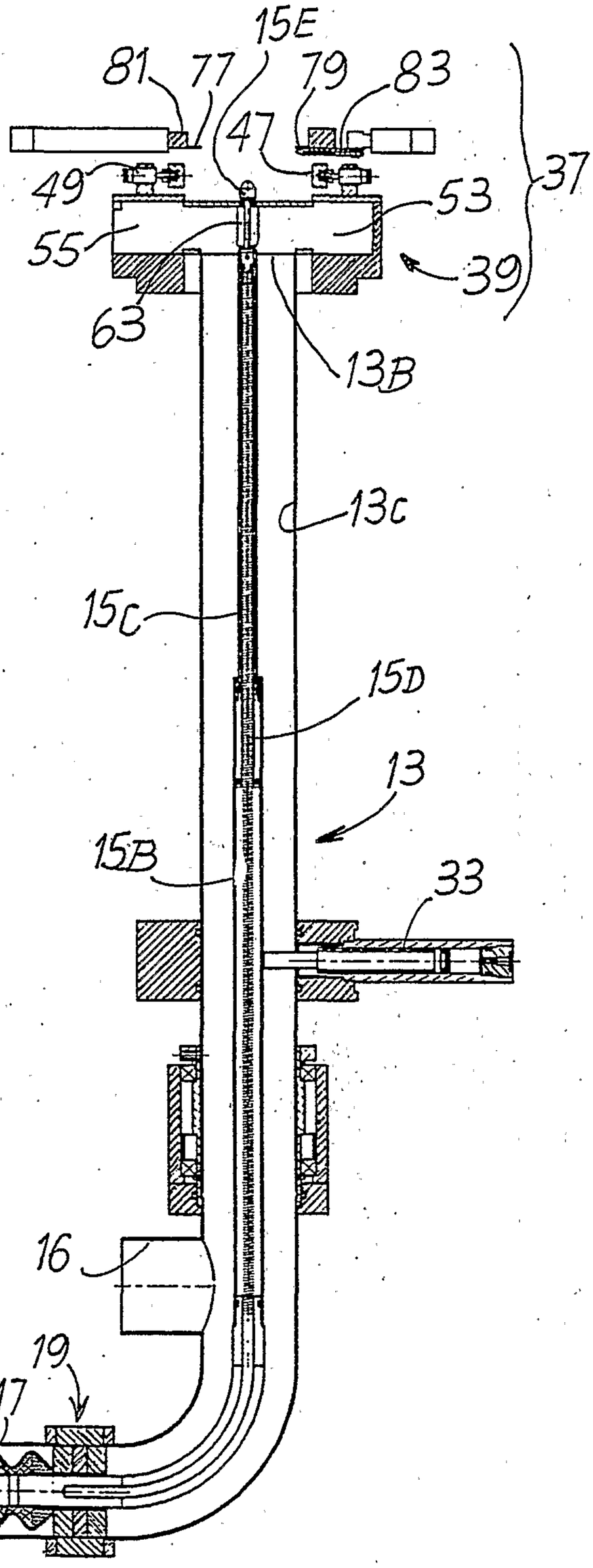
Fig.18


15E
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15B
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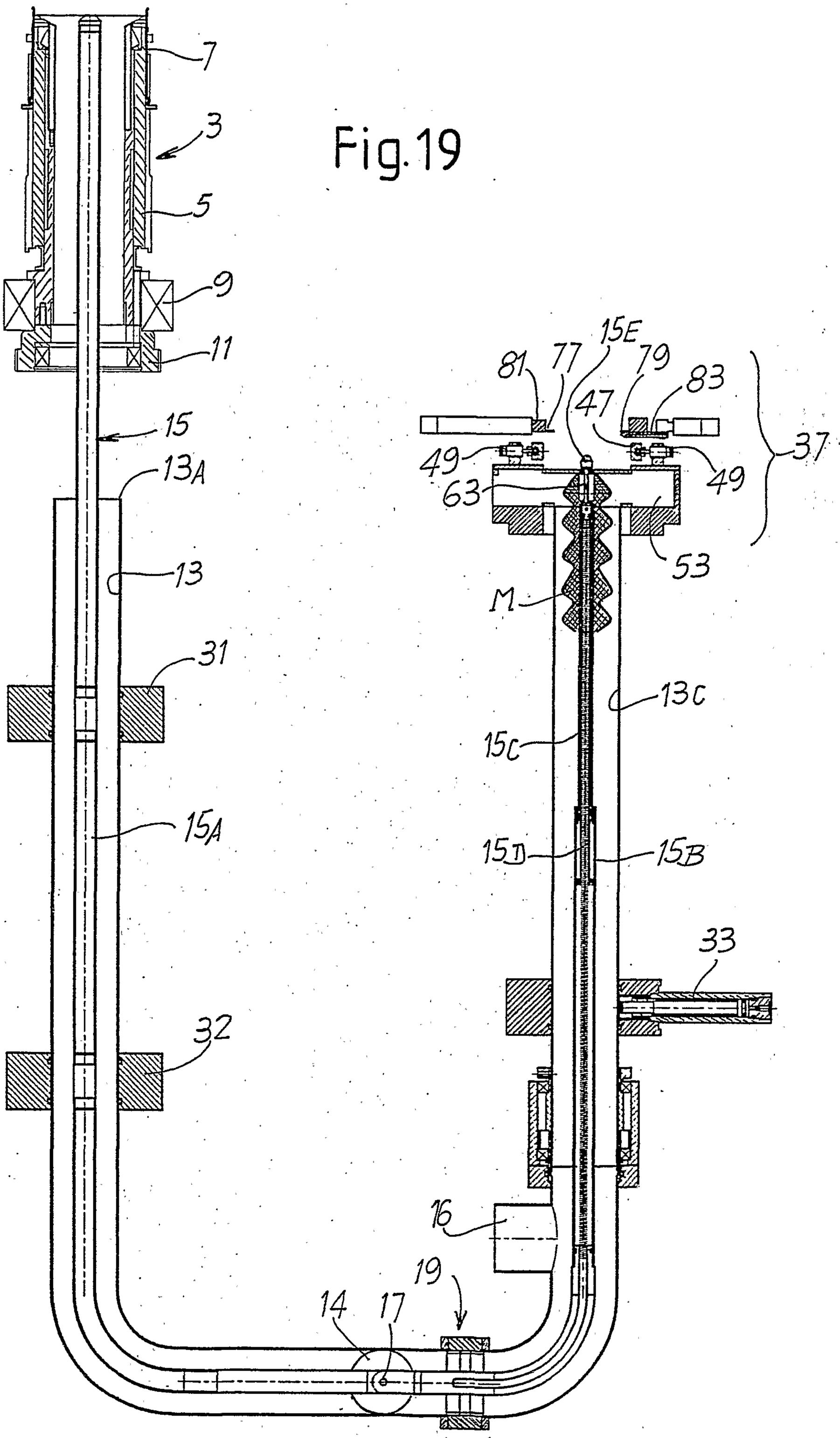
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15D
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Fig.19

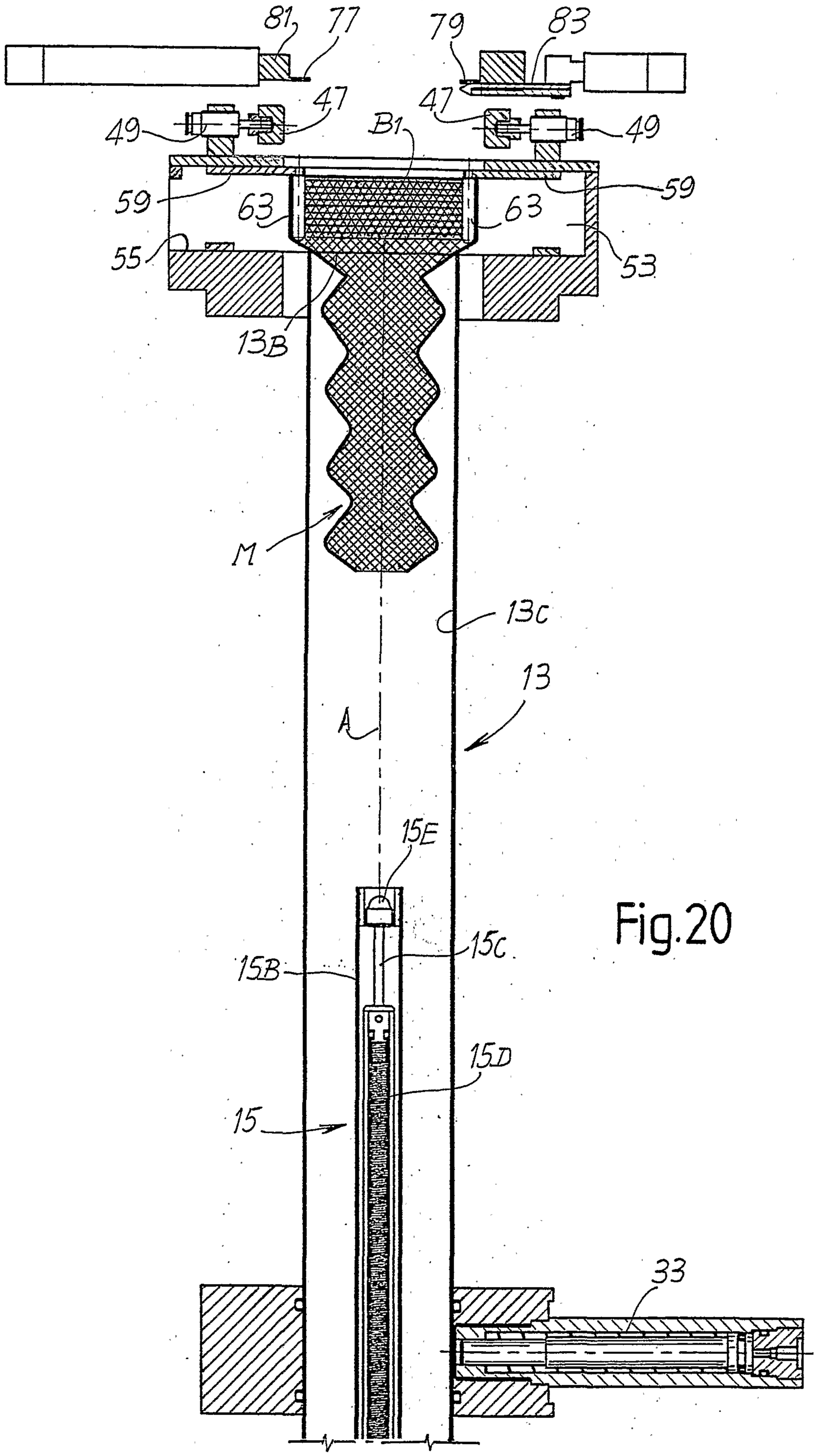
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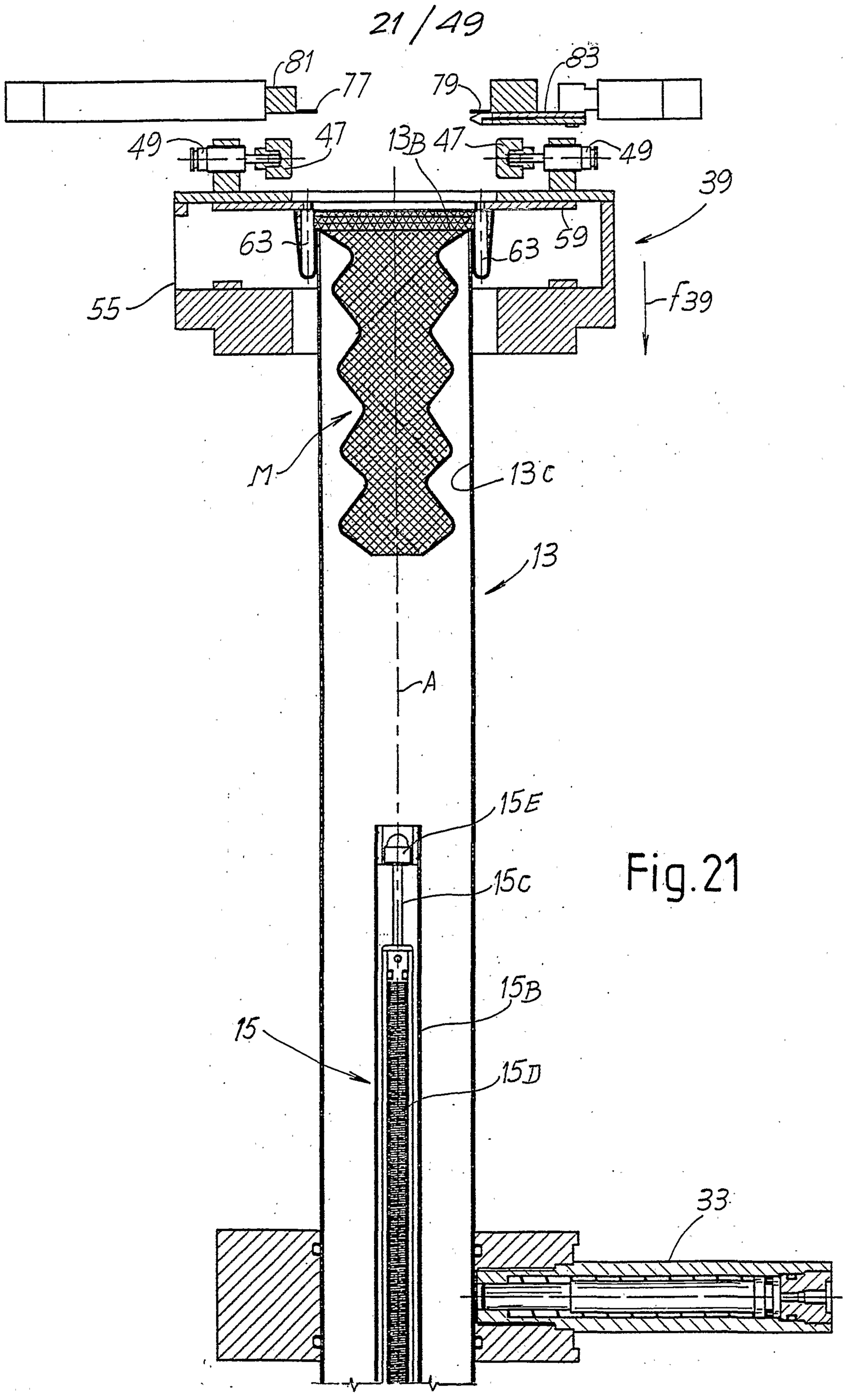
Fig.20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13B
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f39
M
13C
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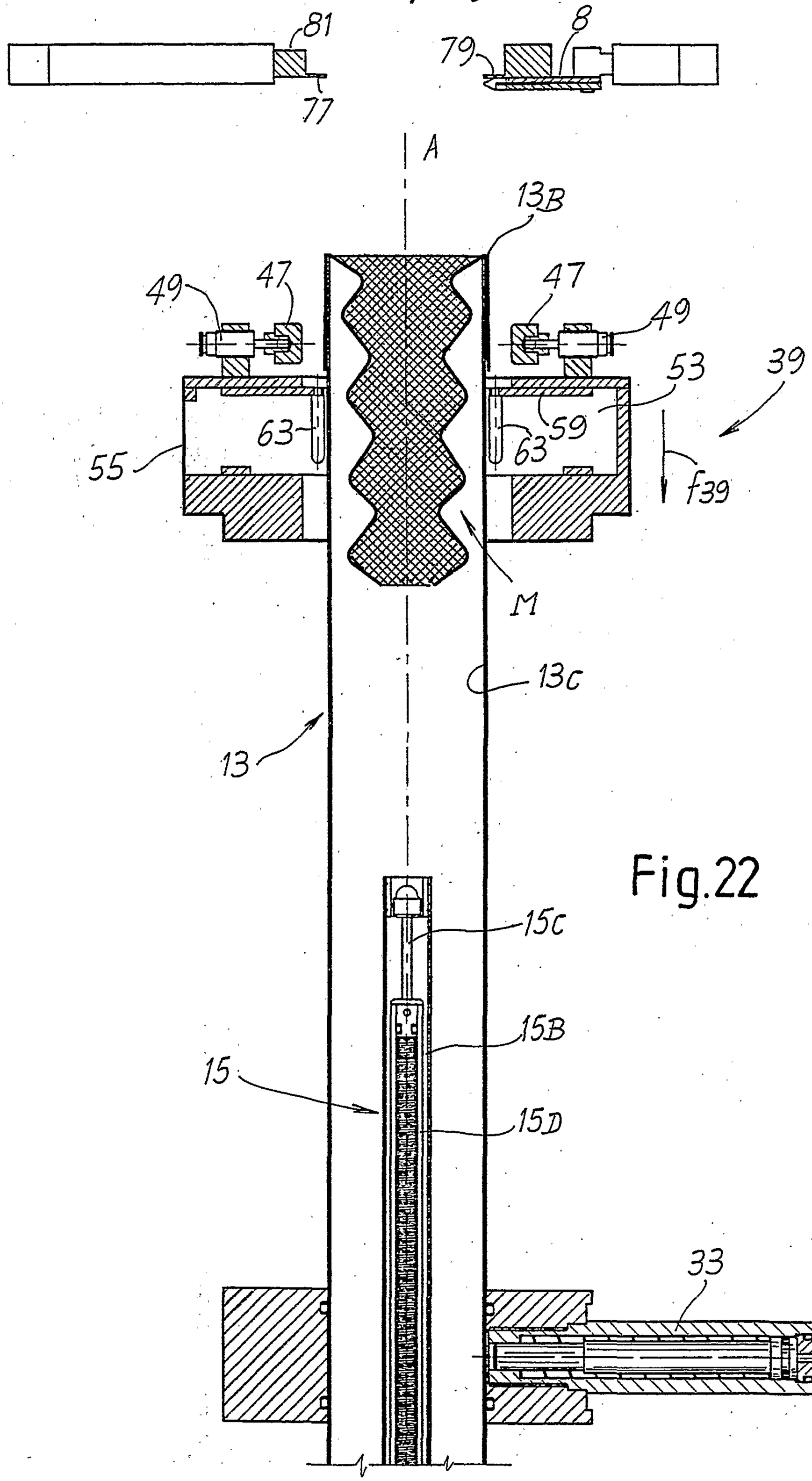
15E
15C
15B
15
15D
33

Fig.21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f_{39}
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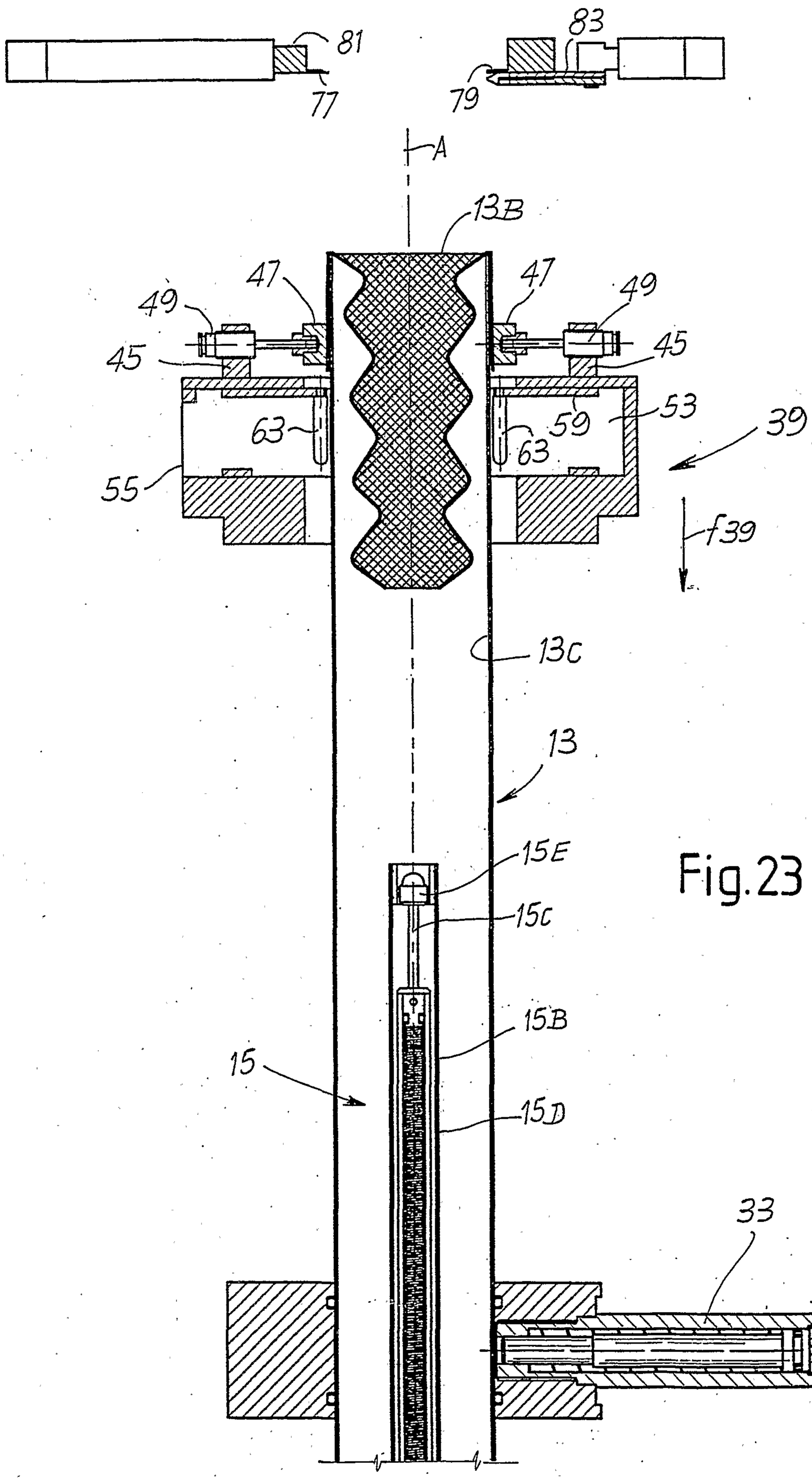
15C
15B
15
15D
33

Fig.22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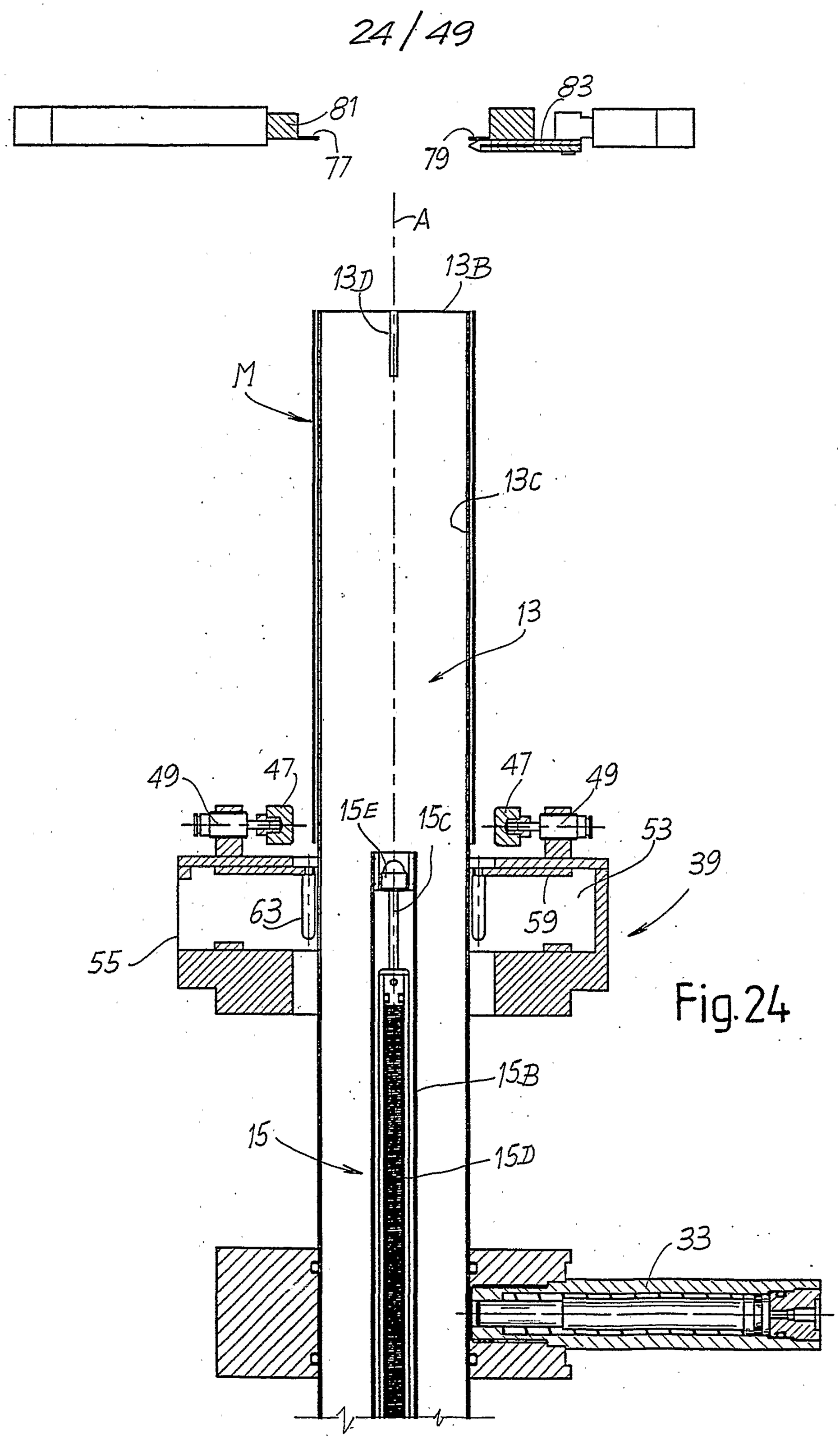
33

Fig.23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15D
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Fig.24

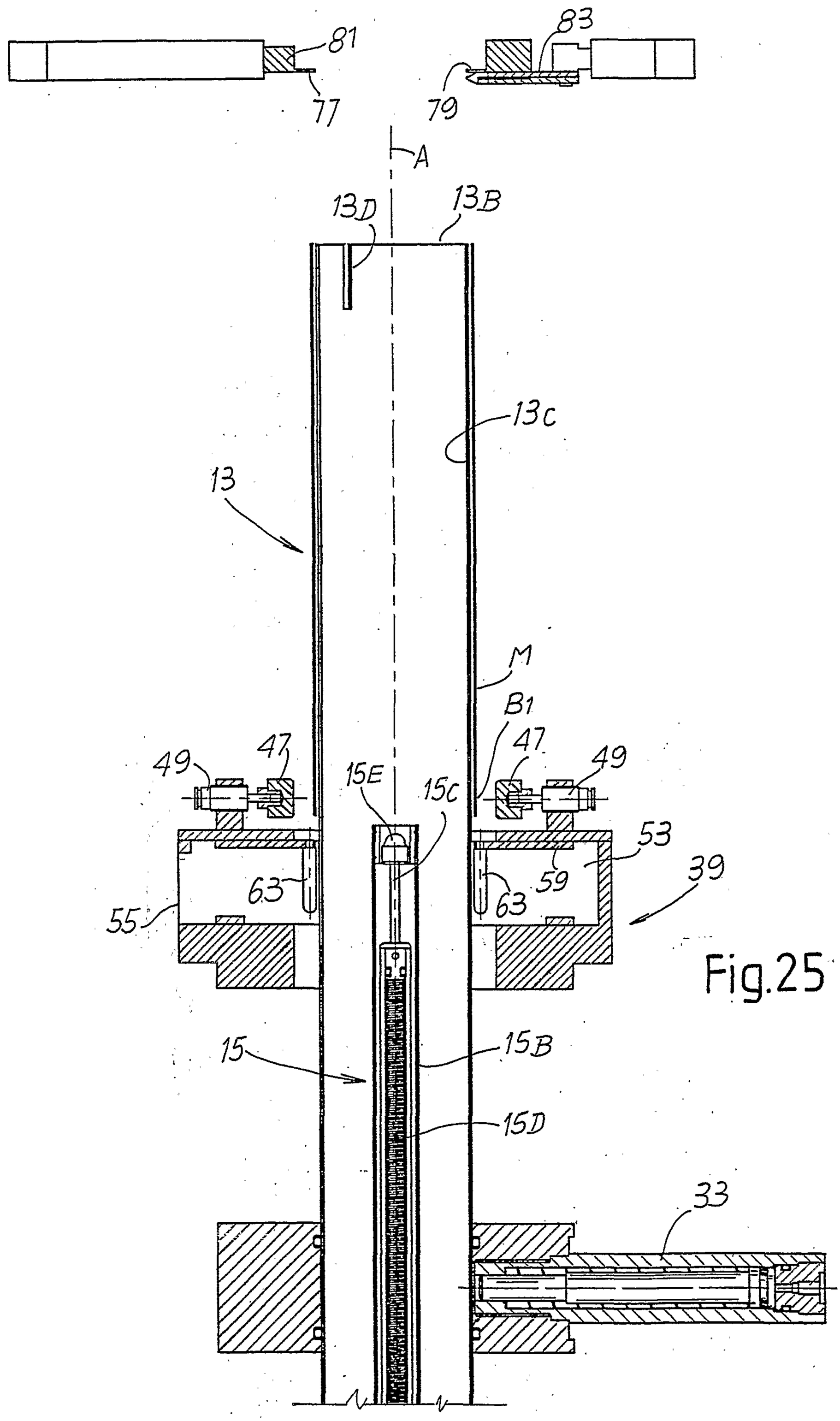
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Fig.25

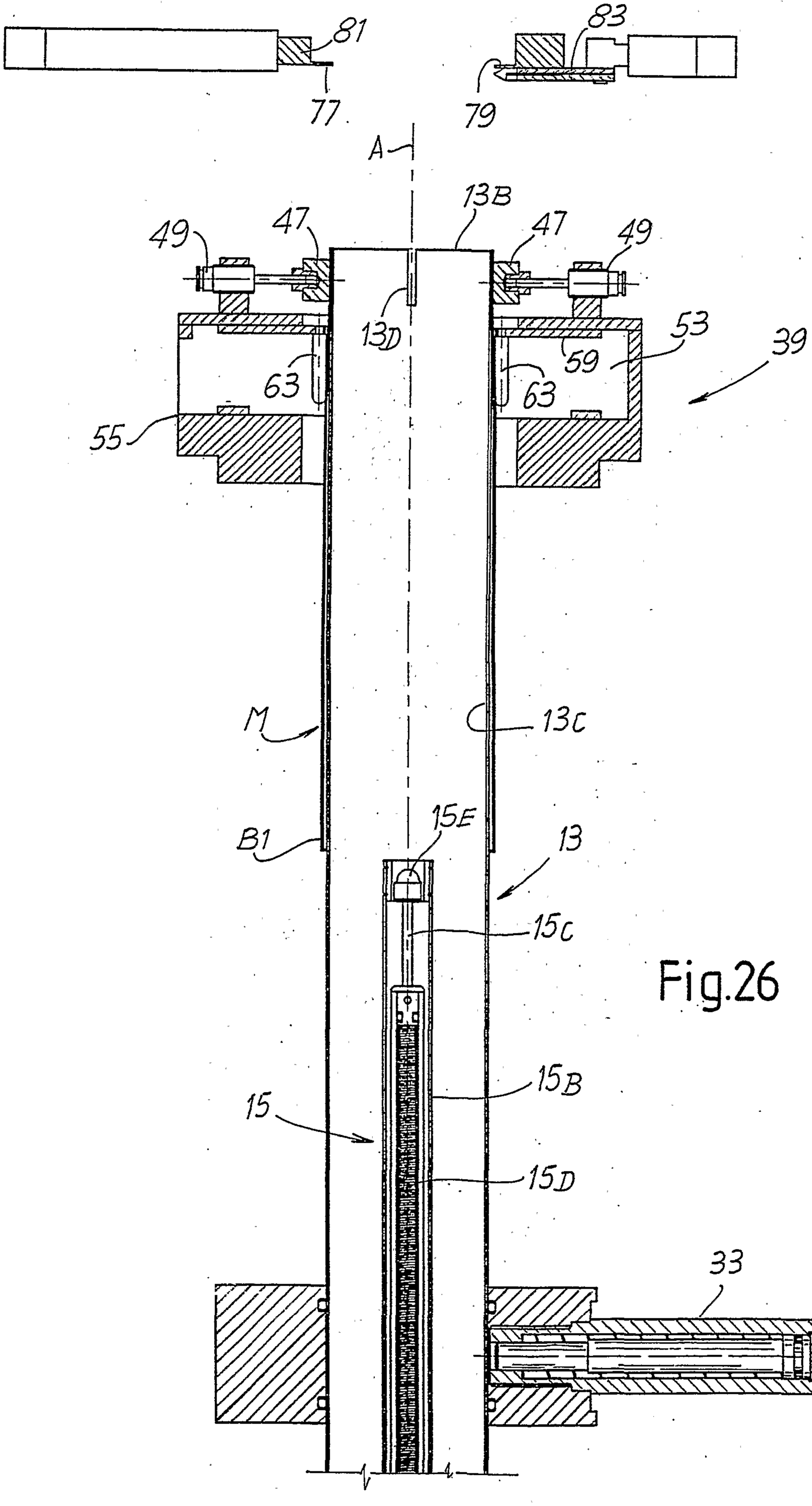
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Fig.26

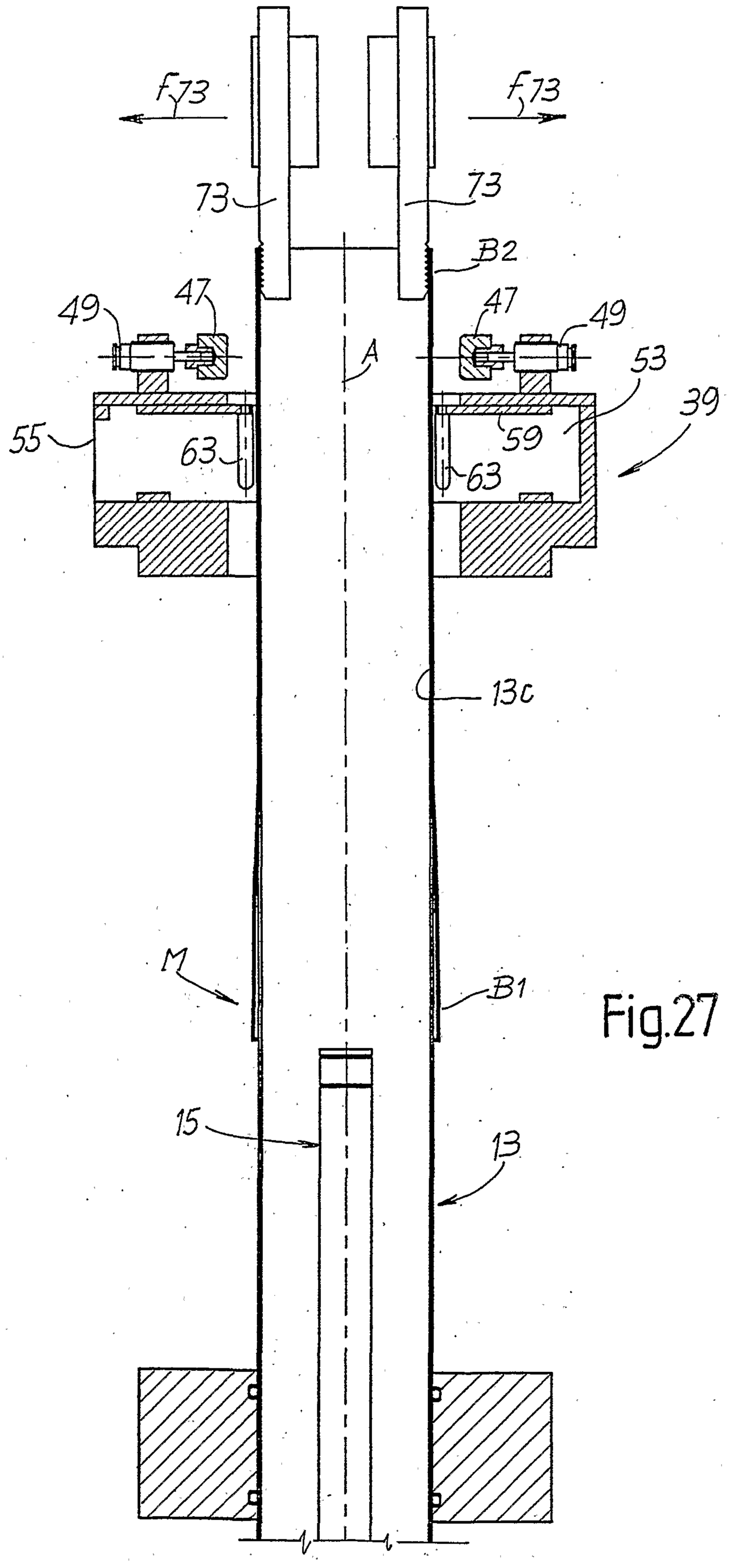


Fig.27

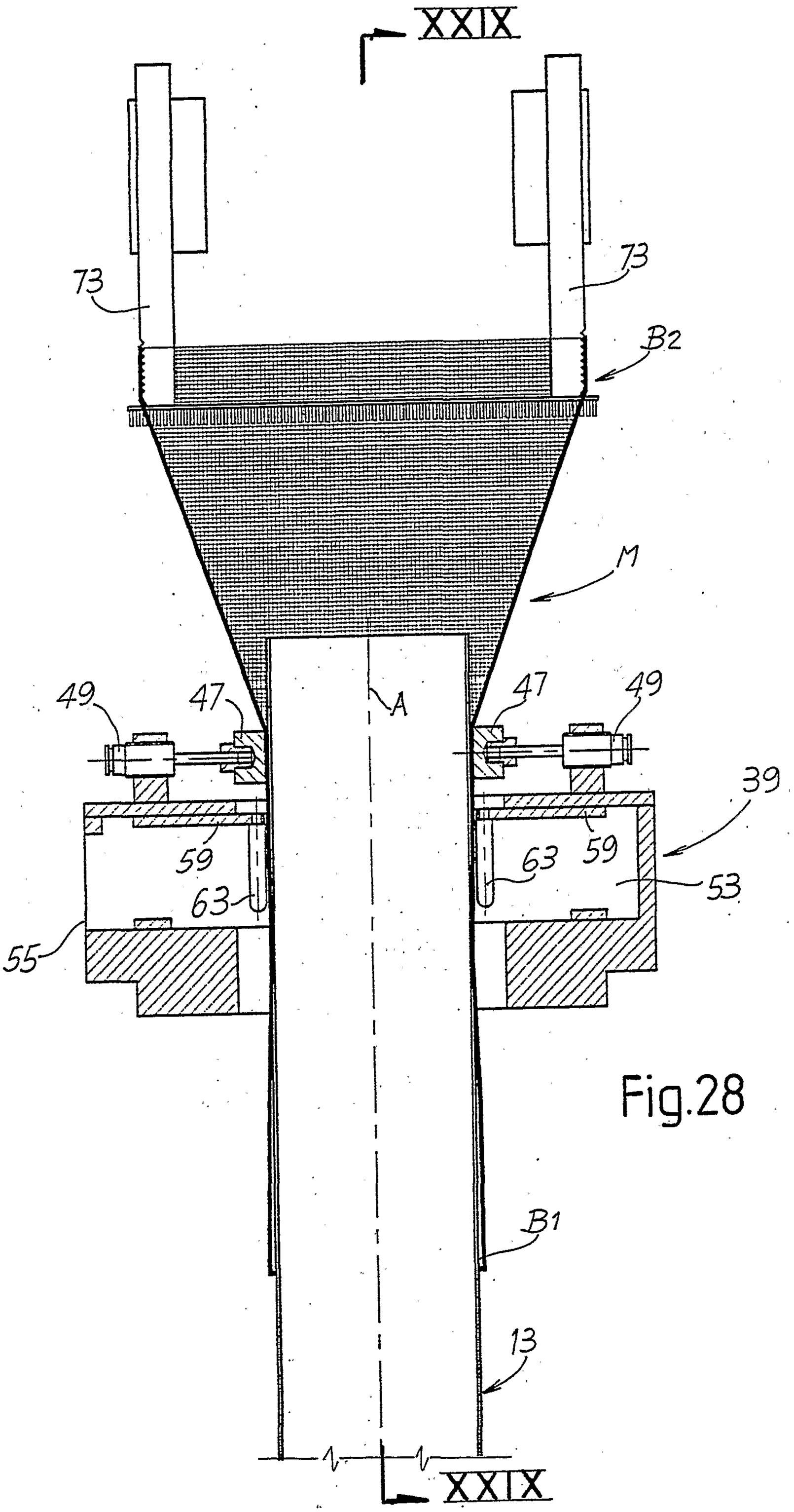
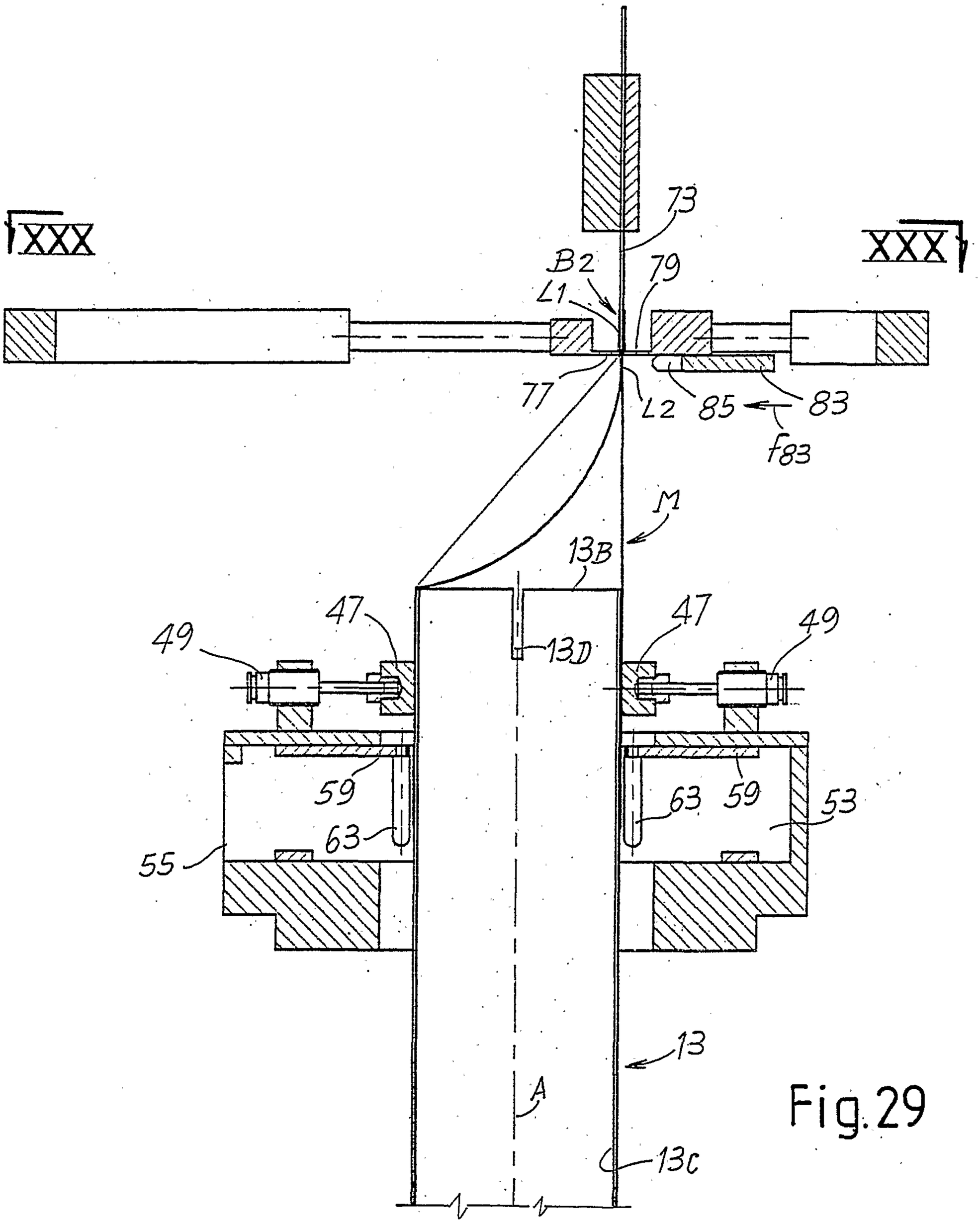


Fig.28


XXX
XXX
73
B2
L1
79
77
L2
85
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f83
M
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A
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Fig.29

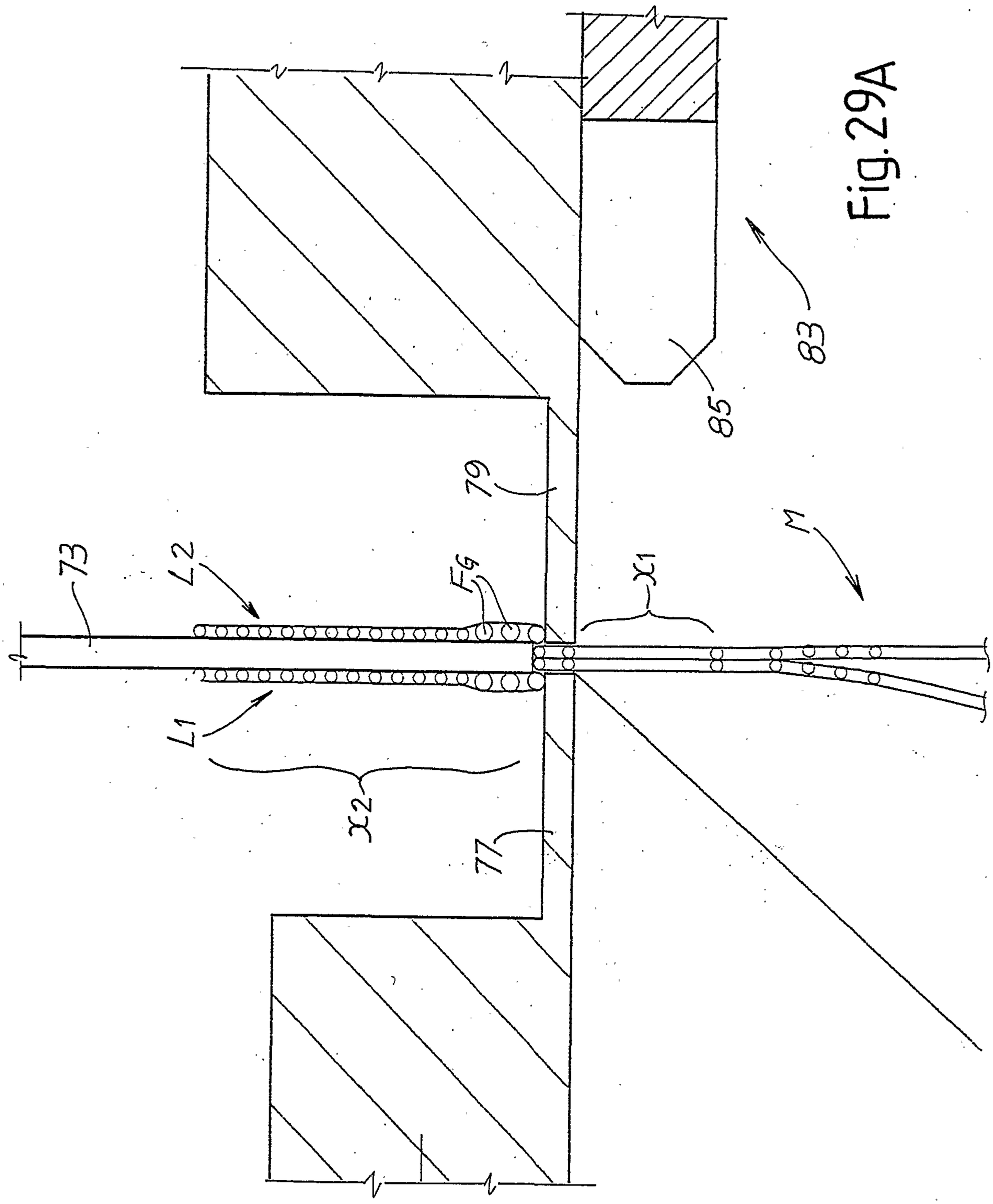


Fig.29A

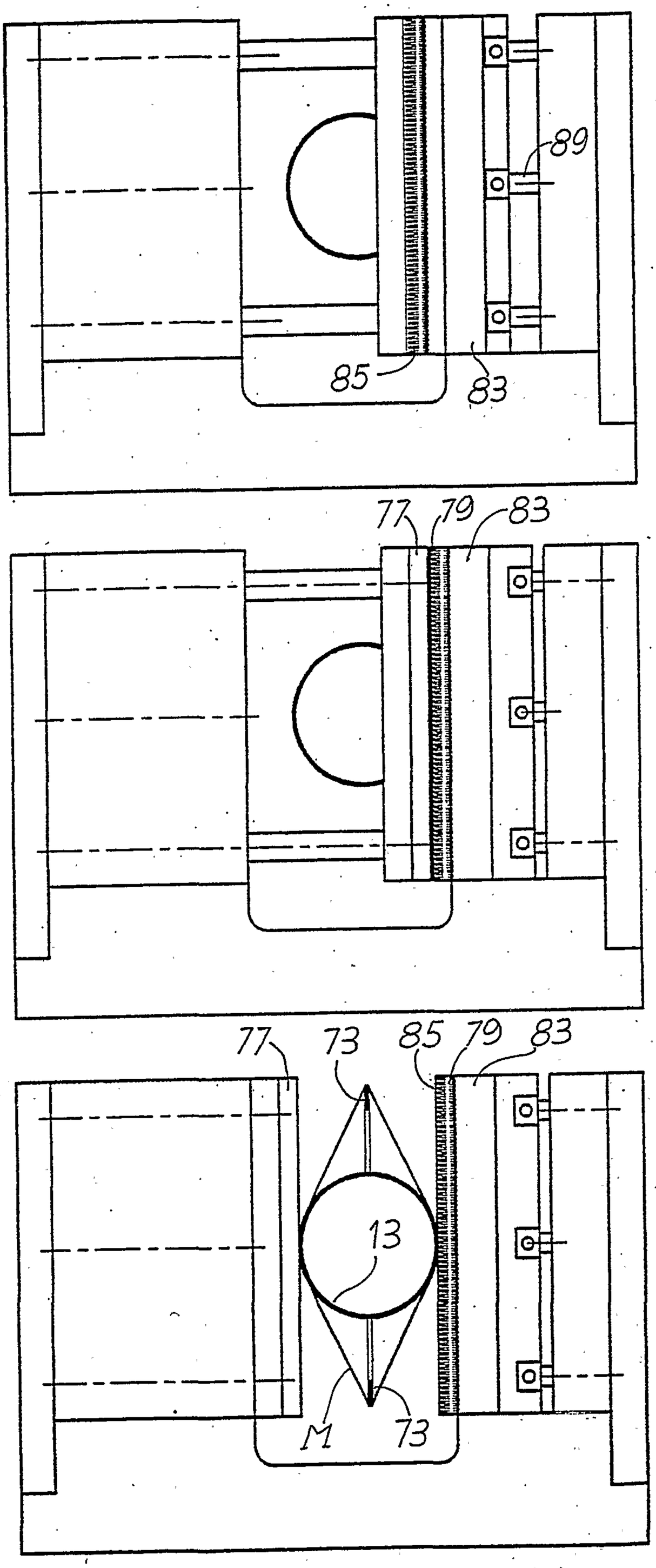
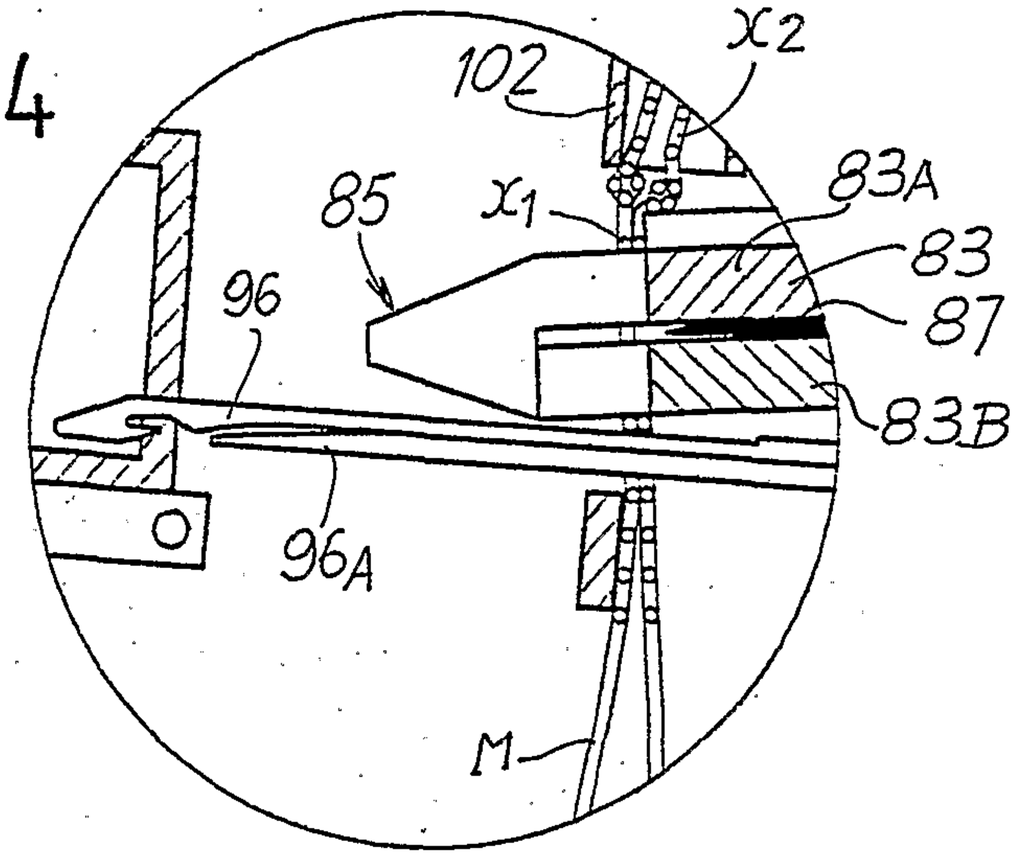


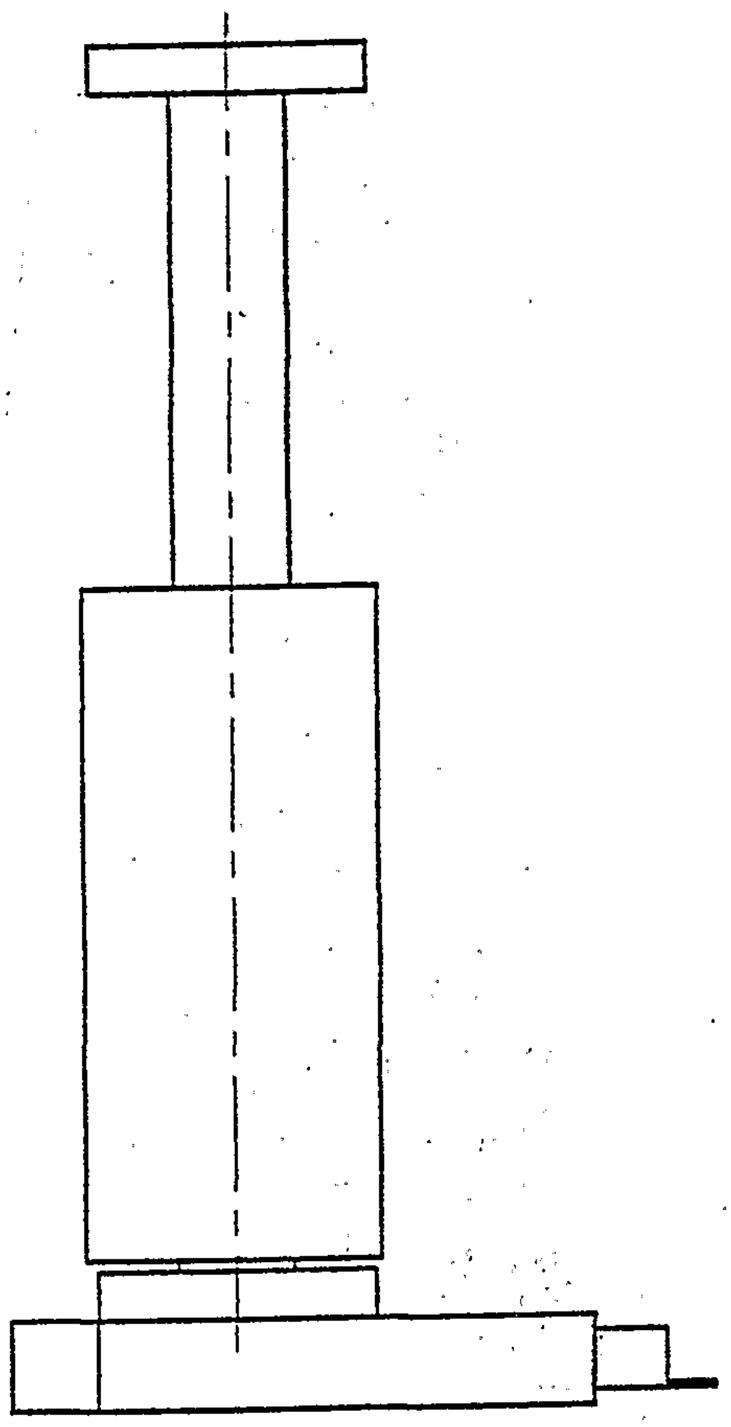
Fig.32

Fig.31

Fig.30

Fig.34





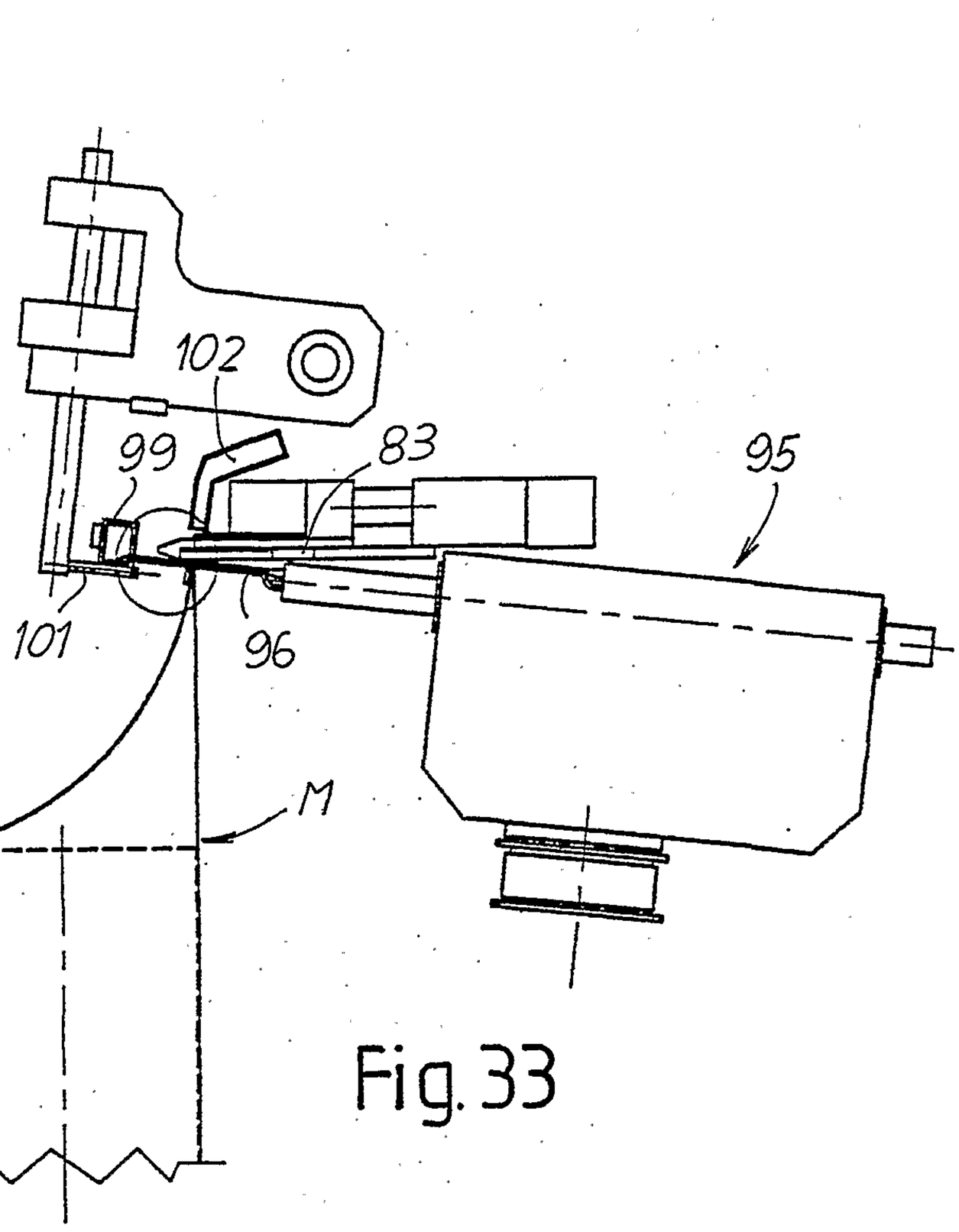


Fig.33

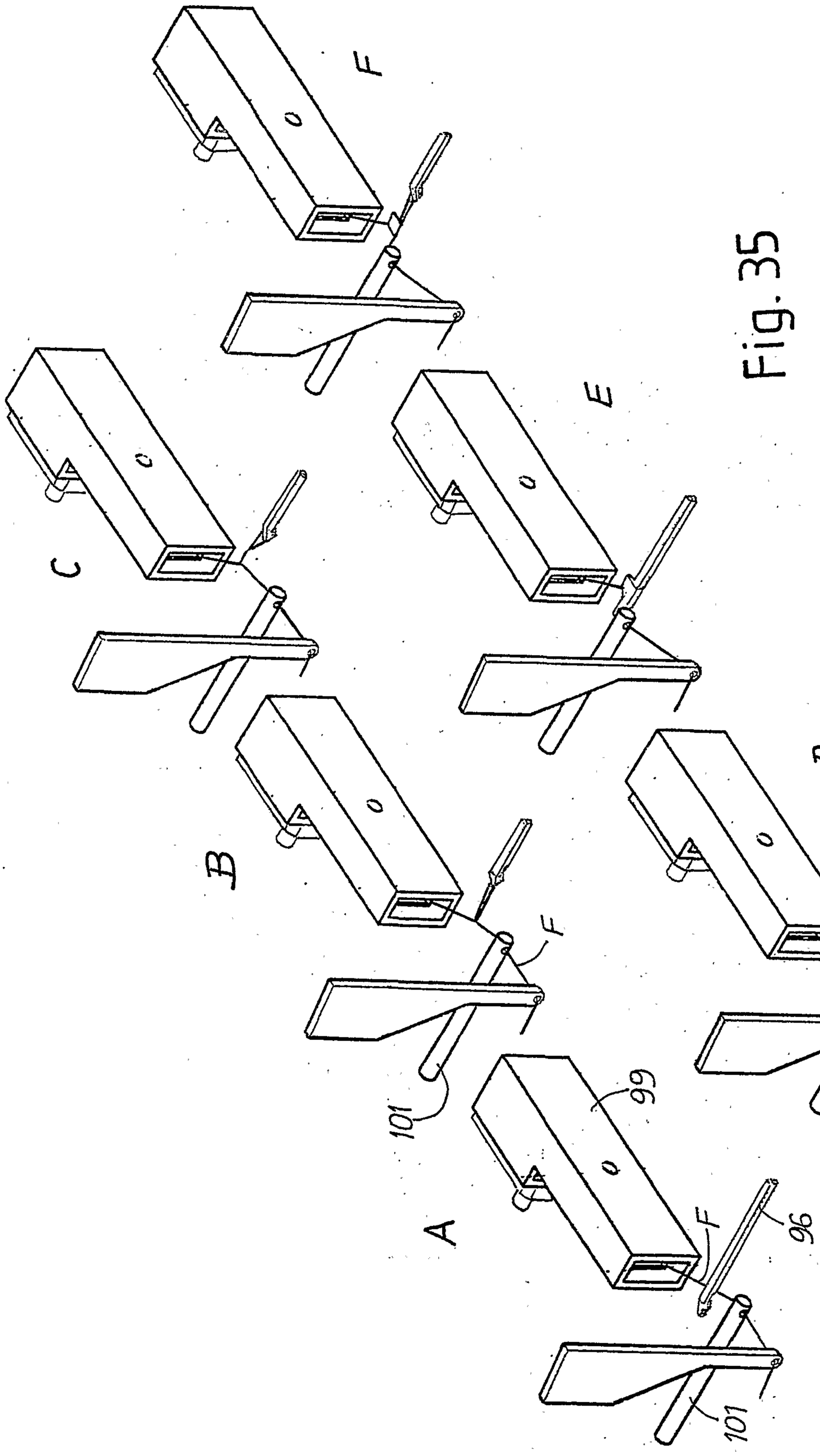


Fig. 35

Fig.36

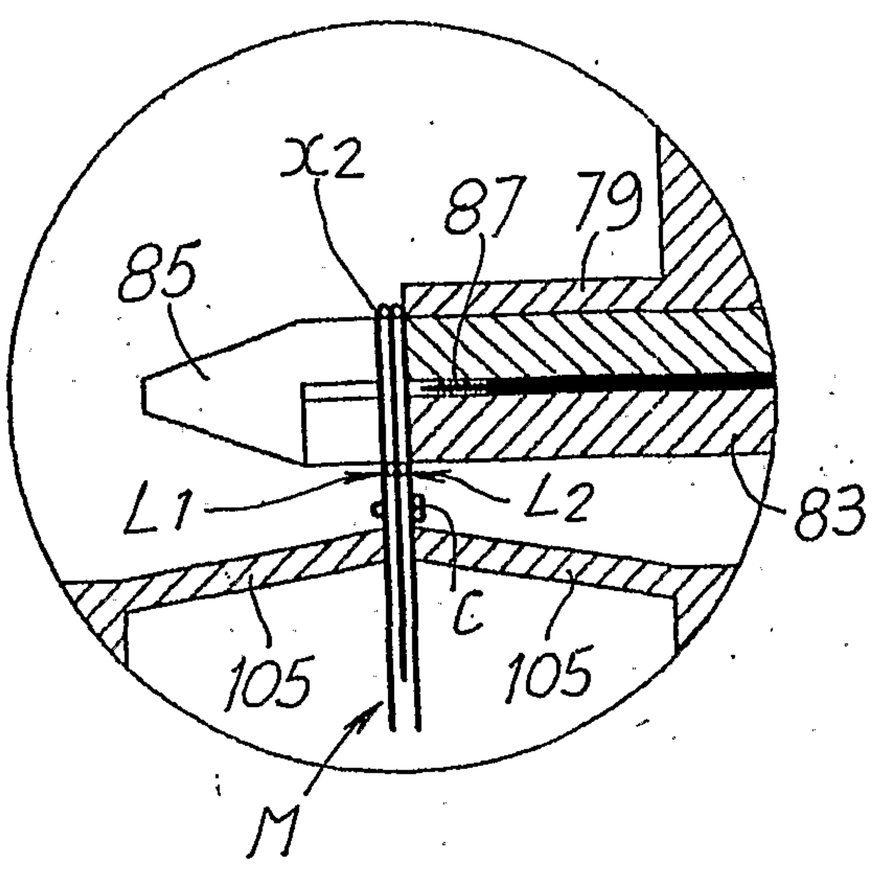


Fig.37

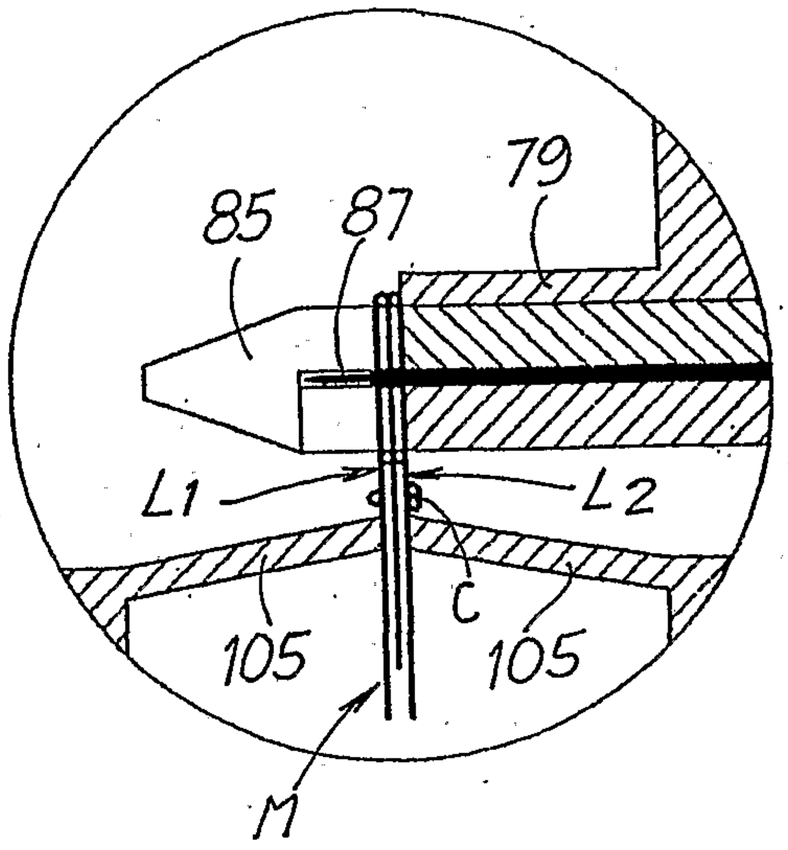


Fig.38

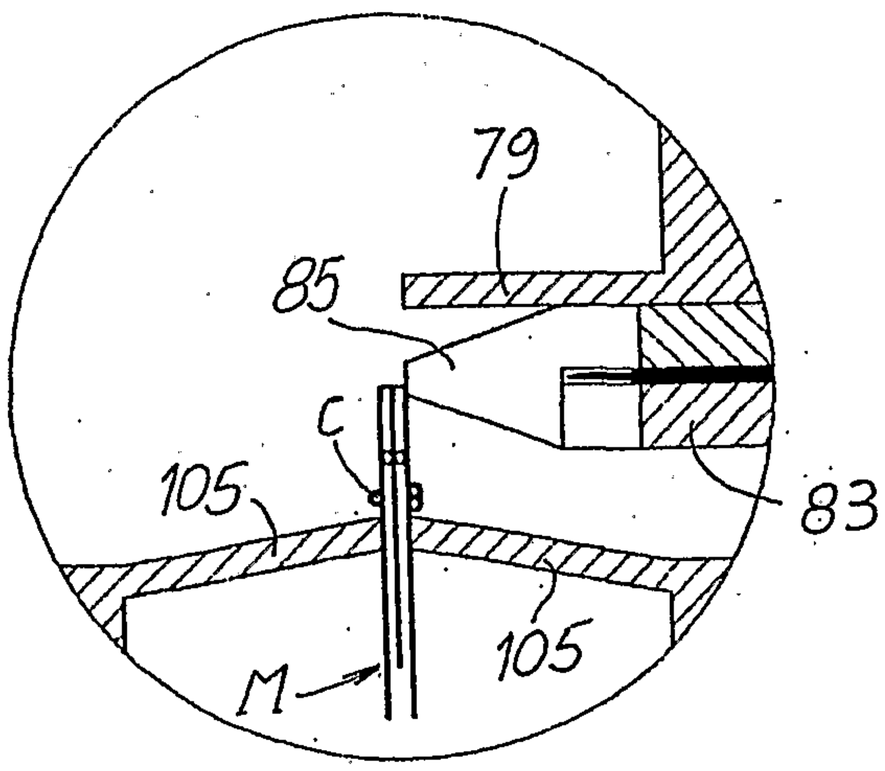
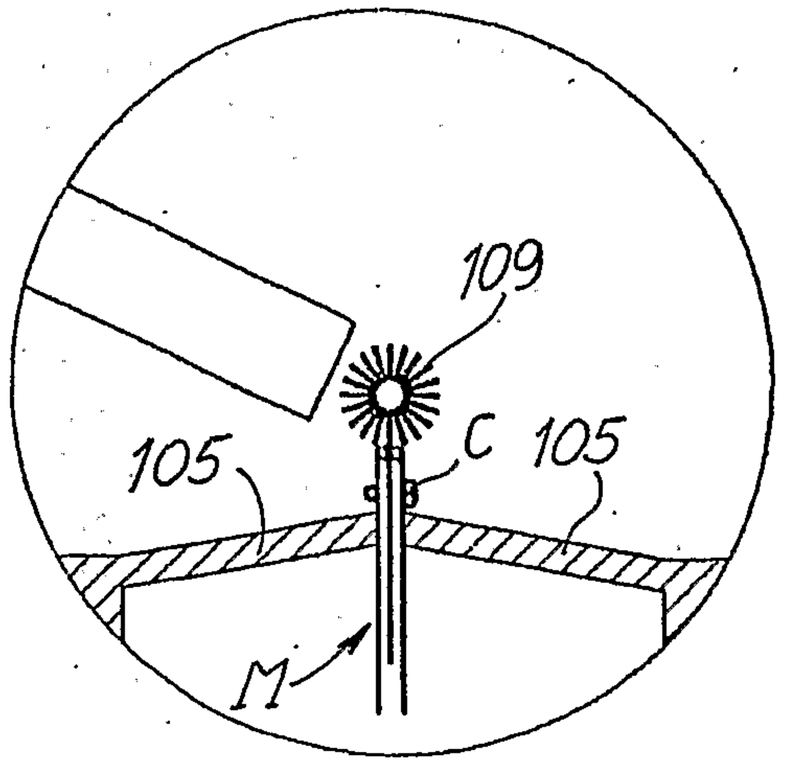


Fig.39



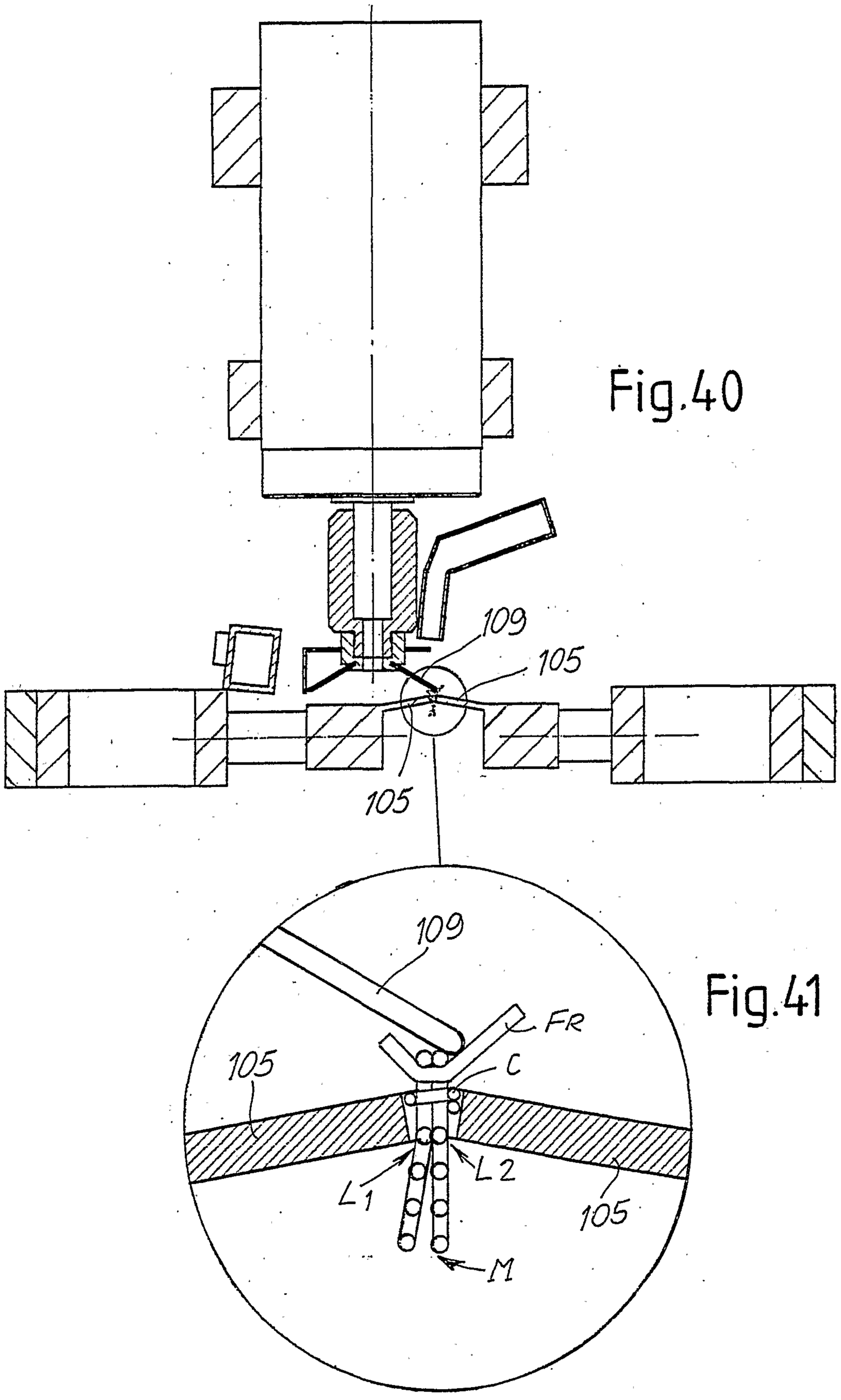
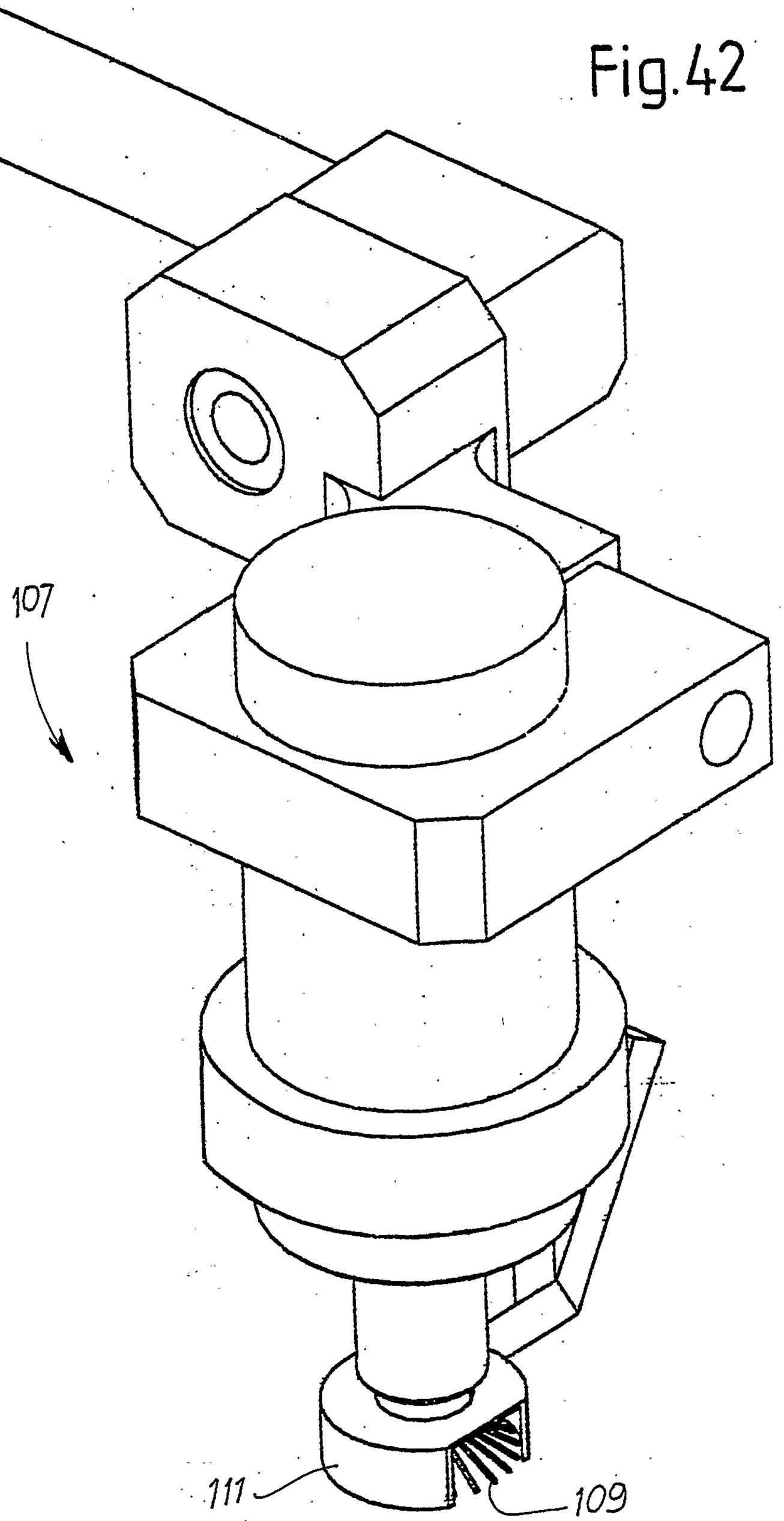


Fig.40

Fig.41

Fig.42



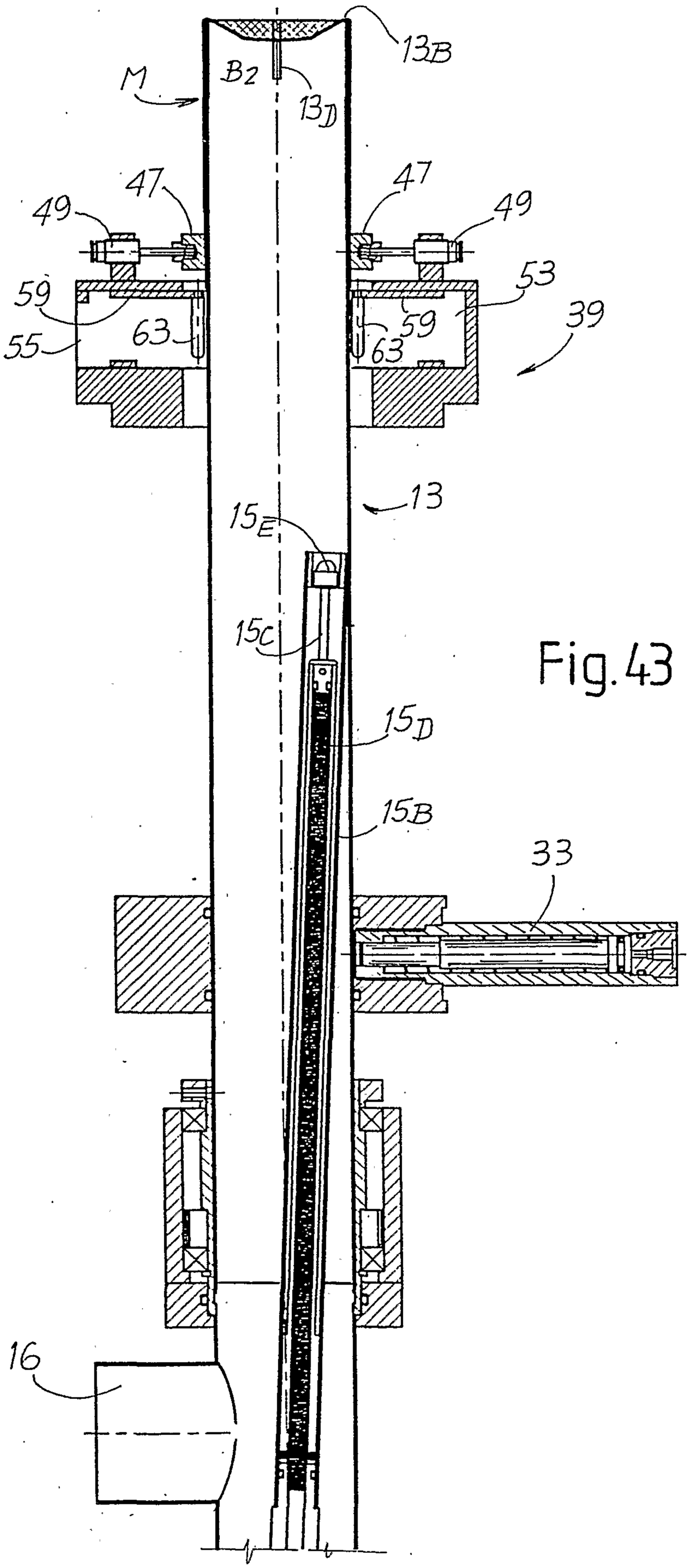


Fig.43

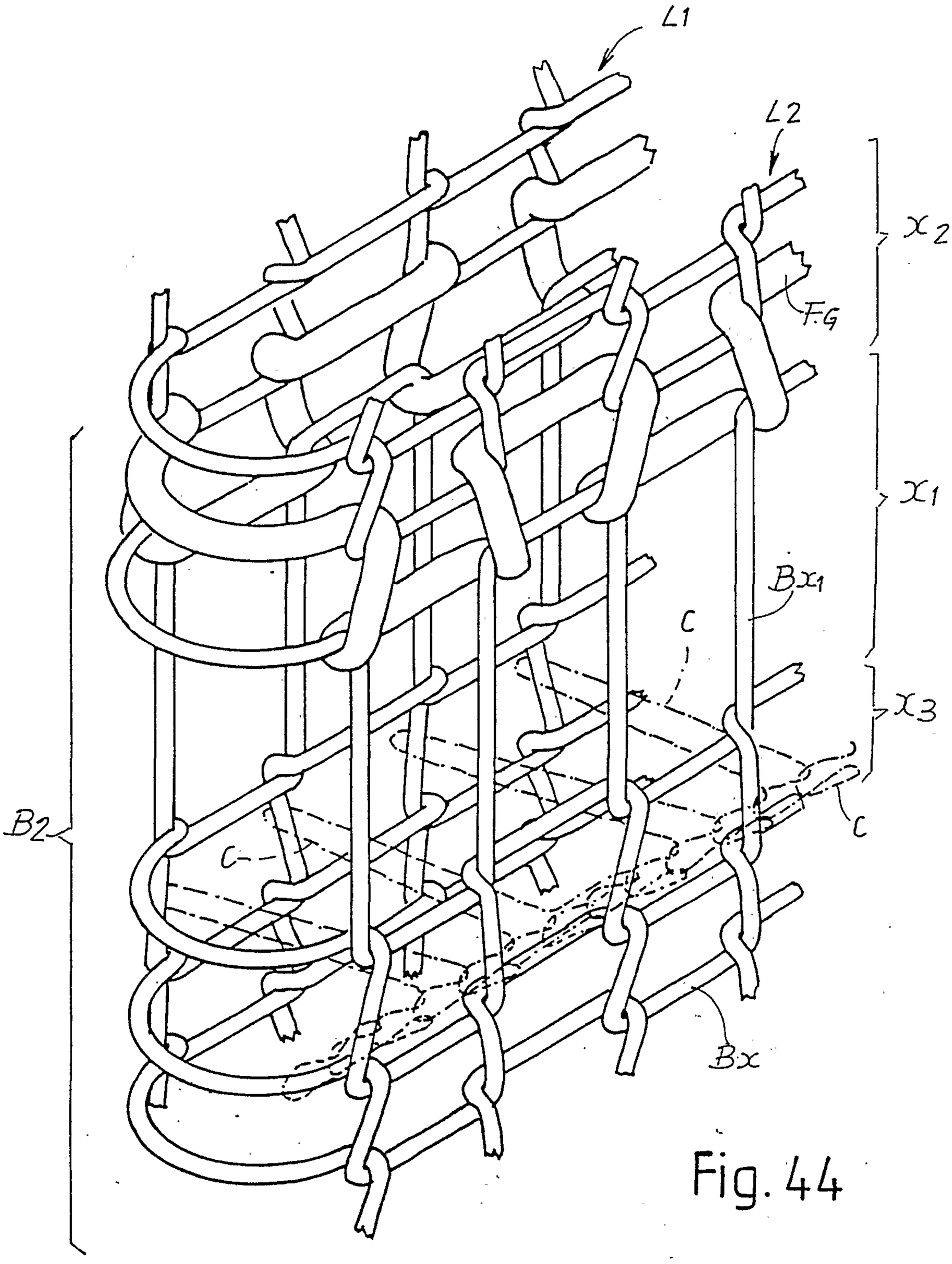


Fig. 44

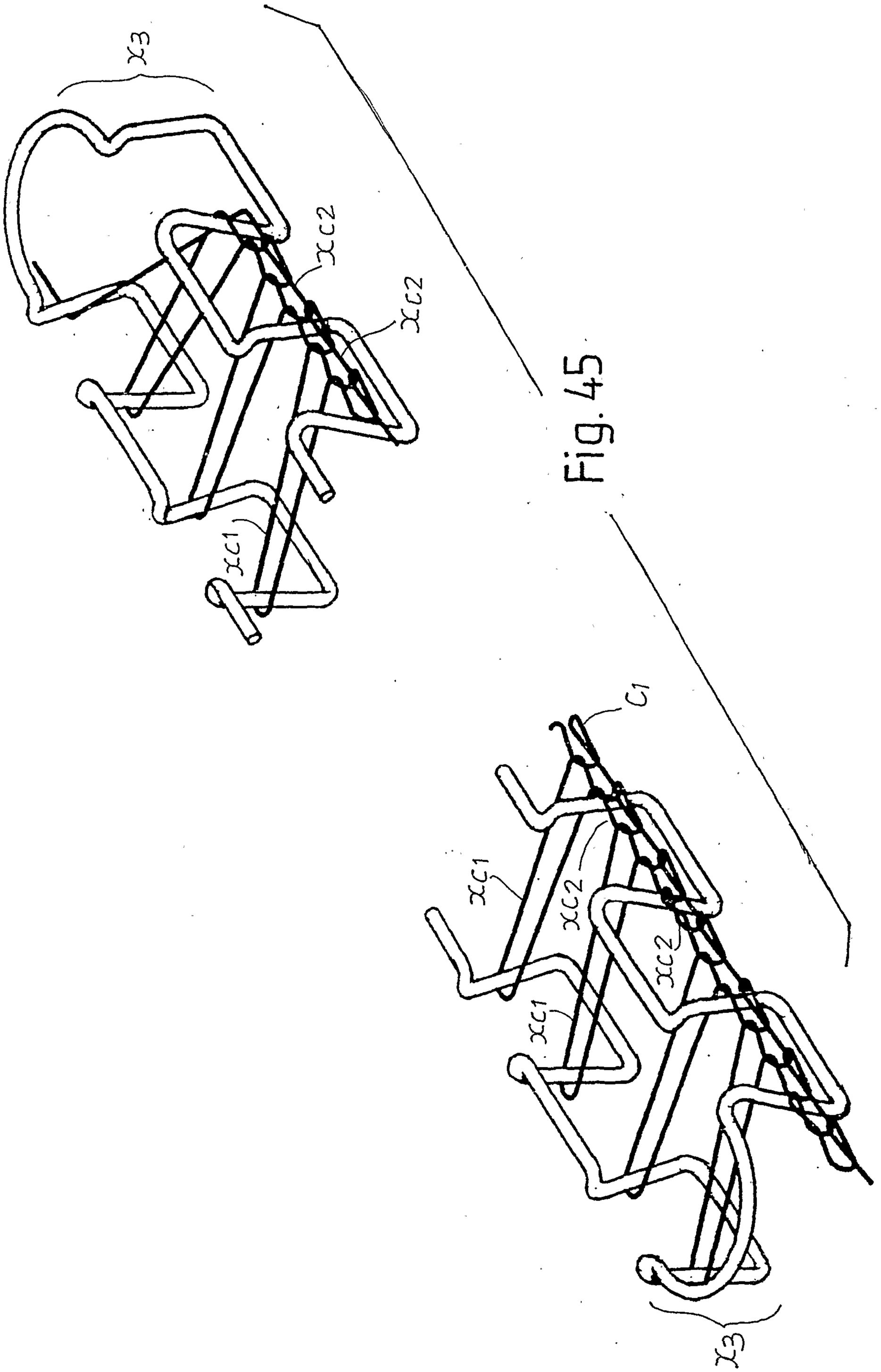


Fig. 45

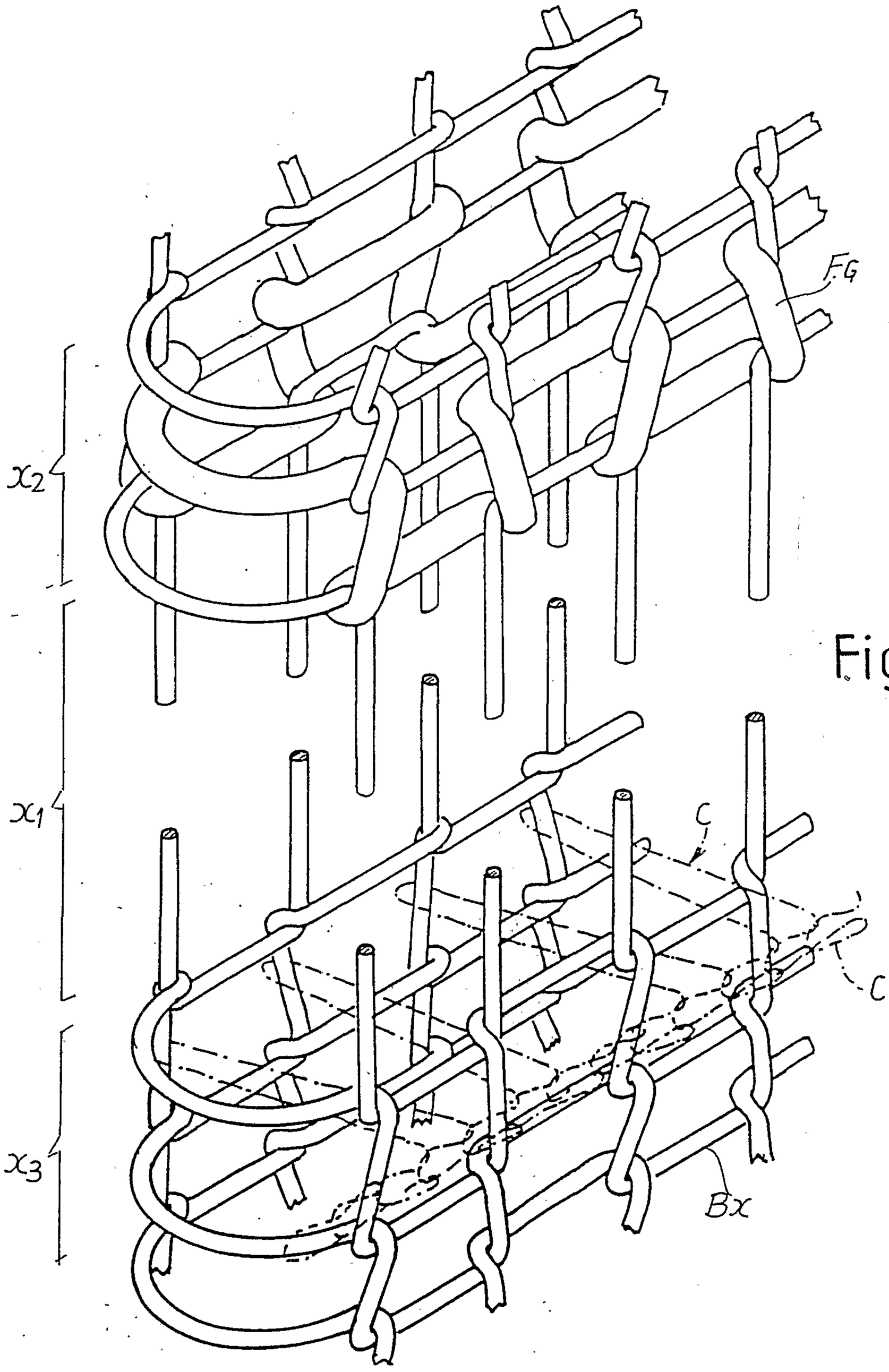
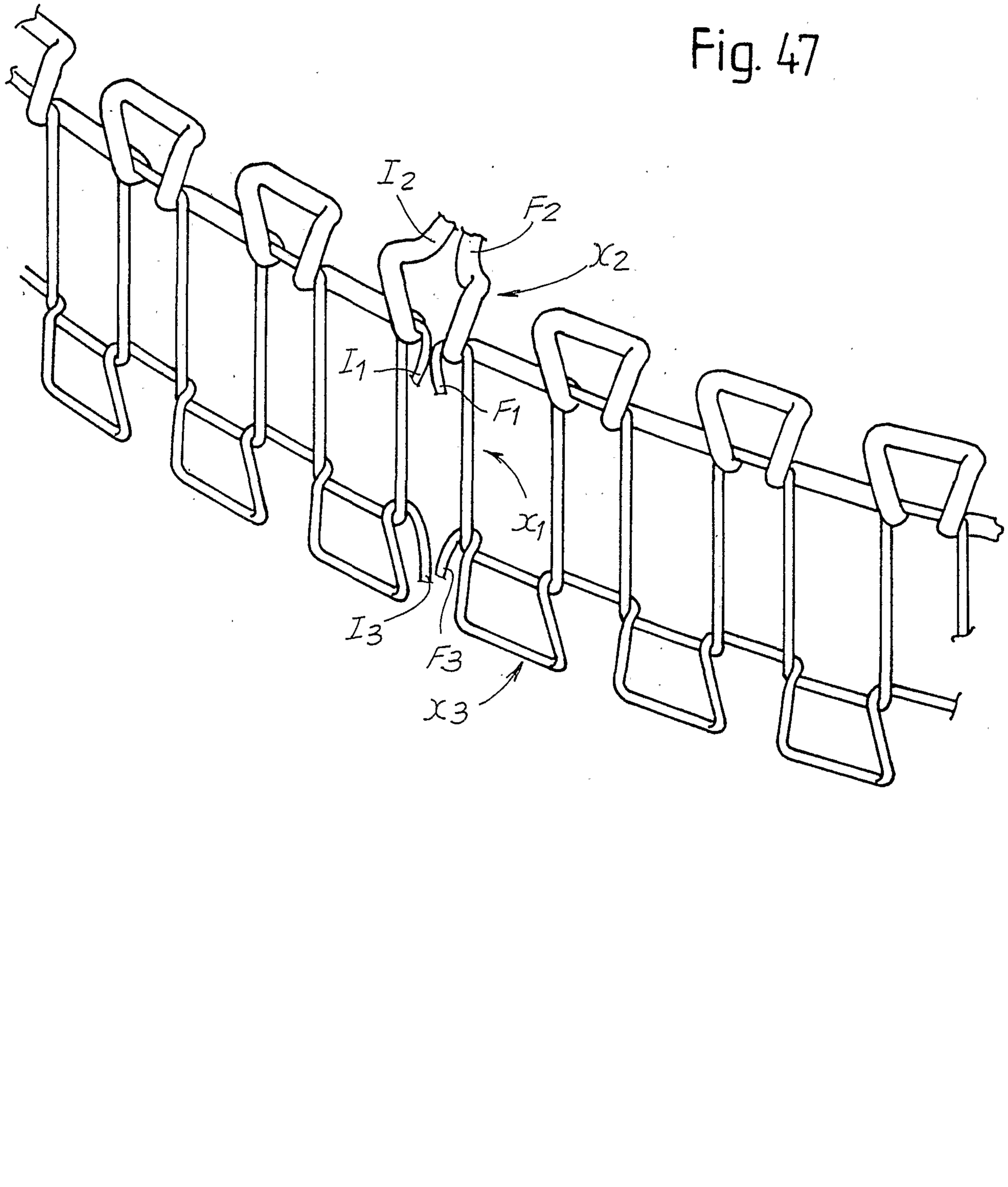


Fig. 46

Fig. 47



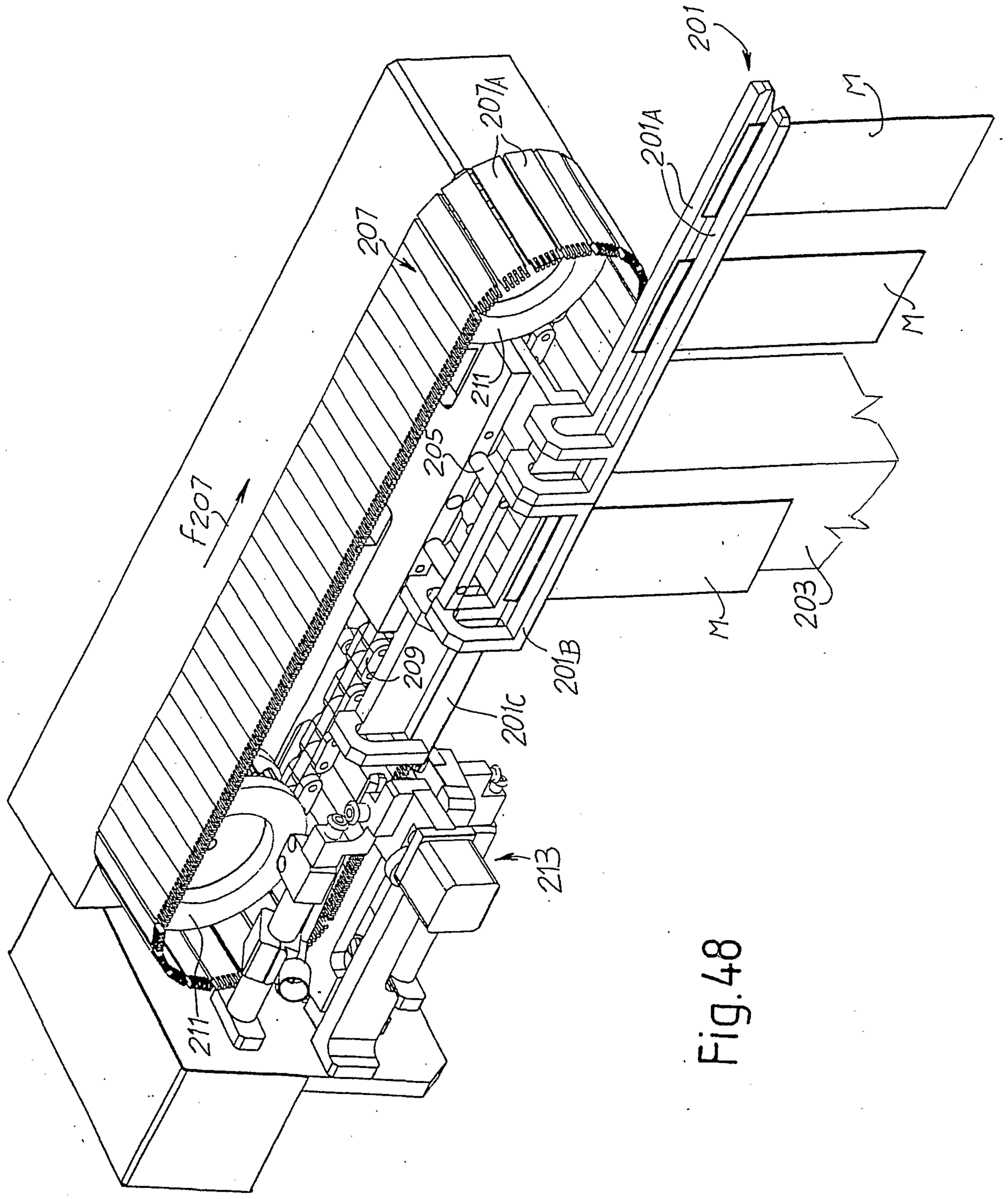


Fig.48

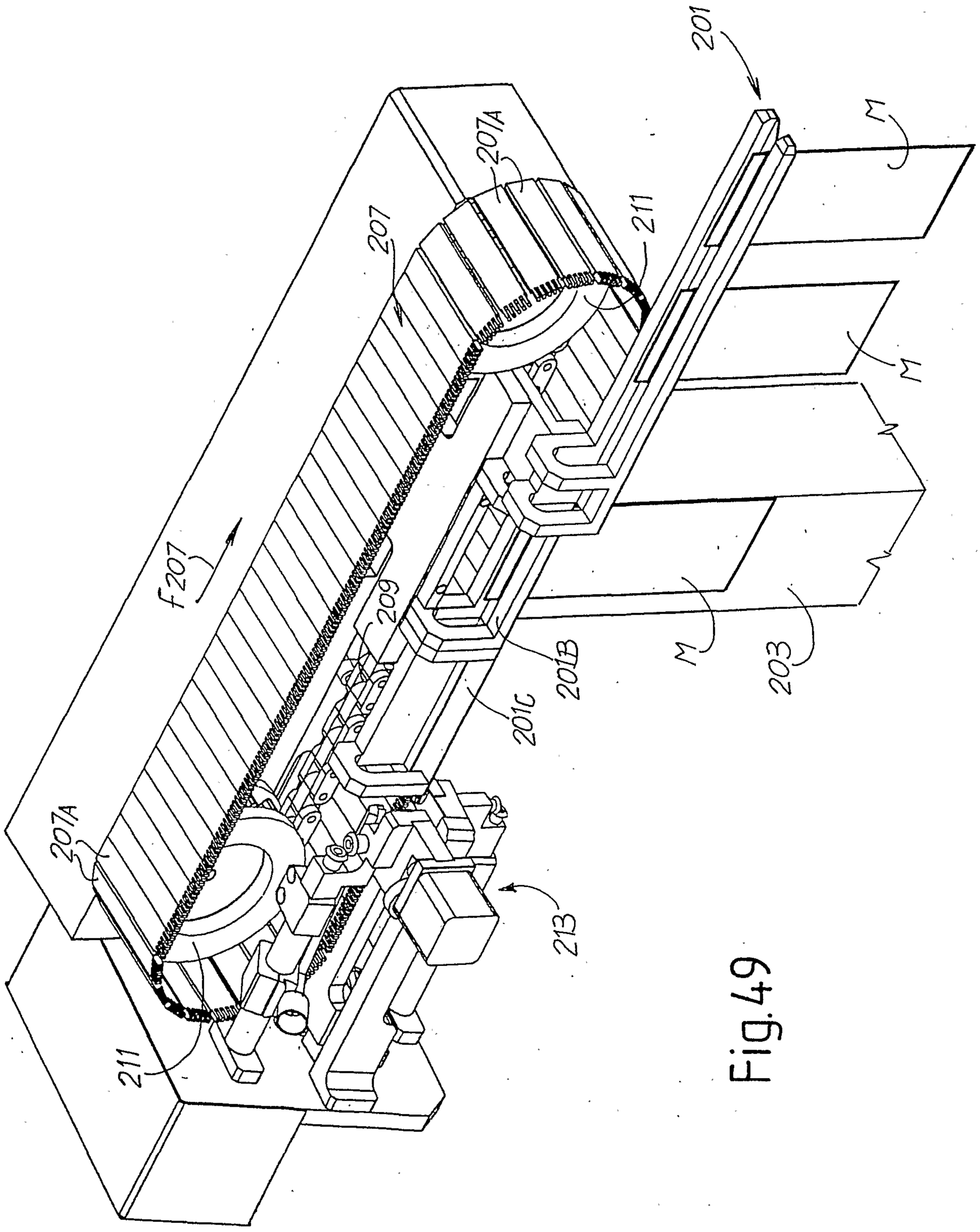


Fig.49

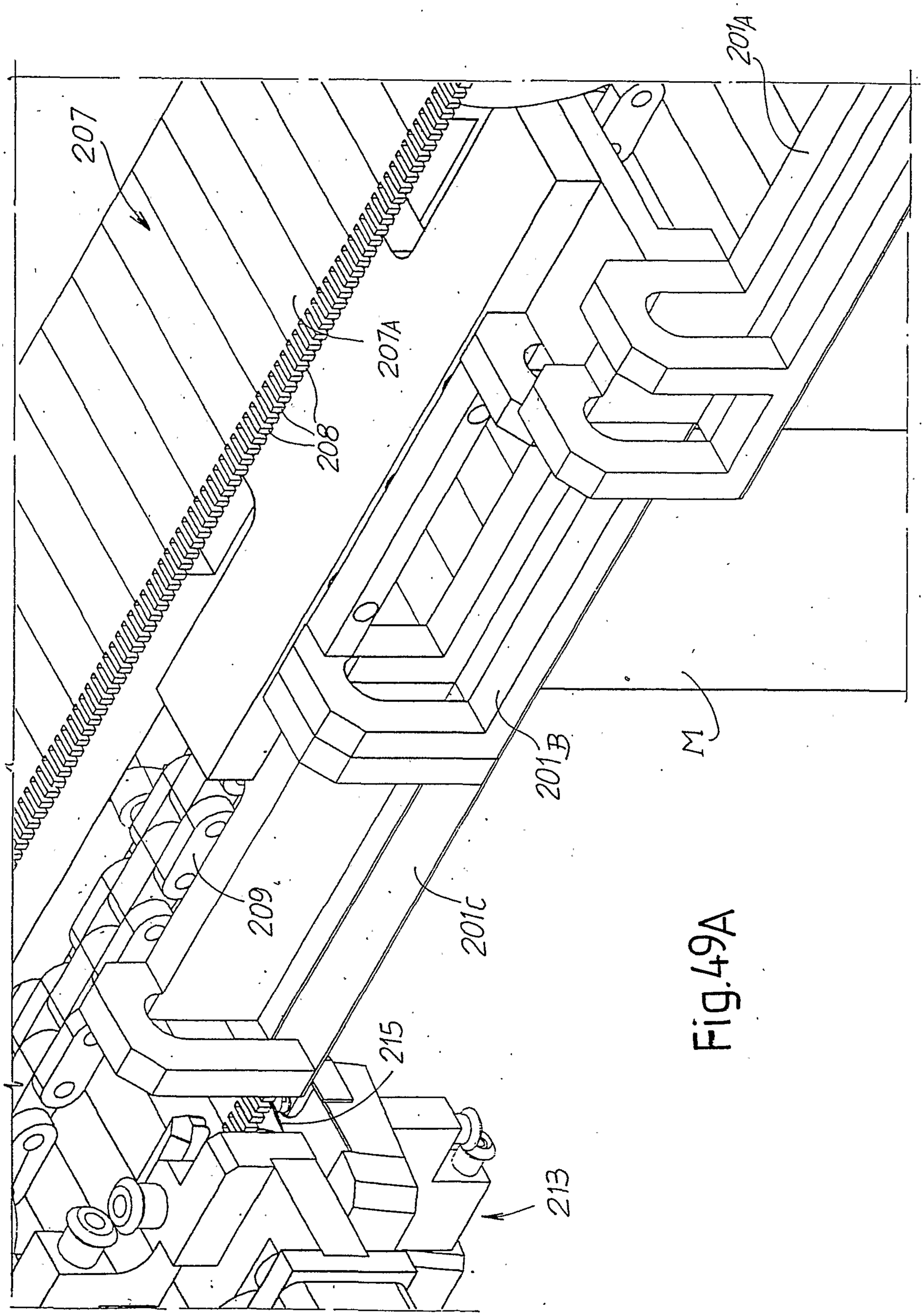


Fig.49A

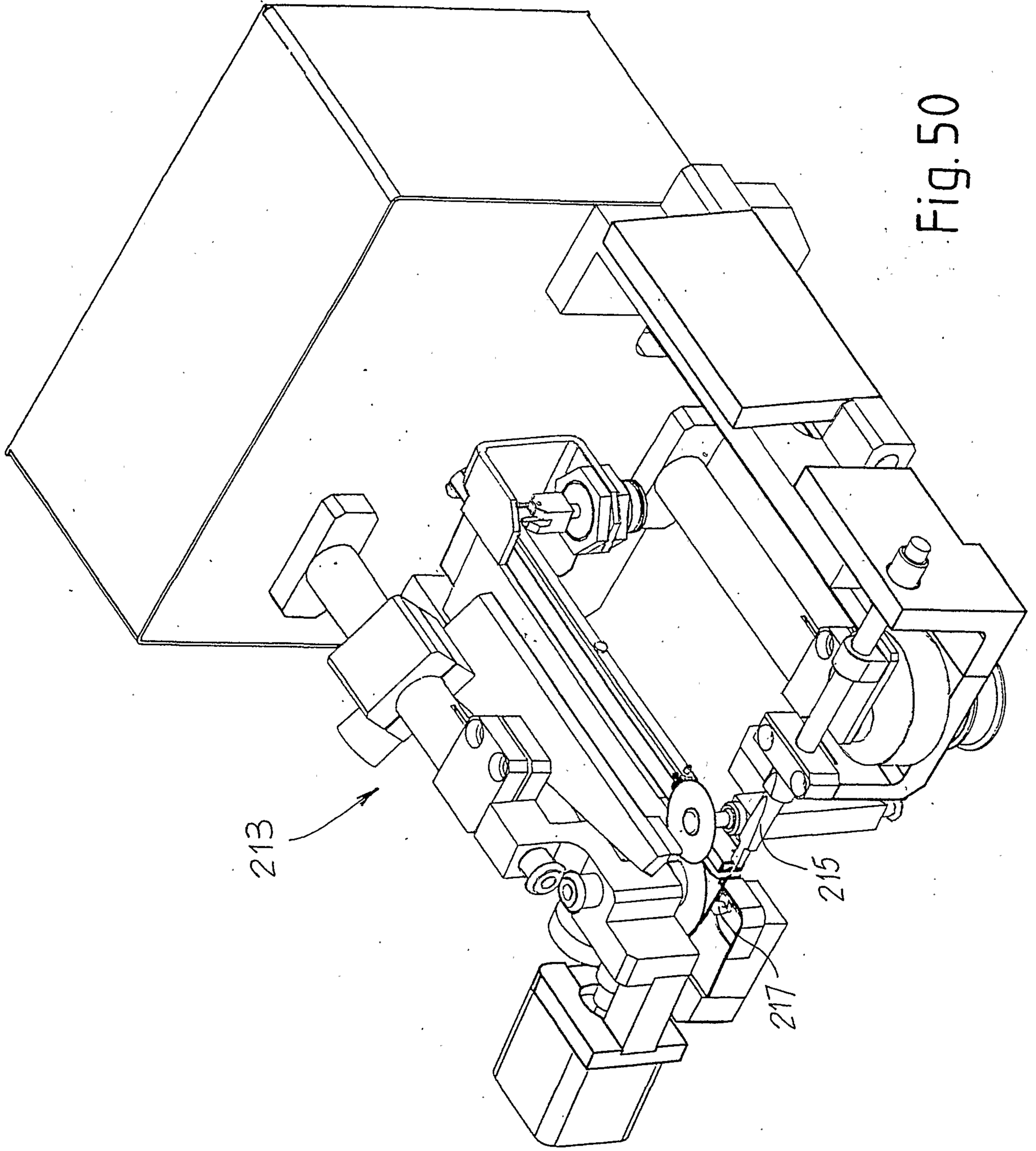
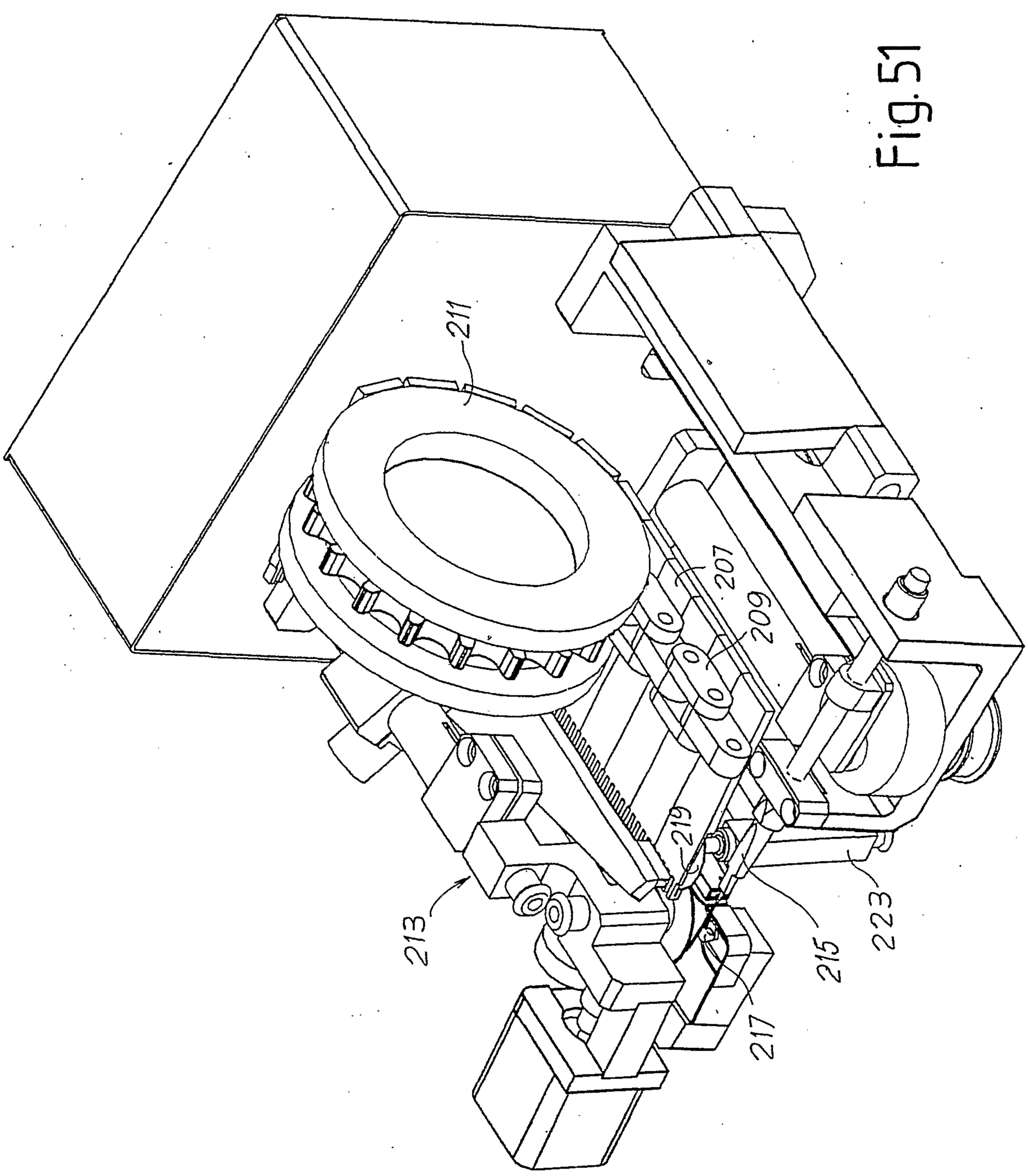


Fig.50



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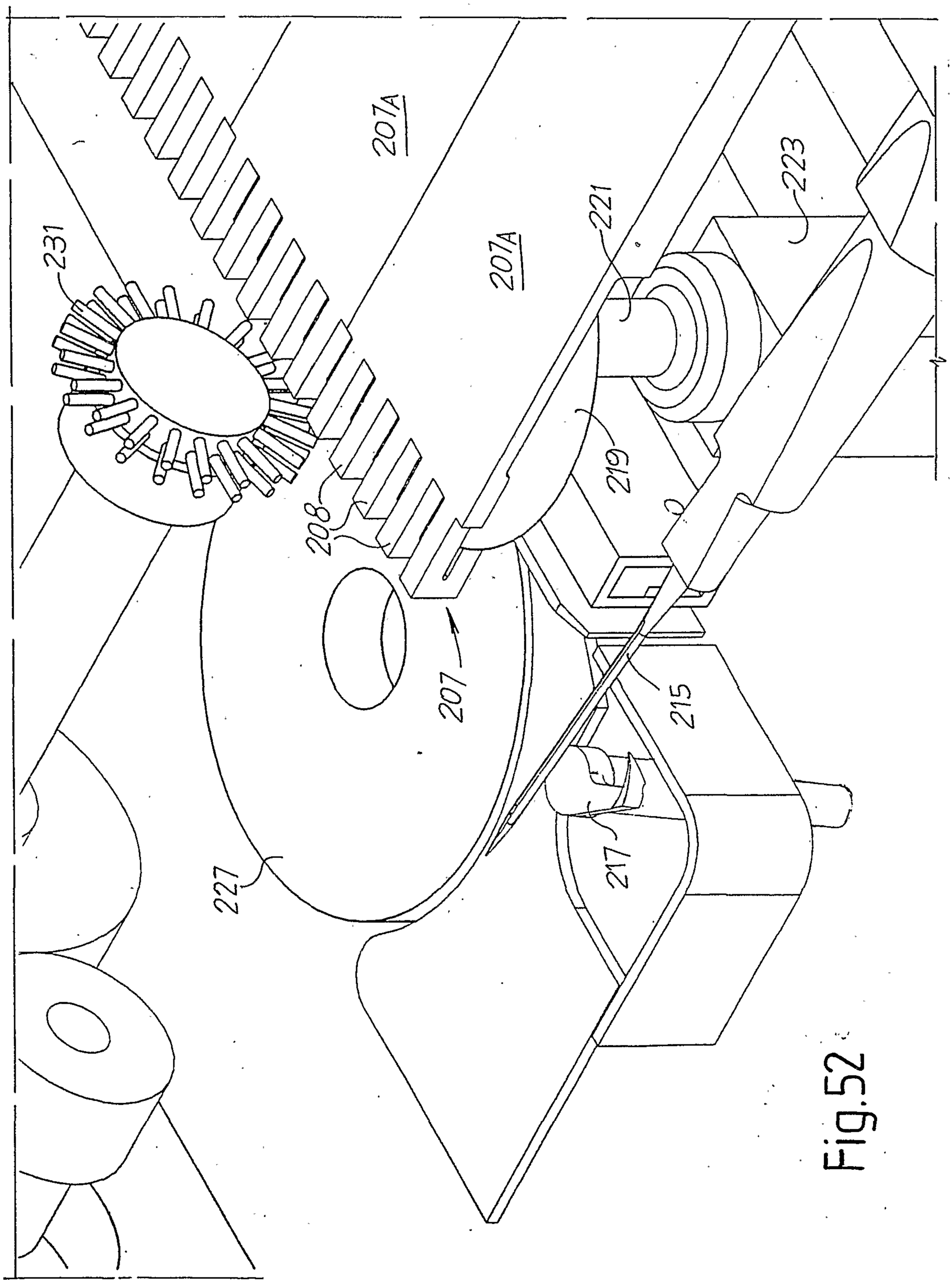


Fig.52

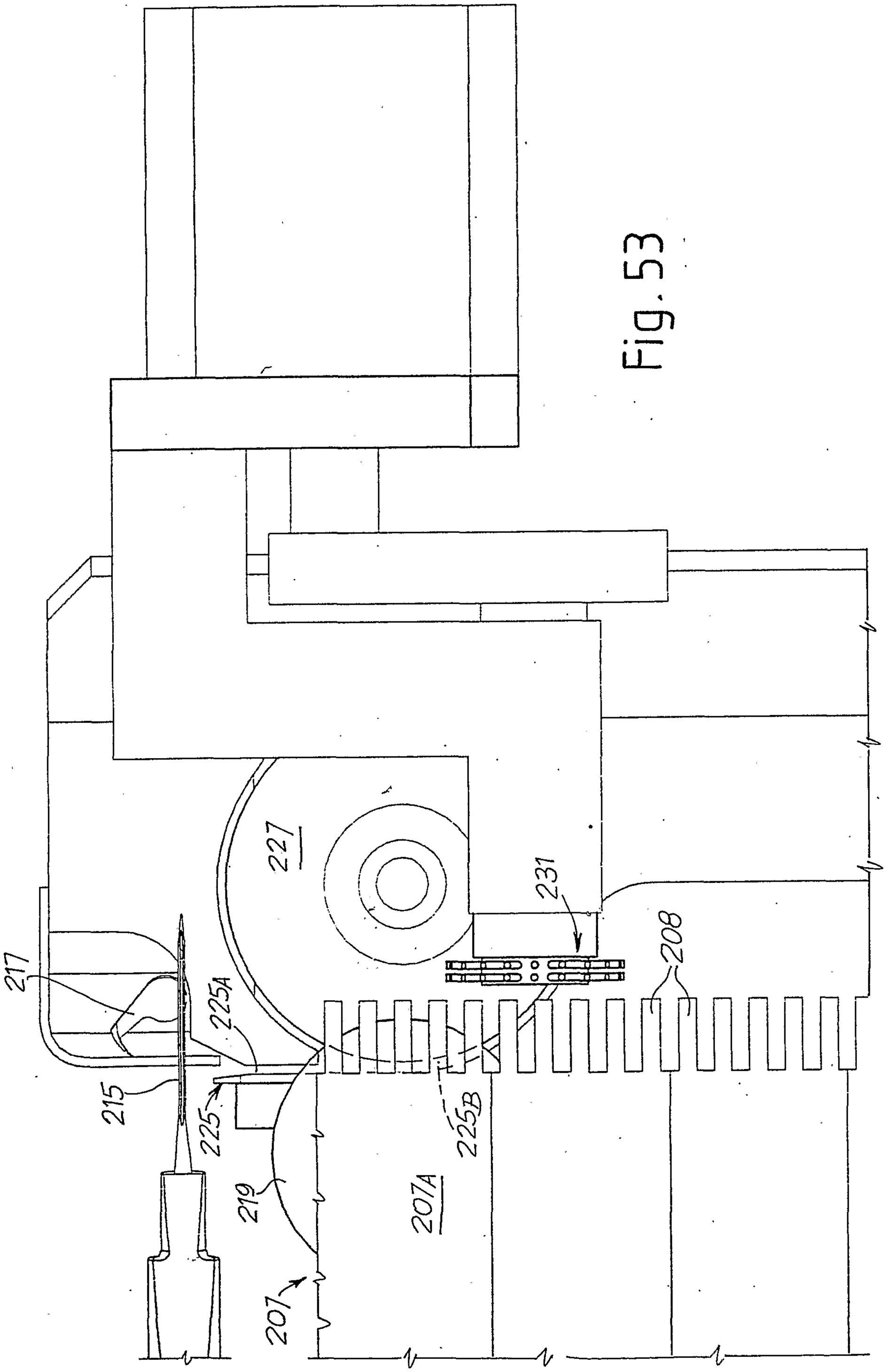
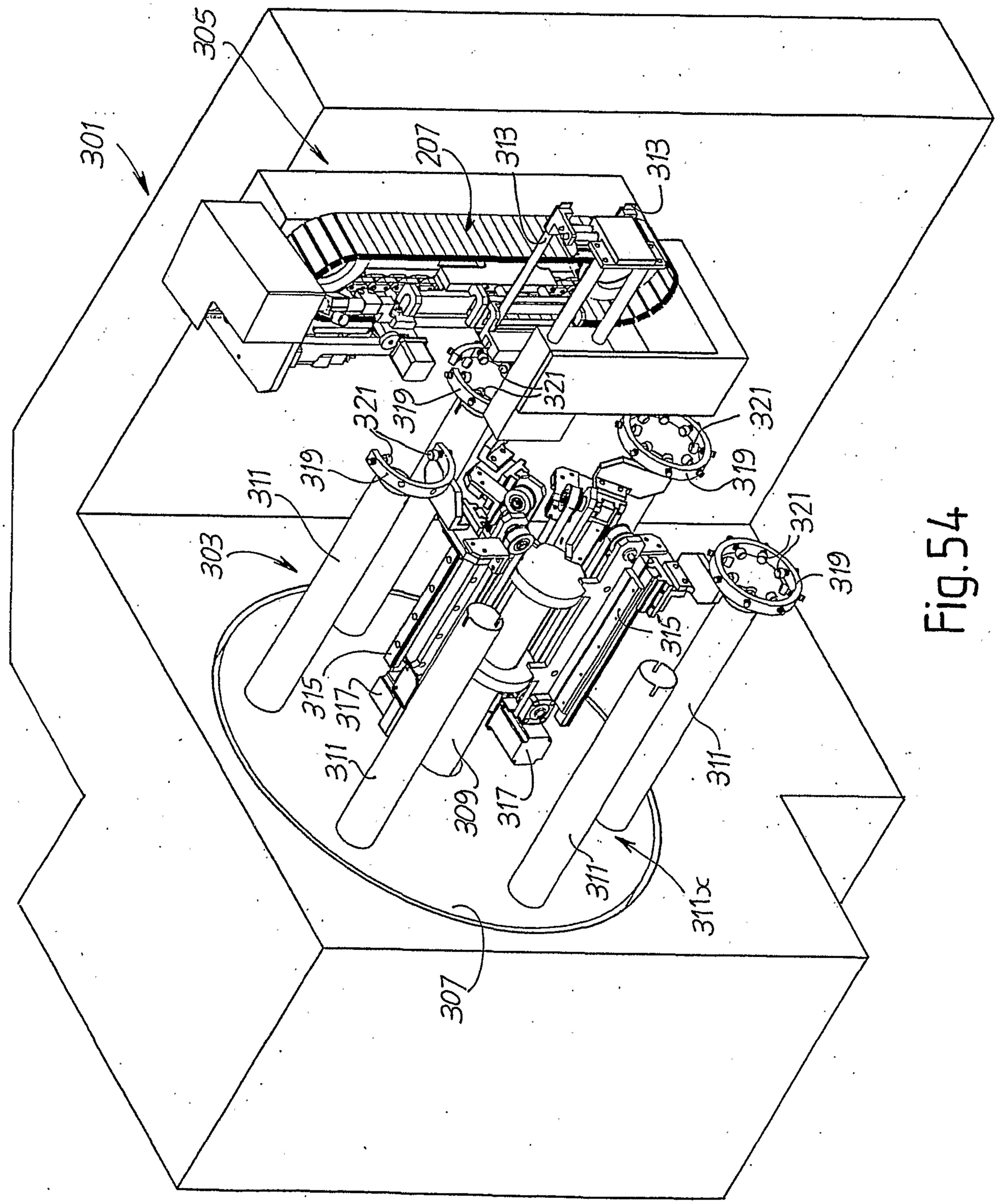


Fig. 53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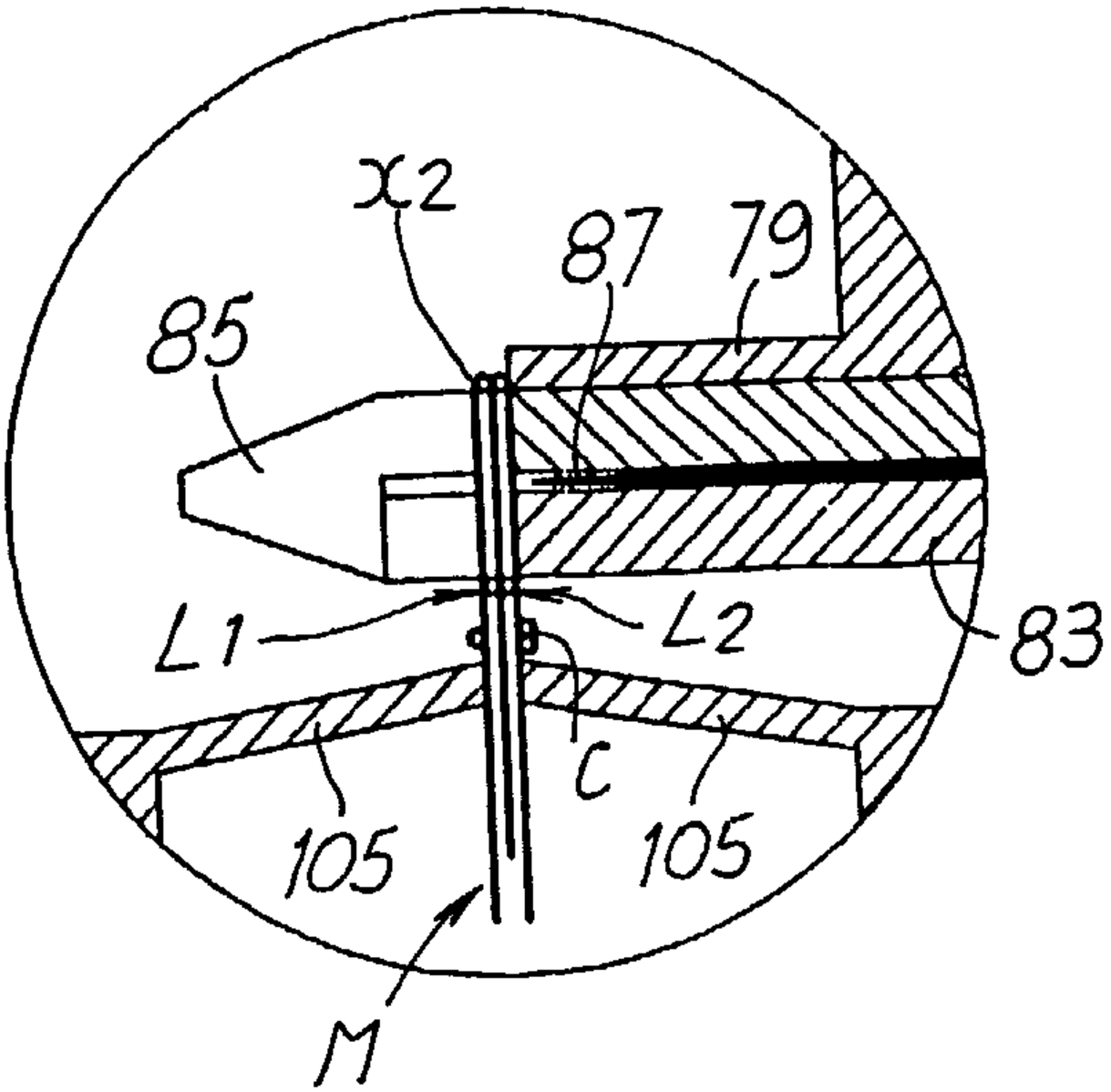
307

Fig.54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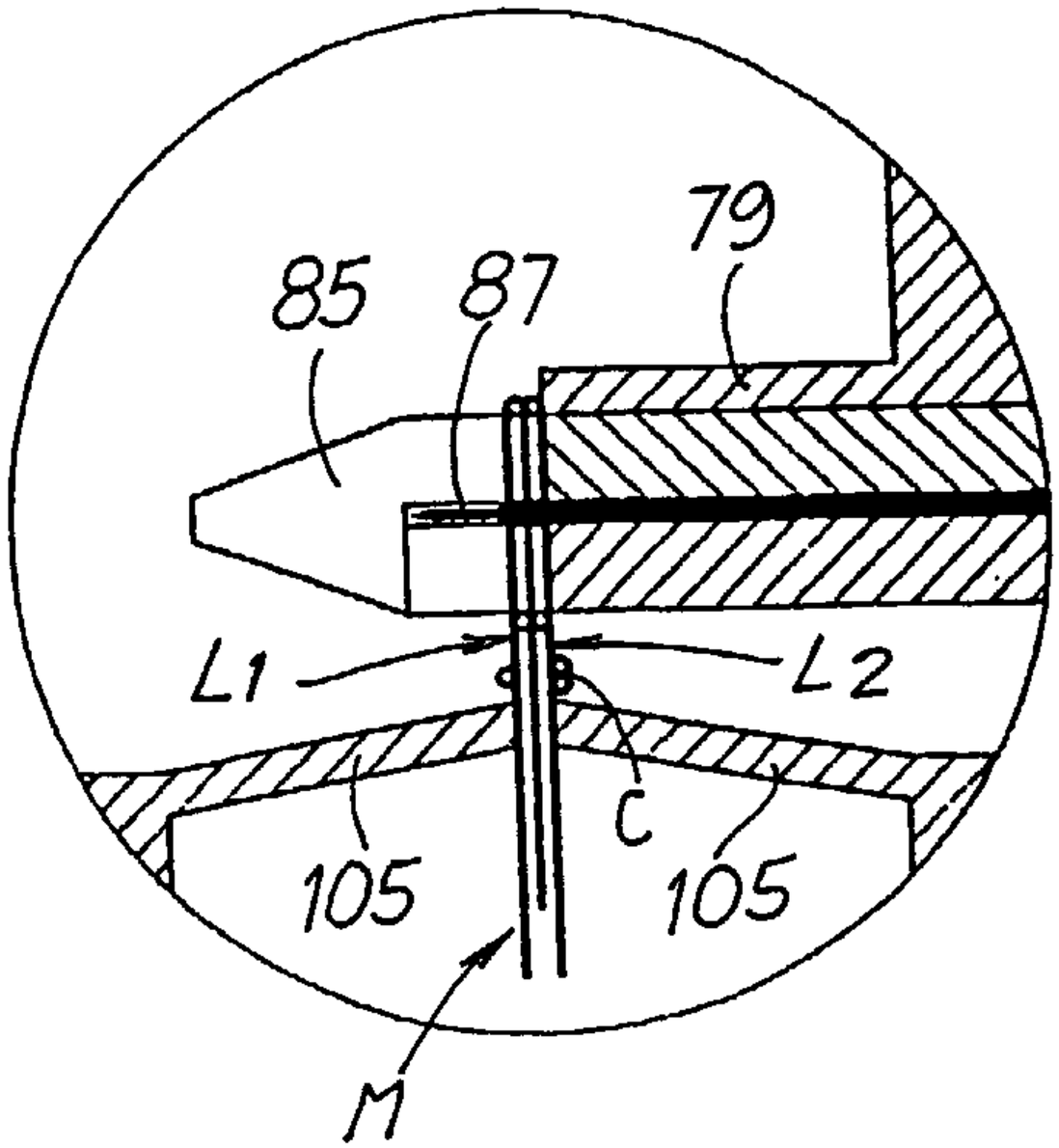
L1
L2
83
C
105
105
M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C
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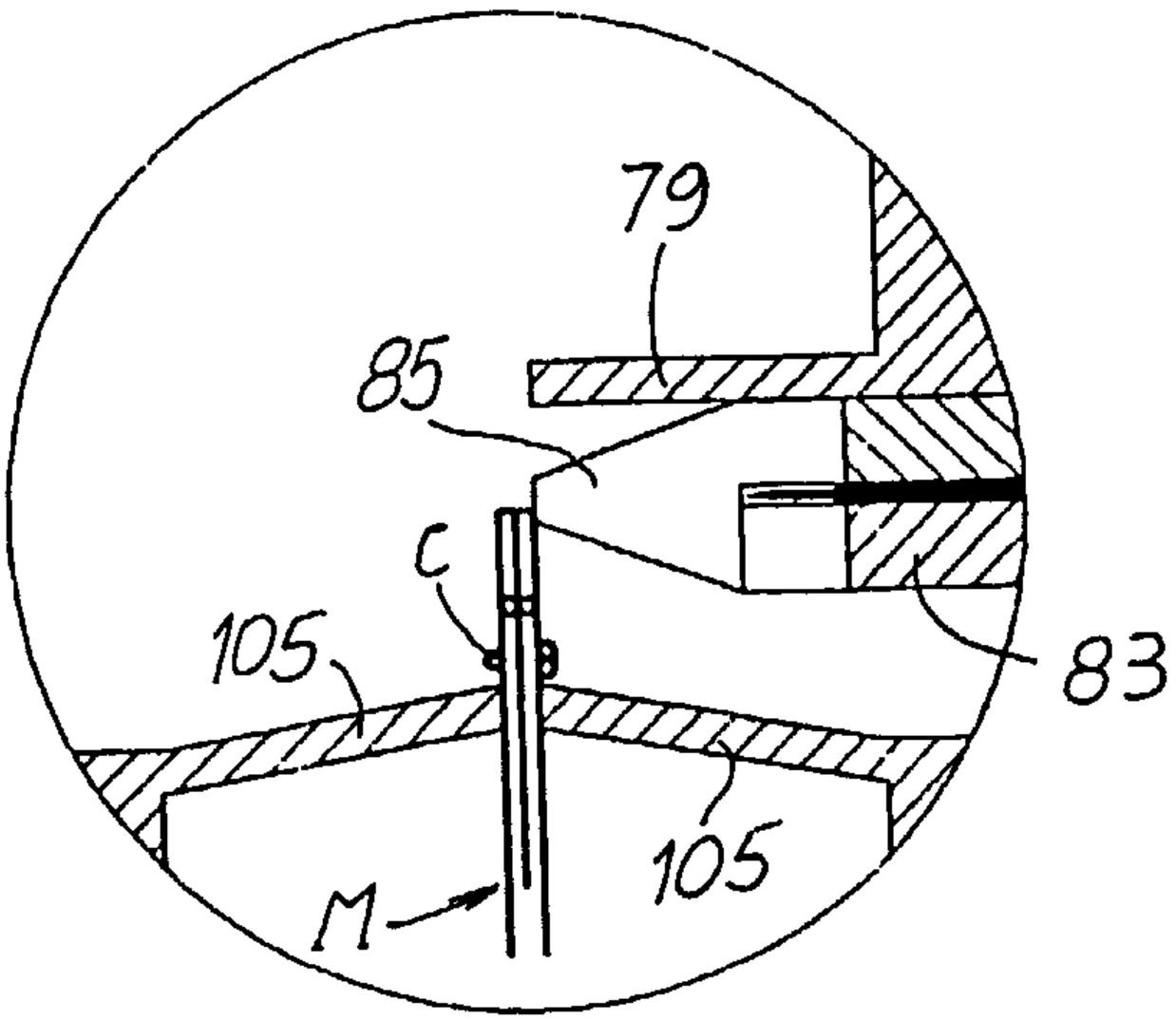
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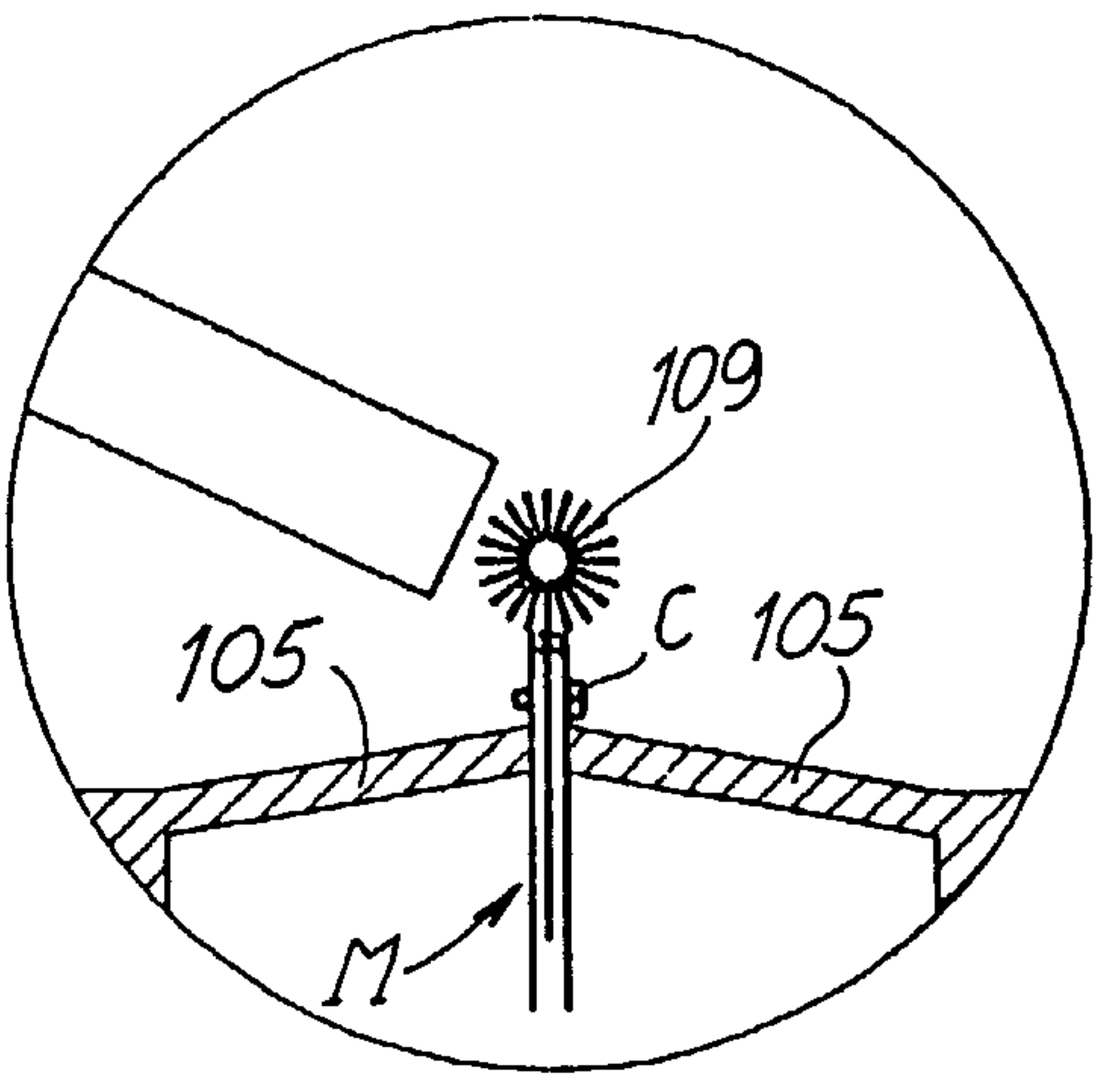
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