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(71) Applicant: **COSTRUZIONI MECANNICHE LONATI S.p.A.**
Via S. Polo, 11
I-25100 Brescia(IT)

(72) Inventor: **Lonati, Francesco**
Via Valsorda, 28
I-25100 Brescia(IT)

(74) Representative: **Modiano, Guido et al,**
MODIANO & ASSOCIATI S.A.S. Via Meravigli, 16
I-20123 Milan(IT)

(54) **Control device for a circular knitting machine, in particular a hose knitting machine.**

(57) The invention provides a circular knitting machine, in particular a single or double cylinder hose knitting machine, wherein various operations, such as the advancement of the main drum (2), speed changing, needle selection, movement of the stitch-adjusting unit (3), etc. are controlled by an electronic programming unit instead of the traditional main chain. The electronic programming unit programmingly controls a series of electro-mechanical transducers, preferably solenoid valves and pneumatic or hydraulic cylinders (12, 23), which determine the required movements of the machine operational members (2, 3). The programming unit is operative at each revolution of the machine to receive drive pulses from a revolution transducer. A considerable constructional simplification and adaptability of the machine to different knitting programs is thus achieved.

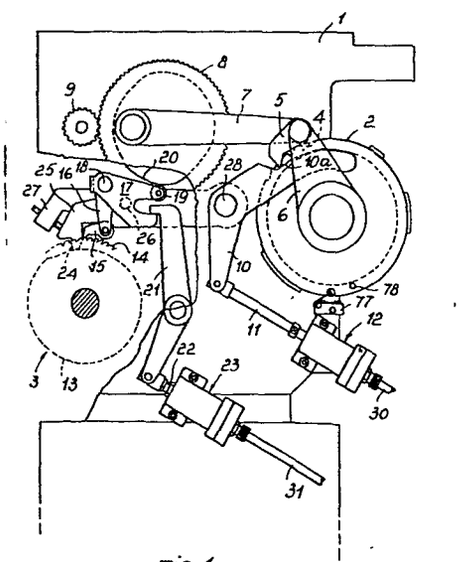

Fig. 1

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TITLE

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This invention relates to a control device for a circular knitting machine, in particular a hose knitting machine.

The various operational members of a circular knitting machine of this general type, are currently controlled by the machine main chain as a function of the product to be obtained. The main chain is advanced stepwise at a rate which is related to the needle cylinder(s) rpm, and is provided with bosses or raised portions, often having varied heights, which are engaged by pawls or other control levers, the raising whereof causes, through intervening elements, determined members of the machine to become operative such as the ones advancing the main drum, driving the stitch-adjusting unit, switching the yarn feeding fingers, etc. One full revolution of the chain usually results in a complete knitting cycle, e.g. a complete hose knitting cycle.

The problems connected with that control device in a circular knitting machine are manifold. First and foremost, the chain is to include all the necessary information to operate, at the appropriate time, the various operational members of the machine which effect the knitting. In view of the current trend toward increasingly more sophisticated knitworks, the main chain also grows more complex, it becoming in particular longer in order to accommodate the higher number of information items involved. This creates in turn space problems which cannot

always be solved by just causing the chain to follow a coiled path before it is closed into a ring.

Furthermore, the chain movement must be braked to avoid sharp accelerations, and consequently movements beyond the halting point at the end of each advancing step. Such a braked advance imposes higher stresses on the chain, which frequently results in a broken chain, as well as requiring a higher power of the members which drive the chain.

Also of considerable significance is the constructional complexity of those members which are placed under direct control by the chain. These are a large number of pawls and levers, located on the side of the machine next to the moving chain, such pawls and levers being designed to interact with one another and transfer to other members the control impulses from the chain, in order for such members to convert them in a useful movement for the knitting functions. The provision of plural mechanical members, in addition to making the construction and tuning more complex and expensive, increases the likelihood of malfunctions, which involve the necessity of stopping the machine and considerable production losses.

It should also be considered that in the event of failures and malfunctions, even when due to causes which cannot be attributed directly to such members, such as the breaking of a needle, it is necessary, after the machine has been stopped, the knitwork discharged, and the trouble repaired, to

bring the machine back to its preparatory condition to knit, in order to initiate another knitting cycle. This involves a manual rotation of the various members involved, such as the main drum, a release of the other members to bring these too to the knitting starting condition, and the advancement of the chain to the position thereof which corresponds to the start of the knitting operation. Also necessary is to check that all the members are again timed to one another to resume normal operation. It will be appreciated that this work results in a considerable waste of time, and requires skilled and appropriate attention from the servicing personnel.

Finally, it should be noted that the adaptation of a circular machine for different knitworks also requires the adaptation of the main chain, this being a time-consuming and complex operation which adversely affects the production costs.

This invention sets out to overcome the cited drawbacks by providing a control device for a circular knitting machine, in particular a hose knitting machine, which is of simpler construction than conventional ones, affords a significant simplification of the machine design, and is readily adaptable for different knitworks.

Within that general aim, it is further possible that the device as indicated has an overall size which is considerably smaller than conventional

chains and associated members, and can be incorporated to circular knitting machines for a very large variety of knitworks.

It is further possible that the device according to the invention has a structure such as to reduce the amount of manual work involved in the event of failure to reset the control device, to thus reduce the downtime and increase the machine output.

Also possible is that this device enables the knitting cycle of a given circular knitting machine incorporating the device to be modified for a limited constructional and labor effort.

According to the present invention, there is provided a control device for a circular knitting machine, in particular a hose knitting machine, adapted for controlling operational machine members, the device being characterized in that it comprises an electronic storage-type programming unit effective to produce control pulses in the sequence of operations required by the knitting process, and at least one electromechanical transducer for converting the control pulses generated by said electronic programming unit into mechanical movements for controlling said operational machine members.

Thus, a machine incorporating this control device will have its conventional main chain removed and replaced with an electronic device. It will be appreciated that all of the problems related to the mechanical chain, such as large overall size, the

risk of breakage, costly adaptability for different knitworks, are, therefore, eliminated, as eliminated are a major part of the mechanical members placed under control by the main chain.

Advantageously, moreover, the knitwork process programming and adaptation for different knitworks, such as can be stored in the electronic unit of one machine, are made much easier.

Also simplified is the resetting of the knitwork in the event of failure, since the mechanical resetting by rotation of the chain is no longer required.

Many other advantages of the invention will be more clearly apparent from the following detailed description of a control device according to the invention, a preferred but not limitative embodiment whereof is illustrated in the accompanying drawings, where:

Figure 1 is a view of the side portion of a circular knitting machine, incorporating a device according to the invention, some operational members of the machine being shown at a first operative position;

Figure 2 is a similar view, showing the same operational members at another operative position;

Figure 3 is an enlarged scale detail view of Figures 1 and 2;

Figure 4 is a sectional detail view of Figures 1 and 2;

Figures 5 and 6 illustrate the members operative to sense the needle cylinder(s) rpm for driving the control device;

Figure 7 is an elevational view, in section, of a needle selecting device according to this invention;

Figure 8 is a plan view, in section, of that same device;

Figure 9 illustrates a variation of the device shown in Figures 7 and 8;

Figure 10 shows a bank of transducer elements for converting the control pulses from the electronic programming unit into mechanical movements of the operational members;

Figure 11 is a block diagram of the electronic programming unit of this control device; and

Figure 12 shows a practical embodiment of the electronic programming unit of the device according to the invention.

With reference initially to Figures 1 and 2, a circular knitting machine, according to the invention, in particular a double cylinder hose knitting machine, has, preferably on the side portion 1 whereat the main chain is normally arranged, the actuating members for the main drum 2 and part of the actuating members for the stitch-adjusting unit 3, which is accommodated in the machine inside.

The main drum 2 comprises, in a manner known per se, a peripheral tooth formation 4, and is advanced stepwise by a pawl 5 pivoted to one end of

a crank lever 6 coaxial with the drum 2. The pawl 5 is also pivoted to one end of a connecting rod 7 which is driven back and forth by a gear wheel 8, whereto the connecting rod 7 is pivoted at an eccentric position on the other end thereof. The gear wheel 8 is meshingly driven by a pinion gear 9 which derives its motion from the machine main drive, not shown.

The pawl 5 is held normally disengaged from the tooth formation or serration 4 by an arcuate lever 10, which is pivoted at an intermediate point thereof to the side portion 1 and is provided with a guiding surface 10a wherealong the pawl 5 slides when disengaged from the serration 4. The arcuate lever 10 is displaceable between a position whereat it raises the pawl 5 above the teeth of the serration 4 (Figure 2), thus preventing the drum 2 from being advanced, and a position whereat it allows the pawl 5 to engage in between the teeth of the serration 4 (Figure 1), and hence the advancement of the drum 2. The movement between said two positions is effected through a linkage element 11, pivoted to the lever 10 at the opposite end to that provided with the guiding surface 10a. The linkage element or tie 11 is rigid with a small piston movable in a pneumatic or hydraulic cylinder 12. The piston is actuated under control by the control device according to the invention, as will be explained hereinafter.

As Figures 1 and 2 illustrate, to the stitch-adjusting unit 3, which controls in a manner known per se the progressive and local narrowing of the

stitches by a relative axial displacement between the needle cylinder and cam ring, there is rigidly attached a cam 13 the profile whereof is designed to match the desired amount of narrowing during the knitting of the product. Rigid with the cam 13 is also a ratchet or sawtooth wheel 14; which is caused to advance by a pawl 15 pivoted to one end of an arm 16, the other end whereof is rigid with a yoke element 17, in turn pivoted for free rotation about an axle 18 extending parallel to the axis of the drum 2. The element 17 carries a small roller 19 which follows a cam 20 rotating with the gear wheel 8. One revolution of the latter results in one or more oscillations of the element 17 about its axle 18, and hence in the advancement of the cam 13 through one or more steps. As is known, one complete revolution of the cam 13 corresponds to the knitting of one hose or other finished product.

Between the prongs or projections of the yoke element 17, a hooked end can be received of a lever 21 pivoted at an intermediate point to the side portion 1 about a parallel axis to the axle 18 and at the opposite end to a linkage member or tie 22. The latter is rigid with a small piston slidable in a pneumatic or hydraulic cylinder 23, preferably similar to the cylinder 12. It will be appreciated that by actuating the piston , in the manner explained hereinafter, the lever 21 is displaced between two angular positions, at one of which (Figure 1) it locks the yoke element 17, which

will no longer ride the profile of the cam 19, thereby the pawl 15 is no longer advanced and the cam 13 remains stationary, whereas at the other angular position (Figure 2) the lever 21 releases the element 17, which results in the stepwise advancement of the gear wheel 14 and, accordingly, of the cam 13.

The cam 13 is followed by the hook 24 of a small lever 25 pivoted at 26 to a lever 27 the free end whereof is supported by the lever 25 with relative adjustment provisions (Figure 3). The lever 27 is pivoted to the stationary structure of the machine, at 28. The raising and dropping movements of the lever 27 in riding the profile of the cam 13 produce, in a manner known per se, the axial relative displacement between the needle cylinder and the cam ring, to result in different length stitches.

Each pneumatic cylinder 12 and 23 includes (Figure 4) a small piston 28 biased by a spring 29 to move into a rest position close to the intake end of the cylinder 12 or 23, whereto a supply conduit 30, respectively 31, is connected. Each conduit 30,31 is connected to a respective solenoid valve 32 in the bank 33 of solenoid valves shown in Figure 10. The programmed actuation of the solenoid valves by the electronic programming unit, to be described hereinafter, results in the admission of pressurized fluid to the cylinder 12 and/or 23, and therefore, in the displacement of the respective small pistons 28 and members connected thereto

between the two positions described hereinabove, depending on knitting requirements. The pressurized fluid is fed to the solenoid valve bank 33 through a conduit 34 from a source of fluid under pressure, not shown. The fluid is discharged from the conduits 30,31 through openings or ports 35 in the solenoid valves.

A machine incorporating the control device of this invention further comprises members for sensing the rpm of the needle cylinder(s) to drive the electronic programming unit. In the embodiment shown in Figures 5 and 6, a disk 36 is provided rigid with a rotating member 37, which is driven rotatively at a 1:1 ratio with the (lower) needle cylinder 38. The disk 36 has a radial pin 39 which moves between a pair of photoelectric members or phototransistors 40. Each passage of the pin 39 will cause the phototransistors 40 to generate a pulse, which is then sent to the electronic programming unit 41 (Figures 11,12). Thus, there will occur a pulse for each revolution of the cylinder, that is for each knitting course.

Advantageously, the control device of this invention also lends itself to electromechanically controlling the machine needle selecting devices. An exemplary embodiment is shown in Figures 7,8 and 9.

The needle selecting device comprises, in this instance, a stationary supporting structure 42 having slidable therein, in a radial direction to

the needle cylinder 38, selection slides 43 adapted for interfering with pattern butts 44 of jacks 45, which control in a conventional manner the needles (not shown). The jacks 45, as selectively urged by one of the slides 43 into the position shown in Figure 7, ride a cam 46 to bring the respective needles to knit. The contrary occurs when the jacks are not pushed to the position shown in Figure 7; in this case, they will pass at a low position externally to the cam 46.

With each slide 43, there is associated a pneumatic actuating device 47 comprising a cylindrical chamber 48, formed in the supporting structure 42, and a small piston 49 arranged to slide in said chamber. The piston 49 has a rod 50 which is passed through a closure element 51 of the chamber 48, on the same side as the cylinder 38, and is effective to engage a respective slide 43. From the opposite end of the chamber 48, there extends a conduit 52 for a fluid under pressure, the conduit terminating into one solenoid valve 32 in the bank 33. Owing to the height dimension of the slide pack 43, the actuating devices 47 of adjacent slides 43 are offset in the structure 42. Each slide 43, moreover, is subjected to the action of a biasing spring 53, one end whereof is secured to the slide 43 and the other to the stationary structure 42.

It will be appreciated that the admission of pressurized fluid through the respective valve 32

into the chamber 48 determines a movement of the piston 49 toward the cylinder 38, and hence the displacement of the slide 43 to the position of Figure 7, whereat the needle associated with the jack 45 in engagement with the slide 43 is brought to knit. It will also be apparent that, by selectively actuating the solenoid valves 32 associated with the slides 43, in accordance with the selection program set in the electronic programming unit to be described hereinafter, the desired needle selection can be accomplished.

Figure 9 illustrates a modified embodiment of the selection device just described. In this embodiment, the pneumatic actuating device 47 has been replaced with an electromagnet 54, program-wise energized directly from the electronic programming unit and provided with a rod-like movable anchor 55, adapted for engaging a respective slide 43. Also in this case, the electromagnets 54 are offset on the structure 42 for space reasons.

Advantageously, with a selection device of the type shown in Figures 7 to 9, where the various slides are selectively actuated by means of electric pulses, it becomes possible to arrange the slides, either in sets or singly, at staggered locations along the cylinder 38, to follow, for example, the arrangement of the pattern butts of adjacent jacks, such as to have sufficient room and time for the actuation of the individual slides during the rotation of the needle cylinder. In this

case, it is possible to derive the control pulses for actuating the slides in succession by means of a photoelectric device of the same type as discussed with reference to Figures 5 and 6, which comprises a rotating pin and a number of phototransistors arrayed in succession along the path of the rotating pin, each phototransistor being associated with one slide or set of slides.

The electronic programming unit 41 comprises essentially a microprocessor 56, a pair of random access memories (RAM) 57,58, a read-only memory (ROM) 59, and a number of peripheral interface adapters (PIA) 60,61,62,and 63. Also provided is a keyboard 64 for writing in the program, which is connected to the unit through the adapter 60, while two displays 65,66 enable the machine revolutions and the spared number of revolutions (when a certain number of operations are to be reiterated identically for a given number of machine revolutions, in which case the preceding program is maintained for the required number of revolutions before fresh knitting operations are resumed), respectively, to be read visually, the displays being connected to the unit through the adapter 61. To the adapter 62 are instead supplied the signals from the revolution transducer 67, in the form of the members 36-40 of Figures 5 and 6, and optionally, also the program information stored in a magnetic recorder represented schematically by the block 68. The control output of the unit 41 is represented by the

adapter 63, which controls a number of amplifiers 69, one for each machine member or unit to be controlled, whereto respective solenoid valves 31 are connected. The unit 41 is fed through a feeder 70 or by a battery 71, and the microprocessor 56 is driven by a crystal controlled oscillator 72. The components of the electronic programming unit are respectively connected through connections 73 and 74, the former being the data bus and the latter the address bus.

It should be noted that the microprocessor 56 processes and checks the data input from the machine, as well as those written with the keyboard in accordance with the machine operational program, to compare them each time with those contained in the various memories. Specifically, the read-only memory 59 stores the main program, which is then adapted, as the case may be, to the requirements of a specific knitting operation by means of the random access memories 57,58. Thus, the unit is made extremely versatile and suitable for a large number of operational programs.

The various components are electronic components which are readily available commercially, and require no further description herein. For example, the random access memories (RAM) 57,58 may be of the Intel 5114 type by CMOS Static RAM Corporation; the read-only memory (ROM) 59 may be of the TMS 2708 JL type by Texas Instruments; the microprocessor 56 may be of the MC 6800 type by

Motorola, Inc.; and the peripheral interface adapters (PIA) 60,61,62,63 may be of the MC 6820 type, also by Motorola, Inc..

In actual practice, the operational program will be prepared with due consideration to the various functions to be performed by the machine at each revolution of the needle cylinder(s) (main drum advancing, stitch-adjusting unit advancing, needle selecting, etc.). Such functions, in actual practice, will be each controlled through one solenoid valve 31. Therefore, the matter is one of actuating and de-actuating the respective solenoid valve 31 at a given time during one or more machine revolutions. Thus, after identifying the various revolutions of the machine with progressive numbers, one dials on the keyboard 64, at each program step (corresponding to the step of the traditional mechanical chain) the number corresponding to the solenoid valve(s) associated with the mechanical members which are to complete certain functions during that particular step, and this until the knitting cycle is completed, to thus accomplish the programming of the electronic unit 40. Thus, the unit is made ready to operate. The keyboard may also include reset, cancellation, fast and unit advance keys, etc.

Advantageously, the programming unit can be supplied with machine control data from a magnetic tape, e.g. as contained in a magnetic tape cassette. Thus, by simply replacing the

cassette with another containing a different program, one is enabled to readily re-program the machine for a different knitting cycle. It will be appreciated how this, in a conventional machine incorporating a mechanical main chain, involves time-consuming work, because the whole chain must be replaced materially with another which has been prepared with a sequence of bosses different from the one replaced.

The programming unit according to this invention can also be utilized to change the machine speed. In this case, the adapter 49 would energize or de-energize, in accordance with the change to be effected (switching from medium speed to a higher or lower speed, and viceversa), a relay, which controls the motor, e.g. through a full wave TRIAC, and applies a voltage to respective windings in the motor or removes it therefrom, to de-energize them.

Figure 12 illustrates diagrammatically one embodiment of the electronic programming unit. This is provided on a printed circuit card, including the various components discussed in the foregoing. The reference numerals 75,76 designate terminals for connecting the unit to the power supply and to the utilizing circuits.

In Figures 1 and 2, moreover, there is shown a microswitch 77, which is actuated by a pin or peg 78 rigid with the main drum 2. The microswitch 77, as suitably connected to the programmer 41,

serves the function of resetting the programmer upon completion of one complete revolution of the main drum 2, thereby initiating a fresh knitting cycle.

It will be apparent from the foregoing description that the control device according to the invention considerably simplifies, from the structural standpoint, the side member or side portion of the machine, which normally carries, in addition to the mechanical main chain, several linkages and other moving mechanical members. Also greatly simplified is the machine setting operation following a failure and discarding of the product. In fact, the zeroing of the electronic programming unit is accomplished instantaneously, e.g. by means of a specially provided key on the keybcard 64, while it also becomes possible, in the case of a single cylinder machine for knitting heel-less stockings or hoses, to achieve an automatic and continuous advancement of the main drum 2, under the action of the pawl 5, at a high speed to the zero position. In the instance of a machine adapted for knitting heeled stockings or hoses, however, the main drum shall have to be zeroed manually, although the advantage is retained that no mechanical chain must be zeroed manually.

The inventive device, moreover, lends itself to a quick change of the knitting program. It is in fact possible to store several programs, and in conformity with the selected program, to push

a key down to start a new knitting machine program. Alternatively, the magnetic tape cassette may be replaced which supplies the knitting data to the electronic unit 41.

The entire electronic unit, according to the embodiment illustrated, can be contained in a very modest space, thereby, when it is considered that many linkages are eliminated from the machine incorporating this control device, the overall dimensions of the machine can be reduced considerably.

The invention as described is susceptible to many modifications and variations within the same inventive concept. Thus, for example, instead of the pneumatic cylinders 12 and 23, and related pistons 28, electromagnets may be provided, under direct control from the respective amplifiers 69 of the electronic programming unit 41, such as to eliminate altogether the solenoid valves 31 and related lines for the pressurized fluid.

In addition to the members indicated, which are controlled by the electronic programmer, other members could also be controlled, such as the movements of the yarn feeding fingers. The expert will have no difficulty to implement this application of the instant inventive concept.

Of course, the device described hereinabove can be applied both to single cylinder machines and double cylinder ones, or cylinder and dial machines.

CLAIMS

1. A control device for a circular knitting machine, in particular a hose knitting machine, adapted for controlling operational machine members, the device being characterized in that it comprises an electronic storage-type programming unit (41) effective to produce control pulses in the sequence of operations required by the knitting process, and at least one electromechanical transducer (33;54) for converting the control pulses generated by said electronic programming unit (41) into mechanical movements for controlling said operational machine members (2, 3, 45).

2. A device according to Claim 1, characterized in that said at least one electromechanical transducer (33) comprises at least one solenoid valve (32) actuated by said electronic programming unit (41) and operative to admit fluid under pressure into a pneumatic or hydraulic cylinder (12,23,48) wherein a piston (28,51) is slidable, said piston (28,51) being operatively connected to a respective one of said operational members (2,3, 45).

3. A device according to Claim 1, characterized in that said at least one electromechanical transducer comprises at least one electromagnet (54) activated by said electronic programming unit (41) and having a movable anchor (55) operatively connected to a respective one of said operational members (45).

4. A device according to Claims 1 and 2 or 1 and 3, characterized in that to said at least one electromechanical transducer (33) there is connected one end of a lever (10) pivoted, at an intermediate point thereof, to the machine stationary structure (1) and having an opposite end adapted for de-actuating, under control by said transducer (33), the advancement pawl (5) of the machine main drum (2).

5. A device according to Claims 1 and 2 or 1 and 3, characterized in that said at least one electromechanical transducer (33) is associated with one end of a lever (21) pivoted, at an intermediate point thereof, to the machine stationary structure (1) and having an opposite end in the shape of a hook adapted for penetrating a yoke element (17) carrying a pawl (15) for advancing a cam (13) of a stitch-adjusting device (3), known per se, the engagement of said opposite end with said yoke element (17) causing said pawl (15) to stop.

6. A device according to Claims 1 and 2, or 1 and 3, characterized in that a plurality of electromechanical transducers (33,54) are provided for selective control by said electronic programming unit (41), said transducers (33,54) being associated each with a selection slide (43) of a needle selecting device to move the respective selection slide (43) between a position whereat the selection slide (43) does not interfere with the pattern butts (44) of jacks (45) associated with the needles

and a position whereat the selection slide (43) interferes with one of said butts (44).

7. A device according to one or more of the preceding claims, characterized in that it comprises members effective to drive said electronic programming unit (41), said drive members including a disk (36) rotating synchronically with the needle cylinder(s) (38) and being provided with at least one radial pin (39), and at least one photoelectric element (40), preferably a phototransistor, in the path of said rotating pin (39) for generating a drive pulse to said electronic programming unit (41) for each revolution of the needle cylinder(s) (38).

8. A device according to one or more of the preceding claims, characterized in that said electronic programming unit (41) comprises a microprocessor (56), at least one read-only memory (ROM) (59) containing a main knitting program, at least a pair of random access memories (RAM) (57,58) containing a specific knitting program, peripheral interface adapters (PIA) (60,61,62,63) for connecting said microprocessor (56) and said memories (57,58,59) to a keyboard type of programming device (64), a machine number of revolutions display (65), a member (67) supplying pulses to said electronic programming unit (41) synchronically with the revolutions of the needle cylinder(s) (38) in the machine, and at least one amplifier (69) adapted for controlling said at least one electromechanical transducer (33,54).

9. A device according to one or more of the

preceding claims, characterized in that said electronic programming unit (41) is controlled by means of a magnetic tape (68) containing a knitting program.

10. A device according to one or more of the preceding claims, characterized in that it comprises a pin or peg (78) rigid with the machine main drum (2) and a microswitch (77) actuated by said pin or peg (78) at each complete revolution of said main drum (2) to zero said electronic programming unit (41) at the end of each knitting cycle.

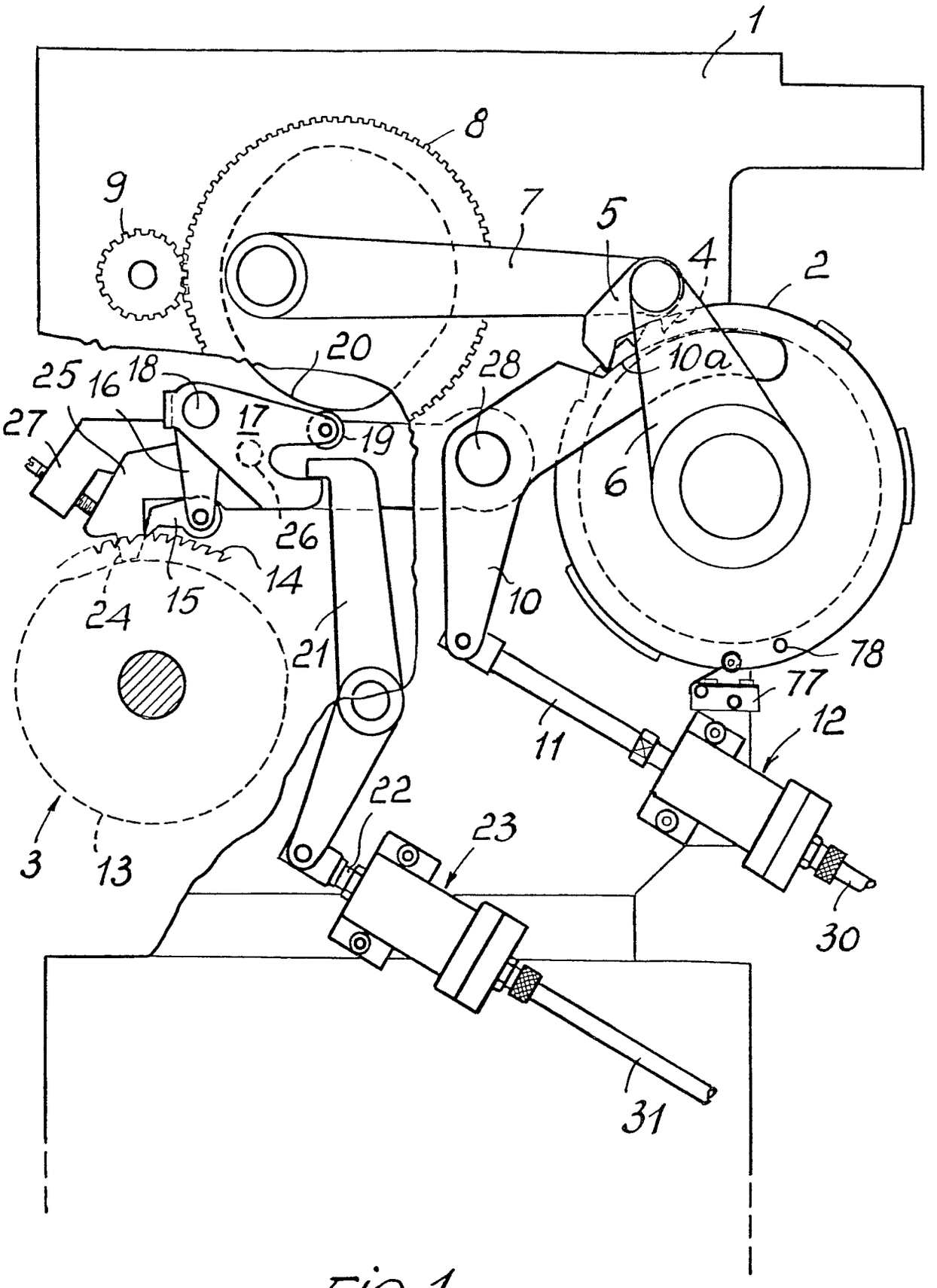
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Fig. 1

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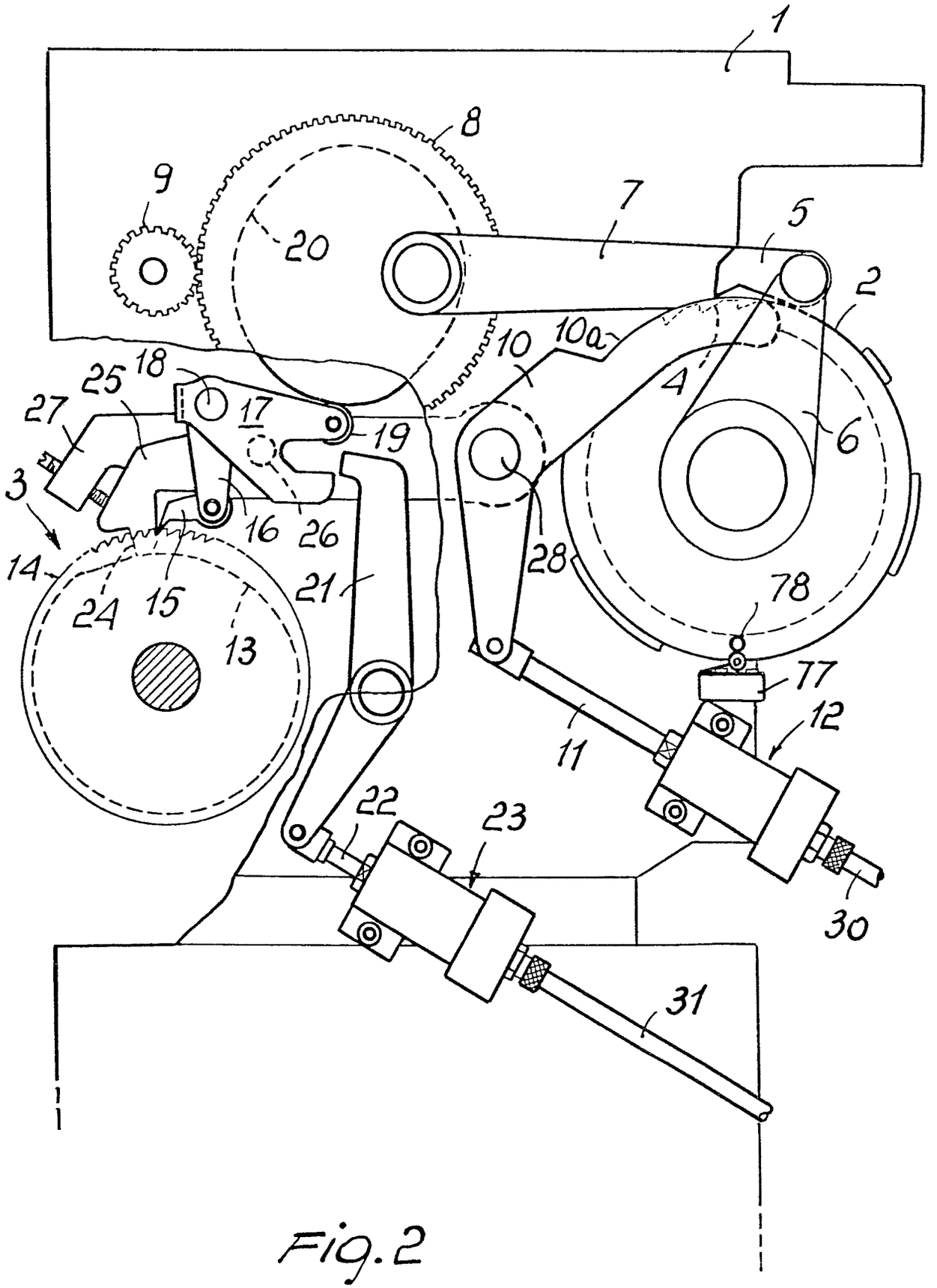

Fig. 2

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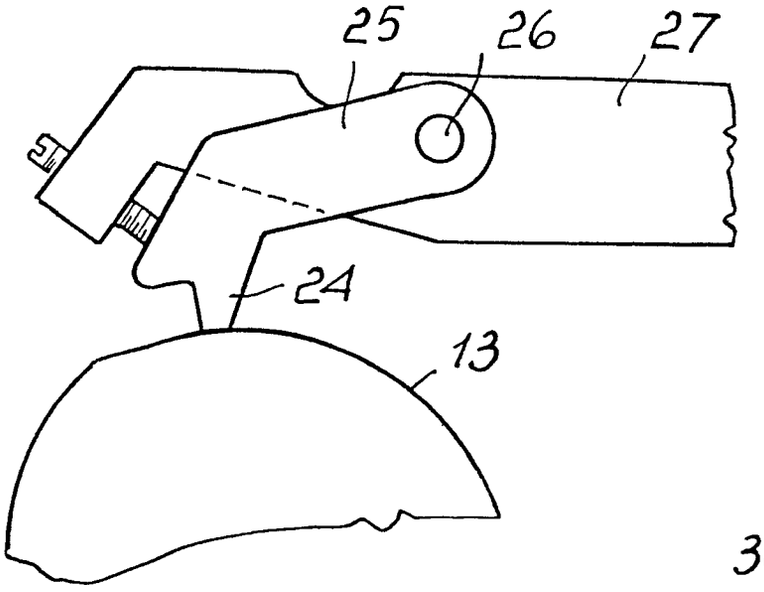

Fig. 3

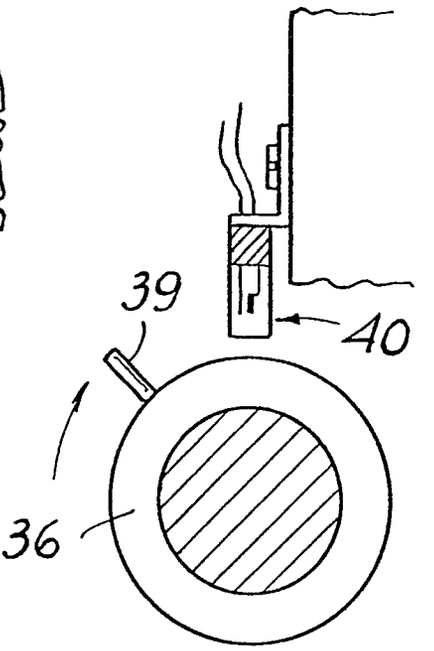

Fig. 6

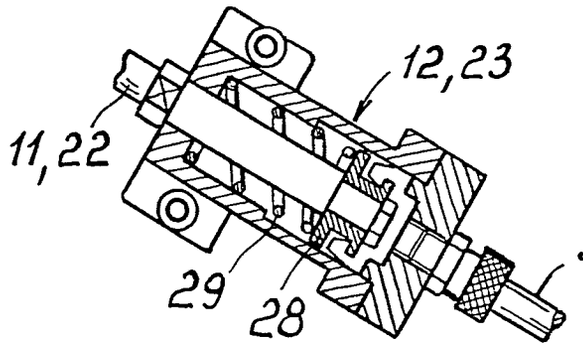

Fig. 4

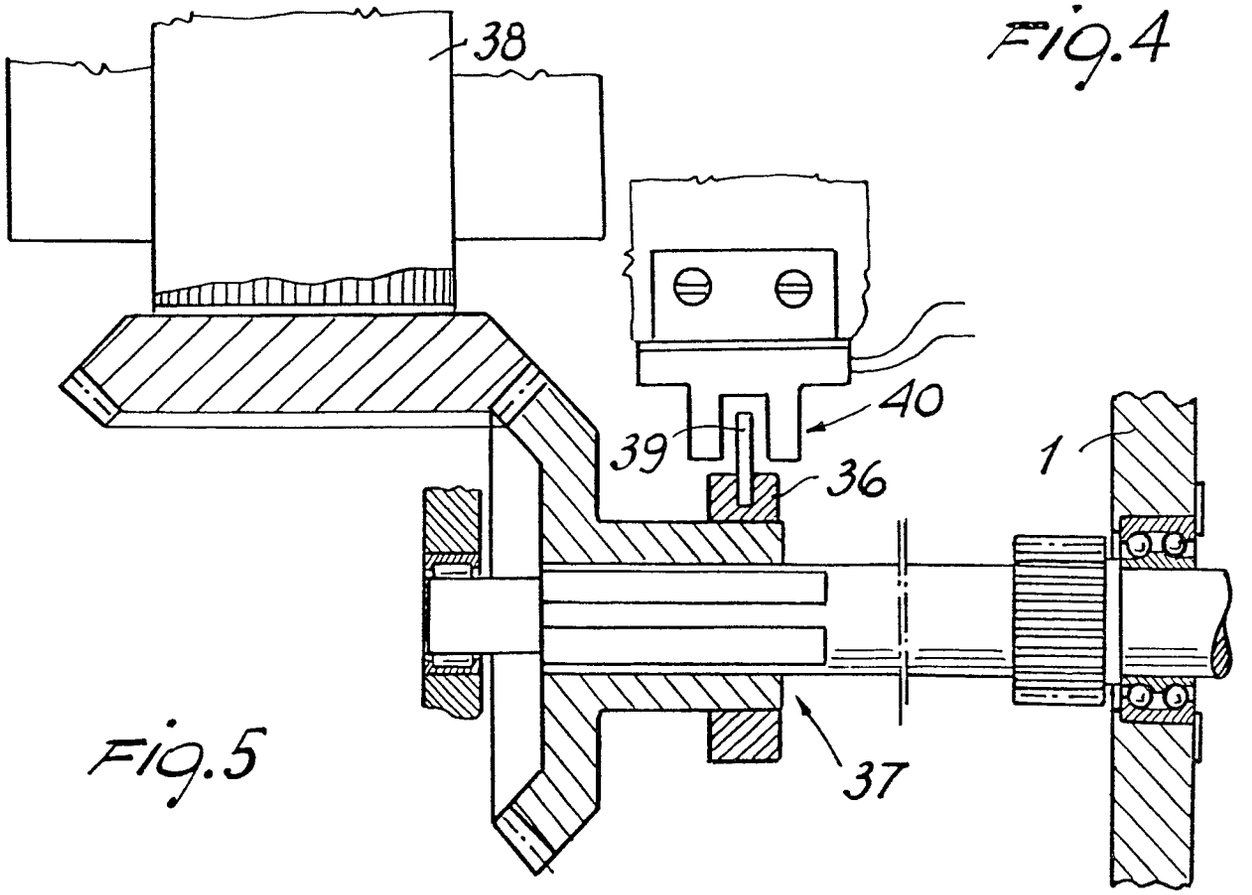

Fig. 5

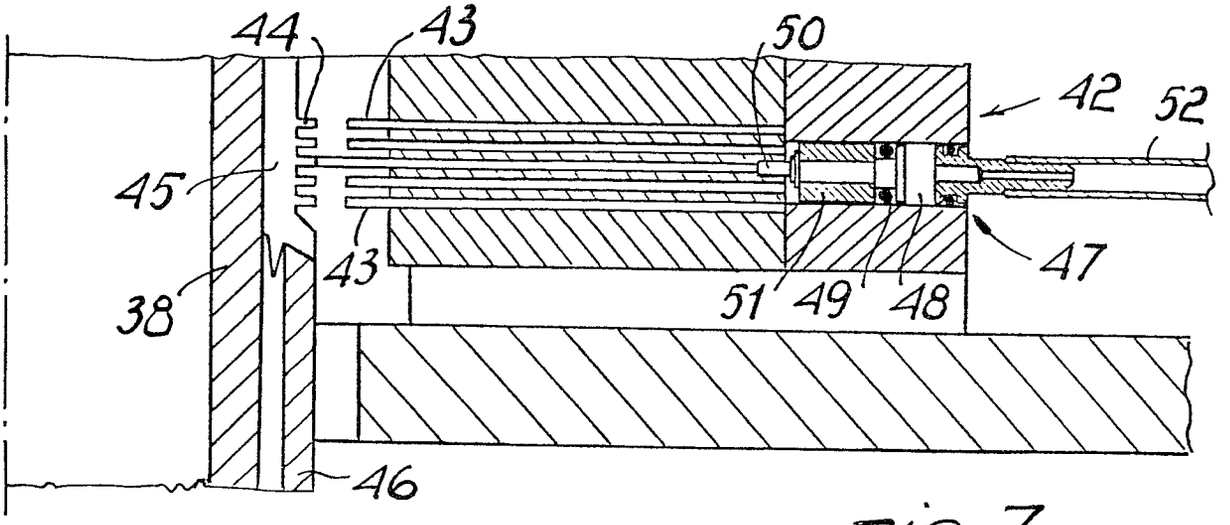

Fig. 7

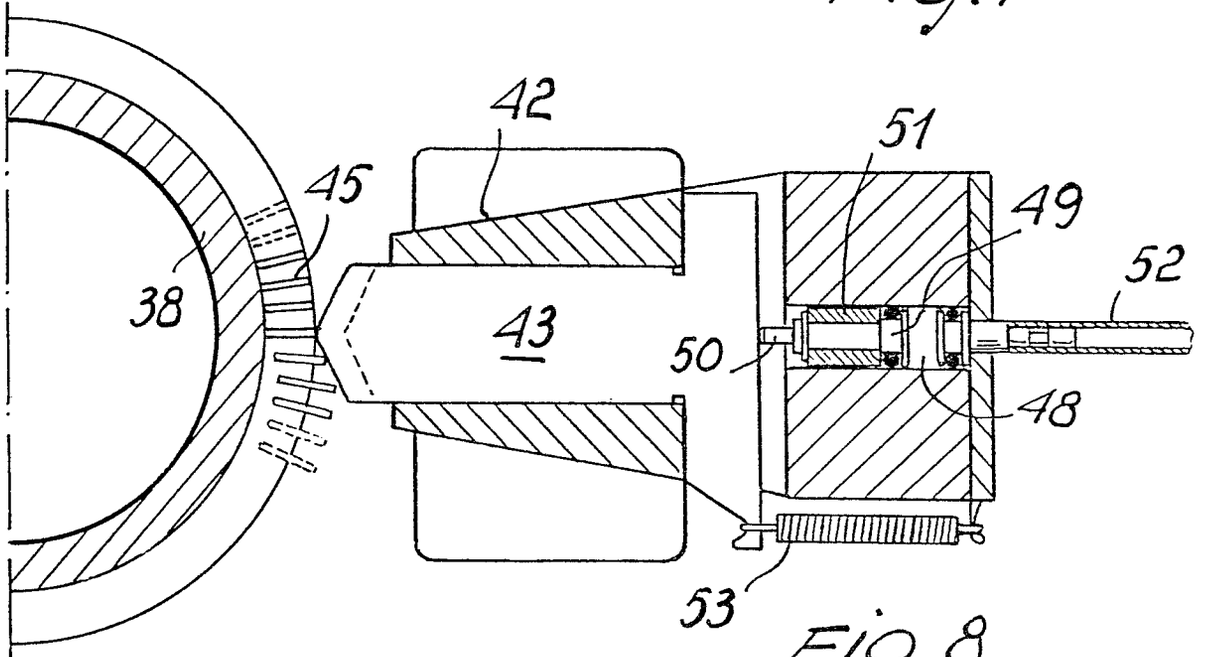

Fig. 8

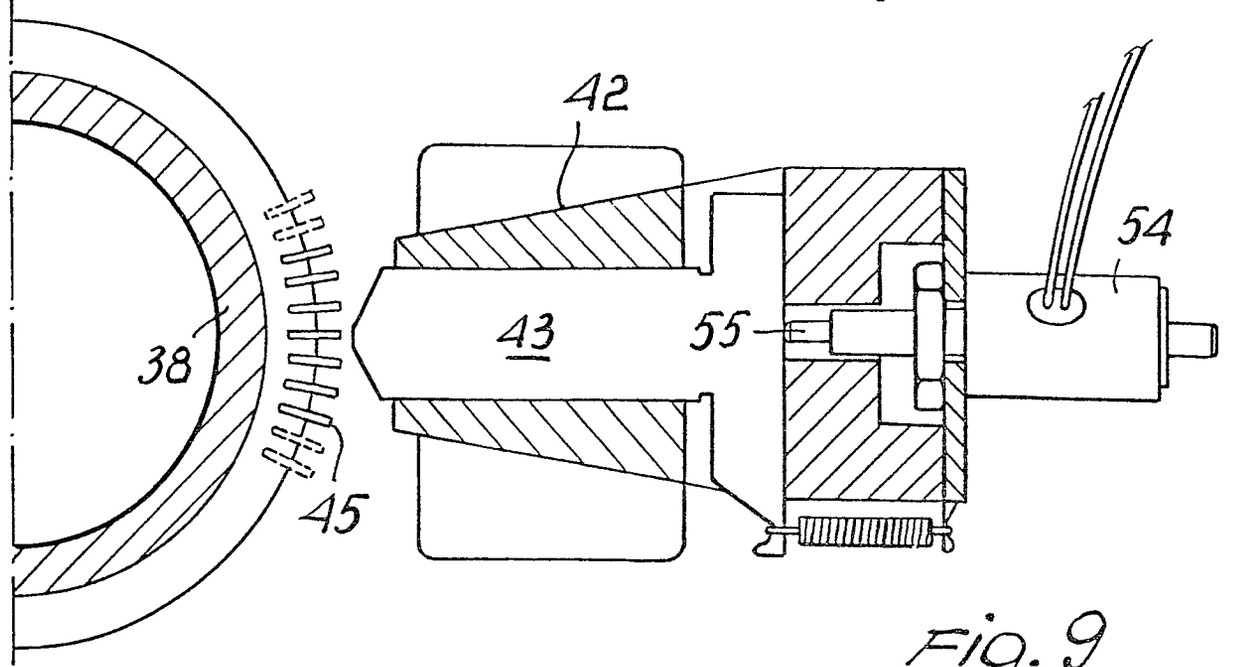

Fig. 9

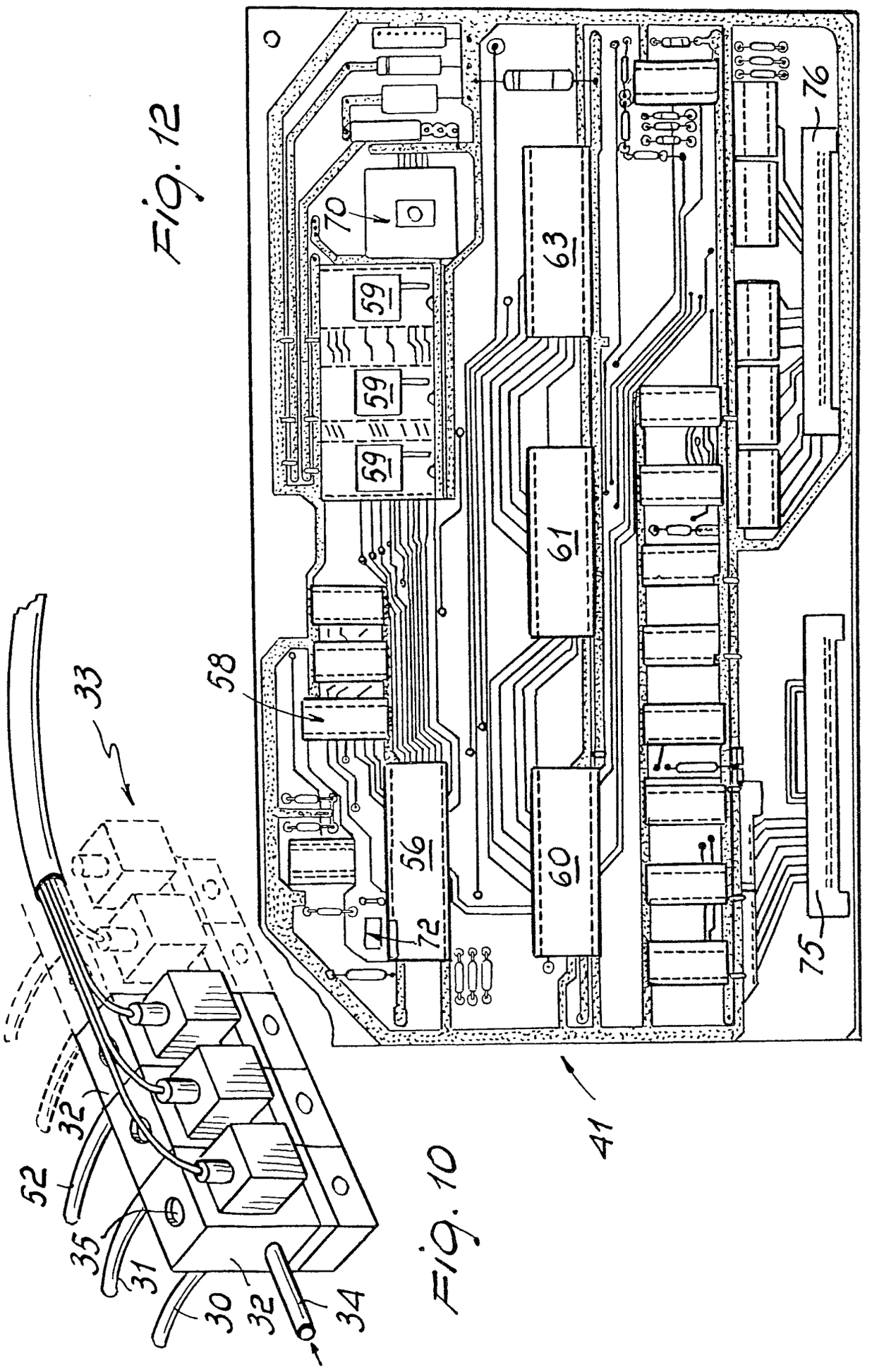

Fig. 10

Fig. 12

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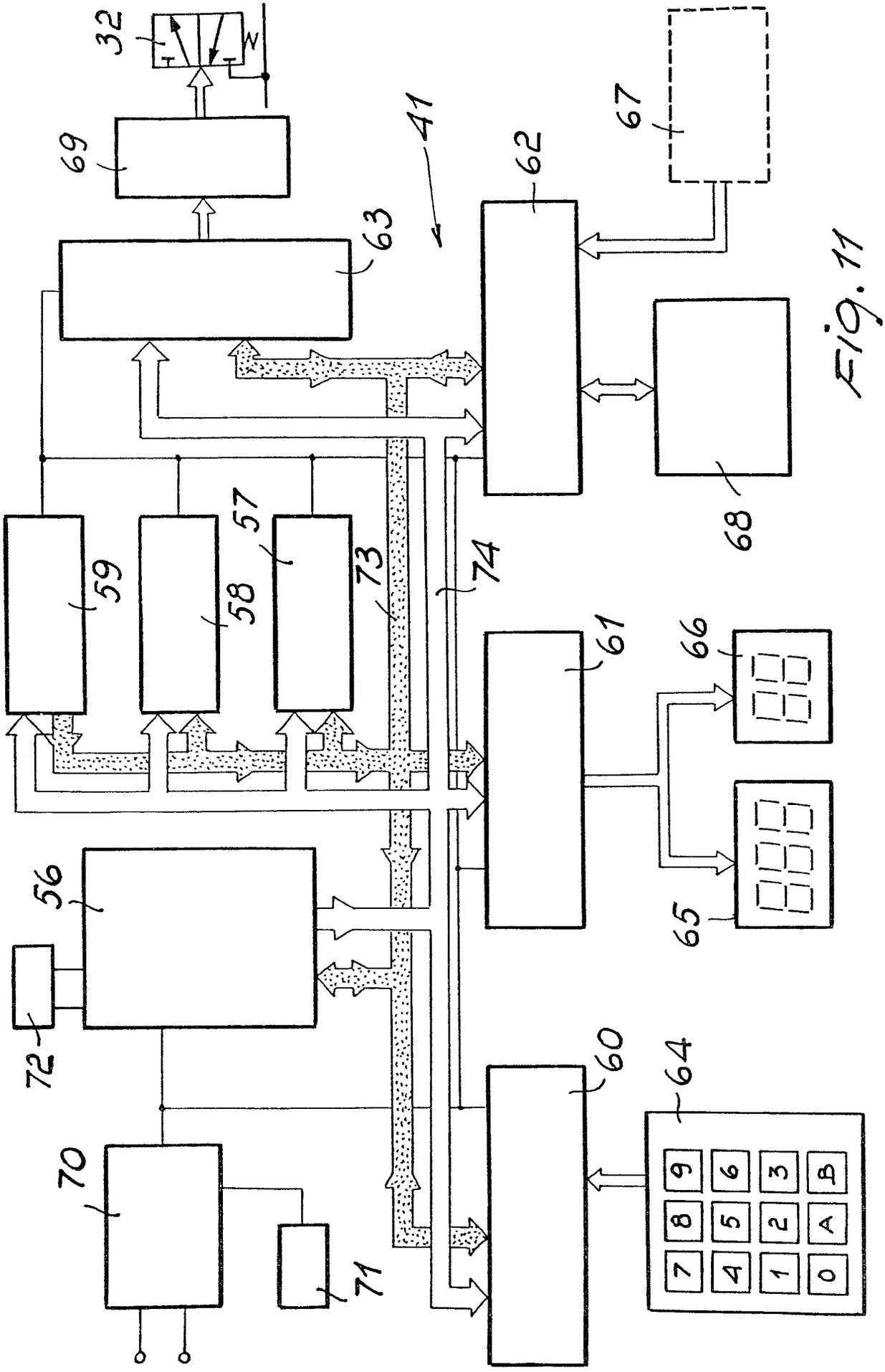

Fig. 11