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(54) IMPROVEMENTS IN AND RELATING TO SEWING MACHINES

(71) We, DORINA NAHMASCHINEN GMBH, a German Company, of Amalienbadstrasse 41, 7500 Karlsruhe-Durlach, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a sewing machine for producing successive stitches of ornamental stitch patterns, with a displaceable control member for controlling a stitch characteristic (e.g. width, length) and which is regulated by an actuator by control signals corresponding to the stitches to be sewn from a programme control device.

In known sewing machines of this type a very high power amplification is necessary for adjusting the actuator controlled by an electronic programme control device in order that the actuator applies the high controlling forces necessary for moving the control member for adjusting the needle bar and/or the feed dog. Thus, in the known arrangements components with a very low inertia are used, so that the control expenditure for power amplification does not become unnecessarily high. However, high power amplification is necessary because with the control signal of the programme control device only a very limited electric power is available which for the satisfactory control of the movement of the known actuator requires enormous amplification in order to apply the high controlling forces necessary for operating the control means. In addition, it is very difficult to control a high electrical power amplification and requires a considerable expenditure on matching and equalising elements in order to prevent divergences from the linear characteristic of the individual amplifier stages.

The invention aims at providing a simple, rapidly responding actuator with very high power amplification. To achieve this aim the technical problem of the invention is to take the controlling force for adjusting the control member from a special drive. Advantageously the existing sewing machine drive is used for this purpose.

According to the invention this problem is solved in that the actuator comprises a clutch mechanism having a driving portion operatively connected to a continuously operating drive mechanism, and a driven portion selectively controllable through the programme control device for displacement by the driving portion of the clutch mechanism to displace the control member in one sense of direction, and the actuator further comprising restoring means capable of displacing the control member in the opposite sense of direction.

Another equivalent solution is characterised in that the actuator comprises two clutch mechanisms each having a driving portion operatively connected to a continuously operating drive mechanism and a driven portion selectively controllable through the programme control device for displacement by the driving portion to displace the control member, and wherein the driven portions are selectively controllable by their respective driving portions to displace the control member in opposite senses of direction.

In the present context the term "controllable" means not only the influencing of the size of the transmission moment of a clutch but also the variability of the action time of a pulse-operated engageable and disengageable clutch as long as this leads to a controllable total transmission moment.

The two proposed solutions have the essential advantage that very high forces can be controlled with very limited electronic powers, because the controlling force is taken from a drive, whose power is selected in random manner. Thus, the drive which supplies the control energy does not itself have to be accelerated during the control processes and the inertia of the drive can be relatively large. Thus, the operating expenditure necessary for such a control system can be low compared with the known arrangements. Furthermore it is sufficient to reduce the mass moment of inertia of the transmission elements, which is in any

case advantageous for the easy operation of the control member, to a level where costs are reasonable. Due to the higher friction damping on the transmission elements compared with the known arrangements a much smaller expenditure is necessary for regulating the proposed solution.

A very simple solution for the restoring means of the first aspect of the invention is obtained by providing for this purpose a spring acting between the control member and a relatively fixed part of the sewing machine, and the second clutch mechanism of the second aspect of the invention is essentially equivalent to the restoring means.

Advantageously the control member is a rotatable cam with a spiral cam path on which engages a follower, displacement of which adjusts the position of the needle bar lever or the feed dog. The part of the cam path which is active for control purposes can extend over the entire periphery thereof or only over part of it. The effective length of the cam path is controlled by the optimum matching between its slope determined by the transmission ratio between the drive and the driving clutch portion and the control member movement time prescribed by the movement cycles of the sewing tools.

In order to assist the restoring force of the restoring means the spiral cam path of the aforementioned cam preferably tapers radially inwardly in the restoring direction of the restoring means.

According to another possible solution in regard to the second aspect, the control member can be screw-threadedly mounted on a threaded spindle connected with the driven portions of both clutch mechanisms and movable along a cam path displacement of which brings about the adjustment of the needle or the feed dog.

A particularly simple and inexpensive solution is achieved in that the driving portion of the or each clutch mechanism is in driving connection with the main shaft of the machine, preferably via a transmission gear. Thus, the power reserve present on the main drive of the machine can be used as a controlling force for adjusting the control member. An improved power transmission into the clutch mechanism is achieved by the reduced driving speed of the clutch portion compared with the main shaft. When the clutch portion is driven by the main shaft of the machine the further advantage is obtained that when sewing at a low speed the speed of the driving clutch portion is also reduced.

An optimum, moment-regulated control drive accompanied by low constructional expenditure is obtained by using an electromagnetic clutch mechanism without slip rings which, compared with its size, can transmit a very high control moment. By means of a controllable electromagnetic field a clutch portion constructed as an armature member can be pressed more or less strongly against a friction lining on the other clutch portion, as a function of the magnetic field strength, so that a sensitively controllable control moment can be transmitted.

Further details of the invention can be gathered by way of example from the following description of the embodiments represented in the drawings, in which:

Fig. 1 is a view of a mechanism for controlling a stitch in a sewing machine, including a first embodiment of actuator;

Fig. 2 is an enlarged section through the actuator shown in Fig. 1 for controlling the stitch width;

Fig. 3 is a cross-section along the line III—III of Fig. 1;

Fig. 4 is an enlarged section corresponding to Fig. 2 but through a second embodiment of actuator;

Fig. 5 is a cross-section along the line V—V of Fig. 4;

Fig. 6 is a cross-section along the line VI—VI of Fig. 4; and

Fig. 7 is a block circuit diagram of the control system for the actuator shown in Fig. 2.

The sewing machine is equipped with a main shaft 1 which by means of a crank 2 and a guide rod 3 causes the vertical lifting movements of a needle bar 6 provided with a needle 4 and mounted in a guide link 5. Guide link 5 is mounted in the not shown sewing machine housing by means of a pin 7.

To the guide link 5 is rigidly connected an angle plate 8, carrying an extension arm 9 which is guided in a sliding guide 10 in a bearing flange 11 fixed to the machine housing. At its free end extension arm 9 carries a follower 12 which, under the influence of a tension spring 13, engages with a spiral cam path 14 (cf also Fig. 3) of a control member 15 comprising a rotatable cam. One end of tension spring 13 is suspended on extension arm 9 and the other end thereof on bearing flange 11. Rotation of the cam 15 is provided by an actuator 56 for the control of the stitch width of needle 4, to be described in greater detail hereinafter.

By means of a not shown chain main shaft 1 drives a lower shaft 17 to which is fixed a gear 18, which meshes with a gear 19 which is fixed to a shaft 20 mounted parallel to shaft 7. A cam member 21 which carries a lifting eccentric 22 is screwed to shaft 20. An eccentric 23, embraced by a support portion of an eccentric member 24 to which are articulated two levers 26 and 27 by means of a pin 25, is fixed to shaft 20. Lever 26 is connected in rotary manner via a bolt 28 to a crank lever 29 which is pivoted on a spindle 30 fixed in the sewing machine housing and is connected to a lever arm 33 via an arm 31 of lever 29 and a rod 32. Lever arm 33 is mounted by means of a bolt 34 in a bearing flange 35 fixed in the

machine housing. Lever arm 33 is guided in a sliding guide 36 in bearing flange 35 and carries a follower 37 which engages on a spiral cam path 38 of a rotatable control member 39 whose rotation is provided by an actuator 40 for controlling the stitch length of the sewing machine.

A tension spring 41, whose one end is suspended on lever arm 33 and whose other end is suspended on bearing flange 35 ensures the engagement of follower 37 on control member 39.

By means of a pin 42 lever 27 is connected in articulated manner to an arm 43 of a rocking lever 44 journalled on shaft 17. A second upwardly projecting arm 45 of rocking lever 44 has at its end a guide slot 46 in which is guided a pin 47. The latter is fixed to a support arm 48 displaceably mounted on a horizontal spindle 49 fixed parallel to the feed direction in the sewing machine housing. At its free end support arm 48 carries a feed dog 50 which is provided for feeding the material to be sewn and which is sewn by needle 4 in conjunction with a not shown shuttle. By means of a downwardly directed projection 51 support arm 48 is supported on the lifting eccentric 22 of cam member 21.

The two actuators 16 and 40 have an identical construction. Therefore it sufficies to describe actuator 16. Identical members in the two actuators 16 and 40 are given the same reference numerals.

Actuator 16 is located in bearing flange 11 in which is mounted a shaft 52 (Fig. 2) which is in driving connection with a gear 54 fixed to main shaft 1 via a gear 53 which is fixed to said shaft 52. To shaft 52 is fixed a driving clutch portion 55 of an electromagnetic clutch 56, behind which is arranged a coil carrier 57 fixed to bearing flange 11. In carrier 57 is provided an anular magnet coil 58. Clutch portion 55 has an annular clutch part 59 with a U-shaped cross-section, which carries an anular friction insert 60. An annular wall 61 in the extension of the periphery of coil carrier 57 covers a large part of the peripheral wall of clutch part 59. Control member 15 is rigidly connected to a shaft end 62 loosely mounted on shaft 52 and is rotatable with a driven clutch portion 63 constructed as an armature disk and separated from the friction insert 60 by a small air gap.

Clutch portion 63 is provided with a square opening 64 (cf also Fig. 3) into which projects a square portion 65 of shaft end 62, the shaft end 62 extending in the opposite direction beyond shaft 52. On its end is provided a hole 66 which is directed coaxially to shaft 52 and into which projects a spindle 67 of a potentiometer 68 fixed to bearing flange 11 and is secured by a screw 69.

To shaft end 62 is fixed a torsion spring 70, whose one end engages in a hole 71 in control member 15 and whose other end engages with a trunnion screw 72 which is screwed into bearing flange 11.

Torsion spring 70 is pre-tensioned in such a way that it twists control member 15 until a pin 73 screwed into the control member engages on a not shown stop connected to the bearing flange 11 in a direction which is opposite to the rotation direction of shaft 52 through gears 53 and 54.

Actuator 40 is the same as actuator 16 but there is a different construction of control member 39 compared with control member 15, whereby the cam path 38 is adapted to the different control function necessary.

Fig. 7 shows a block circuit diagram of a control system which can be used for controlling either of actuators 16 and 40. A separate control system is required for each actuator 16 and 40. As the construction of both control systems is identical only one needle control system is described.

The input of a summing amplifier 76 receives a desired value pulse representing the desired lateral displacement of needle 4 by means of a line 75 from a known programme control device 74 in which stitch formation data are stored. The output signal of amplifier 76 passes via a line 77 to a differentiating amplifier 78 and a scaling amplifier 79 to then be supplied via a line 80 to a differentiating amplifier 81, whilst a proportional signal (see below) at the output of summing amplifier 76 is supplied via a line 82, a scaling amplifier 83 and a line 84 to differentiating amplifier 81. The output signal of differentiating amplifier 81 is now rectified in a rectifier 85 and is fed via a line 86 to a power amplifier 87 with a complimentary Darlington final stage 88 in order to obtain a high current and voltage amplification. The Darlington final stage 88 controls the magnet coil 58 of electromagnetic clutch 56 via a line 89.

The feedback of magnet coil 58 takes place by means of a line 90 via a precision measuring resistor 91 and a line 92 to the input of power amplifier 87 and as a result a voltage — current conversion is obtained. Thus, magnet coil 58 is controlled solely via a current control and its inductance cannot influence the control system.

The poteniometer 68 rotatable with the control member 15 via shaft end 62 supplies an electrical signal, which is proportional to the position of control member 15. This signal is supplied with a corresponding sign to the input of summing amplifier 76 via line 93.

In known manner the control system is controlled by a not shown pulse generator, which responds in the rhythm of the main shaft 1, in such a way that the movement changes of control member 15 controlled by magnet coil 58 take place during the phase when needle 4 is removed.

The apparatus functions in the following manner:

On driving, the sewing machines shaft 52 (Fig. 2) is driven by main shaft 1 via the gears 54 and 53 of actuator 16. Clutch portion 55 of electromagnetic clutch 56 which is firmly connected to shaft 52 rotates with the latter. Magnet coil 58 is energized according to the predetermined control voltage through the control system corresponding to the size of the stitch width of the next stitch to be controlled, so that clutch part 59 is correspondingly strongly magnetized by the magnetic field applied thereto by magnet coil 58. Clutch portion 63, displaceably mounted in non-rotatable manner on portion 65 of shaft end 62, is pressed to a greater or lesser extent against friction insert 60, as a function of the magnetic field strength, and is driven by clutch portion 55.

When clutch portion 63 rotates so does the potentiometer 68 which is connected in rotatable manner therewith. The actual position of control member 15 according to the potentiometer 68 is supplied by line 93 to summing amplifier 76 where it is compared with the desired signal supplied by line 75 and is used for generating a correspondingly strong magnetic field in magnet coil 58.

As the actual position of control member 15 approaches its desired position predetermined by the desired value signal of programme control device 74 the magnetic field strength of magnet coil 58 acting on clutch portions 55 and 63 decreases due to the reduction in the difference between the signals of programme control device 74 and poteniometer 68 at summing amplifier 76. The magnetic field strength in electromagnetic clutch 56 is reduced until an equilibrium is established between the restoring moment of torsion spring 70 and the controlled driving moment of the friction connection between clutch portions 55 and 63. The new rotation position of control member 15 is maintained through slip between clutch part 59 and clutch portion 63 until a new voltage pulse is received at the control system from programme control device 74 and then the above-described control process is repeated.

Rotation of the control member 15 causes via the cam path 14, the extension arm 9 to move by an amount corresponding to the changed rotation position of control member 15, so that guide link 5 is pivoted until needle 4 is set in the position for its next insertion predetermined by programme control device 74.

Actuator 40 (Fig. 1) for adjusting the feed length of feed dog 50 is controlled in the same way. On rotating control member 39 the lever arm 33 is pivoted via follower 37 corresponding to the control of magnet coil 58, by the predetermined control voltage at the control system for the stitch length, of feed dog 50. By means of rod 32 and crank lever 29, lever arm 33 pivots the bolt 28 serving as the rotation axis for lever 26 relative to pin 42. During the deflection movements of bolt 25 through eccentric member 24, lever 26 rotates about bolt 28, whereas lever 27, in addition to this rotary movement, also performs a relative movement about pin 42. By means of rocking lever 44 this relative movement is transmitted to support arm 48 as a sliding movement. Arm 48 slides backwards and forwards on spindle 49 and thereby imparts sliding movements to feed dog 50 fixed to its end, whereby the magnitude of these movements is dependent on the rotary position of control member 39 and consequently on the non-axial alignment of bolt 28 and pin 42. The slope of cam path 38 of control member 39 is selected in such a way that feed movements of feed dog 50 can be performed which are variable between the maximum stitch length performable by feed dog 50 in the forwards direction and the maximum stitch length performable by it in the rearwards direction.

During the sliding movements of feed dog 50, lifting eccentric 22 of cam member 21 rhythmically raises support arm 48, so that the teeth of feed dog 50 can act on the material to be sewn through the not shown stitch plate.

Figs. 4 to 6 show an actuator 101 according to a second embodiment and which can be used on the same machine.

Actuator 101 is received by a bearing flange 102 in whose lateral walls is mounted a shaft 103 on which are loosely mounted a driving clutch portion 104 of a first electromagnetic clutch 105 and a driving clutch portion 104′ of a second electromagnetic clutch 105′ which is spaced from the first. Coil carriers 106 and 106′ firmly connected to bearing flange 101, are positioned behind respective clutch portions 104 and 104′. Annular magnet coils 107 and 107′ are provided in respective carriers 106 and 106′. Each clutch portion 104 or 104′ has a respective annular clutch member 108 or 108′ with a U-shaped cross-section which carries an associated annular friction insert 109 or 109′. Annular walls 108a and 108a′ are provided on respective clutch members 108 and 108′ and cover most of the peripheral wall of the associated coil carrier 106 or 106′ which surround the magnet coils 107 and 107′.

Between the two clutch members 108 and 108′ two bushes 110 and 110′ are provided on shaft 103 and their ends are overlapped by a threaded spindle 111. Two pins 112 connect threaded spindle 111 and bushes 110 and 110′ to shaft 103. Each of the bushes 110 and 110′ has a respective flange 113 and 113′ for a driver clutch portion 114 or 114′, constructed as an armature disk and separated by a small air gap from friction inserts 109 and 109′ respectively.

Each clutch portion 114 or 114′ has a square opening 115 or 115′ into which projects a respective square attachment 116 or 116′ of the associated bush 110 or 110′.

The periphery of clutch member 108 of electromagnetic clutch 105 is provided with teeth 117 which engage in a gear 118, which is fixed to a shaft 119 mounted in bearing flange 102. Gear 118 meshes with a gear 120 fixed to the main shaft 1 of the machine.

Clutch member 108′ of electromagnetic clutch 105′ is also provided with teeth 117′ which engage in a gear 121 fixed to main shaft 1.

A nut 122 screwed to threaded spindle 111 carries a control member 123 defining a follower 124 which co-operates with an inclined plane or cam path 125 of a cam 126. Cam 126 is fixed to the end of extension arm 9 which is connected to guide link 5 of needle 4 and guided in a guide slot 127 of bearing flange 102 to define displacement means for the needle. Nut 122 carries a guide pin 128 which slides in a slot 129 of a guide 130 fixed to bearing flange 102. Here again shaft 103 is connected to a potentiometer 68.

On driving the sewing machine driving clutch portion 104 is driven by main shaft 1 via gears 120 and 118 in the same rotation direction as shaft 1. However, driving clutch portion 104′ is directly driven by gear 121 fixed to main shaft 1, so that it rotates in the opposite direction to clutch portion 104. By means of a control system, which in principle corresponds to the control system of Fig. 7, the energizing of the two magnet coils 107 and 107′ is varied in opposing manner corresponding to the predetermined control voltage corresponding to the size of the stitch width of the next stitch to be controlled, so that correspondingly different magnetic fields are induced in coupling members 108, 108′. The particular clutch 105 or 105′ having the stronger magnetic field at any one time, provides a greater torque on the associated driver clutch portion 114 or 114′ which results in reduced slip of said clutch portion, whilst there is relatively more slip on the driver clutch portion of the clutch with the weaker magnetic field. Thus, the threaded spindle 111, connected to rotate with the two clutch portions 114 and 114′, is rotated in one direction or other. Due to the rotation of threaded spindle 111 there is a displacement of control member 123 in the axial direction via nut 122, whereby cam follower 124 changes its position on the cam path 125 of cam 126 and, via the latter, pivots extension arm 9. Thus, the position of guide link 5 is adjusted to the new desired stitch.

In exactly the same way as for the control of guide link 5 for needle 4 the above-described actuator 101 can also be used for controlling the feed mechanism via lever arm 33 shown in Figs. 1 to 3 in place of actuator 40.

The controlling force of actuator 40 or 101 for control member 39 is so strong that feed dog 50 is controllable not only via the control mechanism comprising members 23 to 30 in Fig. 1, but is instead also directly drivable by means of actuator 40 or 101. With such a solution pull rod 32 is articulated to arm 43 of rocking lever 44 and members 23 to 30 and 42 become redundant.

With such a construction it is obviously necessary for the control pulses given by the programme control device 74 to be adapted to the control requirements which have changed compared with an indirect drive of feed dog 50. It is also necessary for the end positions of feed dog 50 for the sewing machine stitch formation cycle controlled by the control pulses to be controlled in such a way that the feed movement of feed dog 50 takes place when needle 4 is removed and for the non-active return movement of feed dog 50 to take place when needle 4 is inserted.

Control member 39 need not have a cam path 38 whose slope serves as a regulating quantity and instead the latter can be produced by the size of the angular adjustment of the control member. With such a solution the control member can for example be constructed as a lever arm rigidly connected to the shaft end 62 and to which rod 32 is articulated.

The proposed arrangement is not restricted to the electromagnetic friction clutches described in the exemplified embodiments. It is also possible to use other clutches, whose moment to be transmitted is controllable, such as e.g. pneumatic or hydraulic clutches or electromagnetic powder clutches.

WHAT WE CLAIM IS:—

1. A sewing machine for producing successive stitches of stitch patterns comprising a control member which is displaceable to control a stitch characteristic (e.g. length, width), said displacement of the control member being regulated by an actuator responsive to a programme control device to produce a stitch characteristic according to a programme, the actuator comprising a clutch mechanism having a driving portion operatively connected to a continuously operating drive mechanism, and a driven portion selectively controllable through the programme control device for displacement by the driving portion of the clutch mechanism to displace the control member in one sense of direction, and the actuator further comprising restoring means capable of displacing the control member in the opposite sense of direction.

2. A sewing machine for producing successive stitches of stitch patterns, comprising a control member which is displaceable to control a stitch characteristic (e.g. length width), said displacement of the control member being regulated by an actuator responsive to a programme control device to produce a stitch characteristic according to a programme, the actuator comprising two clutch mechanisms each having a driving portion operatively con-

nected to a contnuously operating drive mechanism and a driven portion selectively controllable through the programme control device for displacement by the driving portion to displace the control member, and wherein the driven portions are selectively controllable by their respective driving portions to displace the control member in opposite senses of direction.

3. A sewing machine as claimed in claim 1 in which the restoring means comprises spring means.

4. A sewing machine as claimed in claim 1 or claim 3 in which the control member comprises a rotatable cam having a spiral cam path, and the machine additionally comprises a follower which is engageable with the cam path, adjustment of the position of the follower along the spiral cam path adjusting the position of a sewing needle or of a feed dog capable of feeding material to be sewn by the needle, to define said stitch characteristic.

5. A sewing machine as claimed in claim 4 in which the spiral cam path tapers radially inwardly in the restoring direction of the restoring means.

6. A sewing machine as claimed in claim 2 in which the driven portions of the clutch mechanisms are both drivingly connected to a threaded sleeve on which the control member is screw-threadedly mounted for linear motion upon rotation of the sleeve, the control member being movable along a cam path provided on displacement means for a sewing needle, or for a feed dog capable of feeding material to be sewn by the needle, whereby movement of the control member along the cam path causes the displacement means to adjust the position of the sewing needle or feed dog, respectively, to define said stitch characteristic.

7. A sewing machine as claimed in any one of claims 4, 5 and 6 comprising two of the actuators, each of the actuators regulating the movement of a respective control member, one of the control members being adapted to adjust the position of the sewing needle and the other control member being adapted to adjust the position of the feed dog.

8. A sewing machine as claimed in any one of the preceding claims in which the driving mechanism of the or each clutch mechanism comprises a main drive shaft of the sewing machine.

9. A sewing machine as claimed in claim 8 in which the driving mechanism comprises transmission gearing between the main drive shaft and the driving portion of the or each clutch mechanism.

10. A sewing machine as claimed in any one of the preceding claims in which the or each clutch mechanism operates electro-magnetically without slip rings.

11. A sewing machine as claimed in any one of the preceding claims in which displacement of the driven portion of the or each clutch mechanism is adapted to generate a signal corresponding to the position of the control member, and the programme control device includes means capable of comparing said signal with the signal generated by the programme to move the control member.

12. A sewing machine substantially as described herein with reference to FIGURES 1, 2 and 3 of the accompanying drawings.

13. A sewing machine as claimed in claim 1 and including a programme control device substantially as described herein with reference to FIGURE 7 of the accompanying drawings.

14. A sewing machine substantially as described herein with reference to FIGURES 4, 5 and 6 of the accompanying drawings.

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1588940 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

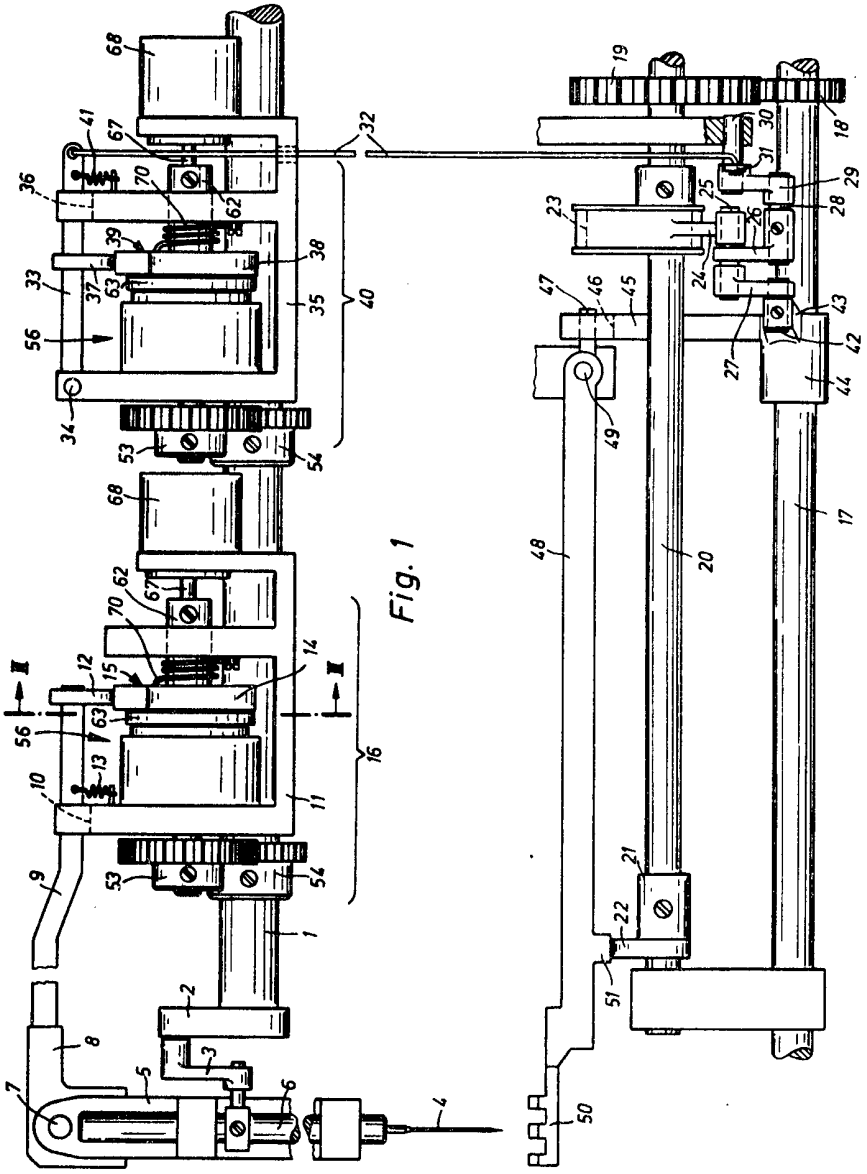

Fig. 1

Fig. 3

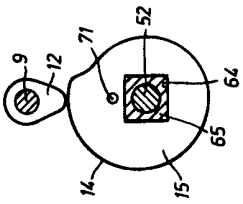
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Fig. 2

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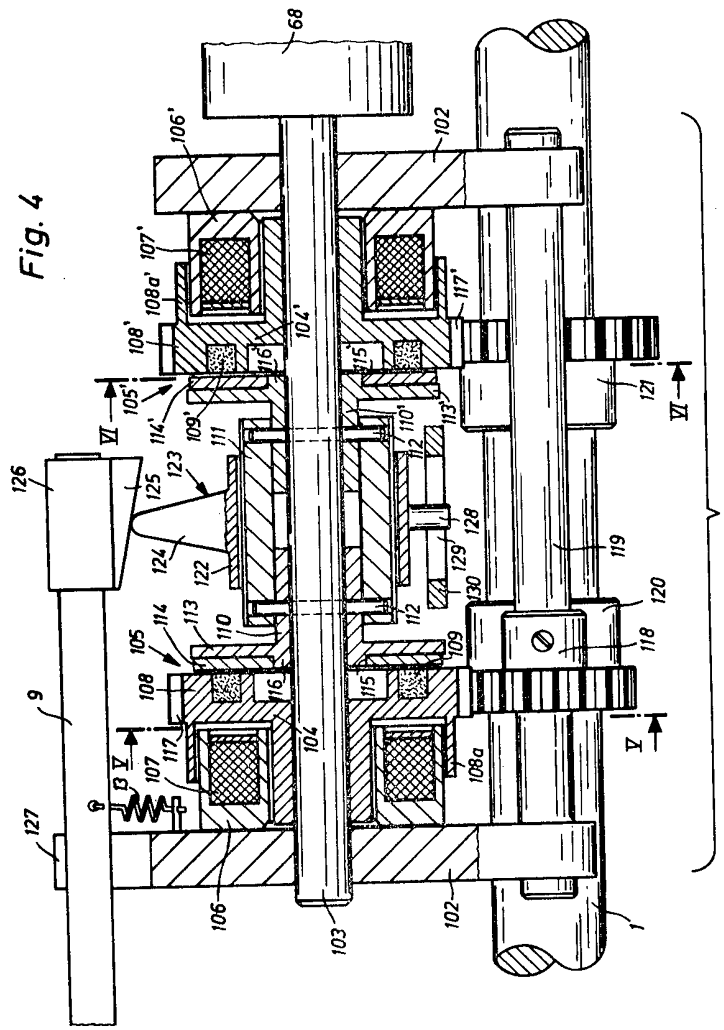
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Fig. 4

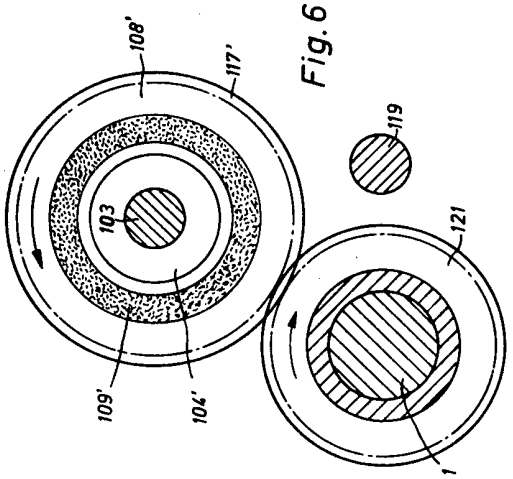

Fig. 6

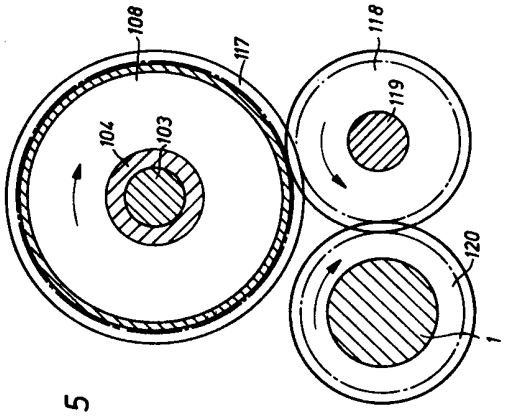

Fig. 5

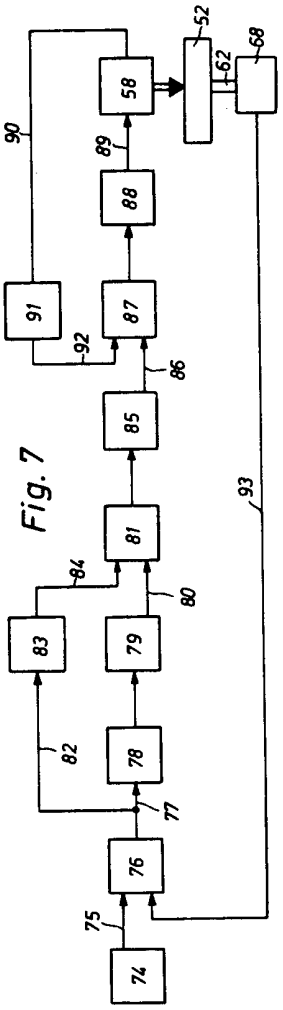

Fig. 7