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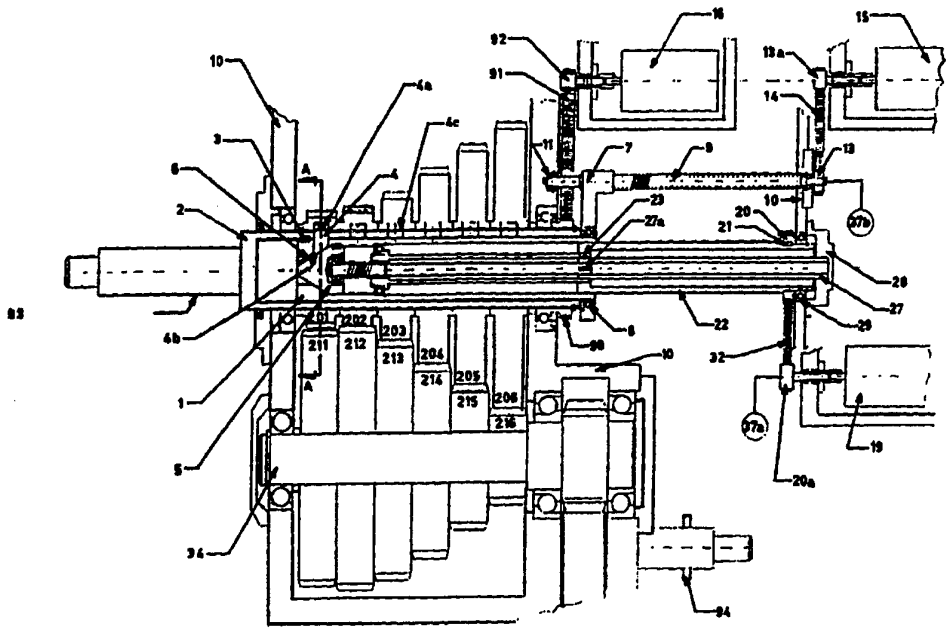
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(54) Title: SINGLE SLIDING KEY TYPE COUNTERSHAFT AUTOMATIC TRANSMISSION



(57) Abstract

A single sliding key type automatic transmission having an input (2) with a sliding locating tube (1), plural rotary gears (201, 202, 203, 204, 205, 206) rotatable on the input shaft (2). An actuating tip (5) rotating with the input shaft (2) moves axially to cause the engagement pins (4) to engage the selected gear (201) to the input shaft (2) so as to transmit rotation to the countershaft (34). The transmission having a motor (16) for synchronizing the rotation of the input shaft (2) to the counter shaft (34) during a gearshift and additional motors (15, 19) for actuation of the gear shift.

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SINGLE SLIDING KEY TYPE COUNTERSHAFT AUTOMATIC TRANSMISSION

The present invention relates to a gear-shifting mechanism controlled and driven by a governing unit in an automatic and controlled way and manually driven by an operator. This mechanism actuates in constantly meshed gear pairs acting in an exclusive way, that is, only a gear pair will be active through this shifting mechanism, on this set of assembled gear pairs, all of them in two of the same shafts, one for movement input and the other for movement output.

Gear pairs shifting mechanisms in a gear box are universally utilized in the form of a hub which is displaced over a striated shaft and through by front teeth engaging one gear or another. Shifting mechanism can have a rotation synchronizing device to provide for the engagement without teeth rubbing of the coupling front teeth. During a speed change or a change of the meshed pair of gears for the operation, which change is made with the machine or vehicle running or moving, a synchronization of the movements of the parts of the transmission box.

These mechanisms have been largely utilized along the time in the mechanical industry and in the automotive transmissions. Mechanisms with synchronizing rings are largely used and therefore fully known and dominated. These shifting mechanisms with synchronizing rings are detailed in studies published by

SAE(Society of Mechanical Engineers) under number 680008, published on January, 1968.

The object of this invention is to offer a new conception of shifting mechanism actuating on the clutch between the motor (engine) and the transmission when the power transmission assembly has a clutch actuating towards selecting and engaging a speed or a gear pair for the operation, thus synchronizing rotation. The shifting mechanism actuates by releasing the clutch in order to permit the selection of the gear pair to be made from a set of constantly meshed gear pairs and once made the selection of said gear pair, the shifting mechanism synchronizes the rotation of the rotary members which are active during operation and once synchronization is achieved, the shifting mechanism provides for the engagement of the selected pair for operation. Once this step is attained, the shifting mechanism causes the clutch between the motor (engine) and the transmission is closed and thus rotation and torque are now transmitted through the engine (motor) transmission to the output.

Figure 1 shows a typical application of the gear shifting mechanism with constantly meshed gear pairs and of mutually exclusive actuation. The transmission box has, a main portion, the constantly meshed gear pairs. The gears which are mounted on the hollow shaft 2 are mounted so as to slide over this shaft and so they are mounted idler over the hollow shaft 2 on slipping bearings. These are the gears carrying reference numerals 201, 202, 203, 204, 205 and 206. Over a shaft 34 parallel to said hollow shaft 2, a set of gear pairs constantly meshed with above cited gears is mounted in a fixed way. These gears 211, 212, 213, 214, 215 and 216 are fixed with the parallel shaft 34 and they rotate therewith as if they would be a part

thereof. Between the parallel shaft 34 and the hollow shaft 2, a gear shaft parallel to the two can be present in order to enable rotation reversion for a specific gear pair. This solution has been already employed in the transmission boxes for vehicles in order to have the reverse speed. Before the hollow shaft 2 as well as after the parallel shaft 34, many shafts as are necessary to the design can be present. The number of constantly meshed gear pairs depends upon the design and the application.

Figure 2 shows a variation of the engagement and disengagement mechanism when actuated by a hydraulic or pneumatic system driven and governed by the governing unit 18 actuating in conjunction with a relay and coil logic 54 driving the opening for the inlet of hydraulic fluid or compressed air.

Figure 3 shows a variation of the engagement and disengagement mechanism when actuated by an actuation system through an electromagnetic solenoid driven and governed by the governing unit 18 which acts on a relay logic set 83 driving the energization or de-energization of coil 75 through a electrical voltage source 84 forming part of the actuating solenoid 71.

Figure 4 shows the shifting mechanism mounted on a machine with a clutch wherein one has the electric motor or other type of constant rotation motor 101 providing power to the machine, a clutch box 102 between the motor and the transmission box 103 with constantly meshed gear pairs, the shifting mechanism 104 and the rotation and torque output 105. In order to actuate the clutch, there is an actuation mechanism forming part of the same shifting mechanism 104 which encompasses also this actuation function in the clutch box 102. Between the clutch box 102 and the transmission box 103, there is a mechanical linkage element which

could be a pair of pulleys 106 coupled by a belt 107, or could be also a rigid or elastic coupling, this element being not detailed for being perfectly known.

Figure 5 shows the shifting mechanism 104 mounted on a automotive vehicle provided with a clutch, the vehicle having the driving motor which could be a internal combustion engine or some other kind of motor 121 delivering power to the vehicle with variable rotation. Between the motor and the transmission box there is the clutch 122, the transmission box with constantly meshed gear pairs 123, the movement and torque output for the differential 128, through an universal joint 126 and drive shaft 127 and from there to the vehicle wheels 129. The same concept of the object of this invention is also applied to forward drive vehicles. The schematic representation seen through figure 5 shows a rear drive vehicle. For forward drive vehicle, the whole concept remains the same, changing only the linkage means between output 125 of the transmission box 123 and differential 128.

The object of this invention is also to offer a way of coupling gears so that the shifting mechanism has one of its portions, that is, the engagement and selection portions mounted internally of a shaft or they can be mounted also in more than one shaft and this mechanism has conditions to be driven through a governing unit 18 automatically or through the governing unit by the action of an operator or driver. The mechanical portion of the shifting mechanism comprises the parts mounted internally to the shaft, the actuating parts, a chain or belt transmission, and actuating electric motors. Between the electric motors and the governing unit 18, there are electro-electronic devices called servo-actuators 17 providing power to the motors as the governing unit 18 sends decoded signals to these servo-actuators so that these

cause the direct or alternating current electric motors to act in the sequence foreseen by the logic of the governing unit.

Figure 6 shows in a schematic way, the hierarchy of the drives. The governing unit 18 is physically constituted by an electronic hardware based on the microprocessor. The governing unit 18 has also in the memory thereof, a program (software) 18A managing all the events of driving, control, actuating and sensing for the shifting mechanism. The managing hardware and software portions 18A of the governing unit 18 in the case of the application shown in figure 4, can be built-in inside the central processing unit (CPU) of a COMPUTERIZED NUMERICAL CONTROL (CNC) or inside the central processing unit of a PROGRAMMABLE LOGIC CONTROLLER (PLC) which can fit the machine wherein the shifting mechanism is being applied. This governing unit 18 receives pulses to operate, manually by action of the operator, through the lever 120 or other data input means, or automatically through the managing software 18A itself which is the managing program which possess the whole logic for automatic functioning. This program is stored in the governing unit 18. At the immediate level, there is the electronic servo-actuator assembly 17 of the actuating motors. Each electronic servo-actuator actuates a motor for the following purposes: clutch actuating motor 33 actuated by the electro-electronic actuator 33A and said clutch can have the releasing and clutching event effected by another sort of system which can be hydraulic or pneumatic, the synchronization actuating motor 16 actuated by the electro-electronic actuator 16A, the actuation motor 15 for selection of the gear pair actuated by the electro-electronic 19A. Concerning the releasing and clutching system of the clutch and the modulation

thereof for its operation, the actuating mechanism can be other such as hydraulic or pneumatic actuators, piloted and governed by the same governing unit 18 with a logic suitable and proper for the application. The engagement motor 19 as well as the whole engagement mechanism disclosed in the can have other constructive options through a hydraulic piston according to figure 2 or a pneumatic piston according to figure 2 or through a mechanism composed by an electromagnetic solenoid and a spring according to figure 3. Said motors as well as the servo-actuators thereof 17 can be of electric direct current or electric alternating current. Lastly, the system is completed in a closed loop through a set of sensors 37 of feedback of positioning, rotation and load data.

The mechanical portion of the shift mechanism 104 has three basic constructions, identical as to the location of the gear pairs, but with three variants of the engagement mechanism of the located and selected gear pairs. The variants are shown through figures 1, 2 and 3 and are explained along such disclosure.

The first construction of the mechanical portion of the shift mechanism 104 is disclosed in detail in its internal part of selection of the gear pair or selection of speed and engagement of said speed. This first construction utilizes the engagement motor 19 as shown in figure 1.

This first construction comprises a locating tube 1 sliding on the hollow shaft 2 of the gears to be engaged. The constantly meshed gear pairs of the transmission box 103, 123 of figures 4 and 5, have one of the gears of the pairs mounted idler on the hollow shaft 2 and the corresponding gears of the constantly meshed gears mounted in a parallel shaft 34, parallel to the hollow shaft 2 and

engaged in said parallel shaft 34 so as to rotate as if the parallel shaft 34 and said gears were an integral one-piece. This locating tube 1 can have at the end thereof five or more or less radial holes, the amount of radial holes will depend on the mechanical torque transmitted through the transmission box.

Figure 7 shows said gears which rotate idler on the hollow shaft 2 and form part of the constantly meshed gear pairs of the transmission box 103, 123. These are gears whose external teeth 150 which transmit torque and rotation, are constructed by the techniques of cutting and machining teeth already known in the mechanical manufacturing art and each constantly meshed gear pair has its transmission ratio in conformity with the plurality of the constantly meshed gear pairs. Said gears which rotate idler on the hollow shaft 2 have at the internal portion thereof and in the inner hole where the hollow shaft 2 centered by its centerline 151 of the external teeth 150, an internal teeth set 4c so that in these teeth, there are coupled the teeth 4a of the engagement pins 4. In both sides of internal teeth 4c, in the inner hole of the idler gear, sliding bearings 152 are embedded which allow that the gear, when it is not engaged by the engagement pins 4, rotates idly on the hollow shaft 2 with minimum friction and with minimum energy dissipation and in a balanced way since said sliding bearings 152 are mounted on both sides of the internal teeth 4c. The spacing of internal teeth 4c and the dimensions thereof permit coupling with teeth 4a of the engagement pins 4. Said gears which rotate idler on hollow shaft 2 have as pair the gears which are engaged on the parallel shaft 34 and are constantly meshed therewith pair by pair. Hollow shaft 2 for each constantly meshed gear pair which gears are mounted thereon, has a row of radially disposed holes equally spaced and

centered exactly in the centerline 151 of each gear mounted idler on the shaft. It is through these holes of the hollow shaft 2 that the engagement pins 4 will transmit torque and rotation of the hollow shaft 2 to the gear of the constantly meshed pair selected for the work. In order to have a perfect location position in the movement of selection of the constantly meshed gear pair, the selection mechanism is provided with a positioning sensor 37b which can be linear or rotary and which senses the position of the locating tube 1 and informs the governing unit 18 so that it monitors and drives the system.

Figure 8 shows the gears engaged on the parallel shaft 34 which are engaged by means of a type of polygonal coupling 160, that is, the central hole of the gear has no more a round shape but rather a polygonal shape 160. In figure 8, there is represented the polygonal hole 160 with three sides, but it can have four or more sides. The advantage of this system is that it does not need to use keys or internal teeth in the gear for attachment with the corresponding shaft. Parallel shaft 34 also is not circular and in the portion thereof on which the gears of the constantly meshed pairs are mounted on this parallel shaft 34, exactly the same outer polygonal contour 160 is present. Therefore, the gear and the shaft are always attached for transmitting rotation and torque. The locating tube 1 has the function of selecting the speeds or of selecting the gear pair to be engaged. In order that the locating tube 1 effects the selection, it has to slide within the hollow shaft 2 so that the centerline of the radial holes which contain the engagement pins 4 is positioned, this centerline 151 as seen in figure 7 is located in the center of the internal teeth 4c of the gear of which the pair will be selected. So that hollow shaft 2 rotates always integral with the locating tube

1, both are attached through a key 3 permitting relative axial sliding between the two, but keep them always with the same rotation. In this locating tube 1 with radial holes are mounted as many engagement pins 4 as many are the number of holes, which pins serve to connect the gear of the selected of the hollow shaft 2 e therefore said gear and its pair start to transmit torque and rotation e all remaining gear pairs which are constantly meshed, which are rotating idler, that is, without transmitting rotation and torque. The engagement pins 4 as shown in figure 1B, are radially mounted on the end of the locating tube 1 and are radially disposed and are equally spaced in the diameter according to figure 1A. Engagement pins 4 have at their clutching end, teeth 4a which are coupled to the internal teeth 4c as shown in figure 7. In figures 1A and 1B, engagement pin 4 is represented with only one tooth 4a, but it can be provided with one or more teeth 4a which will be coupled to the internal teeth of the gears 4c. At the other end of the engagement pin 4, e has a sliding inclined plane 4b with a suitable angle to slide over an actuating tip 5. Engagement pins 4 are engaged on the actuating tip 5 in guides 6 shown in figure 1C. Engagement pins 4 have slots 6A permitting this coupling. In the clutching movement, when the engagement pins 4 are actuated outwardly against the gear internal teeth 4c, engagement pin 4 bears on the actuating tip 5. In the disengagement movement, when the engagement pin 4 goes out of the gear internal tooth 4c. said engagement pin is pulled by the guides 6 of the actuating tip 5 pulling engagement pin 4 through the slot 6a thereof and through the surface 6b of said slot 6a which is T-shaped. Guides 6 of the actuating tip 5 can be slipping or rolling guides. T-shaped slot 6a serve to keep the engagement pin 6 attached to the actuating tip 5 so that this is extracted for disengagement. To retract

said engagement pins 4, retracting springs are used as a solution, wherein a "T"-profile is no longer necessary for retraction. The springs are disposed in a radial fashion like the pins, always keeping the retraction force of engagement pins 4. Once the actuating tip 5 is retracted, engagement pins 4 are also retracted by effect of the springs. When the engagement pins 4 are totally retracted with the locating tube 1, they will have a diameter smaller that the diameter of hollow shaft 2 so that they move with locating tube 1 to select a new gear pair without said engagement pins 4 rubbing out or interfering with the internal hole of hollow shaft 2 during the selection movement of locating tube 1. The selection movement is monitored by a positioning sensor 37b to ensure accuracy of said positioning. The movement of location and selection of the gear pair to be selectively meshed is made by a lug nut 7 engaged in locating tube locating tube 1 by a roller bearing 8 permitting the lug nut 7 causes the locating tube 1 which is rotating with hollow shaft 2, to slide within hollow shaft 2 and to selectively locate the gear of the gear pair to be meshed. Lug nut 7 does not rotate with locating tube 1 because of the roller bearing 8 but, through this roller bearing 8 pushed and pulls locating tube 1 to the selection position. The part which makes lug nut 7 to slide in order to pull or push locating tube 1 into selection is a spindle 9 which is bi-supported on a housing 10 of the transmission, through two roller bearings 11, 12. To this spindle 9, there is splined a synchronizing pulley 13 or a toothed pulley which, through a synchronizing toothed belt or chain 14 is given movement from a direct or alternating current servomotor 15. This motor 15 is driven by an electro=electronic apparatus for power transmission referred to as servo-actuator (15a) which is schematically depicted in figure 6. Servo-actuator 15a receives drives to

actuate motor 15 to actuate motor 14 of the governing unit 18. The clutching movement or the movement of the engagement pins 4 is effected through longitudinal displacement axially of locating tube 1 and relative to this locating tube 1, of the actuating tip 5 to which engagement pins 4 are engaged through slots in the bases of said engagement pins 4, in the guides 6 of said actuating tip 5. The clutching movements of said engagement pins 4 are radial and perpendicular to the axial displacement of the actuating tip 5. The actuating tip 5 besides rotating together with said locating tube 1 e displacing with this locating tube 1 axially to cause the location and selection movement, has also a relative axial movement with this locating tube 1, which axial movement is inherent to the actuating tip 5 which is independent of locating tube 1. This axial movement permits to transfer axial movement to engagement pins 4 through an end cone of the actuating tip 5 and through said end with inclined plane 4b of engagement pins 4. Actuating tip 5 rotates together with locating tube 1 since it is engaged to engagement pins 4 and these are mounted within locating tube 1 by the radial holes. The positioning accuracy of the actuating tip 5 to effect the engagement or disengagement event is ensured by the monitoration made by the positioning sensor 37a which could linear or rotary. As a first alternative, according to figure 1, so that the actuating tip 5 effects axial movement and promotes radial movement of engagement pins 4 into locating tube 1 and engages the gear of the selected gear pair, said actuating tip 5 is given axial movement from an extended screw 25 which is not rotated but is only axially displaced pushing actuating tip 5 through a roller bearing 31. Extended screw 25 is not rotated since it is engaged in an anchoring tube 27 through a key 27a and this anchoring tube is engaged to a cap 28

which in turn is secured to the transmission housing 10. An extended nut 24 which is mounted within locating tube 1 and axially therewith does not rotate with the tube since there is a roller bearing 30 therebetween that permits that said extended nut 24 is only translated axially with locating tube 1. By rotating independently of locating tube 1, extended nut 24 causes the extended screw 25 moves axially within anchoring tube 27 e thereby extended screw 25 pulls or pushes actuating tip 5. Extended nut 24 rotates by being given rotation movement from a turning tube 22 through key 23 which attaches said extended nut 24 to a turning tube 22. Turning tube 22 has its own rotational movement. Turning tube 22 does not displace axially in relation to the transmission housing 10 since it is attached to this transmission housing 10 through roller bearing 29. Extended nut 24 is always attached to turning tube 22 through key 23 as the turning nut 24 which is mounted within locating tube 1 moves axially therewith. Extended nut 24 enters and exits within turning tube 22 as locating tube 1 is displaced for location since extended nut 24 is attached to locating tube 1 by roller bearing 30. Turning 22 rotates by means of synchronizing or toothed pulley 20 which is engaged in said turning tube 22 through key 21. Synchronizing or toothed pulley 20 is given movement through the synchronizing belt or chain 32 which is given rotation movement from the direct or alternating current motor 19 through said synchronizing or toothed pulley 20. Extended nut 24 rotates and thereby actuated extended screw 25 to be axially displaced rightwards or leftwards, depending upon the turning direction imposed by the direct or alternating current motor 19. Therefore, with movement of actuating tip 5 caused by the axial movement of extended screw 25 to which said actuating tip 5 is attached through roller bearing 31, engagement pins

4 engage and disengage the gear from the selected gear pair.

As a second alternative, in accordance with figure 2, so that actuating tip 5 carries out the axial movement and promotes radial movement of engagement pins 4 within locating tube 1 and engage gear of the selected gear pair, said actuating tip 5 is give the axial movement from an actuation piston 40 which does not rotate since it forms part of an actuation cylinder 41. Between actuation piston 40 and actuation cylinder 41, the only exists relatively the axial movement and so that one does not rotate in relation to the other, these two are attached through key 42. Since the actuating tip 5 is attached to engagement pins 4 and this assembly always rotates with hollow shaft 2, in order that non-rotating actuation piston 40 can push and pull actuating tip 5, said actuation piston 40 is attached to said actuating tip 5 through roller bearing 43 which permits transmission of the axial movement from the actuation piston 40 to said actuating tip 5. Actuation piston 40 moves axially within actuation cylinder 41 by hydraulic or pneumatic action, and the actuation movement of said actuation piston 40 is such that engagement pins 4 can engage teeth 4a in internal teeth 4c of the gear from the selected pair, and the hydraulic fluid or compressed air will be sent to an actuation chamber 44 of said actuation cylinder 41 through actuation orifice 45 in the axis of actuation piston 40, a deactuation chamber 46 being connected in a free of pressure fashion to a tank or outlet 56. So that engagement pins 4 are pulled to disengage teeth 4a from internal teeth 4c of the gear from the previously selected pair and that will be now shifted, hydraulic fluid or compressed air will be sent to deactuation chamber 46 through deactuation orifice 47 in the axis of actuation piston 40, actuation chamber being connected in a free of

pressure fashion to tank or outlet 56. Engagement pins 4 are pulled inwardly locating tube 1 permitting that it is displaced for selection. Actuation cylinder 41 does not rotate with hollow shaft 2 but rather it is displaced axially therewith during movement of selection of the gear pair for operation. Actuation cylinder 41 is attached to hollow shaft 2 through roller bearings 48 which allow for relative rotation therebetween and do not allow for axial movement therebetween. Actuation cylinder 41 possess an extension 49 which is connected to an anchoring tube 50. Extension 49 enters and exists anchoring tube 50 during selection movement of the gear pair and anchoring tube 50 is engaged in the housing of the transmission box 10 and therefore is secured without moving. A key 51 attaches said anchoring tube 50 with extension 49 of actuation cylinder 41, thus causing said actuation cylinder 41 not to have relative rotation with housing 10 and have only relative axial movement with housing 10. Said extension 49 also houses within it, actuation and deactuation ducts 52 and 52 which carry hydraulic fluid or compressed air. Flow of compressed air or hydraulic fluid into actuation cylinder 41, to effect actuation of actuation piston 40 and consequently to effect engagement and disengagement of the selected gear pair through engagement pins 4 is made by actuation and deactuation 52 and 53. Governing unit 18 acts in a relay and coil logic 54 which direct hydraulic fluid or compressed air from a source 55 of hydraulic fluid or compressed air for the actuation and deactuation 52 and 53 with return to zero pressure, and tank 56 or outlet on the opposite side to the actuation effect.

As a third alternative, according to figure 3, in order that actuating tip 5 can effect axial movement and promote radial movement of engagement pins 4

within locating tube 1 and engage gear of the selected gear pair, said actuating tip 5 is given axial movement from an actuation pin 70 which does not rotate since it forms part of an actuating electromagnetic solenoid 71. Between actuation pin 70 and electromagnetic solenoid 71, there is only relatively the axial movement and so that one does not rotate relative to the other, these are attached by a key 72. Since actuating tip 5 is attached to engagement pins 4 and this assembly always rotates with hollow shaft 2, in order that actuating pin 70 which does not rotate can push or pull actuating tip 5, said actuating pin 70 is attached to said actuating tip 5 through a roller bearing 73 which permits transmission of axial movement from actuating pin 70 to actuating tip 5. Actuating pin 70 moves axially within electromagnetic solenoid 71 by mechanical or magnetic action through the effect of a spring 74, and the actuation movement of actuating pin 70 pushes engagement pins 4 to engage teeth 4a into the internal teeth 4c of the gear of the selected pair, and the electrical potential difference applied to the coil 75 of electromagnetic solenoid 74 is removed causing spring 74 to push actuating pin 70 to effect engagement movement of actuating tip 5. In the meshed gear position, with all engagement pins 4 coupled to the gear, actuating pin 70 is retained by the action of spring 74 and by a mechanical lock 76. So that engagement pins 4 are pulled to disengage teeth 4a from the internal teeth 4c of the gear of the previously selected pair and that will be now shifted, an electric potential difference is applied to the coil 75 o electromagnetic solenoid 71 to perform disengagement movement of actuating tip 5. The movement of actuating pin 70 is made by the electromagnetic force induced by the coil 75 of electromagnetic solenoid 71 which overcomes the force of spring 74 and the force of the mechanical lock 76

and releases totally engagement pins 4 into locating tube 1, permitting that this will be displaced to effect the selection movement of the new gear pair for operation. Electromagnetic solenoid 71 does not rotate with hollow shaft 2 but rather displaces axially therewith during the selection movement of the gear pair for operation. Electromagnetic solenoid 71 is attached to hollow shaft 2 through of two roller bearings 78 which permit relative rotation therebetween, but do not permit relative axial movement therebetween, Electromagnetic solenoid has an extension 79 which is connected to an anchoring tube 80. Extension 79 enters and exits anchoring tube 80 during the selection movement of the gear pair and anchoring tube 80 is engaged in the housing of the transmission box 10, being therefore fixed and with no movement. A key 81 attaches said anchoring tube 80 to said extension 79 of the electromagnetic solenoid 71, causing said electromagnetic solenoid 71 not to have relative rotation with housing 10 and have only relative axial movement with housing 10. Said extension 79 houses also within it cables 82 which will transmit the electrical current to impart electric potential difference to the coil 75 of electromagnetic solenoid 71. Governing unit 19 acts in a relay logic 83 which can energize or de-energize coil 75 of electromagnetic solenoid 71 by receiving energy from an electric voltage source 84. When coil 75 is energized, actuating pin 70 overcomes the force of spring 74 and of mechanical lock 76 and then disengagement is effected. Without energy, coil 75 does not act on the actuating pin 70 and therefore the action is of spring 74 for engagement of engagement pins 4. In order to ensure that locating tube 1 effects accurately the location movement for speed selection, the mechanism is provided with a sensor for measuring such position so that governing unit 18 monitors and drives the

correct position of speed selection. To ensure that engagement pins 4 attain the engagement and disengagement points, there is in the system a sensor measuring the perfect position of the engaged pin of the disengaged pin so that governing unit 18 monitors and drives the correct position for speed engagement and disengagement.

The present invention also concerns the synchronization system of the rotary parts through of the continuous or alternating current 16 driven by the electro-electronic actuation 16a according to figures 1 and 6. Under the aspect of possibilities of synchronization, the system will depend on how the machine has been assembled: with a constant rotation motor 101 or a variable rotation motor 121. This will depend also on the assembly of hollow shaft 2 which contains the gear shift mechanism of constantly meshed gear pairs and of mutually exclusive actuation, if this hollow shaft 2 is mounted in the rotation input side or in the output rotation side 105. If, in such a case, the motor (101) of the machine is of continuous rotation. according to figure 9, that is, if this motor works with a fixed rotation, supplying this rotation to the machine through clutch 102 and the by a transmission box 103, we can have then the following physical and mathematical considerations:

Rotation of the input shaft of the transmission box

at the motor side: **Nm**

Rotation of the box shaft: **Ns**

Transmission Ratio of a Generic Pair: **Ri**

Transmission Ratio of another Generic Pair: **Rj**

Index related to a Generic Pair: **(i)**

Index related to a Generic Pair: **(j)**

By the transmission equation of mechanics, we have, for a determined generic pair of gears (i):

Nm(i)=Ns(i)xR(i)

For the other generic gear pair (j) we have:

Nm(j)=Ns(j)xR(j)

Since the motor in this case has a set constant rotation, then it is clear that: **Nm(j)=Nm(i)=Nm**

Therefore, for passing from the gear pair (i) to the meshed gear pair (j), said output rotations are related by the following expression:

Ns(i)xR(i)=Ns(j)xR(j)

Then, the end output rotation will be:

Ns(j)=Ns(i)xR(i)/R(j)

Ns(j) differs from Ns(i) by the proportion of the transmission rate R(i) and R(j). Therefore, synchronization motor 16 from the moment wherein the clutch is released and from the moment where the gear pair (i) is disengaged for speed shift, the synchronization motor 16 will have to cause the rotation of output shaft, Ns(j), is equal to that which was prevailing prior to releasing of clutch, Ns(i), multiplied by ratio **R(i)/R(j)**, in predetermined time fraction. Therefore, the rotating masses are accelerated as a function of ratio **R(i)/R(j)**. At the moment that rotation R(j) has been attained, the event of speed shift takes place, that is, there is an engagement of the gear pair 3. For a perfect accuracy of the phenomenon, the input and output rotations are constantly monitored by rotation sensors, by output sensor 94 and by the input sensor 93. Independent from where hollow shaft 2 is mounted or in

the output rotation side 105 (figure 9B), the synchronism system should be mounted in the output rotation side 105, since it is of this side that the rotating masses have to be accelerated or decelerated.

If in this case, the machine motor or vehicle engine is of variable rotation 121, figure 10, supplying this rotation to the machine or vehicle from clutch 122 and then to the transmission box 123, then we have the following equations with the variables already known for a determined generic pair (i):

$$Nm(i)=Ns(i)xR(i)$$

For the other generic pair (j), we have:

$$Nm(j)=Ns(j)xR(j)$$

Since the motor is of variable rotation, and considering that in the period of time of speed shift, the rotation remains unchanged in this period of time, then:

$$Ns(i)=Ns(j)=Ns$$

Therefore, for passing from the meshed pair (i) to meshed pair (j) of gears, said input rotations are related through the following expression:

$$Nm(i)/R(i)=Nm(j)/R(j)$$

Then, the end input rotation should be:

$$Nm(j)=Nm(i)x(R(j)/R(i))$$

Nm(j) differs from Nm(i) by the inverse proportion of the transmission ratios R(i) and R(j). Therefore, the synchronism motor 16, starting from the moment in which clutch is released and from the moment in which the gear pair (i) is disengaged for speed shift, will have to cause rotation of the input shaft, Nm(j),

to be equal to rotation that was prevailing prior to releasing of the clutch, Nm(i), multiplied by the inverse proportion **R(i)/R(j)**, in a predetermined fraction of time. Thereby, the rotating masses are decelerated or accelerated as a function of the inverse ratio **R(i)/R(j)**. At the moment in that rotation Nm(j) has been attained, the speed shift event takes place, that is, the gear pair (j) is engaged. For a perfect accuracy of the phenomenon, the input and output rotations are being constantly monitored by the rotation sensors, by the output sensor 94 and by the input sensor 93. Independently from where hollow shaft 2 is mounted, or from the rotation output side 125, as in figure 10B, or from the rotation input side, as in figure 10A, the synchronization system must be mounted at the input side, since it is in this side that they have to be accelerated or decelerated. The synchronization mechanism applied to the four alternatives disclosed and cited is composed of a direct or alternating current motor 16, driven by an electro-electronic servo-actuator 16A which, in turn, is governed from a governing unit 18 for operation thereof. The direct or alternating current motor 16 has at one shaft thereof, a toothed or synchronizing pulley 91 which, in turn, is connected o transmit rotation to the toothed or synchronizing pulley 90 which is engaged in the shaft to which acceleration or deceleration will be imparted so that synchronism of rotations is achieved. It is only during such synchronization event that the direct or alternating current motor 16 will be energized and in the other events it will be always off and idle.

Although the present invention has been described at some extent of details, it is understood that within the spirit and scope of the present invention, it is possible that parts are rearranged and modified.

CLAIMS

1. Gear-shifting mechanism controlled and driven by a governing unit in an automatic and controlled way and which can be also driven by an operator, forming a speed or gear-shifting mechanism of a transmission box of automobiles or machines, characterized by comprising a set of servo-motors (15, 16, 19) of direct or alternating current each performing a specific function of engagement or disengagement of the speeds by motor (19), of speed selection by motor (15), and of speed synchronization by motor (16), wherein each of said three servo-motors is controlled by an electro-electronic servo-actuator respectively (15a, 16a, 19a) of a set (17) of servo-actuators.

2. A mechanism in accordance with claim 1, characterized in that the set (17) of electro-electronic servo-actuators for acting in the servo-motors (15, 16, 19) of direct or alternating current is governed by a governing unit (18) which, in a logical and sequential way, sends signals to the set (17) of electro-electronic actuators based on a programmed logic recorded in the electronic memory of said governing unit (18) which can have as driving pulses of such signals, the action of an operator or driver which will act on levers (120) or another actuation means which forces the speed shift or shift of the gear pair and in that the pulses for the speed shift can be emanated from the set of sensors (37) and thereby it is said that the operations is effected automatically.

3. A mechanism in accordance with claim 1, characterized in that, so that there is a gear shifting, there is the actuation sequence driven by the governing unit (18), starting from the release of the clutch through the mechanism actuated by

the direct or alternating current servomotor (19) which uncouples the machine or vehicle motor from the transmission opening the power transmission loop followed by the event of speed disengagement through the engagement and disengagement actuated but the direct or alternating current motor (19) followed by the event of selection of a new speed through the location mechanism actuated by the direct or alternating current motor (15) concurrently with the occurrence of the selection of the speed chosen by the system, the synchronization mechanism acting now so as to equalize the rotations of the parts involved in engagement which are synchronized by the synchronization mechanism which is actuated by the direct or alternating current servomotor (16) and thereafter, at the moment at which synchronization has been attained and selection has been completed, said engagement and disengagement acts to engage the speed and immediately after engagement, the clutch is clutched the power transmission loop being regained by the machine or vehicle.

4. A mechanism in accordance with claim 3, characterized in that the speed selection mechanism is mounted internally of one of the transmission shafts which can by one of torque and rotation input or it can be mounted internally of an output shaft, said hollow shaft (2) and all the gears forming part of the constantly meshed pairs are mounted in an idler fashion, that is, so that they can rotate on the hollow shaft (2) with different rotations of said hollow shaft (2) on bearings (152) disposed in the bore of the gears, and only one gear pair is selected and pre-disposed to be engaged to the hollow shaft (2) by the engagement and disengagement mechanism and that the selection mechanism is composed by a locating tube (1) having a set of radial holes equally distributed over the diameter of locating tube (1)

and spaced by an equal angle, each hole housing an engagement pin (4) so that locating tube (1) rotates along with shaft (2) and slides within the same searching for the location of a centerline (151) of the gear of the constantly meshed pair chosen for selection and in that a lug nut which is engaged in locating tube (1) through a roller bearing (8) does not rotate in relation to housing (10) but it is actuated by a spindle (9) to impart to locating tube (1), an axial movement relative to hollow shaft (2) and spindle (9) is actuated by toothed or synchronizing pulleys (13, 13a) and by synchronizing belts or chains (14) which are given movement from the direct or alternating current servomotor (15) and of which the exact accuracy of the centerline of the locating pins (4) with the centerline (151) of the gear of the pair to be selected is assured by a positioning sensor (37b) which can be linear or rotary and which measures the position of locating tube (1) and informs governing unit (18).

5. A mechanism in accordance with claim 3, characterized in that the engagement and disengagement mechanism of is mounted internally of locating tube (1) which in turn is mounted internally of hollow shaft (2), wherein the engagement and disengagement grounds are based on a set of engagement pins (4) having radial movement enabling that notches (4a) at the tip of engagement pins (4) are engaged in female notches (4c) of the bore of the gear of the constantly meshed pair selected at the moment of engagement to transmit torque and rotation and enabling, when requested, disengagement and wherein said engagement pins (4) are pushed or pulled to effect the engagement and disengagement movement, pushed or pulled by an actuating tip (5) which, through an inclined plane (4b) urges engagement pins (4), radially of engagement, through axial movement of actuating tip (5) or pulls said

engagement pins (4) through linkages such as guides (6) from within the notches of the gears for disengagement and further the return of engagement pins (4) is made by springs.

6. A mechanism in accordance with claim 5, characterized in that the engagement and disengagement mechanism is actuated by a direct or alternating current servomotor (19) being servo-driven by an electro-electronic servoactuator (19a) which in turn is driven by governing unit (18) and in that said servomotor has dual rotation direction, one for the engagement movement and the other rotation direction is for the disengagement movement, and the direct or alternating current servomotor (19) actuates synchronizing pulley or toothed pulley (20a) which, by the toothed belt or chain (32), moves synchronizing pulley or toothed pulley (20) which is attached by a key (21) or any other type of notch to a turning tube (22) transmitting movement to a turning nut (24) through key (23) or any other type of notch, and that upon rotating said turning nut (24), this imparts to actuating tip (5), the axial movement towards engagement or disengagement by an extended screw (25) which is attached to housing (10) through an anchoring tube (27) engaged therein and that axial movement of actuating tip (5) is independent from rotation of locating tube (1) and hollow shaft (2) due to roller bearings (30) and (31) which attache said actuating tip (5) and said extended screw (25) and in that the end of the movement of the engagement and disengagement stroke is sensed by a displacement sensor (37a) which can be a rotary or linear sensor sending information to governing unit (18) in a very short time so that governing unit (18) drives and governs the system.

7. A mechanism in accordance with claim 5, characterized in that the

engagement and disengagement mechanism is actuated by a hydraulic or pneumatic system which is driven and governed by governing unit (18) actuating in a set of a logic (54) of relays and coils driving opening for entry of hydraulic fluid or compressed air from a source (55) of hydraulic fluid or compressed air, this hydraulic fluid or compressed air goes to an actuation piston (40) through an actuation duct (52) so as to urge the actuation piston to engagement movement, since the hydraulic fluid or compressed air go to an actuation chamber (44) of an actuation cylinder (41), thus imparting to actuating tip (5) the engagement movement, said actuation cylinder (41) does not rotate together with hollow shaft (2) since there are roller bearings (48) therebetween and further actuation cylinder (41) is attached to housing (10) through an anchoring tube (50) through key (51) and between anchoring tube (50) and actuation cylinder (51), there is only relative axial movement and actuation piston (40) also does not rotate together with actuating tip (5), with hollow shaft (2) and with locating tube (1) since it is mounted in roller bearing (43) and is integral to actuation cylinder (41) by key (42) and, for movement of the actuation piston (40) for disengagement, the hydraulic fluid or compressed air is sent to a deactuation chamber (46), driven by governing unit (18) which acts on the relay logic (54) and which drives opening of a deactuation duct (53) so that disengagement movement of the mechanism is effected.

8. A mechanism in accordance with claim 5, characterized in that the engagement and disengagement mechanism is actuated by an actuation system through an actuating electromagnetic solenoid which is driven and governed by governing unit (18) acting in a set of relay logic (83) and driving energization or not of a coil (75)

through an electric voltage source (84) forming part of the actuation solenoid (71), this energization drive being through cables (82), and so that there is engagement movement of an actuation pin (70) it is necessary that the coil is under no voltage, thus de-energized, and thereby bias of spring (74) pushes actuation pin (70) towards engagement movement, this engagement movement being limited by the end of the mechanical stroke and by the action of a mechanical lock (76), and so that there is the opposite disengagement movement, governing unit (18) drives relay logic (83) to energize coil (75) fed by the electric voltage source (84) once energized coil (75) of electromagnetic solenoid (71) causing actuation pin (70) to overcome the force of spring (74) and of the mechanical lock (76) and to effect disengagement movement, and further electromagnetic solenoid (71) is integral to actuation pin (70) which does not rotate together with actuating tip (5) and with hollow shaft (2) and locating tube (1) since they are attached thereto by roller bearings (73, 78) and electromagnetic solenoid (71) is attached to housing (10) through an anchoring tube (80) by a key (81) and only has therewith a relative axial movement.

9. A mechanism in accordance with claim 5, characterized in that the engagement mechanism has an actuating tip (5) which, upon effecting engagement movement, urges engagement pins (4) radially so that notches (4a) of the pin tip engage into notches (4c) of the internal bore of the gear of the selected constantly meshed pair and that rotates on hollow shaft (2), and when actuating pin (5) effects disengagement movement, said actuating pin (5) pulls engagement pins (4) radially causing the notches (4a) of the tips of engagement pins (4) go out from notches (4c) of the gear bore where it was engaged and said engagement pins (4) which are housed

in the radial holes of locating tube (1) are retracted entirely into said locating tube (1) allowing the same to be able of sliding axially within hollow shaft (2) in a free manner and with no interference.

10. A mechanism in accordance with claim 1, characterized in that a parallel shaft (34) on which gears (211, 212, 213, 214, 215 and 216) are constantly meshed and making pair with constantly meshed gears (201, 202, 203, 204, 205 and 206) mounted idler on hollow shaft (2), has a polygonal shape with rounded corners (164) and wherein the gears that are mounted on this shaft are attached by the central hole which has the same polygonal shape with rounded corners (160).

11. A mechanism in accordance with claim 1, characterized in that the mechanism for the synchronization of rotating parts at the moment of the speed shift has, as an element supplying energy for acceleration or deceleration, the direct or alternating current servomotor (16) which is driven by the electro-electronic servoactuator (16a) which is in turn governed and controlled by governing unit (18).

12. A mechanism in accordance with claim 11, characterized in that the synchronization mechanism (11), when the machine is provided with a supply energy motor (101) of constant rotation, actuates the shaft on the output side of the machine, accelerating and decelerating, and the movement which comes from the direct or alternating current motor (16) through the toothed or synchronizing pulley (92) attached to this motor transmitting, through a synchronizing belt or chain (91), rotation to the synchronizing or toothed pulley (90) attached to the output shaft through a key or any other type of notch and which, depending on the type of application of said output shaft, can be hollow shaft (2) or parallel shaft (34).

13. A mechanism in accordance with claim 11, characterized in that the synchronization mechanism (11), when the machine is provided with a supply energy motor (101) of variable rotation, actuates the shaft on the input side of the machine or vehicle, accelerating and decelerating, and the movement which comes from the direct or alternating current motor (16) through the toothed or synchronizing pulley (92) attached to this motor transmitting, through a synchronizing belt or chain (91), rotation to the synchronizing or toothed pulley (90) attached to the input shaft through a key or any other type of notch and which, depending on the type of application of said output shaft, can be hollow shaft (2) or parallel shaft (34).

14. A mechanism in accordance with claim 11, characterized in that, in the synchronization mechanism when the machine is provided with a supply energy motor (101) of continuous rotation, so that speed shift is effected or to exchange a generic constantly meshed gear pair (i) to a gear pair (j), the direct or alternating current synchronization motor (16) should cause the rotation of output shaft Ns(j) is equal to that rotation at which it was rotating before releasing of the clutch and the consequent disengagement, which was Ns(i) multiplied by the proportion of the transmission ratios of the constantly meshed gear pair which is being out, R(i), divided by the transmission ratio of the constantly meshed gear pair which is being in, that is, is being selected for work, R(j), and that monitoring of said rotations is made by a rotation sensor (94) which, at extremely short intervals of time, sends the actual rotation data to governing unit (18) so that this latter drives and governs the direct or alternating current servomotor (16) through the electro-electronic servoactuator (16a) accelerating or decelerating the rotating parts in order to achieve synchronization.

15. A mechanism in accordance with claim 11, characterized in that, in the synchronization mechanism when the machine is provided with a supply energy motor (101) of variable rotation, so that speed shift is effected or to exchange a generic constantly meshed gear pair (i) to a gear pair (j), the direct or alternating current synchronization motor (16) should cause the rotation of input shaft Nm(j) is equal to that rotation at which it was rotating before releasing of the clutch and the consequent disengagement, which was Nm(i) multiplied by the inverse proportion of the transmission ratios of the constantly meshed gear pair which is being out, R(i), divided by the transmission ratio of the constantly meshed gear pair which is being in, that is, is being selected for work, R(j), and that monitoring of said rotations is made by a rotation sensor (94) which, at extremely short intervals of time, sends the actual rotation data to governing unit (18) so that this latter drives and governs the direct or alternating current servomotor (16) through the electro-electronic servoactuator (16a) accelerating or decelerating the rotating parts in order to achieve synchronization.

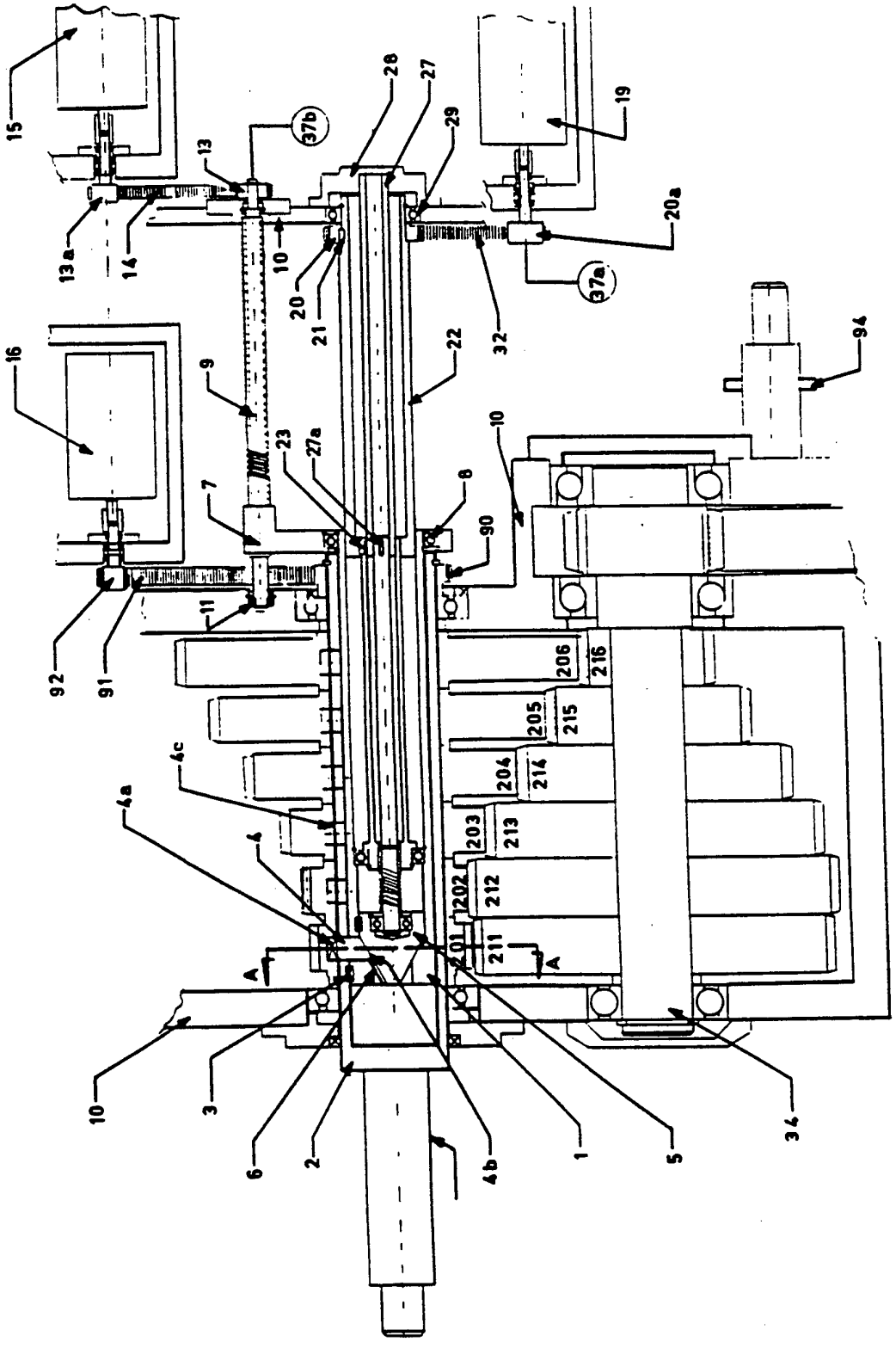

15
13
37b
28
27
29
19
13a
14
10
20
21
20a
37a
32
16
9
22
94
23
27a
10
7
8
90
92
91
11
206
216
205
215
4c
204
214
4a
4
203
213
202
212
201
211
A
A
10
3
6
2
4b
1
5
34
93

FIG.1

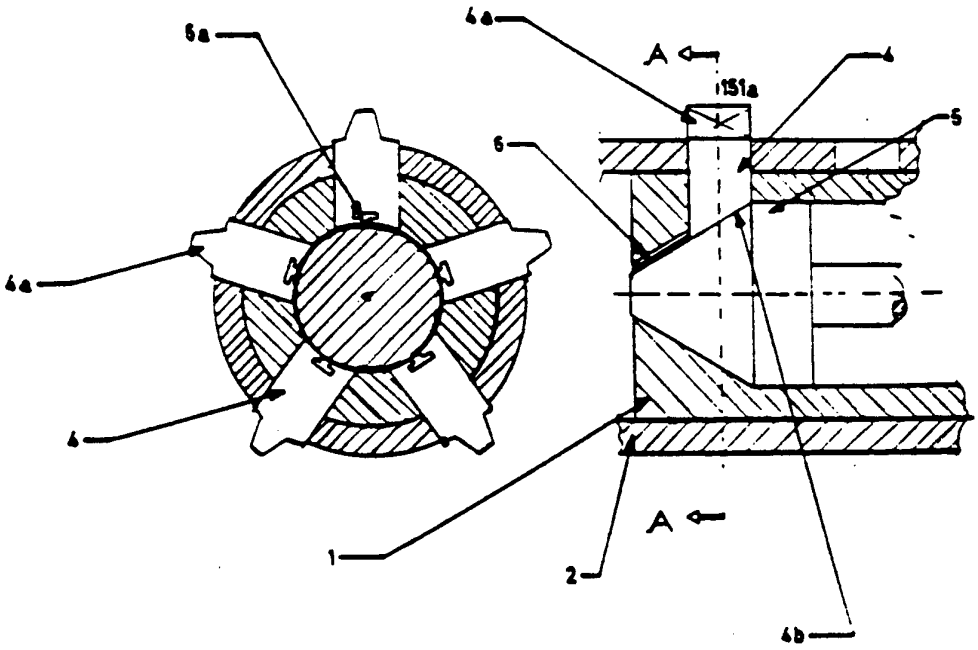


FIG.1(A)

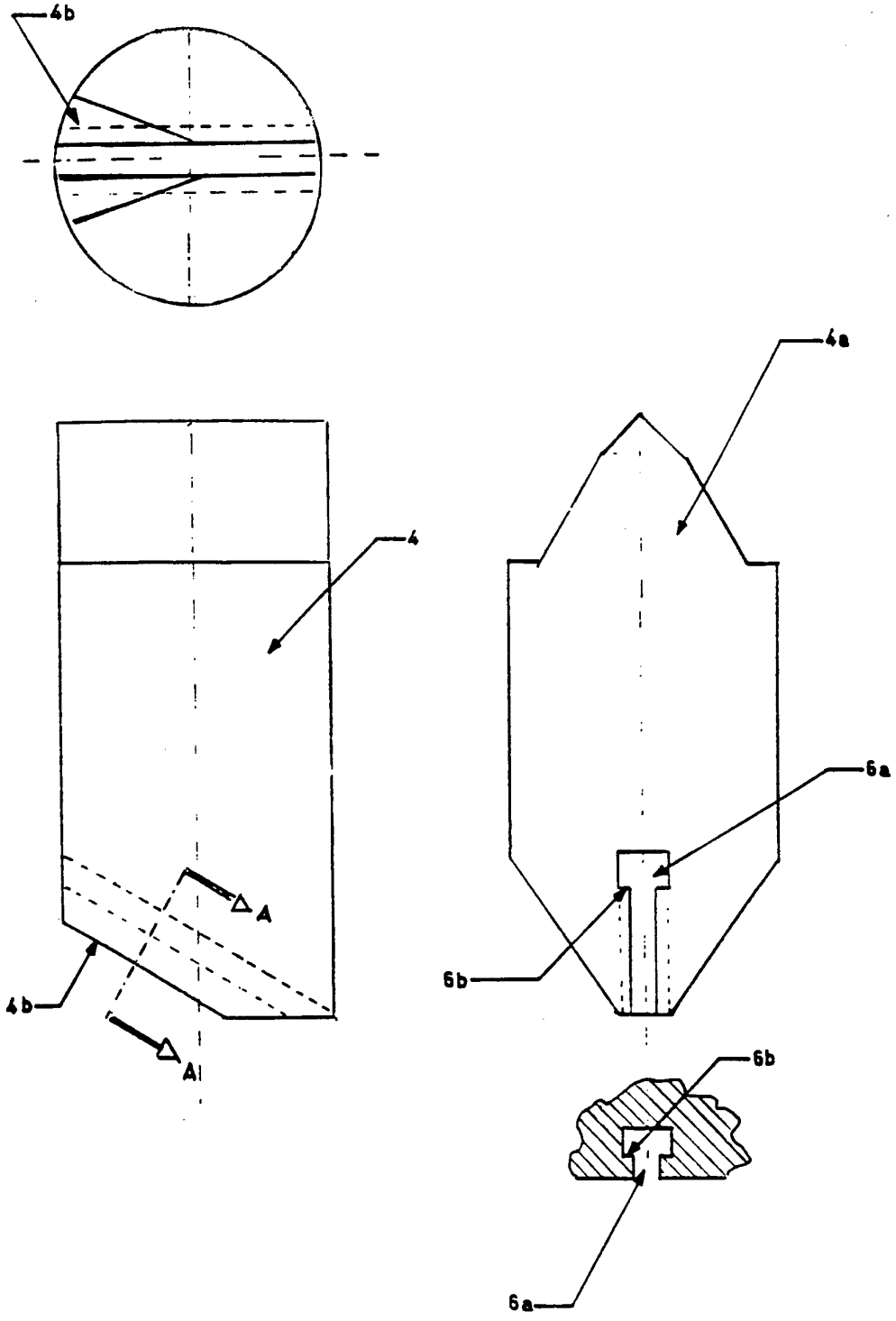


FIG.1B

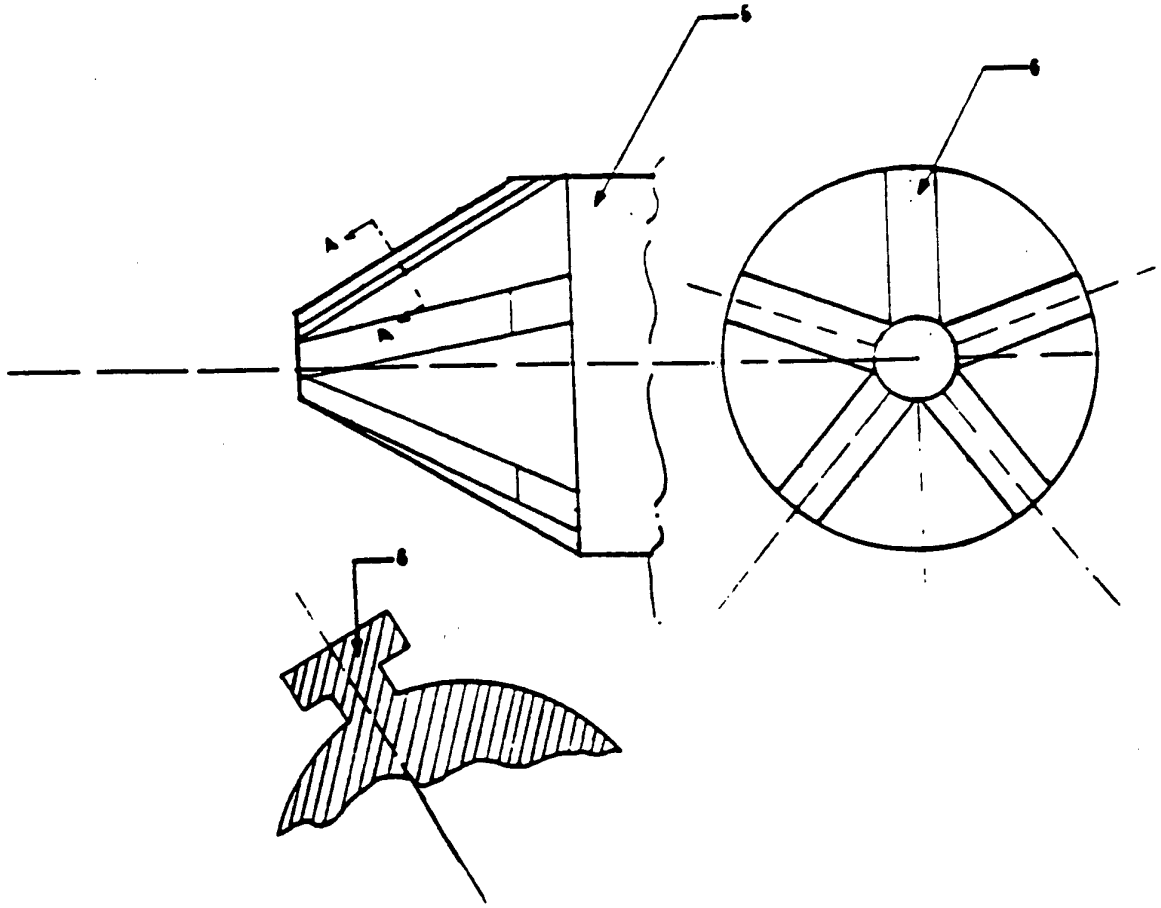


FIG.1(C)

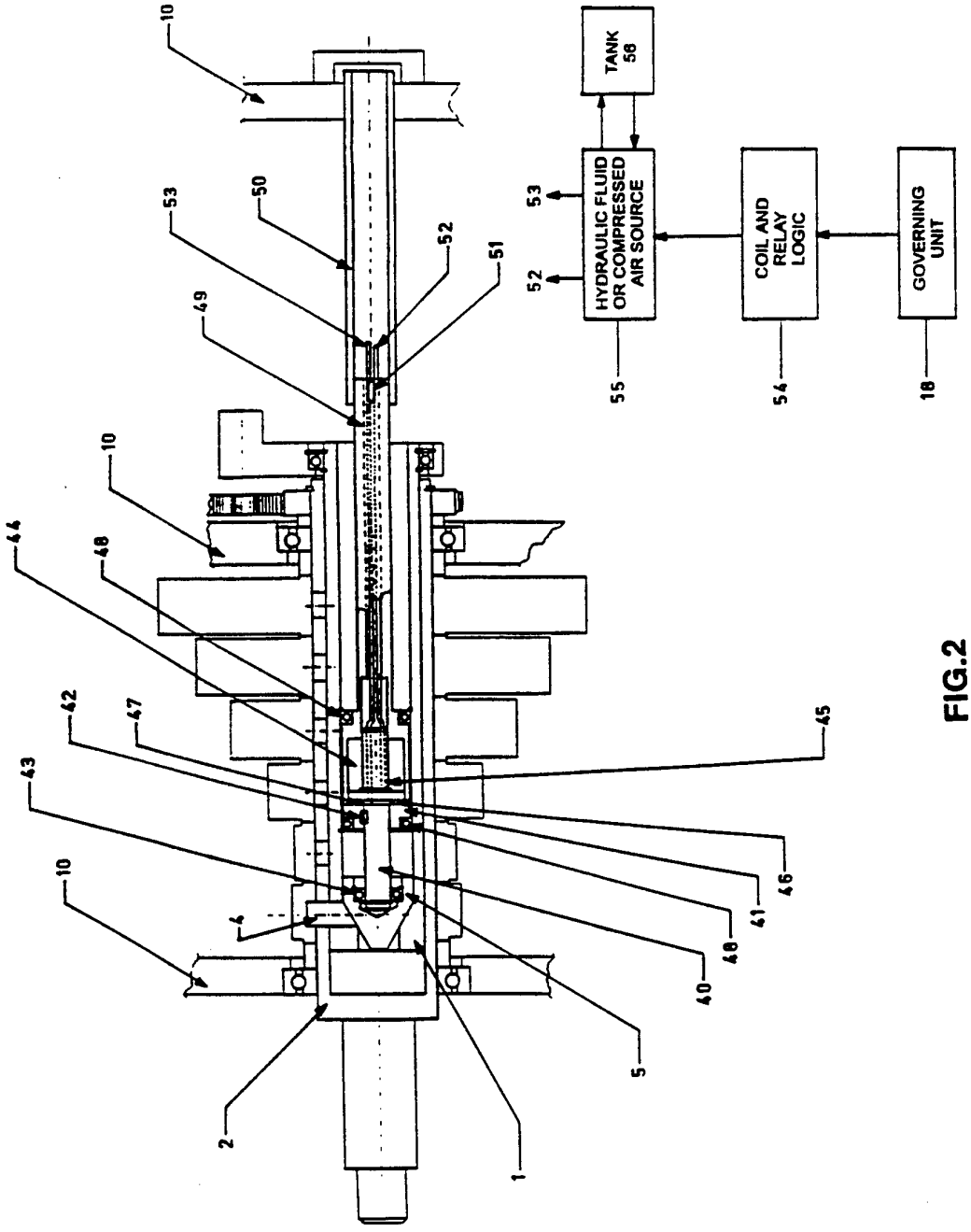

TANK
58
HYDRAULIC FLUID
OR COMPRESSED
AIR SOURCE
COIL AND
RELAY
LOGIC
GOVERNING
UNIT
10
53
50
52
51
49
44
48
42
47
45
43
46
41
40
4
5
2
1
55
54
18

FIG.2

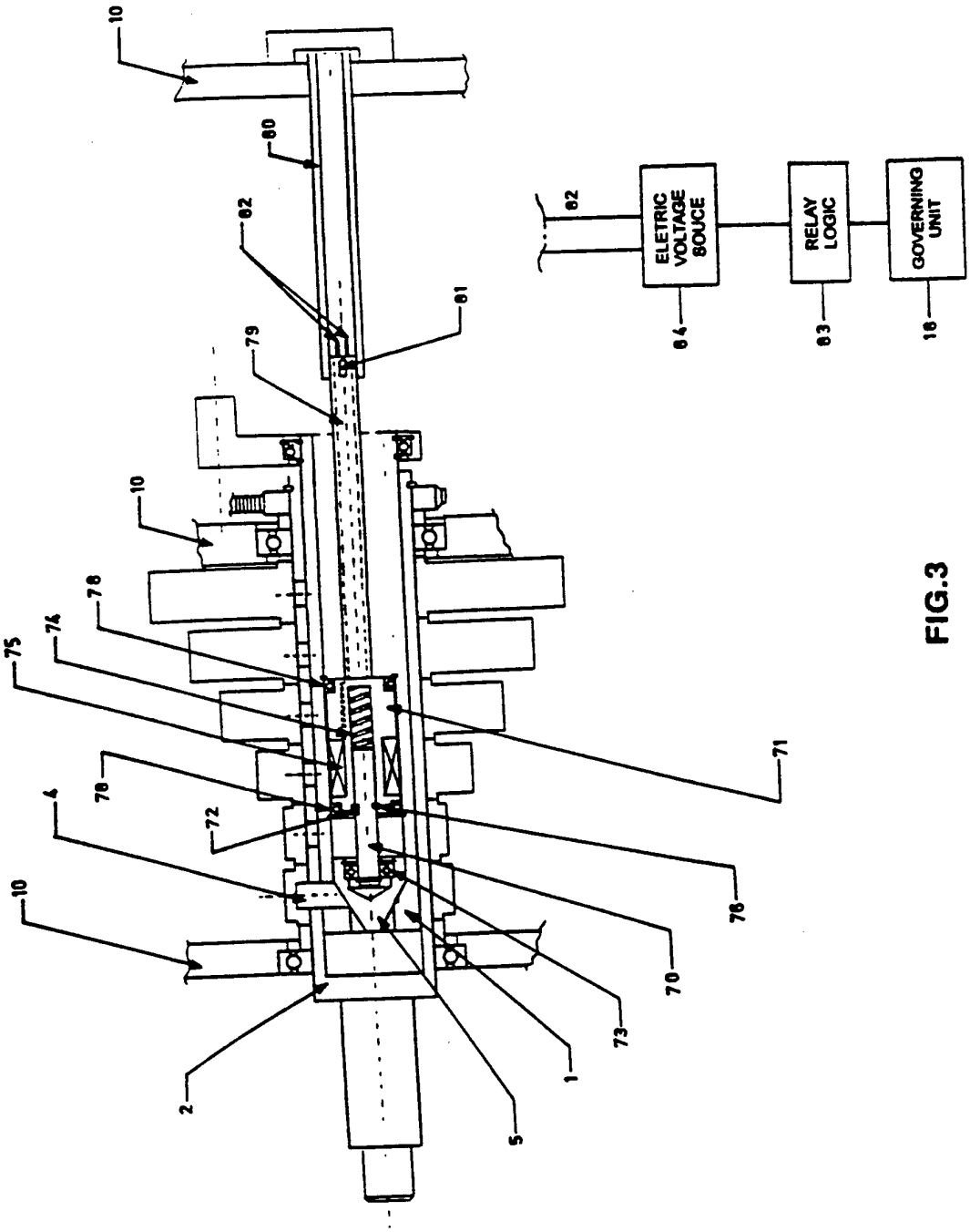

10
60
82
81
79
10
78
74
75
71
76
72
4
10
76
70
73
1
2
5
82
ELETRIC VOLTAGE SOUCE
RELAY LOGIC
GOVERNING UNIT
84
83
16

FIG.3

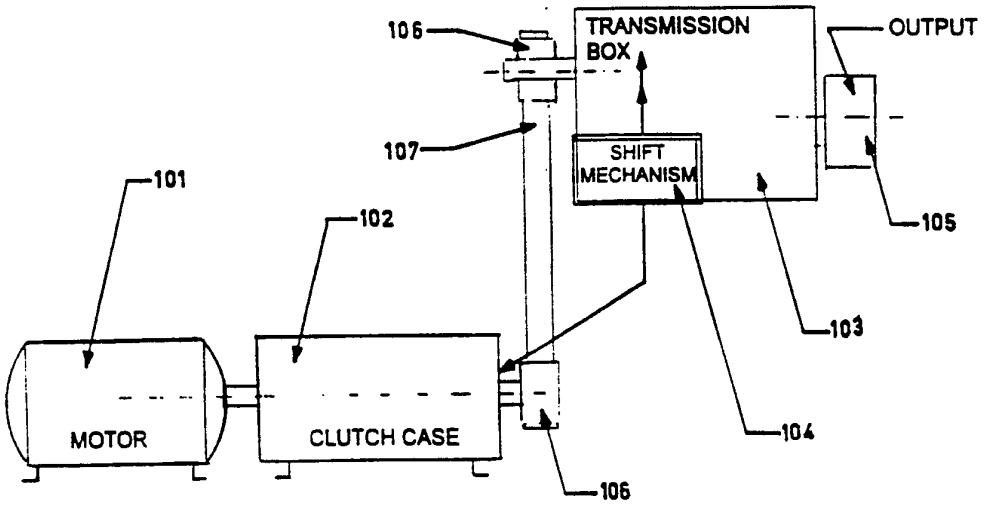

106
TRANSMISSION BOX
OUTPUT
107
SHIFT MECHANISM
101
102
105
103
MOTOR
CLUTCH CASE
104
106

FIG.4

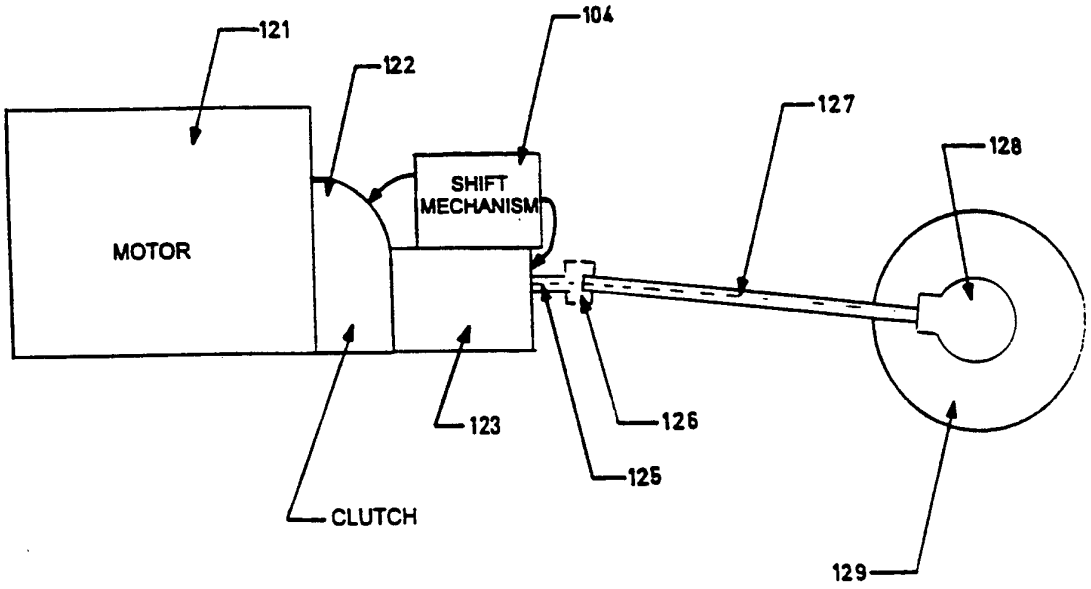

121
122
104
127
128
SHIFT MECHANISM
MOTOR
123
126
125
CLUTCH
129

FIG.5

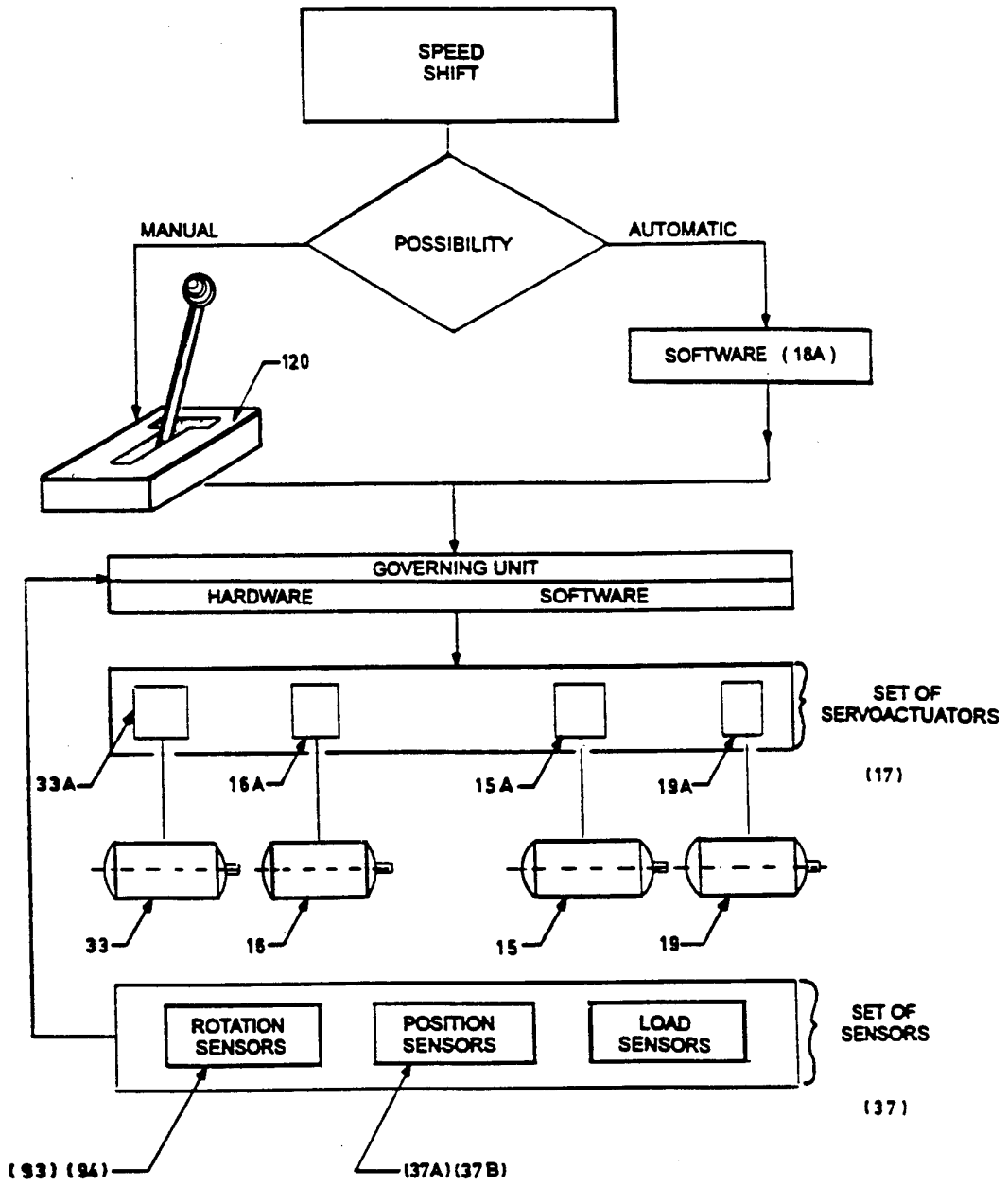

SPEED SHIFT
POSSIBILITY
MANUAL
AUTOMATIC
120
SOFTWARE (18A)
GOVERNING UNIT
HARDWARE
SOFTWARE
SET OF SERVOACTUATORS
(17)
33A
16A
15A
19A
33
16
15
19
ROTATION SENSORS
POSITION SENSORS
LOAD SENSORS
SET OF SENSORS
(37)
(93) (94)
(37A) (37B)

FIG.6

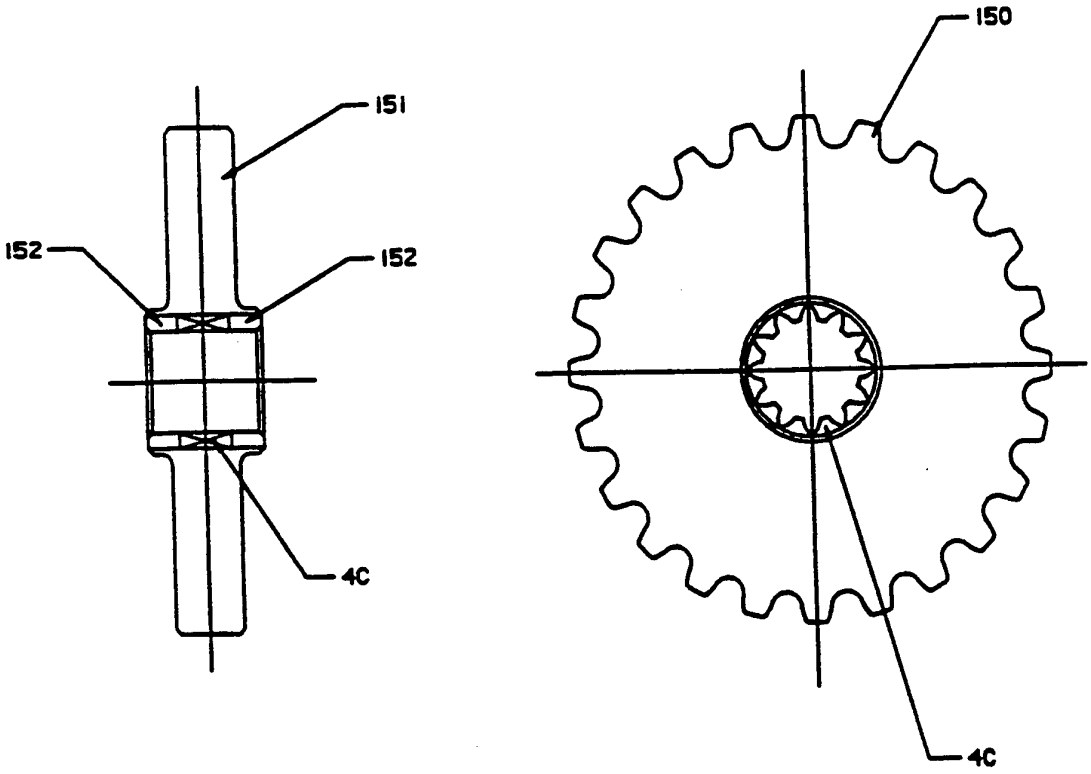


FIG.7

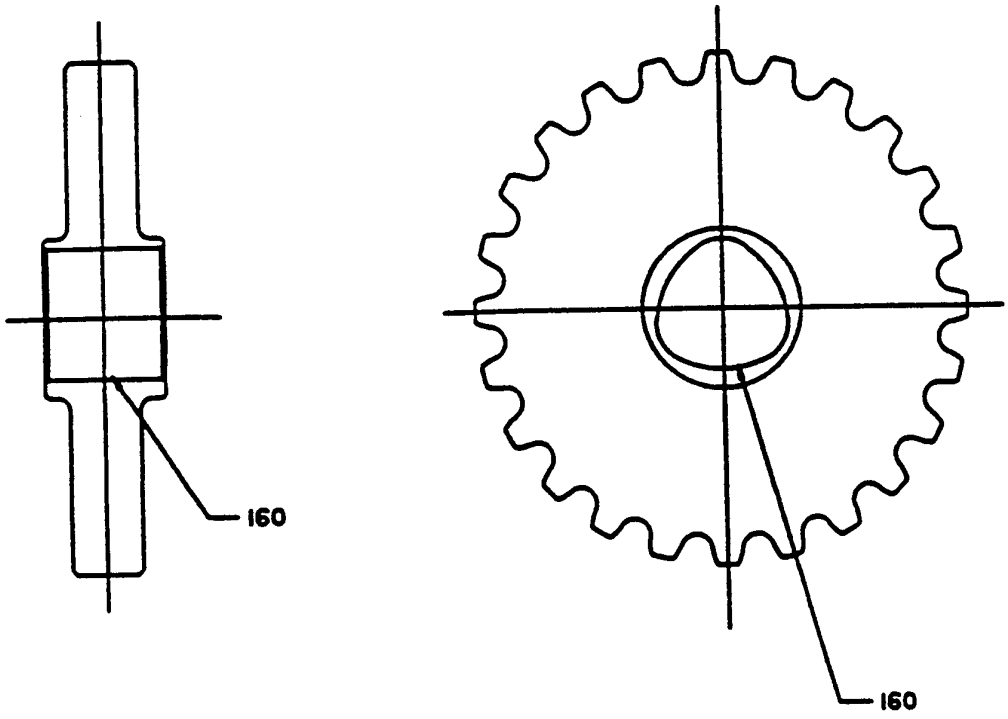


FIG.8

MACHINES WITH CONSTANT ROTATION MOTOR

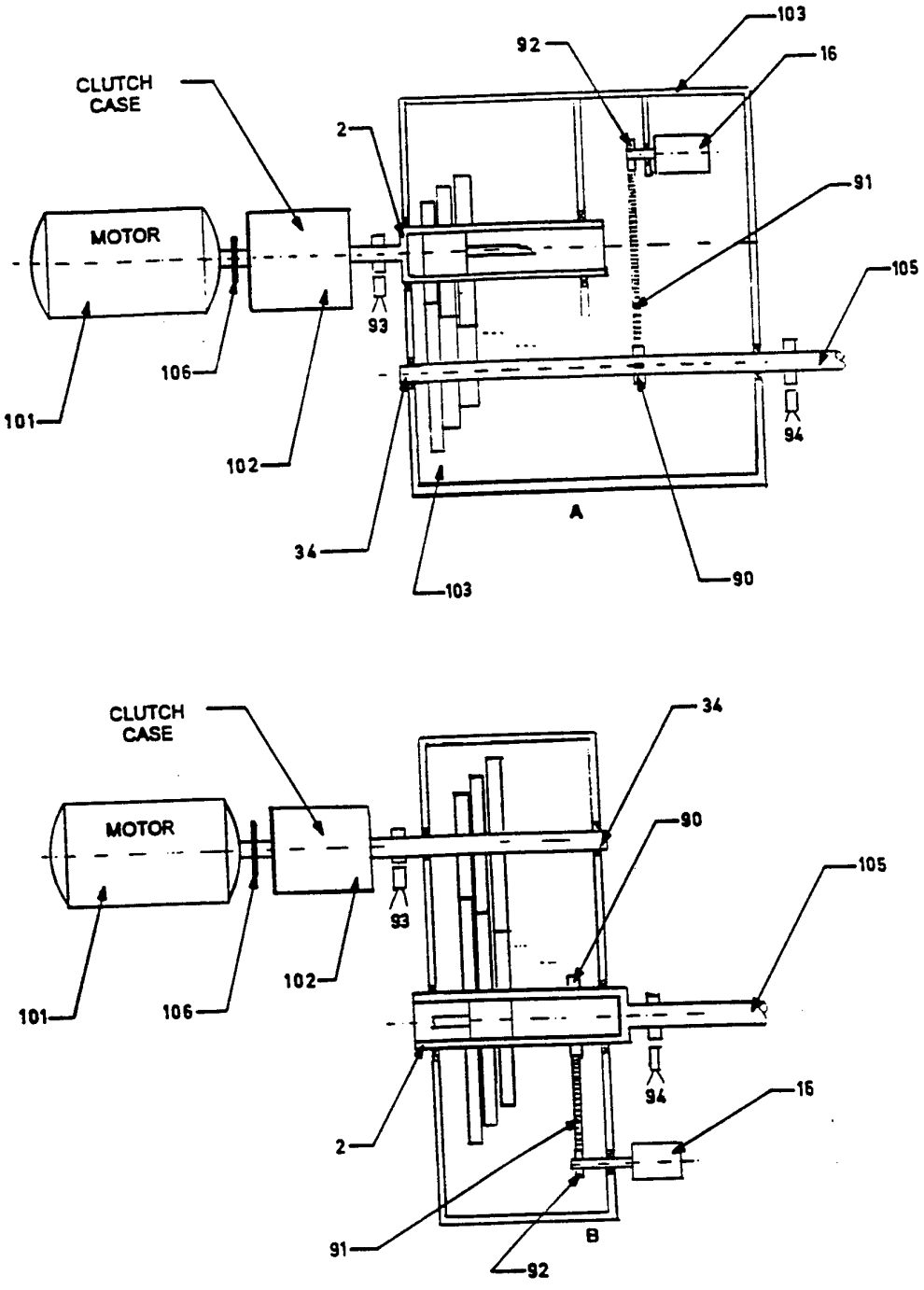


FIG.9

MACHINES WITH VARIABLE ROTATION MOTOR

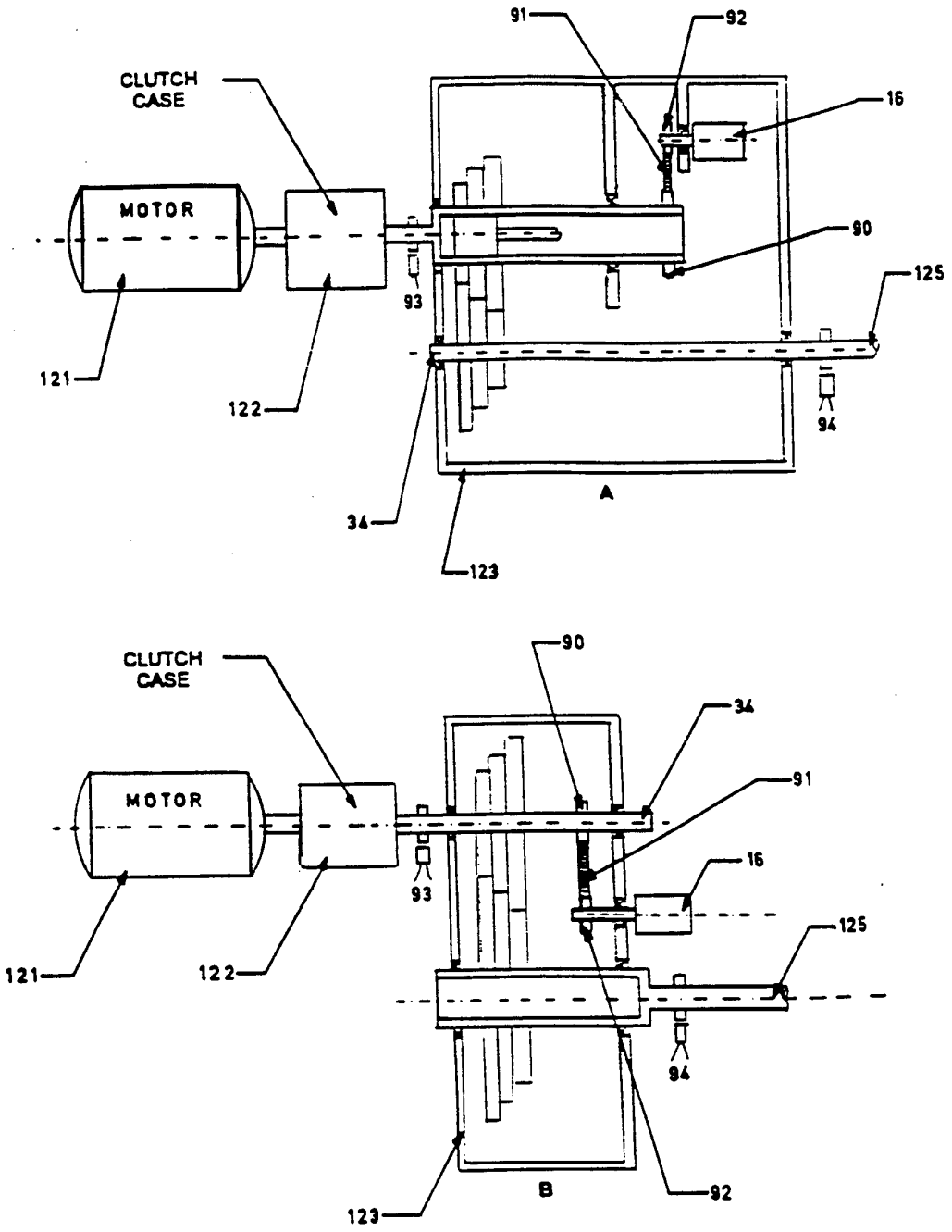


FIG.10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/BR95/00002

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : F16H 3/089, 3/091, 3/12, 3/16
US CL : 74/325, 335, 336R, 369, 371, 372; 477/75, 79, 80, 86, 87
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 74/325, 335, 336R, 369, 371, 372; 477/75, 79, 80, 86, 87

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---,P Y	WO, 94/05931 (LIPMAN) 17 MARCH 1994, FIGS. 3,4	1, 4, 5,7,8, 9 --- 10
Y	US, A, 3,600,962 (IVANCHICH) 24 AUGUST 1971, FIG. 4	10
A	US, A, 4,544,057 (WEBSTER ET AL) 1 OCTOBER 1985	8
A	US, A, 3,793,898 (ESPENSCHIED ET AL) 26 FEBRUARY 1974	10
A	US, A, 5,214,974 (MORBIDELLI) 01 JUNE 1993	10
A	US, A, 1,661,892 (GIRONES) 06 MARCH 1928	5, 7

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
04 MAY 1995	15 JUN 1995
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer KHOI TA Telephone No. (703) 308-2168

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/BR95/00002

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,E	US, A, 5,404,768 (HWANG ET AL.) 11 APRIL1995	5