



(72) BRANAS, José, CH

(72) ROTA, Daniel, CH

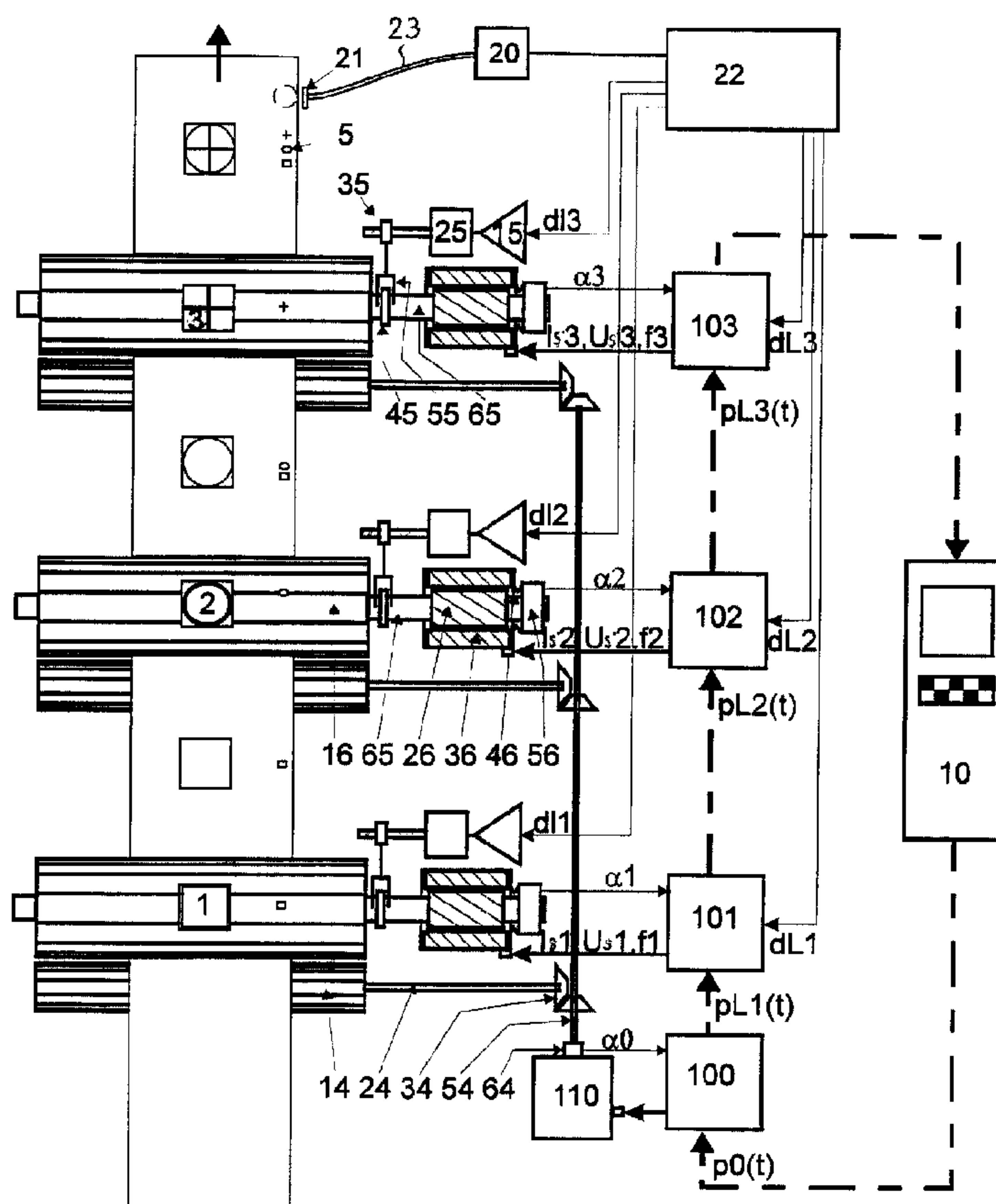
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(54) **MACHINE A IMPRIMER ROTATIVE**

(54) **ROTATING PRINTING MACHINE**



(57) The rotating printing machine comprises several printing stations in which the form cylinder (16) of each printing station (1, 2, 3) is driven directly by an asynchronous vectorial electric motor (26/36) controlled by an electronic circuit (101) for monitoring and control of the angular position ( $\alpha$ ), at a command value ( $p_{L1, 2, 3}(t)$ ) that changes over time and is received from a central electronic calculating station (10) for the synchronization of stations with one another. More particularly, the cylinder/axle/rotor assembly (16/65/26) of at least one station can be moved in axial translation for the correction of the lateral registry of the form(s) of the cylinder. In addition, the machine comprises an arrangement (20-23) that reads registry marks (5) printed by each station, and establishes the possible lateral ( $d_{l1, 2, 3}$ ) and longitudinal ( $d_{L1, 2, 3}$ ) registry error for each station (1, 2, 3). Each lateral error ( $d_{l1, 2, 3}$ ) is then applied to the electronic control circuit (15) of an electric motor (25) of the corresponding station that controls, by means of a mechanism (35), the axial position of the rotor/axle/cylinder assembly (16/65/26). Each longitudinal registry error ( $d_{L1, 2, 3}$ ) is added directly to the cylinder position command ( $p_{L1, 2, 3}(t)$ ) of the corresponding station.



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ABSTRACT

The rotating printing machine comprises several printing stations in which the form cylinder (16) of each printing station (1,2,3) is driven directly by an asynchronous vectorial electric motor (26/36) controlled by an electronic circuit (101) for monitoring and control of the angular position ( $\alpha$ ), at a command value ( $p_{L1, 2, 3}(t)$ ) that changes over time and is received from a central electronic calculating station (10) for the synchronization of stations with one another. More particularly, the cylinder/axle/rotor assembly (16/65/26) of at least one station can be moved in axial translation for the correction of the lateral registry of the form(s) of the cylinder. In addition, the machine comprises an arrangement (20-23) that reads registry marks (5) printed by each station, and establishes the possible lateral ( $d_{l1,2,3}$ ) and longitudinal ( $d_{L1,2,3}$ ) registry error for each station (1,2,3). Each lateral error ( $d_{l1,2,3}$ ) is then applied to the electronic control circuit (15) of an electric motor (25) of the corresponding station that controls, by means of a mechanism (35), the axial position of the rotor/axle/cylinder assembly (16/65/26). Each longitudinal registry error ( $d_{L1,2,3}$ ) is added directly to the cylinder position command ( $p_{L1,2,3}(t)$ ) of the corresponding station.

(Figure 1)

The present invention relates to a rotating printing machine of strip elements or plate elements, and more particularly to a polychrome printing machine comprising several stations for printing primary colors, these printings being superposed in order to produce the final image. Each station comprises, among other things, a lower form cylinder that works together with, on the one hand, an inking cylinder and a subjacent transfer cylinder, and, on the other hand, an upper support cylinder.

In this connection, the document EP 352 483 describes a printing machine in which all the support cylinders are driven by angle gears engaged with a first mechanical shaft driven by a first electric motor, and all the form cylinders are driven from a second mechanical shaft driven by a second electric motor. These two motors are controlled by a central digital calculating station that adapts the angular velocity of the shaft of the form cylinders to the case in which their diameter does not correspond to that of the support cylinders, avoiding the necessity of exchanging them.

Nonetheless, this type of driving by means of one or two shafts equipped with angle gear mechanisms is rather costly. The precision of this driving is likewise limited, all the more so since a jolt in one of the stations is reflected in the others. In addition, this driving can easily be set into vibration due to its own weak mechanical frequency.

The document FR 2 541 179 describes a machine for making flexible boxes from sheets of cardboard, in which a printing section with four printing groups is intercalated between an upstream introduction section and

downstream sections for driving back, notching, cutting, folding and reception. A DC motor M1 drives the lower and upper transporters of each printing group, of which the form cylinders are individually driven by four DC motors M2-M5. The regulation of the longitudinal registry among the printing groups is realized by acting electrically on the angular position of each of the motors M2 to M5. The form cylinder of each printing group is constructed so as also to be able to be displaced laterally, in order to align the printings of different groups between them. In order to do this, it is mounted on bearings that permit a lateral displacement of the cylinder under the action of motors M105 to M108.

This machine has an arrangement for driving the motors M1 to M5 consisting of a command group, comprising a command generator circuit and a circuit for synchronization by motor; a calculating group made up of a microprocessor with input/output circuits; a signal processing group comprising a component for discerning the direction of, and for multiplication of, impulses coming from impulse generators G1 to G5 of the motors M1 to M5, as well as a processing circuit for interphasing and transformation of the signals coming from the first and second groups; and a command logic group made up of a logical circuit for selection of the driving and of a logical circuit for selecting manual commands.

This arrangement realizes, between the motors M2 to M5, a virtual electric synchronization shaft for printing groups, by fastening them on the master general sheet driving motor M1, from which it receives electric impulses from an encoder. This arrangement notably realizes the verification of the concordance between the programmed values and the effective state of the components of the machine; a pre-positioning of the motors M1 to M5 upon change of task or after breakage of

the electric shaft connecting them; the execution of the angular corrections of the motors M1 to M5, whether commanded by pushing buttons or by units for controlling the registry of the sheets, as well as the execution of lateral corrections by acting on motors M105 to M108; and monitoring of the correct operation of the different motors.

Though already more precise, this machine is nonetheless handicapped by the disadvantages inherent to DC motors, i.e.: their awkwardness due to necessarily large diameter; regular maintenance of sliding contacts permitting looping-in of the rotor circuits in conventional machines, or the cost in the case of what are called "brushless" motors, due to the fact that it is necessary to bake large magnets onto the rotor in order to constitute the poles.

A recent development, described for example under the name SYNAX in the September 1994 catalogue of the electric motor manufacturer MANNESMANN REXROTH, consists of the use of asynchronous electric control motors, called "vectorial," whose electronic circuits for monitoring and controlling the angular position of the motor are connected, by a transmission loop, to a central electronic calculating station for synchronization of the stations among themselves, this station assigning to each control circuit a "volatile" position command value, i.e. one that changes with the desired velocity of the machine.

A primary point of interest of asynchronous motors is that they are less expensive to purchase and to maintain, due to the fact that their rotors comprise only large turns, short-circuited to themselves.

The main point of interest of asynchronous motors is the remarkable precision of the output torque, and thereby of the velocity and of the angular position, obtained by means of a "vectorial" control, in which the supplying of the stator ensues by means of a voltage undulator by acting on the frequency and the amplitude of the stator voltage. Alternatively, in place of a controlling of the stator frequency, a controlling of the phase of the statoric voltage ensues in relation to the rotor flux, permitting a more rapid response to be obtained.

Usefully, the position commands are transmitted from the central calculating station to the control circuits in digital fashion along a loop of optical fiber, this transfer being particularly insensitive to the electromagnetic perturbations present in workshops.

In addition, angular encoders are known, provided for mounting at the end of the rotating axle, and generating a sinusoidal output signal, whose interpolation permits the determination of the angular position of the axle at close to  $1/2,000,000$  of a millimeter. Thus, the regulation effected by a control circuit whose negative feedback loop receives the signal from an encoder of this type permits the ensuring of a synchronization precision of less than 0.005 angular degrees, which corresponds, for a form cylinder with the standard diameter on the order of 800 millimeters, to a peripheral error of 0.07 millimeters, i.e. well below the positioning error of 0.10 mm standardly tolerated in printing.

It can thus be proposed to connect the output axle of the vectorial asynchronous motor directly with the axle of the form cylinder, enabling the suppression of all standard reducing coupling, which always has an elastic play that disturbs the transmission of the torque and of the position. More preferably, it is proposed to realize

an axle common to the rotor of the motor and to the form cylinder, this axle being of a larger diameter and hollow in order to optimize the relation between the torque transmission rigidity and the rotational inertia.

In addition, and as mentioned in the description of the machine with DC motors, it is important to be able to correct, in the course of production, the position of a form cylinder dependent on the position of the others, when the corresponding printing turns out no longer to be correctly registered. When the error is in the direction of travel of the element, this is called a "longitudinal" error, and it is appropriate to modify the peripheral position of the form, thus the angular position of the corresponding cylinder. If the error is transversal, this is called a "lateral" error, and it is appropriate to displace the form cylinder along its axle.

The document EP 401 656 describes for example an arrangement for driving and regulating a form cylinder and its support cylinder, which arrangement is situated at only one side of the machine. In this arrangement, the driving torque of the cylinders is transmitted by three toothed wheels in series, with helical toothing. The second toothed wheel is mounted freely in rotation on the axle of the form cylinder by means of a bearing. Next to the first helically toothed wheel, a double toothed wheel presents a toothed collar with spur toothing that engages with a toothed wheel, likewise with spur toothing, mounted rigidly on the axle of the form cylinder. The lateral registry is thus effected by advancing or drawing back the axle of the form cylinder, which has no effect on the velocity of rotation of the cylinder, due to the spur toothing and the floating second wheel. The peripheral registry is effected by displacing the double toothed wheel parallel to the axle, thus the first helical wheel in relation to the second,

which advances or draws back the peripheral position of the form cylinder in relation to the support cylinder.

The documents US 4 782 752, EP 262 298, EP 154 836, DE 27 20 313 and FR 2 380 137 specify other equivalent arrangements, whose mechanisms for correcting longitudinal and lateral registry include a gearing with helical toothing and another with spur toothing, the corrections being capable of being made separately, manually or remotely by means of electric motors. Incidentally, the use of gearings permits the insertion of a reducer that reduces the required power of the motor, and likewise divides the necessary resolution of the subsequent correcting calculations by the value of the factor of reduction.

Nonetheless, these known double correction arrangements require the presence of gear reduction arrangements intercalated between the driving motor and the axle of the form cylinder, the functioning of which reducers is modified, dependent on the correction desired, by a mechanism of connecting rods, cams or levers, acting on one or the other of the toothed wheels or on this or that support bearing of the cylinder axle. In addition, these complex arrangements are expensive to realize. These arrangements also cause significant inertial forces, which must be overcome either manually or with the help of powerful motors, which slow down the placing into effect of the correction. In addition, the unavoidable wear of the pieces over time induces mechanical play in the arrangements, altering the precision of the corrections.

These effects thus considerably reduce the advantage of the use of sophisticated electric motors, particularly asynchronous motors with high-precision vectorial control. For machines using this type of motor, there

thus remains a complex controlling of longitudinal registry using traveling cylinders for the modification of the strip tension between two stations, and no lateral correction is provided.

The aim of the present invention is a printing machine based on vectorial asynchronous motors that directly drive the form cylinders, and also the support cylinders if desired, this machine additionally comprising means for double correction, manual or automatic, of the longitudinal and lateral registers of the forms, foregoing any reduction mechanism intercalated between a motor and its form cylinder.

These correction means must be as precise as possible, i.e. must react effectively beginning with very small errors, in a dynamic manner, i.e. with a very short response time. For this, these means must first of all have components whose structures are at once rigid, in order not to induce errors by elasticity, and simple, in order to accordingly reduce the costs of realization. These components must also be able to be assembled without play, or with simple compensation, in order to be able to transmit adequate corrective forces in a precise manner.

These aims are achieved in a rotating printing machine in which the form cylinder of each printing station is driven directly by a vectorial asynchronous electric motor controlled, by an electronic circuit for monitoring and control of the angular position, at a command value that changes over time and is received from a central electronic calculating station for the synchronization of stations with one another, each form cylinder axle being fixed in prolongation of, or being common with, the axle of the rotor of its motor, due to the fact that the cylinder/axle/motor assembly of at least one station can

be moved in axial translation in relation to the chassis of the machine and to the stator of the motor, for the correction of the lateral registry of the form(s) of the cylinder.

It is known a priori to an electrical engineer that the displacement of a rotor in relation to its stator induces substantial modifications in the internal electromagnetic fluxes, thus modifying the mechanical torque at the exit in a way that is hardly predictable. Nonetheless, vectorial asynchronous motors are in fact known that are rather elongated, e.g. on the order of 500 millimeters, while the range of displacement necessary in order to effect the lateral corrections is only 10 millimeters. Trials in the workshop have shown that slight variations in flux can thus be entirely eliminated by the monitoring and control circuit of the asynchronous motor.

Advantageously, the form cylinders of all the stations are movable in translation with their associated rotor, and the machine has an arrangement that reads registry marks printed by each station and establishes the possible lateral and longitudinal registry error for each station. Then each lateral error is applied to the electronic control circuit of an electric motor of the corresponding station that controls, by means of a mechanism, the axial position of the rotor/axle/cylinder assembly, and each longitudinal registry error is added directly to the cylinder position command of the corresponding station.

As soon as it is possible to forego intercalated gearing mechanisms for the axial displacement of the form cylinder in such a way as to preserve a direct rigid connection between the cylinder and its rotor, only a fine and dynamic longitudinal correction is justified, by direct action of the asynchronous motor in association

with a lateral correction. This proves to be particularly advantageous for printing machines with strip elements, in which, in addition to the heavy correction mechanisms, it is likewise possible to do away with the traveling cylinders for controlling registry by modification of the tension of this strip.

According to a preferred embodiment, an angular encoder is mounted at one end of each rotor/cylinder axle in order to generate a signal representing the angular position of the axle, which is applied in the feedback loop of the monitoring and control circuit of the corresponding asynchronous motor, the housing of the angular encoder being connected to the chassis of the machine by means of a fastener that is angularly rigid but permits it to follow the axial displacements of the axle.

Notably, the angular fastener for the encoder can comprise a plurality of lamellae in the form of parallel coaxial collars, connected with one another by diametral pairs of mounting devices arranged in quadrature from one lamella to the next.

The control of the angular position of the cylinder is thus particularly improved when the monitoring and control circuit is provided with feedback information of the momentary angular position of the given axle by means of an angular encoder mounted directly on the axle, but only insofar as this information is reliable. In order to do this, it has first of all also proved preferable to maintain the encoder in relation with the axle, and not fixed to the chassis. Notably, the fastener according to the invention ensures an axial displacement of the encoder for the following of this axle, without effort by the housing, but also a very high torsional rigidity, which is an important condition for a correct reading of

the angular position. Above all, the inventive angular fastening arrangement for the encoder avoids the necessity of displacing the assembly of the asynchronous motor with the cylinder, which would have constituted a mass too great to permit the realization of fine dynamic lateral corrections.

Advantageously, the common axle of the rotor and the cylinder is mounted on needle bearings, and it comprises a protruding flange grasped by a fork displaced axially by an endless screw parallel to the axle and driven by the electric motor for lateral correction. It is thus preferable that the flange or the fork comprise a first ball bearing or bearing with cylinders for the reduction of frictional force and for taking up play. In addition, the fork is also guided through a second bearing, along a support axle. The endless screw is for example connected to its motor by a reduction mechanism comprising a pinion and a toothed wheel, or a pinion connected to a pulley by means of a timing belt.

This displacement mechanism for the rotor/axle/cylinder assembly proves to be relatively simple to realize, while assuring a precise displacement by means of the reducer connecting the motor to the endless screw, and by means of the firm mounting of the fork, by means of bearings for taking up play, along a rigid axle on the one hand and in its grasping of the flange of the axle on the other hand.

Advantageously, the end of the axle at the side opposite the motor is held by an immovable bearing. Thus, the form cylinder is fixed on the axle by clamping of its two end hubs between a first cone fixed at the side of the motor and a second, opposed, immovable cone that can be pushed in the direction of the first by a mechanical

means, for example by a nut engaged on a threading provided at the end in correspondence with the axle.

When the form cylinder has to be exchanged for another one of a different diameter in order to be better adapted to the size of a subsequent series, the axle remains stationary; thus, only the cylindrical envelope, provided with two end hubs, is exchanged. This operation is considerably easier than the previous exchanging of the cylinder with its axle and its gearings, because the new assembly is much lighter and can be attached to a stationary axle that guides the installation. The clamping into position of the cylinder is simple and rapid. In addition, the encoder is then preferably placed at the end of the axle at the motor side, in order to leave space free for the changing of the cylinder, and incidentally so as not to be falsified by possible residual parasitic torsions of the axle.

The invention is explained in more detail below by means of an embodiment, not to taken as limiting, illustrated in the attached figures, in which:

- Figure 1 is a schematic drawing of the machine according to the invention,
- Figure 2 is a schematic drawing of the arrangement for correcting lateral and longitudinal error in a printing station of the machine,
- Figure 3 is a view, in longitudinal section, of an electric motor connected with its form cylinder in a printing station of the machine, and
- Figure 4 is a perspective view of the fastener of an angular encoder to the chassis of the machine.

Figure 1 schematically illustrates a strip element 4, such as a strip of paper or cardboard, passing successively through three printing stations 1, 2 and 3, each comprising a form cylinder 16 facing a support cylinder 14 that operates in the manner of a mill. In the example shown, these stations successively deposit a square impression, a circular one, and a cross-shaped one, intended to be precisely superposed on one another.

In the machine shown, all the axles 24 of the support cylinders 14 are mechanically connected to one drive shaft 54, running up the machine from upstream to downstream along its printing stations. The coupling of these axles 24 of the support cylinders is realized by means of angle gears 34 with conical toothed wheels. This shaft 54 is driven by an electric motor 110 controlled by a first electronic circuit for monitoring and control of the angular position 100. The angular position  $\alpha_0$  of the shaft 54, reflecting the advance of the strip 4, is read by an encoder 64 of which the electrical signal representing this angular position is applied in the feedback loop of the circuit 100.

In addition, the form cylinder 16 of each of the stations 1, 2 and 3 is mounted directly on an output axle 65 of an electric motor, i.e. the rotor 26 of this motor is constructed on the same end of this axle, while the stator 36 is firmly attached to the chassis of the machine. In this case, the diameter of this axle 65 is relatively large, on the order of 50 to 80 mm, in order to transmit large torques without elastic tension, but it is also hollow in the center in order to reduce its moment of inertia. These motors are preferably asynchronous AC motors controlled by an electronic circuit for the monitoring and control of the angular position, respectively 101, 102 and 103 for each of the stations.

In this machine, all the monitoring and control circuits 100-103 are connected by a network looped with a central calculating unit 10. This unit has a keyboard for the entry of commands and instructions, a microprocessor, a plurality of memories containing programs and management data depending on the characteristics of the machine, and a screen for viewing entered parameters and/or data applied at the output on the loop. Preferably, this transmission loop is made of a coaxial cable of optical fibers, a first conductor connecting the output of the central unit 10 to the control circuit 100 of the motor for driving the assembly of the support cylinders, a second conductor connecting the circuit 100 to the circuit 101 for controlling the motor of the first station, a third conductor connecting the circuit 101 to the circuit 102 for controlling the motor of the second station, a fourth conductor connecting the circuit 102 to the circuit 103 for controlling the motor of the third station, and, finally, a fifth conductor ensuring the return loop to the central calculating unit 10.

On this transmission loop, there travels command information for the position of each of the motors at a given moment  $t$ : respectively,  $p_0(t)$ , representing the desired angular position of the motor 110, thus of the shaft 54 and thereby of all the support cylinders 14 defining the advance of the strip 4; as well as the values  $p_{L1}(t)$ ,  $p_{L2}(t)$  and  $p_{L3}(t)$ , representing the desired angular position respectively of the motors of stations 1, 2 and 3, and thus of the corresponding form cylinders. Each command value is established by the calculating unit 10 so as to take into account the length of the machine, notably the intervals between the stations, the size of each block possibly arranged on the cylinders of different diameters, in such a way as to ensure a rigorous synchronization of the stations among themselves, so that the printings are correctly

superposed to give a high-quality final image. These position commands are "volatile"; i.e. they change over time depending on the desired velocity of production of the machine.

There is thus realized, in place of a traditional mechanical shaft parallel to the shaft 54, a virtual electric synchronization shaft in which all the motors of the machine are individually slaved to the central calculating station 10.

In addition, in each station an angular encoder 56 delivers a signal a 1, a 2, and a 3, representing the momentary angular position of the corresponding rotor 26, thus of the form cylinder, as soon as it is acknowledged that the axle 65 is sufficiently rigid through its dimensions. In each station, the signal generated by this encoder 56 is applied in the feedback loop of the corresponding electronic monitoring and control circuit 101, 102 and 103.

These identical monitoring and control circuits 101-103 directly supply the stators of their corresponding motors with triphased alternative electric energy, characterized respectively by the statoric intensity values  $I_{s1}$ - $I_{s3}$ , crest-to-crest voltage amplitude values  $U_{s1}$ - $U_{s3}$ , and frequency values  $f_1$ - $f_3$ .

The lower part of Figure 2 shows the schematic diagram of the monitoring and control circuit 101. This circuit comprises, first, a first subassembly for controlling torque  $G$ , comprising a circuit  $K_i$  that generates the statoric electrical energy  $I_{s1}$ ,  $U_{s1}$  and  $f_1$ , as well as a feedback loop for reading either of intensity by phases or of flux for the establishment of a possible error of correction.

Such torque control circuits Ki for asynchronous motors are known. For example, the document US-3 824 437 describes a circuit in which the magnetic field is measured in its air gap, and the statoric current is measured; the measured statoric current is transformed into two components of statoric current in quadratures, oriented in relation to the measured magnetic field; one of the components of the statoric current in quadrature is regulated, proportionally to the command amplitude of the total effective flux of the rotor, at a constant level fixed by a constant reference input quantity, corresponding to the command amplitude of the total effective flux of the rotor; and the other component of the statoric current in quadrature is varied with a second reference or command quantity applied at the input and proportional to the command torque of the asynchronous motor. Another command process of an asynchronous motor, specified in the document SU-193 604, consists in the phase-by-phase regulation of the momentary phase currents of the stator of an asynchronous motor, by comparing the commands and the momentary phase current measurements of the stator, varying the statoric current with the sum in quadrature of two components of statoric current, of which one is constant and corresponds to the constant magnetic flux to be achieved, and the other is variable as a function of a command variable corresponding to the command torque of the asynchronous motor. At the same time, the frequency of the statoric current is varied with the sum of the two frequencies, of which one is that of the rotation of the rotor, the other being subjected to the variation of the command torque.

The monitoring and control circuit 101 additionally comprises a velocity control loop based on the signal PL1(a) emitted by the angular encoder 56; this signal is derived in time in the feedback loop in order to obtain

an effective velocity information, which is compared with the command value in order to establish the possible error, and then to control the velocity in the circuit  $kV$ , placed in series with the torque control circuit  $Ki$ .

In fact, in the inventive machine it is especially desirable to ensure a position command. For this purpose, the information  $pL1(a)$  emitted by the encoder 56 is likewise compared to the command signal  $pL1(t)$  received from the optical fiber transmission loop, in order to establish a possible position error, and then to control the position in the circuit  $Kp$ , placed in series with the velocity control circuit  $Kv$ . Thus, the angular position of the output axle 65 of the motor approximately reflects the command value applied at the input.

More particularly according to the invention, and as can be better seen in Figure 3, the axle 65 is freely mounted in rotation on roller or needle bearings 40, 40' and 40'', likewise enabling an axial displacement when desired, this axial displacement carrying on the one hand the rotor 26 and on the other hand the form cylinder 16. More precisely, these bearings are in contact with the axle 65 through friction rings 42. The first bearing 40 is installed in a seating 32 situated at the rear of the stator 36 of the motor, and fixed on the chassis 37 of the machine by the casing 33 of the electric motor. The second bearing 40' is located between the electric motor and the form cylinder 16, or more precisely is installed in a collar 38 fixedly attached to the chassis 37. The third bearing 40'' is, for its part, installed at the other end of the axle 65 and of the cylinder 16, in a block 80 of the chassis that is capable of being displaced rearwards in order to be disengaged.

As shown in Figures 1 and 3, the axial position of the rotor/axle/cylinder assembly 26/65/16 is applied by a

fork 55 engaged with a flange 45 that protrudes from the axle, which fork can be displaced parallel to the axle by a mechanism 35 driven by a synchronous step-by-step motor 25, which motor is itself controlled by an electronic control circuit 15.

More precisely, the flange 45 is made up of two bearings crimped on the axle 65 and pushed against a shoulder 44 of this axle by a nut 43 engaged with an external threading of the axle, this pushing being effected through a separating ring 41, leaving free access to the fork 55.

Due to considerations of rigidity, the fork 55 is itself mounted through a ball bearing 53 along a support axle 58, mounted in the chassis 37 parallel to the axle 65. This fork is guided in axial translation by a cart 52 in two parts, engaged with a double endless screw 30. The adjustment of the grasping of these two parts of the cart 52 enables the elimination of any residual play. The end of the endless screw 30 carries a pulley 29 driven by a timing belt 28 engaged with the output pinion 27 of a step-by-step motor 25, mounted rigidly on an upper flange 39 of the chassis 37.

It will be noted that this assemblage can be realized in a very rigid manner. The precision of the displacement of the fork 55, thus of the axle 65, is obtained on the one hand by the pitch of the micrometric screw 30, and on the other hand by the relation of the diameter of the pulley 29 and of the pinion 27.

Moreover, the angular encoder 56 is mounted at the rear of the motor at the end of the axle 65. More particularly, the fastener 46 of the encoder housing to the fixed seating 32 is such as to permit an axial displacement of this housing so that it always remains in

exact correspondence with its rotating internal mechanism 57, which is fixedly attached to the axle 65, but holds this housing rigidly in a precise, fixed angular position in relation to this seating 32.

In order to do this, and as can be better seen in Figures 3 and 4, this fastener 46 is made up of a plurality of lamellae in the form of concentric collars 47, fastened to one another by diametral pairs of fixing means 48, a pair between two lamellae being offset at a right angle in relation to the following pair. Since these lamellae are thin, they are flexible in the axial direction. On the other hand, the collar shape of these lamellae prevents any rotation in relation to the central axle. The encoder 56 is protected by a cover 31 fixed to the seating 32.

The inventive printing machine additionally comprises an arrangement for locating marks printed on the edge of the strip by each of the stations, this locating enabling the detection of possible longitudinal and lateral registry errors of one or the other of the printings. As shown in Figures 1 and 2, the marks 5 pass under an optical reading head 21 that focuses a beam of light transmitted by a first part of a bundle of optical fibers 23. The reflected light is read by the reading head 21 and is conducted by the second part of the optical fiber 23 towards photosensitive elements 20, which generate electric signals that are applied to a registry control unit 22.

This control unit 22 comprises a processing circuit 220 for processing and selection of signals, which it directs either to a circuit for calculating longitudinal error 222 or a circuit for calculating lateral error 224. The circuit 222 comprises three output lines, permitting the application of a signal representing the longitudinal

error dL1 to the monitoring and control circuit 101 of the first station, and, in an analogous fashion, to apply the signals representing a registry error dL2 and dL3 to the monitoring and control circuits 102 and 103 of the corresponding stations. In parallel fashion, the circuit for the calculation of the lateral error 224 comprises, among other things, three outputs enabling the application of a signal representing the error in the lateral registry dl1 to the preamplification and control circuit 15 of the motor 25 of the first station and, in parallel fashion, of the signals dl2 and dl3, representing the lateral errors, to the pilot circuits of the lateral correction motors 25 of the stations 2 and 3 respectively.

Thus, if a lateral registry error of one of the stations is detected by the control unit 22, the corresponding correction signal dl(i) triggers the rotation, in one direction or the other, of the relevant motor 25, which advances or draws back the fork 55, and thus the axle 65, with its form cylinder, and thereby corrects the lateral position of the faulty form.

The range of correction of the lateral error is commonly  $\pm 5\text{mm}$ . In holding an asynchronous motor that is rather elongated, e.g. with active parts of a length on the order of 500 mm, it is to be noted that the displacement of the rotor in relation to the stator due to a lateral correction remains less than 1% of their total length, which causes only very slight perturbations in the flux, which are moreover rapidly eliminated by the electronic monitoring and control circuit 10(i). In addition, this displacement due to a lateral correction of registry has no influence on the precision of the reading of the angular encoder 56, thanks to its special fastener 46, which thus enables the pursuit of a correct functioning

of the monitoring and control circuit of the vectorial asynchronous motor.

On the other hand, this rigorous respecting of the proper functioning of the piloting of this asynchronous motor thus allows it to be used only for the correction of longitudinal errors as well. Referring to Figure 2, the longitudinal error signal  $dL_1$  is directly added in the addition of the control signal  $pL_1(t)$  and of the feedback signal  $pL_1(a)$  at the input of the monitoring and control circuit 101. This registry error  $dL_1$  is then processed simply and spontaneously, as if it were in fact only an error detected by the negative feedback. The asynchronous motor accelerates (or slows down) slightly during a revolution in order to set itself back in relation to the advance of the strip 4 as imposed by the rotation of the counter-cylinders 14. A new registry mark is then read by the reading head 21. If the circuit 22 detects a residual error, it reapplies a smaller corrective adjustment  $dL_1'$  for the following revolution.

In order to facilitate and accelerate this registry control, it is preferable to overdimension the power of the asynchronous motor, up to a value between 4 and 5 kW. In addition, the installation of the motor, in direct engagement with and close to its form cylinder, enables a corresponding reduction of intermediary parasitic torsional vibrations, with the result that practically the totality of the correction is transmitted instantaneously.

For certain printing sizes, it proves useful to exchange the form cylinder for one with a different diameter. Rather than using an axle 65 with several sections, attached by bolted flanges, such as are currently used, it has proved preferable to maintain the integrity of this axle through the entire length of the machine, in

order to install there only a cylindrical envelope, fixed in an immovable manner. In this connection, and with reference to Figure 3, the cylinder 16 in fact comprises a light, rigid cylindrical envelope, e.g. made of aluminum, at the ends of which there are fixed, by soldering or other means, two hubs 74 presenting a conical concave central cavity directed outward.

The axle 65 is thus provided with a first cone 70 with a fixed position. For example, this first cone 70 is supported on the ring 42 emerging from the second roller bearing 40'. The end of the axle opposite the motor thus comprises a first part with a limited diameter, engaged in the bearing 40'', the following part thus presenting an external threading on which a nut 43 can be engaged, enabling a second mobile cone 72 to be pushed forward.

An exchange of the form cylinder is thus effected simply, by disengaging the bearing 40'' from the axle by withdrawing the mobile block 80 and tipping. The nut 43 can then be unscrewed, freeing the second mobile cone 72 and thus the cylinder 16, which can be removed. It will then be noted that the presence of the axle 65, remaining stationary, permits the guiding of the new cylinder on which it is threaded. The mobile cone 72 is reinstalled and then pushed forward by rotating the nut 44. The hubs 74 are thus clamped between the two cones 70 and 72, realizing a rigid fastening without play. The bearing 40'' is finally put into place again by advancing the block 80. Notably, since these cylinders are lighter than before, they can be handled more rapidly and more precisely. It would even be possible to automate such an exchange by means of a robot.

In addition, since these simplified form cylinders are less costly to realize, it may be desirable to keep on hand a range of basic cylinders, e.g. in four standard

diameters: 117.9 mm, 149.7 mm, 181.5 mm and 213.4 mm. This is moreover facilitated by the virtual electric shaft managed by the central unit 10 of the machine. In fact, it is thus sufficient to carry out a new calculation of the volatile position commands for the relevant motor, conversely to the gearing changes previously necessary to ensure concordance between the form cylinder and the support cylinder.

A sleeve of expanded material is commonly threaded on the form cylinder, with a certain internal radial elasticity, and on whose rigid peripheral envelope the forms are effectively fixed by gluing. In order to facilitate this sleeve installation, it is useful to arrange the hollow central part of the axle 65 so as to realize a circulation of compressed air between the exterior of the cylinder and the interior of the sleeve. More precisely, a flexible tube 67, protected by the cap 31, connects an external compressed air connector socket 68 with the internal channel 66 of the axle. At the end of the axle, this channel 66 debouches on one or several radial openings 76 that diffuse the compressed air to the interior of the form cylinder 18. The end hub can thus comprise one or several internal channels 75 permitting the diffusion of the compressed air under the sleeve 19. Under the effect of this air cushion, the sleeve dilates radially, thus augmenting its internal diameter, which eliminates all frictional force. It is thus possible to use a range of sleeves with thicknesses between 2.5 mm and 66.2 mm, used alone or in superposition.

The reference character 17 designates a form cylinder with a particularly large diameter, on which the forms are directly glued, this configuration being useful in countries where the supply of flexible sleeves is deficient.

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Numerous improvements can be made in the printing machine within the scope of the claims.

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CLAIMS:

1. Rotating printing machine in which a form cylinder (16) of each of a plurality of printing stations (1, 2, 3) is driven directly by an asynchronous vectorial electric motor (26/36) controlled, by an electronic circuit (101) for monitoring and control of angular position (a1), at a command value (pL1, 2, 3(t)) that changes over time and is received from a central electronic calculating station (10) for the synchronization of said stations with one another, each form cylinder axle (65) being fixed in prolongation of, or being common with, the axle of the rotor of its motor, characterized in that the cylinder/axle/rotor assembly (16/65/26) of at least one station can be moved in axial translation for correction of lateral registry of the form(s) of the cylinder.
2. Printing machine according to claim 1, in which all the form cylinders (16) are movable in translation with their associated rotor (26), characterized in that the machine has an arrangement (20-23) that reads registry marks (5) printed by each station, and establishes the possible lateral (d11, 2, 3) and longitudinal (dL1, 2, 3) registry error for each station (1, 2, 3), and in that each lateral error (d11, 2, 3) is applied to the electronic control circuit (15) of an electric motor (25) of the corresponding station that controls, by means of a mechanism (35), the axial position of the rotor/axle/cylinder assembly (16/65/26), and in that each

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longitudinal registry error ( $dL_{1,2,3}$ ) is added directly to a cylinder position command ( $pL_{1,2,3}(t)$ ) of the corresponding station.

3. Printing machine according to claim 1 or 2,  
5 characterized in that an angular encoder (56) is mounted at one end of each rotor/cylinder axle (65) in order to generate a signal representing the angular position ( $a_{1,2,3}$ ) of the axle, which is applied in the feedback loop of the monitoring and control circuit (101) of the corresponding asynchronous  
10 motor, the housing of the angular encoder being connected to the chassis of the machine by means of a fastener (46) that is angularly rigid but permits it to follow the axial displacements of the axle.

4. Printing machine according to claim 3, characterized  
15 in that the fastener (46) of the angular encoder (56) comprises a plurality of lamellae (47) in the form of parallel coaxial collars, connected with one another by diametral pairs of mounting devices (48) arranged in quadrature from one lamella to the next.

20 5. Printing machine according to claim 1, characterized in that the common axle (65) of the rotor (26) and the cylinder (16) is mounted on needle bearings (40, 40', 40''), and in that it comprises a protruding flange (45) grasped by a fork (55) displaced axially by an endless screw (30) parallel  
25 to the axle and driven by the electric motor (25) for lateral

correction.

6. Printing machine according to claim 5, characterized in that the flange (45) or the fork (55) comprises a first ball bearing or bearing with cylinders, and in that the fork (55) is guided through a second bearing (53), along a support axle (58), and in that the endless screw (30) is connected to the motor (25) by a reduction mechanism comprising a pinion and a toothed wheel, or a pinion (27) connected to a pulley (29) by means of a timing belt (28).

7. Printing machine according to claim 1, characterized in that the end of the axle (65) at the side opposite the motor is held by an immovable bearing (40''), and in that the form cylinder (16, 17, 18) is fixed on the axle by clamping of its two end hubs (74) between a first cone (70) fixed at the side of the motor and a second, opposed, immovable cone (72) that can be pushed in the direction of the first by a mechanical means (43).

SMART & BIGGAR  
OTTAWA, CANADA

PATENT AGENTS

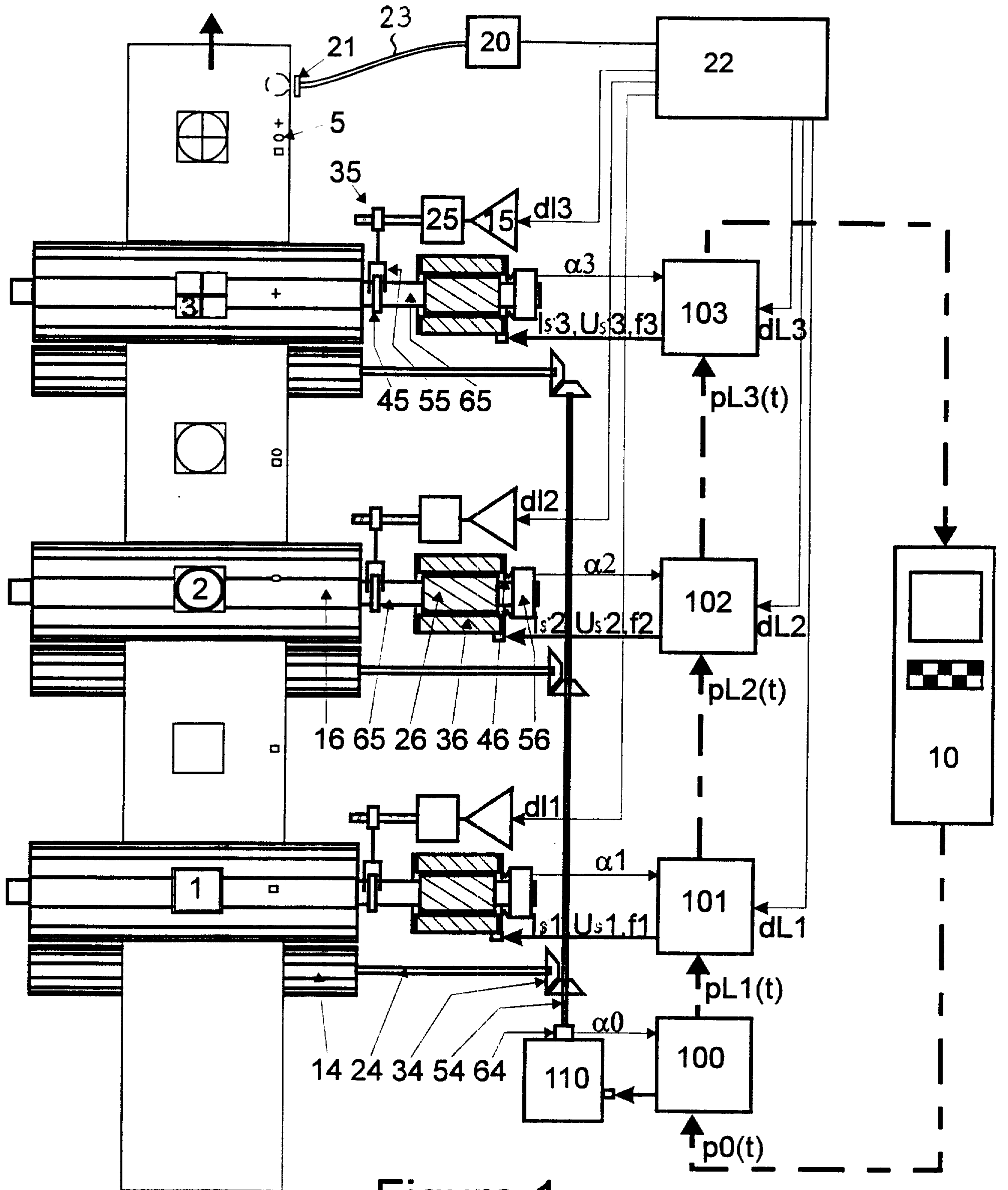


Figure 1

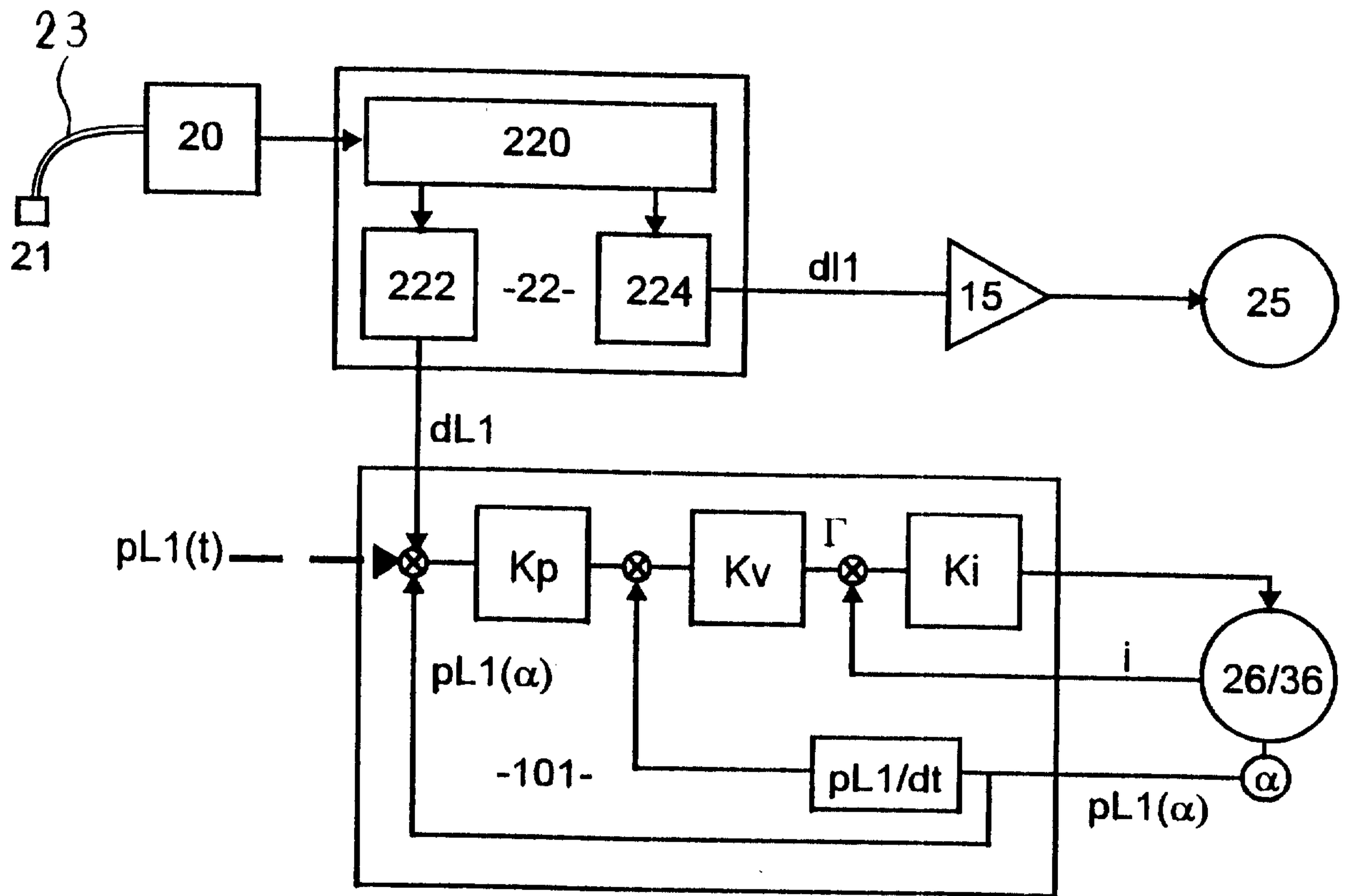


Figure 2

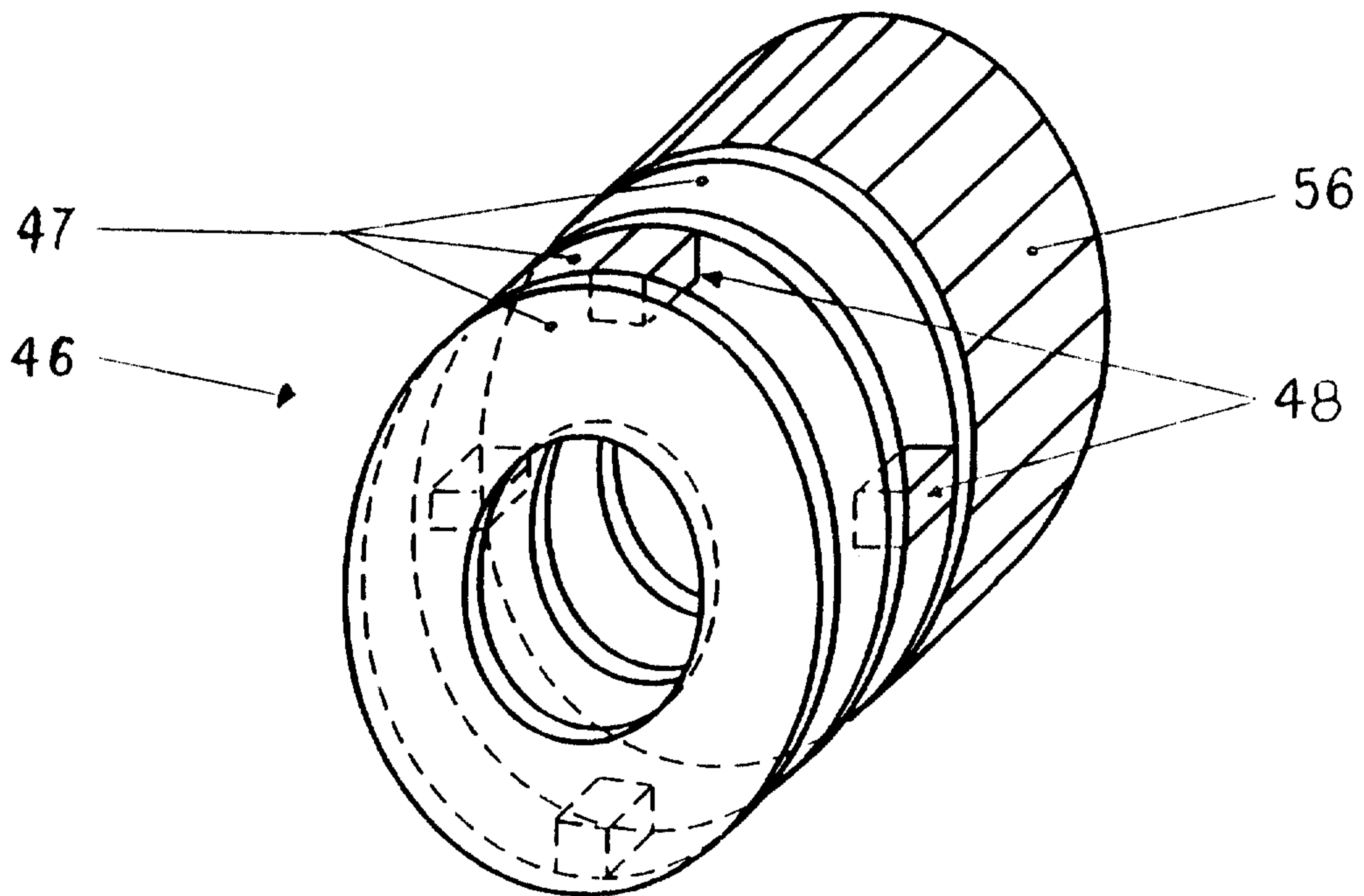


Figure 4

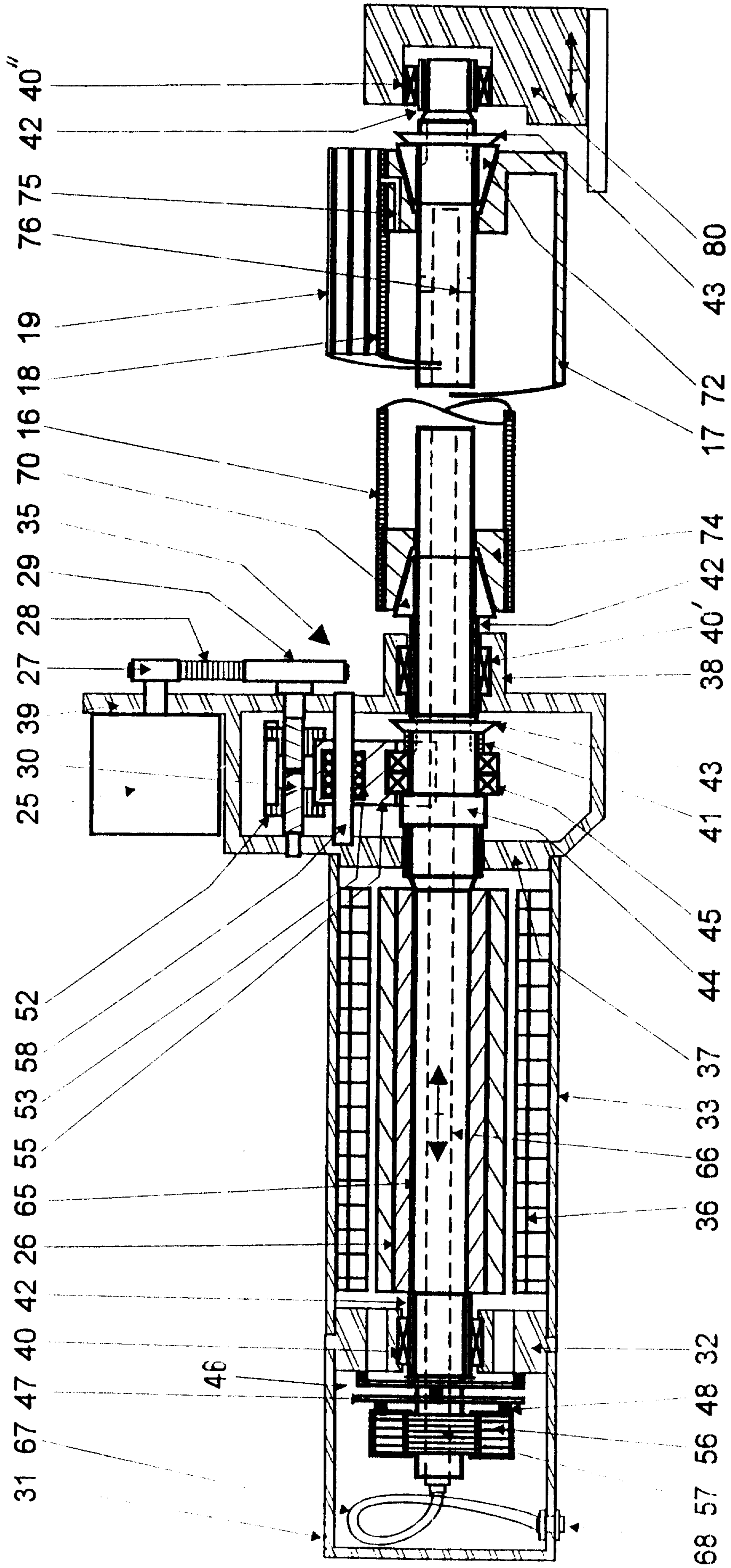


Figure 3

