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(71) Applicant: **Satalite Dishes Ltd.**
Valletta VLT 08 (MT)

(72) Inventor: **Bergamini, Giorgio**
44031 Copparo (FE) (IT)

(74) Representative:
Leone, Mario et al
Società Italiana Brevetti S.p.A.
Piazza di Pietra 39
00186 Roma (IT)

(54) Rotor device for a satellite reception assembly

(57) A polar rotor device (1) for a satellite reception assembly (100), apt to drive eastward and westward rotations of a dish antenna (300) of such assembly, comprising: a motor (2); a transmission system (3), interposed between the motor and the dish antenna to transform the output motion of the motor into the eastward and westward rotations of the dish antenna, wherein the rotations comprise descending rotations, during which the dish antenna is rotated downward, and ascending rotations, during which the dish antenna is rotated upward; and elastic means (4), arranged at the transmission system, apt to store elastic energy during the descending rotations, and to return elastic energy during the ascending rotations, so that the rotor device can be fed by a receiver of the satellite reception assembly.

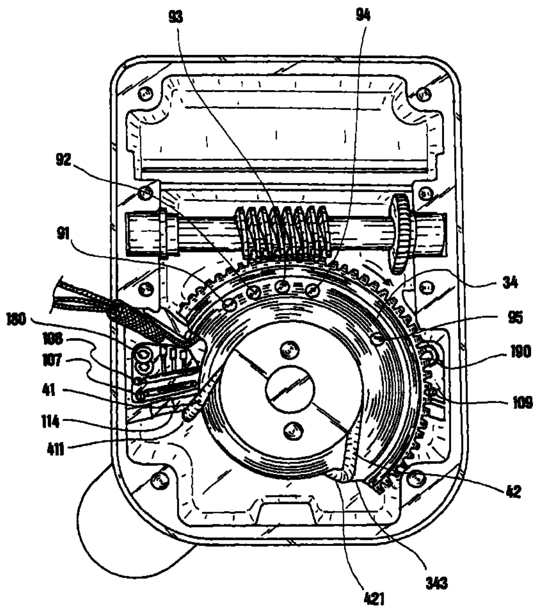

FIG.3

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Description

[0001] The present invention relates to a polar rotor device for a satellite reception assembly. In particular, this invention relates to a rotor device apt to drive eastward and westward rotations of a dish antenna of such assembly, comprising a motor, a transmission system, interposed between said motor and the dish antenna to transform the output motion of said motor into said eastward and westward rotations of the dish antenna, wherein said rotations comprise descending rotations, during which the dish antenna is rotated downward, and ascending rotations, during which the dish antenna is rotated upward.

[0002] Geostationary satellites hover according to a circumferential path concentric with the imaginary circle corresponding to the Equator. Therefore, whenever a person is in the northern hemisphere of the Earth, all the "visible" geostationary satellites can be traced by an arc described from east to west across the sky, with the apex thereof exactly oriented to the south of the person (north in the southern hemisphere). Of course, the farther away the person is from the Equator, the lower in the sky this geo-arc appears.

[0003] Signals transmitted by the above satellites can be received by a satellite reception assembly. This assembly comprises a dish antenna for capturing such signals, to be arranged outside the house, electrically connected to a receiver device for de-codifying such signals, to be placed inside the house. As it will be well-known for those skilled in the art, the dish antenna generally includes a so-called satellite dish of a paraboloid shape and a "horn" fixed with it, usually indicated as LNB ("Low Noise Block").

[0004] In order to capture signals from different satellites, the dish antenna must be rotated eastward and westward. In particular, for an optimal reception from a large number of satellites, the ideal focus of the paraboloidal satellite dish should follow a substantially semi-elliptic path.

[0005] In up-to-date satellite reception assemblies, the antenna dish is rotated by a rotor device, located at the dish antenna mount. This rotor device comprises at least a motor, generally of a DC type, and a transmission system, apt to transform the output motion of the motor into a final rotation of the dish antenna. The above optimal path of the dish antenna is obtained by mounting the rotor device so that an output antenna mounting pin thereof, i.e. the output axis of rotation, is inclined with respect to a vertical line. It will be understood that the required inclination depends upon the latitude of the geographic site where the satellite reception assembly is installed. In particular, such inclination should be greater at the lower latitudes (i.e. towards the Equator) and lower at the higher latitudes (i.e. towards the Poles).

[0006] Rotor devices apt to be mounted with their output pin axis of rotation inclined are generally denoted as polar, or horizon-to-horizon, rotors.

[0007] In polar rotors, the inclination of the rotation axis entails that the westward and eastward rotations of the dish antenna comprise descending and ascending rotations. As it will be understood, during the descending rotations the dish antenna is moved downward, i.e. in the same direction of the gravity force, while during the ascending rotations the dish antenna is moved upward, i.e. in a direction opposite to the gravity force.

[0008] The driving torque that should be supplied by the polar rotors for rotating the dish antenna, and the related electrical power required by rotors, depend upon the weight of the satellite dish, but it varies according to the inclination of rotor axis and to the instantaneous westward or eastward orientation of the dish antenna. In particular, the greater the rotation axis inclination, the greater the antenna gravitational moment applied to with respect to said axis, and, consequently, the greater the electric power to be absorbed. Similarly, the greater the antenna angular displacement towards east or west, the greater its gravity moment arm with respect to the rotation axis, the greater the electrical power absorbed by the polar rotor.

[0009] In order to manage efficiently the transmission and de-codification of signals between the receiver and the dish antenna, a standard protocol named DISEqC® ("Digital Satellite Equipment Control") has been developed. This protocol allows controlling any part of a satellite reception assembly, included its rotor device, over a single co-axial cable running from the receiver to the LNB.

[0010] Therefore, according to this protocol, the power supply to the rotor device is provided by the receiver. In particular, current standards entail that a receiver can supply a total output current of 500 mA, at a voltage of 13 or 18 V. Of such 500 mA, about 150 to 200 mA are necessary to feed the LNB, and the remaining 300 to 350 mA are available for the rotor device.

[0011] The DISEqC® protocol, and especially its later version known as DISEqC 1.2®, possesses a great potential for simplifying the operation of a satellite reception assembly. Furthermore, it allows such assembly to be much less cumbersome than previous systems, which used separate controllers and power supplies for the LNB and the rotor device.

[0012] In general, the satellite reception assemblies of the known art described above suffer of some relevant drawbacks.

[0013] The main disadvantage is that the output current provided by the receiver is generally not sufficient to feed both the LNB and the rotor device, especially at the higher latitudes, for dishes of larger diameter, i.e. weight, and during the ascending rotations of the dish antenna. This entails a limitation in the allowed westward/eastward angular displacement of the dish antenna, and therefore in the number of satellites "reachable" for a user. Furthermore, this problem prevents the full exploitation of the potential of the DIS-

EqC® protocol.

[0014] The above problem becomes apparent when, while the dish antenna is rotating, the TV screen becomes black. This is due to the fact that the dish antenna has "lost" the satellite signals due to the overwhelming power absorption of the rotor device. Alternatively, the rotor device blocks without producing the required angular displacement.

[0015] The technical problem underlying the present invention is that of providing a rotor device allowing to overcome the drawbacks mentioned with reference to the known art.

[0016] Such problem is solved by a polar rotor device for a satellite reception assembly, apt to drive eastward and westward rotations of a dish antenna of such assembly, comprising a motor, a transmission system, interposed between said motor and the dish antenna to transform the output motion of said motor into said eastward and westward rotations of the dish antenna, wherein said rotations comprise descending rotations, during which the dish antenna is rotated downward, and ascending rotations, during which the dish antenna is rotated upward, characterised in that it comprises elastic means, arranged at said transmission system, apt to store elastic energy during said descending rotations, and to return elastic energy during said ascending rotations.

[0017] The present invention provides some relevant advantages. The main advantage lies in the fact that the aforementioned elastic means regulate the rotor current consumption during the eastward/westward rotations of the dish antenna, thus enabling rotor feeding directly by the receiver. In particular, the elastic means decrease the power supply required by the rotor device during the ascending rotations.

[0018] Other advantages, features and operation steps of the present invention will be made apparent in the detailed description of an embodiment thereof, given by way of example and not for limitative purposes. It will be made reference to the figures of the annexed drawings, wherein:

Figure 1 shows a perspective, partially sectional view of a polar rotor device according to the present invention;

Figure 2 relates to a few internal components of the rotor device of Figure 1, showing a perspective view;

Figure 3 shows an elevational plan view of the internal components of Figure 2 during operation of the rotor device;

Figure 4 shows a perspective view of a satellite reception assembly comprising the rotor device of Figure 1;

Figure 5 shows a block diagram relating to the operation of the satellite reception assembly of Figure 4;

Figure 6A refers to experimental graphics relating current consumption with angular displacement of a first dish antenna, in a known art rotor device; Figure 6B refers to experimental graphics relating

current consumption with angular displacement of the same dish antenna of Figure 6A, in a first embodiment of the rotor device according to the present invention; Figure 6C refers to experimental graphics relating

current consumption with angular displacement of the same dish antenna of Figure 6A, in a second embodiment of the rotor device according to the present invention;

Figure 7A refers to experimental graphics relating current consumption with angular displacement of a second dish antenna, in a known art rotor device;

Figure 7B refers to experimental graphics relating current consumption with angular displacement of the same dish antenna of Figure 7A, in the rotor device of Figure 6B; and

Figure 7C refers to experimental graphics relating current consumption with angular displacement of the same dish antenna of Figure 7A, in the rotor device of Figure 6C.

[0019] Referring initially to Figure 1, a polar rotor device, globally indicated as 1, comprises a motor 2, a transmission system, globally indicated as 3, and elastic means 4 arranged at the transmission system 3.

[0020] Each of these components will be now described in greater detail with reference to the specific embodiment herein presented.

[0021] First of all, all the aforementioned components are enclosed within a rotor housing, composed of a shaped top shell element 11 and a shaped bottom shell element 12, fixed one with the other by conventional connection means.

[0022] The top shell element 11 has a circular flange 111 projecting outwardly, for coupling the rotor device 1 with an antenna mounting pole 5 that will be described in greater detail later on. In proximity of the lower edge of this circular flange 111, the top shell element 11 has an angular graduation 112 engraved on its surface.

[0023] The top shell 11 also comprises intermediate stop walls for the elastic means 4, the role of which will be clarified later on. One of these stop walls, indicated with 114, is visible in Figure 1.

[0024] The top shell element 11 further comprises two bolt seats 113 projecting upwardly, arranged at its opposite sides. Each of these seats is apt to receive a rotor fixed-bolt for connecting the rotor device 1 with a stationary pole, as it will be detailed later on with reference to Figure 4. In Figure 1, only one of these rotor fixed-bolt seats is visible.

[0025] For the above connection with the stationary pole, the rotor device 1 also has two bolt seats 121 projecting rearward formed on the bottom shell 12, each apt to receive a rotor adjustment bolt.

[0026] The bottom shell 12 also comprises a first intermediate wall 122 integral with it and a slot 123 formed nearby. These intermediate wall 122 and slot 123 define a seat for a main printed circuit 101 that will be described later on.

[0027] The motor 2 is bi-directional, and it is preferably a brushless DC motor. According to the present preferred embodiment, the motor 2 is a ratio-motor or gear-motor, thus incorporating a gearbox 23.

[0028] Furthermore, motor 2 is equipped with an outer magnetic shield 21, so as to avoid electromagnetic interference with signals to and from a dish antenna. Motor 2 also includes three internal capacitors (not shown in the figures), which act as a noise filter.

[0029] In the present embodiment, motor 2 further has an encoder 22, the function of which will be clarified later on.

[0030] Motor 2 is controlled by a motor control system, implemented by a main printed circuit 101 and a secondary printed circuit 104, which are represented schematically in Figure 1. This control system can incorporate means for memorising the "co-ordinates" of a certain number of satellites with respect to the location of the rotor device 1.

[0031] The main printed circuit 101 is connected by a flat cable 103 to the secondary printed circuit 104, in its turn in direct electric connection with motor 2.

[0032] The main printed circuit 101 incorporates a microprocessor 102, thus being programmable. The main printed circuit 101 also has a receiver connector 105, for connection with a receiver of a satellite reception assembly, and an antenna connector 106, for connection with a dish antenna of said satellite reception assembly.

[0033] The motor control system implements the DISEqC 1.2® protocol. Thus, the rotor device 1 is apt to be driven by a DISEqC®-compatible satellite receiver. This protocol will be already well-known for a person skilled in the art, thus no further description of it will be herein provided.

[0034] The transmission system 3 comprises the aforementioned gearbox 23, coupled to a wormscrew 31. In particular, an output gear 231 of the gearbox 23 engages a wormscrew gear 32 fixed with the wormscrew 31.

[0035] The wormscrew 31 has a threaded profile 311 for a length indicated by a quote 312 in Figure 2.

[0036] The wormscrew 31 is kept in place on the one side by the engagement between the wormscrew gear 32 and the output gear 231, and on the other side by a clamp element 33 which blocks it with the top shell element 11.

[0037] The wormscrew 31 engages a shaped gear wheel 34. In this way, the output motion of the motor 2 is transformed by the transmission system 3, comprising the gearbox 23, the wormscrew gear 32, the wormscrew 31 and the gear wheel 34, into a final rotary motion about the rotation axis 35 of the gear wheel 34. This rotation axis 35 will be from now on referred to as the rotor axis.

[0038] Preferably, in order to increase shear strength, all the gears of the transmission system 3 are double thick gears.

[0039] Figure 2 relates to an internal view of the rotor device 1, taken above from down, wherein all the components obstructing the view of the gear wheel 34 are not shown.

[0040] Referring from now on also to this latter figure, the gear wheel 34 comprises a portion of greater diameter, having a toothed profile 341, and a portion of smaller diameter. In particular, the toothed profile 341 covers an angle β of the gear wheel perimetral surface In the present example, this angle is about 240 degrees. The aforementioned length 312 of the threaded profile 311 of the wormscrew 31 and the angle β are chosen jointly, so as to implement a mechanical stop for the eastward and westward rotation of the gear wheel 34, as will be illustrated in greater detail later on.

[0041] At the intersection of said portions 34' and 34", two radial abutting edges are formed, at opposite sides of the gear wheel 34. By way of example, these opposite sides will be from now on regarded as a west side and an east side. Consequently, the above abutting edges will be indicated as a west abutting edge 342 and an east abutting edge 343.

[0042] In the proximity of its toothed profile 341, the gear wheel 34 incorporates a plurality of magnets, arranged according to an arc. Going from the west abutting edge 342 towards the east abutting edge 343, these magnets will be denoted as a zero magnet 91, a first rotation magnet 92, a second rotation magnet 93, a west stop magnet 94 and an east stop magnet 95. The first four of these magnets are at substantially the same distance one from another.

[0043] The reasons for the names and arrangement of the above magnets will be clarified later on, in relation to the operation of the rotor device 1.

[0044] The gear wheel 34 also has a central shaped mounting hole (not visible in the Figures), for example in the form of a "D", for connection with the aforementioned antenna mounting pole 5.

[0045] This antenna mounting pole 5 has a main body 51 projecting outside the top shell element 11 of the rotor housing. This main body 51 is of a substantially cylindrical shape, having a longitudinal axis indicated with the numeral 52. At the external longitudinal end thereof, the main body 51 has a closure cap 53. At the other longitudinal end, the main body 51 is coupled to the gear wheel 34 by a coupling pin 54 integral with it.

[0046] The coupling pin 54 has a smaller cross section than the main body 51. Its longitudinal axis substantially coincide with the rotor axis 35, and it is more inclined with respect to the vertical than the main body longitudinal axis 52, forming with the latter an angle α. This angle α is needed for assuring an optimal mounting of a dish antenna onto the antenna mounting pole 5, as it will be explained more in detail later on.

[0047] The coupling pin 54 comprises a first shaped portion (not visible in the Figures), matching the central shaped hole of the gear wheel 34. The coupling pin 54 further has a threaded end portion 541, apt to be screw connected with a threaded locking ring 6 adjacent to the gear wheel 34.

[0048] This threaded locking ring 6 has substantially circular cross sections. In particular, it comprises a base disc 61 of greater diameter and an upper disc 62 of smaller diameter. The locking ring 6 also has a central threaded seat 63, passing from side to side thereof, for receiving the threaded end portion 541 of the coupling pin 54.

[0049] The locking ring 6 further has two mounting holes 64 for a mounting key.

[0050] Summarising, the coupling pin 54 is inserted through the circular flange 111 of the top shell 11, through the central mounting hole of the gear wheel 34 and it is screwed in the central threaded seat 63 of the locking ring 6, in this order. The pin insertion in the circular flange 111 takes place by interposition of two groups of thrust bearings 7, separated by a ring spacer 8.

[0051] In the present embodiment, the elastic means 4 are located at the connection between the antenna mounting pole 5 and the gear wheel 34. In this example, these elastic means 4 comprise a helical torsion spring, it too denoted as 4, wounded around the upper disc 62 of the locking ring 6.

[0052] The helical spring 4 has two abutment arms, and specifically a first and a second side arm 41 and 42, respectively, each projecting from a respective lower or upper turn of the spring 4 according to a tangential direction. These side arms 41 and 42 are separated by an angular distance of approximately 90 degrees. Each of them has an end leg curved upwardly, 411 or 421 respectively, substantially orthogonal to the respective tangential portion.

[0053] In Figure 2, the rotor device 1 is represented in a rest configuration, which is conventionally associated with a "zero" rotation of the gear wheel 34. In this configuration, also the spring 4 is in a rest condition. In particular, each of its end legs 411 and 421 abuts a respective west or east abutting edge 342 or 343 of the gear wheel 34, and a respective west or east stop wall 114 or 115 of the top shell 11. Furthermore, the zero magnet 91, the two rotation magnets 92 and 93 and the west stop magnet 94 are all positioned on the same west side of the rotor device 1, while the east stop magnet 95 is positioned on the east side, in a symmetrical position with respect to the west stop magnet 94.

[0054] The rotor device 1 further comprises a plurality of relays, and specifically a west stop relay 107, a zero relay 108 and an east stop relay 109. These relays are fixed with the top shell 11, and arranged above the gear wheel 34. In particular, the west stop relay 107 and the zero relay 108 are arranged in proximity of the west stop wall 114, at substantially the same distance between two of the magnets of the west side. The east stop relay 109, instead, is arranged on the east side, in proximity of the east stop wall 115, in a symmetrical position with respect to the west stop relay 107. The zero relay 108 and the east stop relay 109 have an adjustment screw each, indicated as 180 and 190, respectively, which is preferably a socket head screw.

[0055] For the sake of fabrication and assembly simplicity, the above relays are preferably reed relays.

[0056] These relays are apt to electromagnetically interact with the above-described magnets to implement an angular position sensing system. In particular, when, during the rotation of the gear wheel 34, one of the above magnets passes above one of the relays, it keeps it excited, i.e. closed, as it will be explained in greater with reference to the operation of the rotor device 1. The relays transmit to the motor 2 signals carrying information about the angular position of the gear wheel 34 by means of relay cables 110.

[0057] Figure 4 shows a satellite reception assembly, globally indicated with 100, comprising the rotor device 1, a receiver 200 and a dish antenna 300.

[0058] The receiver 200 is supposed to be DISEqC 1.2® compatible, and therefore able to memorise a certain number of satellites and to command the rotor device 1 accordingly.

[0059] For those skilled in the art, it will be apparent that multiple functions could be provided by the receiver 200, such as an auto-focus for the fine-tuning of the dish antenna orientation with respect to a certain satellite.

[0060] The receiver 200 is electrically connected to the rotor device 1 by a coaxial cable 201 running from the receiver 200 to the receiver connector 105. Signals form the receiver 200 are generally modulated at 22 kHz.

[0061] The dish antenna 300 comprises a satellite dish 301 and a LNB 302. The latter is electrically connected to the rotor device 1 by the same coaxial cable 201 running from the LNB connector 106.

[0062] The rotor device 1 is mounted on a stationary pole 400 by stationary brackets 501 attached to a stationary flange 502. For the mechanical connection with the rotor device 1, the stationary flange 502 has two flange fixed-bolt seats 503, each of which receives a rotor fixed-bolt 601, and two flange slots 504, each of which receives a rotor adjustment-bolt 602. In particular, each rotor fixed-bolt 601 is also received in a respective rotor fixed-bolt seat 113, and each rotor adjustment-bolt 602 is also received in a respective rotor adjustment-bolt seat 121. Flange slots 504 allow regulating the inclination of the rotor axis 35 according to the latitude of the site where the satellite reception assembly 100 is installed.

[0063] The dish antenna 300 is fixed to the antenna mounting pole 5 by a mounting system similar to the one already described for the rotor device 1. In particular, also in this case antenna brackets 701 attached to an antenna flange 702 are provided. Furthermore, an antenna adjustment-bolt 801 sliding inside an antenna flange slot 703 allows regulating the so-called elevation of the dish antenna 300 according to the latitude.

[0064] The antenna brackets 701 work better if associated with a substantially vertical pole. This is the main reason for having an antenna mounting pole 5 less inclined with respect to the vertical line than the rotor axis 35. Furthermore, this more vertical mounting prevents mechanical interference between the antenna mounting pole 5 and the stationary pole 400.

[0065] The first time the reception assembly 100 is installed, the dish antenna 300 must be manually and/or automatically oriented towards the true south (north in the southern hemisphere), i.e. towards the apex of the geo-arc mentioned with reference to the known art. This can be done using a compass or a reference satellite. To this initial orientation of the dish antenna 300 corresponds the "zero" rotation of the gear wheel 34 shown in Figure 2.

[0066] The way the above regulations and initial orienting of the dish antenna are carried out will be well-known for a person skilled in the art, and therefore no further description of them will be herein given.

[0067] In order to capture signals from the various satellites arranged along the geo-arc, the dish antenna 300 can be rotated eastward or westward with respect to its initial orientation by the rotor device 1. In particular, the user can select a certain satellite by means of a user interface of a conventional type, for example a remote control 900 interacting with the receiver 200. Of course, the greater the angular displacement allowed by the rotor device 1, the larger the number of satellites that can be "seen" by the dish antenna 300.

[0068] The operation of the rotor device 1 according to the present invention will now be described with reference to Figures 3, 4 and 5.

[0069] Referring initially to Figures 4 and 5, suppose a user chooses, by the remote control 900, to see the programs transmitted by a certain satellite. This user command is receipted by the receiver 200, which in its turn transmits it to the motor control system by the coaxial cable 201.

[0070] In the main integrated circuit 101, the receiver command is de-codified, i.e. the angular displacement to be imparted to the gear wheel 34 in order to bring the dish antenna 300 into the required westward or eastward orientation is calculated. This calculation is made taking into account the current orientation of the dish antenna 300. Information about such current orientation is supplied by the aforedescribed angular position sensing system associated with the gear wheel 34, according to a sensing method which will be illustrated briefly afterward, and by the encoder 22.

[0071] In order to perform the above functions, the motor control system comprises: means for processing a receiver command that identifies a required satellite; means for processing a sensing signal coming from said angular position sensing system; means for processing an encoder signal coming from said encoder; and means for processing the receiver signal, the sensing signal and the encoder signal and for calculating the angular displacement to be imparted to the dish antenna in order to bring it into the westward or eastward orientation corresponding to the required satellite.

[0072] Once the angular displacement to be imparted to the gear wheel 34 has been calculated, the microprocessor 102 sends to the motor 2, by the flat cable 103 and the secondary integrated circuit 104, an appropriate command. Therefore, the motor 2, by the transmission system 3, rotates the antenna mounting pole 5 of the required amount. During this rotation, the angular position sensing system and the encoder 22 send to the motor control system feedback signals about the actual angular position of the dish antenna 300.

[0073] Signals captured by the chosen satellite are transmitted from the LNB to the antenna connector 106, and from there to the receiver 200, by the coaxial cable 201.

[0074] The role of the elastic element 4 according to the invention will now be described with reference to Figure 3, which shows the gear wheel 34 and the associated angular position sensing system during an eastward rotation.

[0075] As already mentioned, when the rotor device 1 is in its rest configuration, the dish antenna 300 is oriented toward the true south (north), the gear wheel 34 has zero rotation and the spring 4 is in its rest condition. Suppose now that, starting from the above rest configuration, the gear wheel 34 is rotated eastward, as in Figure 3. This gear wheel rotation corresponds to a descending rotation of the dish antenna 300. During such rotation, the second spring arm 42 moves with the gear wheel 34 by virtue of the abutment of its second leg 421 against the east abutting edge 343. The first arm 41, instead, remains in abutment against the west stop wall 114. In this way, the spring 4 is torsionally deformed, thus storing elastic energy, i.e. the spring 4 is "charged".

[0076] Suppose that afterward, starting from the so-reached eastward angular position, the gear wheel 34 is rotated in the opposite sense, i.e. westward, for selecting a different satellite. This subsequent westward rotation of the gear wheel 34 corresponds of an ascending rotation of the dish antenna 300. In this ascending rotation, the spring 4 returns part of the elastic energy stored in the previous descending rotation, thus reducing the driving torque that the motor 2 has to supply, and, therefore, its current absorption from the receiver 200.

[0077] At this point, it will be better appreciated how the spring 4 allows a more regular current consumption from the receiver 200 with respect to the rotors of the known art. In particular, it should be noted that the elastic energy stored by the spring in a descending rotation depends upon the spring own elastic properties, i.e. upon its material and diameter, upon the dish antenna weight, upon the inclination of the rotor axis and upon the instantaneous orientation of the dish antenna. As already mentioned, the latter two factors determine the magnitude of the gravity force moment about the rotor axis. This implies that the elastic properties of the spring should be chosen as a compromise between the force required to charge it and the elastic force returned, by taking into account the latitude of the site where the assembly is to be installed and the angular distance between the western and eastern satellite that are to be reached.

[0078] An appropriate choice of the above spring elastic properties makes rotor current consumption much less dependent from the rotor axis inclination and from the instantaneous westward or eastward inclination of the dish antenna, as it will be better appreciated with reference to Figures 6A to 7C.

[0079] These figures allow to a comparison between the performance of a rotor device according to the present invention and the performance of a rotor device of the known art, given the same rotor axis inclination and dish antenna weight and for various latitudes.

[0080] In particular, Figures 6A refer to experimental trials carried out with a known art rotor device. Graphics show rotor current consumption vs. angular displacement of a satellite dish having a diameter of 80 mm. Rotation of the satellite dish starts from an eastern angular position of 60 degrees and ends at a 60 degrees western angular position. Continuos lines refer to the rotor axis inclination corresponding to latitude 70 degrees, dotted lines to latitude 45 degrees and bold dashed lines to latitude 15 degrees. Two sets of graphics are shown, one referring to a voltage supply of 18 V, and the other to a voltage supply of 13V.

[0081] Figures 6B and 6C refer to the same type of graphics of Figure 6A, relating to a rotor device according to the present invention comprising a 3.8 mm diameter helical spring and a 4 mm diameter helical spring, respectively.

[0082] Figures 7A to 7C refers to the same type of experimental graphics reported in the corresponding Figures 6A to 6C, except for the fact that the satellite dish considered has a diameter of 100 mm.

[0083] The experimental results of Figures 6A and 7A show that the maximal current consumption of the known art rotors occurs at the initial western angular position of 60 degrees, and that it ranges between 100 mA 400 mA, always exceeding 350 mA for satellite dishes of larger diameter at the higher latitude. As already mentioned, in this condition the receiver would not be able to feed simultaneously the rotor device and the LNB. In these same conditions, the rotor device according to the invention has, instead, a maximal current consumption of 300 mA.

[0084] Therefore, the lower power supply needed by the rotor device of this invention with respect to the known art rotors makes possible to feed it directly by the commercial receivers. Accordingly, this allows to fully exploiting the potential of the DISEqC® protocol, by definitely eliminating the need for assemblies having separate rotor supply unit and cables.

[0085] Furthermore, from the above graphics it is apparent that the rotor device of the present invention allows eastward or westward rotations of up to 60 degrees, thus enlarging the number of satellites that can be received by the associated satellite reception assembly with respect to the known art polar rotors. At the same time, as current consumption does not exceed 300mA, it is envisaged that the diameter, i.e. weight, of the satellite dish could be augmented up to 120 cm, thus further increasing the number of receivable satellites.

[0086] These graphics further show that two values of spring diameter are suitable for all the possible latitudes. Specifically, a diameter of about 3.8 mm suits higher latitudes, particularly from ±37 degrees to the Pole, and a diameter of about 4.0 mm suits the lower latitudes, i.e. from the Equator to about ±37 degrees.

[0087] From these graphics, it can be also appreciated that the elastic resistance of the spring 4 reduces current consumption during the descending rotations as well. During these rotations, in fact, such resistance helps the braking action that the motor 2 has to exercise to counterbalance the gravity force moment, which tends to accelerate dish antenna descending.

[0088] With the specifications reported up to now for the spring 4, the motor 2 and the transmission system 3, the dish antenna 300 can be effectively moved at an angular velocity between about 1.6 deg s^{-1} and 2.5 deg s^{-1}, which allows quick satellite finding.

[0089] It will be understood that the same considerations as those reported above could be done in case of an initial westward descending rotation and a subsequent eastward ascending rotation.

[0090] To the one skilled in the art it will be apparent that other elastic means instead of a single spring could be used, such as a spring system, or an elastic assembly including a damping element.

[0091] The operation of the angular position sensing system will be now described with reference to Figures 2 and 3.

[0092] Referring initially to Figure 2, when the rotor device 1 is in the above-described rest configuration, only the zero relay 108 is activated, by the zero magnet 91 superimposed to it. Therefore, the zero magnet 91 and the zero relay 108 implement a zero rotation sensing unit, being one above the other when said rotor device is in its rest configuration.

[0093] When, starting from this rest configuration, the gear wheel 34 is rotating westward, both the zero relay 108 and the west stop relay 107 are activated by the zero magnet 91, the rotation magnets 92 and 93 and the west stop magnet 94, taken in couples of adjacent magnets.

[0094] When the rear wheel 34 reaches the maximal westward rotation allowed, equal to about 60 degrees from zero in the present application, only the west stop relay 107 remains activated by the west stop magnet 94.

[0095] When, instead, starting from the rest configuration, the gear wheel 34 is rotating eastward, no relay is activated until the east stop relay 95 passes above the east stop relay 109. This indicates that the gear wheel 34 has reached the maximum eastward rotation allowed, i.e. about 60 degrees from zero in the present application.

[0096] Therefore, the two stop magnets 94 and 95 and the two stop relays 107 and 109 implement a stop sensing unit, apt to reveal that the rotor device 1 has reached a maximal eastward or westward angular displacement.

[0097] From the above description, it will be understood that the relays, through the relay cables 110, can supply to the motor control system information about the westward or eastward angular position of the gear wheel 34, i.e. of the dish antenna 300.

[0098] It will be appreciated that the adjustment screws 180 and 190 allow regulating the relay position, for an optimal detection of the gear wheel angular position.

[0099] It will be also understood that zero magnets 91, the rotation magnets 92 and 93 and the west stop magnet 93 could be also arranged at the east side of the gear wheel 34, and the arrangement of the east stop relay 95 and of the relays 107, 108 and 109 modified accordingly, without affecting the principle of operation of the angular position sensing system.

[0100] In case, for whatever reason, the stop relays 107 and 109 and stop magnets 94 and 95 should not detect that the gear wheel 34 has reached the maximal angular displacement allowed, the limited extension of the engagement between the wormgear 31 and the gear wheel 34 provides an emergency stop system. In particular, such limited engagement extension is determined by the limited length 312 of the threaded profile 311 and by the limited angular extension β of the toothed profile 341.

[0101] The present invention has been hereto described with reference to preferred embodiments thereof. It is understood that other embodiments might exist, all falling within the concept of the same invention, and all comprised within the protective scope of the claims hereinafter.

Claims

1. A polar rotor device (1) for a satellite reception assembly (100) , apt to drive eastward and westward rotations of a dish antenna (300) of such assembly, comprising:

   - a motor (2); and
   - a transmission system (3), interposed between said motor and the dish antenna to transform the output motion of said motor into said eastward and westward rotations of the dish antenna,

   wherein said rotations comprise descending rotations, during which the dish antenna is rotated downward, and ascending rotations, during which the dish antenna is rotated upward, characterised in that it comprises:

   - elastic means (4) , arranged at said transmission system, apt to store elastic energy during said descending rotations, and to return elastic energy during said ascending rotations.

2. The rotor device (1) according to claim 1, wherein said elastic means comprise a helical torsion spring (4).

3. The rotor device (1) according to any of claim 2, wherein said spring (4) has a first (41) and a second (42) side arm for abutting a rotor housing (11).

4. The rotor device (1) according to claim 3, wherein each of said arms (41, 42) has a curved end leg (411, 421).

5. The rotor device (1) according to claim 3 or 4, comprising a rotor housing (11) having two intermediate stop walls (114, 115) for the abutment of said first (41) and second (42) side arm of said spring (4).

6. The rotor device (1) according to any of claims from 3 to 5, wherein said transmission system (3) comprises a shaped gear wheel (34), having two radial abutting edges (342, 343), for the abutment of said first (41) and second (42) side arm of said spring (4).

7. The rotor device (1) according to claim 6, wherein said transmission system (3) comprises: a gearbox (23), coupled to said motor (2); a wormscrew gear (32), coupled to an output gear (231) of said gearbox; and a wormscrew (31), fixed with said wormscrew gear and engaging said shaped gear wheel (34).

8. The rotor device (1) according to claim 7, comprising a mechanical stop for said eastward and westward rotations of the dish antenna (300), which mechanical stop comprises a threaded profile (311, 312) of said wormscrew (31) and a toothed profile (341, β) of said gear wheel (34).

9. The rotor device (1) according to any of claims 2 to

8, comprising a locking ring (6) for connecting the dish antenna (300) with said transmission system (3), wherein said spring (4) is wounded around said locking ring.

10. The rotor device (1) according to any of the preceding claims, wherein said motor (2) has an outer magnetic shield (21) to avoid electromagnetic interference with signals to and from the dish antenna (300).

11. The rotor device (1) according to any of the preceding claims, wherein said motor (2) comprises an encoder (22).

12. The rotor device (1) according to any of the preceding claims, comprising an angular position sensing system (91, 92, 93, 94, 95, 107, 108, 109), arranged at said transmission system (3).

13. The rotor device (1) according to claim 12, wherein said angular position sensing system comprises a plurality of magnets (91, 92, 93, 94, 95), incorporated in a gear wheel (34) of said transmission system (3), and a plurality of relays (107, 108, 109), fixed with a rotor housing (11), each of said relays being apt to be activated by a magnet of said plurality of magnets when said magnet is above said relay.

14. The rotor device (1) according to claim 13, wherein a zero magnet (91) of said plurality of magnets and a zero relay (108) of said plurality of relays implement a zero rotation sensing unit, being one above the other when said rotor device is in a rest configuration.

15. The rotor device (1) according to claim 13 or 14, wherein two stop magnets (94, 95) of said plurality of magnets, arranged on opposite sides of said gear wheel (34), and two stop relays (107, 109) of said plurality of relays, arranged at opposite sides of said rotor housing (11), implement a stop sensing unit, apt to reveal that said rotor device has reached a maximal eastward or westward angular displacement.

16. The rotor device (1) according to any of claims 13 to 15, wherein said plurality of magnets comprises five magnets (91, 92, 93, 94, 95), incorporated in said gear wheel (34) according to an arc arrangement, and said plurality of relays comprises three relays (107, 108, 109), wherein two relays (107, 108) are arranged on one side of said rotor housing (11) and the other relay (109) is arranged on the other side of the rotor housing.

17. The rotor device (1) according to any of claims 13 to 16, wherein said relays (107, 108, 109) are reed relays.

18. The rotor device (1) according to any of the preceding claims, comprising a motor control system (101, 102, 103, 104) for controlling said motor (2).

19. The rotor device (1) according to claim 18, wherein said motor control system comprises a microprocessor (102).

20. The rotor device (1) according to claim 18 or 19, wherein said motor control system (101, 102, 103, 104) comprises a receiver connector (105), for connection with a receiver (200) of the satellite reception assembly (100), and an antenna connector (106), for connection with the dish antenna (300).

21. The rotor device (1) according to any of claims 18 to 20, wherein said motor control system comprises a main printed circuit (101) and a secondary printed circuit (104), both arranged within a rotor housing, said secondary printed circuit being in direct electric connection with said motor (2).

22. The rotor device (1) according to claim 11, to any of claims 12 to 17 and to any of claims 18 to 21, wherein said motor control system comprises: means for processing a receiver command, coming from a receiver (200) of the satellite reception assembly (100) and apt to identify a required satellite; means for processing a sensing signal coming from said angular position sensing system (91, 92, 93, 94, 95, 107, 108, 109); means for processing an encoder signal coming from said encoder (22); and means for processing said receiver signal, said sensing signal and said encoder signal for calculating the angular displacement to be imparted to the dish antenna (300) in order to bring it into the westward or eastward orientation corresponding to the required satellite.

23. The rotor device (1) according to any of claims 18 to 22, wherein said motor control system (101, 104) implements the DISEqC 1.2® protocol.

24. A satellite reception assembly (100), comprising a polar rotor device (1) according to any one of the preceding claims.

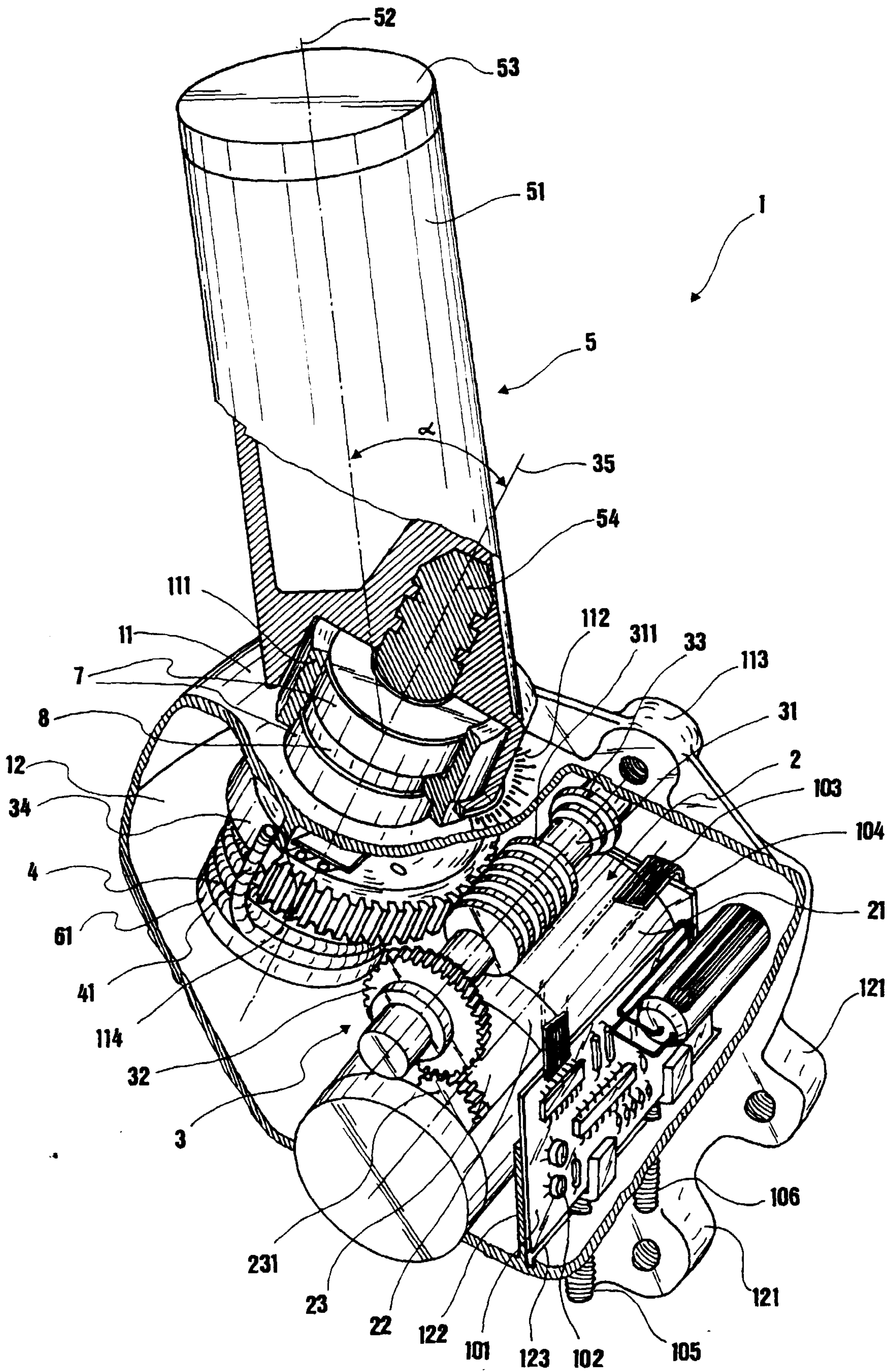

52
53
51
1
5
α
35
54
111
11
7
8
12
34
4
61
41
114
32
3
112
311
33
113
31
2
103
104
21
121
106
121
105
102
123
101
122
22
23
231

FIG.1

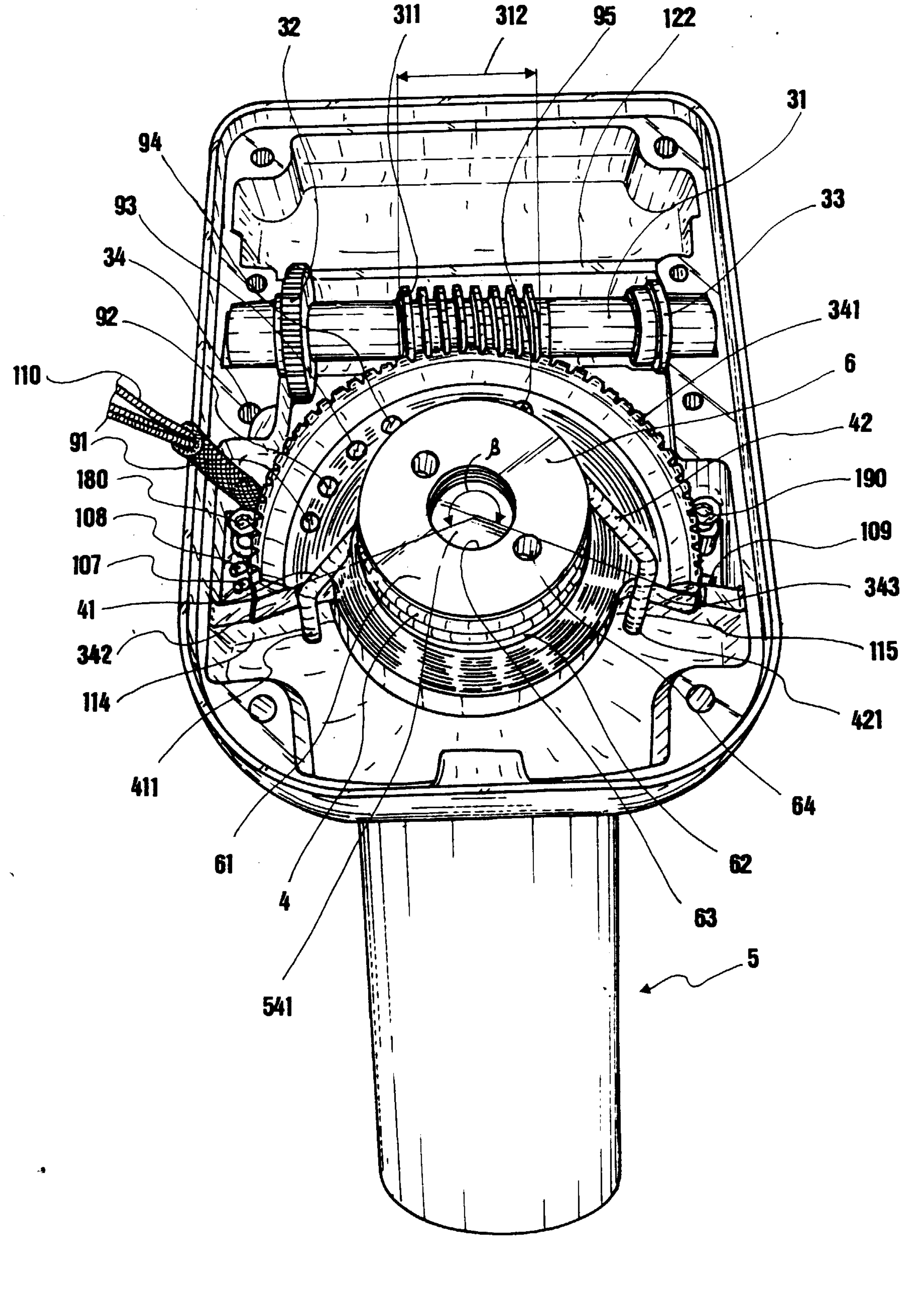

32
311
312
95
122
31
94
93
33
34
341
92
6
110
42
91
180
190
108
109
107
343
41
115
342
114
421
411
64
61
62
4
63
5
541
β

FIG.2

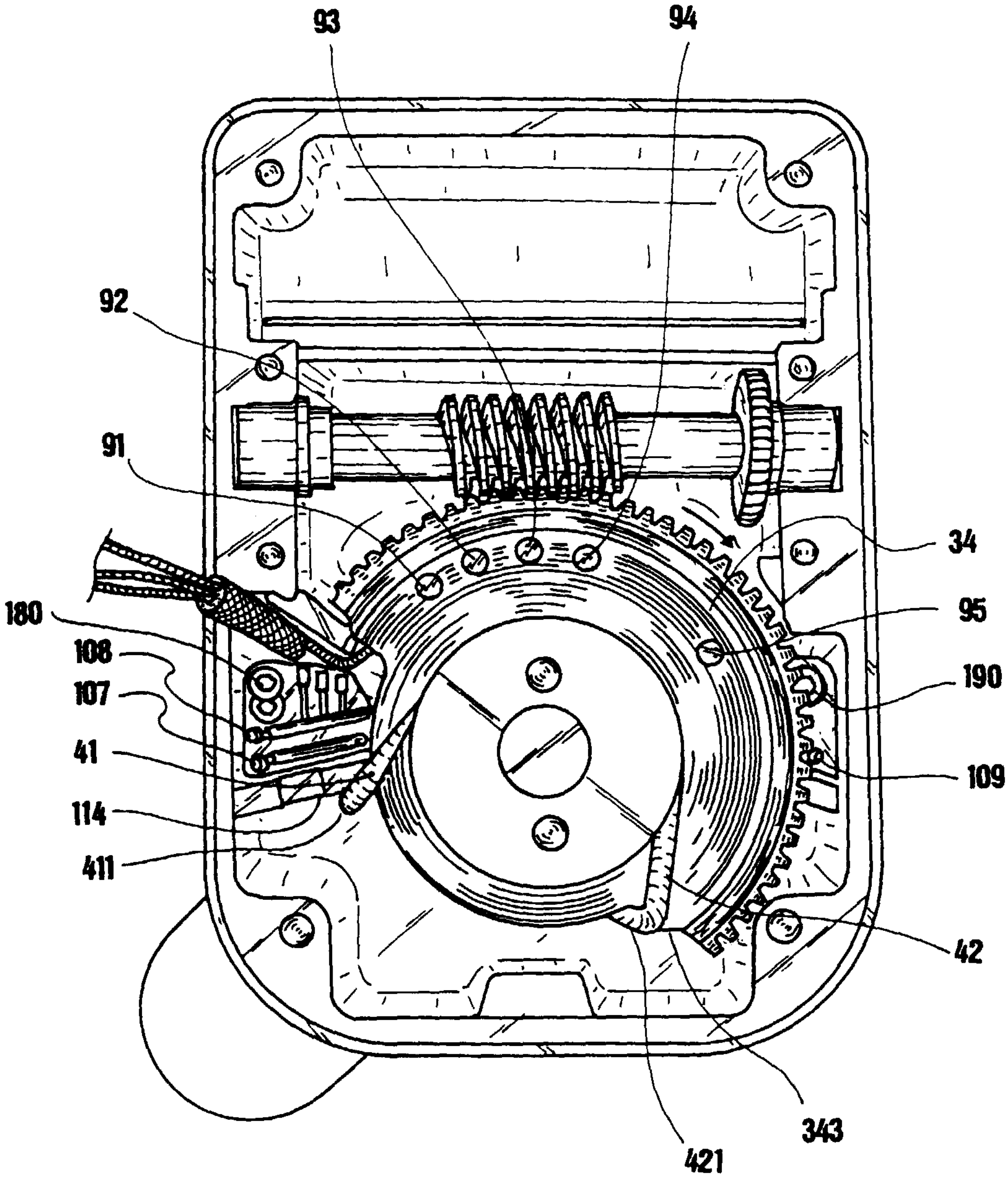


FIG.3

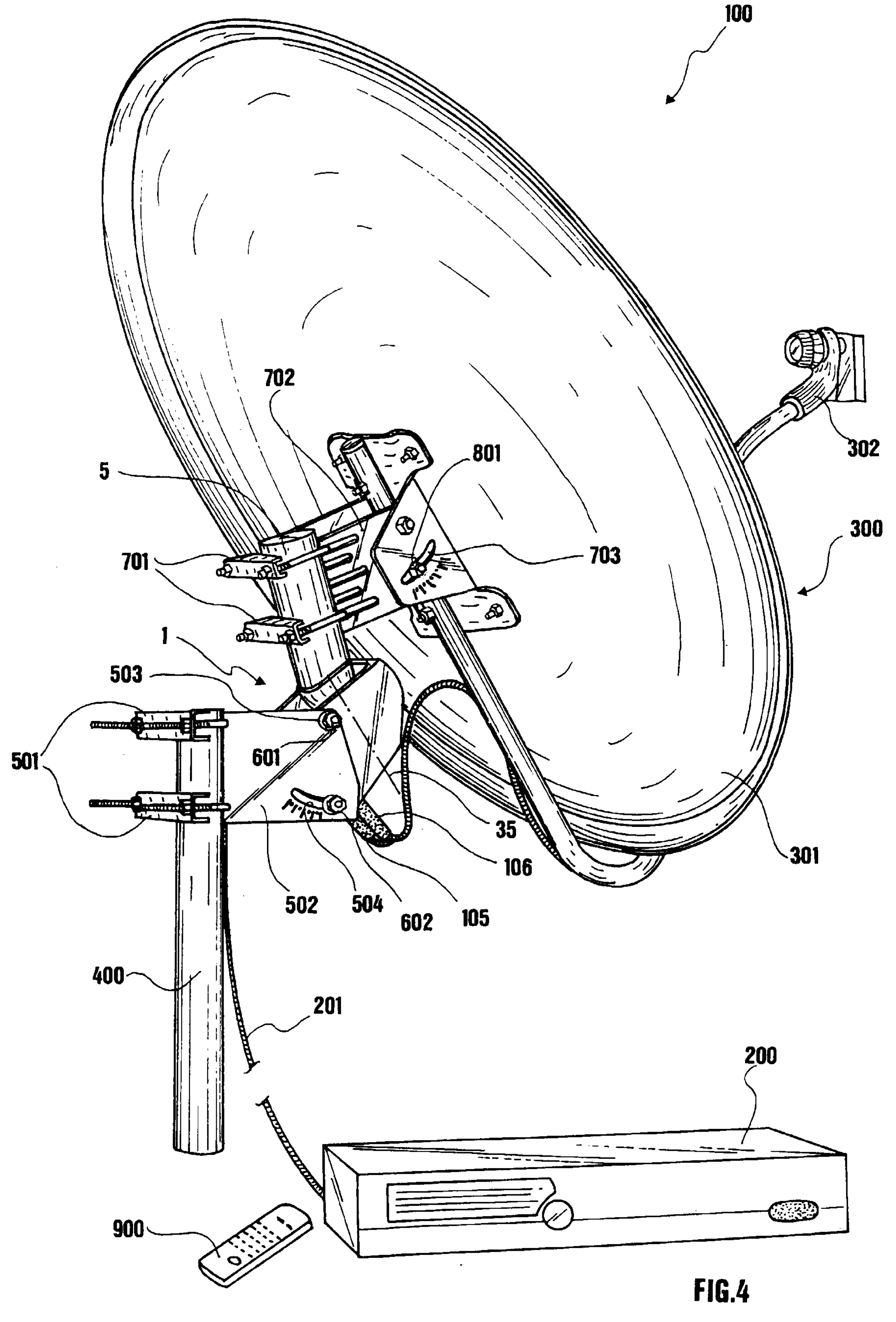

100
702
801
302
5
300
701
703
1
503
501
601
35
106
301
502
504
602
105
400
201
200
900

FIG.4

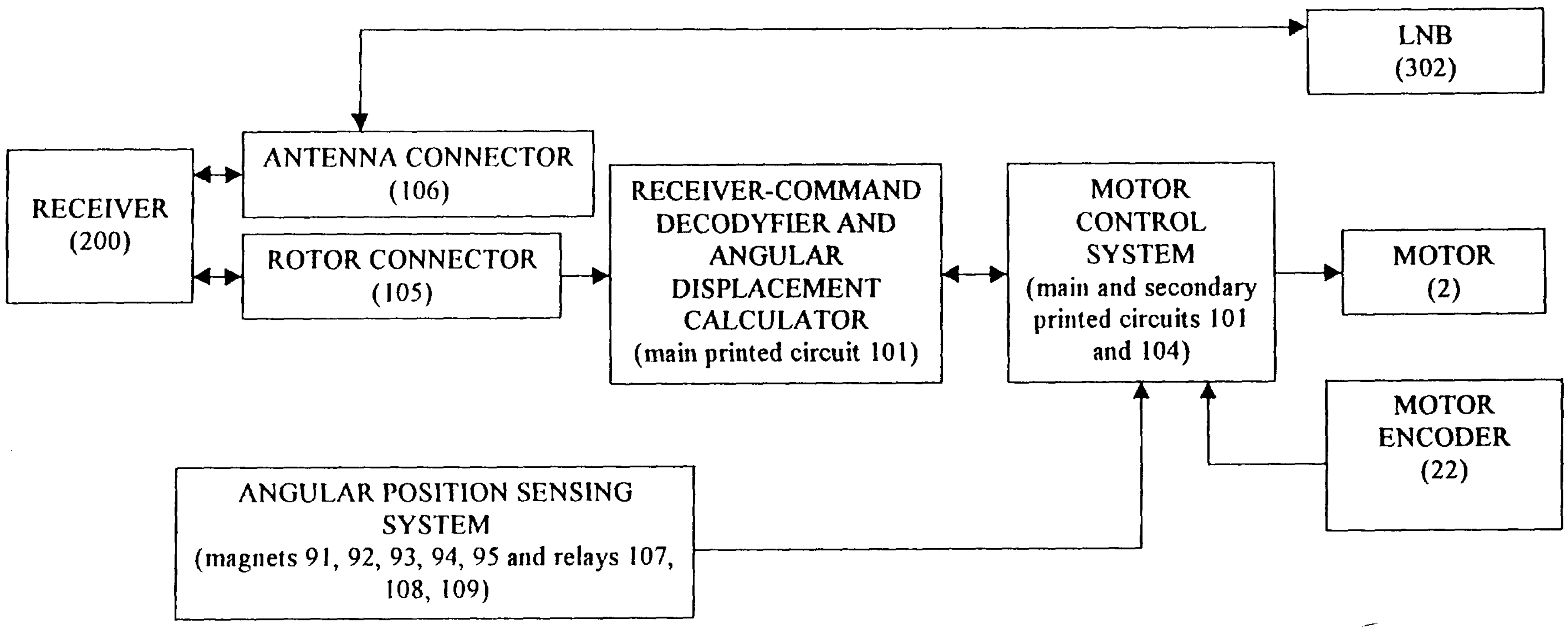
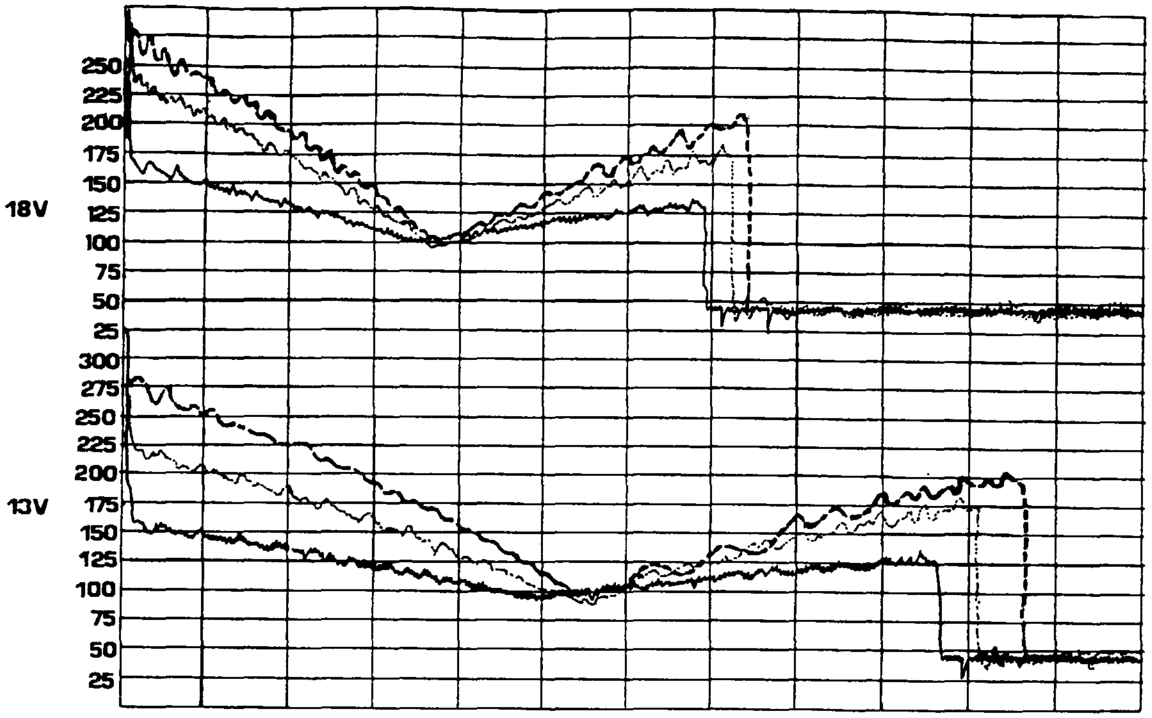

LNB
(302)
RECEIVER
(200)
ANTENNA CONNECTOR
(106)
ROTOR CONNECTOR
(105)
RECEIVER-COMMAND DECODYFIER AND ANGULAR DISPLACEMENT CALCULATOR
(main printed circuit 101)
MOTOR CONTROL SYSTEM
(main and secondary printed circuits 101 and 104)
MOTOR
(2)
MOTOR ENCODER
(22)
ANGULAR POSITION SENSING SYSTEM
(magnets 91, 92, 93, 94, 95 and relays 107, 108, 109)

FIG.5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225
200
175
150
125
100
75
50
25
13V
300
275
250
225
200
175
150
125
100
75
50
25

FIG.6A

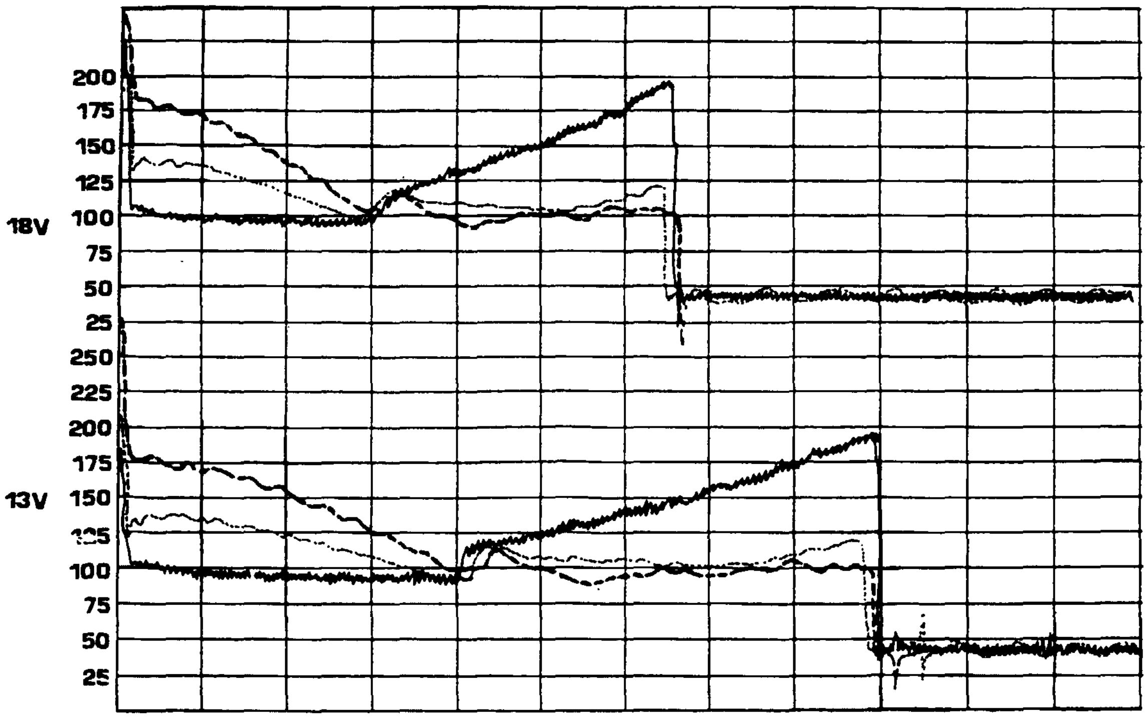

18V
200
175
150
125
100
75
50
25
13V
250
225
200
175
150
125
100
75
50
25

FIG.6B

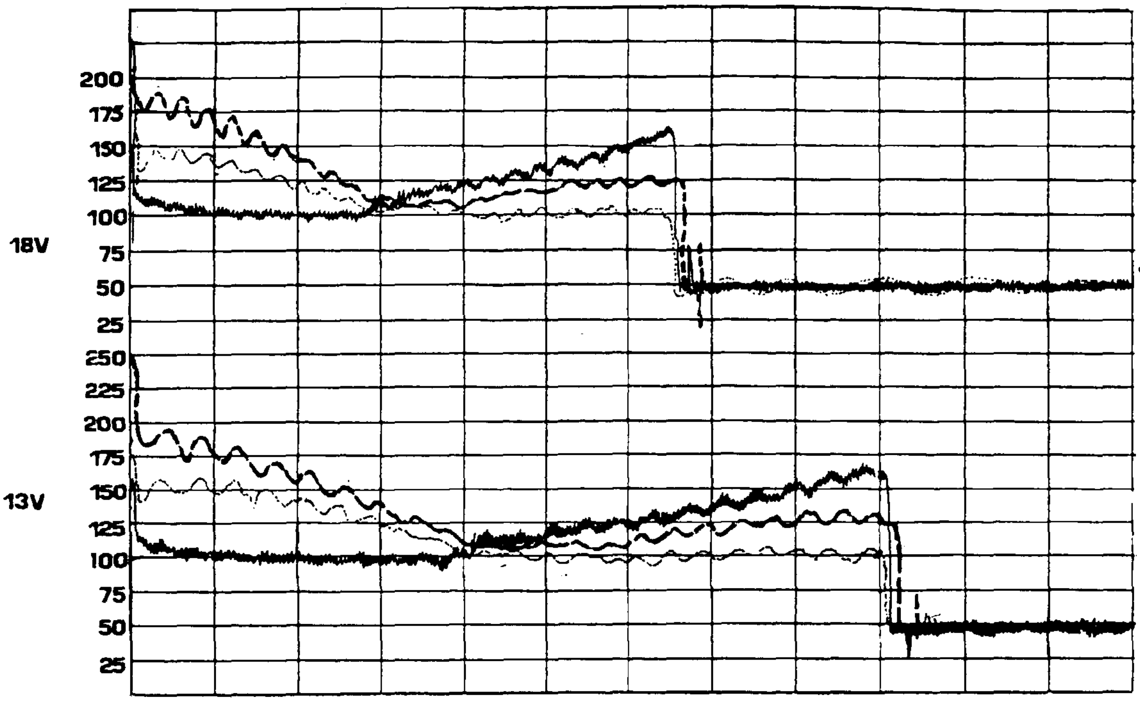
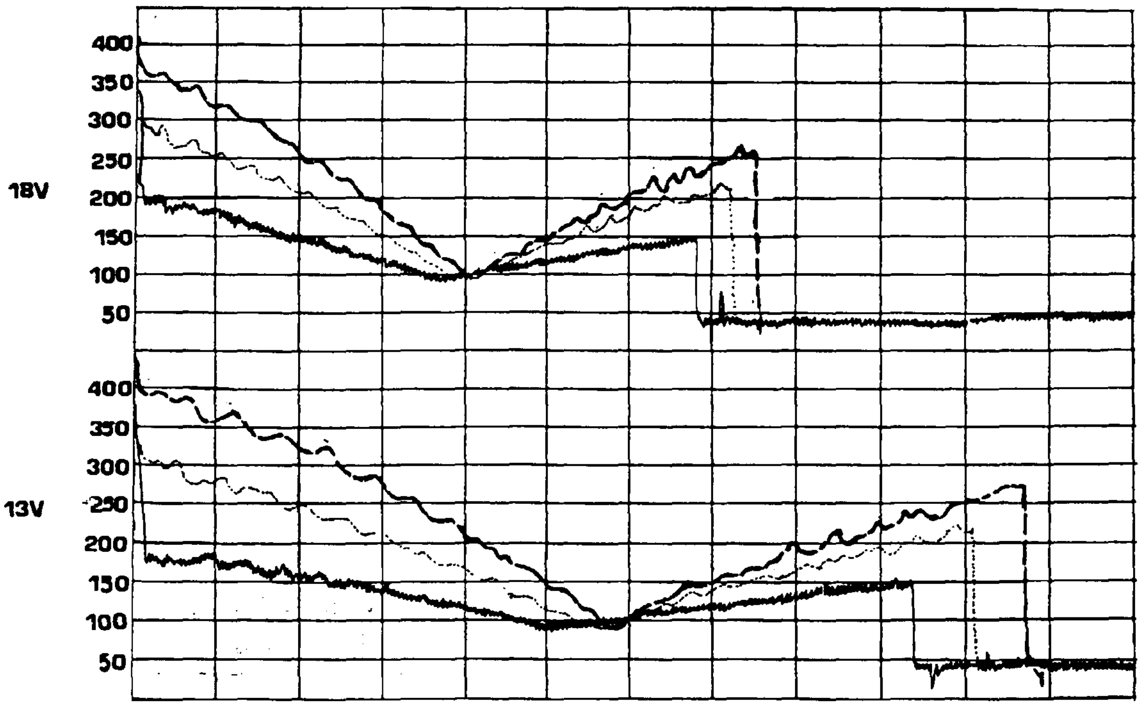

200
175
150
125
100
18V
75
50
25
250
225
200
175
13V
150
125
100
75
50
25

FIG.6C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300
250
18V
200
150
100
50
400
350
300
13V
250
200
150
100
50

FIG.7A

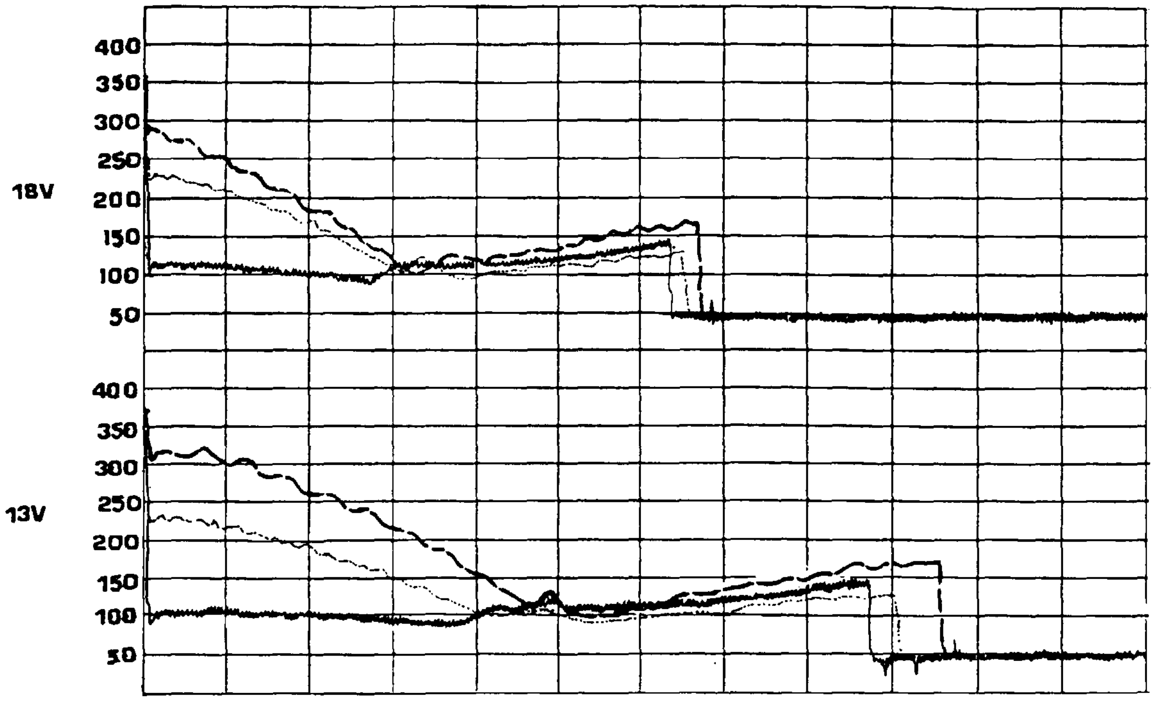
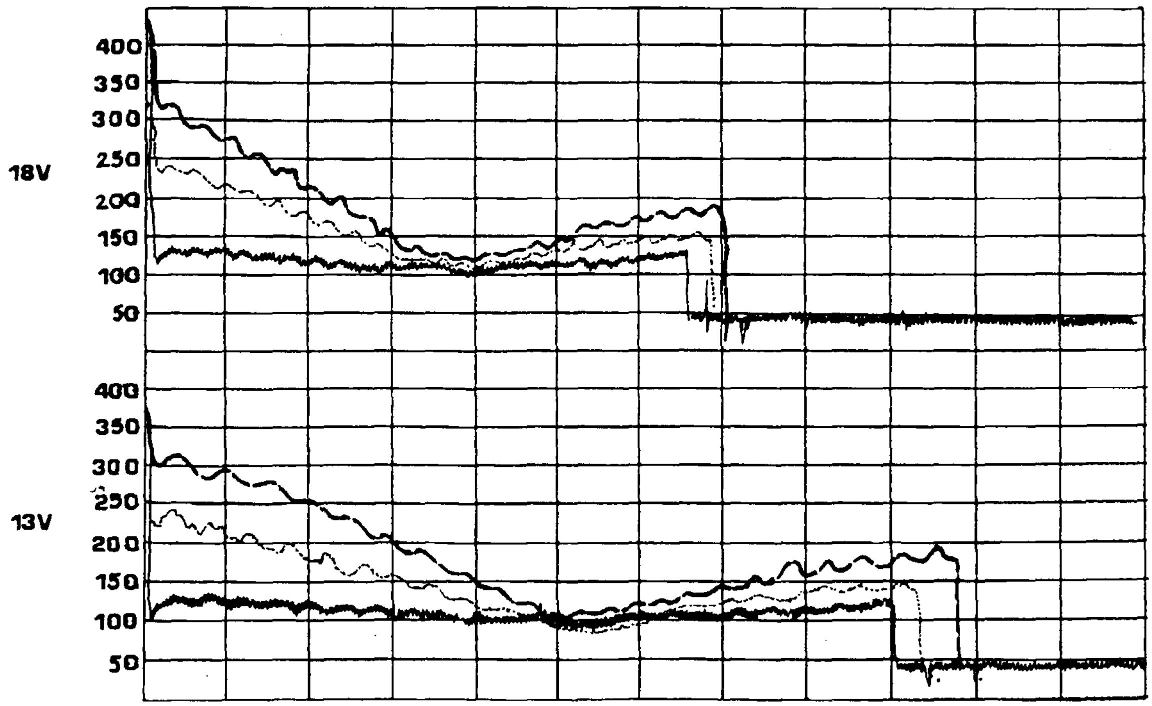

400
350
300
250
18V
200
150
100
50
400
350
300
250
13V
200
150
100
50

FIG.7B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350
300
250
18V
200
150
100
50
400
350
300
250
13V
200
150
100
50

FIG.7C