



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.12.2016 Bulletin 2016/49

(51) Int Cl.:
H01Q 1/24 (2006.01) **H01Q 3/32 (2006.01)**
H01Q 21/30 (2006.01)

(21) Application number: **15190172.5**

(22) Date of filing: **16.10.2015**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

(72) Inventors:
• **LEZA ABAD, Daniel Alfredo**
50196 LA MUELA (Zaragoza) (ES)
• **MERINO RUBIO, Ana Edelmira**
50196 LA MUELA (Zaragoza) (ES)
• **CORTÉS SANTAOLALLA, Francisco Javier**
50196 LA MUELA (Zaragoza) (ES)
• **MESA DOMÍNGUEZ, Ignacio**
50196 LA MUELA (Zaragoza) (ES)

(30) Priority: **02.06.2015 ES 201530770**

(71) Applicant: **Telnet Redes Inteligentes, S.A.**
50196 La Muela (Zaragoza) (ES)

(74) Representative: **Ungria López, Javier**
Avda. Ramón y Cajal, 78
28043 Madrid (ES)

(54) **SYSTEM FOR REMOTELY CONTROLLING THE RADIATION BEAMS OF MULTI-BEAM ANTENNAS**

(57) A system for remotely controlling the radiation beams of multi-beam antennas, such that the system internal to the modular and scalable antenna comprises:
✓ mechanical means based on, at least, one movement transmission module (B) for transmitting the rotary movement of a motor-reducer (14) to the linear movement required by phase shifters included in the antenna and whose rotary movement transmission module (B) is formed by: a modular bedplate set (I), anchored to the antenna frame, and a motor set (II) that is removable and

accessible from the lower part of the antenna, and
✓ electronic control means (A) that govern the rotary movement transmission modules (B) comprising: at least, one housing set (III) and one removable cartridge (IV) connected to the housing set (III),

whereupon the transmission modules (B) and electronic control means (A) are communicated by means of respective cables connected to connectors (19a) and (19b).

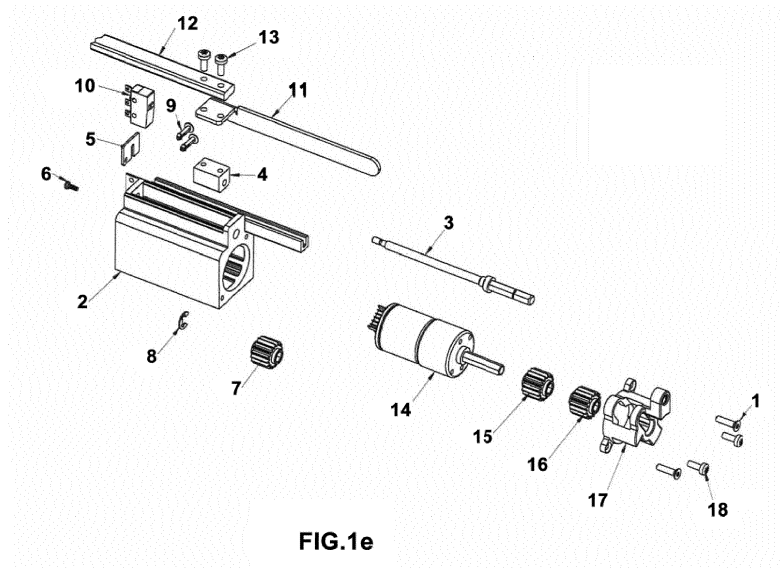


FIG.1e

Description

OBJECT OF THE INVENTION

[0001] The following invention, as expressed in the title of this specification, relates to a system for remotely controlling the radiation beams of multi-beam antennas, whose object belongs to the field of antenna control, and describes a mechanical/electronic system for remotely controlling the radiation beams of a multi-beam antenna.

[0002] Therefore, the system consists of two differentiated parts: i) the modular mechanical movement transmission part and ii) the electronic control part that governs the mechanical part, both of which can be integrated in the interior of the antenna and are accessible to the end user.

[0003] The mechanical system, which in the materialisation of the present invention is internal, modular and accessible, makes it possible to configure the tilt of each antenna band separately, both manually and electrically, and to individually remove each motor without disassembling the antenna, without affecting the tilt position and leaving the actual tilt position visible to the user at all times.

[0004] The electronic control system, which in the materialisation of the present invention is internal, modular and removable, makes it possible to control the tilt of each band through one or more control entities in a completely independent manner, without interference therebetween, and without need to include any additional element.

FIELD OF APPLICATION

[0005] The present specification discloses a system for remotely controlling the radiation beams of multi-beam antennas, which is applicable in the field of mobile telephony antennas, more specifically in the field of multi-beam antennas that include what is widely known as remotely controlled beam shaping.

[0006] This invention is fully leveraged according to the specific representation and materialisation shown in the figures, where both the electronic and mechanical system are internal to the antenna, modular and removable; installed in shared antennas, a term widely known in literature as "site sharing", where various mobile telephony operators share a single antenna that includes various radiation systems.

BACKGROUND OF THE INVENTION

[0007] Conventionally, beam-shaping antennas are used particularly in mobile telephony base stations, wherein their most well-known field of application is the remote configuration of the inclination angle of the main beam or tilt through the installation of RET (Remote Electrical Tilt) devices on the antenna.

[0008] These antennas allow network operators to tilt

the direction where the main radiation beam of the antenna points from a remote control centre without need to physically tilt the antenna. The electrical phase shift is achieved by electromechanically actuating elements internal to the antenna that modify the signal phase delivered to each radiation element (elements widely known as phase shifters). The diagram of radiation upon the coverage surface is higher in quality on achieving main beam tilt by means of the electrical phase shift than if the antenna was mechanically tilted. Also, on performing this operation by means of individualised actuations per band a different tilt is achieved for each band despite being assembled on the same mechanical infrastructure.

[0009] In the field of mobile telephony, multi-beam antennas are widely extended. In the present invention we refer indistinctly to multi-beam or multi-band antennas, understanding as such antennas that include more than one radiation system within a single radome; for example, a dual-band antenna may have two radiation systems in the 1710-2690 MHz bandwidth; or a dual-band antenna may have a radiation system over the 690-960 MHz range and another radiation system over the 1710-2690 MHz range; a hexa-band antenna may have two radiation systems over the 690-960 MHz range and four radiation systems over the 1710-2690 MHz range and so on. Each radiation system may function in various sub-bands; for example, a radiation system that covers the 1710-2690 MHz range may be used in the sub-bands GSM1800 (1710-1880 MHz), PCS1900 (1850-1990 MHz), UMTS2100 (1920-2170 MHz), TDD Band 40 (2300-2500MHz), 3G-LTE Extension 2500 (2500 - 2690 MHz), etc. Hereinafter, the term multi-band antennas shall be used to refer to various radiation systems within a single radome or envelope, where each band is referred to as a radiation system.

[0010] There is increasing demand for multi-band antennas by mobile telephony operators for several reasons: i) on the one hand, they allow the operator to deploy a new technology replacing old mono-band antennas by multi-band antennas without need to seek new sites, with the ensuing savings in permit application fees for deploying the new network technology, as well as savings in operating and maintenance costs; and, on the other, ii) they allow various operators to share a single site by sharing the antenna, wherein the bands of each operator are fully independent from those of the other operators, therefore also sharing permit application fees.

[0011] Multi-band antennas wherein the radiation beam can be independently controlled by installing external remote control devices in each of the bands or at least in bands that must be constantly controlled to optimise the network already exist on the market. Currently, there is increasing demand among network operators for these devices to be internal to the antenna for three reasons: i) if the RET is external and is connected to the antenna at the time of its installation at the site, the RET is prone to failures due to blows received during installation; ii) if the RET is not disposed on the antenna at the

time of installation thereof at the site, the RET must then be connected and normally the skills required of the RET installer and integrator at the base station are not the same skills required of an antenna installer; and iii) the operator prefers the RET to be installed in-factory by the manufacturer thereof to avoid configuration errors. Therefore, despite the fact that the in-factory incorporation of these devices could initially represent a higher cost for the antenna than that of installing RETs only in the desired bandwidths, this may not be the case in the installation as a whole.

[0012] The requirements demanded by network operators for antennas with internal RET are: i) possibility of onsite replacement at an active site without need to un-install the antenna; ii) possibility of manually configuring the tilt of each band by the antenna installer, who ideally should not need more tools than those required to install the antenna on the mast; iii) the tilt configuration must be visible at all times through a marker; and iv) it must be flexible in order to share sites among various mobile telephony network operators.

[0013] In the case of multi-band antennas, an independent mechanism must be included to control the beam of each of the bands, as well as providing the necessary mechanisms for ensuring the maximum independent control of the beam of each band in the event of sharing among various operators or various base stations.

[0014] Currently, there are antennas that include similar technology to that of the present invention, but lack some characteristics exclusive thereto:

- The solution adopted in patent application MX2010008830 (A) includes an internal system but not completely accessible such as that proposed, as the internal part of the mechanical system cannot be accessed. In addition, it has a drawback that this invention resolves, that of not being able to remove or replace an inoperative engine without disassembling the antenna.
- Patent application MX2010008830 (A) allows the manual actuation of the mechanical system, but always disengaging the corresponding motor. However, in the case at hand, it would not be necessary to disengage the motor to manually actuate the system regardless of whether or not electronics have been inserted or of the existence of power failures.
- Patent application MX2010008830 (A) guarantees that, during manual actuation of the system, the mechanical steering remains connected between the system and the phase shifters, maintaining the tilt and its respective indicator in the original position. However, in the event of having to replace one or more motors, the antenna must be disassembled and the steering disconnected, therefore losing a functionality that, in the case of the proposed invention, continues being effective.
- Patent EP2668693 B1 shows a beam-shaping de-

vice in a multi-band antenna having only one control interface for all the bands, which makes it impossible to share the antenna with the electronic equipment of various operators.

- Patent DE102011015551 B4 discloses a supplementary device for adding to the shared sites, but it is not located or included in the radome of the antenna nor can it be considered part of the internal RET. With the present invention, no external or additional element must be included to enable antenna sharing among various operators.
- Patent US8860334 B2 discloses a system for controlling a multi-band antenna which only envisages the inclusion of a receiver port in the control board to receive commands from the base station and a serial port. The present invention includes various control interfaces for independently sharing the antenna among various base stations.
- Patent US8860334 B2 discloses a system for controlling a multi-band antenna wherein various motors cannot simultaneously be moved to simultaneously control the beam of various radiation systems, even connecting a site-sharing system according to patent DE 102011015550 B4.

DESCRIPTION OF THE INVENTION

[0015] The present invention describes a system for remotely controlling the radiation beams of multi-beam antennas, such that the internal system of the modular and scalable antenna comprises:

✓ mechanical means based on, at least, one movement transmission module for transmitting the rotary movement of a motor-reducer to a linear movement required by phase shifters included in the antenna and whose rotary movement transmission module is formed by:

- o a modular bedplate set, anchored to the antenna frame, and;
- o a motor set, removable and accessible from the lower part of the antenna wherein, in the absence of rotation of a motor-reducer shaft, the beam can be manually adjusted by actuating a spindle, wherein the tilt indicator plate indicates the reading of the actual antenna tilt position at all times; and

✓ electronic control means that govern the rotary movement transmission modules, capable of connecting to various independent control entities for independently controlling each beam through the rotary movement transmission modules, where the assignment of bands by the control interface is flexible and configurable, which comprises:

- o at least one housing set; and

o a removable cartridge connected to the housing set,

such that the movement transmission modules that transmit the rotary movement to the motor-reducer and the electronic control means are connected by means of respective cables connected to connectors.

[0016] The modular bedplate set consists of a motor bedplate, a threaded spindle, a cart-nut, a fixation plate for fixing the threaded spindle, a first screw of the fixation plate, a pinion of the threaded spindle, a lock washer, end-of-travel quick rivets, an end-of-travel micro-switch, a tilt indicator plate, a push rod of the phase shifter and second fixation screws for fixing the rod/indicator plate.

[0017] The motor set is composed of a motor-reducer, an intermediate pinion, a second pinion of the motor-reducer shaft, a motor cover and third joining screws for joining the motor-reducer to the cover thereof.

[0018] The third joining screws for joining the motor-reducer to the motor cover make it possible to seal the motor set in its entirety to convert it into a replaceable block.

[0019] The rotation of the motor-reducer actuates a gear mechanism, transferring the motor shaft torque to the intermediate pinion and, in turn, to the first spindle pinion, transforming the circular movement of the motor-reducer into the linear movement required by the phase shifters by means of the spindle-nut mechanism mounted thereon.

[0020] On establishing a distance between the motor shaft and spindle by means of an intermediate pinion, the motor-reducer can be removed or installed without releasing any pinion and without affecting the connected part of the phase shifters.

[0021] Upon removing the motor set, the spindle-nut set remains mounted with the tilt degree indicator plate and joined to the phase shifter push rod, allowing manual actuation on the projecting part of the spindle shaft, maintaining its functionality even without the motor installed.

[0022] The system includes one or more end-of-travel micro-switches which allow calibration of the motor-reducer, identifying its relative position with respect to the end-of-travel stop without forcing the spindle-nut set at the ends-of-travel thereof.

[0023] Furthermore, each removable cartridge is formed by a control interface module and a control block, whose modules may or may not be printed on the same printed circuit board. In a practical embodiment, they are built on two differentiated boards for greater flexibility, but they could also be built on a single board.

[0024] Also, the control interface module contains one or more control interfaces.

[0025] In a practical embodiment, each control interface module is composed of an 8-way circular connector and an 8-way female circular connector, although any type and number of connectors may be adapted.

[0026] The control block is composed of an electronic control module, a feed control module and motor driver circuit control module.

[0027] The motor driver circuits are electrically connected to the motors through a connector that joins the housing set to the removable cartridge and, in turn, through the motor connectors.

[0028] The control block assigns any motor to any input interface, an ideal condition for shared antennas where there is no restriction on assigning to each operator the band it wishes to control.

[0029] Likewise, the control electronics module is in turn capable of managing the data flows it receives from each control entity in a completely independent manner.

[0030] The control electronics module interprets the commands it receives through each control interface and activates the control signals, activating the motor drivers.

[0031] The feed control electronics module receives the voltages stemming from each control interface and, after passing through lightning and surge protections, and after conveniently transforming them into the necessary values for the installed motors, attacks the motor drivers with voltages and currents and, likewise, the feed control module also provides the feed voltage to the control electronics module.

[0032] Each motor driver acts on each motor.

[0033] A motor block containing only the necessary connectors for connecting the different "motor sets" necessary for each antenna model is implemented on the printed circuit board present in the "housing set".

[0034] A cable extends from each motor block connector that is connected to each of the removable motors through the connector enabled for such purpose, where-through it is fed the necessary voltage and current to rotate the motor.

[0035] Complementing the following description, and for the purpose of helping to make the characteristics of the invention more readily understandable, this specification is accompanied by a set of drawings whose figures, by way of illustration and not limitation, represent the most characteristic details of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036]

Figures 1a, 1b and 1c show different perspective views of the internal mechanical system that forms part of the proposed invention.

Figure 1d shows a schematic view of the assembly of the two subsets of said mechanical system.

Figure 1e shows an exploded view of the entire mechanical system object of the invention.

Figure 2a shows a perspective view of the modular bedplate set that forms part of the mechanical system.

Figure 2b shows an exploded view of the modular bedplate set of the preceding figure.

Figure 3a shows a perspective view of the motor set integrated in the mechanical system.

Figure 3b shows a perspective exploded view of the motor set of the preceding figure.

Figure 4 shows a view of three modular mechanical systems mounted contiguously in the interior of an antenna.

Figure 5 shows an external view of the antenna, showing the layout of the internal electronic system and mechanical system and integrated therein.

Figure 6a shows a view of the internal electronic system that forms part of the invention proposed in this specification.

Figure 6b shows a schematic view of the assembly of the two subsets of said electronic system.

Figure 7 shows a block diagram of the electronics associated with the multi-band internal RET, composed of a control interface module, a control module and the motor connection module.

Figure 8 shows a practical example of the use of the internal RET of the system.

DESCRIPTION OF A PREFERRED EMBODIMENT

[0037] In light of the aforementioned figures and in accordance with the numbering adopted, it can be observed that the present invention describes a system for controlling the radiation beams of a multi-beam antenna, which is internal, modular and scalable for mechanically/electronically controlling the beam of a mobile telephony multi-beam antenna.

[0038] The system comprises two basic parts: a mechanism that transmits the linear movement required by the phase shifters and electronic control means that govern the aforementioned mechanism.

[0039] As can be observed in figures 1a, 6a and 5, the electronic control means are identified by the letter "A" and the mechanical means by the letter "B", such that figure 6b details the electronic system composed of a "housing set" (III) mounted in all cases on the antenna and which houses a connector whereto a "removable cartridge" (IV) is connected wherever necessary.

[0040] Furthermore, figure 1d shows that the mechanical system is formed by a "modular bedplate set" (I) that is anchored to the antenna frame and which may or may not contain, depending on the model chosen, a "motor set" (II) secured by fourth screws (1).

[0041] Both sets (mechanical and electronic) are interconnected by means of cables which allow the easy connection and disconnection thereof when replacing the motors.

[0042] Analysing the mechanical means in further detail, in figure 1d it can be observed that the main advantage of the invention is precisely this capability of removing or installing the motor set (II) in its housing of the modular bedplate set (III), with the simple action of removing the two fourth screws (1) and releasing their corresponding cable.

[0043] Figure 3b shows the components of the motor set (II), defined by the motor-reducer (14), the intermediate pinion (15), a second pinion (16) of the motor-reducer shaft (14), a cover (17) of the motor-reducer and third joining screws (18) that join the motor-reducer (14) to its cover (17). Said third screws (18), upon introducing the intermediate pinion (15) and second pinion (16) of the motor-reducer shaft (14) in their housing of the cover (17) of the motor-reducer and motor-reducer shaft, make it possible to seal this subset so as to convert it into a single replaceable block.

[0044] The operation of this subset is simple: the motor-reducer (14), on rotating, actuates the gear mechanism, transferring the torque to the intermediate pinion (15). In the event that the motor-reducer (14) is mounted on the bedplate and there is a power failure or it simply does not receive the commands from the electronic control means, its interior could be accessed (by means of an opening in the outer cover of the antenna) to directly and manually actuate the projecting part of the hexagonal shaft of the motor-reducer (14) (using a common socket wrench), which would make it possible to keep its functionality intact.

[0045] Figure 2b details the assembly of the modular bedplate set (I), which is composed of the motor-reducer (14) bedplate (2), a threaded spindle (3), a cart-nut (4), a fixation plate (5) for fixing the threaded spindle (3), a first screw (6) of the fixation plate (5), a first pinion (7) of the threaded spindle (3), a lock washer (8), end-of-travel quick riveting (9), an end-of-travel micro-switch (10), a tilt indicator plate (11), a push rod (12) of the phase shifter and third fixation screws (13) for fixing the rod/indicator plate.

[0046] The design of this modular bedplate subset (I) is basically a mechanism for transforming the circular motor-reducer (14) movement into the linear movement required by the phase shifters of the antenna. This transformation is performed by means of the spindle-nut (4) mechanism mounted thereon, but other enhancements provided by the present invention are added to this function.

[0047] One such enhancement, resulting from the establishment of a distance between the motor-reducer (14) shaft and the threaded spindle (3) through the introduction of an intermediate pinion (15), is that it leaves sufficient distance therebetween so that the motor-reducer (14) itself can be removed or installed without releasing any pinion and without affecting the part connected to the phase shifters.

[0048] Upon removing the motor set, the cart-nut (4), with its respective tilt indicator plate (11) and joined to the push rod (12) of the phase shifters, will remain mounted, allowing manual actuation on the projecting part of the hexagonal shaft of the threaded spindle (3) (using a common socket wrench), maintaining its functionality even without the motor-reducer (14) installed. Another important characteristic of this system is that it includes an end-of-travel micro-switch (10), which allows the cal-

ibration of the motor-reducer (14), identifying its position without forcing the spindle-nut assembly at the ends-of-travel thereof.

[0049] Figure 4 shows that this modular mechanical system allows the installation of various units per antenna in a very small space and completely independent in order to repair, manually actuate or even not install any of them without affecting the rest of the system.

[0050] Figure 5 shows how said mechanical system is accessed in the interior of the antenna through an opening in the general cover, which can be sealed by its corresponding additional small cover.

[0051] The electronic system or control electronics represented in figure 7 is composed of three differentiated blocks which in practice are implemented on three printed circuit boards for the purpose of flexibility and modularity: the control interface block (100), the control block (110) and the motor block (120).

[0052] Therefore, said figure 7 shows a block diagram of the electronics associated to the multi-band internal RET, composed of a control interface module (100), a control module (110) and the motor connection module (120). The control interface module is constituted by 25 or more interfaces (20_i). The control module (110) contains the control electronics module (25), the feed control module (26) and the motor drivers (27_i). The control electronics (25) are in charge of managing communications with each and every one of the control interfaces (20_i), fulfilling the communication protocol of each, and of generating the relevant control signals towards the motor drivers (27_i) in accordance with the commands received. The feed control (26) is in charge of generating the feed voltage (27) of the control electronics module (25) and power supplies to the motor drivers (27_i). The motor drivers (27_i) are in charge of activating the relevant signals for initiating the rotation of the motors (28_i) in the adequate direction or ordering them to brake and stop, in accordance with the indications received from the control electronics (25).

[0053] The control interface block (100) contains the necessary connectors to connect to the control entities. The control entities are usually mobile telephony base stations, although it is not limited to these. Any other system having the appropriate software to send beam-shaping commands can also act as a control entity. The control interfaces (20) are composed of connectors where-through feed voltage and control data are supplied to the electronic module of the RET.

[0054] Currently, these control interfaces (20) are most commonly composed of two 8-way circular connectors pursuant to standard IEC 60130-9, in accordance with standardisation group AISG in its versions 1.1 and 2.0, and as drawn in figure 6a. However, this invention is not limited to this type of connectors and to the pinout defined in these recommendations, but rather is open to any type of connector and physical level.

[0055] In case of following AISG and 3GPP recommendations, wherein each interface has a male input con-

nector and a female output connector for the cascaded connection of various ALDs (*Antenna Line Devices*), in the practical embodiment of this invention the control interface block is in charge of taking the signals from one connector to another to implement the bus in cascaded connection, rendering the other modules independent from this functionality. However, this simple functionality can also be performed by means of other simple means and is not limited to being implemented in the control interface plate.

[0056] The control block (110) is composed of a control electronics module (25), a control module for controlling feeds (26) and motor driver circuits (27_i). The control block is basically in charge of:

- i) communicating with each of the control entities in a completely independent manner from the rest, interpreting the commands received to order the movements of the motors that move the tilt adjustment mechanism, and fulfilling the necessary timings for proper communication;
- ii) managing the feed voltages of the motor drivers (DM_i) in such a manner that a motor is only fed by the control entity that governs it and not by any other;
- iii) ordering the start of rotation, direction of rotation and braking/stopping of the motors, ensuring the correct position thereof for the tilt to be configured.

[0057] The architecture of the control block (110) offers total flexibility to assign any motor (28) to any input interface (20), an ideal condition for shared antennas (site sharing), where there is no restriction on assigning to each operator the band it wishes to occupy.

[0058] Figure 8 shows a practical example of the use of the internal RET object of this invention. In the example, the antenna is composed of six different radiation systems (30_i), wherein each radiation system is composed of a phase shifter whose movement is caused by a motor connected to its corresponding connector (28_i). In the example, this antenna is controlled by three independent control entities (20_j). Control entity 20₁ controls bands 30₁, 30₃ and 30₆, control entity 20₂ controls bands 30₄ and 30₅, and control entity 20₃ controls band 30₂.

[0059] Likewise, as mentioned earlier, it shows three control entities (20) whereamong six radiation systems (30) are distributed, all of which housed in a single radome. This assignment is performed by programming software (writing assignment of bands to the EEPROM memory) and can be reprogrammed at any time.

[0060] The control electronics module (25) is capable of simultaneously managing the data flows received from each control entity (21_i) in a completely independent manner. Similarly, if communication with one of the control entities fails for any reason, the others would not be affected and would continue functioning normally. The control electronics module (25) interprets the commands it receives through each control interface (20_i) and activates the control signals (23_i), activating the motor drivers

(27_i). Currently, the specifications of AISG 1.1/AISG 2.0 and recommendations of the 3GPP that define both the physical, link and application levels are widely extended, ensuring interaction between the control entities and the RET devices of any manufacturer. The aforementioned standards have been implemented in the real materialisation of this invention, achieving excellent results.

[0061] The feed control module (26) receives the voltages stemming from each control interface and, after passing through the lightning and surge protections, and after conveniently transforming them into the necessary values for the motors installed, attacks the motor drivers (27_i) with the voltages and currents (24_i). The feed control module (26) also supplies the feed voltage to the control electronics module (25).

[0062] Each motor driver (27_i) has the possibility of acting upon each motor (28_j). It is the software configuration that assigns the driver (27) that will be controlling each motor (28) at a given time, such that there cannot be collisions between signals (29_{ij}) and only one driver (27) will control a certain motor (28).

[0063] The motor block (120) is composed of the same number of connectors (19b) as antenna bands. A cable extends from each motor block connector (19b) that is connected to one of the removable motors through the connector enabled for such purpose (19a), where through the necessary voltage and current for the rotation of the motor are provided. The motor sensor signal indicating the state thereof and its relative position with respect to the end-of-travel micro-switch (10) is also present in this connector.

[0064] In summary, encompassing all that proposed above and due to its design, this invention provides the following advantages:

- System fully integrated in the interior of the antenna, whereupon it is protected against external agents and allows a more compact and robust global antenna design.
- Modular and flexible system, adaptable and automatically extendable to any antenna regardless of the number of radiation systems it includes.
- Motors individually accessible and removable from the lower part of the antenna, without need to uninstall the antenna from its site. This characteristic is the most important advantage from the mechanical viewpoint, since it allows the replacement of any individual motor which has failed without affecting the operation and assembly of the others in any way. This reduces the cost of a possible maintenance and spare parts management operation, allowing the company and the user to solve any problems that could arise from a specific motor on site, without need to replace those that function properly. This will also allow the customer to acquire an antenna with the flexibility of selecting the motors initially installed in-factory and subsequently, without disassembling or affecting the other systems, install the necessary

motor sets acquired in subsequent phases.

- Possibility of manually modifying the system to vary the tilt of each band individually, with or without its motor geared (also with or without connecting the electronics). This advantage ensures that the tilt of each band can always be manually modified individually, regardless of the existence or non-existence of communication with a control centre.
- On replacing a motor-reducer, the mechanical steering between the system and the phase shifters is not disconnected, which makes it possible to maintain the tilt and its respective indicator in its original position. This characteristic facilitates the replacement or inclusion of motors at any time, without affecting the position in which the tilt of each bank was disposed.
- The motor-reducers are connected by means of connectors (without welds), allowing the connection or disconnection thereof at any time without need for complex tools.
- Modular system which can be assembled individually or in groups of several units, depending on each antenna model. This characteristic implies that each mechanical bedplate system plus individualised motor set unit is assembled for each band, adapting exclusively to the number of bands of the antenna and without need to assemble any additional multiple housing.
- On being modular and easy to assemble, it allows the antenna to be purchased with only some motors installed initially and subsequently incorporate the rest, and with or without the electronics installed. This characteristic allows the creation of a customised range of antennas wherein some come with all the motors initially installed and others with only some, at the customer's request, with the possibility of modifying the tilt of each band separately in all cases.
- Includes an end-of-travel switch that informs the motor of the end of its travel. This characteristic ensures that the motors will never block the phase shifting system due to physical limitation and can be calibrated in order to know their position at any time.
- Lightweight and inexpensive system (plastic housings and gears). The design of the assembly allows the use of plastic materials, thereby making it possible to reduce both the weight and cost of the structure of the system.
- Electronic system accessible and removable from the lower part of the antenna, which allows replacement thereof in the event of electronic malfunction without need to uninstall the antenna from its site without causing network service outage.
- These modular and accessible electronics makes it possible to purchase the antenna without remote tilt control functionality and update it in subsequent phases of network deployment or optimisation.
- The electronics have an interface module with flex-

ible control, such that the same number of control interface connectors as independent control entities that share the radiation systems of the antenna can be installed. This allows the antenna to be shared by various operators without need to integrate any additional external device.

- The electronics manage the feed of the motors equally, such that each motor is only fed by the control entity that governs it, without adversely affecting or consuming current of the other control entities (35).
- Completely flexible electronics, such that the bands/motors governed by each control entity can be assigned by means of software, thereby ensuring the non-existence of collisions.
- The assignment of bands by control entities can be performed at any point during the life of the antenna, without need to uninstall it from the site (40).
- Modular electronics, capable of independently managing all communication flows of the control entities, tested in accordance with the specifications of AISG 2.0 and 3GPP of various manufacturers of mobile telephony base stations. In the event that a communications flow is interrupted for any reason, it does not interfere with the other interfaces.

Claims

1. **A system for remotely controlling the radiation beams of multi-beam antennas, characterised in that** the modular and scalable system internal to the antenna comprises:

✓ mechanical means based on, at least, one movement transmission module (B) for transmitting the rotary movement of a motor-reducer (14) to a linear movement required by phase shifters included in the antenna and whose rotary movement transmission module (B) is formed by:

- o a modular bedplate set (I), anchored to the antenna frame, and;
- o a motor set (II), removable and accessible from the lower part of the antenna, wherein, in the absence of rotation of a motor-reducer shaft (14), the beam can be manually adjusted by actuating a threaded spindle (3), wherein the tilt indicator plate (11) indicates the reading of the actual antenna tilt position at all times; and

✓ electronic control means (A) that govern the rotary movement transmission modules, capable of connecting to various independent control entities for independently controlling each beam through the rotary movement transmission mod-

ules (B), where the assignment of bands by control interface is flexible and configurable, which comprises:

- o at least one housing set (III); and
- o one removable (IV) cartridge connected to the housing set (III),

such that the movement transmission modules (B) that transmit the rotary movement of the motor-reducer (14) and the electronic control means (A) are connected by means of respective cables connected to connectors (19a) and (19b).

2. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 1, **characterised in that** the modular bedplate set (I) is composed of a bedplate of the motor (2), a threaded spindle (3), a cart-nut (4), a fixation plate (5) for fixing the threaded spindle (3), a first fixing screw (6) for fixing the plate (5), a first pinion (7) of the threaded spindle (3), a lock washer (8), end-of-travel quick rivets (9), an end-of-travel micro-switch (10), a tilt indicator plate (11), a push rod (12) of the phase shifter and second fixation screws (13) for fixing the rod/tilt indicator plate.

3. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 1, **characterised in that** the motor set (II) is composed of a motor-reducer (14), an intermediate pinion (15), a second pinion (16) of the motor-reducer (14) shaft, a cover (17) of the motor-reducer and third screws (18) for joining the motor-reducer (14) to its cover (17).

4. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 3, **characterised in that** the third screws (18) for joining the motor-reducer (14) to its cover (17) make it possible to seal the motor set (II) in its entirety in order to convert it into a replaceable block.

5. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 3, **characterised in that**, based on the distance established between the motor-reducer (14) shaft and the threaded spindle (3) by means of an intermediate pinion (15), the motor-reducer (14) may be removed or installed without releasing any pinion and without affecting the part connected to the phase shifters (12).

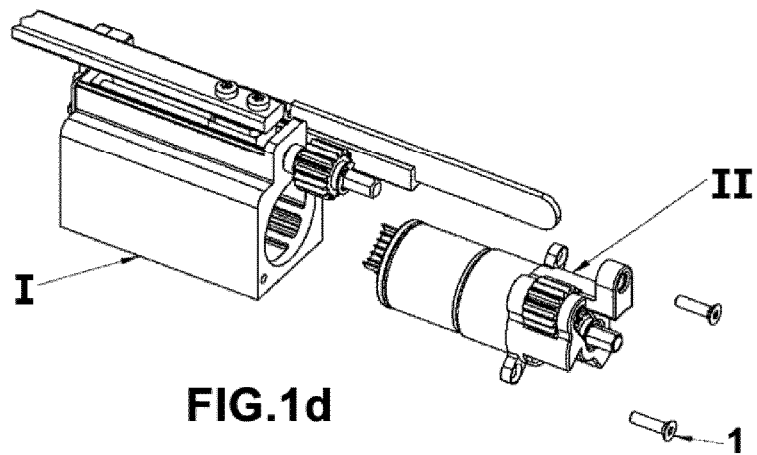
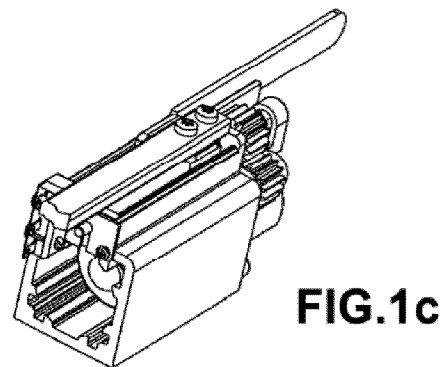
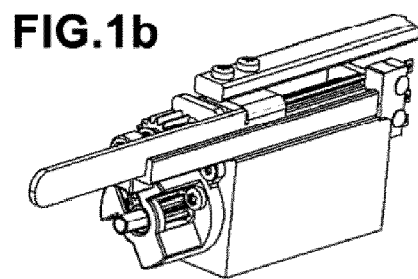
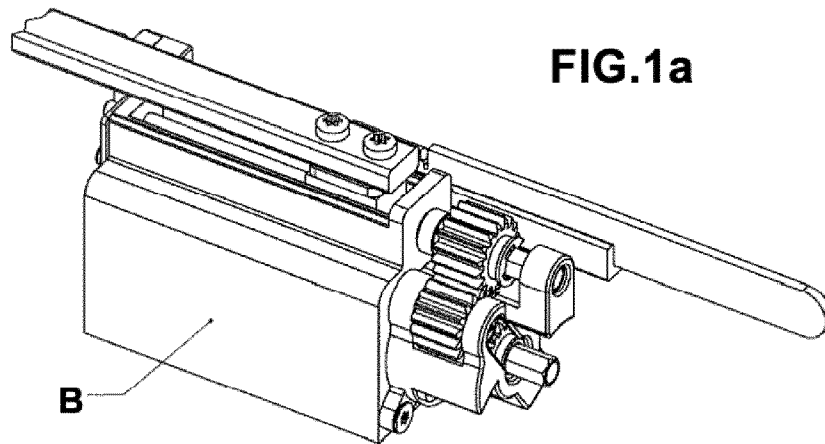
6. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 3, **characterised in that**, upon removing the motor set, the threaded spindle (3) - nut (4) assembly re-

mains mounted with the tilt degree indicator plate (11) and joined to the push rod (12) of the phase shifter (12), allowing manual actuation of the projecting part of the spindle shaft and maintaining its functionality even with the motor uninstalled.

7. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 6, **characterised in that** it includes one or more end-of-travel micro-switches (10) which allow the calibration of the motor-reducer (14), identifying its relative position with respect to the end-of-travel stop without forcing the threaded spindle (3) - nut (4) assembly at the ends-of-travel thereof.
8. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 1, **characterised in that** each removable cartridge (IV) is formed by a control interface module (100) and a control block (110), whose modules may or may not be printed on the same printed circuit board.
9. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 8, **characterised in that** the control interface module (100) contains one or more control interfaces (20).
10. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 8, **characterised in that** the control block (110) has a control electronics module (25) and a control module for controlling the feeds (26) and motor driver circuits (27_i).
11. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 10, **characterised in that** the motor driver circuits (27_i) are electrically connected to the motors through a connector that joins the housing set (III) to the removable cartridge (IV) and, in turn, through the motor connectors (19b).
12. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 8, **characterised in that** the control block (110) assigns any motor (28) to any input interface (20), an ideal condition for shared antennas where there is no restriction on assigning to each operator the band it wishes to control.
13. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 10, **characterised in that** the control electronics module (25) is capable of simultaneously managing the data flows that it receives from each control entity (21_i) in a completely independent manner.
14. **The system for remotely controlling the radiation**

beams of multi-beam antennas, according to claim 10, **characterised in that** each motor driver (27_i) actuates each motor (28_j).

- 5 15. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 1, **characterised in that** a motor block (120) containing only the connectors (19b) necessary for connecting the different "motor sets" (II) necessary for each antenna model is implemented on the printed circuit board, present in the "housing set" (III).
- 10 16. **The system for remotely controlling the radiation beams of multi-beam antennas**, according to claim 1, **characterised in that** a cable extending from each connector (19b) of the motor block is connected to one of the removable motors (II) through the connector enabled for such purpose (19a), whereby it receives the necessary voltage and current for the rotation of the motor.
- 15 20 25 30 35 40 45 50 55



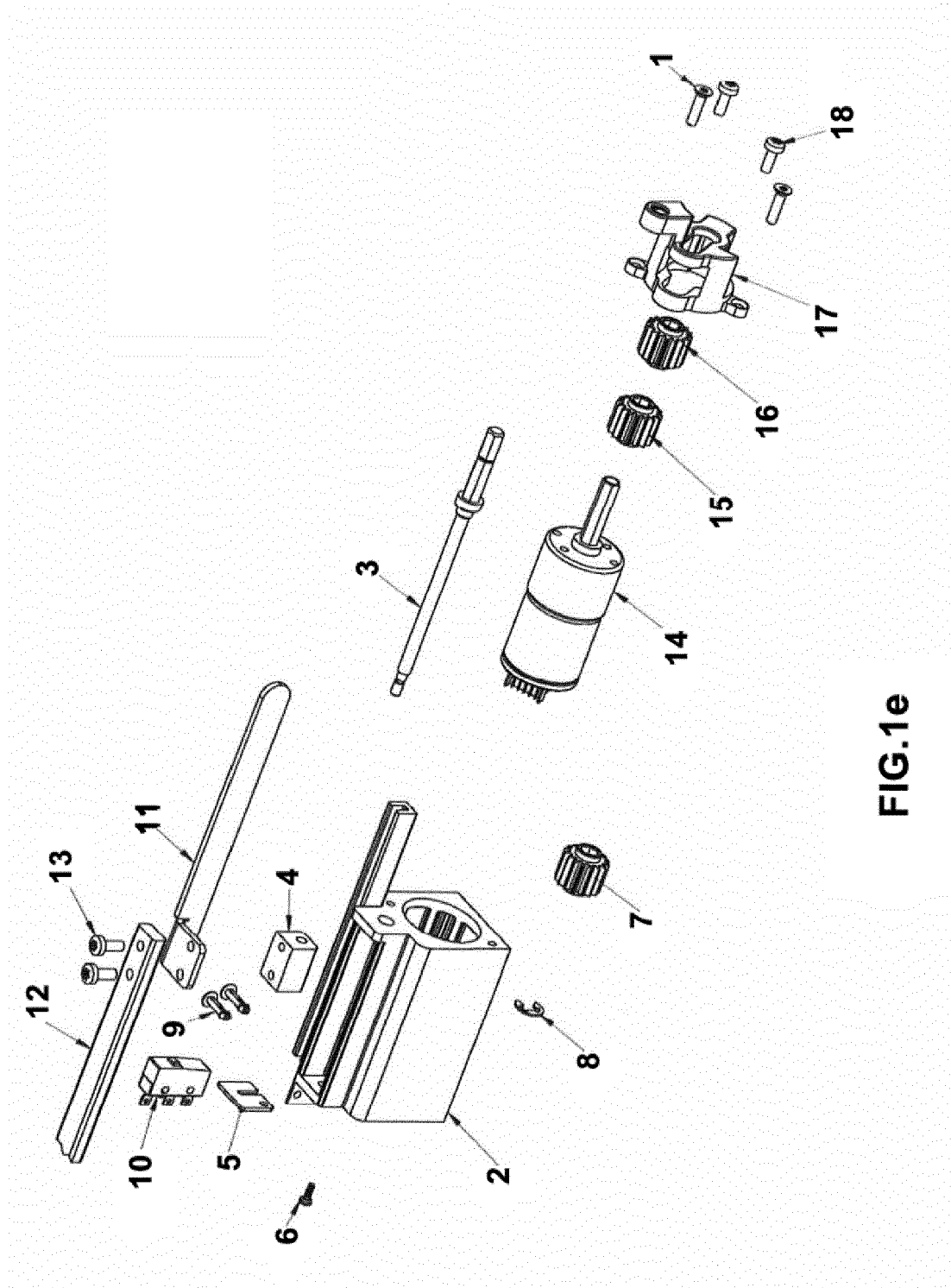


FIG.1e

FIG.2a

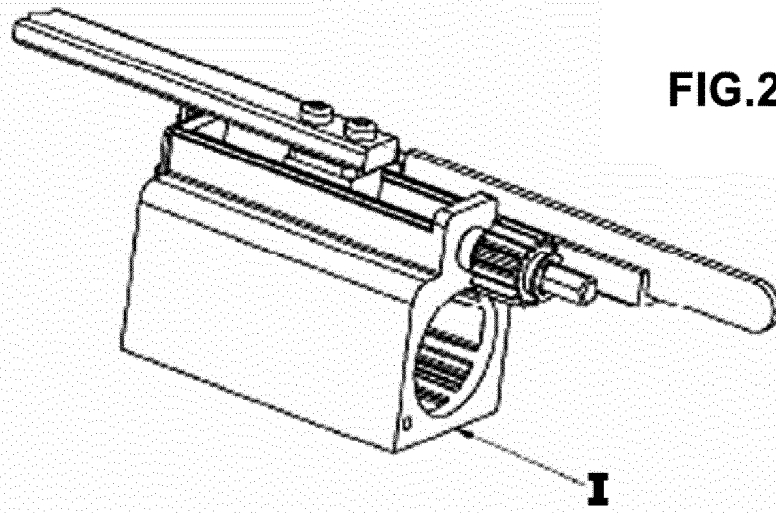
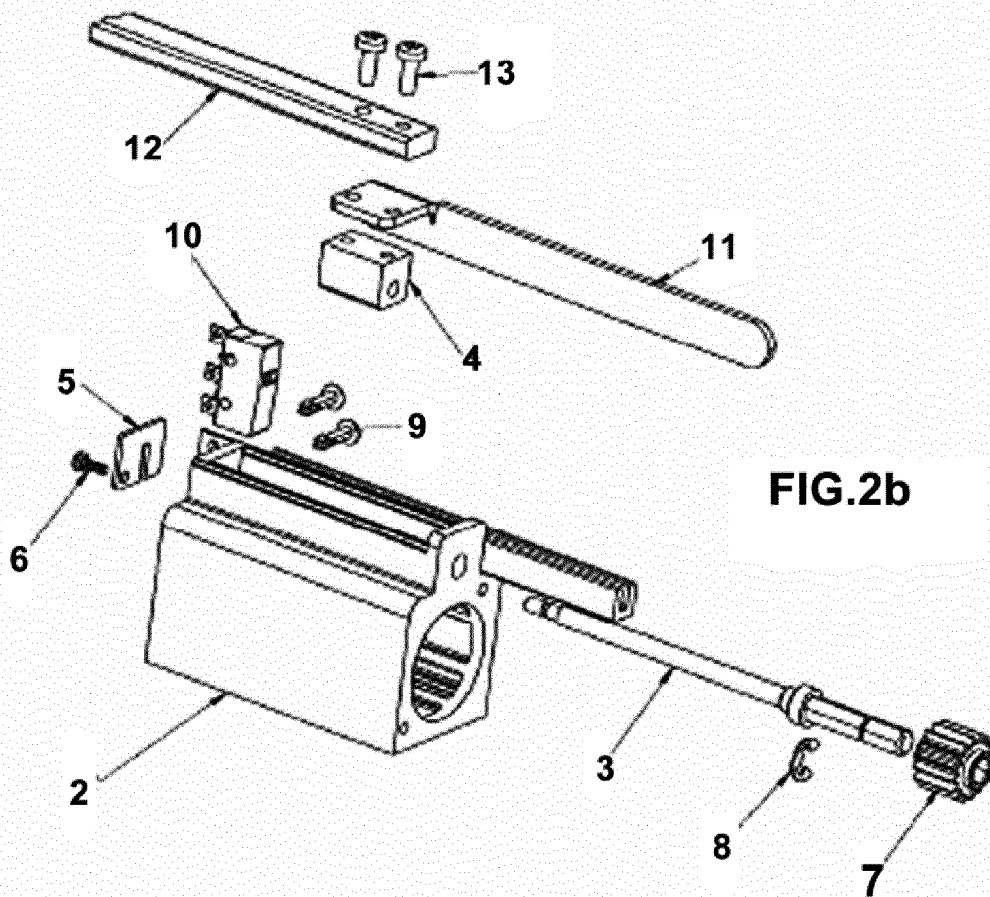
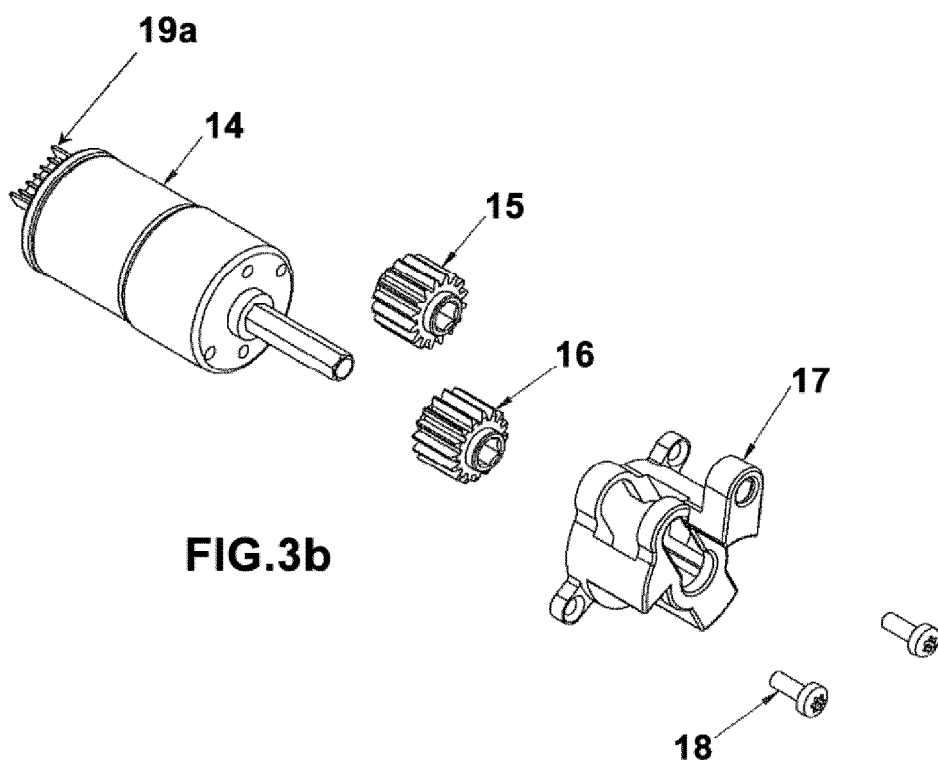
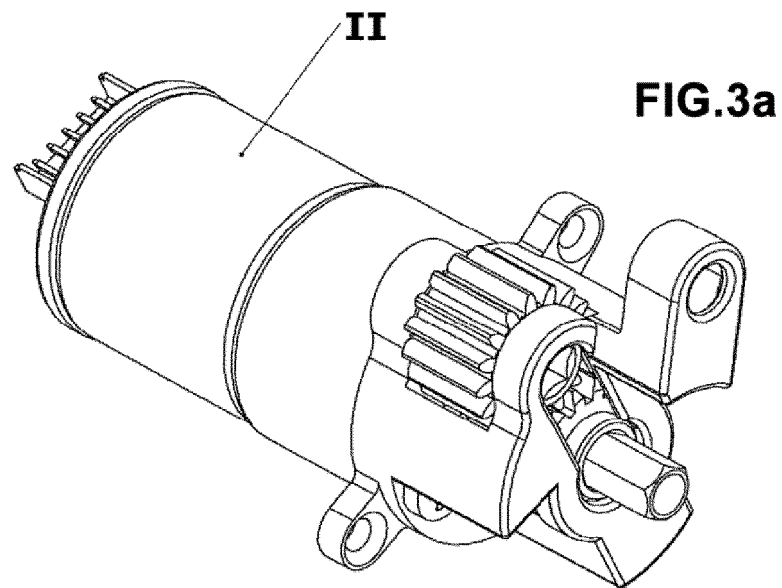


FIG.2b





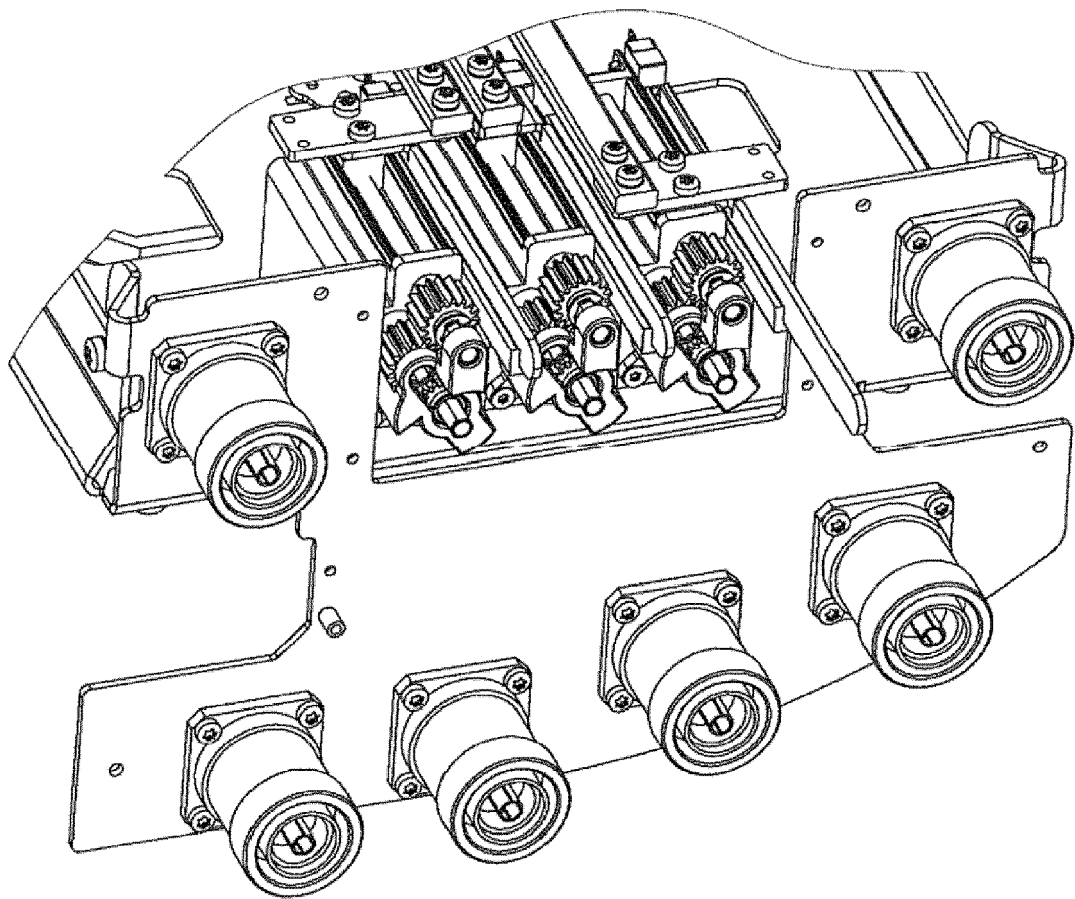
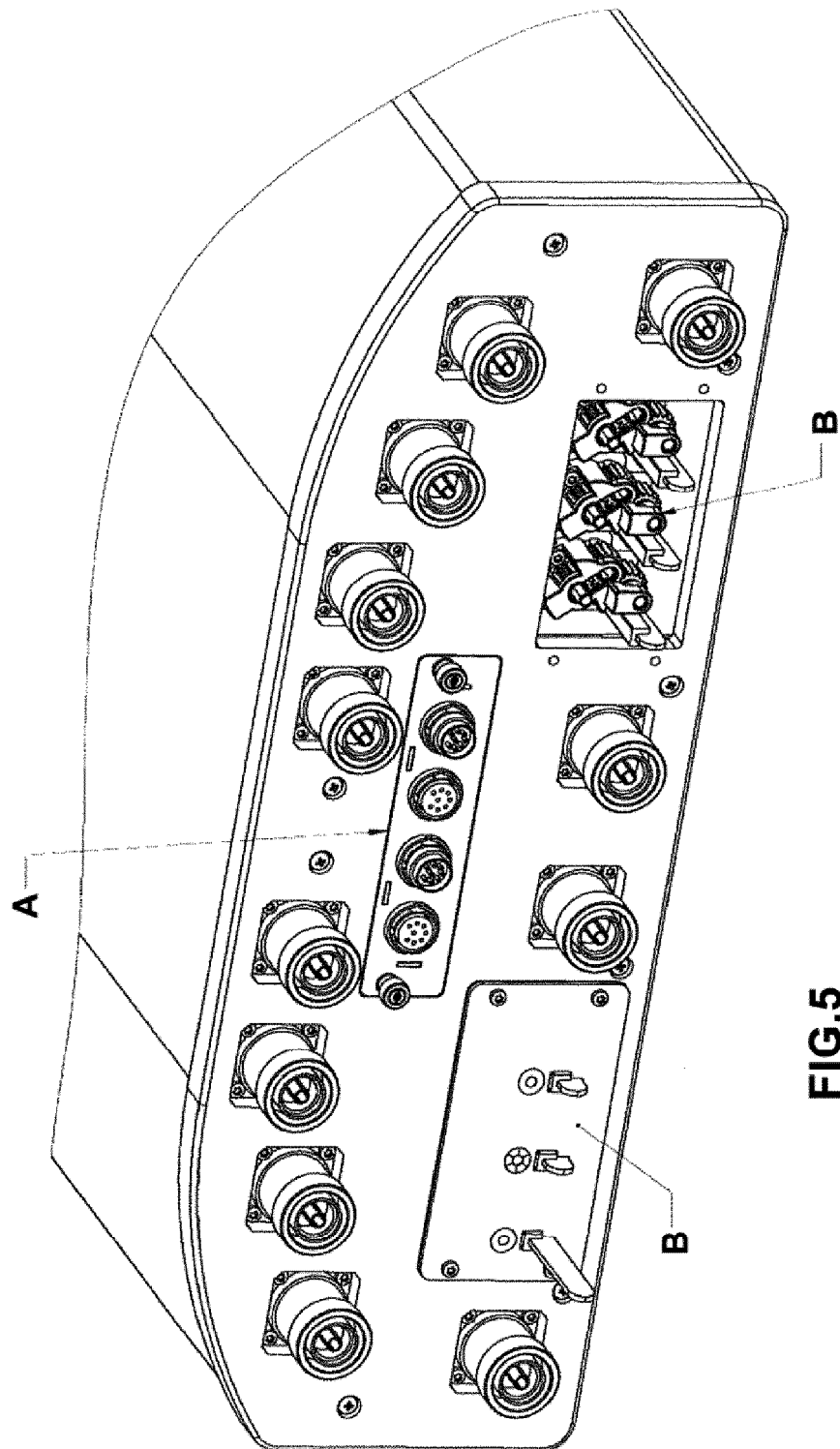


FIG.4



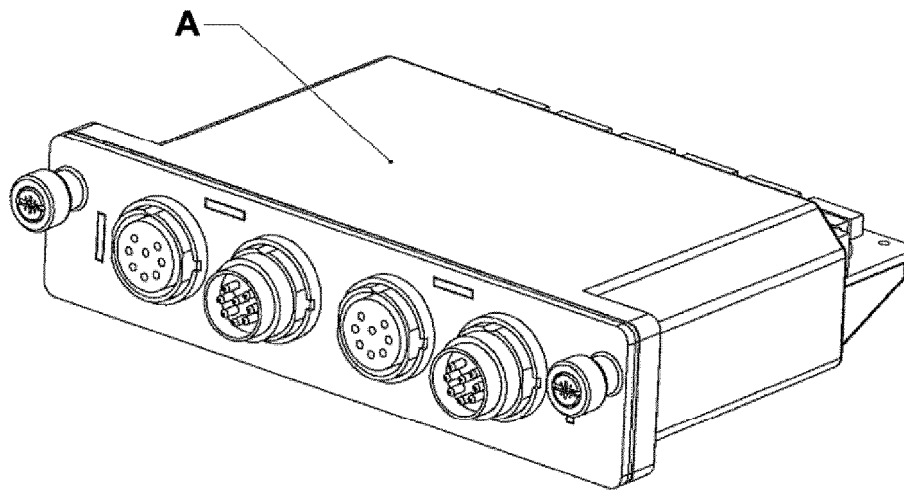


FIG. 6a

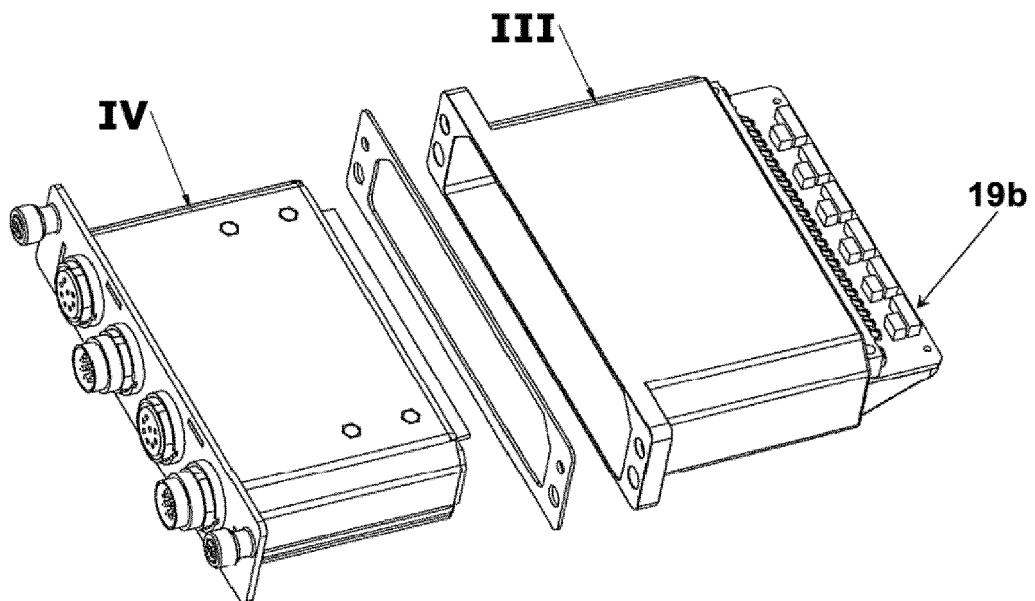


FIG. 6b

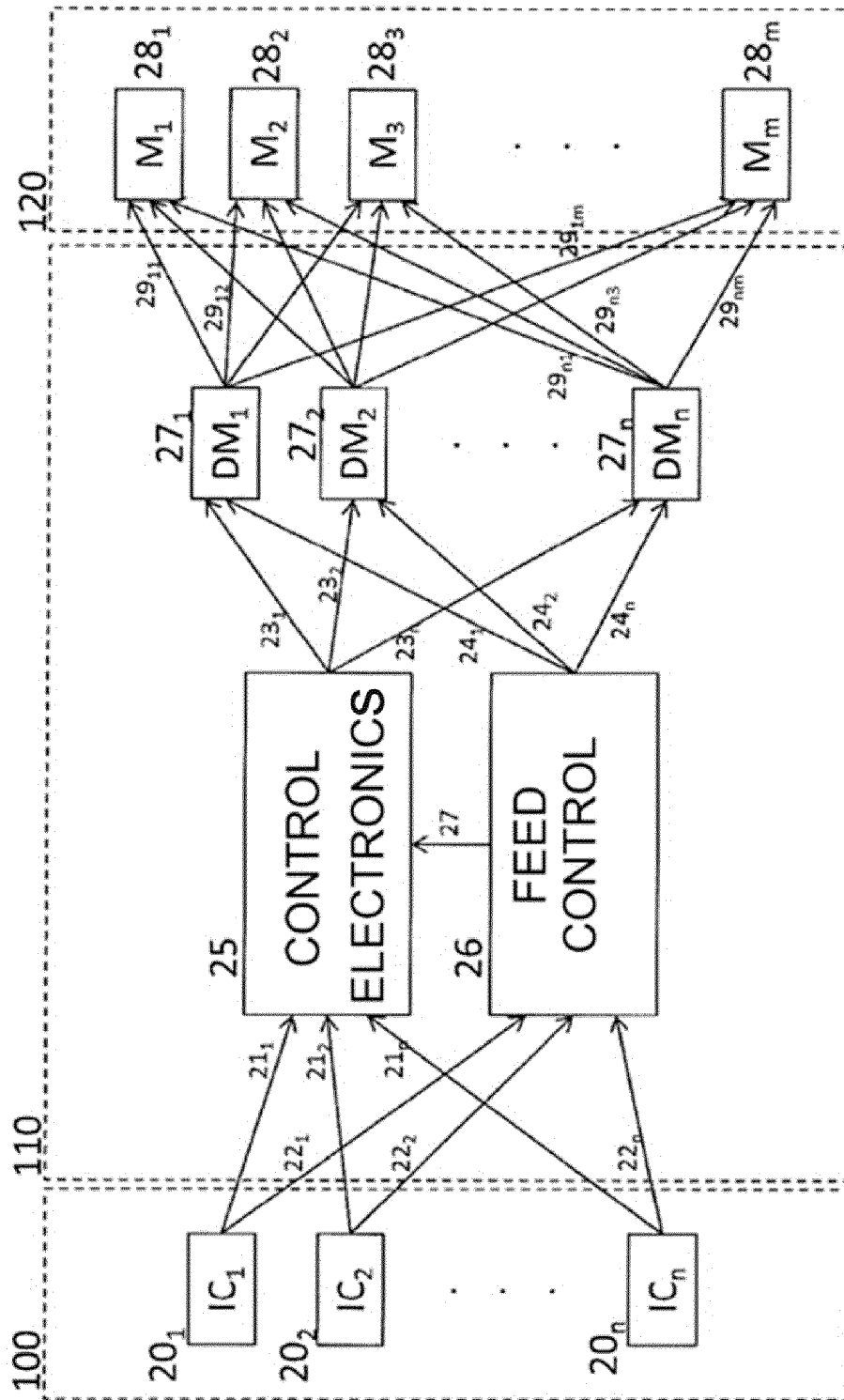
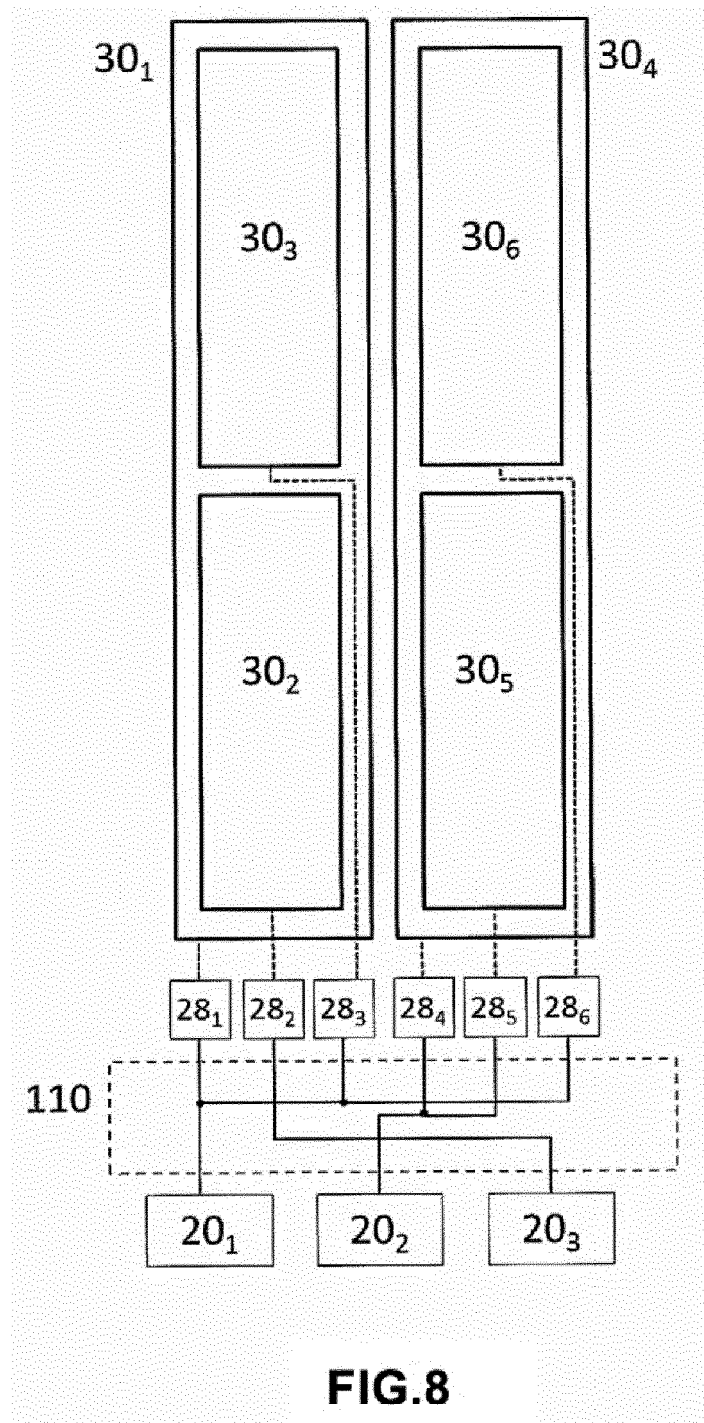


FIG. 7





EUROPEAN SEARCH REPORT

Application Number
EP 15 19 0172

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Y	* abstract *	2-7,16	
	* figures 2-3, 6-7 *		
	* paragraph [0002] *		
	* paragraph [0006] *		
	* paragraph [0009] - paragraph [0012] *		
	* paragraph [0023] *		
	* paragraph [0026] - paragraph [0028] *		
	* paragraph [0032] - paragraph [0034] *		

Y	US 2008/316133 A1 (GUIXA ARDERIU RAMON [ES]) 25 December 2008 (2008-12-25)	2-7,16	
	* abstract *		
	* figures 1, 2, 7 *		
	* paragraph [0008] - paragraph [0012] *		
	* paragraph [0017] *		
	* paragraph [0057] - paragraph [0062] *		

A	US 8 860 334 B2 (ZHAO ZHIXIONG [CN]) 14 October 2014 (2014-10-14)	1-16	TECHNICAL FIELDS SEARCHED (IPC)
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	* figures 2-4 *		
	* line 6 - column 6, line 16 *		

The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		14 October 2016	Yvonnet, Yannick
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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