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(54) **MOVABLE TARGET SYSTEM IN WHICH POWER IS INDUCTIVELY TRANSFORMED TO A TARGET CARRIER**

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Related U.S. Patent Documents

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(52) **U.S. Cl.** **273/406**
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(56) **References Cited**

U.S. PATENT DOCUMENTS

645,229 A		3/1900	Muller	
919,378 A		4/1909	Pinkston	
1,061,577 A		5/1913	Whitney	
1,266,348 A		5/1918	Thompson	
1,281,687 A		10/1918	Stelling	
2,586,958 A		2/1952	Keller	273/105.6
3,006,648 A		10/1961	Devitt, Jr. et al.	273/102.2
3,128,096 A		4/1964	Hammond et al.	273/102.2
3,324,832 A		6/1967	McCain	119/29
3,559,994 A	*	2/1971	Larsen	
3,586,331 A	*	6/1971	Tickell, Jr.	
3,614,102 A		10/1971	Nikoden, Sr.	273/105.6
3,865,373 A	*	2/1975	Knight	
4,088,322 A		5/1978	Nikoden, Jr.	273/105.6
4,092,554 A		5/1978	Quinn	
4,170,077 A	*	10/1979	Pardes	
4,222,564 A	*	9/1980	Allen et al.	
4,505,481 A		3/1985	Knight	273/348
4,509,301 A		4/1985	Head	52/79.8
4,634,126 A	*	1/1987	Kimura	
4,665,831 A		5/1987	Matsui et al.	104/165
4,741,418 A		5/1988	Kaiser	
4,889,346 A		12/1989	Destry et al.	273/406
5,207,304 A		5/1993	Lechner et al.	
5,467,718 A	*	11/1995	Shibata et al.	
5,551,350 A		9/1996	Yamada et al.	
5,967,522 A	*	10/1999	Corcoran et al.	

FOREIGN PATENT DOCUMENTS

JP	53-124813	10/1978
SU	659-426	4/1979
SU	1105-342 A	7/1984
SU	1318-461 A	6/1987
SU	1402-450 A	6/1988

* cited by examiner

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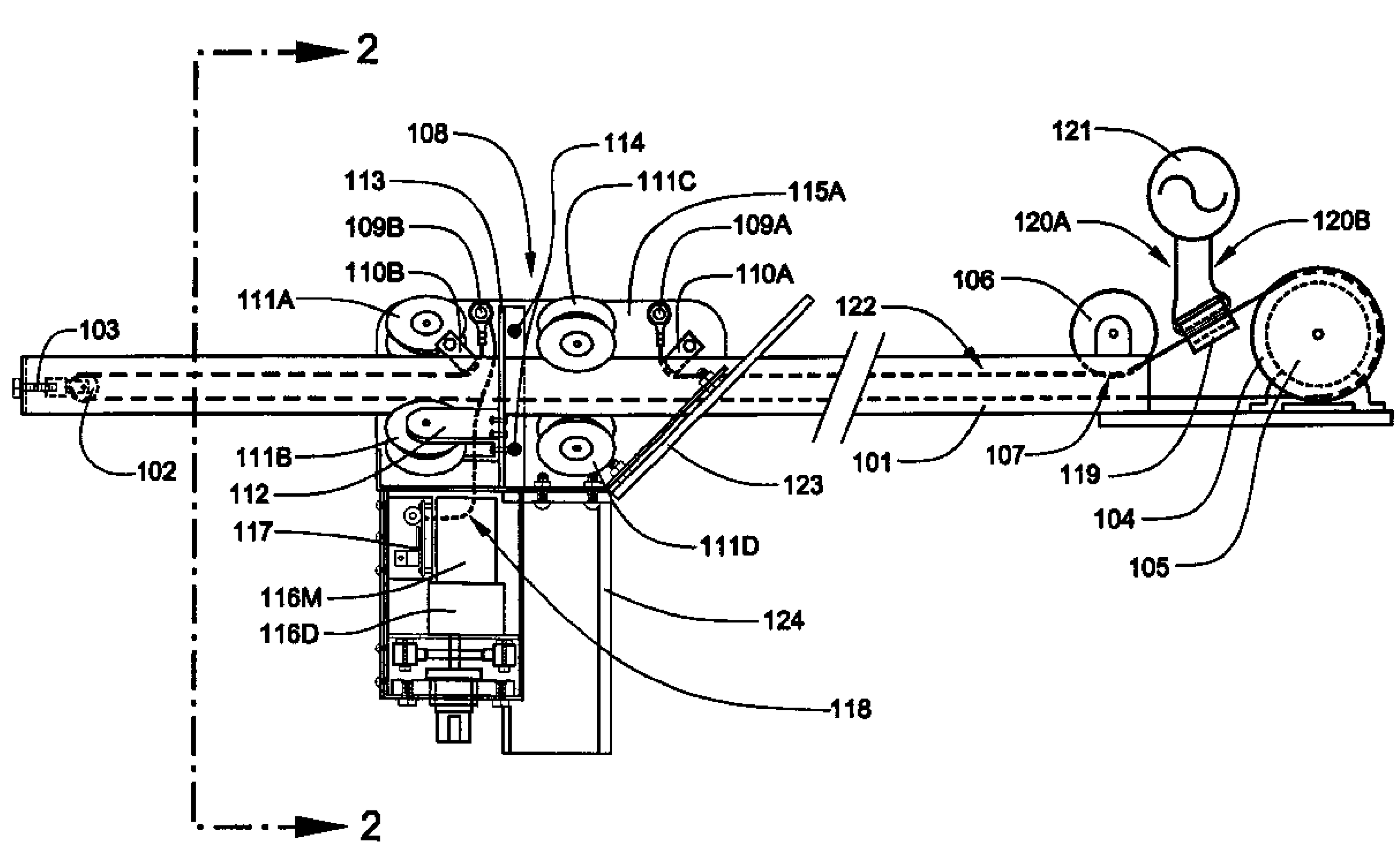
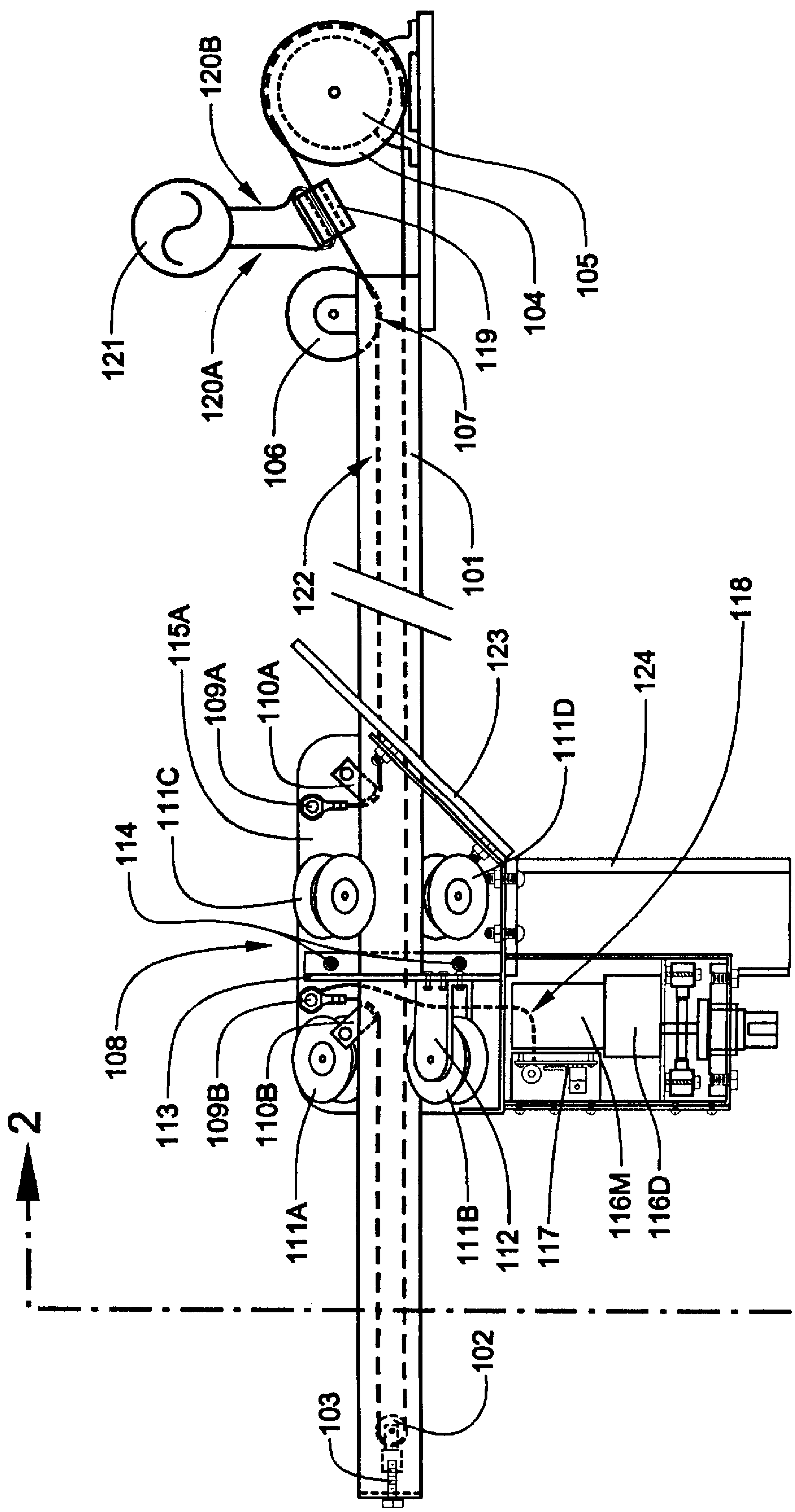
(57) **ABSTRACT**

An improved track-mounted movable target system is disclosed. Power is inductively transferred to a target carrier movable between first and second locations. The transferred power is used to power electrical equipment on board the target carrier. The electrical equipment may include electric motors, lights, solenoids, and control circuitry for the motors and solenoids. Preferred embodiments of the invention are implemented as track-based systems, as the track provides not only stability to the target carrier, but also protection from stray bullets to the conductive cable. For a first embodiment of the invention, power is transferred to a target carrier via a stationary inductor and a movable cable, which also provides motive force to the target carrier. For a second embodiment of the invention, power is transferred to a target carrier via a stationary cable and an inductor movable with the target carrier. For this second embodiment of the invention, electrical equipment on board the target carrier includes a drive motor for moving the carrier bidirectionally along the track. For both embodiments of the invention, communications with the target carrier may be achieved by modulating the frequency of the applied alternating current and demodulating it at the target carrier to provide control signals for control circuitry on board the target carrier.

34 Claims, 6 Drawing Sheets





120B
121
120A
106
107
119
104
105
122
101
123
115A
109A
110A
111D
124
118
114
111C
108
113
109B
110B
111A
111B
112
117
116M
116D
2
2
102
103

FIG. 1

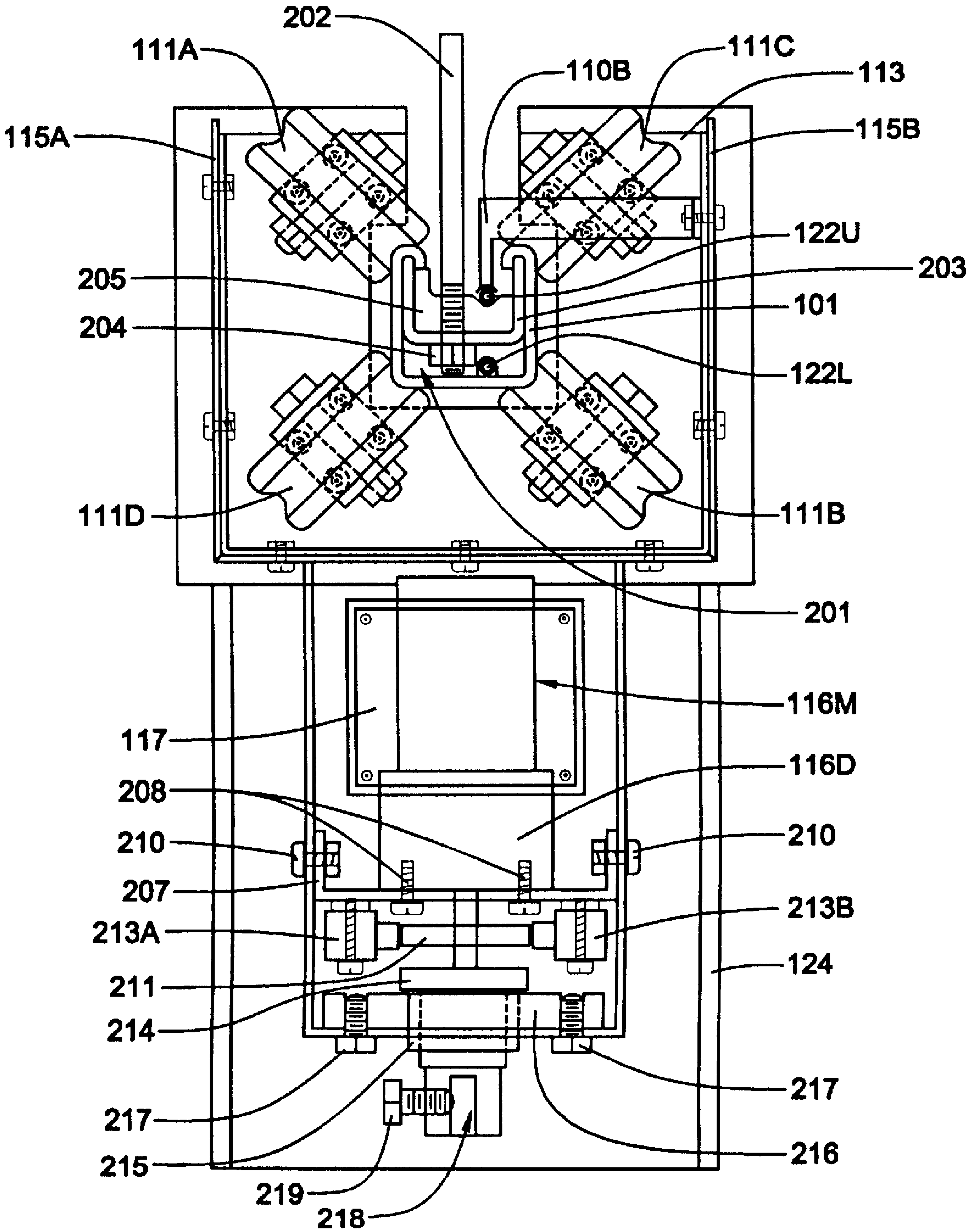

202
111A
111C
110B
113
115A
115B
122U
203
205
101
204
122L
111D
111B
201
116M
117
116D
208
210
210
207
213A
213B
211
124
214
217
217
215
216
219
218

FIG. 2

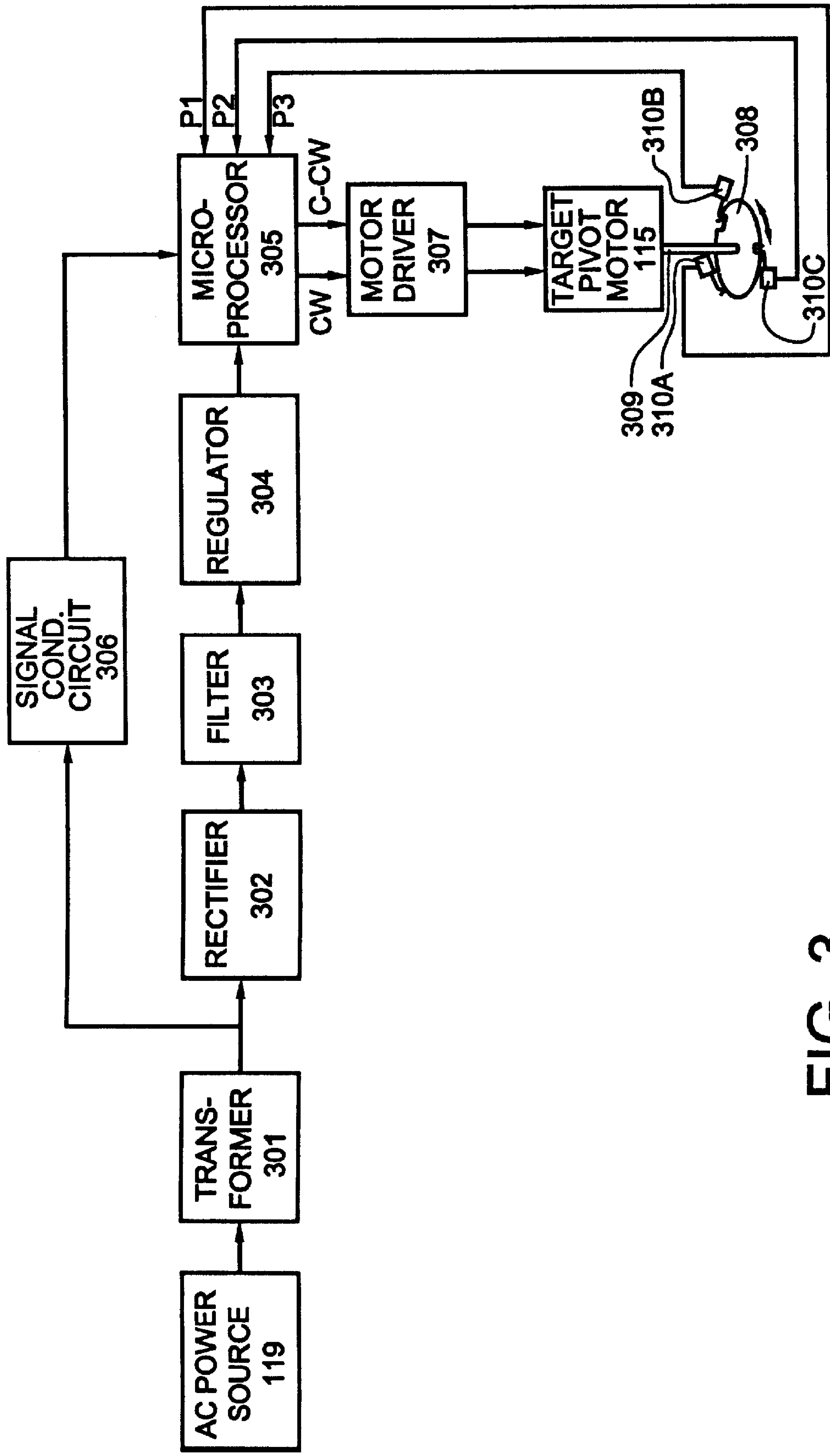

AC POWER SOURCE 119
TRANS-FORMER 301
RECTIFIER 302
FILTER 303
REGULATOR 304
MICRO-PROCESSOR 305
SIGNAL COND. CIRCUIT 306
MOTOR DRIVER 307
TARGET PIVOT MOTOR 115
CW
C-CW
P1
P2
P3
308
309
310A
310B
310C

FIG. 3

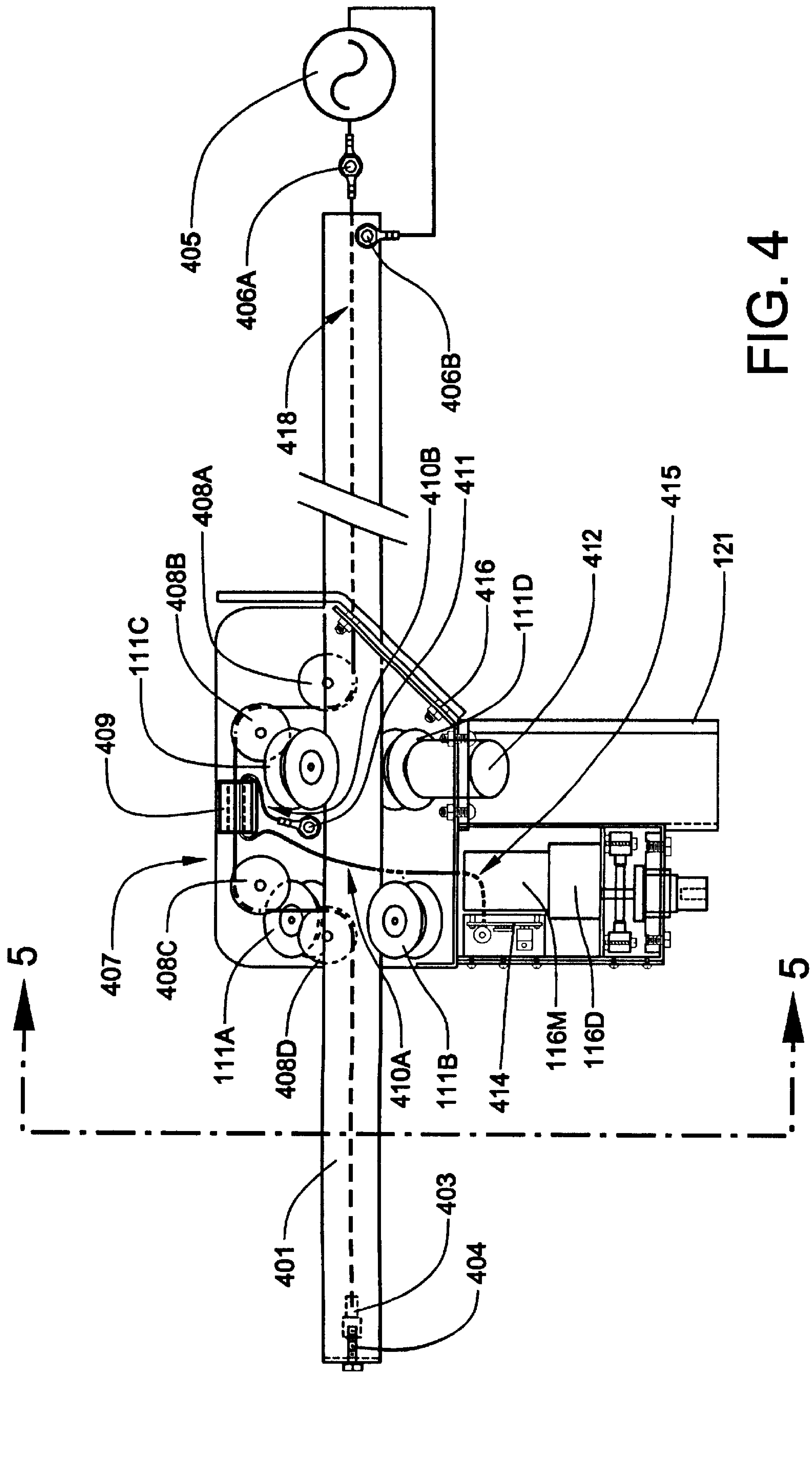
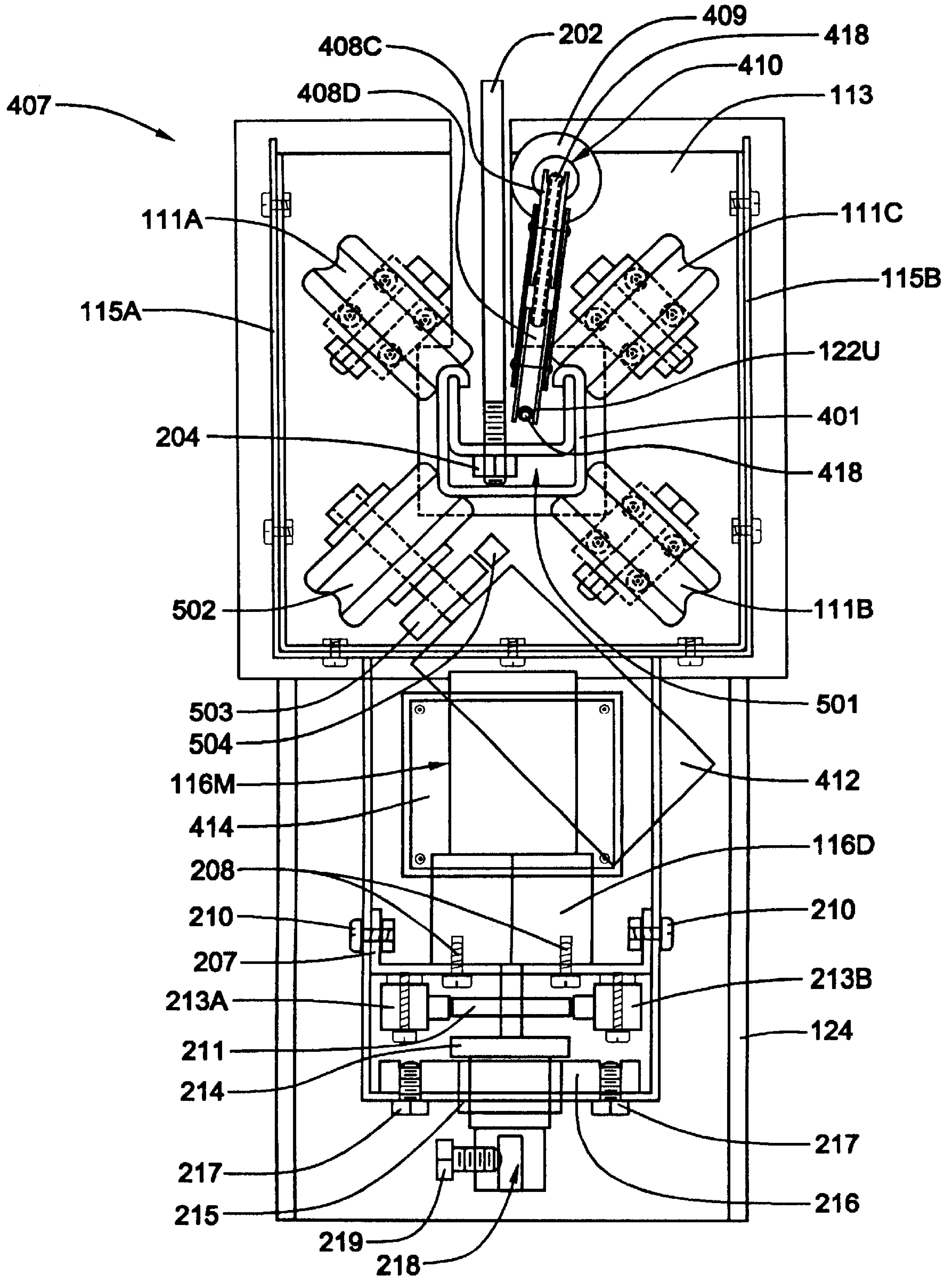
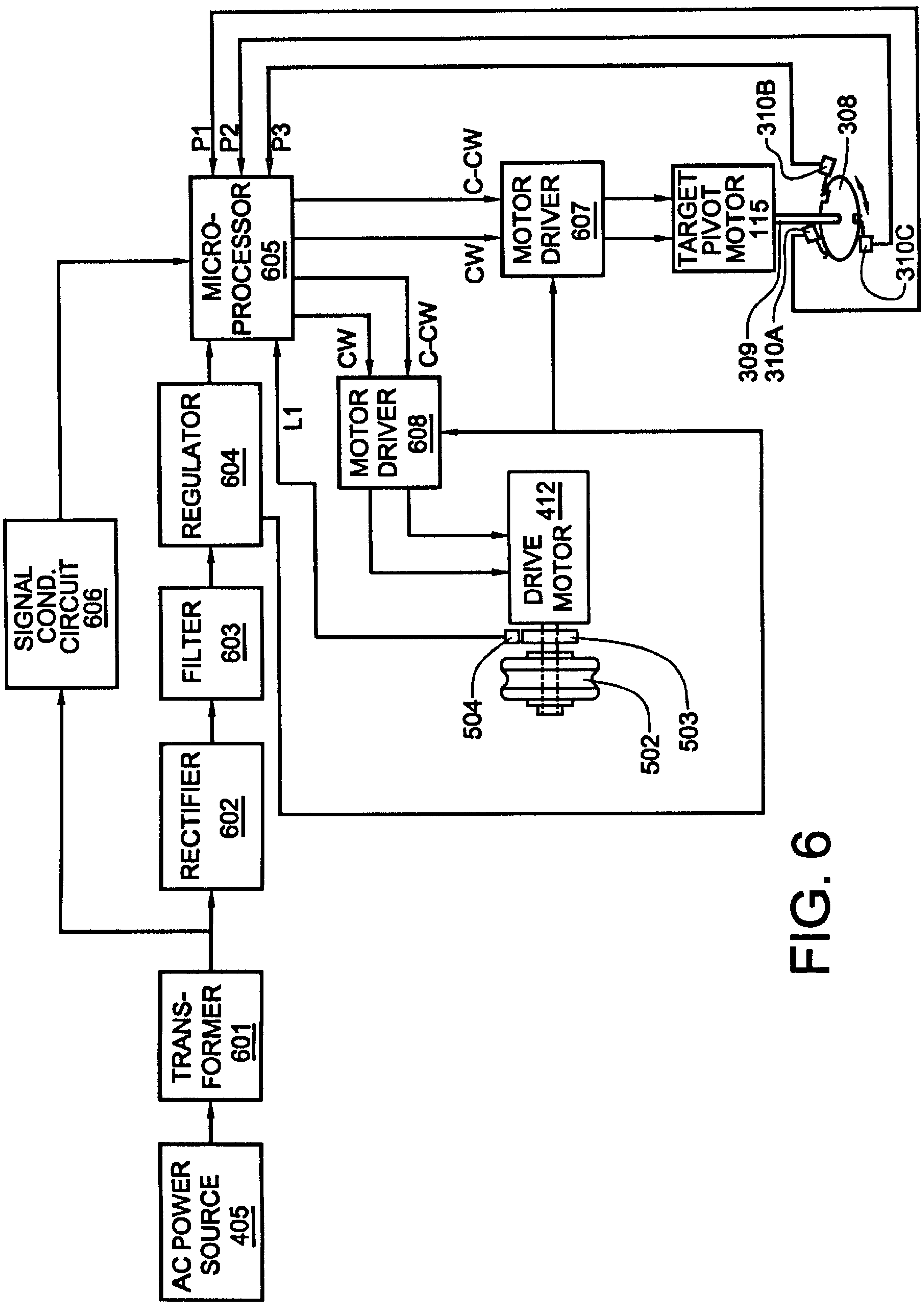

405
406A
406B
418
408A
410B
411
415
408B
416
111D
412
121
111C
409
407
408C
5
111A
408D
410A
111B
414
116M
116D
401
403
404

FIG. 4



407
408C
202
409
418
410
408D
113
111A
111C
115B
115A
122U
401
204
418
502
111B
503
504
501
116M
412
414
116D
208
210
210
207
213A
213B
211
124
214
217
217
215
216
219
218

FIG. 5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TRANS-FORMER 601
RECTIFIER 602
FILTER 603
REGULATOR 604
SIGNAL COND. CIRCUIT 606
MICRO-PROCESSOR 605
P1
P2
P3
L1
CW
C-CW
MOTOR DRIVER 607
MOTOR DRIVER 608
TARGET PIVOT MOTOR 115
DRIVE MOTOR 412
308
309
310A
310B
310C
502
503
504

FIG. 6

MOVABLE TARGET SYSTEM IN WHICH POWER IS INDUCTIVELY TRANSFORMED TO A TARGET CARRIER

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

FIELD OF THE INVENTION

This invention relates to equipment for target ranges and, more specifically, to movable track-mounted target carriers having onboard electrical equipment to which power must be supplied from an external source. The invention also relates to induction-based electrical power transmission systems.

DESCRIPTION OF RELATED ART

Movable target systems typically employ a target carrier that is movable along a rail or track. There is often a requirement that the target attached to the carrier be movable (e.g., pivotable about its vertical central axis). The provision of linear movement to the carrier and movement to the target with respect to the carrier has resulted in various movable target system designs.

One solution to providing linear movement to a carrier and pivotal movement to a target makes use of a pair of parallel conductor strips mounted on the track which are electrically insulated from one another and between which a voltage potential is applied. Alternatively the track itself may serve as one of the conductors (typically at ground potential) and a single conductor strip or wire insulatedly mounted along the track serves as the other. In either case, the carrier is equipped with brushes or rollers which pick up electrical power from the conductors as the carrier moves along the track, much as a toy electric train derives its power from the rails. Such an arrangement is depicted in U.S. Pat. No. 3,128,096 to C. G. Hammond, et al. Power may be supplied to a first electric motor which drives the carrier along the track, as well as to a second electric motor which is used to pivot the target. Such a design suffers from the drawback that bullet fragments and other debris may alight on the conductor strips and thereby interfere with the electrical connection between the brushes and the conductor strip. Arcing between the brushes and the conductor strips will result in the formation of oxides which will increase the resistance at the connection and result in lower voltages being supplied to the electric motors. In addition, the brushes tend to wear with use, requiring periodic monitoring and replacement to prevent harmful arcing conditions.

Another design employed to provide linear movement to a carrier and pivotal movement to a target is depicted in U.S. Pat. No. 3,614,102 to J. Nikoden, Sr. A first insulated, single-conductor cable has one end spooled clockwise on a rotatable take-up drum which moves laterally about its central axis on a threaded shaft as the drum rotates. The opposite end of the cable is connected to a target carrier, providing motive force in one direction along a track and one conductor for power at the carrier. A second insulated cable has one end spooled counterclockwise on the rotatable take-up drum and the opposite end connected to the target carrier, thus providing motive force in a direction opposite that provided by the first cable and a second conductor for power at the carrier. The pitch of the threads on the shaft is equal to the diameter of the first and second insulated cables. One of the cables wraps around an idler pulley at the end of

the track opposite the take-up spool mechanism. Such a design is rather complex and requires constant frequent lubrication of the threaded shaft and brush type contacts to transfer current to each cable at the take-up spool.

Still another design used to provide linear movement to a carrier and pivotal movement to a target utilizes a folded power cable which is dragged behind the carrier. Such a target system design is depicted in U.S. Pat. No. 4,889,346 to Donald M. Destry, et al. Computer printers having a track-mounted, movable print head have a similar cable connection arrangement. As the print head slides on its track, a ribbon cable having conductors encased in a resilient plastic sheath automatically folds upon itself and unfolds as the print head moves. Electricity for both a linear motion motor and a target pivoting motor are provided by the power cable which is attached at one end to the carrier, and at the other end to a power source. Abrasion to the insulated sheath covering the cable caused by frequent movement of the cable, as well as fatigue and eventual breakage of the cable conductors caused by frequent flexing of the cable are significant problems of this design. Another problem relates to the need to provide a mechanism which will maintain the power cable (which is no lightweight ribbon cable) neatly folded as the carrier moves toward the cable power source, regardless of the carrier's position on the track.

What is needed is a simple and reliable new system for providing linear movement to a track-mounted carrier and pivotal movement to a target attached to the carrier which dispenses with contact brushes, complicated cable spooling/despooling equipment, and folded power cables.

SUMMARY OF THE INVENTION

The present invention is embodied in an improved movable target system which meets the need heretofore expressed. Power is inductively transferred to a target carrier movable between first and second locations. The transferred power is used to power electrical equipment on board the target carrier. The electrical equipment may include electric motors, lights, solenoids, and control circuitry for the motors and solenoids. Preferred embodiments of the invention are implemented as track-based systems, as the track provides not only stability to the target carrier, but also protection from stray bullets to the conductive cable.

For a first embodiment of the invention, power is transferred to a target carrier via a stationary inductor and a movable cable, which also provides motive force to the target carrier. An idler pulley is mounted at one end of a track or rail, and a drive motor having a drive pulley is mounted near the opposite end thereof A target carrier, having an onboard power requirements, such as an electric target-pivoting motor, is movably mounted on the track or rail. A first end of an electrically-conductive drive cable is anchored to the carrier, and also connected to a first power-input terminal on the carrier. From the anchoring point on the carrier, the cable extends directly to the drive pulley. The cable wraps around the drive pulley, thus reversing directions. From the drive pulley, the cable extends all the way to the idler pulley, wraps around the idler pulley, and returns to the target carrier to which the second end of the cable is also anchored. However, the second end of the cable is connected to a second power-input terminal on the carrier, which is electrically insulated from the first power-input terminal. The drive cable, at some point along its length, passes near a stationary inductor. For preferred embodiments of the invention, the drive cable passes through the stationary inductor, which is a closed-loop ferromagnetic core, such as a toroid, having at least one turn of wire passing through the core's aperture. When an alternating current is applied to the stationary inductor, an alternating current of the same frequency is induced in the drive cable. This induced current, received at the first and second power-input terminals, is used to provide the target carrier's onboard power requirements. Some of the induced current may be rectified, filtered and regulated to provide DC power at the target carrier. The frequency of the applied alternating current may be modulated in order to send control signals to the target carrier. Microprocessor-based circuitry on board the target carrier decodes the modulated AC signals and converts them to binary signals which may be used to directly control functions on board the target carrier. Although not presently considered to be a preferred implementation of the invention, at least this first embodiment of the invention may be implemented as a trackless design by maintaining the cable taut, and suspending the target carrier directly from the cable.

For a second embodiment of the invention, power is transferred to a target carrier via a stationary cable and an inductor movable with the target carrier. One end of a conductive cable is connected to one terminal of a stationary alternating current source that is mounted near one end of an electrically-conductive track or rail having a channel which extends the length of the track, and to which the other terminal of the alternating current source is connected. The cable is routed within the channel to the target carrier, at which point it passes beneath a first in-channel guide pulley that is rotatably mounted on the target carrier. The cable then leaves the channel and passes over at least one out-of-channel guide pulley that is rotatably mounted on the target carrier. While the cable is outside the channel, it passes near or through an inductor affixed to the target carrier. For preferred embodiments of the invention, the drive cable passes through the inductor, which is a closed-loop ferromagnetic core, such as a toroid, having at least one turn of wire passing through the core's aperture. The cable is then routed beneath a second in-channel guide pulley that is rotatably mounted on the target carrier. From there, the cable is routed to an anchoring device at the opposite end of the track, which may incorporate a cable tensioning device. The cable anchoring device is electrically connected to the track. As the target carrier moves along the track, the guide pulleys mounted on the target carrier lift a short section of the cable from the track. When an alternating current is applied to the cable, an alternating current is induced in the inductor affixed to the carrier. The channel acts much like the outer conductor of a coaxial cable, in that its electromagnetic shielding minimizes power losses caused by energy radiated from the cable. For this second embodiment of the invention, electrical equipment on board the target carrier includes a drive motor for moving the carrier bidirectionally along the track. Thus the current induced in the inductor affixed to the target carrier is used to power not only the drive motor, but any other electrical equipment that may be on board the target carrier, such as motors which move the target with respect to the carrier. Some of the induced current may be rectified, filtered and regulated to provide DC power at the target carrier. Communications with the target carrier may be achieved by modulating the frequency of the applied alternating current. For a preferred embodiment of the invention, modulation involves alternating between two distinct frequencies so that a stream of serial binary data may be sent to the target carrier. Microprocessor-based circuitry on board the target carrier decodes the modulated AC signals and converts them to binary signals which may be used to

directly control functions on board the target carrier. For example, the decoded signals may direct the drive motor to move the carrier forward or backward, or direct a target-pivoting motor to rotate the target to a desired position. Return communication for such information as hits on the target or status information can be effected by modulating the load at the coil at a frequency different from that of source alternating current. This modulation will be reflected in measurable current flow fluctuations at the alternating current source. These fluctuations can be decoded in much the same manner that frequency modulation is decoded by the circuitry on board the target carrier.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevational cutaway view of a first embodiment of the improved movable target system;

FIG. **2** is a cross-sectional view of the first embodiment of the improved movable target system of FIG. **1** through line **2—2**;

FIG. **3** is a block schematic diagram of the electrical circuitry and electrically-powered equipment employed in connection with the first embodiment of the improved movable target system;

FIG. **4** is a side elevational cutaway view of a second embodiment of the improved movable target system;

FIG. **5** is a cross-sectional view of the second embodiment of the improved movable target system of FIG. **4** through line **5—5**; and

FIG. **6** is a block schematic diagram of the electrical circuitry and electrically-powered equipment employed in connection with the second embodiment of the improved movable target system.

DETAILED DESCRIPTION OF THE INVENTION

A first embodiment of the invention may be characterized as a movable target system having a target carrier that is driven by a movable, looped cable along a track. Electrical power is transferred to the movable cable via a stationary inductor which is inductively coupled to the cable. Power induced in the cable is received by the carrier and used to power electrical equipment on board the carrier. This first embodiment of the invention will now be described.

Referring now to FIG. **1**, an overhead track **101** of substantially rectangular, U-shaped cross section, having an upward-facing groove or channel (see FIG. **2**, item **201**) that extends along the length of the track, is provided between two locations between which a target must be movably positionable. A first idler pulley **102** incorporating a tensioning device **103**, is mounted within the channel **201** at a first end of the track **101**. A drive pulley **104**, powered by a drive motor **105**, is mounted in line with the channel **201** near the opposite, or second, end of the track **101**. A second idler pulley **106** is mounted at the second end of the track **101** so that its grooved edge **107** extends into the channel **201**. A target carrier **108**, having power input connections **109**A and **109**B and anchoring brackets **110**A and **110**B, is movably mounted on the track **101** with grooved dielectric transport wheels **111**A, **111**B, **111**C and **111**D. The target carrier **108** is movable between first and second locations. The maximum travel is dictated by several factors. The absolute maximum travel will be the length of the track. This maximum travel will be limited, first, by the location of the first and second idler pulleys, which will obstruct movement of the carrier is either of them are physically located within the channel. The maximum travel may also be further limited by limit stops which may be affixed to the track. In any case, the term "inboard", as used in this disclosure refers to a direction toward the center of the track **101**, while the term "outboard" refers to a direction away from the center of the track. Each of the grooved wheels rides on one of the four corners of the track. Each grooved wheel is affixed to the carrier by a bracket **112** (the bracket **112** is depicted for only grooved wheel **111**B) which is riveted or fastened with screws to a bulkhead **113**, which is, in turn, retained with screws **114** between opposing side plates **115**A and **115**B (not shown) of the target carrier **108**. Anchoring brackets **110**A and **110**B are rigidly attached to side plate **115**B. Electrical equipment, which may include a geared target pivoting motor **116** and electrical circuitry **117** for the controlling the target pivoting motor **116**, is mounted on board the target carrier **108**. An insulated wire **118** connects power input connection **109**B to electrical circuitry **117**. Power input connection **109**A is attached directly to the target carrier housing, which includes side plate **115**A.

Still referring to FIG. **1**, a first end of an insulated, electrically-conductive cable **122** is secured to the first power input connection **109**A. From this first power input connection **109**A, the cable **122** extends to and is wrapped around the first anchoring bracket **110**A, from which the cable **122** is routed under and partially around the second idler pulley **106**, and looped around the groove of drive pulley **105**. From the bottom of the drive pulley **105**, the cable **122** then extends to the bottom of the first idler pulley **103**, is looped around the groove of the first idler pulley **103** one-half turn, before returning to the target carrier **108**. At the target carrier **108**, the cable **122** is wrapped around the second anchoring bracket **110**B, from which the cable **122** extends to the second power input connection **109**B. The opposite, or second, end of the cable **122** is secured to the second power output connection **109**B. An inductor device **119**, characterized as having a coil with at least one turn of wire, the wire having first and second ends which, respectively, form first and second leads **120**A and **120**B, and a ferromagnetic core which at least partially surrounds the cable **122** and which concentrates the magnetic flux of the coil thereby increasing the coil's inductance. The ferromagnetic core may take a variety of shapes. For example, the core may be toroidally shaped, or substantially in the shape of a geometric solid enclosed by the surface generated by rotating a rectangle 360 degrees about an axis that is outside the rectangle, parallel to one side of the rectangle, and equiplanar with the rectangle. The core of inductor device **19** may also be a square shaped frame substantially in the shape of a geometric solid enclosed between two perimetrally parallel, equiplanar rectangles, one of which is smaller than and inside the other, as they are simultaneously moved along a line perpendicular to the plane in which they lie. The term "substantially" is used to indicate that the square corners of the surfaces so generated may be rounded. The leads **120**A and **120**B of inductance device **119** are coupled to an alternating current power source **121**. In order to prevent stray bullets from piercing the target carrier **108**, it is protected on the side facing the marksman with an angled, tempered steel plate **123**. Likewise, the target-pivoting motor **116** and the onboard control circuitry **117** are protected with a vertically-oriented, tempered steel plate **124**. **41**

Still referring to FIG. **1**, it should be readily apparent that as the drive pulley **105** is rotated by the drive motor **106**, the target carrier **108** will move, in response to the movement of cable **122**, until it reaches the limit of its travel in one direction along the track **101**. Likewise, when the rotational direction of the drive pulley **105** is reversed, the target carrier **108** will travel in the opposite direction along the track **101** until it reaches the limit of its travel at the opposite end of the track **101**. Additionally, when an alternating current is applied to the power input leads **120**A and **120**B of inductor device **119**, a current is induced in electrically-conductive cable **122**. For the preferred embodiment of the invention, alternating current of various frequencies within a range of about 20 to 30 kilohertz and a potential of approximately 170 volts is applied to inductor device **119**, which has 6 turns of wire thereon. Thus, the current induced on the cable **122** is about one-sixth of the applied voltage, or a nominal voltage of about 24 volts. As 24 volts is the maximum voltage that is still considered low-voltage, no special shielding or ground-fault detection devices are required as safety measures. Although the induced alternating current could be utilized to directly power an AC target-pivoting motor, for the preferred embodiment of the invention, nearly all the induced AC current is rectified, filtered and regulated to provide 5 volts DC, which is used to power all electrical equipment on board the target carrier **108**. Only a very small portion of the induced AC current is used as is for sampling the frequency of the AC power applied to inductor device **119**. The particular frequency applied to inductor device **119** is used as a control signal for motor control on board the target carrier **108**. This will be later explained in more detail with reference to FIG. **3**. Although it is conceivable that a movable target system could be designed using an uninsulated cable in place of the insulated cable **122**, an uninsulated cable must be adequately isolated from the track **101** and any other grounded items. The use of a steel cable having an insulating sheath greatly simplifies design and construction of the movable target system. The insulating sheath may be formed from a material such as nylon, polytetrafluoroethylene, or other flexible polymeric dielectric material. In any case, electrical contact to an end of the cable **122** is made by stripping the insulated sheath from the end thereof and securing the stripped end to the terminal using one of many known techniques. A lug-type connector crimped to the end of the cable and secured to power input connections **109**A or **109**B with a threaded nut is depicted.

Referring now to the cross-sectional view of FIG. **2**, the rectangular, U-shaped cross-section of track **101** is readily visible, as is the channel **201** within the U-shaped cross section. At certain locations along the track, the track **101** is suspended from a threaded overhead support rod **202** that is anchored to a bracket **203** that is slidable within the track **101**. As the threaded nut **204** is tightened on rod **202**, both the bracket **203** and the rod **202** exert a force on the track, thus securing the support rod **202** to the track **101**. A slidable plastic insert **205** provides separation between the upper strand **122**U and the lower strand **122**L of drive cable **122**. The target carrier **108** rolls along the track **101** on two pairs of perpendicularly angled, spaced-apart plastic guide wheels which are rotatably affixed to the carrier **108**, as heretofore described. Though not evident from this cross-sectional drawing, the first pair of guide wheels, **111**A and **111**B, are nearer the viewer than the second pair of guide wheels, **111**C and **111**D. Each wheel rides on one of the four edges, or corners, of the track **101**. Such a mounting arrangement provides a high degree of stability to the target carrier **108** as it moves along the track **101**. The bulkhead **113**, which is seen in FIG. **1** as an edge of a piece of sheet metal and folded tabs by which it attached to side plate **115**A by threaded screws **114**, is shown more clearly in this view. Both the bulkhead **113** and the angled steel plate **123** have a cutout **206** to clear the track **101** and overhead support rod **202**. In this view, the target pivoting motor **116**M and its geared-drive mechanism **116**D are more clearly seen. The geared-drive mechanism **116**D is mounted on a support plate **207** with screws **208**. The support plate is attached to the lower carrier housing **209** with screws **210**. A notched cam wheel **211** is affixed to the output shaft **212** of the target-pivoting motor **116**M/**116**D. Two of three micro switches **213**A, **213**B and **213**C, which detect the location of the notches on the cam wheel **211** are also visible. A target attachment fitting **214** is rotatably positioned within an oil impregnated sintered brass bushing **215**, which is pressed into base plate **216**, which secured to lower carrier housing **209** with bolts **217**. A hole **218** in the target attachment fitting **214** is adapted to receive a cylindrical rod to which the target is attached (neither the rod nor the target is shown). The rod is retained within fitting **214** by securing bolt **219**.

Referring now to the block schematic diagram of FIG. **3**, the circuitry **117** on board the target carrier **108** includes all circuit items labeled **302–307**. The alternating current power source **121** is transformed by inductor device **119** (which functions as a primary transformer winding) and the insulated drive cable **122** (which functions as a secondary transformer winding), which together constitute power transformer **301**, into the induced alternating current received at power input connections **109**A and **109**B. The induced AC current is rectified by diode rectifier circuit **302**, filtered by filter circuit **302** and regulated by regulator circuit **304**. The regulated DC current powers a microprocessor **305**, which samples the frequency of the induced AC power through signal conditioning circuit **306**. The microprocessor **305** decodes the received AC frequency signal into position information for the target-pivoting motor **116**M. In response to both this decoded signal and signals **P1**, **P2** and **P3** received from micro switches **213**A, **213**B, and **213**C, respectively, which make rubbing contact with the edge of a notched cam wheel **211** affixed to the target-pivoting motor shaft **212**, either a clockwise rotation signal or a counter-clockwise rotation signal is sent from the microprocessor **305** to a motor driver circuit **307**, which sends DC power to target-pivoting motor **116**M in normal or reverse polarity until the desired target position is achieved. It should be emphasized that all electrical equipment on board the target carrier is powered by the regulated DC current derived from the current induced in the drive cable **122**.

A second embodiment of the invention may be characterized as a movable target system having a target carrier movable along a track which encloses a stationary cable to which alternating current is applied. The carrier incorporates onboard electrical equipment that at least includes an electric transport motor. The onboard electrical equipment receives it power from an inductor which slides along the stationary cable. This second embodiment of the invention will now be described.

Referring now to FIG. **4**, a conductive overhead track **401** of substantially rectangular, U-shaped cross section, having an upward-facing groove or channel (see FIG. **5**, item **501**) that extends along the length of the track, is provided between two locations between which a target must be movably positionable. A first cable anchoring device **403**A incorporating a cable tensioner **404** is longitudinally aligned with and positioned at one end of the track **401**, being electrically connected thereto. An alternating current source **405**, having first and second power output connections **406**A and **406**B, respectively, is positioned at the opposite end of the track. The first output connection **406**A is electrically

connected to the track **401**. A target carrier is **407** is movably mounted on the track **401** in the same way that the target carrier **108** is movably mounted to track **101** (see the description of FIG. **1**). The target carrier **407** is equipped with a cable lifting device consisting of four idler pulleys **408**A, **408**B, **408**C and **408**D. An inductor device **409** is affixed to the target carrier between idler pulleys **408**B and **408**C. The physical characteristics of the inductor device **409** are fundamentally the same as those identified for inductor device **119** of the first embodiment of the invention. A first lead **110**A of inductor device **409** is electrically connected to the target carrier frame at input connection **411**. The target carrier **407** is also equipped with onboard electrical equipment which includes a drive motor **412** having a resilient drive wheel **413** which rides against the lower surface of the track **401**, a target-pivoting motor **116**M having a geared drive **116**D, and circuitry **414** for controlling the operation of both motors. An insulated wire **415**, which makes electrical connection to the other, or second, lead **110**B of inductor device **409**, is coupled to the circuitry **414**. In order to prevent stray bullets from piercing the target carrier **407**, it is protected on the side facing the marksman with a tempered steel plate **416** that is positioned both vertically and angularly with respect to the marksman. Likewise, the target-pivoting motor **116**M/**116**D and the onboard control circuitry **414** are protected with a vertically-oriented, tempered steel plate **121**. A first end of an insulated conductive cable **418** is conductively anchored to the first cable anchoring device **403**A, from which the cable **418** extends to a second cable anchoring device **403**B, which is longitudinally aligned with the channel of track **401**, stationary with respect the track **401**, and electrically connected to the second power output connection **406**B. Between the second cable anchoring device **403**B and the first cable anchoring device **403**A, the cable is routed to the target carrier **407**, where it passes beneath idler pulley **408**A, out of the channel **401** and over idler pulley **408**B, through the inductor device **409**, over idler pulley **408**C, back into the channel **401** and under idler pulley **408**D. When a source alternating current is applied to the conductive cable **413**, a corresponding alternating current is induced in the inductor device **409**. Some of the induced current may be rectified, filtered and regulated to provide DC power at the target carrier. Communications with the target carrier **407** may be achieved by modulating the frequency of the applied alternating current at AC source **405**. For a preferred embodiment of the invention, modulation involves alternating between two distinct frequencies so that a stream of serial binary data may be sent to the target carrier. Microprocessor-based circuitry **414** on board the target carrier decodes the modulated AC signals and converts them to binary signals which may be used to directly control functions on board the target carrier. For example, the decoded signals may direct the drive motor to move the carrier forward or backward, or direct a target-pivoting motor to rotate the target to a desired position. Nearly all the AC current induced in inductor device **409** is rectified, filtered and regulated to provide 5 volts DC, which is used to power all electrical equipment on board the target carrier **407**. Only a tiny portion of the induced AC current is used as is for sampling the frequency of the AC power applied to cable **418**. A more detailed explanation of communications procedures will be subsequently given with reference to FIG. **6**.

Still referring to FIG. **4**, it should be readily apparent that as the target carrier **407** is moved in either direction along the track **401** by drive motor **412** between the limit of its travel as afforded by the length of the track, the cable will be lifted out of the channel by idler pulleys **408**A, **408**B, **408**C and **408**D within the confines of the target carrier **407**. In this way, the cable **418** is protected from stray bullets. In addition, the channel **501** within the track **401** acts much like the outer conductor of a coaxial cable. Power losses caused by energy radiated from the cable **418** are minimized.

Referring now to the cross-sectional view of FIG. **5**, the rectangular, U-shaped cross-section of track **401** is readily visible, as is the channel **501** within the U-shaped cross section. In order to provide clearance for idler pulleys **408**A, **408**B, and **408**C and **408**D, track **401** is somewhat wider than track **101**. Many features visible within FIG. **5** are identical to those of FIG. **2**. This description will cover only the basic differences. The most notable difference is the presence of the idler pulleys, which extract the cable **418** from the channel **501** within the confines of the target carrier **407**. Only idler pulleys **408**C and **408**D are visible in this view. Also notable is the presence of a single strand of cable **418**, as the cable is not looped within the channel **501**. In addition, because of clearance requirements, there are no plastic inserts such as item **205** of FIG. **2**. Idler pulleys **408**A, **408**B, **408**C and **408**D may be secured to the target carrier **407** in much the same manner as the grooved transport wheels **111**A, **111**B, **111**C and **111**D are attached. However, grooved transport wheel **111**D is replaced with a grooved drive wheel **502** that is mounted on the output shaft of drive motor **412**, which may be secured to the target carrier frame with a mounting bracket (not shown). The drive motor **412** is also equipped with a pulse generator **503** and a sensor **504**, which will be described in more detail with reference to FIG. **6**. In this cross-sectional view, the end of inductor device **409** is seen. The central aperture **505** of a closed-loop ferromagnetic core of device **409** is readily visible in this view. For the sake of simplicity, the windings on inductor device **409** are not shown in this view.

Referring now to the block schematic diagram of FIG. **6**, which is similar to that of FIG. **3**, the circuitry **414** on board the target carrier **407** includes all circuit items labeled **602–608**. The alternating current power source **405** is transformed by the insulated cable **418** (which functions as a primary transformer winding) and the inductor device **409** (which functions as a secondary transformer winding), which together constitute power transformer **601**, into the induced alternating current received at terminal **411** and lead wire **415** (i.e., the outputs of inductor device **409**). The induced AC current is rectified by diode rectifier circuit **602**, filtered by filter circuit **603** and regulated by regulator circuit **604**. The regulated DC current powers a microprocessor **605**, which samples the frequency of the induced AC power through signal conditioning circuit **606**. For a preferred embodiment of the invention, modulation involves alternating between two distinct frequencies so that a stream of serial binary data may be sent to the target carrier. The microprocessor **605** samples a pulsating DC signal at the received AC frequency from the signal conditioning circuit **606**, decoding this pulsating signal into binary signals which, in turn, code for certain control functions on board the target carrier. For example, one decoded signal may direct the drive motor to move the carrier forward or backward. In response to another signal decoded from the induced AC and signals **P1**, **P2** and **P3** received from micro switches **213**A, **213**B and **213**C, respectively, either a clockwise rotation signal or a counterclockwise rotation signal is sent from the microprocessor **605** to a motor driver circuit **607**, which sends DC power to target-pivoting motor **116**M in normal or reverse polarity until the desired target position is achieved. Motor driver circuit **608** controls drive motor **412**. Drive motor **412** is responsible for bidirectional movement of the target carrier **407** along the track **401**. As with motor driver circuit **607**, either a clockwise rotation signal or a counterclockwise rotation signal is sent from microprocessor **605** to motor driver circuit **608**. Drive motor **412** has a rotating pulse generator **503** attached to its output shaft **504**. The pulses are monitored by sensor **504**, which feeds information back to microprocessor **605** via signal line L1, so that the microprocessor **605** can keep track of the target carrier's position on the track **401**. It should be mentioned that the drive motor of the embodiment depicted in FIG. **1** may also be equipped with a pulse generator and a sensor so that the position of the target carrier **108** may be monitored by a separate microprocessor offboard the target carrier **108**. Additionally, it should be emphasized that all electrical equipment on board the target carrier is powered by the regulated DC current derived from the current induced in the inductor device **409**. Nearly all the AC current induced in inductor device **409** is rectified, filtered and regulated to provide 5 volts DC, which is used to power all electrical equipment on board the target carrier **407**. Only a tiny portion of the induced AC current is used as is for sampling the frequency of the AC power applied to cable **418**.

Although only a single embodiment of the improved movable target system is depicted and described herein, it will be obvious to those having ordinary skill in the art that changes and modifications may be made thereto without departing from the scope and the spirit of the invention as hereinafter claimed. For example, although the preferred embodiments of the improved movable target system as heretofore described have been implemented as a target carrier movable along an overhead track, the system principles may be readily adapted to a system having a target carrier movable along a ground-supported track, or even as a trackless system, with the target carrier suspended on the conductive cable.

What is claimed is:

1. A movable target system comprising:

a target carrier movable between first and second locations, said carrier having onboard electrical equipment;

a [stationary] power supply [having first and second output connections]; and

a power transmission system for transferring electrical power from the [stationary] power supply to the on board electrical equipment via at least two mutually-coupled inductors, one of which is movable with respect to another.

2. The movable target system of claim **1**, wherein power is transferable while one of said inductors is moving with respect to another.

3. The movable target system of claim **2**, wherein said pair of inductors includes:

a first inductor, which is an electrically-conductive cable; and

a second inductor comprising:

a coil having at least one turn of wire, said wire having first and second ends which, respectively, form first and second leads; and

a ferromagnetic core which at least partially surrounds said cable and which magnifies the inductance of said coil.

4. The movable target system of claim **2**, wherein said core is toroidally-shaped.

5. The movable target system of claim **2**, wherein said core is substantially in the shape of geometric solid enclosed by the surface generated by rotating a rectangle 360 degrees about an axis that is outside the rectangle, parallel to one side of the rectangle, and equiplanar with the rectangle.

6. The movable target system of claim **3**, which further comprises a track on which said target carrier is movably mounted, said track having a full-length channel within which said cable is positioned along substantially the entire length of said track;

first and second power input connections on said target carrier to which said electrical equipment is electrically coupled*;* and

wherein said cable is movable, having first and second ends respectively coupled to said first and second power input connections, said first and second ends each also being secured to said target carrier; and

wherein said second inductor is stationary, having first and second leads [respectively] coupled to said [first and second connections of said stationary] power supply.

7. The movable target system of claim **6**, which further comprises:

a first idler pulley longitudinally aligned with said channel and positioned outboard of said first location; and

a drive pulley rotatably powered by a drive motor, said drive pulley aligned with said channel and positioned outboard of said second location; and

wherein said cable is looped between said idler pulley and said drive pulley.

8. The movable target system of claim **7**, which further comprises a second idler pulley mounted between said second location and said drive pulley, said second idler pulley engaging said cable and serving to maintain said cable within said channel, and wherein said second inductor is positioned between said drive pulley and said second idler pulley.

9. The movable target system of claim **8**, wherein said electrical equipment includes at least one electric motor for moving a target and control circuitry for controlling the operation of said electric motor.

10. The movable target system of claim **9**, wherein said electrical equipment further includes frequency sampling and decoding circuitry, and wherein the frequency of an induced alternating current in said cable matches that of an alternating current applied to said second inductor by said [stationary] power supply, and wherein the frequency of the applied alternating current is modulated to provide decodable signals at the target carrier which are sampled by said frequency sampling circuitry and decoded by said decoding circuitry to produce control signals for said control circuitry.

11. The movable target system of claim **10**, wherein said electric motor, said control circuitry, said sampling circuitry, and said decoding circuitry are powered by direct current produced by rectifying at least some of said induced alternating current.

12. The movable target system of claim **3**, which further comprises:

an electrically-conductive track on which said target carrier is movably mounted, said track having a full-length, upwardly-open channel within which said cable is positioned along substantially the entire length of said track;

a first cable anchoring device to which a first end of said cable is anchored, said first anchoring device being longitudinally aligned with said channel, positioned outboard of said first location, said first *end of said* cable [anchoring device] being coupled to [said first power output connection via] said track; and

a second cable anchoring device to which the opposite, or second, end of said cable is anchored, said second anchoring device being longitudinally aligned with said channel and positioned outboard of said second location; said second *end of said* cable [anchoring device] being electrically coupled to said second power output connection; and

wherein said second inductor is affixed to said target carrier *and said power supply has first and second output connections, said first output connection being coupled to said track, and said second output connection being coupled to the second end of said cable*.

13. The movable target system of claim **12**, wherein said target carrier includes means for lifting a portion of said cable from said channel within the confines of said carrier as it moves along said track.

14. The movable target system of claim **13**, wherein said means for lifting comprises:

first and second guide pulleys rotatably and rigidly affixed to said target carrier, said first and second guide pulleys being positioned at least partially within said channel; and

at least one other guide pulley rotatably and rigidly affixed to said carrier at a level above said first and second guide pulleys, said cable being routed from said *first* cable anchoring device, beneath said first guide pulley, out of said channel and over said at least one other guide pulley, into said channel and under said second guide pulley, then to said [first power output terminal] *second cable anchoring device*, said cable passing through said [first inductor] while *said cable* is out of said channel.

15. The movable target system of claim [**14**] *12*, where said electrical equipment includes a drive motor for driving said target carrier along said track, at least one target movement motor, and control circuitry for controlling the operation of said drive motor and said at least one target movement motor.

16. The movable target system of claim **15**, wherein said electrical equipment further includes frequency sampling and decoding circuitry, and wherein the frequency of the induced alternating current in the second inductor matches that of [the] *a* source alternating current *output by said power supply*, and wherein the frequency of the source alternating current is modulated to provide decodable signals at the target carrier which are sampled by said frequency sampling circuitry and decoded by said decoding circuitry to produce control signals for said control circuitry.

17. The movable target system of claim **16**, wherein the source alternating current is modulated to provide a stream of serial binary data.

18. A movable target system comprising:

a track having a channel extending substantially the full length thereof;

a target carrier movably mounted on said track between first and second locations, said carrier having first and second power-input connections and onboard electrical equipment coupled to said first and second power-input connections;

a first idler pulley longitudinally aligned with said channel and positioned outboard of said first location;

a drive pulley rotatably powered by a drive motor, said drive pulley longitudinally aligned with said channel and positioned outboard of said second location;

a stationary power supply having first and second power output connections;

an electrically-conductive drive cable having a first end that is both electrically coupled to said first power-input connection and secured to said carrier, said drive cable also having a second end that is both electrically coupled to said second power-input connection and secured to said carrier, said cable being looped between said idler pulley and said drive pulley, said cable being positioned within said channel between first and second locations; and

an input inductance device that is stationary with respect to said track, said device having

a coil with at least one turn of wire, said wire having first and second ends respectively coupled to first and second power output connections; and

a ferromagnetic core which at least partially surrounds said cable and which magnifies the inductance of said coil.

19. The movable target system of claim **18**, wherein said core is toroidally-shaped.

20. The movable target system of claim **18**, wherein said core is substantially in the shape of geometric solid enclosed by the surface generated by rotating a rectangle 360 degrees about an axis that is outside the rectangle, parallel to one side of the rectangle, and equiplanar with the rectangle.

21. The movable target system of claim **18**, which further comprises a second idler pulley mounted between said second location and said drive pulley, said second idler pulley engaging said cable and serving to maintain said cable within said channel.

22. The movable target system of claim **18**, wherein said electrical equipment includes control circuitry and at least one electric motor for moving a target, said control circuitry controlling the operation of said electric motor.

23. The movable target system of claim **22**, wherein said electrical equipment further includes frequency sampling and decoding circuitry, and wherein the frequency of an induced alternating current in said cable matches that of a source alternating current, output by said power supply to first and second power output connections, and wherein the frequency of the source alternating current is modulated to provide decodable signals at the target carrier which are sampled by said frequency sampling circuitry and decoded by said decoding circuitry to produce control signals for said control circuitry.

24. The movable target system of claim **23**, wherein said electric motor, said control circuitry, said sampling circuitry, and said decoding circuitry are powered by direct current produced by rectifying at least some of said induced alternating current.

25. A movable target system comprising:

an electrically-conductive track having an upwardly-open channel extending substantially the full length thereof;

a target carrier movably mounted on said track between first and second locations, said carrier having first and second input connections and onboard electrical equipment coupled to said input connections;

a stationary power supply having first and second power output connections;

an electrically-conductive cable having first and second ends, said cable being positioned within said channel between said first and second locations, except within the confines of said target carrier;

an output inductance device mounted on and stationary with respect to said target carrier, said device having

a coil with at least one turn of wire, said wire having first and second ends respectively coupled to first and second power output connections; and

a ferromagnetic core which at least partially surrounds said cable, and which magnifies the inductance of said coil,

a first cable anchoring device to which said first end of said cable is anchored, said first anchoring device being longitudinally aligned with said channel, positioned outboard of said first location, said first *end of said* cable [anchoring device] being coupled to said first power output connection via said track; and

a second cable anchoring device to which said second end of said cable is anchored, said second anchoring device being longitudinally aligned with said channel and positioned outboard of said second location; said second *end of said* cable [anchoring device] being electrically coupled to said second power output connection.

26. The movable target system of claim **25**, wherein said core is toroidally-shaped.

27. The movable target system of claim **25**, wherein said core is substantially in the shape of geometric solid enclosed by the surface generated by rotating a rectangle 360 degrees about an axis that is outside the rectangle, parallel to one side of the rectangle, and equiplanar with the rectangle.

28. The movable target system of claim **25**, wherein said first cable anchoring device incorporates a cable tensioner.

29. The movable target system of claim **25**, wherein said target carrier includes means for lifting a portion of said cable from said channel within the confines of said carrier as it moves along said track.

30. The movable target system of claim **29**, wherein said means for lifting comprises:

first and second guide pulleys rotatably and rigidly affixed to said target carrier, said first and second guide pulleys being positioned at least partially within said channel; and

at least one other guide pulley rotatably and rigidly affixed to said carrier at a level above said first and second guide pulleys, said cable being routed from said first cable anchoring device, beneath said first guide pulley, out of said channel and over said at least one other guide pulley, into said channel and under said second guide pulley, then to said second cable anchoring device, said cable passing through said [output inductance device] *ferromagnetic core* while said cable is out of said channel.

31. The movable target system of claim **25**, where said electrical equipment includes a drive motor for driving said target carrier along said track, at least one target movement motor, and control circuitry for controlling the operation of said drive motor and said at least one target movement motor.

32. The movable target system of claim **31**, wherein said electrical equipment further includes frequency sampling and decoding circuitry, and wherein the frequency of an induced alternating current in said output inductance device matches that of a source alternating current output by said power supply to first and second power output connections, and wherein the frequency of said source alternating current is modulated to provide decodable signals at the target carrier which are sampled by said frequency sampling circuitry and decoded by said decoding circuitry to produce control signals for said control circuitry.

33. The movable target system of claim **32**, wherein said source alternating current is modulated to provide a stream of serial binary data.

34. The movable target system of claim **25**, wherein at least a portion of said induced alternating current is rectified to direct current and used to power at least a portion of said electrical equipment.

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