April 23, 1957 J. F. MARTIN 2,790,121

ANTENNA ROTATOR AND CONTROL SYSTEM

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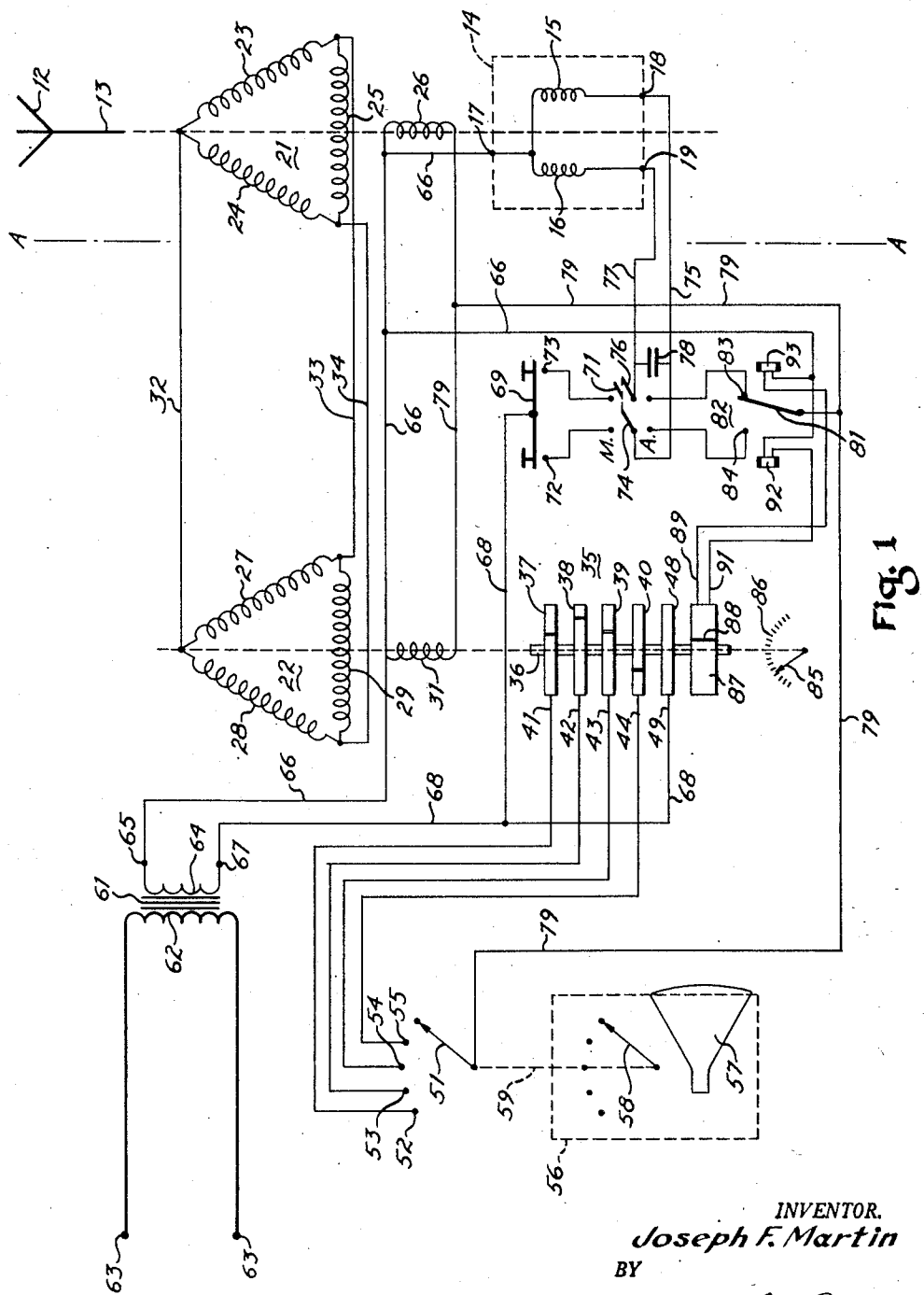


Fig. 1

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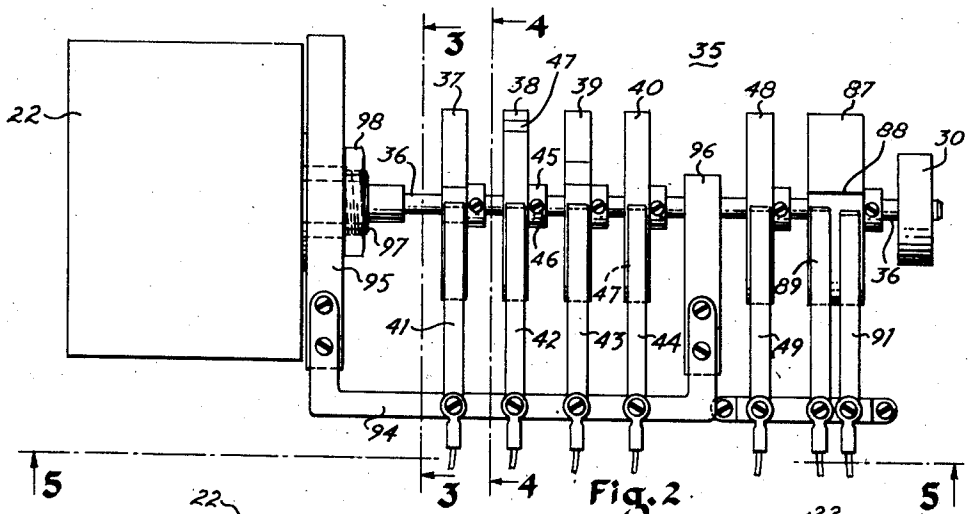


Fig. 2

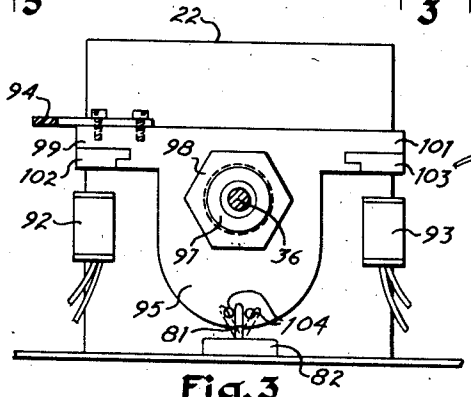


Fig. 3

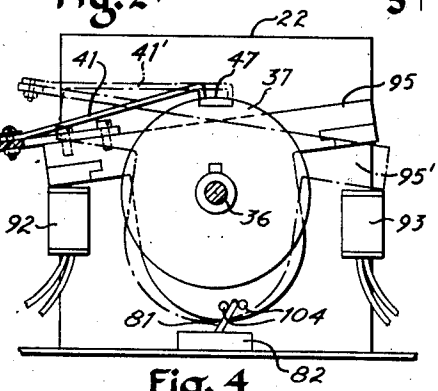


Fig. 4

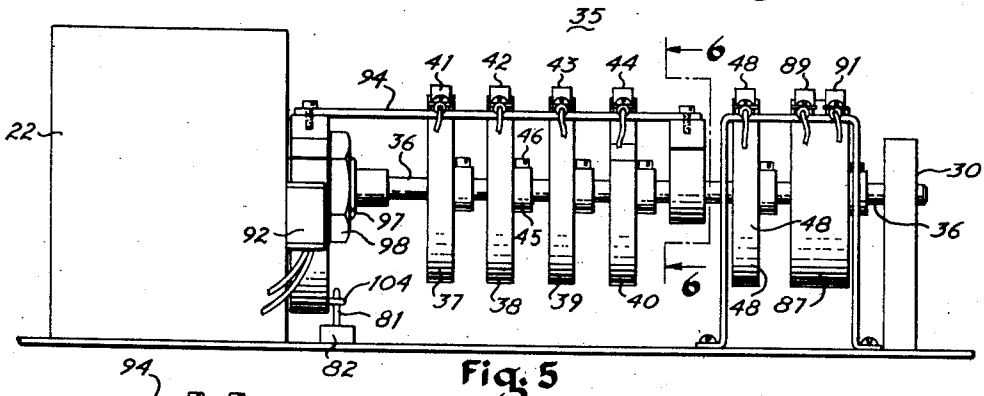


Fig. 5

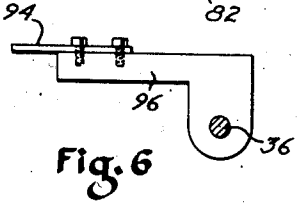


Fig. 6

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ANTENNA ROTATOR AND CONTROL SYSTEM

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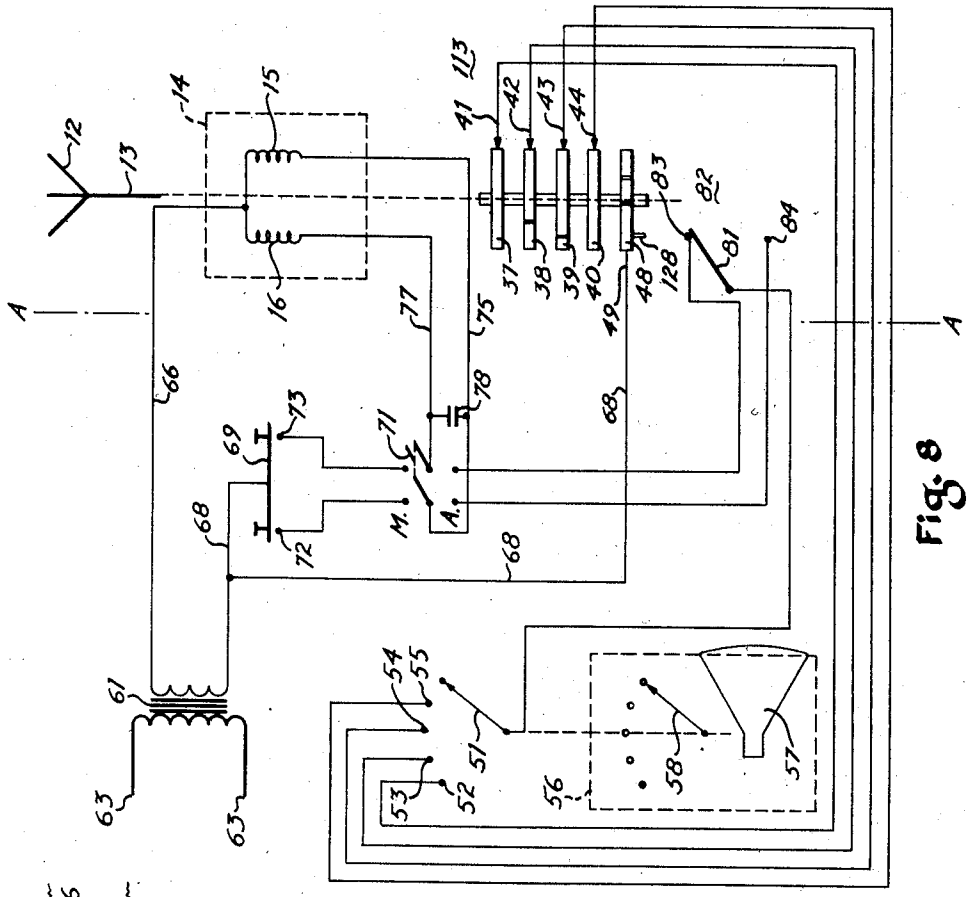


Fig. 8

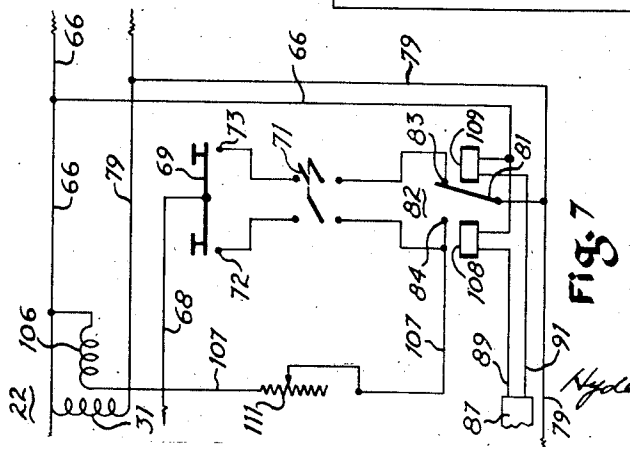


Fig. 7

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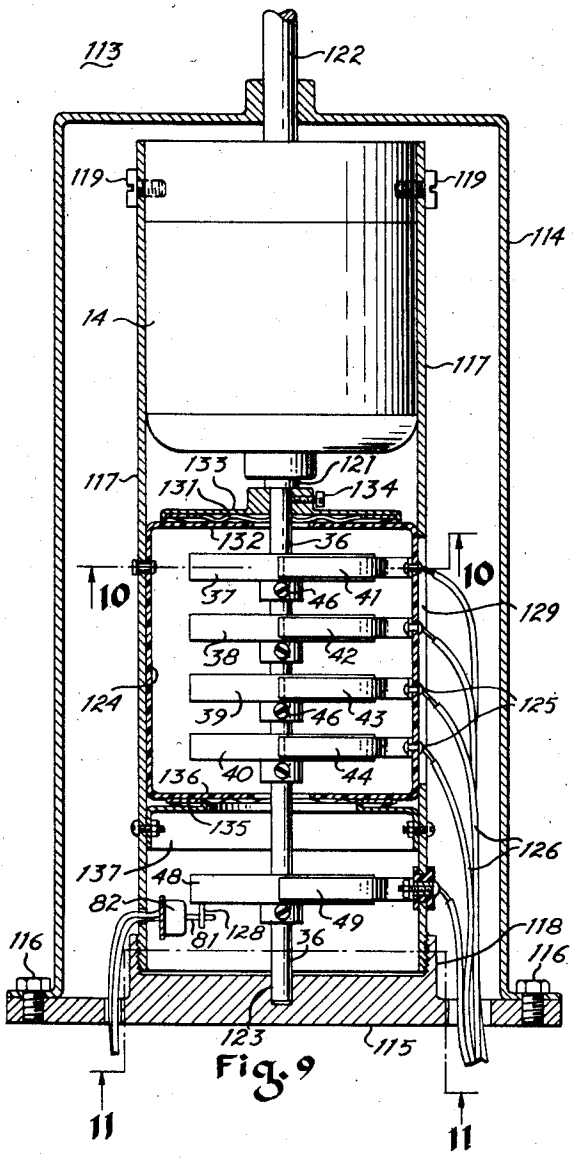


Fig. 9

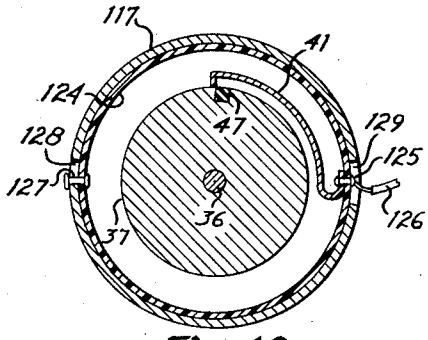


Fig. 10

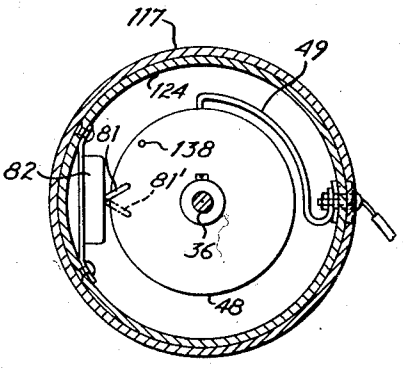


Fig. 11

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2,790,121

ANTENNA ROTATOR AND CONTROL SYSTEM

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Application August 9, 1954, Serial No. 448,556

21 Claims. (Cl. 318—33)

This invention relates in general to control systems for determining the angular position of a remote object in accordance with a selection made at a control point.

The invention is particularly concerned with television antenna rotators and is especially useful in providing a control system for such rotators which makes it possible through a single control to select the frequency channel and to orient the antenna in the direction of the television station.

The majority of television antennas in use at the present time have directional characteristics providing greatly increased sensitivity to signals arriving from a particular direction. The directivity is especially pronounced with high-gain antennas such as are used for fringe area reception. With such antennas, it is necessary to rotate the receiving axis of the antenna to point at the transmitting station in order to achieve good reception.

Various types of antenna rotators for this purpose are commercially available at the present time. Some units comprise a rotating mechanism which is mounted at a suitable elevation, for instance on a chimney or roof top, and which supports the antenna mast, and a control which is located at a point accessible from the television set. The rotating mechanism generally comprises a reversible electric motor which is geared down to a hollow hub accommodating the antenna mast.

The control may be a simple reversing switch for causing the electric motor to rotate the hub in one direction or the other. Generally the hub is limited to 360° of rotation; the antenna lead-ins or the transmission line can readily twist through this limited rotation and the need for slip rings with attendant maintenance and reception problems is thereby avoided. With this type of control the operator must gauge the orientation of the antenna by observing the increased signal strength as evidenced by the improvement in picture clarity when the antenna is pointing towards the transmitting station. This requires a certain amount of skill on the part of the operator and is at best a tedious procedure. With some units a form of indicator is provided at the control point to indicate on a compass card the training of the antenna. This control system falls short of the mark of completely automatic performance since the operator must, for each station which he desires to receive, make a special adjustment of the antenna control.

Accordingly the object of this invention is to provide a control system whereby an antenna rotator will automatically train the antenna to the transmitting station upon selection at the control point.

Another object of the invention is to provide a control system for an antenna rotator in connection with a television receiver which will automatically effect the training of the antenna towards the transmitting station upon the selection of the channel at the receiver.

Another object of the invention is to provide a control system for an antenna rotator including a plurality of training direction controller elements having means

allowing convenient adjustment and pre-setting of the training direction with relation to each of the elements.

A further object of the invention is to provide a control system for an antenna rotator having means for compensating for errors and discrepancies normally encountered in such systems and arising out of the limited tolerances of the components.

In accordance with the invention the antenna rotator control system comprises a training controller which is constrained to rotate in unison with the antenna. The training controller comprises a rotary driving portion which is maintained in unvarying angular relation to the antenna, and a plurality of conductive driven portions which are angularly adjustable with respect to the driving portion. Each of the driven portions is included in a separate translation circuit and determines one training direction of the antenna. The driven portions are angularly adjustable with respect to the driving portion whereby to allow for adjustment and pre-setting of the antenna training direction in each translation circuit. The translation circuits, each including a driven portion, are energized by a selector switch at the control point. Where desired, the selector switch may be incorporated in the channel selector switch of the television receiver in order to effect television channel selection and automatic antenna training through the operation of a single control or knob on the television receiver.

In the illustrated embodiment of the invention, the controller comprises a plurality of conductive discs angularly adjustable with respect to a shaft. The shaft constitutes the driving portion previously referred to which is maintained in constant angular relationship to the antenna. Each disc is provided with an insulator or non-conductive gap over a small angle and is engaged by a contactor which runs over the insulator as the disc rotates. The translation circuits, each including one of the discs and its contactor, determine the training direction of the antenna by reason of the interruption of the voltage supply to the training motor when the contactor encounters the insulator in its cooperating disc. The controller is provided with an additional disc for actuating a reversing circuit whose function is to automatically reverse the direction of rotation of the training motor at the 360° limits of rotation.

In one arrangement according to the invention, the training controller is located at the control point and is maintained in angular constancy with respect to the antenna by means of self-synchronous followers generally known as selsyns, the selsyn transmitter being located at the antenna and the selsyn receiver at the control point. In a variant of the invention, the training controller is located at the antenna and may be directly coupled to the hub in which the antenna mast is engaged. In either case the selector switch is located at the control point, for instance in the television receiver. Where the training controller is located at the antenna, a cable is provided to connect the training selector switch contacts to the discs of the training controller.

In any control system, errors will unavoidably occur due to the finite tolerances and performance characteristics of the component elements. For instance, an error may creep in with respect to the training of the antenna by reason of the finite width of the insulator in the controller disc and of the finite width of the contactor where it engages the disc. Error may also occur as a result of lag of the selsyn receiver relative to the selsyn transmitter if the units selected tolerate appreciable phase differences. In accordance with the invention, such errors may be eliminated or substantially reduced by providing a correction, either mechanical or electrical, in respect of the engagement of the insulators in the controller discs by their associated contactors. In one em-

bodiment of the invention, such correction is effected by swinging or oscillating the whole bank of contactors back or forth through a small angle whenever the training motor reverses its direction of rotation. In another embodiment of the invention, the correction is effected electrically by shifting the phase of the signal to the selsyn receiver through a small angle.

For further objects and advantages and for a better understanding of the invention and appreciation of its various features, attention is now directed to the following description and accompanying drawings. The features of the invention believed to be novel will be more particularly pointed out in the appended claims.

Fig. 1 is a combined electrical and schematic diagram illustrating the control system for an antenna embodying the invention.

Fig. 2 is a plan view of the training controller schematically represented in Fig. 1.

Fig. 3 is a section through the controller along lines 3—3 in Fig. 2

Fig. 4 is a section through the controller along lines 4—4 in Fig. 2.

Fig. 5 is a side elevation of the controller, being the view of Fig. 2 seen along lines 5—5.

Fig. 6 is a detail of the controller, being a view of Fig 5 seen along lines 6—6.

Fig. 7 illustrates schematically a modification applicable to the circuit of Fig. 1 for effecting error correction through phase shifting in the selsyn units.

Fig. 8 is a mechanical and electrical schematic diagram of a variant of the invention wherein the controller is located at the antenna.

Fig. 9 is a sectional elevation through the form of training controller used with the control system of Fig. 8.

Fig. 10 is a sectional view through the training controller of Fig. 8 taken along lines 10—10 of Fig. 9.

Fig. 11 is a sectional view through the training controller of Fig. 8 taken along lines 11—11 of Fig. 9.

Referring to Fig. 1, the elements illustrated to the right of broken line A—A in the drawing are located at the antenna whereas those to the left are located at the control point, either in the television receiver itself or at some place close thereto. Antenna **12** may be of any type suitable for high frequency reception and having directional characteristics as a result of which it has increased sensitivity along its receiving axis. In the usual case, antenna **12** will be designed for reception of television signals either in the very high frequency band, or in the ultra high frequency band, or in both. In its physical structure the antenna will normally consist of an assembly of spaced radiators, some operating as receptors and others as reflectors, the assembly or stack being supported on a vertical mast or post **13**.

The antenna is supported at a suitable elevation by an antenna rotator represented in block form by dotted rectangle **14**. The antenna rotator may be of conventional construction in any of the styles commercially available. In the usual case the rotator comprises a hollow hub supported in bearings in a casing, the casing being fixed at a siutable elevated point, for instance, on a chimney or a roof ridge, with the axis of the hub vertical. The hub is usually made hollow right through in order to allow adjustment of the antenna height by sliding the mast vertically through the hub prior to clamping it. The hub is rotated by a reversible electric motor which is geared thereto by reduction gearing in conventional fashion. For convenience herein, winding **15** will be taken to denote the circuit of the training motor causing forward or clockwise rotation of the antenna, and winding **16** to denote the circuit causing reverse or counter-clockwise rotation, as viewed in Fig. 1 looking upwardly from antenna rotator **14** toward antenna **12**. Of course only one winding is energized at one time; thus the application of a suitable A. C. voltage across common terminal **17** and terminal **18** will energize winding **15** to produce forward rotation of the antenna, whereas the application of voltage across common terminal **17** and terminal **19** will energize winding **16** to produce reverse rotation of the antenna.

The training or angular orientation of the antenna is repeated at the control point by means of synchronous followers generally referred to as selsyns. The selsyn transmitter **21** is located at the antenna, and the selsyn receiver **22**, at the control point. In the usual construction, the selsyn transmitter comprises a stator and a rotor; the stator includes a magnetic frame with three windings **23—25** spatially distributed thereon with magnetic axes at 120° angular intervals, whereas the rotor comprises a rotatable magnetic core with a single winding **26** to define a single magnetic axis. The rotor **26** may be arranged for continuous rotation, in which case it is provided with slip rings, or may be arranged for limited rotation only within a range of approximately 360°, in which case slip rings may be dispensed with and use made of flexible leads allowing the required degree of twist. The selsyn receiver **22**, which may be identical in construction to the selsyn transmitter **21**, comprises stator windings **27—29** and rotor winding **31**.

The operation of the selsyn units may be summarized as follows. In use, both rotor winding **26** of transmitter **21** and rotor winding **31** of receiver **22** are energized in identical fashion from an alternating voltage source, for instance, from the usual 60 cycle commercial supply. The alternating magnetic field produced by rotor winding **26** will induce components of voltage in stator windings **23—25** in accordance with the components of their magnetic axes along the magnetic axis of the rotor winding. For instance, if the magnetic axis of the rotor should coincide with the magnetic axis of one of the stator windings, that stator winding will have a maximum A. C. voltage induced in it, where as the other two stator windings will have equal and opposite A. C. voltages of lesser magnitude induced in them. A similar condition prevails at selsyn receiver **22**. If now rotors **26** and **31** are in the same angular orientation relative to their respective stator windings, the voltages induced across the stator windings in the transmitter and in the receiver will be exactly equal; therefore no current will flow through conductors **32—34** interconnecting the terminal points of the windings in the two selsyns. If now rotor winding **26** is angularly displaced, voltage differences will arise between the stator windings of the transmitter and those of the receiver resulting in current flow through conductors **32—34**. These currents circulating through stator windings **27—29** of receiver **22** will tend to set up a magnetic axis coinciding with the magnetic axis of rotor **26** in transmitter **21**. The resultant magnetic axis will exert a torque on rotor **31** which will thereupon rotate until its magnetic axis arrives into coincidence with that resulting from current flow in the stator windings. Upon achieving coincidence, the voltages induced in the stator windings in the transmitter and receiver are restored to equality and current flow through conductors **32—34** ceases. Thus rotor windings **26**, **31** are maintained in identical angular orientation. It will be appreciated of course that either one of selsyns **21** or **22** may operate as the transmitter, the other then operating as the receiver. In the present arrangement, rotor **26** is coupled to the shaft or hub of antenna rotator **14** so that selsyn **21** operates as the transmitter. Selsyn **22** operates as the receiver and its rotor repeats, at the control point, the rotation of the antenna, its angular orientation being determined by the training of the antenna.

The rotor **31** of selsyn receiver **22** is coupled to the driving portion of a training controller **35**. In the illustrated embodiment in Fig. 2, the driving portion is a shaft **36**, fast to the rotor shaft of the selsyn receiver at one end and supported in a bearing bracket **30** at the other end. The shaft supports the driven members in the form of a plurality of discs **37—40** of any desired num-

ber but here shown as four in number, which are engaged peripherally by contactors 41–44. As may be seen in Figs. 2 and 5, provision is made for allowing angular adjustment of the discs relative to the shaft. Each disc has a hub portion 45 provided with a radial locking screw 46 which is loosened to allow the disc to be rotated relative to the shaft and which is tightened to lock the two together. The controller discs 37–40 and also the shaft 36 are electrically conductive so that circuit continuity from the shaft to the contactors exists for all angular positions of the discs except when a non-conductive portion or insulator 47 in a disc happens to come underneath the edge of the contactor. Circuit continuity into the shaft is effected through an auxiliary disc 48 and its associated contactor 49; disc 48 does not have a non-conductive portion or insulator and serves as an ordinary slip ring.

Each of the controller discs 37–40 along with its associated contactor is included in an individual translation circuit for determining a particular training direction or orientation of the antenna upon selection at the control point. The training direction afforded by any one circuit is determined by the angular adjustment of its controller disc relative to shaft 36. Since the shaft 36 is maintained by the selsyns in constant angular relationship with the antenna, adjustment of the selector discs with respect to the shaft is in fact equivalent to adjustment with respect to the antenna.

The choice of controller disc or translation circuit is effected through selector switch 51 located at the control point. The switch has a terminal for each controller disc, terminals 52–55 being connected to contactors 41–44 of discs 37–40 respectively. Selector switch 51 is located so as to be accessible to the operator in tuning the receiving equipment, for instance it can be mounted in a small cabinet suitable for placing on top of a television receiver.

In a preferred arrangement, the training selector switch is mechanically linked to the channel selector switch of a television set so that turning the channel selector knob to the desired channel will at the same time result in training the antenna to the required direction, that is, with its axis directed towards the transmitting station to which the set is tuned. In the usual case, a television set, represented herein by the dotted rectangle 56 containing kinescope or picture display tube 57, includes a station selector switch 58 of the multi-section rotary type. In the majority of television sets, these switches are of the continuous rotation type having twelve positions, one for each of the now existing V. H. F. channels 2 to 13. In a preferred arrangement according to the invention, the training selector switch 51 is included as an additional wafer or section carried on the same shaft as the sections of the channel selector switch 58 of the television receiver, the common shaft being represented in the drawing by the dotted line 59. It will readily be appreciated that such an arrangement provides the ultimate in convenience since after the initial adjustment of the discs on the training controller, the operator of the television receiver has only to turn the channel selector knob in the usual fashion to receive the desired television station and the antenna will automatically be oriented in the proper direction.

The circuit arrangement for determining the training of the antenna rotator through the training controller is as follows. A step-down transformer 61 has a primary winding 62 which is energized at 63 from the usual 115–120 volt 60 cycle A. C. supply and a secondary winding 64 providing an output voltage in the range of 20 to 30 volts, for instance 24 volts as commonly used for control circuits. This lower voltage is suitable for operating the reversing motor of the antenna rotator 14 and also for operating the selsyn units; it is used in preference to the usual 115–120 volts because its reduces the personnel shock hazard and the insulation requirements.

Terminal 65 of secondary winding 64 is connected through conductors 66 to one side of the rotor windings 26, 31 of the selsyn units and to common terminal 17 of the antenna rotator. The other terminal 67 of secondary winding 64 is connected through conductors 68 to contactor 49 of the auxiliary disc or slip ring 48 on the training selector, and to the armature of a double pole reversing switch 69.

In the illustrated embodiment, provision has been made for manual or automatic control of the antenna rotator by means of a double-pole double-throw switch 71. When switch 71 is thrown to its upper position marked M, the unit is under manual control; when the switch is thrown to its lower position marked A, the unit is under automatic control through the selsyns and the training controller.

In manual operation, the antenna rotator is rotated forward, that is in a clockwise direction, by closing switch 69 to terminal 72; it is rotated in the reverse direction by closing the switch to terminal 73. In the former case, the circuit continuity from terminal 67 occurs through conductor 68, contact 72 of switch 69, blade 74 of switch 71 and conductor 75 to terminal 18 of the antenna rotator to energize forward winding 15. In the latter case, circuit continuity is effected through contact 73 of switch 69, blade 76 of switch 71 and conductor 77 to terminal 19 of the antenna rotator to energize reverse winding 16. The usual capacitor 78 for the antenna training motor is connected across conductors 75, 77. The standard antenna rotator 14 generally has means to prevent rotation substantially beyond 360° by manual switch 69, if necessary to protect the leads from antenna 12.

In automatic operation, the circuit continuity from terminal 67 of secondary 64 is effected through one of the discs 37–40 of training controller 35 and one of the contacts of selector switch 51, through conductor 79 to the armature 81 of an automatic reversing switch 82, and to the opposite side of the selsyn rotors 26 and 31. The choice of controller disc or translation circuit is made by turning selector switch 51 to the desired position. Continuity from terminal 67 to conductor 79 will occur except in the event that the antenna is already trained in the proper direction. In such case, the contactor of the controller disc would be bearing against the insulator in that disc and circuit continuity would not occur; however that would mean that the antenna is already trained in the proper direction and no rotation is required. However in the usual case, the training direction will be different for each television channel so that upon turning switch 51, say to contact 52, circuit continuity would occur through contactor 41 and its associated disc 37. Depending upon the position of armature 81 of switch 82, either in engagement with contact 83 as shown or in engagement with contact 84, circuit continuity is effected to conductors 77 or 75 and to terminals 19 or 18 of the antenna rotator.

The function of automatic reversing switch 82, whose structure and organization will be described in detail shortly, is to reverse the connections to terminals 18 and 19 at the 360° limits of rotation of the antenna. The operation of the system then is as follows. Assuming that in moving control switch 51 to a new contact, the new training direction is angularly located in a forward or clockwise direction from the old and that the reversing switch is already positioned to cause clockwise rotation of the antenna rotator, the antenna will immediately begin rotating and will stop when the contactor of the controller disc in circuit engages the insulator in the disc. Assuming however that the new training direction is angularly located counter-clockwise from the old and that the reversing switch is already positioned for clockwise rotation, then the antenna will rotate in a clockwise direction to its 360° limit of rotation. At that point, switch 82 will reverse and the antenna will proceed to rotate in a counter-clockwise direction until the contactor of the

controller disc in circuit engages the insulator of that disc. Rotation will thereupon cease and the antenna will be properly oriented.

It will be noted that the circuit continuity of the selsyn rotor coils 26 and 31 is also effected through the controller disc so that the selsyns are also deenergized when the antenna is properly oriented. This feature economizes on power and also permits underrating the selsyn units by reason of the very low duty cycle, it being assumed that the antenna rotator is inactive most of the time and is rotated at relatively long intervals only.

If desired, a pointer 85 may be attached to shaft 36 of the training controller to indicate on a compass card 86 the training direction of the antenna.

The reversing switch 82 is controlled through auxiliary disc 87 on shaft 36 of the training controller. This disc, unlike discs 37—40 and 48, is made of insulating or non-conductive material except for a thin conductive strip or bar 88 on its circumference which is connected to shaft 36. Disc 88 is approximately twice as wide as the other discs of the selector and is engaged by a pair of contactors 89, 91 which bear against its periphery. One of the contactors, 89 as shown in Fig. 2, is advanced a few degrees with respect to the other contactor 91. The purpose of this arrangement is to insure that the conductive strip 88 will always be positively engaged by only one contactor at the limit of rotation in one direction, and by only the other contactor at the limit of rotation in the other direction. Considering the direction of rotation as seen in a right end view of the selector in Fig. 2, when the controller shaft 36 is rotating clockwise, strip 88 will always first engage contactor 91; in counter-clockwise rotation, the strip will always first engage contactor 89. As soon as a contactor is engaged, the reversing switch is energized and the direction of rotation reverses, so that only one of the contacts in switch 82 is engaged at the limit of rotation in either direction. This arrangement leaves a narrow blind spot in the control system which is of approximately the angular width between the ends of the contactors 89, 91. This blind spot is at most a few degrees wide and its location can be made to coincide with an antenna training direction in which there is no television station so that it does not constitute any real disadvantage or shortcoming.

The actuation of reversing switch 82 is effected by the energization of one or the other of solenoids 92, 93, which energization of course occurs at the instant when strip 88 in auxiliary disc 87 engages contactors 89 or 91. It will be appreciated that an ordinary reversing type of lock-in relay could be used for switch 82.

In the illustrated embodiment, as shown particularly in Figs. 3 and 4, a specialized arrangement is used which also serves to compensate for errors in antenna training resulting from the finite tolerances of the various elements in the system and from the appreciable width of the insulator gaps 47 in the controller discs 37—40.

If no error compensation were made, antenna orientation might vary depending upon whether the antenna moved clockwise or counter-clockwise in arriving at its rest position. Error may result from the width of the insulator gaps 47, the coasting angle of the rotator before coming to a full stop, the amount of inertia and rotational friction of the rotating parts, any angular lag of the selsyn receiver with respect to the selsyn transmitter, etc. The summation of these errors may, upon reversal of rotation, require shift of the contactors 41—44 in the rotational direction of shaft 36 or in the opposite direction. Or again, no shift may be required since the errors may cancel each other out because some of the factors cause error in opposite directions. For example, selsyn 22 may lag behind the angular position of selsyn 21 to require the contactors to be shifted opposite to the direction of rotation while a large circumferential width of each insulator gap 47 would require the contactors to be shifted in the direction of rotation so as to compensate for the respective errors.

Compensation for the error summation can take various forms. First, the circumferential width of insulator gap 47 can be designed so as to compensate for and cancel out the other errors. Second, the whole bank of contactors 41—44 may be oscillated back or forth through a small angle each time the direction of rotation of the antenna reverses, as shown by the construction in Figs. 1–6 and Figs. 8–11. Third, the magnetic axis in one of the selsyns 21—22 may be shifted to compensate for the summation of errors, as shown in Fig. 7 construction. It will be apparent as the description proceeds that error compensation may be caused to take place in either direction, upon suitable modification, by the Figs. 1–7 constructions or in only one direction by the Figs. 8–11 construction. However, only one direction of error compensation is illustrated in each form of the invention.

The arrangement in Figs. 1–6 will first be described and has the advantage of permitting easy and convenient adjustment of the small angle of contactor shift when the antenna installation is being made.

Referring particularly to Figs. 3 and 4, the contactors 41—44 are shown, for example, as being shifted in the direction of rotation of the discs in order to retard the instant of circuit interruption. To this end, contactors 41—44 are mounted on a non-conductive frame 94, supported near the selsyn receiver 22 by a rocking plate 95 and at an intermediate point rotatably on shaft 36 by means of an L-shaped bracket 96 shown in Fig. 6. Rocking plate 95 is pivotally borne on a bushing 97 coaxial with shaft 36, and is axially restrained by nut 98 threaded on the end of the bushing. Rocking plate 95 has laterally extending wings 99—101 provided with pole pieces 102, 103 respectively. When solenoid 92 is energized, pole piece 102 is attracted and the rocking frame tilts, thereby rotating contacts 41—44 in a counter-clockwise direction to a position indicated in solid lines in Fig. 4. When solenoid 93 is energized, pole piece 103 is attracted and the contactors are rotated in a clockwise direction to a dot-dash line position shown at 41′ in Fig. 4. Armature 81 of switch 82 is at the same time engaged by armature straddling pins 104 near the lower edge of the rocking plate and the pins cause the armature to snap to either its right or left position corresponding with circuit continuity to contacts 83 or 84 as shown in Fig. 1. The rocking plate 95 is held in one position or the other of Fig. 4 after solenoid energization by suitable means such as the frictional support of its mounting, by the position of reversing toggle switch armature 81 straddled by pins 104 or by a toggle mechanism or other suitable means. The angle through which the contactors are shifted or oscillated back and forth when the antenna training motor reverses is varied for example, by adjusting solenoids 92, 93 on their support so as to shift the place of engagement with pole pieces 102, 103.

Hence, the contactors 41—44 are shifted in the direction of rotation. For example, when shaft 36 is being rotated counter-clockwise in Fig. 3, conductive strip 88 engages contactor 89 to energize solenoid 93. This rocks frame 94 clockwise, closes reversing switch 82 to contact 84, and energizes motor winding 15 to cause clockwise rotation. If it is desired to shift the contactors in the direction opposite to rotation, it is merely necessary to rearrange the leads to energize opposite solenoids and to reverse the position of reversing switch 82. Then when shaft 36 is being rotated counter-clockwise in Fig. 3, conductive strip 88 engages contactor 89 to energize solenoid 92. This rocks frame 94 counter-clockwise, closes reversing switch 82 to contact 84, and energizes motor winding 15 to cause clockwise rotation.

Referring to Fig. 7, there is shown another arrangement in accordance with the invention for effecting correction of the errors introduced by the finite tolerances of the system components. The circuit fragment shown

in Fig. 7 is directly transposable into the circuit of Fig. 1 and corresponding elements have been assigned the same reference numerals. The circuit of Fig. 7 is accordingly to be considered as merely a part of a modified version of the circuit of Fig. 1. Any modifications that do occur are shown in the portion of the circuit illustrated in Fig. 7.

Instead of relying upon mechanical shifting of the contactors to correct for training errors inherent in the system, the modification of Fig. 7 achieves the same end by electrically shifting the magnetic axis of the rotor of the selsyn receiver **22**. This requires a modified form of selsyn where, in addition to usual rotor winding **31**, there is provided an auxiliary rotor winding **106**. The auxiliary winding is disposed with its magnetic axis at right angles to the main rotor winding **31** so that if the auxiliary winding alone were energized, the effective magnetic axis of the rotor would be shifted by 90°. One side of auxiliary winding **106** is connected to conductor **66** which, as shown in Fig. 1, provides circuit continuity to terminal **65** of secondary winding **64** of transformer **61**. The other side of auxiliary winding **106** is connected by conductor **107** to terminal **84** of reversing switch **82**. The armature **81** of switch **82** is connected by conductor **79**, through control switch **51** and training controller **35**, to terminal **67** of secondary winding **64** of transformer **61** (Fig. 1). The switching arrangement for reversing switch **82** including the solenoids **92, 93** and the rocking plate **95** shown in Figs. 2 to 5 may be used if desired in the instant modification. However it will be appreciated that the relatively complex arrangement of the rocking plate and solenoids **92, 93**, one of whose primary functions is to shift or oscillate the contactors, is not needed here. A simple form of snap-action reversing switch with reversing windings **108, 109** may be used as shown in Fig. 7. The circuit connections to the reversing windings are similar to those used with solenoids **92, 93**. One side of each reversing winding is connected to conductor **66**. The other side of winding **108** is connected to contactor **89** of auxiliary disc **87** whereas the other side of winding **109** is connected to contactor **91**. However, engagement of contactor **89** by strip **88** during counter-clockwise rotation energizes solenoid **93** in Fig. 1 to close contact **84** but energizes solenoid **108** in Fig. 7 to close contact **84** to cause antenna rotation in the same direction.

It will be seen that when the antenna is rotating in the direction corresponding to the closing of armature **81** to contact **83** in reversing switch **82**, main rotor winding **31** only in selsyn **22** is energized. However when thereafter the antenna rotation is reversed by the closing of armature **81** to contact **84**, auxiliary winding **106** also becomes energized in addition to main winding **31** in the rotor of selsyn receiver **22**. This causes an angular shift in the effective or resultant magnetic axis of the selsyn receiver, either clockwise or counter-clockwise depending on the direction of the magnetic force caused by auxiliary winding **106** and on whether winding **106** is on rotor **31**, as shown, or on rotor **26**. The rotor of the selsyn receiver is shifted with respect to the rotor of the selsyn transmitter, and correspondingly with respect to the antenna. The degree of correction may be controlled by adjusting potentiometer **111**, connected in series by conductor **107** between auxiliary winding **106** and switch contact **84**.

Similar magnetic shift is obtained by substituting a condenser in Fig. 7 for coil **106** and potentiometer **111** with this condenser connected in parallel with selsyn rotor windings **26, 31** or disconnected responsive to the position of armature **81**. Condenser means may, instead, be in parallel with one or more of the stator windings **23—25, 27—29** with connection or disconnection controlled by location of armature **81**.

Fig. 8 illustrates a variant of the invention. Controller **113**, located at the antenna, is coupled directly to antenna rotator **14** and antenna mast **13**. Elements appearing to the right of broken vertical line A—A are at the antenna and elements appearing to the left are at the control point or in the television receiver **56**. Contactors **41—44** engaging discs **37—40** in training controller **113** are connected to terminals **52—55** respectively of control switch **51**.

Controller **113** in Figs. 9 to 11 makes use of a different arrangement for shifting the contactors back and forth for error compensation. The unit is enclosed in housing **114** standing upright on base member **115** and fastened thereto at **116**. Within the housing, upstanding cylindrical casing **117** is supported by the base member by being threaded into an upwardly extending flange portion **118**. The reversing motor and the reduction gearing for antenna rotator **14** are mounted by screws **119** in casing **117**. The internal structure of rotator **14** is not critical to the invention and it may take any convenient form achieving as an end result that lower projecting shaft portion **121** rotates at the same speed as the antenna. In the usual case, upper projecting shaft portion **122** will also rotate at the same speed as portions **121** and will be used directly to rotate the antenna **12**. The shaft **36** is coupled directly to shaft portion **121** and extends downwardly and coaxially through the casing, the lower end of the shaft being accommodated in a bearing at **123** in base member **115**. Discs **37—40** are mounted in the usual fashion on shaft **36**, the locking screws **46** allowing angular adjustment of the discs as explained earlier.

The contactors **41—44** which engage controller discs **37—40** are fastened on the interior cylindrical wall of a drum **124**. The drum **124** makes a bearing fit within casing **117**. As best seen in Fig. 10, the contactors **41—44** are fastened to drum **124** by rivets **125** which also serve as terminals whereat to solder the lead wires **126** for the contactors. As illustrated in the drawings, drum **124** is made of a non-conductive material such as a suitable insulating plastic. The drum could be made of a conductive material such as metal, but in that case it would be necessary to rivet or otherwise fasten the ends of the contactors to insulating eyelets fastened to the drum. The drum is free to rotate with respect to the casing but is limited to a few degrees of angular displacement by a stop pin **127** locked into the drum and having a projecting portion riding in a circumferential slot **128** in the casing **117**. Casing **117** is vertically slotted at **129** in order to accommodate the projections of rivets **125** and also to permit access for the lead wires **126**. The slot is of sufficient circumferential width to accommodate the rivet projections without contact throughout the angular displacement or oscillation of the drum relative to the casing, as determined by the width of slot **128** in conjunction with stop pin **127**.

Drum **124** is frictionally coupled to shaft **36** by means of a ruffled spring clutch plate **131** of circular form which is compressed lightly between the upper circular wall **132** of the drum **124** and a friction plate **133** locked to a shaft **36** by a set screw **134** in its hub portion. The axial downward thrust on the drum is taken up by a washer **135** which bears against the lower circular wall **136** and which is supported in turn by an inwardly flanged ring **137** fastened to casing **117**.

A different and simplified arrangement is provided for operating reversing switch **82** wherein auxiliary disc **87** and solenoids **92, 93** are eliminated. Switch **82** is supported within casing **117** with its armature **81** extending inwardly, that is toward shaft **36**. Auxiliary disc **48** which serves here, in the same fashion as in training controller **35**, to provide circuit continuity to shaft **36**, is provided with a downwardly projecting pin **138**. The pin is disposed to engage armature **81** of switch **82** at the limits of rotation in either direction. The armature **81** is thereby snapped from one position indicated in solid lines at **81** to the other position indicated in broken

lines at 81' when disc 48 rotates in the direction of the arrow (Fig. 11) whereby to reverse the circuit connections to the antenna rotator as explained heretofore. Hence, counter-clockwise rotation of shaft 36 in Fig. 11 moves switch armature 81 to position 81' in Fig. 11 to close contact 84 in Fig. 8. The final result is the same as that achieved in Fig. 1 wherein shaft 36 causes strip 88 to engage contactor 89 to energize solenoid 93, thereby closing switch 82 to contact 84 to cause antenna rotation in the same direction.

As the antenna and the shaft 36 begin to rotate in one direction immediately after throwing reversing switch 82, the ruffled spring clutch plate 131 causes a turning effort to be transmitted to drum 124. The drum thus initially rotates in the same direction as the shaft and selector discs, but its motion is arrested as soon as pin 127 reaches the limiting edge of circumferential slot 128. The contactors 41—44, being supported by the drum, thus oscillate back or forth through a small angle each time the selector shaft reverses its direction of rotation. By suitable adjustment of the circumferential width of slot 128, the training error such as that resulting from the width of the insulator or non-conductive gap 47 in the controller discs, may be compensated for.

The remaining elements of the circuit of Fig. 8 are similar to those which have been described by reference to Fig. 1. The control system is energized from transformer 61 and there are provided the reversing switch 69 for manual operation and the double-pole double-throw switch 71 for placing the unit under either manual or automatic control. Under manual operation, the direction of rotation of the antenna rotator is controlled by reversing switch 69. Under automatic operation, the direction of rotation of the antenna reverses automatically at the limits through the actuation of switch 82; the training direction is determined by the adjustment of the controller disc 37—40 included in the translation circuit energized by selector switch 51.

The circuit of Fig. 8 has the advantage of eliminating the additional complication and cost entailed by the selsyn followers. It has the disadvantage that the discs of the controller, being located at the antenna, are not as readily accessible for adjustment and that no pointer 85 of Fig. 1 is provided at the control point to facilitate adjustment by manual actuation of switch 69. However in view of the fact that the discs are only adjusted at rare intervals, as when a television station changes frequency channel or when a new station becomes available, this is not a very serious objection and, in the case of a low cost unit, is more than offset by the savings effected through the elimination of the selsyn units.

It should be apparent that the reversing switches in each circuit are only used when antenna rotation is restricted to 360° to protect the antenna leads from damage by twisting. If slip rings or other suitable means are provided for removing the antenna signal so that rotation in the same direction is satisfactory, the reversing switches can be removed and error compensation may no longer be important.

The number of sets of contactors 41—44 and discs 37—40 in each form of the invention correspond with the number of antenna positions to be automatically obtained. Four are shown herein but any number of sets may be used. Also, the scope of this invention includes not only these contactors and discs but also other means responsive to different predetermined positions of the rotary shaft 36 for deenergizing antenna rotor 14 to perform the same results.

While certain specific embodiments of the invention have been shown and described, they are intended as illustrative examples and not as limitations relative to the invention. The broad principles which have been stated and explained for effecting completely automatic training of an antenna through a selection made at the control point and for other inventive aspects of the disclosure may be carried out in structural arrangements differeing considerably from those which have been described. The appended claims are intended to cover any such modified arrangements or variants coming within the true spirit and scope of the invention.

What I claim and desire to secure by Letters Patent of the United States is:

1. In combination with a high frequency receiver having a frequency channel selector, a system for controlling the training of an antenna for said receiver comprising an antenna rotator including an electric motor, a rotary member, means constraining said rotary member to angular constancy with respect to said antenna, a selector switch for energizing a circuit in at least two switch positions for rotating said motor, each of said circuits including means responsive to a different predetermined position of said rotary member for deenergizing said motor, said selector switch being operatively connected to said frequency channel selector to move in response thereto, means for reversing the rotation of said motor when predetermined angular limits are reached in either direction of rotation, and means for shifting the relationship between said rotary member and said position responsive means upon each reversal to compensate for errors in antenna training resulting from such reversal.

2. A system for controlling the training of an antenna comprising driving means for rotating said antenna, a training controller comprising a rotary driving member supporting a conductive rotary driven member, means constraining said driving member to angular constancy with respect to said antenna, a contactor engaging said driven member throughout its angular displacement, a non-conductive portion in said driven member extending over a narrow sector of the path of engagement of the member by the contactor, said driven member being angularly adjustable with respect to the driving member in order to allow adjustment of the angular position of said non-conductive portion to determine a training direction for said antenna, means connecting said driven member and said contactor in a circuit for energizing said driving means, means for reversing the rotation of said driving means when predetermined angular limits are reached in either direction of rotation, and means for shifting arcuately the relationship between said rotory driven member and contactor upon each reversal to compensate for errors in antenna training resulting from such reversal.

3. A system for controlling the training of an antenna comprising driving means for rotating said antenna, a training controller comprising a rotary driving member supporting a plurality of rotary driven members, means constraining said driving member to angular constancy with respect to said antenna, a plurality of contactors engaging said driven members throughout their angular displacement, a non-conductive portion in each of said driven members extending over a narrow segment of the path of engagement of the member by its contactor, said driven members being angularly adjustable with respect to the driving member in order to allow adjustment of the angular positions of said non-conductive portions to determine various training directions for said antenna, a selector switch for connecting one of said driven members and its associated contactor into a circuit for energizing said driving means, means for reversing the rotation of said driving means when predetermined angular limits are reached in either direction of rotation, and means for shifting arcuately the relationship between each of said rotary driven members and contactors upon each reversal to compensate for errors in antenna training resulting from such reversal.

4. A system for controlling the training of an antenna comprising driving means for rotating said antenna, a training controller comprising a rotary driving member supporting a plurality of conductive rotary driven members, means contraining said driving member to angular constancy with respect to said antenna, a plurality of con-

tactors engaging said driven members throughout their angular displacement, a non-conductive portion in each of said driven members extending over a narrow segment of the path of engagement of the member by its contactor, said driven members being angularly adjustable with respect to the driving member in order to allow adjustment of the angular positions of said non-conductive portions to determine various training directions for said antenna, a selector switch for connecting one of said driven members and its associated contactor into a series circuit for energizing said driving means whereby said circuit is opened and said driving means is deenergized when the non-conductive portion in the driven member engages its associated contactor, means for reversing the rotation of said driving means when predetermined angular limits are reached in either direction of rotation, and means for shifting arcuately the relationship between each of said rotary driven members and contactors upon each reversal to compensate for errors in antenna training resulting from such reversal.

5. A system for controlling the training of an antenna comprising a rotator including an electric motor for rotating said antenna, a training controller comprising a rotary driving member supporting a plurality of conductive controller discs, means constraining said driving member to angular constancy with respect to said antenna, a plurality of contactors engaging said discs throughout their rotation, a non-conductive portion in each of said discs extending over a narrow sector of the path of engagement of the disc by its associated contactor, said discs being angularly adjustable with respect to the driving member in order to allow adjustment of the angular positions of said non-conductive portions to determine various training directions for said antenna, a plurality of translation circuits each including one of said conductive discs and its associated contactor, a seelctor switch located at a control point for energizing one of said translation circuits, means connecting said translation circuit to said electric motor for energizing same, means for reversing the rotation of said motor when predetermined angular limits are reached in either direction of rotation, and means for shifting arcuately the relationship between each of said discs and contactors upon each reversal to compensate for errors in antenna training resulting from such reversal.

6. In combination with a high frequency receiver having a frequency channel selector, a system for controlling the training of an antenna for said receiver comprising an antenna rotator including an electric motor, a training controller comprising a rotary driving member supporting a plurality of conductive controller discs, means constraining said driving member to angular constancy with respect to said antenna, a plurality of contactors engaging said discs throughout their rotation, a non-conductive portion in each of said discs extending over a narrow sector of the path of engagement of the disc by its associated contactor, said discs being angularly adjustable with respect to said driving member in order to allow adjustment of the angular positions of said non-conductive portions to determine various training directions for said antenna, a plurality of translation circuits each including one of said selector discs and its associated contactor, a selector switch for energizing one of said translation circuits, means mechanically interconnecting said selector switch with the frequency channel selector of said receiver, means for connecting said translation circuits to said electric motor for energizing said antenna rotator, means for reversing the rotation of said motor when predetermined angular limits are reached in either direction of rotation, and means for shifting arcuately the relationship between said discs and contactors upon each reversal to compensate for errors in antenna training resulting from such reversal.

7. A system for controlling the training of an antenna comprising reversible electric motor driving means for rotating said antenna, a training controller comprising a rotary driving member supporting a plurality of conductive rotary driven members, means constraining said driving member to angular constancy with respect to said antenna, a plurality of contactors engaging said driven members throughout their angular dispalcement, a non-conductive portion in each of said driven members extending over a narrow sector of the path of engagement of the member by its contactor, said driven members being angularly adjustable with respect to the driving member in order to allow adjustment of the angular positions of said non-conductive portions to determine various training directions for said antenna, a selector switch for connecting one of said driven members and its associated contactor into a series circuit for energizing said driving means, a reversing switch in said circuit for reversing the direction of rotation of said driving means, means for actuating said reversing switch whenever the antenna reaches predetermined angular limits in either direction of rotation, and means for shifting arcuately the relationship between said rotary driven members and contactors upon each reversal to compensate for errors in antenna training resulting from such reversal.

8. A system for controlling the training of an antenna comprising electric motor driving means for rotating said antenna, a training controller comprising a rotary driving member supporting a plurality of conductive rotary driven members, means constraining said driving member to angular constancy with respect to said antenna, a plurality of contactors engaging said driven members throughout their angular displacement, a non-conductive portion in each of said driven members extending over a narrow sector of the path of engagement of the member by its contactor, said driven members being angularly adjustable with respect to the driving member in order to allow adjustment of the angular positions of said non-conductive portions to determine various training directions for said antenna, a selector switch for connecting one of said driven members and its associated contactor into a series circuit for energizing said driving means, means for reversing the direction of rotation of said driving means, a frame pivotally mounted in coaxial relation to said shaft supporting said contactors, and solenoid means for rocking said frame in opposite directions at each reversal of said driving means whereby to shift said contactors back or forth in order to compensate for training errors resulting form said reversals.

9. A system for controlling the training of an antenna comprising electric motor driving means for rotating said antenna, a training controller comprising a shaft supporting a plurality of conductive discs, a pair of selsyn followers one driven by said antenna and the other driving said shaft for constraining the shaft to unvarying angular relation to the antenna, a plurality of contactors peripherally engaging said discs, a non-conductive portion in each disc extending over a narrow sector of its periphery in the path of engagement of the disc by its contactor, said discs being angularly adjustable with respect to said shaft in order to allow adjustment of the angular positions of said non-conductive portions to determine various antenna training directions, a plurality of translation circuits each includng one of said controller discs and its associated contactor, a voltage source, a switch located at a control point for connecting one of said translation circuits in series between said source and said electric motor whereby to energize said electric motor until the non-conductive portion of the included disc engages said contactor to cause deenergization of said motor with the antenna trained in a predetermined direction.

10. A system for controlling the training of an antenna comprising reversible electric motor driving means for rotating said antenna, a training controller comprising a shaft supporting a plurality of conductive discs, a pair of selsyn followers one driven by said antenna and the

other driving said shaft for constraining the shaft to angular constancy relative to the antenna, a plurality of contactors peripherally engaging said discs, a non-conductive portion in each disc extending over a narrow sector of its periphery in the path of engagement of the disc by its contactor, said discs being angularly adjustable with respect to said shaft in order to allow adjustment of the angular positions of said non-conductive portions to determine various antenna training directions, a plurality of translation circuits each including one of said controller discs and its associated contactor, a voltage source, a switch located at a control point for connecting one of said translation circuits in series between said source and said electric motor, a reversing switch connected in circuit with said motor and said source, and means for actuating said switch at the limits of rotation of said antenna in either direction.

11. A system for controlling the training of an antenna comprising electric motor driving means for rotating said antenna, a training controller comprising a shaft supporting a plurality of conductive discs, a pair of selsyn followers one driven by said antenna and the other driving said shaft for constraining the shaft to angular constancy relative to the antenna, a plurality of contactors peripherally engaging said discs, a non-conductive portion in each disc extending over a narrow sector of its periphery in the path of engagement of the disc by its contactor, said discs being angularly adjustable with respect to said shaft in order to allow adjustment of the angular positions of said non-conductive portions to determine various antenna training directions, a plurality of translation circuits each including one of said controller discs and its associated contactor, a voltage source, a switch located at a control point for connecting one of said translation circuits in series between said source and said electric motor, means for reversing the direction of said driving means at the limits of rotation of said antenna in either direction, means for shifting the effective magnetic axis of one selsyn follower relative to that of the other, and circuit connections for energizing said last-named means when said driving means reverses direction, whereby to compensate for errors in antenna training resulting from such reversal.

12. A system for controlling the training of an antenna comprising an antenna rotator including an electric motor for rotating said antenna, a training controller comprising a shaft supporting a plurality of conductive discs, means mechanically interconnecting said shaft to said antenna, a plurality of contactors engaging said discs throughout their rotation, a non-conductive portion in each of the conductive discs extending over a narrow sector of the path of engagement of the disc by its associated contactor, said discs being angularly adjustable with respect to said shaft in order to allow adjustment of the angular positions of said non-conductive portions to determine various training directions for said antenna, a plurality of translation circuits each including one of said discs and its associated contactor, a switch located at a control point for energizing one of said translation circuits, means for connecting said translation circuits to said electric motor for energizing same, means for reversing the rotation of said motor when predetermined angular limits are reached in either direction of rotation, and means for shifting arcuately the relationship between said discs and contactors upon each reversal to compensate for errors in antenna training resulting from such reversal.

13. A system for controlling the training of an antenna comprising an antenna rotator including an electric motor for rotating said antenna, a training controller comprising a shaft supporting a plurality of conductive discs, means mechanically interconnecting said shaft to said antenna, a plurality of contactors engaging said discs throughout their rotation, a pivotally mounted frame supporting said contactors and allowing oscillation thereof between fixed limits, a non-conductive portion in each of the conductive discs extending over a narrow sector of the path of engagement of the disc by its associated contactor, said discs being angularly adjustable with respect to said shaft in order to allow adjustment of the angular positions of said non-conductive portions to determine various training directions for said antenna, a plurality of translation circuits each including one of said discs and its associated contactor, a selector switch located at a control point for energizing one of said translation circuits, means connecting said translation circuits to said electric motor for energizing same, means for reversing the direction of rotation of said motor at the limits of rotation of said antenna in either direction, and friction clutch means interconnecting said shaft and said frame to cause said frame and contactors to shift back or forth at each reversal of rotation of said motor.

14. A system, as set forth in claim 11, wherein said means for shifting the effective magnetic axis of one selsyn follower relative to that of the other comprises a coil operatively connectable to one of said selsyns.

15. A system, as set forth in claim 11, wherein said means for shifting the effective magnetic axis of one selsyn follower relative to that of the other comprises a condenser operatively connectable to one of said selsyns.

16. A system, as set forth in claim 9, including means for reversing the rotation of said driving means when predetermined angular limits are reached in either direction of rotation, and means for shifting arcuately the relationship between said discs and contactors upon each reversal to compensate for errors in antenna training resulting from such reversal.

17. A system, as set forth in claim 9, including means for reversing the rotation of said driving means when predetermined angular limits are reached in either direction of rotation, the width of each non-conductive portion is such that it compensates for errors in antenna training resulting from such reversal.

18. A system for controlling the training of an antenna comprising, driving means for rotating said antenna, a rotary member, means constraining said rotary member to angular constancy with respect to said antenna, a selector switch for energizing a circuit in at least two switch positions for energizing said driving means, each of said circuits including means responsive to a different predetermined position of said rotary member for deenergizing said driving means, means for reversing the direction of rotation of said driving means, said position responsive means including a plurality of contactors engaging said rotary member with said contactors carried by a frame pivotally mounted coaxially with said rotary member, and means for rocking said frame in opposite directions responsive to each reversal of said driving means whereby to shift said contactors in order to compensate for training errors resulting from said reversals.

19. A system, as set forth in claim 18, wherein said frame rocking means is a solenoid means.

20. A system for controlling the training of an antenna comprising, driving means for rotating said antenna, a rotary member, means constraining said rotary member to angular constancy with respect to said antenna, a selector switch for energizing a circuit in at least two switch positions for energizing said driving means, each of said circuits including means responsive to a different predetermined position of said rotary member for deenergizing said driving means, means for reversing the direction of rotation of said driving means, said position responsive means including a plurality of contactors engaging said rotary member with said contactors carried by a frame pivotally mounted coaxially with said rotary member, and friction clutch means interconnecting said rotary member and said frame to shift said contactors in order to compensate for training errors resulting from said reversals.

21. A system for controlling the training of an antenna

comprising, driving means for rotating said antenna, a rotary member, a pair of selsyn followers one driven by said antenna and the other driving said rotary member for constraining said rotary member to angular constancy with respect to said antenna, a selector switch for energizing a circuit in at least two switch positions for energizing said driving means, each of said circuits including means responsive to a different predetermined position of said rotary member for deenergizing said driving means, means for reversing the direction of rotation of said driving means, means responsive to reversal

of said driving means for shifting the effective magnetic axis of one selsyn follower relative to that of the other to compensate for training errors resulting from said reversals.

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