July 4, 1967 A. F. DEMING 3,329,945

CONTROLLABLE SERVOMOTOR WITH BALANCEABLE CIRCUIT INDICATOR

Filed April 27, 1965 2 Sheets-Sheet 1

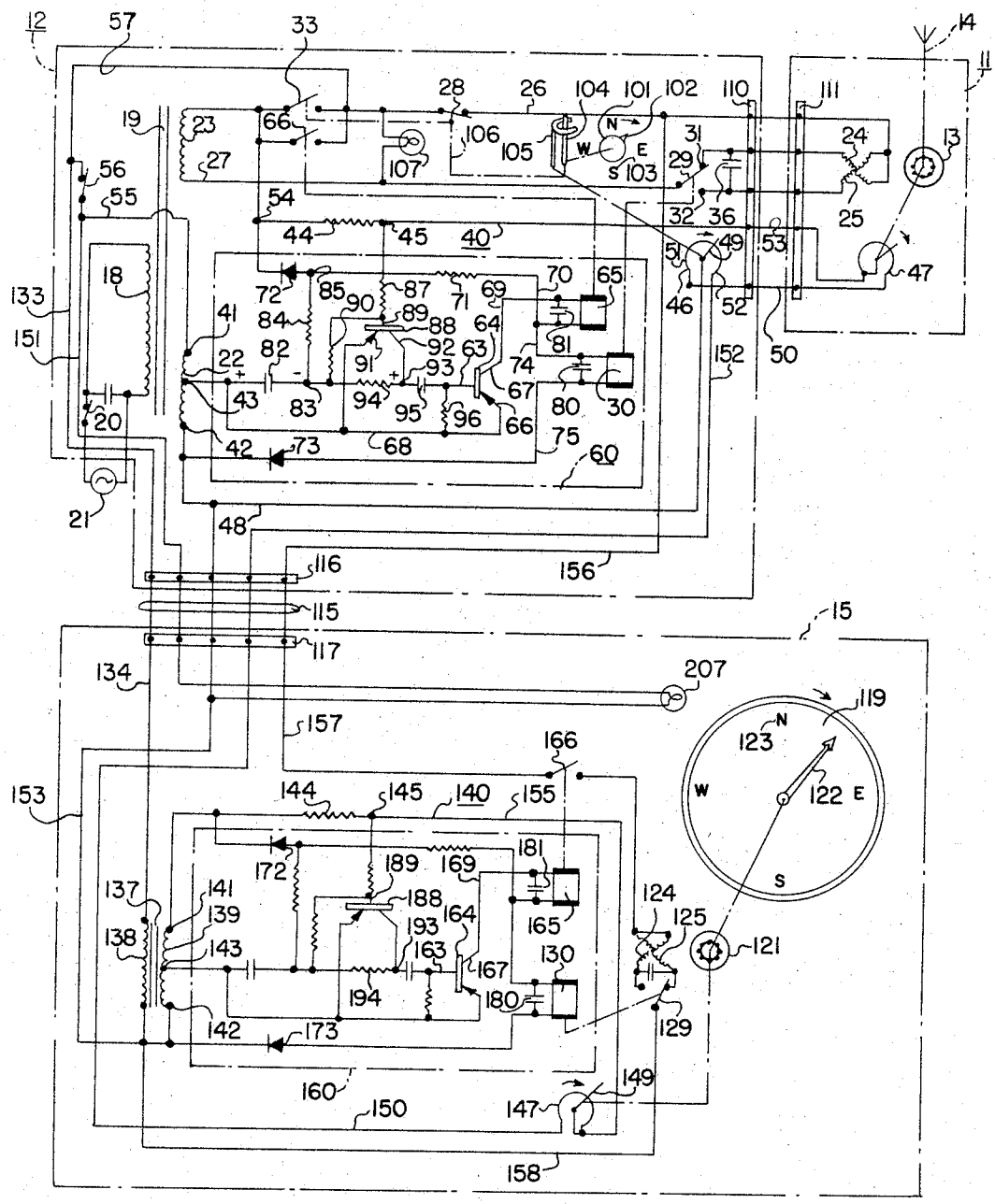


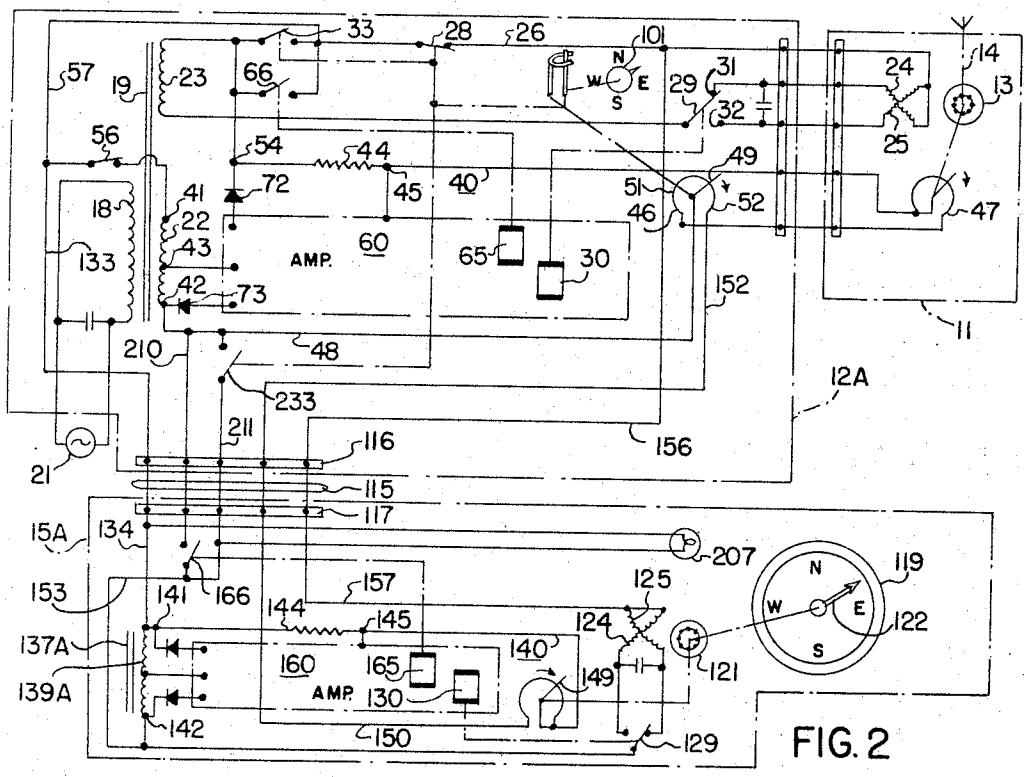
FIG. 1

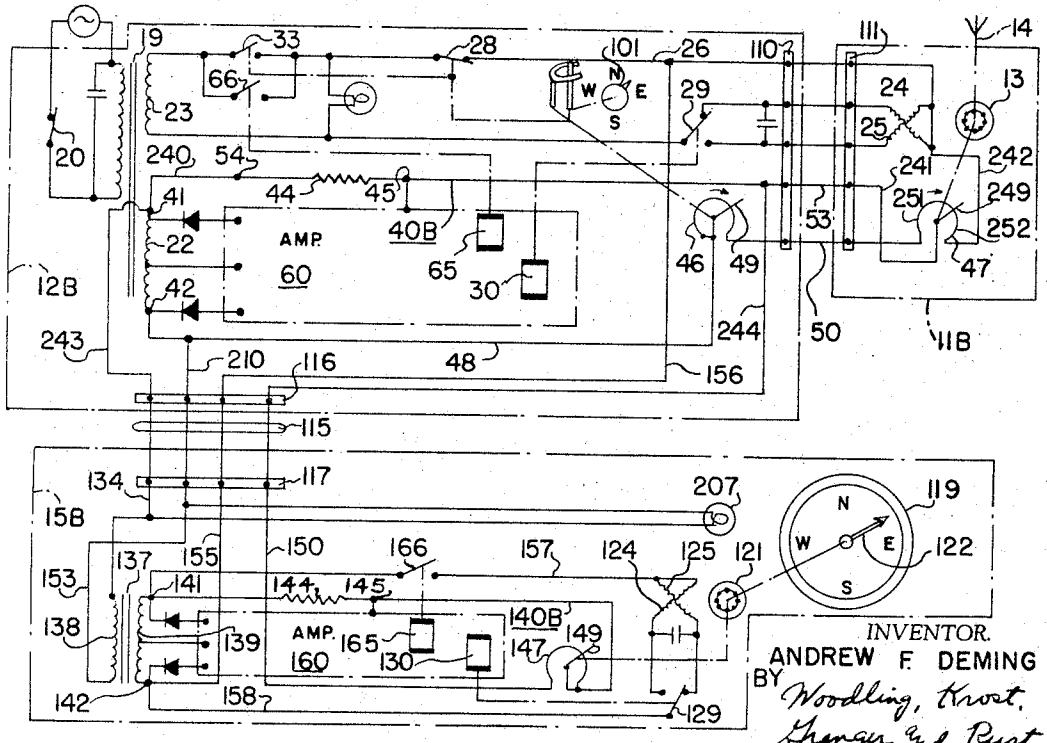
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3,329,945

CONTROLLABLE SERVOMOTOR WITH BALANCEABLE CIRCUIT INDICATOR

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The invention relates in general to control systems for servomotors, and more particularly to a control system for first and second balanceable circuits, each independently balanceable with the first having an output to a load and an output to rebalance the first circuit upon unbalance thereof, and the second circuit having an output to an indicator and an output to rebalance the second circuit upon unbalance thereof, with common means to cause unbalance in the two circuits.

The control system of the invention may be used with a servomotor such as a rotatable drive device, and one example of such a servomotor is for use with an antenna rotator which is remotely controllable from a first balanceable circuit. The antenna rotator may be provided with an indicator which is supplied from the output of a second balanceable circuit. A variable impedance is common to both balanceable circuits and is capable of unbalancing each of these circuits. An output is fed back from the rotator to balance the first circuit and a separate output is fed back from the indicator to separately balance the first circuit.

An object of this invention is to provide a rotator control system wherein an antenna rotator may be remotely controlled through connections on a first terminal strip on the rotator control device, and with a second terminal strip on the rotator control device to which an indicator device may be added at any time, which indicator will move approximately in step with the rotator device and will shut off in synchronism with the rotator device.

A further object of the invention is to provide a separate following indicator unit which may be made of large size so that it may be mounted on the station operator wall and be made so that maps may be secured thereon so that a large motorized sweeping hand will indicate the position of the desired station while maintaining the present small size of the control box for the antenna rotator.

A further object of the invention is to provide an antenna rotator system complete in itself, to which the feature of a separate indicator may be added at any desired time, so that initial purchase of the antenna rotator device and remote control therefor may be made without requiring purchase of the indicator at that time.

A further object of the present invention is to provide a remote control device and indicator device where the indicator requires no special interconnecting cable but may be wired with the same low voltage five-wire cable which is used for the regular interconnection between the rotator and the control device.

A further object of the present invention is to provide a rotator cintrol and indicating system which makes use of a double electrical bridge whereby a single control movable arm of such bridge is made to insure complementary operation of both such bridges, and yet full independence of operation of both bridge circuits is achieved so that synchronism of the rotator is independently achieved from synchronism of an indicator with the control box thereby assuring that inaccuracies of running synchronism between the indicator and rotator motors are corrected at each shut off to insure synchronism of the system.

A further object of the present invention is to provide a system where the indicator mechanism and control

mechanism will be initiated only on movement of the control knob and not upon movement of the rotator by wind.

A further object of the present invention is to provide a control system where rotation of the antenna may be stopped at any time by actuating a stop switch and where such stop switch is capable of stopping the operation of both the antenna rotator and the indicating means when such indicating means is used with the device.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a schematic diagram of the invention applied to an antenna rotator, and

FIGURES 2 and 3 are modifications of the invention.

The invention relates to control systems for balanceable circuits and FIGURE 1, for purposes of illustration and not limitation, shows the invention as applied to a control system **12** controlling an antenna rotator **11**. The antenna rotator **11** includes a motor **13** to rotate a load such as an antenna **14**. This may be an amateur band antenna or a television receiving antenna for connection to a television receiver, not shown. The motor **13** is capable of rotating the antenna **14** to point in any azimuthal direction and an indicator system **15** may optionally be added to the control system **12** to indicate the direction in which the antenna **14** is pointed.

The control system **12** may conveniently take the shape of a small housing, not shown, which may rest upon or near the television receiver. This control system **12** includes a transformer **19** having a primary **18** energizable through a manual switch **20** from an alternating current source **21**. The transformer **19** has secondaries **22** and **23**, each of which is preferably a low voltage secondary in the order of 24 volts for safety.

The antenna rotator **11** may be a separate housing mounted on the exterior of the dwelling, for example, and carrying the mast of the antenna **14** for rotation of same. The motor **13** may be a reversible induction motor and is shown as having first and second motor windings **24** and **25**. These motor windings are energized from the secondary **23** in the control system **12** through conductors **26** and **27**. A single-pole double-throw switch **29** is connected in conductor **27** and selectively to the motor windings **24** and **25** through switch contacts **31** and **32**. The switch **29** is actuated by a relay **30**. A capacitor **36** is connected across the contacts **31** and **32** to provide reversible rotation to the motor **13**.

Manual switches **28** and **33** are provided in the conductor **26** between the secondary **23** and the common connection of the motor windings **24** and **25**. The manual switch **28** is normally closed and the manual switch **33** is normally open.

The control system **12** includes a balanceable circuit shown as a bridge **40**. This bridge **40** is energizable from the transformer secondary **22**. The secondary **22** has end terminals **41** and **42** and a midtap **43**. The two halves of the secondary **22** on either side of the midtap **43** constitute the first and second legs of the bridge **40**. A first impedance **44**, shown as a resistor, forms a third leg of the bridge. A first output terminal **45** of the bridge is connected at one end of this first impedance **44**. The midtap **43** is the second output terminal of the bridge **40**. Variable impedance means are shown in the fourth leg of the bridge connected between terminals **42** and **45**. These are illustrated as potentiometers **46** and **47**. A conductor **48** connects transformer secondary terminal **42** to a movable blade **49** which divides the potentiometer **46** into first and second complementary impedance sections **51** and **52**, respectively. One end of potentiometer **46** is connected by a conductor **50** to the potentiometer **47** and the other end

of this potentiometer is connected by a conductor 53 to the bridge output terminal 45. The opposite end of the first impedance 44 is connected to a terminal 54 which is connected through the manual switch 33, conductors 57 and 55 and a normally closed emergency stop switch 56 to the transformer secondary terminal 41. This completes the bridge 40 upon closing of the manual switch 33. The secondary end terminals 41 and 42 may be considered the input terminals of the bridge and the midtap 43 is the second output terminal of the bridge cooperating with the first output terminal 45.

The output of the bridge at terminals 43 and 45 is fed to an amplifier 60 and the output of this amplifier controls the relay 30 and a relay 65. The relay 65 has normally open contacts 66 which are connected in parallel with the manual switch 33. The amplifier 60 may include a transistor 64 as the amplifying device.

The transistor 64 has a base 63, an emitter 66 and a collector 67. The emitter 66 is connected by a conductor 68 to the midtap 43. The collector 67 is connected by a conductor 69 to one end of the relay winding 65 and the other end of this relay is connected through a conductor 70, an optional voltage dropping resistor 71 and a diode 72 to the terminal 54. The diode 72 is poled to conduct current toward the terminal 54. Another diode 73 is poled to conduct current toward the transformer secondary terminal 42. The lower end of the relay 65 is also connected through a conductor 74 to the upper end of relay 30 and the lower end of this relay 30 is connected through a conductor 75 and the diode 73 to the secondary terminal 42. A filter capacitor 80 is connected across the relay 30 and a filter capacitor 81 is connected across the relay 65.

The diode 72 supplies direct current operating voltages to the amplifier 60 when the manual switch 33 or relay contact 66 is closed. A filter capacitor 82 is connected between the midtap 43 and a terminal 83. A filter resistor 84 is connected between the terminal 83 and a terminal 85 at the junction of the diode 72 and resistor 71. This connection develops a rectified positive direct current voltage at the midtap 43 and a negative direct current voltage at terminal 83.

The amplifier 60 may also include a transistor preamplifier shown by transistor 88. This increases the sensitivity of the entire control system 12. The transistor 88 has a base 89 connected by a bias resistor 90 to the terminal 83. The transistor 88 also has an emitter 91 connected to the midtap 43, and a collector 92 connected to a terminal 93. A load resistor 94 for the transistor 88 is connected between terminals 83 and 93 to receive the collector current of this transistor 88. The potential at terminal 93 is passed by a coupling capacitor 95 to the base 63 of the transistor 64. A self bias resistor 96 is connected between base 63 and emitter 66 of transistor 64. The base 89 of the transistor 88 is connected through a current limiting resistor 87 to the terminal 45 to provide an input to the amplifier 60.

A manual knob 101 moves a pointer 102 cooperating with indicia 103 to indicate the desired directional position of the antenna 14. The knob 101 has an output to a lost motion device shown as a pin 104 and yoke 105, as an example. The yoke 105, after the lost motion is taken up, is connected to move the movable blade 49 of the manual potentiometer 46. The knob 101 also has a direct connection 106 to actuate the manual switches 28 and 33. This connection is such that upon initial movement of the knob 101 and during the take up of the lost motion connection, the first movement opens the normally closed switch 28, next the normally open switch 33 closes and third the lost motion connection is taken up to actuate the movable blade 49. An indicator lamp 107 may be connected across the conductors 26 and 27.

The control system 12 has a terminal strip 110 with five terminals thereon. These are connected to the conductor 26, terminals 31 and 32 and conductors 53 and 50, respectively. A five conductor low voltage cable may interconnect the terminal strip 110 and a corresponding terminal strip 111 in the antenna rotator device 11. This cable may be of any convenient length to interconnect the control system 12 and rotator unit 11.

The above described system provides a remote control of a servomotor, illustrated as a rotator 11, from a remotely positioned control system 12. The control system 12 may control the desired position of the antenna 14 which will rotate to the new position. There is a feedback from the rotator unit 11 to the control system 12 to rebalance the balanceable circuit or bridge 40 and de-energize this bridge or at least terminate the output therefrom to terminate operation of the motor 13 in the rotator unit 11.

In addition, the present invention provides the indicator system 15 which may be a part of the control system 12 or may be added at any later date. For convenience, the indicator system 15 has been shown as a completely separate unit connected to the control system 12 only through a five conductor cable 115. For convenience this cable may be the same low voltage cable as for interconnecting the terminal strips 110 and 111. The five conductor cable 115 interconnects terminals on a terminal strip 116 in the control system 12 and a terminal strip 117 in the indicator system 15. The indicator system 15 may provide a small size indicator device 119 in which case the indicator system 15 will be sufficiently compact to rest upon the top of the television receiver set or any other convenient location desired. Alternatively the indicator device 119 may be a large dial which may be hung on the wall. For example, it might be used with an amateur radio operator's equipment and hung on the wall of the "ham shack." In this case the indicator system 15 may conveniently be built into the back of the large dial face indicator device 119.

The indicator system 15 is powered from the same alternating current source 21 as powers the control system 12 with power received over the five conductor cable 115. A balanceable circuit or bridge 140 is provided in the indicator system 15. This bridge 140 has an output which controls an indicator motor 121 which in turn drives a pointer 122 to cooperate with indicia 123 on the indicator device 119.

The bridge 140 is quite similar to the bridge 40 in construction and operation and includes a relay 130 and a relay 165 energized by the output of the bridge 140. Relay 130 controls contacts 129 which are single-pole double-throw contacts to control reversible energization to motor windings 124 and 125. Relay 165 controls normally open contacts 166.

The indicator system 15 includes a transformer 137 having a primary 138 and a secondary 139. This secondary has end terminals 141 and 142 and a midtap 143. The terminals 141 and 142 are the first and second input terminals of the bridge 140 and the upper and lower sections of secondary 139 on either side of the midtap 143 constitute the first and second legs of the bridge 140. The third leg of the bridge 140 is constituted by a first impedance 144 shown as a resistor. A first bridge output terminal 145 is connected to one end of this resistor 144 and the other end thereof is connected to terminal 141. The second output terminal of the bridge 140 is the midtap 143. The output terminals 143 and 145 are connected to an amplifier 160 with components therein the same as the components in amplifier 60 with numerals all being 100 units larger.

The fourth leg of the bridge 140 includes two variable impedance devices. The first variable impedance device is the complementary section 52 of the first potentiometer 46, which is physically located in the control system 12. The second variable impedance device is shown as a third potentiometer 147. This potentiometer has a movable blade 149 moved by the output from the indicator motor 121. The connection of this fourth leg is from the bridge

output terminal **145** through a conductor **155**, the potentiometer **147**, a conductor **150**, the terminal strip **117**, a conductor of the five conductor cable **115**, terminal strip **116**, a conductor **152**, the complementary section **52** of potentiometer **46**, conductor **48**, terminal strip **116**, a conductor of cable **115**, terminal strip **117** and a conductor **153** to the secondary terminal **142**. Accordingly it will be seen that the variable impedance device **46** is connected in both the balanceable circuits **40** and **140**. The first complementary section **51** of the first potentiometer **46** is connected in the bridge **40** and the second complementary section **52** of the first potentiometer **46** is connected in the bridge **140**. Accordingly any change of position of the movable blade **49** will simultaneously and inversely vary the impedance in the bridges **40** and **140**.

Power is supplied to the transformer **137** by a conductor **133**, through terminal strips **116** and **117** and a conductor **134** to one end of the primary **138**. The other end of the primary is connected by the conductor **153** to terminal strips **117** and **116** to the end terminal **42** of secondary **22**. Power is supplied to the indicator motor **121** from the secondary **22**. A conductor **156** is connected to conductor **26** and through terminal strips **116** and **117** and a conductor **157**, through relay contacts **166** to the motor windings **124** and **125**. The single-pole double-throw switch **129** is connected by a conductor **158** and conductor **153**, terminal strips **117** and **116** to end terminal **42** of secondary **22**. The end terminal **41** of this secondary **22** is connected through the previously mentioned emergency stop switch **56** and conductors **55** and **57** to the conductor **26**.

An indicator lamp **207** may be connected across the conductor **153** and a conductor **151** leading to conductor **55** and terminal **41** to provide illumination for the indicator device **119**.

Operation of FIGURE 1

The control system **12** may control the position of the rotator unit **11** by causing selected direction of rotation of the motor **13**. The manual knob **101** moves the potentiometer blade **49** and this unbalances the bridge **40** to cause an output therefrom. This selectively energizes either the relays **30** and **65** or just the relay **65** and together these relay means **30** and **65** control the selected direction of rotation of the motor **13** and energization of bridge **40**. This motor **13** rotates to the desired position and in so doing drives the second potentiometer **47**. This has a feedback connection to the first bridge **40** to rebalance this bridge and upon rebalance the output from the bridge **40** ceases, to stop rotation of the motor **13**. At this time the position of the antenna **14** is oriented with the selected direction of the pointer **102** on knob **101**.

Additionally, the indicator system **15** operates substantially in synchronism with the operation of the rotator unit **11** to provide a visual indication of the approximate position of the antenna **14**. The indicator motor **121** may be a small reversible induction motor or, since the load is small, may be a reversible synchronous motor. If it is a synchronous motor it will run slightly faster than the inductor motor **13** in the rotator unit **11**. Thus the pointer **122** may be slightly ahead of the antenna position, depending upon gearing, but the entire system is such that the bridge **40** balances independently from the balance of the bridge **140** and thus the indicator will shut off in synchronism with the position of the antenna **14**.

FIGURE 1 illustrates the knob pointer **102** as pointing roughly toward the northeast. Let it now be assumed that the knob is rotated clockwise in the direction of the arrow to the south position. The movement is first to open the switch **28**, next to close the manual switch **33**, and when the lost motion connection is taken up, then the potentiometer blade **49** will be rotated to increase the resistance of the section **51** and decrease the resistance of the section **52**. It is assumed that the manual switch **20** has previously been closed to energize the transformer **19** and that the bridge **40** was previously balanced at shut off and that the movement of potentiometer blade **49** unbalanced this bridge **40**. Upon the opening of the manual switch **28**, the motor **13** is prevented from rotating until the correct direction of rotation is selected. This prevents false starts of rotation of this motor **13** in the wrong direction. Upon the closing of manual switch **33**, voltage is supplied from secondary **22** to the terminal **54**, to energize the bridge **40**, and this, plus the bridge unbalance, establishes an output therefrom. This output energizes the relay **65** to close the relay contacts **66** within about one-tenth of a second after the rotation of the knob **101** and thereafter the knob **101** may be released to open the contact **33** without change in the circuit condition. This will be because the relay contacts **66** have closed in parallel with the manual switch **33** to maintain energized the bridge **40**.

The unbalance of the bridge **40** is in a direction caused by the increased impedance in the fourth leg constituted by potentiometer section **51** and the potentiometer **47**. These potentiometers are thus variable impedance means having first and second sections of concurrently variable impedance, in this case complementary in impedance value. This increases the voltage drop in this fourth leg and accordingly shifts the phase of the potential of output terminal **45** in such a manner that the voltage from output terminal **45** to output terminal **43** is in phase with the input voltage from end terminal **41** to end terminal **42**. When terminal **41** is positive, terminal **45** will be positive. Bias resistor **90** establishes a small normal current flow through transistor **88**. Accordingly when terminal **45** is positive at the time that terminal **41** is positive, this drives the base **89** of transistor **88** positive to turn off this transistor **88**. The terminal **93** of load resistor **94** is normally positive with reference to terminal **83** from this small current flow through the transistor **88**. The turn off of the transistor **88** drives the terminal **93** less positive or more negative, and this negative going signal is passed by the capacitor **95** to the base **63** of transistor **64**. This turns on the transistor **64** to have an output signal from the collector **67** to the relay **65**. Current through this relay **65** may not flow through diode **72** because terminal **41** is positive during this positive half cycle. Instead it flows through diode **73** to terminal **42**, which is negative during this half cycle. Accordingly both relays **65** and **30** are energized during this condition of bridge unbalance. The switch **29** thus moves to engage contact **32** to directly energize motor winding **25** and to energize motor winding **24** with a leading current through capacitor **36**. This provides rotation of the motor **13** in a clockwise direction to rotate the antenna clockwise from the northeast position toward the south position.

During rotation of this motor **13**, the potentiometer **47** is driven in a clockwise direction which reduces the impedance thereof. At some point the reduced impedance of the potentiometer **47** will again balance the bridge **40**. Upon this balance condition being reached, the bridge will terminate its output and this will de-energize the relay **65** to open contact **66**. This will stop the motor **13** in the desired position and also de-energize the bridge **40**.

The aforementioned description relates to the control system **12** controlling the rotator unit **11**. The knob **101** is described as moving the potentiometer blade **49** through the lost motion connection **104–105**. The movement of the movable blade **49** changes the impedance of the potentiometer section **51** and also changes the impedance of potentiometer section **52** in an inverse manner. The section **51** is connected in the bridge **40** and the section **52** is connected in the bridge **140** of the indicator system **15**. It will be noted that the secondary **22** is continuously energized so long as switch **20** is closed and accordingly the transformer **137** is also energized continuously. The bridge **140** is also continuously energized and upon a change in the impedance value of potentiometer section **52**, this will unbalance the bridge **140**. Conversely to the operation of the bridge **40**, this is a decrease rather than

an increase of impedance in the fourth leg of this bridge **140**. This decrease of impedance in the fourth leg shifts the voltage between the output terminals **143** and **145** to be in phase with the input voltage from terminals **141** to **142**. Now during the negative half cycles, terminal **142** will be positive relative to terminal **141** and simultaneously terminal **145** will be positive relative to the terminal **143**. This positive signal on terminal **145** decreases the normal current flow through transistor **188** and decreases the normal collector current flow through the load resistor **194**. This makes the terminal **193** more negative, which negative signal is passed to the base **163** of transistor **164** to turn on this transistor. This transistor current flow is through the relay **165** and diode **172** to the terminal **141** which is negative during this half cycle. Energization of relay **165** closes relay contacts **166** to energize the indicator motor **129**. The non-energization of relay **130** establishes that switch **129** directly energizes motor winding **125** and energizes motor winding **124** with a leading current so that motor **121** rotates clockwise. This drives pointer **122** toward the south position. This clockwise rotation of the pointer **122** coincides with a clockwise rotation of the potentiometer blade **149**. This increases the impedance of the potentiometer **147** to increase the impedance in the fourth leg of this bridge **140**. At some point a balance of the bridge **140** will be reached and at this balance position the output from the bridge will drop to a minimum or null condition so that relay **165** becomes de-energized. This opens the contacts **166** to de-energize and stop the motor **121**. Thus the pointer **122** will be at the south position. The motor **121** may move slightly faster than the motor **13**, especially if motor **121** is a synchronous motor and motor **13** is an induction motor. This difference in rotational speed does not matter, because each bridge **40** and **140** is separately balanced, yet each is balanced at a position dependent upon the selected position of potentiometer blade **49** in the first potentiometer **46**.

The capacitor **81** in parallel with relay **65** may be made smaller than the capacitor **80** in parallel with relay **30**. Accordingly capacitor **81** has a shorter time constant and relay **65** will be the first to pull in. The pull in and drop out characteristics also may be varied by changing the gap on the relay armature as well as the spring tension. Relay **65** being the first to pull in will close contacts **66** to condition the motor circuit for energization. Relay **30** being the second to pull in will establish the direction of motor rotation. Thus the direction of motor rotation will have been established before the manual switch **28** is closed which actually provides motor current. The relay **65** being the first to drop out will actually open contact **66** and deenergize the motor before relay **30** drops out. This means that there will not be any last second reversal of the motor directional rotation and also means that contacts **29**, **31** and **32** may be made light duty contacts since they do not make and break the circuit.

Pull in and drop out specifications may be similarly arranged for relays **130** and **165**. With relay **165** the last to pull in and first to drop out, the contacts **166** will actually make and break the current to motor **121**, thus relieving contacts **129** of this function.

Now if the knob **101** is rotated counterclockwise to a new position, this moves potentiometer blade **49** counterclockwise to decrease the impedance of potentiometer section **51** and increase the impedance of section **52**. The decreased impedance in section **51** decreases the impedance in the fourth leg of bridge **40**. This shifts the phase of voltage **43–45** to be in phase with the voltage **41–42**. Thus during negative half cycles when terminal **41** is positive, output terminal **45** is positive. This applies a positive voltage on base **89** of transistor **88** to turn off transistor **88** and turn on transistor **64**. Collector current from transistor **64** flows through relay **65** and diode **72** to terminal **41**, which is negative at that time. This energizes only relay **65** and not relay **30**. Accordingly upon the closing of relay contacts **66**, motor winding **24** is energized directly and motor winding **25** is energized with a leading current for counterclockwise rotation of the motor **13**. This drives the antenna in a counterclockwise direction to the new desired location.

Counterclockwise rotation of motor **13** also drives potentiometer **47** counterclockwise to increase the impedance thereof. This will continue until bridge **40** is balanced whereupon output therefrom drops to a minimum or null to de-energize relay **65**. This opens contacts **66** to de-energize motor **13** and also the bridge **40**.

Concurrently the manual movement of potentiometer blade **49** counterclockwise not only decreased the impedance of potentiometer section **51**, but also increased in inverse ratio the impedance of potentiometer section **52**. This increase of impedance of potentiometer section **52** increased the impedance in the fourth leg of bridge **140** to unbalance same. Since this bridge is continuously energized, this unbalance is in a direction to make the voltage **143–145** in phase with the voltage **142–141**. Thus during positive half cycles when terminal **141** is positive, terminal **145** is also positive. During these positive half cycles the base **189** of transistor **188** is driven positive to turn off this transistor thus turning on transistor **164**, and the transistor collector current passes through relays **165** and **130** and diode **173** to terminal **142** which is negative during this half cycle. This energizes both relays **165** and **130** with relay **130** pulling in first to select the desired counterclockwise direction of rotation of indicator motor **121**. Relay **165** pulls in second to close contacts **166** and effect actual energization of motor **121**. Rotation of this motor **121** drives the pointer **122** counterclockwise and also drives the potentiometer blade **149** counterclockwise to a position of balance. The balance will be reached when the decreased impedance of potentiometer **147** matches the increased impedance of potentiometer section **52**. Upon balance relay **165** drops out to open contacts **166** and de-energize motor **121**.

The potentiometers **46**, **47** and **147** may be the type permitting a full 360 degrees of rotation from maximum to minimum impedance or they may be the type which has about 300 degrees of rotation between stops. In the latter case, the gearing to the actuating motors will be such as to permit 360 degree rotation of the antenna **14** or pointer **122** for the 300 degree rotation of the associated potentiometers.

It will be noted that control system **12** and rotator unit **11** form a complete remotely controlled servomotor with a closed loop feedback system. Thus these two units **11** and **12** are completely operable by themselves. Accordingly an antenna rotator system embodying this invention may be manufactured and sold and provided with terminal strip **116**. Thus a user may purchase the indicator system **15** separately at any time and add it to the rotator unit and control system. The only interconnections necessary are to interconnect the terminal strips **116** and **117** by commonly available low voltage five conductor cable. Also the indicator system **15** may be a small table top model with a small indicator device **119** or may be a large wall hung model. The indicator motor **121** may be a small clock type synchronous motor requiring only a lower power input such as 2 to 5 watts, which power will place a negligible drain on the secondary **22**.

It does not matter whether the bridge **40** is balanced before or after the bridge **140**. Movement of potentiometer **47** balances bridge **40** and movement of potentiometer **147** balances bridge **140**. The two systems, namely control system **12** and indicator system **15**, are separately balanced and will shut off independently of the other. The shut off will establish the pointer **122** in synchronism with the position of the antenna **14**, this despite the fact there might be a slight variation in speed of motors **13** and **121**. In both cases it is the movement of potentiometer

blade **49** which establishes the initial unbalance of the two bridges and this unbalance is effected in an inverse manner for the two bridges.

If wind or other force on the antenna **14** should move the potentiometer **47**, this will not start the indicator system **15**. The reason is that the birdge **40** is normally not energized until manually energized by manual switch **33** through actuation of the knob **101**. Thus this prevents annoying starts and stops of the indicator pointer **122** such as might occur during a wind storm.

The emergency stop switch **56** is provided to stop the rotator at any desired time, regardless of the fact that the bridge **40** may not be balanced. Also, this emergency stop button stops the indicator system **15** so that the pointer **122** will indicate the approximate position of the antenna. This may be desirable in many cases. For example, if the direction of the received signal is not known and the radio operator is merely rotating the antenna trying to locate the position of strongest received signal, once this strongest signal is received, the operator may press the emergency stop switch **56**. This de-energizes the bridge **40** and de-energizes motor **13**. De-energization of bridge **40** makes relay **65** drop out to open contact **66** thereof. Thus even when the push button **56** is released, bridge **40** will not become re-energized. Also opening of the switch **56** de-energizes the transformer **137** in the indicator system **15**. This shuts down this entire indicator system **15**, dropping out relay **165**. When the switch **56** is reclosed, this will re-energize the indicator bridge **140**. However, the operator will have observed the present position of the antenna **14** by observing the pointer **122** and thus the knob **101** may be reset to coincide with the position of pointer **122**. This will enable manual rebalance of bridge **40** and of bridge **140**.

FIGURE 2 shows a modified schematic diagram of a control system **12A** controlling the antenna rotator **11** and having an indicator system **15A** optionally connectable thereto by the five conductor cable **115**. The antenna rotator **11** may be the same as in FIGURE 1. The control system **12A** and the indicator system **15A** are similar but somewhat different. In the control system **12A** the bridge **40** and the amplifier **60** may be identical to those shown in FIGURE 1 and accordingly the internal wiring of the amplifier **60** has not been shown. The circuit elements and connections thereto which are common between the control system **12** of FIGURE 1 and the control system **12A** of FIGURE 2 will not be described, reference being made to the description above in connection with FIGURE 1.

In the control system **12A** of FIGURE 2 the transformer primary **18** is shown as being always energized from the voltage source **21**, without a switch in the primary circuit. The emergency stop switch **56** is connected directly to line **57** and line **133**, without any separate conductor **151** being provided. A conductor **210** is provided from terminal **42** to the terminal strip **116**. A manually controlled switch **233** is also connected to terminal **42** and then to a conductor **211** and to another terminal on the terminal strip **116**. Manual switch **233** is controlled for actuation directly with the knob **101**. Switch **233** is a normally open switch and closes preferably at the same time as manual switch **33**.

The indicator system **15A** includes a bridge **140** and an amplifier **160** which may be identical with the counterparts in FIGURE 1. In the indicator system **15A** conductor **134** connects to conductor **133** and to end terminal **141** on an inductive winding **139A**. This may have a magnetic core **137A**, however no actual transformer is supplied as in FIGURE 1, and this is a simplification in the circuit of FIGURE 2. Conductor **210**, after passing through the terminal strips **116** and **117**, is connected through the relay contacts **166** and then the conductor **153** and to the lower end terminal **142** of the inductive winding **139A**. Conductor **211** extends through the terminal strips **116** and **117** and also connects to this conductor **153**. In conductor **157** the relay contacts **166** have been omitted.

Operation of FIGURE 2

With the emergency stop switch **56** in closed position, the transformer **19** is energized as is the secondary **22** and secondary **23**. Upon turning the knob **101** clockwise to a new desired position for the antenna **14**, this first opens manual switch **28** to prevent false direction starts of the motor **13**. Next manual switches **33** and **233** are closed. Thirdly, the manual potentiometer blade **49** is moved clockwise to increase the resistance in section **51** and decrease the resistance in section **52**. These sections are complementary impedance sections connected in the bridges **40** and **140**, respectively. The closing of manual switch **33** energizes the bridge **40** and because of the change of impedance in potentiometer section **51**, the bridge **40** is unbalanced and will have an output on positive half cycles to energize both relays **65** and **30**. This will close relay contacts **66** within about 50 to 100 milliseconds to maintain the bridge **40** energized. Whether or not relay **30** is energized depends upon the direction of unbalance of the bridge, and as in FIGURE 1, it is assumed that this unbalances the bridge **40** in a direction to cause energization of relay **30**. This means that relay contacts **29** engage the contact **32** for direct energization of motor winding **25** and leading current energization to motor winding **24**. This causes clockwise rotation of motor **13** and of potentiometer **47**. As in FIGURE 1, the bridge **40** will be rebalanced when the antenna **14** and potentiometer **47** reach the desired position.

The closing of manual switch **233** upon the initial turning of the knob **101** will supply power to energize the inductive winding **139A**, as well as the bridge **140** and amplifier **160**. The changing impedance in potentiometer section **52** will unbalance the bridge **140** causing an output therefrom and energization of relay **165**. This will close relay contacts **166** to maintain energized the indicator system **15A** even after opening of manual switch **233** upon release of knob **101**. As in the description of FIGURE 1, it is assumed that the decreasing impedance of potentiometer section **52** causes unbalance of the bridge **140** in a direction which does not energize relay **130** and accordingly motor winding **125** is energized directly and winding **124** is energized with a leading current for clockwise rotation of the motor **121**. This will rotate the pointer **122** and the potentiometer blade **149** clockwise to a position of balance of the bridge **140**. When this occurs, the relay **165** will drop out to de-energize the indicator system **15A**.

If the emergency stop switch **56** is opened at any time during rotation of the motor **13**, this will de-energize the bridge **40** and amplifier **60** in the control system **12A** to stop motor **13**. Also it de-energizes the complete indicator system **15A** to stop the indicator motor **121**. Preferably this emergency stop switch **56** is a latching or toggle type switch which must be manually reset to the closed condition in order to render the control system operative. This will give a definite indication to the operator that the system has been shut down out of synchronism and that the knob **101** should be turned to reorient the antenna and to synchronize the position of antenna **14** with the position of the indicator **122**.

The circuit of FIGURE 2 has the advantage of normally having the indicator system **15A** completely de-energized and it is only energized upon closing of the manual switch **233**.

FIGURE 3 illustrates still another modification of the invention. This figure shows an antenna rotator **11B** which is similar to but slightly different from the rotator unit **11** of FIGURE 1. FIGURE 3 also shows a control system **12B** and an indicator system **15B** which are similar to but slightly different from the counterparts in FIGURE 1. In the control system **12B** there is a bridge **40B** which is slightly different from the counterpart in FIGURE 1. An amplifier **60** is provided which may be identical to that in

FIGURE 1. In this FIGURE 3 only those circuit elements and connections which are different from those in FIGURE 1 will be hereinafter described. FIGURE 3 provides no connection such as conductor **57** of FIGURE 1, and instead the bridge **40B** is permanently connected to the secondary **22** by a conductor **240** interconnecting terminals **54** and **41**. The manual potentiometer **46** has been changed to use only one section thereof instead of complementary sections. Conductor **50** extends from the lower right terminal of potentiometer **46** to a lower left end terminal of the motor driven potentiometer **47**. This potentiometer **47** is now the variable impedance means having first and second complementary impedance sections **251** and **252** connected in the control bridge and indicator bridge, respectively. The movable blade **249** of potentiometer **47** is connected by a conductor **241** through the terminal strip **111** to the conductor **53**. The right end terminal of potentiometer **47** is connected by a conductor **242** to the common connection of motor windings **24** and **25**.

A conductor **243** is connected to the end terminal **41** of the secondary **22** and connects to a terminal on terminal strip **116**. A conductor **210** interconnects secondary end terminal **42** with a second terminal on terminal strip **116**. Conductor **156** connects conductor **26** with a third terminal on the terminal strip **116**. A conductor **244** connects conductor **53** with a fourth terminal on terminal strip **116**.

The indicator system **15B** is changed slightly from that shown in FIGURE 1. One change is that only four terminals on the terminal strips **116** and **117** need be used. Conductor **134** leads from the first terminal on terminal strip **117** to the upper terminal on primary **138**. Conductor **153** connects the second terminal of terminal strip **117** with the lower terminal of primary **138**. Conductor **155** connects the third terminal of terminal strip **117** and terminal **142**. Conductor **150** interconnects the fourth terminal of terminal strip **117** and the left end terminal of potentiometer **147**. The motor **121** is energized directly across the secondary **139** through conductors **157** and **158** and through relay contacts **166** connected in the conductor **157**. The indicator lamp **207** is connected across conductors **134** and **153**.

Operation of FIGURE 3

Assuming that switch **20** is closed the transformer **19** will be energized to energize secondaries **22** and **23**. The bridge **40B** and amplifier **60** will be energized at this time. The transformer **137** of indicator system **15B** will also be energized to energize bridge **140B** and amplifier **160**. If the knob **101** is now rotated clockwise, this first opens switch **28** to prevent initial rotation of motor **13**. Next switch **33** is closed to condition the motor energization circuit upon output from the bridge **40B**. Rotation of the potentiometer blade **49** clockwise decreases the impedance in this potentiometer **46** and unbalances the bridge **40B**. Accordingly there will be an output therefrom to energize relay **65** and close contact **66** to effect motor energization in accordance with the selected direction of rotation, depending upon whether or not relay **30** is energized. The motor **13** will rotate clockwise to rotate the antenna **14** and potentiometer blade **249** clockwise. This increases the impedance in potentiometer section **251** to gradually re-establish balance in the bridge **40B**.

The motor driven clockwise movement of potentiometer blade **249** will decrease the impedance in potentiometer section **252**. This will unbalance the bridge **140B** and produce an output from amplifier **160** to energize relay **165**. This closes relay contacts **166** to energize the indicator motor **121** and drive the pointer **122** in a selected direction, in this example, a clockwise direction. This also drives the movable blade **149** clockwise to increase the impedance in potentiometer **147** and this gradually re-establishes balance of the bridge **140B**.

Each bridge **40B** and **140B** is separately balanced depending upon the complementary impedance sections **251** and **252** of the potentiometer **47**. It will be noted that in this circuit of FIGURE 3 the indicator system **15B** is dependent for rebalance upon a change of impedance caused by the motor driven potentiometer **47** rather than a change of impedance in the manual potentiometer **46**. Thus in this circuit of FIGURE 3 the indicator pointer **122** follows the actual position of the antenna **14**. Should the antenna be iced, for example, and fail to rotate, then the indicator pointer **122** will also fail to rotate and this will inform the operator that the rotator is not operating properly. Also this FIGURE 3 circuit is one wherein the motor driven potentiometer actually sends two separate feedback signals, one to the control system **12B** and the other to the indicator system **15B**.

The manual switch **20** may be used as an emergency stop switch. If it is opened the entire circuit will become de-energized to stop both motors **13** and **121** even though they may previously have been moving.

The present disclosure includes that contained in the appended claims, as well as that of the forgoing description.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of the circuit and the combination and arrangement of circuit elements may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. A control system, comprising, in combination, first ant second balanceable circuits each having an output,
an indicator,
said second circuit having an output to said indicator,
variable impedance means having first and second concurrently variable impedance sections,
means connecting said first and second sections in said first and second circuits, respectively,
means including said impedance means to affect the balance of said first circuit and upon unbalance establishing an output from said first circuit,
a variation in impedance of said impedance means also unbalancing said second circuit to establish output therefrom,
means connecting the output of said first circuit to effect rebalance of said first circuit to terminate output from said first circuit,
and means connecting the output of said second circuit to effect rebalance of said second circuit to terminate output from said second circuit.

2. A control system comprising, in combination, first and second balanceable circuits each having an output,
an indicator,
said second circuit having an output to said indicator,
variable impedance means having first and second concurrently variable impedance sections,
connecting means connecting said first and second sections in said first and second circuits, respectively,
means including said impedance means to affect the balance of said first circuit,
first means to establish an output from said first circuit upon unbalance of said first circuit and said first circuit connected to maintain the output from said first circuit after deactuation of said first means,
a variation in impedance of said impedance means also unbalancing said second circuit to maintain the output from said second circuit after deactuation of said first means,
means connecting the output of said first circuit to effect rebalance of said first circuit to terminate output from said first circuit,
and means connecting the output of said second circuit to effect rebalance of said second circuit to terminate output from said second circuit.

3. A control system comprising, in combination, first and second balanceable circuits each having an output,
an indicator,
said second circuit having an output to said indicator,
variable impedance means having first and second concurrently variable impedance sections,
means connecting said first and second sections in said first and second circuits, respectively,
switch means,
means including said switch means and said impedance means to affect the balance of and output from said first circuit and upon unbalance establishing an output from said first circuit after opening of said switch means,
a variation in impedance of said impedance means also varying the impedance of said second section and unbalancing said second circuit to maintain the output from said second circuit after opening of said switch means,
means connecting the output of said first circuit to effect rebalance of said first circuit to terminate output from said first circuit,
and means connecting the output of said second circuit to effect rebalance of said second circuit to terminate output from said second circuit.

4. A control system comprising, in combination, drive means,
a first balanceable circuit,
an indicator,
a second balanceable circuit having an output to said indicator,
multi-terminal variable impedance means having first and second sections between pairs of terminals,
means connecting said first and second sections in said first and second circuits, respectively
means connected to vary the impedance of said impedance means,
switch means actuatable to establish an output from said first circuit,
means including said impedance means to effect the balance of said first circuit and upon unbalance establishing an output from said first circuit,
a variation in impedance of said impedance means also varying the impedance of said second section and unbalancing said second circuit to maintain the output from said second circuit after opening of said switch means,
means connecting said drive means to effect rebalance of said first circuit to terminate output from said first circuit and de-energize said drive means,
and means connecting the output of said second circuit to effect rebalance of said second circuit to terminate output from said second circuit.

5. A control system according to claim 4, wherein said variable impedance means is driven from the output of said drive means.

6. A control system comprising, in combination, drive means controlled by a first balanceable circuit,
an indicator,
a second balanceable circuit having an output to said indicator,
multi-terminal variable impedance means having first and second sections between pairs of terminals,
means connecting said first and second sections in said first and second circuits, respectively,
manual means connected to vary the impedance of said impedance means,
manual switch means moved in accordance with said manual means to establish an output from said first circuit,
a variation in impedance of said impedance means causing unbalance of and output from said first circuit to maintain the output from said first circuit after opening of said manual switch means to effect operation of said drive means,

a variation in impedance of said impedance means also unbalancing said second circuit to maintain the output from said second circuit after opening of said manual switch means,
means connecting said drive means to effect rebalance of said first circuit to terminate output from said first circuit and de-energize said drive means,
and means connecting the output of said second circuit to effect rebalance of said second circuit to terminate output from said second circuit.

7. A control system comprising, in combination, drive means,
a first phase sensitive circuit,
an indicator,
a second phase sensitive circuit having relay means connected to control energization to said indicator,
a three terminal variable impedance device having first and second sections between pairs of terminals,
means connecting said first and second sections in said first and second phase sensitive circuits, respectively,
manual means connected to vary the impedance of said impedance device,
manual switch means moved in accordance with said manual means to establish an output from said first phase sensitive circuit,
a variation in impedance of said impedance device causing unbalance of and output from said first phase sensitive circuit to maintain the output from said first phase sensitive circuit after opening of said manual switch means to effect operation of said drive means,
a variation in impedance of said impedance device also unbalancing said second phase sensitive circuit to energize said relay means to energize said second drive means,
means connecting said drive means to effect rebalance of said first phase sensitive circuit to terminate output from said first phase sensitive circuit and de-energize said drive means,
and means connecting the output of said second circuit to effect rebalance of said second phase sensitive circuit to de-energize said relay means.

8. A control system comprising, in combination, first drive means,
a first phase sensitive circuit,
an indicator,
second drive means connected to drive said indicator,
a second phase sensitive circuit having relay means connected to control energization to said second drive means,
a potentiometer having first and second sections,
means connecting said first and second sections in said first and second phase sensitive circuits, respectively,
manual means connected to move said potentiometer,
manual switch means moved in accordance with said manual means to establish an output from said first phase sensitive circuit,
movement of said potentiometer causing unbalance of and output from said first phase sensitive circuit to maintain the output from said first phase sensitive circuit after opening of said manual switch means to effect operation of said first drive means,
the movement of said potentiometer also unbalancing said second phase sensitive circuit to energize said relay means to energize said second drive means,
means connecting said first drive means to effect rebalance of said first phase sensitive circuit to terminate output from said first phase sensitive circuit and de-energize said first drive means,
and means connecting said second drive means to effect rebalance of said second phase sensitive circuit to de-energize said relay means to de-energize said second drive means.

9. A control system comprising, in combination, first drive means,

a first phase sensitive circuit,
first relay means controlled by the output of said circuit and connected to control energization to said drive means,
an indicator,
second drive means connected to drive said indicator,
a second phase sensitive circuit having relay means connected to control energization to said second drive means,
a potentiometer having first and second sections,
means connecting said first and second sections in said first and second phase sensitive circuits, respectively,
a manual knob connected to move said potentiometer,
manual switch means moved in accordance with said knob to establish an output from said first phase sensitive circuit,
movement of said knob also moving said potentiometer to unbalance said first phase sensitive circuit and energize said first relay means to maintain the output from said first phase sensitive circuit after opening of said manual switch means upon release of said knob,
means to establish an output from said second phase sensitive circuit,
the movement of said potentiometer also unbalancing said second phase sensitive circuit to energize said second relay means to energize said second drive means,
means connecting said first drive means to effect rebalance of said first phase sensitive circuit to de-energize said first relay means to terminate output from said first phase sensitive circuit and de-energize said first drive means,
and means connecting said second drive means to effect rebalance of said second phase sensitive circuit to de-energize said second relay means to de-energize said second drive means.

10. A control system comprising, in combination, first drive means,
a first phase sensitive circuit,
first relay means controlled by the output of said circuit and connected to control energization to said drive means and to said circuit,
an indicator,
second drive means connected to drive said indicator,
a second phase sensitive circuit having relay means connected to control energization to said second drive means,
first manual switch means connected to control energization to said first phase sensitive circuit,
a potentiometer having first and second sections,
means connecting said first and second sections in said first and second phase sensitive circuits, respectively,
a manual knob connected to move said potentiometer,
second manual switch means moved in accordance with said knob to energize said first phase sensitive circuit,
movement of said knob also moving said potentiometer to unbalance said first phase sensitive circuit and energize said first relay means to maintain said first phase sensitive circuit energized after opening of said second manual switch means upon release of said knob,
means to effect energization of said second phase sensitive circuit, the movement of said potentiometer also unbalancing said second phase sensitive circuit to energize said second relay means to energize said second drive means,
means connecting said first drive means to effect rebalance of said first phase sensitive circuit to de-energize said first relay means to de-energize said first phase sensitive circuit and de-energize said first drive means,
and means connecting said second drive means to effect rebalance of said second phase sensitive circuit to de-energize said second relay means to de-energize said second drive means.

11. A control system comprising, in combination, reversible output drive means,
a first phase sensitive circuit,
first relay means controlled by the output of said circuit and having contact means connected to control energization to said drive means and to said circuit,
an indicator,
second reversible output drive means connected to drive said indicator,
a second phase sensitive circuit having second relay means with contact means connected to control energization to said second drive means,
first manual switch means connected to control energization to said first and second phase sensitive circuits,
a potentiometer having first and second sections,
means connecting said first and second sections in said first and second phase sensitive circuits, respectively,
a manual knob connected to move said potentiometer,
second manual switch means moved in accordance with said knob to energize said first phase sensitive circuit,
movement of said knob also moving said potentiometer to unbalance said first phase sensitive circuit and energize said first relay means to maintain said first phase sensitive circuit energized after opening of said second manual switch means upon release of said knob,
the movement of said potentiometer also unbalancing said second phase sensitive circuit to energize said second relay means to energize said second drive means,
means connectng said first drive means to effect rebalance of said first phase sensitive circuit to de-energize said first relay means to de-energize said first phase sensitive circuit and de-energize said first drive means,
and means connecting said second drive means to effect rebalance of said second phase sensitive circuit to de-energize said second relay means to de-energize said second drive means.

12. A control system comprising, in combination, drive means having a reversible output,
a first phase sensitive circuit having an input energizable from alternating current source means and having an output,
first relay means controlled by the output of said circuit and having first contact means,
means connecting said first contact means to control energization to said drive mean and to said first circuit,
an indicator,
second reversible output drive means connected to drive said indicator,
a second phase sensitive circuit having an input and having an output,
second relay means controlled by the output of said second circuit and having second contact means,
means connecting said second contact means to control energization to said second drive means,
a first manual switch connected to control energization from said alternating current source means to said first phase sensitive circuit,
a potentiometer having first and second sections,
means connecting said first and second sections in said first and second phase sensitive circuits, respectively,
a manual knob connected to move said potentiometer,
a second manual switch moved in accordance with said knob to disable energization of both said drive means,
a third manual switch actuated closed in accordance with movement of said knob to energize said first phase sensitive circuit,
movement of said knob also moving said potentiometer to unbalance said first phase sensitive circuit and energize said first relay means and to close said

first contact means to maintain said first phase sensitive circuit energized after opening of said third manual switch upon release of said knob,

the movement of said potentiometer also unbalancing said second phase sensitive circuit to energize said second relay means and close said second contact means to energize said second drive means,

means connected to be operated in accordance with said first drive means to effect rebalance of said first phase sensitive circuit to de-energize said first relay means and open said first contact means to de-energize said first phase sensitive circuit and de-energize said first drive means,

and means connected to be operated in accordance with said second drive means to effect rebalance of second phase sensitive circuit to de-energize said second relay means and open said second contact means to de-energize said second drive means.

13. An indicator and follow-up control system for drive means having an output, comprising, in combination.

first and second bridges each having an input and an output,

a potentiometer connected in said first and second bridges,

means connecting the output of said first bridge to control the movement of said drive means,

a change of impedance of said potentiometer unbalancing said first bridge to establish controlled movement of said output of said drive means,

means connecting said output of said drive means as a follow-up toward rebalance of said first bridge,

an indicator device,

second drive means connected to drive said indicator device,

means connecting the output of said second bridge to control the movement of said second drive means,

a change of impedance of said potentiometer also unbalancing said second bridge to establish controlled movement of said output of said second drive means,

and means connecting said output of said second drive means as a follow-up toward rebalance of said second bridge.

14. A remote indicator and follow-up control system for drive means having a reversible output, comprising, in combination,

first and second balanceable alternating current bridges each having an input energizable from alternating current source means and each having an output,

first and second potentiometers connected in said first bridge,

means connecting the output of said first bridge to control the movement of said drive means,

a change of impedance of said first potentiometer unbalancing said first bridge to establish controlled movement of said reversible output of said drive means,

means connecting said second potentiometer for movement in accordance with movement of said output of said drive means as a follow-up toward rebalance of said first bridge,

a remote indicator device,

second reversible output drive means connected to drive said indicator device,

a third potentiometer,

means connecting said first and third potentiometers in said second bridge,

means connecting the output of said second bridge to control the movement of said second drive means,

a change of impedance of said first potentiometer also unbalancing said second bridge to establish controlled movement of said output of said second drive means,

and means connecting said third potentiometer for movement in accordance with movement of said output of said second drive means as a follow-up toward rebalance of said second bridge.

15. A remote indicator and follow-up control system for first drive means having a reversible output comprising, in combination,

first and second balanceable alternating current bridges each having an input energizable from alternating source means and each having an output,

first, second and third potentiometers,

said first potentiometer having first and second complementary sections with concurrently and inversely changeable impedance,

means connecting said second potentiometer and the first section of the first potentiometer in said first bridge,

means connecting said third potentiometer and said second section of said first potentiometer in said second bridge,

manual switch means to establish energization of said first and second bridges from said alternating current source means,

means connected to the output of said first bridge controlling the energization to said drive means and maintaing energization to said first bridge,

a change of impedance of said first potentiometer unbalancing said first bridge to establish an output therefrom and to establish selected directional movement of the output of said drive means,

means connecting said second potentiometer for movement in accordance with movement of said output of said drive means as a follow-up toward rebalance of said first bridge,

a remote indicator device,

second reversible output drive means connected to drive said indicator device,

means connected to the output of said second bridge to effect energization to said second drive means,

a change of impedance of said second section of said first potentiometer also unbalancing said second bridge to establish an output therefrom and to establish selected directional movement of the output of said second drive means,

and means connecting said third potentiometer for movement in accordance with movement of said output of said second drive means as a follow-up toward rebalance of said second bridge.

16. A remote indicator and follow-up control system for first drive means having a reversible output comprising, in combination,

first and second balanceable alternating current bridges each having an input energizable from alternating current source means and each having an output,

first, second and third potentiometers,

said first potentiometer having a movable blade to concurrently and inversely change the impedance of first and second complementary sections thereof,

means connecting said second potentiometer and the first section of the first potentiometer in said first bridge,

means connecting said third potentiometer and said second section of said first potentiometer in said second bridge,

first and second relay means controlled in energization from the output of said first and second bridges, respectively,

manual switch means to establish energization of said first and second bridges from said alternating current source means,

normally open contact means on said first relay means of said first bridge controlling the energization to said drive means and maintaining energization to said first bridge,

movement of said movable blade of said first potentiometer unbalancing said first bridge to energize said

first relay means and to establish selected directional movement of said drive means,

means connecting said second potentiometer for movement in accordance with movement of said output of said drive means as a follow-up toward rebalance of said first bridge,

a remote indicator device,

second reversible output drive means connected to drive said indicator device,

normally open contact means of said second relay means connected to effect energization of said second drive means,

movement of said movable blade of said first potentiometer also unbalancing said second bridge to energize said second relay means therein and to establish selected directional movement of the output of said second drive means,

and means connecting said third potentiometer for movement in accordance with movement of said output of said second drive means as a follow-up toward rebalance of said second bridge.

17. A remote indicator and follow-up control system for first drive means having a reversible output comprising, in combination,

first and second balanceable alternating current bridges each having an input energizable from alternating current source means and each having an output,

first, second and third potentiometers,

said first potentiometer having a movable blade to concurrently and inversely change the impedance of first and second complementary sections thereof,

means connecting said second potentiometer and the first section of the first potentiometer in said first bridge,

means connecting said third potentiometer and said second section of said first potentiometer in said second bridge,

first and second relay means controlled in energization from the output of each said bridge,

manual switch means to establish energization of said first and second bridges from said alternating current source means,

normally open contact means on said first relay means of said first bridge controlling the energization to said drive means and maintaining energization to said first bridge,

contact means on said second relay means of said first bridge connected for selected bi-directional rotation of said drive means,

movement of said movable blade of said first potentiometer unbalancing said first bridge to energize at least one of said relay means therein to establish selected directional movement of said drive means,

means connecting said second potentiometer for movement in accordance with movement of said output of said drive means as a follow-up toward rebalance of said first bridge,

a remote indicator device,

second reversible output drive means connected to drive said indicator device,

normally open contact means of said first relay means of said second bridge connected to effect energization of said second drive means,

contact means of said second relay means in said second bridge connected for selected bi-directional rotation of the output of said second drive means,

movement of said movable blade of said first potentiometer also unbalancing said second bridge to energize at least one of said relay means therein to establish selected directional movement of the output of said second drive means,

and means connecting said third potentiometer for movement in accordance with movement of said output of said second drive means as a follow-up toward rebalance of said second bridge.

18. A remote indicator and follow-up control system as claimed in claim **17**, including means connecting said second bridge for energization in accordance with energization of said first relay means of said second bridge.

19. A remote indicator and follow-up control system for drive means having a reversible output comprising, in combination, a first and a second balanceable alternating current bridge each having two output terminals,

means to energize each said bridge from alternating current source means,

first and second relay means in each bridge,

means including normally open contacts controlled by said first relay means in said first bridge connected to control the output from said first bridge,

means including contact means of said second relay means connected for selective bi-directional rotation of the output of said drive means,

first, second and third potentiometers,

means connecting said first and second potentiometers in said first bridge,

means connecting said first and third potentiometers in said second bridge,

first and second rectifiers connected in each bridge and oppositely poled for conduction on opposite half cycles of the voltage of the alternating current source means,

a transistor amplifier in each bridge,

means connecting the output of each said bridge to the input of the respective amplifier,

means in each bridge connecting the output of the respective amplifier through said first rectifier to said alternating current source means to energize said first relay means upon movement of said first potentiometer in a first direction to unbalance the respective bridge output in a first direction to cause conduction of the respective amplifier on a first one of first and second half cycles of the alternating current source voltage,

means in each bridge for connecting the output of the respective amplifier through said second rectifier to said alternating current source means to energize said second relay means upon movement of said first potentiometer in the second direction to unbalance the respective bridge output in a second direction to cause conduction of the respective amplifier on a second one of first and second half cycles of the alternating current source voltage,

means connecting said second potentiometer to be moved in accordance with movement of the output of said drive means as a follow-up to terminate movement of said drive means upon rebalance of said first bridge,

a remote indicator,

a second reversible drive means connected to drive said indicator,

means including normally open contacts controlled by by said first relay means in said second bridge to control energization to said second bridge,

means including contact means of said second relay means in said second bridge connected for selective bi-directional rotation of the output of said second reversible drive means,

and means connecting said third potentiometer to be moved in accordance with movement of the output of said second drive means as a follow-up to effect rebalance of said second bridge and to terminate movement of said second drive means.

No references cited.

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