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SYNCHRONOUS COUNTER SYSTEM

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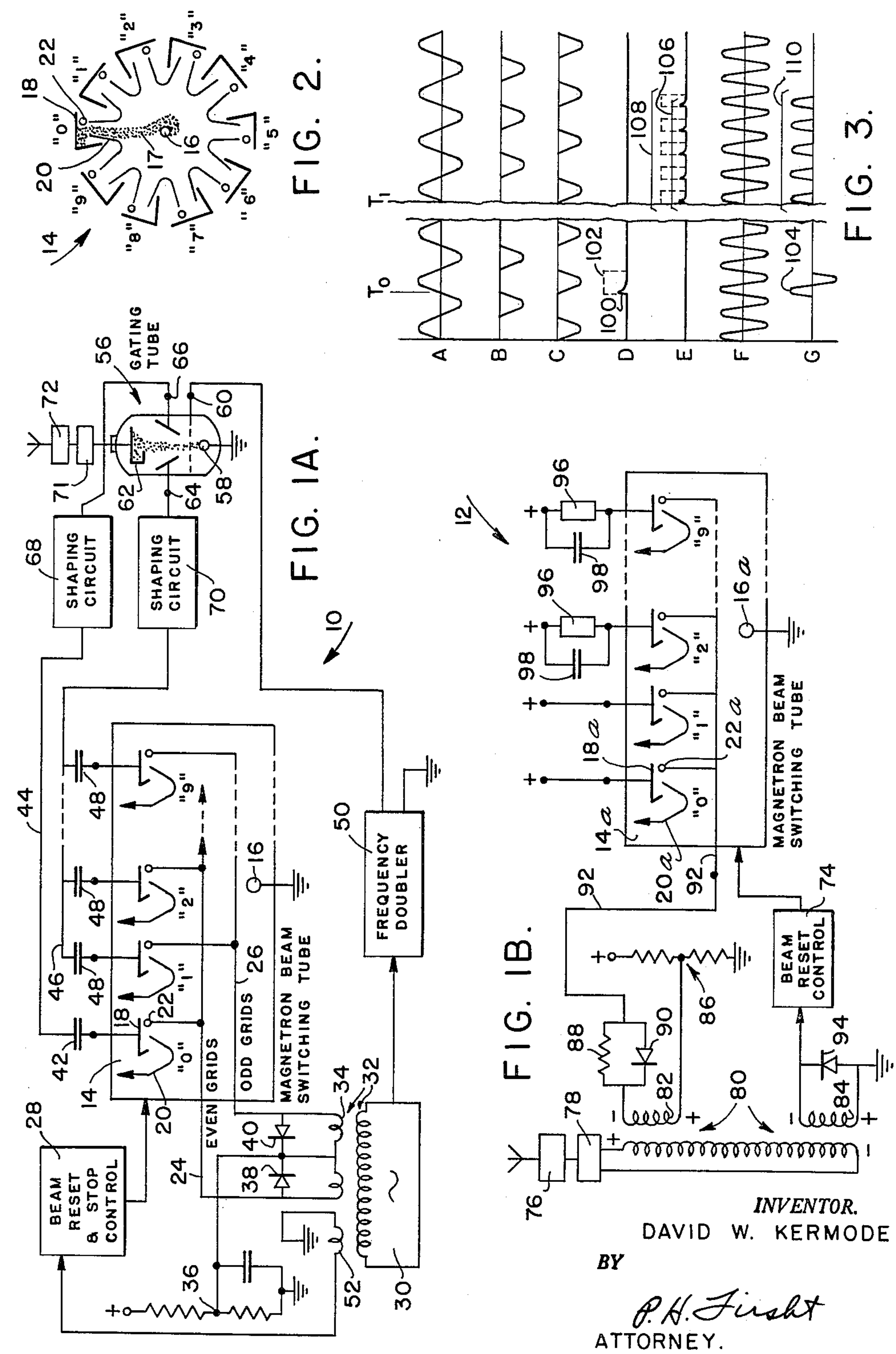

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SYNCHRONOUS COUNTER SYSTEM

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The invention herein described may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to telecontrol systems of the type in which a sending counter synchronously controls a receiving counter by means of a pulsed signal, and more particularly to such a telecontrol system employing magnetron beam switching tubes.

Telecontrol systems of the type referred to offer many advantages over the types of telecontrol systems employing fixed frequency tone signals or linear amplitude variation signals. Among these advantages are (1) relative freedom from interference by noise and variation of receiver input signal level due to the inherent reliability of detection of pulsed signals, (2) simplicity of the accessory equipment for detecting the pulse signals at the receiver, and (3) the considerable flexibility afforded as the result of the almost unlimited number of independent counter states which may be provided by techniques for cascading the counters.

The synchronous counter systems of the prior art have generally been electro-mechanical, employing relays and electromagnetic stepping switches, and have used mechanical switches which operate by the opening and closing of switch contacts. One disadvantage of such prior art systems is their inherent slowness due to the inertia of the mechanical parts and relative slowness of opening and closing mechanical switch contacts. Also the electro-mechanical components are bulky and heavy and in many instances require a power supply which is several orders of magnitude larger than the power supply needed for the communication equipment.

Accordingly, an object of the present invention is to provide a novel and improved telecontrol system of the type employing synchronously operated counters.

Another object is to provide a telecontrol system of the type employing synchronously operated counters capable of very high speeds of operation.

A further object is to provide a telecontrol system of the type employing synchronous counters capable of operation from communication equipment power supplies.

Other objects, features and many of the attendant advantages of this invention will be readily appreciated as the same become better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIGS. 1A and 1B are a schematic of a remote radio control system in accordance with the invention;

FIG. 2 is a diagrammatic representation of the physical structure of the magnetron beam switching device of FIGS. 1A and 1B; and

FIG. 3 is a series of curves illustrating waveforms taken at various points in FIG. 1A.

Referring now to the drawing, the invention comprises a telecontrol system employable in various organizations in which a mechanism is to be controlled and operated at a distance, such as in remote control systems for dirigible vehicles, timing systems for test range instrumentation, and circuit selection systems for dial telephone apparatus or automatic computers. Illustrative of one such organization is a radio remote control system intended for controlling a target drone (not shown) comprising a sending station 10, FIG. 1A, and a receiving station 12, FIG. 1B.

Sending station 10 comprises a conventional magne-

tron beam switching tube 14, FIGS. 1A and 2, such as the 6700 series type tube manufactured by the Burroughs Corporation of Plainfield, N.J. Referring to FIG. 2, tube 14 comprises an evacuated and sealed envelope (not shown) containing a central beam emitting electrode 16. An electron beam 17 may be formed in any one of a successive series of equiangularly spaced generally radial positions numbered "0," "1," "2" etc., in the clockwise direction. Ten positions have been illustrated, which is typical of a tube designed for decade counting. At each position there is disposed a generally L-shaped electrode 18 commonly known as a target, which serves as an anode to receive the beam 17; a generally U-shaped electrode 20 commonly known as a spade, which serves to shape and hold the electron beam; and a beam switching grid 22. A negative voltage applied to the beam switching grid at the position next in series to the existing position of the beam causes the beam to be switched to the target of such next position. Similar voltage variations on grids other than the one next in series to the existing position of the beam do not cause this switching. Beam emitting electrode 16 is connected to ground and the spades 20 and targets 18 are connected to positive direct current (D.C.) sources (not shown) to provide operating voltages for the tube. The beam switching grids 22 of the even numbered (including "0") positions are connected to a common conductor 24 while the grids of the odd numbered positions are connected to a different common conductor 26.

Forming the control input of sending station 10 is a beam reset and stop control 28 for resetting the beam to its "0" position and limiting subsequent stepping of the beam under successive switching signals to a selected position, so that the beam will stop at the elected position. Such a control is commonly known as a "preset" and is conventional in the art of counter circuits. One type of beam reset and stop control operates by controlling the potentials supplied to the spades and targets of tube 14. For example, the beam may be reset to the "0" position by momentarily depressing the potentials of all spade electrodes and maintaining the potential of the spade at the "0" position depressed a finite time longer than the spades of the other position. Under subsequent switching, the beam may be caused to stop at the selected position by applying operating potentials only to the spades and targets of the beam positions of the series extending through the selected position. The beam will simply be prevented from forming at positions subsequent in series to the selected position because of absence of operating potential, and will therefore remain formed at the selected position. Control 28 has a suitable preselection input (not shown) by which it may be set to stop the beam at the selected position, which input may be adapted for manual operation, as by actuation a preset count control element, or it may be operated by control circuits which in turn are part of a more comprehensive circuit selection system.

A source of alternating current (A.C.) such as oscillator 30 produces an A.C. signal which is coupled to the primary winding of a transformer 32. The secondary winding 34 of transformer 32 has a center tap which is connected to a tap 36 of a voltage dividing network located between a positive source and ground. One end of secondary winding 34 is connected to conductor 24 and one side of a diode 38, the diode 38 being poled with its cathode connected to the center tap of winding 34. The other end of winding 34 is connected to conductor 26 and one side of a diode 40, the diode 40 being poled with its cathode connected to the center tap. During the half cycle when the end of secondary winding 34 connected to conductor 24 is positive with respect to the other end, diode 38 acts as a short circuit preventing the application of any pulse signal to the switching grids of the even sets and diode 40 acts as an open circuit permitting a negative pulse to be applied by way of conductor 26 to the switching grids of the odd sets. When the polarity reverses, a negative signal will be applied to switching grids of the even sets and no signal to the switching grid of the odd sets. Thus, negative pulses formed by each half cycle of the signal produced by oscillator 30 will alternately appear on the even and odd beam switching grids tending to successively switch the beam from position to position of the series of beam positions at a swtiching rate equal to twice the frequency of oscillator 30. The D.C. potential at tap 36 of the voltage divider provides the operating bias for the grids and is applied to the switching grids of the even and odd sets through the respective halves of secondary winding 34. Upon formation of beam 17 at any target 18, a transient deflection signal appears at the target. The deflection signals appearing at target 18 of the "0" position are coupled, by any suitable coupling device, which in its most simplified form may be coupling capacitor 42, to an output line 44. Similarly, the deflection signals at the target electrodes 18 at position "1" through "9" are coupled to a common output line 46, through coupling capacitors 48. If desired, the coupling between the targets and the respective output lines, may be achieved by a pulse transformer in place of capacitors 42 and 48, which would permit better isolation of the signal. Oscillator 30 also drives a frequency doubler 50 which produces an A.C. signal having twice the frequency of the output of oscillator 30 with a predetermined phase relationship relative thereto. For example, frequency doubler 50 may be synchronously driven to cause a start of the positive half cycle of the doubled frequency signal to coincide with the start of the positive half cycle of the output of oscillator 30. The beam reset portion of control 28 is synchronized with the output of oscillator 30 by means of a pickup coil 52 associated with the primary winding of transformer 32 to cause resetting of the beam to its "0" position in synchronous relation to the A.C. signal output of the oscillator, with the resetting occurring in predetermined phase relationship with the A.C. signal output of oscillator 30 and the A.C. signal output of frequency doubler 50. In the case of the aforementioned exemplary phase relationship of the signals of oscillator 30 and frequency doubler 50, resetting of the beam to its "0" position would be synchronized to coincide with the positive going half cycle of the signal out of oscillator 30.

The doubled frequency signal from doubler 50 is applied to a high speed gating tube 56, such as beam deflection amplifier tube, type NU 2206–SW6, manufactured by National Union Electric Corporation of Bloomington, Illinois. Tube 56 has a beam emitting electrode 58, a control grid 60, a non-symmetrical beam receiving anode 62, and opposed deflection plates 64 and 66, the signal from doubler 50 being applied to control grid 60. The deflection signal through output line 44, which occurs when the beam forms at its "0" position, triggers a wave shaping circuit 68, such as a conventional phantastron circuit, producing a pulse having a duration equal to the period of one full cycle of the doubled frequency signal of the frequency doubler 50. Each deflection signal through output line 46, due to switching of the beam to successive positions, triggers a wave shaping circuit 70, which is similar to shaper 68 but produces a pulse having a duration equal to one half the period of one cycle of the doubled frequency. The outputs of shaping circuits 68 and 70 are applied to deflection plates 66 and 64, respectively. Tube 56 acts as a normally closed gate with deflection plates 64 and 66 forming a pair of gating inputs. When no signal is present on either of the deflection plates the electron beam is directed centrally in the tube to anode 62 and no signal appears at the anode. Presence of a signal at one or the other of the deflection plates deflects the beam from its central position permitting the signal appearing at control grid 60 to be passed to the anode 62. The signal output at anode 62 is applied as the modulating signal to a conventional modulation stage 71 of any suitable type providing a scheme for modulating a radio carrier signal in such way that negative and positive inputs provide distinguishable modulation signal components. The signal components at the output of the modulator 71 are then coupled to a conventional radio transmitter power output 72 and antenna.

Receiving station 12, FIG. 1B, comprises a magnetron beam switching tube 14*a* similar to tube 14, the corresponding parts thereof being designated by like reference numerals with the suffix letter "*a*." Operatively associated with tube 14*a* is a beam reset control 74 for resetting the beam of tube 14*a* to its "0" position. Beam reset control 74 is similar in structure and operation to the portion of control 28 which serves to reset the beam of tube 14 to "0" position.

Forming the input of receiving station 12 is a conventional receiver front end 76 tuned to the frequency of transmission of the sending station 10. The output of receiver front end 76 is coupled to a demodulation stage 78 for detecting the signal components corresponding to the positive and negative signal components applied to the modulation stage 71 in the circuit of sending station 10. The detected signal is then applied to the primary winding of a transformer 80 having a pair of secondary windings 82 and 84. Transformer 80 is so wound that when the detected signal from the demodulator 78 is of positive polarity the signals at each secondary will have the exemplary instantaneous polarity relationships shown on the drawing. The lower end (as it appears on the drawing) of secondary winding 82 is connected to a tap 86 of a voltage divider located between a positive source and ground, and the upper end of secondary winding 82 is connected, through a parallel network consisting of a resistor 88 and a diode 90, to a conductor 92 connected to each beam switching grid 22*a* of tube 14*a*. The parallel network of resistor 88 and diode 90 forms a polarity discriminating circuit which passes only negative polarity signals to the beam switching grids. Diode 90 is poled with its cathode connected to the end of winding 82 and resistor 88 has a relatively large value of resistance. When a positive potential is applied to the secondary winding 82, diode 90 is cut off and substantially none of the signal is applied to the grids due to the high resistance 88 in series with winding 82. When a negative polarity signal appears secondary winding 82, diode 90 short circuits resistor 88 and the signal is applied to the beam switching grids. The upper end of secondary winding 84 is connected to the trigger input of beam reset control 74 and the lower end of winding 84 is connected to ground. A diode 94 is shunt connected across winding 84 and poled with its cathode connected to the upper end of winding 84 and forms a polarity discriminating circuit which short circuits positive polarity signals and passes only negative polarity signals to beam reset control 74.

Coupled between each target electrode 18*a* at beam positions "2" through "9" and the source of operating potential for the targets are individual functioning means 96 to be selectively energized by the sending station. Each functioning means 96 independently performs a control operation for the mechanism operated by the telecontrol system. For example, in a remote control system for a dirigible vehicle such functioning means may be the individual actuators which steer the vehicle, in a timing system for a test range they may be the triggers to actuate instruments at various stations, or in a circuit selection system they may be selector switches for making a desired connection. Each functioning means 96 is adapted to be energized only when the beam is stopped, or otherwise formed in a relatively steady state, at the target to which the functioning means is connected. This adaptation is symbolically shown in the drawing by bypass capacitors 98 through which relatively transient signal inflections are passed. However, it is to be understood that in many practical circuits in which the rate of switching the beam is relatively high, the difference between the amount of energy imparted to the target as the beam is stepped across the target by a continuously applied switching signal and the energy imparted to the target when the beam is stopped thereat is of several orders of magnitude and the threshold of operation of the functioning means may itself serve to be selective of whether the beam is formed to the target in a steady state relationship or not. No functioning means has been connected to hte target **22a** at the "1" position of the tube for the reason that in the event receiving station **12** would receive an unwanted signal modulated by a sine wave, the beam **17a** of tube **14a** would alternately shift between the targets of the "0" and "1" positions and could cause the unwanted energization of a functioning means at the "1" position.

For a better understanding of the operation of the radio control system of FIGS. 1A and 1B, reference is now made to FIG. 3 wherein the abscissa represents time; curve A the signal at the output of oscillator **30**; curve B the signal at the beam switching grids **22** of the "even" beam positions of tube **14**; curve C the signal at the beam switching grids **22** of the "odd" beam positions of tube **14**; curve D the signal through output line **44**; curve E the signal through output line **46**; curve F the signal output of frequency doubler **50**; and curve G the signal at the output anode **62** of tube **56**.

As an example of system operation, suppose that it is desired to remotely energize the functioning means **96** connected to the target **18a** of position "5" (not shown) of tube **14a** in the receiving station. Accordingly, the appropriate preset count control element of control **28** is actuated to initiate movement of the beam of tube **14** and limit such movement to position "5"; actuation of the control element serving to interrupt the reset function of control **28**. At a time T_0 the beam reset and stop control **28** effects formation of the beam at the "0" position. Due to synchronization means **52**, time T_0 coincides with the start of a positive half cycle of both the signal out of oscillator **30**, curve A, and the signal out of frequency doubler **50**, curve F. Formation of the beam at the "0" position of tube **14** produces an inflection signal **100**, curve D, which triggers shaping circuit **68**, which in turn produces a pulse **102**, shown by broken line superimposed on curve D, of a duration equal to one full period of double frequency signal, curve F. Application of pulse **102** to deflection plate **66** gates the signal out of frequency doubler **50** for one full cycle, producing a full cycle signal **104**, curve G, at output anode **62** of tube **56**. Signal **104** is then transmitted as a modulation component of the radio signal. Upon demodulation in the receiving station **12** the negative half cycle of full cycle signal **104** passes through the polarity discriminating arrangement associated with secondary winding **84** and triggers beam reset control **74** to reset the beam of tube **14a** to its "0" position. It is to be noted that the positive half cycle of full cycle signal **104** is an unwanted signal which could be eliminated by suitable delay network in wave shaper **68** or diode network for by-passing it. However, such elimination is not necessary since the unwanted positive half cycle causes no more than a highly transistory switching of the beam to the "1" position of tube **14a**, which in any case precedes the reset action. The inherent inertia of control **28** may cause the beam to remain at the "0" position of the tube **14** for a finite time. At the conclusion of such finite time, at some moment T_1, the negative half cycles pulses alternately applied to the even and odd beam switching grids **22**, curves B and C, will cause the beam to step to the position "5" where the beam stops by reason of beam reset and stop control **28**. Stepping of the beam causes a series of inflection signals **106**, curve E, through output line **46**, which trigger shaper circuit **70** to in turn produce a series of pulses **108**, shown by broken line superimposed on curve E, each pulse **108** having a duration equal to one half cycle period of the doubled frequency signal, curve F. Due to synchronization the pulses **108** are applied to deflection plate **64** only during the positive half cycle of the double frequency signal, resulting in a train of positive pulses **110**, curve G, at anode **62** of tube **56**. Pulses **110** are transmitted and subsequently received and demodulated in receiver **12** where they are passed through the positive passing discriminating network to grids **22a** of tube **14a**, stepping its beam to the target at position "5." Until the preset control **28** is again actuated, the beam remains in this position energizing the corresponding functioning means **96**. It is to be understood that the speed at which the described operations take place is limited only by the maximum frequency of switching of the beam of tube **14** which is in the megacycle range, so that the entire described operation may take place in several microseconds or less.

It will be apparent, from the aforesaid description of operation that the output of frequency doubler **50**, curve F, is in effect a carrier signal which is modulated by the gating inputs to deflection plates **64** and **66** to produce the positive and negative half cycle positive pulses at anode **62**. It has been found that satisfactory results may be obtained with the omission of modulation stage **71** in the sending station and demodulation stage **78** in the receiving station. In such case, the output of anode **62** is coupled directly to transmitter output **72**, and the output of receiver front end **76** is coupled to the primary winding of transformer **80**. The doubled frequency signal, curve F, then becomes the radio carrier frequency. As an example of such operation, satisfactory results without modulation and demodulation stages **71** and **78** have been obtained at radio frequencies from 30 kilocycles to 2 megacycles using a conventional tuned radio frequency type receiver as front end **76**.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. Remotely controlled counting apparatus comprising, a sending counter and a receiving counter, each of said counters adapted to be switched from a reference count condition through a series of successive count conditions in step by step response to each pulse of a train of pulses applied to the input thereof, each of said counters having an associated reset means actuable to switch the counter to its reference counting condition, said sending counter having an individual counter output associated with each count condition and upon assuming a count condition adapted to provide a count signal at the associated output, said sending counter including control means for stopping the counter at a desired count condition, a first source for producing a first A.C. signal, circuit means for deriving a train of pulse signals for switching the sending counter from said first A.C. signal, each pulse of said series of pulses corresponding to a half cycle of said first A.C. signal, circuit means for deriving a second A.C. signal from said first A.C. signal, said second A.C. signal having twice the frequency of said first A.C. signal and having a predetermined phase relationship to said first A.C. signal, normally closed gating means having a signal input, a signal output, and first and second gate inputs, said second A.C. signal being applied to said signal input, first signal shaping means interconnecting the output of the sending counter associated with the reference count condition thereof and the first gate input, said first signal shaping means being adapted to gate a half cycle of said second A.C. signal of one of opposite polarities to provide a reset signal to switch the receiving counter to its reference condition, a second signal shaping means interconnecting the outputs of the sending counter associated with the count conditions thereof subsequent to the reference condition and the second gate input, said second signal shaping means adapted to gate a half cycle of said second A.C.

signal of the other of opposite polarities in response to each pulse signal appearing at the aforesaid outputs to provide a count signal to switch the receiving counter to the count condition thereof corresponding to the count at which the sending counter is stopped, said receiving counter having operatively associated therewith polarity discrimination means to actuate the reset means of the receiving counter in response to said reset signal and count signal to the input thereof, and communication circuit means connecting the output of the gating means and the polarity discrimination means.

2. Apparatus in accordance with claim 1, said sending counter comprising an electronic beam switching device having a beam emitting electrode and a sequential series of beam receiving electrodes, each beam receiving electrode having an individual switching electrode associated therewith for shifting the beam thereto from the preceding beam receiving electrode of the series, the switching electrodes associated with the beam receiving electrodes of the series forming the input of the sending counter, said beam receiving electrodes each forming a counter output with the signal inflect thereat upon the beam being switched thereto providing the count signal.

3. Apparatus in accordance with claim 2, said reset means effecting formation of the beam at the first beam receiving electrode of the series, said circuit means for deriving a train of pulse signals for switching the sending counter being adapted to apply only one of two successive pulses to the beam switching electrode associated with the first beam receiving electrode and only the other of the two successive pulses to the beam switching electrode associated with the second beam receiving electrode.

4. Apparatus in accordance with claim 1, said communication circuit being of the radio type including a radio transmitter having means for modulating a radio carrier signal in accordance with the output of said first means for modulating, and a radio receiver having means for demodulating the received radio signal coupled to the input of the polarity discrimination means.

5. Apparatus in accordance with claim 1, said communication circuit being of the radio type including a radio transmitter having output means for transmitting a radio signal at the frequency of said second signal, said output of the gating means being connected directly to said output means, and a radio receiver having a frequency selective circuit tuned to the frequency of said second A.C. signal, the output of said frequency selective circuit being directly coupled to said discriminator means.

6. A telecontrol system for selectively energizing one of a plurality of functioning means, comprising; a receiving station including a magnetron beam switching tube having a beam emitting electrode, a series of beam receiving electrodes disposed in a successive series, and means actuable to form an electron beam between said beam emitting electrode and the first beam receiving electrode of said series, a plurality of functioning means each individually connected to a different beam receiving electrode and energizable in response to formation of a steady state electron beam to the associated beam receiving electrode, each beam receiving electrode having an individual switching electrode associated therewith for shifting the beam thereto from the preceding beam receiving electrode, a transmitting station including means for generating a first reset signal to actuate said means actuable to form an electron beam and means for generating a second signal comprising a train of pulses having a selective number of pulses to shift the beam from the first beam receiving electrode to the beam receiving electrode associated with the desired functioning means, and communication circuit means communicating the first signal to said means actuable to form an electron beam and communicating the second signal to the beam switching electrodes of the magnetron beam switching tube in such manner that the beam is successively shifted through the intermediate beam receiving electrode positions to the beam receiving electrode associated with the desired functioning means in step with the pulses of the pulse train.

No references cited.