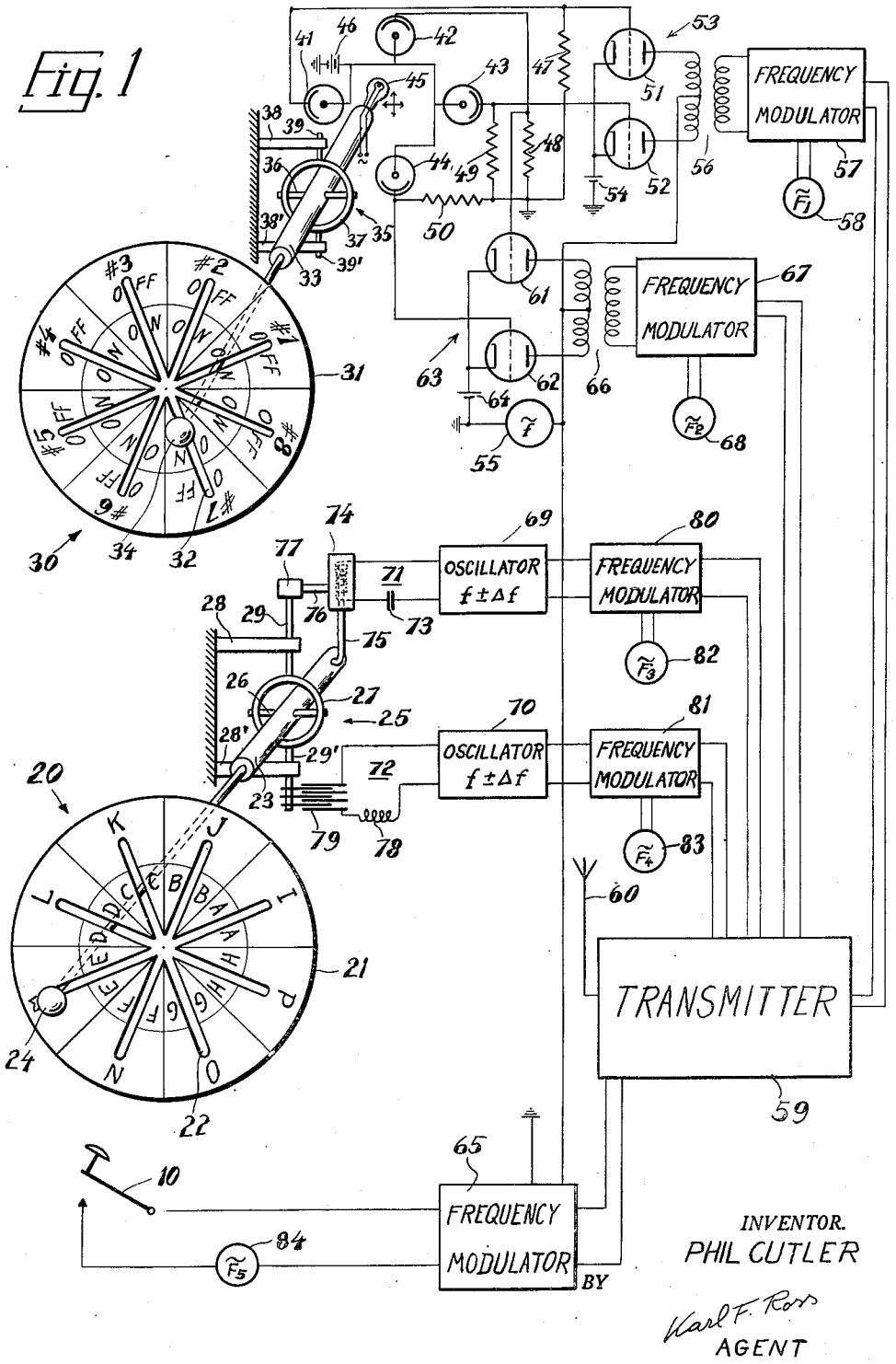
March 16, 1954 P. CUTLER 2,672,603

REMOTE-CONTROL AND INDICATING SYSTEM

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Fig. 1



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REMOTE-CONTROL AND INDICATING SYSTEM

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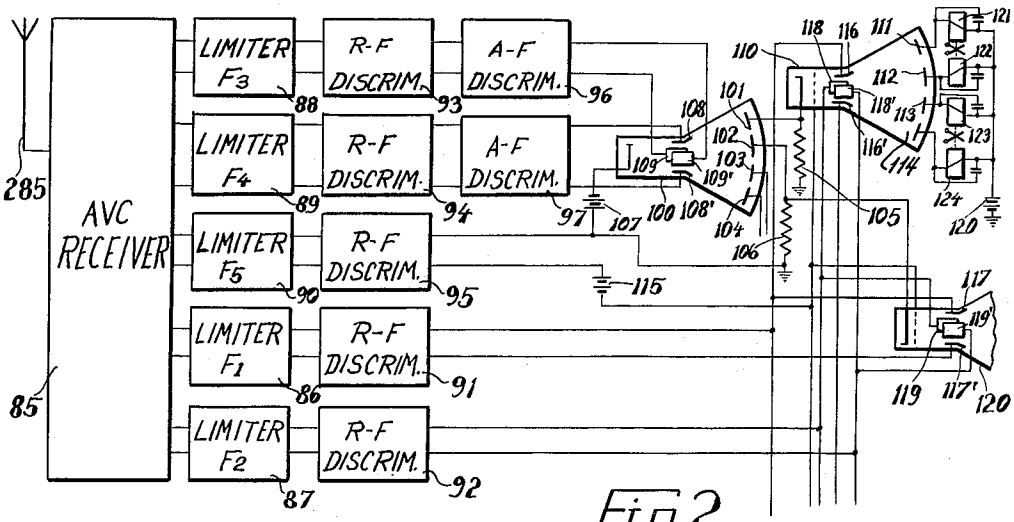


Fig. 2

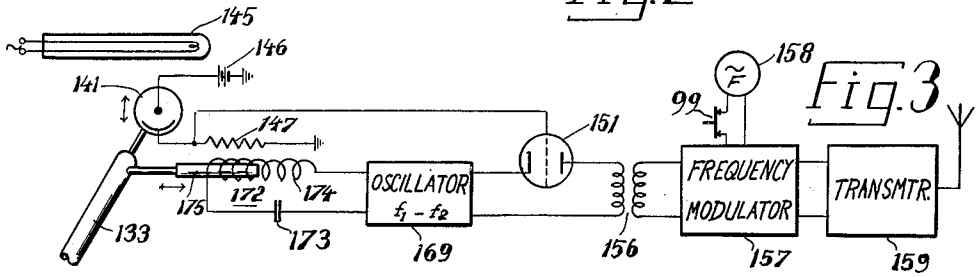


Fig. 3

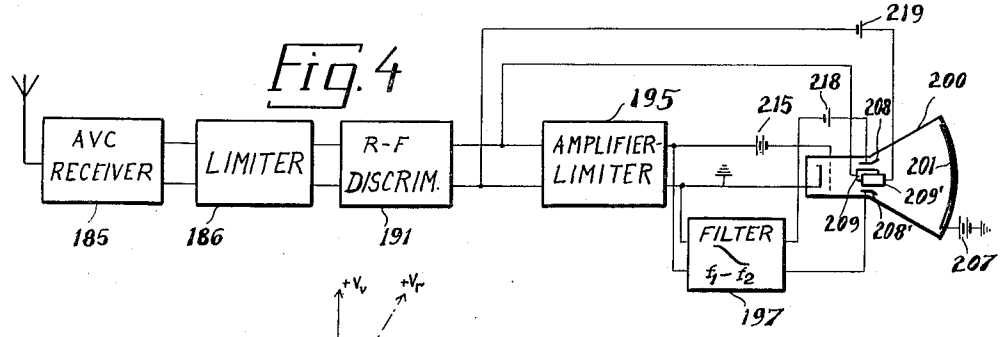
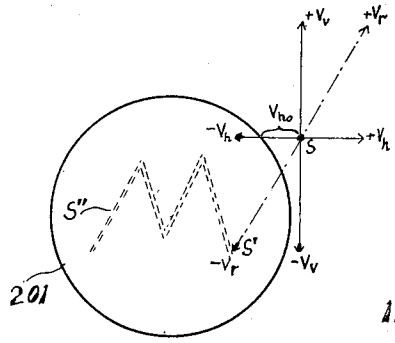


Fig. 4



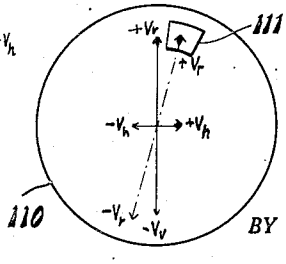


Fig. 6

Fig. 5

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REMOTE-CONTROL AND INDICATING SYSTEM

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4 Claims. (Cl. 340—282)

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The present invention relates to remote-control and indicating systems in which a controlled device, for instance a switch or an indicator, is selectively actuated by means of signals transmitted over a communication path which interconnects a control point and a remote point. The term "communication path" includes radio links as well as metallic circuits.

An object of the present invention is to provide, in a system of the character described, means for transmitting a great diversity of signals through the intermediary of electromagnetic waves occupying only a small number of communication channels each of relatively limited band width.

Another object of my invention is to provide, in a system of this type, novel and improved means for the remote actuation of a controlled device, such as a cathode ray tube.

A further object of this invention is to provide, in a remote-control and/or indicating system, receiver means at a remote point including one or more cathode ray tubes adapted to respond quickly and faithfully to a large number of commands given by a control device at a control point.

The above and other objects of the invention will become apparent and the invention will be best understood from the following description of certain embodiments, reference being had to the accompanying drawing in which:

Fig. 1 is a circuit diagram showing the control station in a remote-control system according to the invention;

Fig. 2 is a circuit diagram showing the remote station associated with the control station of Fig. 1;

Fig. 3 is a circuit diagram showing a modified control station, forming part of a remote-indicating system;

Fig. 4 is a circuit diagram showing the remote station associated with the control station of Fig. 3; and

Figs. 5 and 6 are diagrams illustrating the operation of the systems of the preceding figures.

Referring now to Fig. 1, there is shown a control station having means for selectively actuating a large number of controlled devices provided at a remote point. In the particular example illustrated it has been assumed that it is desired to control sixteen different groups of switches, such as relays, each group including eight different switches each having an "on" and an "off" position, thus making a total of 256 distinct switching operations.

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The means I provide for carrying out these different operations include a push button or circuit breaker **10**, a first selector **20** and a second selector **30**. Each of the two selectors includes a slotted disk **21**, **31**, respectively, each disk being divided into sixteen segments. The first selector disk, **21**, has its segments marked A through P; the sixteen segments of second selector disk **31** are labeled #1 On through #8 On and #1 Off through #8 Off. The slots **22**, **32** bisect each inner segment (A–H and #1 On–#8 On) and extend into each outer segment (I–P and #1 Off–#8 Off) along the line of symmetry thereof.

Each selector is further provided with an actuating member comprising a rod **23**, **33** a reduced portion of which passes through one of the slots of the associated disk and carries a knob **24**, **34**. The arrangement of the slots in the manner just described enables the knob **24**, **34** to be selectively positioned on any segment, thereby indicating the group, switch or function selected. It will be understood that rests or stops, not shown, may be provided for the purpose of more positively arresting the knob in a centered position with respect to any selected segment.

The lower extremity of each rod **23**, **33** is journaled for rotation in two planes in a universal joint **25**, **35**, respectively. Joint **25** comprises a pin **26** supporting the rod **23** in a gimbal ring **27**, the latter being rotatably mounted on brackets **28**, **28'** by means of studs **29**, **29'**. Similarly, the joint **35** comprises a pin **36** supporting the rod **33** in a gimbal ring **37**, this ring being pivotally held on brackets **38**, **38'** by means of studs **39**, **39'**.

While it is entirely possible to make the two selectors identical, I have shown for purposes of illustration two different arrangements utilizing amplitude and frequency modulation, respectively. Rod **33** carries at its lower end a source of light, shown here as a bulb **45** which is equidistant from four photocells **41**, **42**, **43** and **44** when the knob **34** is at the center of disk **31**. The anodes of these photocells are all connected to positive potential provided by a battery **46**; the cathodes are grounded by way of respective resistors **47**, **48**, **49** and **50**.

The cathodes of photocells **41**, **43** are connected to the grids of vacuum tubes **51**, **52** forming part of a push-pull amplifier **53**. This amplifier is biased by a battery **54** and is energized from an audio frequency oscillator **55** of frequency *f*. The output of amplifier **53** is applied through an output transformer **56** to a frequency modulator **57** which is also connected to a radio frequency

oscillator 58, producing a first carrier frequency F_1. The modulator 57 works into a transmitter 59 having an antenna 60.

The cathodes of the remaining photocells 42, 44 are connected to the grids of vacuum tubes 61, 62 forming part of a push-pull amplifier 63. This amplifier is biased by a battery 64 and is energized from the audio frequency oscillator 55 which also feeds a frequency modulator 65. The output of amplifier 63 is applied through an output transformer 66 to a frequency modulator 67 which is also connected to a radio frequency oscillator 68, producing a second carrier frequency F_2. Modulator 67 also works into the transmitter 59. The modulated carrier frequencies F_1 and F_2 represent two of the five channels used in this particular system and should be sufficiently spaced from each other to make them readily separable at the receiving end.

From the foregoing description it will be understood that the peak amplitude and phase of the modulation of carrier wave F_1 depend on the position of bulb 45 relative to photocells 41, 43 while the peak amplitude and phase of the modulation of carrier wave F_2 similarly depend on the position of the bulb relative to the photocells 42, 44. Thus, when the knob 34 is placed in its "neutral" position at the center of disk 31, bulb 45 is equidistant from the two pairs of differentially connected photocells and the output of both amplifiers 53, 63 is, therefore, zero. When the bulb approaches, say, the photocell 41, oscillations of frequency f and increasing amplitudes are set up in the secondary of transformer 56; on approaching the opposite cell 43, the amplitudes increase similarly but the oscillations are 180° out of phase with respect to those mentioned above. An analogous situation exists upon a change in the relative distance between bulb 45 and cells 42, 44.

From the foregoing it will also be apparent that the A.-F. signal applied to either modulator 57, 67 will be either in phase or in phase opposition with respect to the signal applied to modulator 65.

In the case of selector 20, a displacement of the knob 24, affects the frequency of two audio frequency oscillators 69, 70 having tank circuits 71, 72, respectively. Tank circuit 71 comprises a fixed element 73, shown here as a condenser, and a variable element 74, shown here as an inductance coil having a movable core 75 secured to the lower end of rod 23. Coil 74 is pivotally held on a pin 76 projecting from a head 77 mounted on journal stud 29. Tank circuit 72 comprises a fixed coil 78 and a variable condenser 79 having a set of stationary plates as well as a set of movable plates, the latter being secured to the journal stud 29'.

The oscillators 69 and 70 are preferably designed so that each of them produces a center frequency f when the knob 24 occupies the center of disk 21.

Oscillators 69, 70 work into respective frequency modulators 80, 81. Modulator 80 receives a carrier frequency F_3 from a radio frequency oscillator 82. Modulator 81 receives a carrier frequency F_4 from a radio frequency oscillator 83. The outputs of both modulators are applied to the transmitter 59.

A fifth radio frequency oscillator 84, operating at a frequency F_5, is connected to the modulator 65 by way of circuit breaker 10. Modulator 65 also works into the transmitter 59.

The remote station, Fig. 2, comprises a receiver 85, having an antenna 285, which works into five limiters 86, 87, 88, 89 and 90 responsive to frequencies F_1–F_5, respectively. The output of each limiter is applied to a respective radio frequency discriminator, indicated at 91–95. Radio frequency discriminators 93, 94 feed a pair of audio frequency discriminators 96, 97, respectively.

The remote station also comprises a primary cathode ray tube 100 and a set of secondary cathode ray tubes of which only two, 110 and 120, are shown. Tube 100 is the counterpart of first selector 20 (Fig. 1) and is provided with sixteen targets such as 101–104 (only four shown) each connected to the cathode of a respective one of the secondary cathode ray tubes 110, 120 etc., the targets being further grounded through resistors such as 105, 106. The cathode of tube 100 is connected to the negative terminal of grounded battery 107. Vertical deflecting electrodes 108, 108' of tube 100 are connected across the output of discriminator 97, while horizontal deflecting electrodes 109, 109' are connected across the output of discriminator 96.

Each of the secondary cathode ray tubes, such as 110, is provided with sixteen targets such as 111–114 (only four shown), the secondary tubes in their totality being the counterpart of the second selector 30 (Fig. 1). The output of radio frequency discriminator 95 is applied, by way of a biasing battery 115, to the grids or intensity control electrodes of all secondary cathode ray tubes in parallel. The vertical deflecting electrodes such as 116, 116' and 117, 117' of all these tubes are connected in parallel across the output of discriminator 91, while the horizontal deflecting electrodes such as 118, 118' and 119, 119' are all connected in parallel across the output of discriminator 92.

The targets 111–114 are connected to the positive terminal of grounded battery 126 by way of respective switching devices 121–124. Each of these devices comprises a condenser-shunted relay, the relays being grouped in pairs with mechanically interlocking armatures, as shown. Relays 121 and 123 may be termed the "on" relays and relays 122, 124 the "off" relays of the respective pairs, there being eight such pairs for each secondary tube. It will be understood that the targets of tube 100 correspond to respective sections A–P of selector 20 and that the eight pairs of relays controlled by and associated with each secondary tube correspond to the units designated #1–#8 on disk 31 of selector 30.

We shall assume, by way of example, that target 101 corresponds to section M on disk 21 and that the paired relays 121, 122 correspond to sections #7 On and #7 Off on disk 31, respectively. It will be understood that any desired load, for example a motor, may be switched "on" and "off" by relays 121 and 122, respectively.

In order to illustrate the operation of the system of Figs. 1 and 2, let us suppose that the operator at the control point (Fig. 1) desired to turn "on" the unit #7 in group M. The three steps necessary to accomplish this are: Place knob 24 on the field M of disk 21; place knob 34 on the field #7 On of disk 31; depress momentarily the knob 10.

At the remote point (Fig. 2) the first step, having resulted in certain adjustments of the reactive elements in the input circuits of oscillators 69 and 70 which control the modulators

80 and 81, produces oscillations in the output of R.-F. discriminators 93 and 94 which correspond to the output voltages of oscillators 69 and 70, respectively, their frequencies being characteristic of the position of the knob 24. A.-F. discriminators 96 and 97 derive from these frequencies characteristic potentials which are applied to the horizontal deflecting electrodes 109, 109' and to the vertical deflecting electrodes 108, 108' of tube 100, respectively, thereby causing the beam of this tube to impinge upon the selected target 101. This positioning of the beam results in a voltage drop across the resistor 105 which drives the cathode of tube 110 more negative, this drop being, however, insufficient to overcome the bias of battery 115. The beam of the tube 110, as well as that of any other secondary tube, remains therefore suppressed.

The second step, having resulted in modifications of the gain of amplifiers 53, 63 which control the modulators 57 and 67, produces oscillations in the output of R.-F. discriminators 91 and 92 which are of constant frequency f but which vary in peak amplitude and phase in the same manner as do the output voltages of transformers 56 and 66, respectively. These oscillations are directly applied to the deflecting electrodes of all the secondary tubes but, with the beams thereof suppressed, have no effect for the time being. They tend, however, to deflect the beam of each tube across the associated targets in a direction and with an amplitude which corresponds to the vector sum of the two oscillations; each beam would, therefore, carry out a linear sweep one end of which coincides with the position of the selected target (the #7 On target in this case).

The third step, having actuated the modulator 65 to apply to the transmitter 59 the output of oscillator 84 modulated by the output of oscillator 55, produces oscillations of frequency f in the output of R.-F. discriminator 95. These oscillations are in phase or in phase opposition with respect to the oscillations derived from R.-F. discriminators 91 and 92, hence the peaks of all three oscillations will coincide. The output of discriminator 95 is of constant amplitude such as to overcome the bias of battery 115, together with the voltage drop developed across the resistor 105, only at the positive peaks of the oscillations produced; thus the beam of tube 110 will be triggered on only at the end of its linear sweep at which time it impinges upon the target 111. The other secondary tubes, in the absence of a voltage drop across their respective cathode resistors, will remain inoperative.

The foregoing will be better understood from Fig. 5 in which the horizontal deflecting voltage is indicated by V_h and the vertical deflecting voltage by V_v. Only at those peaks of the resulting voltage V_r which coincide with the target 111 is the beam of tube 110 of sufficient intensity to excite any target, resulting in the operation of the associated relay 121. (The provision of a condenser in shunt with this relay has the purpose of smoothing the intermittent current resulting from the periodic impingement of the beam upon the target.)

From Fig. 5 it will also be understood that, when the outputs of both push-pull amplifiers 53 and 63 are zero (corresponding to the "neutral" position of knob 34), the beam of tube 110 will be centered; similarly, when the outputs of oscillators 69 and 70 are of the center frequency f (corresponding to the "neutral" position of knob 24), the beam of tube 100 will likewise be centered. In the system illustrated, no targets are provided at the centers of any tube.

The receiver 85 is preferably provided with automatic volume control means, as indicated, which together with the limiters 86—90 will serve to make the amplitudes of the discriminator outputs and, hence, of the deflecting and grid biasing voltages substantially independent of transmission conditions. The positions of the beams will, therefore, faithfully duplicate the positions of the rods 23, 33 of selectors 20 and 30.

In the modified form of the invention shown in Figs. 3 and 4, there is provided at the control station (Fig. 3) a rod or stick 133 which may be similar to the members 23, 33 previously described. The lower end of this stick carries a photocell 141 as well as the movable core 175 of an induction coil 174. This coils forms part of a tuned circuit 172 which also includes a fixed condenser 173 and is the tank circuit of an oscillator 169.

The photocell 141 is illuminated from a stationary lamp 145 and has its anode energized from a battery 146. The cathode of the cell is grounded via a resistor 147 and is also connected to the grid of an amplifier tube 151 inserted in the output circuit of oscillator 169, in series with the primary of an output transformer 156. Connected to the secondary of this transformer is a frequency modulator 157 to which carrier energy of frequency F is applied by a radio frequency oscillator 158. The modulator 157 works into a transmitter 159.

The remote station, Fig. 4, comprises a receiver 185 feeding a limiter 186 which in turn works into a radio frequency discriminator 191. The discriminator 191 applies a deflecting potential directly to the horizontal deflecting electrodes 209, 209' of a cathode ray tube 200. The discriminator also feeds an amplifier-limiter 195 which energizes the grid of tube 200 by way of a biasing battery 215. The vertical deflecting electrodes 208, 208' are connected to the output of a board-band filter 197 having a sloping characteristic in the frequency range f_1—f_2 which is the working range of oscillator 169 (Fig. 3). The filter 197 is connected across the output of limiter 195.

In this embodiment the cathode ray tube 200 is shown provided with a fluorescent screen 201 in place of the targets previously described, this screen being connected to the positive pole of a grounded battery 207. A biasing battery 218 is inserted between the filter 197 and the vertical deflecting electrode 208, and a similar battery 219 is inserted between the discriminator 191 and the horizontal deflecting electrode 209'.

The operation of the system illustrated in Figs. 3 and 4 is as follows:

Batteries 218 and 219 tend to focus the beam of tube 200 upon a spot S off the screen 201, as illustrated in Fig. 6. The deflecting voltages V_h and V_v vary in step with each other, and with the voltage applied to the grid of the tube 200 by the limiter 195, the variable frequency of these voltages corresponding to the operating frequency of oscillator 169. From Fig. 6 it will be seen that a certain minimum voltage swing V_{ho} is necessary for allowing the beam to reach the screen 201, and the limiting amplifier 195 is preferably designed so that its output will have a constant amplitude when the output of discriminator 191 is of amplitude V_{ho} or larger. The oscillations obtained from the limiter 195 are

used to render the beam visible at their positive peaks only, occurring simultaneously with the negative peaks of deflecting voltages V_v and V_h at a time when the beam of the tube impinges upon the screen **201**. A luminous spot S' will thus be produced on the screen, its position being determined by the sum of the vectors V_v and V_h.

It will be understood that the variations in amplitude of horizontal deflecting voltage V_h will correspond to the amplitude variations of the output of transformer **156** (Fig. 3), the latter resulting from the changes in the gain of amplifier **151** due to displacement of photocell **141** relative to light source **145**, while the amplitudes of the vertical deflecting voltage V_v will be substantially independent of these variations, being strictly a function of signal frequency as determined by the sloping characteristic of filter **197**, the signal frequency in turn being determined by the position of movable control member **175** in the input circuit of oscillator **169**. (It may be mentioned that this filter may comprise or be supplemented by a sloping amplifier having the transmission characteristic shown.) Thus it can be seen that the position of the spot S' can be changed by displacing the stick **133**, the latter being operable to give any desired indication on the screen **201**. By using a fluorescent material of high persistence for the screen, a trace S'' of any desired configuration may be produced.

The control station, Fig. 3, may also be provided with a switch or interrupter **99** for the purpose of discontinuing the transmission of a carrier wave after a signal has been sent out.

The invention is not limited to the specific embodiments shown and described but is on the contrary capable of numerous modifications and adaptations which, after an understanding of the present disclosure, should be obvious to those skilled in the art. Thus the transmission of signals from the control point to the remote point may be effected by means other than a frequency-modulated carrier wave; the beam of the cathode ray tube or tubes may be used for actuation of any type of controlled devices, such as photo-electric cells, vacuum tubes, thyratrons and the like; also, the sweep of some or all of the tubes need not be orthogonal but may be circular, helical, spiral and so forth. It is, therefore, intended that all such variations be embraced in the scope of the appended claims unless otherwise limited.

The term "remote-control system," as used in the claims, is intended to cover telemetering and other remote-indicating systems as well as remote-actuating systems.

I claim:

1. A remote-control system comprising a signal transmitter at a control point, a signal receiver at a remote point, a communication path connecting said transmitter to said receiver, oscillator means at the control point connected to said transmitter and having a variable output representing a signal wave, selector means at the control point having a movable member connected to said oscillator means for varying the output thereof, a cathode ray tube at said remote point connected to said receiver and provided with beam-deflecting means and with a beam intensity control electrode, first circuit means in said receiver connected to said beam-deflecting means for applying thereto an oscillation derived from the received signal wave and having a peak amplitude varying with the displacement of said movable member at the control point, second circuit means in said receiver connected to said control electrode for applying thereto a control wave of substantially constant peak amplitude in step with said oscillation, and biasing means so connected to said control electrode as substantially to suppress the beam of said tube except at peak portions of said control wave and, thereby, of said oscillation.

2. A remote-control system comprising a signal transmitter at a control point, a signal receiver at a remote point, a communication path connecting said transmitter to said receiver, oscillator means at the control point connected to said transmitter and having a variable output representing a signal wave, selector means at the control point having a movable member connected to said oscillator means for varying the peak amplitude of said signal wave, a cathode ray tube at said remote point connected to said receiver and provided with beam-deflecting means and with a beam intensity control electrode, first circuit means in said receiver connected to said beam-deflecting means for applying thereto an oscillation derived from the received signal wave and having a peak amplitude varying with the displacement of said movable member at the control point, limiter means connected to said first circuit means for deriving from said received signal wave a control wave of substantially constant peak amplitude in step with said oscillation, second circuit means connecting the output of said limiter means to said control electrode, and biasing means so connected to said control electrode as substantially to suppress the beam of said tube except at peak portions of said control wave and, thereby, of said oscillation.

3. A remote-control system comprising a signal transmitter at a control point, a signal receiver at a remote point, a communication path connecting said transmitter to said receiver, oscillator means at the control point connected to said transmitter and having a variable output representing a signal wave, first selector means at the control point having a first movable member connected to said oscillator means for varying the peak amplitude of said signal wave, second selector means at the control point having a second movable member connected to said oscillator means for varying the frequency of said signal wave, a cathode ray tube at said remote point connected to said receiver and provided with a beam intensity control electrode and with first and second beam-deflecting means adapted to deflect the beam of said tube in two different directions, first circuit means in said receiver connected to said first beam-deflecting means for applying thereto an oscillation derived from the received signal wave and having a peak amplitude varying with the displacement of said first movable member, limiter means connected to said first circuit means for deriving from said received signal wave a control wave of substantially constant peak amplitude in step with said oscillation, second circuit means connecting the output of said limiter means to said control electrode, broadband filter means connected to the output of said limiter means and having a sloping characteristic so as to derive from said control wave a wave of peak amplitude varying with frequency and, hence, with the displacement of said second movable member, third circuit means connecting the output of said filter means to said second beam-deflecting means, and biasing means so connected to said control electrode as substantially to suppress the beam of said tube except at peak portions of said control wave and, thereby, of said oscillation.

4. A remote-control system comprising a signal transmitter at a control point, a signal receiver at a remote point, a communication path connecting said transmitter to said receiver, oscillator means at the control point connected to said transmitter and having a variable output representing a signal wave, selector means at the control point having a movable member connected to said oscillator means for varying the output thereof, a cathode ray tube at said remote point connected to said receiver and provided with beam-deflecting means and with a beam intensity control electrode, circuit means in said receiver connected to said beam-deflecting means for applying thereto an oscillation derived from the received signal wave and having a peak amplitude varying with the displacement of said movable member at the control point, and threshold means in said receiver connected to said control electrode for applying thereto a train of

beam-brightening pulses in step with respective peak portions of said oscillation.

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