

Nov. 15, 1949

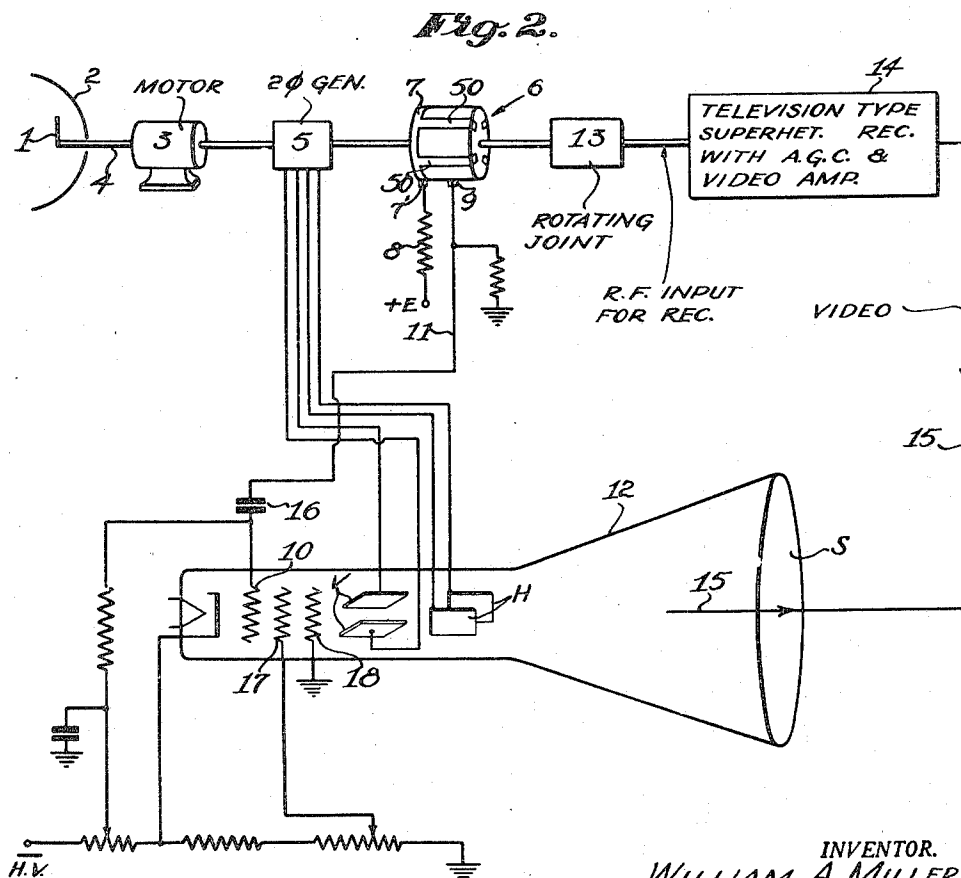
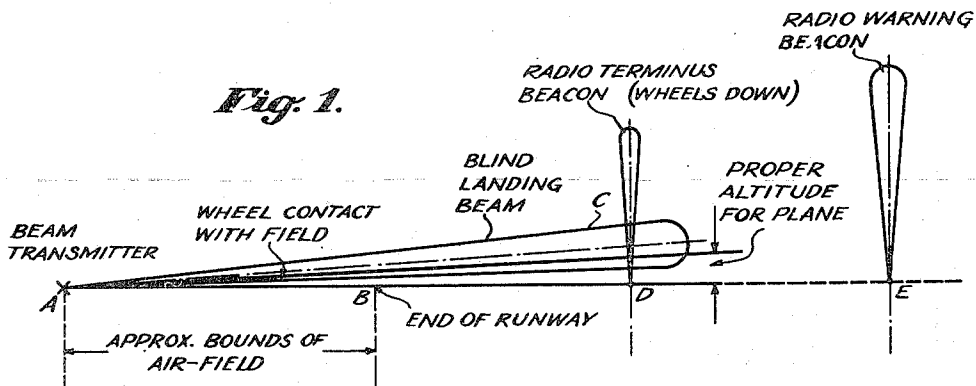
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2,488,022

RADIO RECEIVING AND INDICATING SYSTEM

Filed Feb. 1, 1945

7 Sheets-Sheet 1



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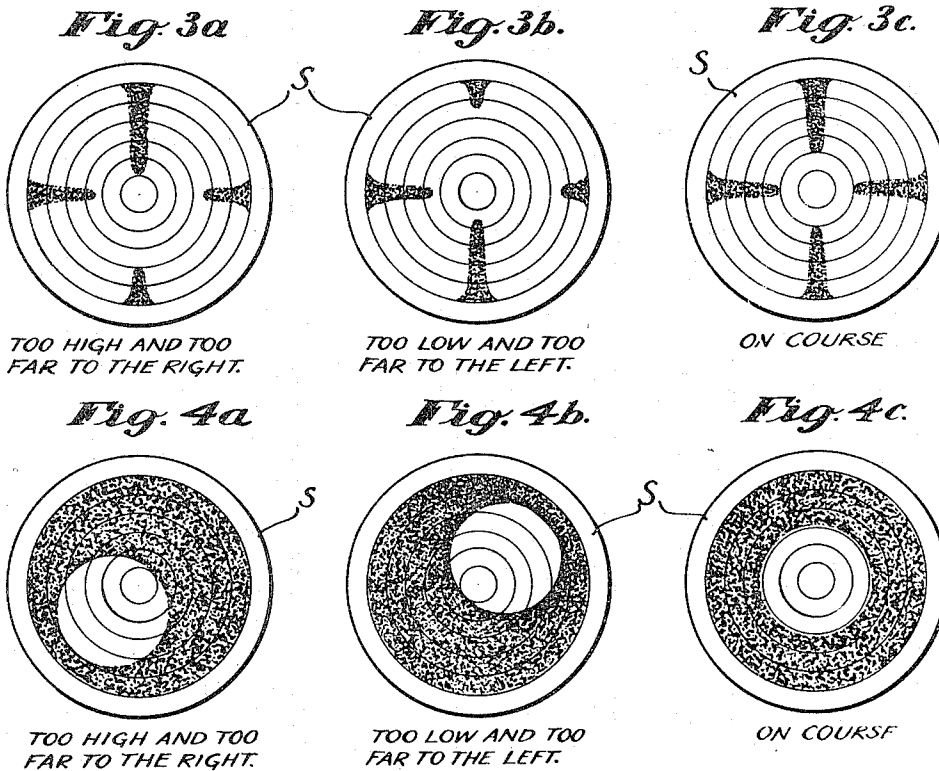
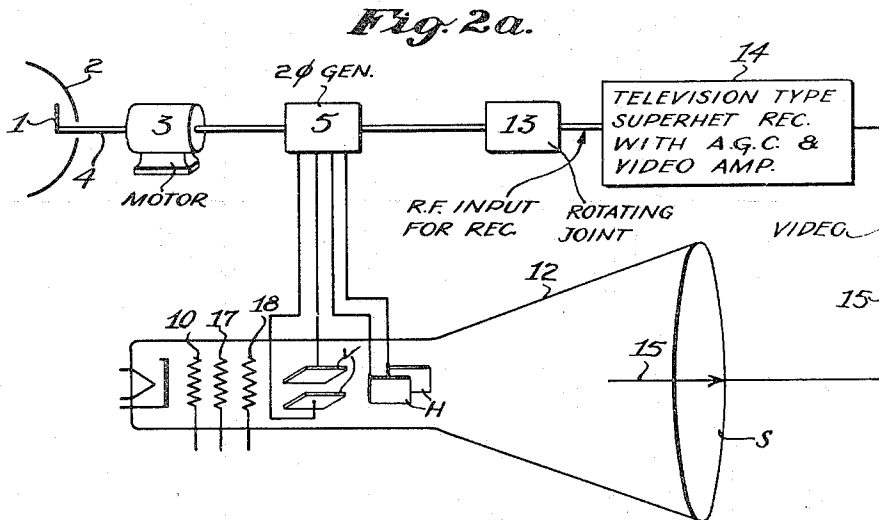
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7 Sheets-Sheet 2



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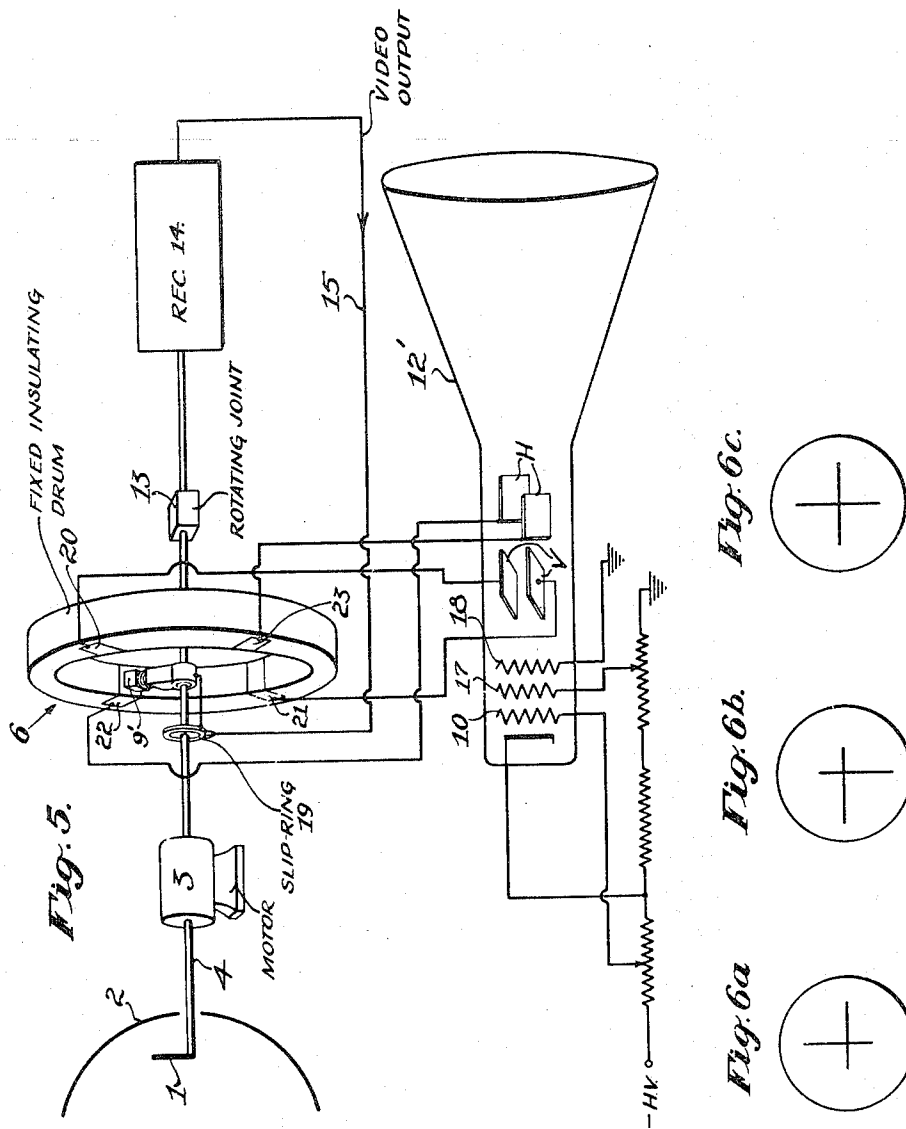
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RADIO RECEIVING AND INDICATING SYSTEM

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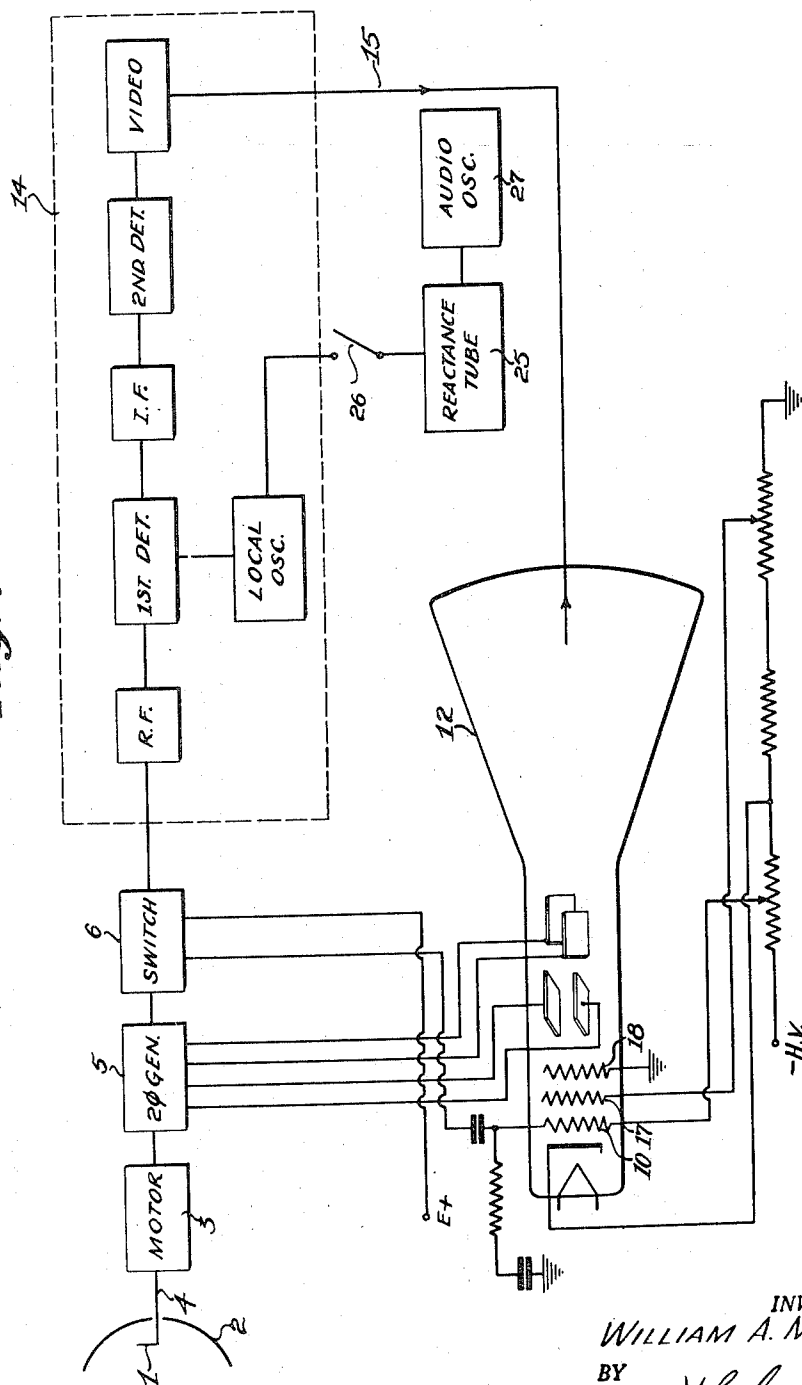
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RADIO RECEIVING AND INDICATING SYSTEM

Filed Feb. 1, 1945

7 Sheets-Sheet 4

Fig. 7.



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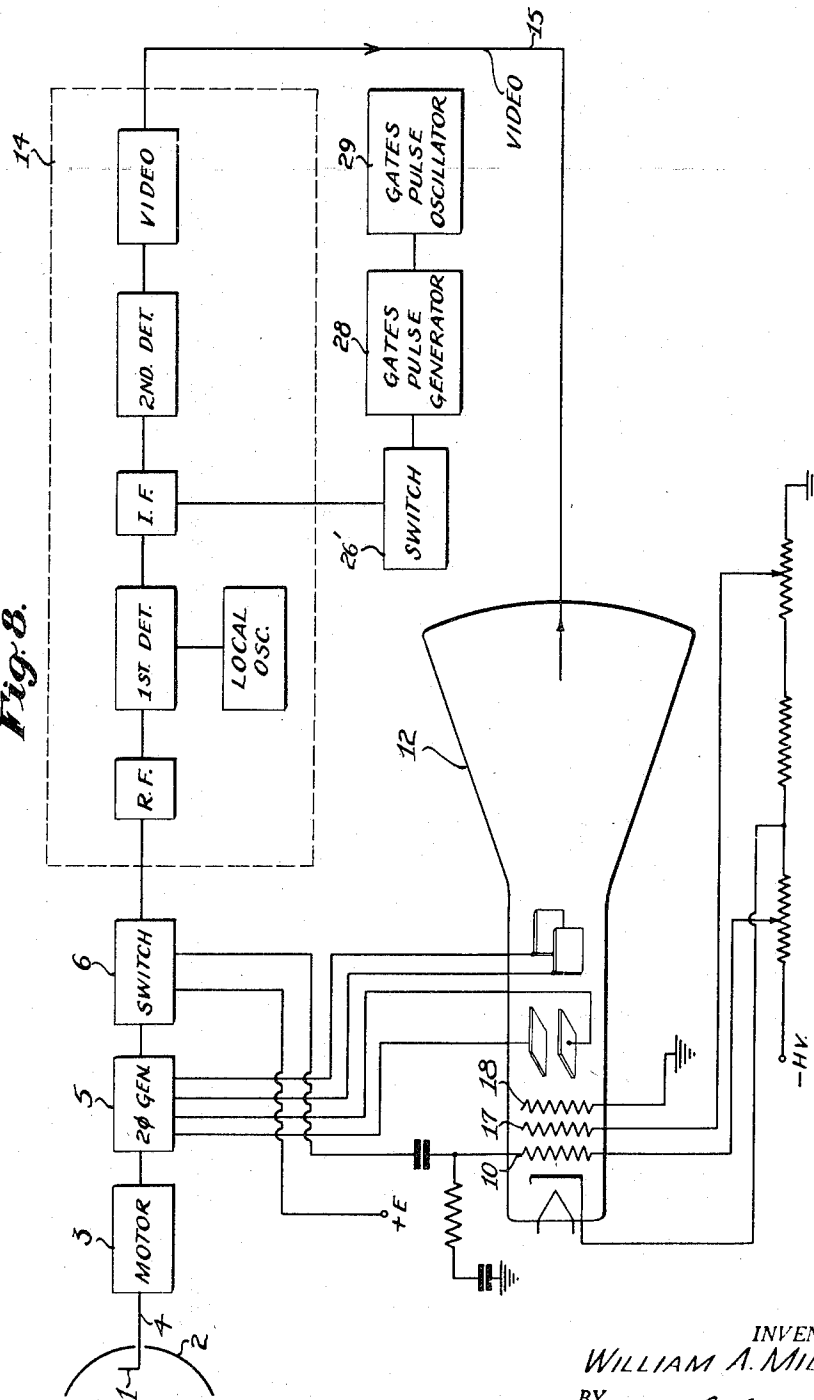
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RADIO RECEIVING AND INDICATING SYSTEM

Filed Feb. 1, 1945

7 Sheets-Sheet 5

Fig. 8.



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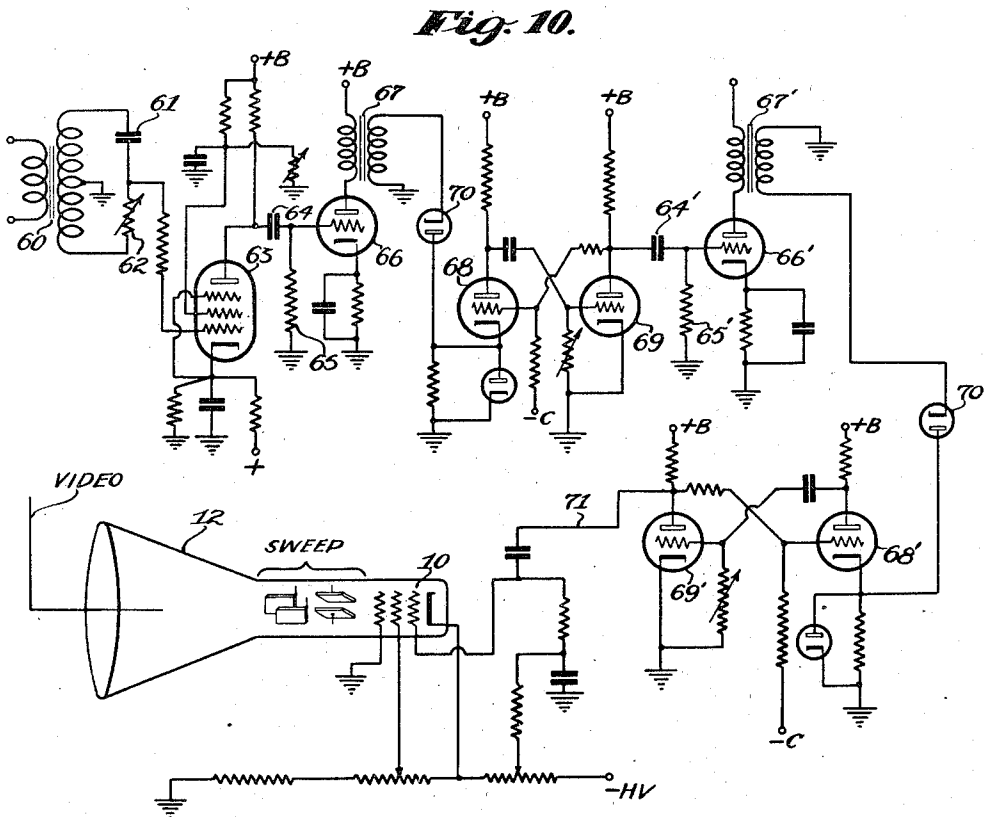
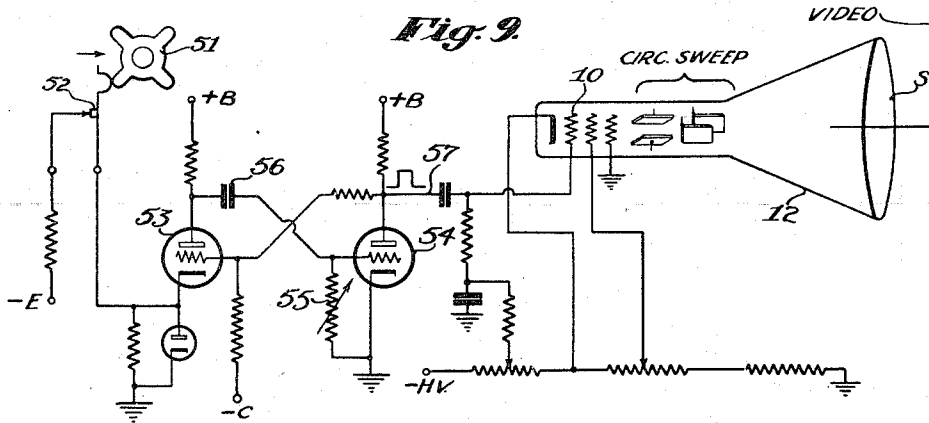
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RADIO RECEIVING AND INDICATING SYSTEM

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7 Sheets-Sheet 6



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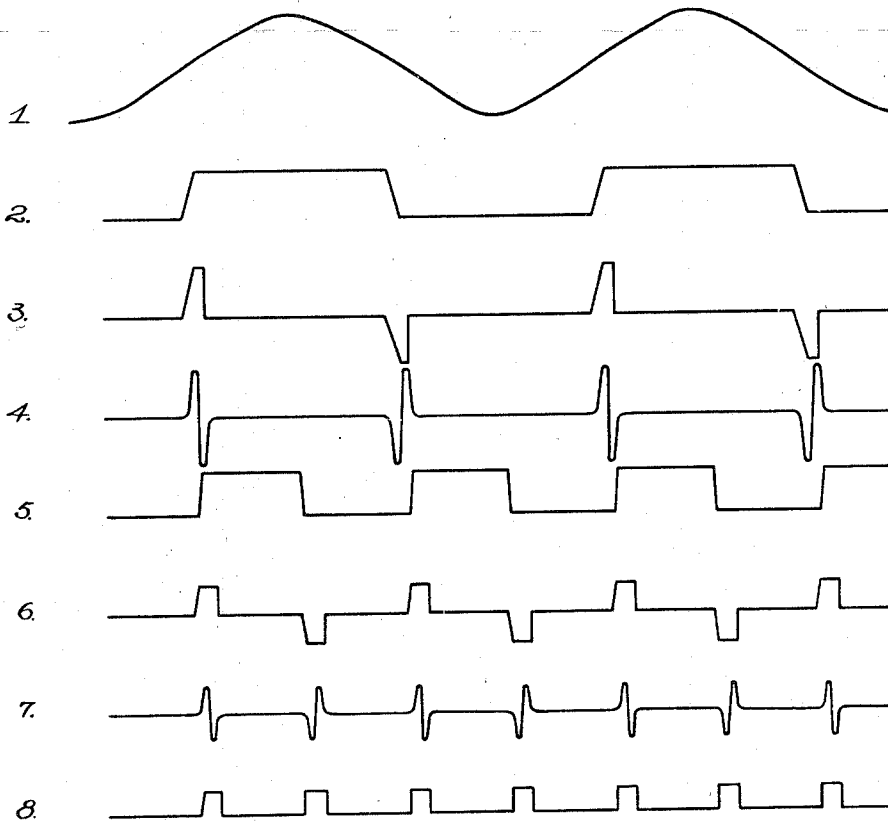
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RADIO RECEIVING AND INDICATING SYSTEM

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7 Sheets-Sheet 7

Fig. 11.



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UNITED STATES PATENT OFFICE

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RADIO RECEIVING AND INDICATING
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Application February 1, 1945, Serial No. 575,630

10 Claims. (Cl. 343—118)

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This invention relates broadly to the field of direction finding, and more particularly to a system for enabling the operator of a moving vehicle, such as an aircraft, to quickly determine his position relative to a remotely located radio transmitter. One specific application of the invention is a blind landing system for aircraft in which the pilot can easily follow a radio beam having a pattern corresponding to the glide path for landing the aircraft safely.

An object of the present invention is to provide the pilot of an aircraft with a radio receiving system which furnishes a simple and efficient visual indication on a cathode ray tube of his position relative to the axis of a radio beam emitted from a remote radio transmitter.

Another object is to provide direction finding radio receiving apparatus employing a lobe switching or conical scanning antenna coupled to a television type of receiver whose video output appears on a cathode ray oscilloscope, for use in determining the position of the radio receiving apparatus relative to a remotely located radio transmitter.

Other objects and the features of the invention will appear from a reading of the following description in conjunction with drawings, wherein:

Fig. 1 illustrates an airfield equipped with suitable radio transmitting apparatus, which can be used with the receiver of the invention located on an aircraft, for enabling the pilot to land safely by following the radio beam (sometimes referred to as a blind-landing beam);

Figs. 2 and 2a schematically show two circuit embodiments of radio receiving equipment which can be used on an aircraft in connection with a blind-landing system, or for general direction finding purposes;

Figs. 3a, 3b, and 3c illustrate the visual markings on the fluorescent screen of the cathode ray oscilloscope of Fig. 2 for different positions of the aircraft relative to the axis of the radio beam radiated from the remote transmitter;

Figs. 4a, 4b and 4c illustrate other possible visual markings on the fluorescent screen of the oscilloscope of the receiving system for different positions of the aircraft relative to a remote radio transmitter when the system of Fig. 2 is employed without the use of intensification pulses;

Fig. 5 schematically shows another circuit embodiment of radio receiving equipment in accordance with the invention, employing a more conventional cathode ray tube indicator than

2

that used in Fig. 2, and a different kind of switching arrangement;

Figs. 6a, 6b and 6c illustrate the visual markings on the fluorescent screen of the cathode ray oscilloscope of the receiving system of Fig. 5 for different positions of the aircraft relative to the axis of the radio beam radiated from the remote radio transmitter;

Figs. 7 and 8 schematically illustrate two other radio receiving circuit embodiments of the invention, especially adapted for use either with incoming unmodulated continuous waves or modulated continuous waves;

Figs. 9 and 10 schematically illustrate two different electronic switching circuits which can be used in the receiving systems of the invention in place of the mechanical switches; and

Fig. 11 graphically illustrates the operation of the electron switching system of Fig. 10.

Referring to Fig. 1 of the drawing, there is shown an airfield equipped with a blind-landing radio transmitter system with which the present invention may be used. At this field, there is provided a radio transmitter at point A for transmitting pulses of ultra short wave energy toward B, along a runway suitable for the landing of aircraft. The pattern or lobe of the radiated beam is designated C. The axis of the cone of radiation C corresponds to the glide path which would land an airplane safely. Suitable radio marking beacons radiating vertical beams are located at points D and E in such positions relative to the airfield that the pilot is given sufficient warning of his approach to the field in order for him to attain the proper altitude before entering the blind landing area. It is preferred that the transmitter radiate ultra short wave energy in order to enable the use of a small compact receiving antenna on the aircraft; although longer waves can be used at the transmitter with a correspondingly larger antenna at the receiving equipment in the aircraft.

Fig. 2 shows the radio receiving and visual indicating apparatus which is placed in the plane for enabling the pilot to determine his position relative to the axis of the beam C and to land his aircraft safely. The receiving antenna and the reflector are designated respectively 1 and 2, and are located in the nose of the airship. The mean axis of the reflector (which by way of example may be a paraboloid) and antenna will correspond to the longitudinal axis of the aircraft.

The antenna 1 is any off-axis rotating element, such as a dipole, driven by a motor 3 which in

combination with the reflector provides a receiving antenna pattern or lobe switching system such as described in my copending applications Serial Nos. 501,050, filed September 3, 1943, now Patent No. 2,470,939, issued May 24, 1949, and 532,929, filed April 27, 1944. Such a lobe switching system involves causing the receiving antenna pattern to sequentially change direction uniformly over the four quadrants of a circle; that is, the direction of maximum effectiveness of the receiving antenna pattern sweeps through a cone whose apex is at the receiving antenna. This is done by spinning the antenna 1 positioned off the center or axis of the reflector 2, or by spinning a deflecting element off the focus of the reflector. If a spinning element is employed, it may be rotated around one end as an axis or, preferably the entire radiator element 1 is rotated around a circle without changing its polarization, a process termed nutation. The antenna 1 thus travels in a circle in the focal plane of the paraboloid. The receiving antenna system, it will be seen, scans a cone of revolution in the space ahead of the aircraft. The directions of the receiving antenna lobe patterns are, of course, different for different quadrants of the circle as the antenna 1 rotates, and these patterns are made to intersect at those places where the slopes are greatest, thus providing maximum sensitivity. These lobes are effective sequentially; that is, one at a time, and would overlap if they were effective simultaneously.

In the practice of the invention, the speed of rotation of element 1 is made to be small compared to the pulse rate of the transmitted energy; for example, antenna 1 may be driven at a rate of ten revolutions per second while the pulse rate of the remote transmitter may be 1000 per second.

Receiving antenna 1 is driven by a direct current motor 3 over a metallic shaft 4. This driving motor also turns a small two-phase generator 5 over the same metallic shaft, and this generator 5 supplies voltages in phase quadrature to the vertical deflection plates V and the horizontal deflection plates H of a cathode ray oscilloscope tube 12. The motor 3, by means of a metallic shaft, also drives a rotating switch in the form of a rotating insulating drum 6 having four metallic segments 50 embedded in its periphery and spaced ninety mechanical degrees apart. These metallic segments 50 are directly connected together by a metallic band 7 and are connected to a source of positive direct current potential +E through a brush 7' and a resistor 8. A brush 9 engages the periphery of the drum 6 and supplies a positive intensifier pulse to the control grid 10 of the oscilloscope 12 over lead 11 each time the brush contacts one of the segments 50. Condenser 16 is a blocking condenser which isolates the control grid 10 from the negative source -HV and from ground. The metallic shaft which drives the drum 6 is connected to a rotating joint 13 as a result of which the shaft to the left of joint 13 can rotate while the metallic shaft to the right of joint 13 is stationary. It will thus be seen that the metallic shafts form a radio frequency transmission line from antenna 1, through elements 3, 5, 6 and 13, to the receiver 14.

It should be understood that the mechanical arrangement of direct current motor, two-phase generator and rotating switch 6 is only a special embodiment, and that other variations of these elements are possible. For example, if alternating current is available in the aircraft, then direct current motor 3 can be replaced by a syn-

chronous motor, while the two-phase generator can be replaced by a phase splitting circuit to provide a circular sweep for the oscilloscope. I can thus use either mechanical or electrical phasing equipment. The rotating switch 6 can be replaced by an electronic switching scheme along the lines described in my copending application Serial No. 532,929, supra, in order to provide intensifier pulses. Suitable electronic switchers to replace the mechanical switch 6 are described hereafter in connection with Figs. 9 and 10.

Cathode ray tube 12 is constructed in such manner, and has its deflected plates V and H provided with voltages in phase quadrature, that the electron beam which would normally be seen on the screen S traverses a circle. This tube 12 is provided with a control grid 10, a focussing electrode 17 and a second anode 18. A subsidiary electrode 15 on the oscilloscope is provided to which the radial deflecting voltage is applied from the output of the receiving system 14 over lead 15. Such an oscilloscope is available and known in the art. The electron beam spot on the screen of the oscilloscope is arranged to traverse a circular path in synchronism and in a 1:1 relation with the antenna lobe rotation. This means that the spot should travel once over the circle on the screen S each time the receiving antenna patterns or lobes are switched through all four consecutive quadrants. The intensifier pulse supplied to the control grid 10 from the rotating switch is of sufficient magnitude to overcome the cut-off bias normally applied to this grid and render the cathode ray beam visible on the screen. It will be noted that in the absence of an intensifier pulse applied to the control grid 10, the electron beam in the oscilloscope will not reach the screen S.

The receiver 14 is a television type of super-heterodyne receiver and has a wide intermediate frequency band width, wide band detector, an automatic gain control (A. G. C.) circuit of this television type of receiver, and provides a video output for lead 15. The gain of the receiver 14 is controlled by the particular incoming signal having maximum amplitude. This gain control is not necessary since manual control could be used, but the automatic feature is desirable from an operational standpoint. Some control is necessary, however, since the receiver cannot be allowed to saturate because this system depends for its operation upon matching the amplitudes on the oscilloscope, of signals delivered by the receiver to the oscilloscope when the receiving antenna is in various positions. By the term "saturate," I mean that the pulse in the preceding part of the receiver should not have such a large amplitude as to drive a succeeding stage appreciably beyond the linear portion of the operating characteristic curve; for example, the grid voltage-plate current characteristic. This may also be avoided by amplified back-bias; a system which provides very little loss in gain for signals of low amplitude but great loss in gain for signals of large amplitude. The video output of the receiver need not have as wide a frequency range as the television receiver but may for example be as wide as 2000 kilocycles (2 megacycles). Receiver 14, however, requires no synchronization circuit such as is present in the conventional television receiver. The duration of the pulses radiated by the remote transmitter (assuming ultra high frequency energy is employed), and the rate at which these pulses build up determine the necessary band width in the video circuit in the re-

ceiver 14. For example, the transmitter may send out pulses of one-microsecond duration in which case the video circuit band width of the receiver 14 should not be less than one megacycle. If, for example, the transmitted pulse is constituted by 3000 megacycle radio frequency energy, and the variation in radio frequency is $\pm 0.5\%$, it will be seen that the variation of the radio frequency energy will be ± 15 megacycles, or a total possible variation of 30 megacycles. For this reason, the receiver must have a wide enough radio frequency and intermediate frequency pass band to accommodate any possible frequency deviation of the transmitter, in the assumed case 30 megacycles. The video portion of the receiver 14, however, is controlled only by the width and build up time of the received pulse passed on to it by the second detector, and hence the band width of this video circuit need only be 1 to 3 megacycles wide.

A brief description of the operation of the receiving system of Fig. 2 will now be given: Assuming that pulses are radiated from the remote transmitter located at A in Fig. 1 at a rate of 1000 per second, and that the receiving antenna rotates at 10 revolutions per second, and further that the switch segments 50 on drum 6 are each nine mechanical degrees wide, it will be evident that there are received in the system of Fig. 2 two and one-half pulses during the passage of the brush 9 over each segment. The width of the segments 50 is a matter of choice. Each time the switch 6 supplies a positive intensification pulse to the grid 10, there will be supplied two and one-half video pulses to the radial deflecting electrode 15. The intensification pulse will permit the electron beam to pass through it to the screen S of the tube 12 while the simultaneously occurring radial deflecting pulses on electrode 15 serve to pull the electron beam toward the center of the screen S and produce a line on the screen similar to that shown in Figs. 3a, 3b and 3c. The circular lines on the screen are engraved on transparent material placed over the face of the screen to facilitate comparing or matching of the dimensions of the radial beam lines appearing on the screen. Since the intensification pulses occur four times per revolution corresponding to the four lobe positions, there will be four radial lines on the screen. Due to the repeated occurrence of these pulses and the phenomenon known as the persistence of vision, the lines on the screen S will appear to be stationary. If the receiving antenna system in the nose of the aircraft is not pointed directly toward the axis of the transmitted radio beam, then the pulses received on antenna 1 and reflector 2 during some lobes or patterns will be of greater magnitude than others and may approximate the conditions represented in Figs. 3a and 3b. Where the axis of the airplane is pointed toward the axis of the transmitted radio beam, the pulses received on antenna elements 1, 2 will be of the same magnitude during all four lobes or patterns and the condition on screen S will be as represented in Fig. 3c. Figs. 3a, 3b and 3c thus show the position of the aircraft relative to the distant indicating transmitter.

The receiving system of the invention is not limited to a blind landing system for aircraft but has general application to a direction finding system. For example, a pulse type of transmitter preferably positioned at a high location relative to the earth's surface may be arranged to send out pulses of ultra high frequency energy on an omni-directional pattern. The receiving system

of Fig. 2 can then be used to determine the direction of the aircraft accommodating the equipment relative to the remote pulsing transmitter. In this last case, the transmitter can be located on a high tower or mast, or in a stationary balloon or on a very tall building. This receiver may also be used at a fixed location to determine the bearing of transmitters whose positions are unknown.

Fig. 2a shows a modification of the system of Fig. 2, in which no intensification pulses are required for the control grid of the cathode ray tube. In both of these figures the same parts are designated by the same reference characters. The control grid 10 of the tube 12 of Fig. 2a is now so biased that the electron beam in tube 12 impinges on the screen S at all times. Grid 10 can now act as a brilliancy control for the electron beam. It should be noted that there is no switching arrangement in Fig. 2a such as is disclosed by the drum of Fig. 2. As a result, the appearance of the screen S in the tube 12 of Fig. 2a will look something like Figs. 4a, 4b, and 4c for conditions corresponding to Figs. 3a, 3b and 3c.

The systems of Figs. 2 and 2a may be so designed that the quadrature voltages applied to the vertical and horizontal deflection plates of the cathode ray tube are 180° different with respect to those hereinbefore assumed and which result in the showing of Figs. 3a, 3b, 3c and 4a, 4b, 4c so that the indication on the screen S corresponds to the position of aircraft relative to the remote radio transmitter, rather than the position of the transmitter relative to the aircraft.

Fig. 5 shows a receiving system for use with the invention wherein a more conventional type of cathode ray tube 12' is employed requiring no radial deflecting electrode. In Fig. 5 the two vertical deflection plates V and the two horizontal deflection plates H are so connected to a switch 6' that the plates are sequentially supplied with deflecting potentials. Thus, the vertical plates V are connected to two different stationary metallic segments 20, 21 on the insulating mounting, and the horizontal plates H connected to two other stationary metallic segments 22, 23, as shown. A rotating brush 9' makes successive contacts with the segments 20, 23, 21 and 22, and this brush is connected through a slip ring 19 to the video output of television type receiver 14 over lead 15. The slip ring 19 is, of course, insulated from the drive shaft forming part of the radio frequency line supplying input to the receiver. Rotating joint 13 serves the same purpose as described in connection with the systems of Figs. 2 and 2a.

In the operation of Fig. 5, the electron beam in tube 12' strikes the center of the screen S in the absence of received incoming pulses. The grid 10 acts as a brilliancy control. When pulses are received, they are applied as video pulses by the receiver output to the deflection plates of tube 12' in succession through the intermediary of switch 6', and thus the electron beam is deflected first in one direction and then in another direction. The screen of tube 12' looks something like Figs. 6a, 6b and 6c for conditions corresponding to those of Figs. 3a, 3b and 3c or Figs. 4a, 4b and 4c. It should be noted that the screen of tube 12' provides a visual indication in the form of a cross whose legs, measured from the center of the screen, indicate the position of the aircraft (accommodating the receiver) relative to the axis of radio beam emanating from remote pulsing radio transmitter. This circuit may be

modified by using a motor driven potentiometer or phase-shifting transformer to produce a circular ball-shaped spot of light which moves over the scope in sympathy with direction finder sense.

Although the receiving system of Figs. 2, 2a and 5 have been described in association with a remote radio pulse transmitter, it should be understood that the invention is not limited to the transmission of pulses but that the receiving system can be used with unmodulated or modulated continuous waves. A pulse is actually an amplitude modulated wave varying from minimum amplitude (corresponding to no radiated carrier, to maximum amplitude (carrier full on). Although it is preferred to transmit pulses for blind landing purposes, the use of transmitted continuous waves is effective with the receiving system of the invention for general direction finding purposes. Thus the remote radio transmitter can send out a sine wave signal modulated by a 1000 cycle tone or even by voice, in which case the receiving system is provided with a switching circuit which selects a section of the voice or sine wave modulated signal, or for voice other modulation is directly impressed on the oscilloscopes. The carrier radiated by the remote transmitter is preferably very high frequency above three hundred megacycles, in order to allow the use of a small and compact antenna at the receiver mounted in an aircraft. The carrier radiated from the remote transmitter may either be amplitude or frequency modulated, and if frequency modulated then the receiver should have a discriminator and detector system for supplying a video or audio voltage to the cathode ray deflection electrode or electrodes. The receiver, it should be understood, looks at the modulation whether it be from an interrupted carrier (pulse) or a continuous carrier which is modulated. If desired, the transmitter can send out an unmodulated continuous carrier and the modulation supplied at the receiver.

Fig. 7 illustrates an arrangement for receiving either an unmodulated continuous carrier or a modulated carrier. This figure follows generally the principles of Fig. 2 and the same parts in both of these figures are similarly designated. The receiver in Fig. 7 is shown in more detail than that of Fig. 2. In order to enable the reception of unmodulated continuous waves, there is provided a reactance tube modulator 25 which can be connected to the local oscillator through a switch 26 in order to vary the frequency of the local oscillator. The reactance tube modulator 25 is connected to a source 27 of audio oscillations; for example, 1000 cycles, which is continuously effective on the modulator 25, or the reactance tube may be pulsed. With the switch 26 closed, the receiving system then supplies its own modulation in order to receive an unmodulated continuous high frequency radio wave. With the switch 26 open, the effective portion of the receiving and indicator system of Fig. 7 is identical with the system of Fig. 2, and is able to receive interrupted (pulse) carrier waves, or ordinary amplitude or frequency modulated continuous carrier waves.

Fig. 8 illustrates a system similar to Fig. 7, except that in Fig. 8 there is provided a gating system, sometimes known as a shutter, for use in gating (keying or interrupting) the intermediate frequency stage in the event it is desired to receive an unmodulated carrier. This gating system replaces the local modulation feature of Fig. 7. For receiving an unmodulated radio carrier wave, the switch 26' is closed and the gate pulse genera-

tor 28 coupled to the intermediate frequency stage. The pulse generator 28 is controlled by a gate pulse oscillator 29 which may be a rectangular pulse oscillator generating audio frequency and video frequencies at a repetition rate of 1000 per second, in which case the intermediate frequency stage will be gated or interrupted at the rate of 1000 times per second. With the switch 26' open, the effective portion of the receiving and indicator system of Fig. 7 is identical with Fig. 2, and is able to receive interrupted (pulse) carrier waves or ordinary amplitude or frequency modulated continuous carrier waves. Switch 26' is so arranged in the circuit that it causes the proper bias to be applied to the intermediate frequency stage in order to enable this stage to function properly. When the switch is closed, there is added a positive voltage to the anode of the tube in the intermediate frequency stage, in accordance with one form of gating circuit.

Fig. 9 illustrates one form of electronic switch which can be used to take the place of the drum arrangement 6 in any one of the circuits of Figs. 2, 7 and 8. Fig. 9 illustrates how an intensifier pulse or pulse of positive polarity can be applied to the control grid 10 of the cathode ray tube 12 for each of four quadrants of the circle traversed by the receiving antenna pattern. This electronic switch includes a contact maker 51 which is driven by a shaft of the motor 3 and rotates in synchronism therewith. This contact maker is arranged to close a pair of contacts 52 four times during each revolution of the contact maker, as a result of which there will be four pulses of negative polarity supplied from the negative terminal of a source of unidirectional potential -E through the contacts to a trigger circuit 53, 54 for each revolution of the contact maker. Or, putting it in other words, during each quadrant of the circle traversed by the contact maker there will be a negative pulse supplied to the trigger circuit 53, 54. This trigger circuit is of the self-restoring type and comprises a pair of vacuum tubes 53 and 54 whose grid and anode electrodes are interconnected regeneratively. Normally, vacuum tube 53 is non-conducting, while vacuum tube 54 is conducting. The application of a negative pulse from contacts 52 to the cathode of 53 (as shown), and of sufficient magnitude to overcome the negative bias on the vacuum tube 53, will change the trigger circuit from its normal or steady state (in which tube 53 is non-conducting and tube 54 conducting) to the active state in which the current passing conditions of both of these tubes interchange. These tubes will stay in the active state for a time period determined by the time constant of condenser 56 and resistor 55, primarily. After a period of time, the trigger circuit will restore itself to the steady state. Each time the trigger circuit 53, 54 is fired, a pulse of positive polarity is passed on from the anode of the tube 54 via lead 57 to the control grid 10 of the cathode ray tube 12. This positive pulse supplied to the control grid 10 is of sufficient magnitude to overcome the bias on this control grid and enables the electron stream from the cathode of the tube 12 to pass through to the fluorescent screen S of the cathode ray tube. It will thus be seen that the circuit of Fig. 9 comprises an electronic arrangement for enabling an intensifier pulse to be applied to the cathode ray tube 12 once for each quadrant of a circle of revolution scanned by the receiving antenna which, in

effect, is equivalent to four intensifier pulses for each revolution of the contactor 51.

Fig. 10 is an alternative type of electronic switch which can take the place of the drum arrangement 6 of Figs. 2, 7 and 8, and achieves the same results as Fig. 9. In Fig. 10, power is supplied to the primary winding of transformer 60 whose secondary winding is connected to the terminals of a phase shifter comprising condenser 61 and resistor 62. The primary winding of transformer 60 can be connected to the power supply of the receiving and indicating system if this power supply is alternating current, or, alternatively, to one phase of the two-phase generator 5, shown in Figs. 2, 7 and 8. It is assumed that the input to the transformer 60 is of sine wave form which is synchronized with the rotation of the receiving antenna 1, 2. That is, if the antenna 1, 2 rotates at a speed of 60 revolutions per second, then the power supply to the transformer 60 should be a sine wave of 60 cycles per second. It should be noted at this time that if the power supply from the airplane is employed as an input to the transformer 60, then the motor 3 should be a synchronous motor, whereas if the input to the transformer 60 is from one phase of the two-phase generator 5, then the motor 3 need not be a synchronous motor but should be of fairly constant speed. The output from the phase shifter 61, 62 is taken from the junction point and supplied to the control grid of a pentode vacuum tube limiter 63. This limiter 63 serves to clip off the top and bottom of the sine wave so as to change the incoming wave shape from a sine wave to a substantially rectangular wave form. The output from the limiter 63 is passed through a differentiator circuit comprising a condenser 64 and a resistor 65 to the grid of amplifier 66 operating class A. The differentiator passes on to the grid of the amplifier 66 sharp pulses derived from the slopes corresponding to the starting and trailing edges of the rectangular wave form pulses in the output of the limiter. Vacuum tube 66 has in its output circuit a transformer 67 which is arranged to differentiate the output of the amplifier tube so as to produce pulses of both polarities from each of the pulses applied to the grid of tube 66. The secondary winding of the transformer 67 is coupled to the cathode of a self-restoring type of trigger circuit comprising vacuum tubes 68 and 69. Vacuum tubes 68 and 69 have their grids and anodes interconnected regeneratively. Normally, tube 68 is non-conducting and tube 69 is conducting in the stable state, and the current passing conditions of these two tubes are reversed in the active state.

The diode 70 which is located between the secondary winding of transformer 67 and the trigger circuit 68, 69 assures the application of only a negative pulse to the cathode of tube 68. This negative pulse is of the proper polarity and of sufficient magnitude to trip the trigger 68, 69 from the stable to the active state. This trigger circuit will restore itself to normal after a time interval depending upon the time constants of its associated circuit elements.

Output from the trigger circuit is obtained from the anode of tube 69 and this output is in the form of positive pulses which are passed through differentiator circuit 64', 65' to another amplifier tube 66', also operating class A. The output of the amplifier 66' is passed through a differentiating transformer 67' from which pulses of negative polarity are passed through a diode 70' and

to a self-restoring trigger circuit 68', 69'. It should be noted that elements 64' to 69' have been given the same reference numerals as 64 to 69 (described above) except for the prime designations. This is because the elements having corresponding numbers function similarly.

The output of the trigger circuit 68', 69' is in the form of positive pulses and is passed over lead 71 to the control grid 10 of the cathode ray tube 12. The time constants and adjustments of the circuit elements of Fig. 10 are so arranged that a positive intensifier pulse is applied to the control grid 10 of tube 12 four times for every cycle of the sine wave constituting the input of the transformer 60.

The operation of the system of Fig. 10 may be better understood from an inspection of the graphs of Fig. 11. Curve 1 shows the appearance of the sine wave derived from the junction point of the elements 61 and 62 of the phase shifter and which is applied to the first grid of the limiter 63. Curve 2 shows the appearance of the reshaped wave after it has passed through the limiter. It should be noted that this wave is substantially rectangular in wave form. The wave of curve 2 appears on the anode of the limiter 63 and is applied to the differentiator circuit 64, 65. Curve 3 shows the pulses which are the results of differentiation by differentiator circuit 64, 65. These pulses are derived from the slopes of the wave form of Fig. 2. Curve 4 shows positive and negative pulses derived in the output of the transformer 67 from each of the differentiated pulses of curve 3. Curve 5 shows the rectangular wave form pulses derived from the output of the trigger circuit 68, 69. This wave form is obtainable from the anode of vacuum tube 69 and, it should be noted, is essentially square. The waves of curve 5 have a frequency substantially twice those of curve 2. Curve 6 shows the results of differentiating the waves of curve 5 in a circuit 64', 65'. Curve 7 illustrates the output of transformer 67'. The pulses of curve 7 comprise positive and negative pulses for each of the differentiated pulses of curve 6. Curve 8 shows the rectangular wave form obtained from the output of trigger circuit 68', 69'. More specifically, the pulses of curve 8 are obtained from the anode of tube 69' and constitute the intensifier pulses of positive polarity for rendering the cathode ray beam of the tube 12 visible.

What is claimed is:

1. A receiving and indicating system for use in determining the position of a moving vehicle accommodating said system relative to a remote radio transmitter sending out pulses of radio frequency energy, comprising a directional receiving antenna arrangement, a motor operating at a slow speed relative to the repetition rate of the pulses sent out by the remote radio transmitter, a link between said motor and said antenna arrangement for causing the receiving pattern of said antenna to assume different positions of effectiveness for each revolution of said motor, said different positions corresponding to lobes which would overlap if they were produced simultaneously, a superheterodyne receiver coupled to said antenna and provided with a detection circuit supplying a video output, a cathode ray tube having a cathode, a control electrode normally biased to prevent the passage of electrons therethrough, a pair of horizontal and a pair of vertical electron deflection elements and a radial electron deflection electrode, a circuit for supplying voltages in phase quadrature to said pairs

of deflection elements, a connection from the output of said detection system to said radial deflection electrode, and a switch operating in synchronism with said motor for supplying said control electrode with a pulse of positive polarity of sufficient magnitude to overcome said bias during each of the different positions assumed by said antenna receiving pattern for each revolution of said motor.

2. For use in a direction finding system wherein a radio transmitter radiates a carrier wave, a receiving and indicating system remotely located with respect to said transmitter and mounted in a moving vehicle, said last system including a directional antenna and means for causing the pattern of said antenna to sequentially and periodically assume different positions of effectiveness, a superheterodyne multi-stage receiver coupled to said antenna and provided with a circuit supplying a video output, a circuit for supplying local audio frequency modulation to the intermediate frequency stage of said receiver, a cathode ray oscilloscope tube having electron deflection elements, and a connection from said video output to an electron deflection element of said cathode ray oscilloscope.

3. For use in a direction finding system wherein a radio transmitter radiates a carrier wave, a receiving and indicating system remotely located with respect to said transmitter and mounted in a moving vehicle, said last system including a directional antenna, and means for causing the pattern of said antenna to sequentially and periodically assume different positions of effectiveness, a superheterodyne receiver coupled to said antenna and provided with a circuit supplying a video output, a reactance tube modulator for varying the frequency of the heterodyning oscillator of said superheterodyne receiver, a cathode ray oscilloscope tube having electron deflection elements, and a connection from said video output to an electron deflection element of said cathode ray oscilloscope.

4. A receiving and indicating system for use in continually determining the position of a moving vehicle accommodating said system relative to a remote radio transmitter sending out a radio beam, comprising a unidirectional receiving antenna and means for causing the receiving pattern of said antenna to sequentially and periodically assume different positions of effectiveness corresponding to lobes which would intersect if they were produced simultaneously, a superheterodyne receiver coupled to said antenna and provided with a detection circuit supplying a video output, a cathode ray tube having a pair of horizontal and a pair of vertical deflection elements and a radial deflection electrode, a circuit for supplying voltages in phase quadrature to said pairs of deflection elements, a connection from the output of said detection system to said radial deflection electrode, and a gating circuit coupled to said receiver for keying said receiver.

5. A receiving and indicating system for use in continually determining the position of a moving vehicle accommodating said system relative to a remote radio transmitter sending out a radio beam, comprising a unidirectional receiving antenna and means for causing the receiving pattern of said antenna to sequentially and periodically assume different positions of effectiveness corresponding to lobes which would intersect if they were produced simultaneously, a superheterodyne receiver coupled to said antenna

and provided with a detection circuit supplying a video output, a cathode ray tube having a pair of horizontal and a pair of vertical deflection elements and a radial deflection electrode, a circuit for supplying voltages in phase quadrature to said pairs of deflection elements, a connection from the output of said detection system to said radial deflection electrode, and means for gating the intermediate frequency stage of said receiver comprising a gate pulse generator coupled to said intermediate frequency stage under control of a pulse frequency oscillator.

6. A receiving and indicating system for use in determining the position of a moving vehicle accommodating said system relative to a remote radio transmitter sending out a radio beam, comprising a unidirectional receiving antenna and means for causing the receiving pattern of said antenna to sequentially and periodically assume different positions of effectiveness corresponding to lobes which would intersect if they were produced simultaneously, a superheterodyne receiver coupled to said antenna and provided with a detection circuit supplying a video output, a circuit for modulating the energy passing through said receiver at an audio frequency rate, a switch between said last circuit and said receiver, a cathode ray tube having electron deflection electrodes, and a connection from the output of said detection system to at least one of said deflection electrodes.

7. A receiving and indicating system for use in determining the position of a moving vehicle accommodating said system relative to a remote radio transmitter sending out a radio beam, comprising a unidirectional receiving antenna and means for causing the receiving pattern of said antenna to sequentially and periodically assume different positions of effectiveness corresponding to lobes which would intersect if they were produced simultaneously, a superheterodyne receiver coupled to said antenna and provided with a detection circuit supplying a video output, a cathode ray tube having a pair of horizontal and a pair of vertical deflection elements and a radial deflection electrode, a circuit for supplying voltages in phase quadrature to said pairs of deflection elements, a connection from the output of said detection system to said radial deflection electrode, a circuit coupled to said receiver for modulating the energy passing through said receiver, and a switch for disconnecting said last circuit from said receiver.

8. For use in a direction finding system wherein a radio transmitter radiates a radio frequency carrier wave, a receiving and indicating system remotely located with respect to said transmitter and mounted in a moving vehicle, said last system including a directional antenna located in the front of said vehicle and means for causing the pattern of said antenna to sequentially and periodically assume different positions of effectiveness, said different positions corresponding to lobes which would overlap at points of substantially greatest slope if they were produced simultaneously, a television type of superheterodyne receiver coupled to said antenna and provided with a wide band intermediate frequency stage, a wide band detector stage, an automatic gain control circuit and a video detector circuit having a band with considerably narrower than the band width of the preceding stages of the receiver, a cathode ray oscilloscope tube having electron deflection elements, and a connection from the output of said video detector circuit

to an electron deflection element of said cathode ray oscilloscope.

9. A system in accordance with claim 1, characterized in this, that said switch is an electronic type of switch including a self-restoring trigger circuit.

10. A receiving and indicating system for use in determining the position of a moving vehicle accommodating said system relative to a remote radio transmitter sending out pulses of radio frequency energy, comprising a directional receiving antenna arrangement, a motor operating at a slow speed relative to the repetition rate of the pulses sent out by the remote radio transmitter, a link between said motor and said antenna arrangement for causing the receiving pattern of said antenna to assume different positions of effectiveness for each revolution of said motor, said different positions corresponding to lobes which would overlap if they were produced simultaneously, a superheterodyne receiver coupled to said antenna and provided with a detection circuit supplying a video output, a cathode ray tube having a cathode, a control electrode normally biased to prevent the passage of electrons therethrough, and electron deflection electrodes, a connection from the output of said detection system to one of said deflection electrodes, and a switch operating in synchronism with said motor for supplying said control electrode with

pulses of positive polarity of sufficient magnitude to overcome said bias during said different lobe positions.

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