

July 3, 1945.

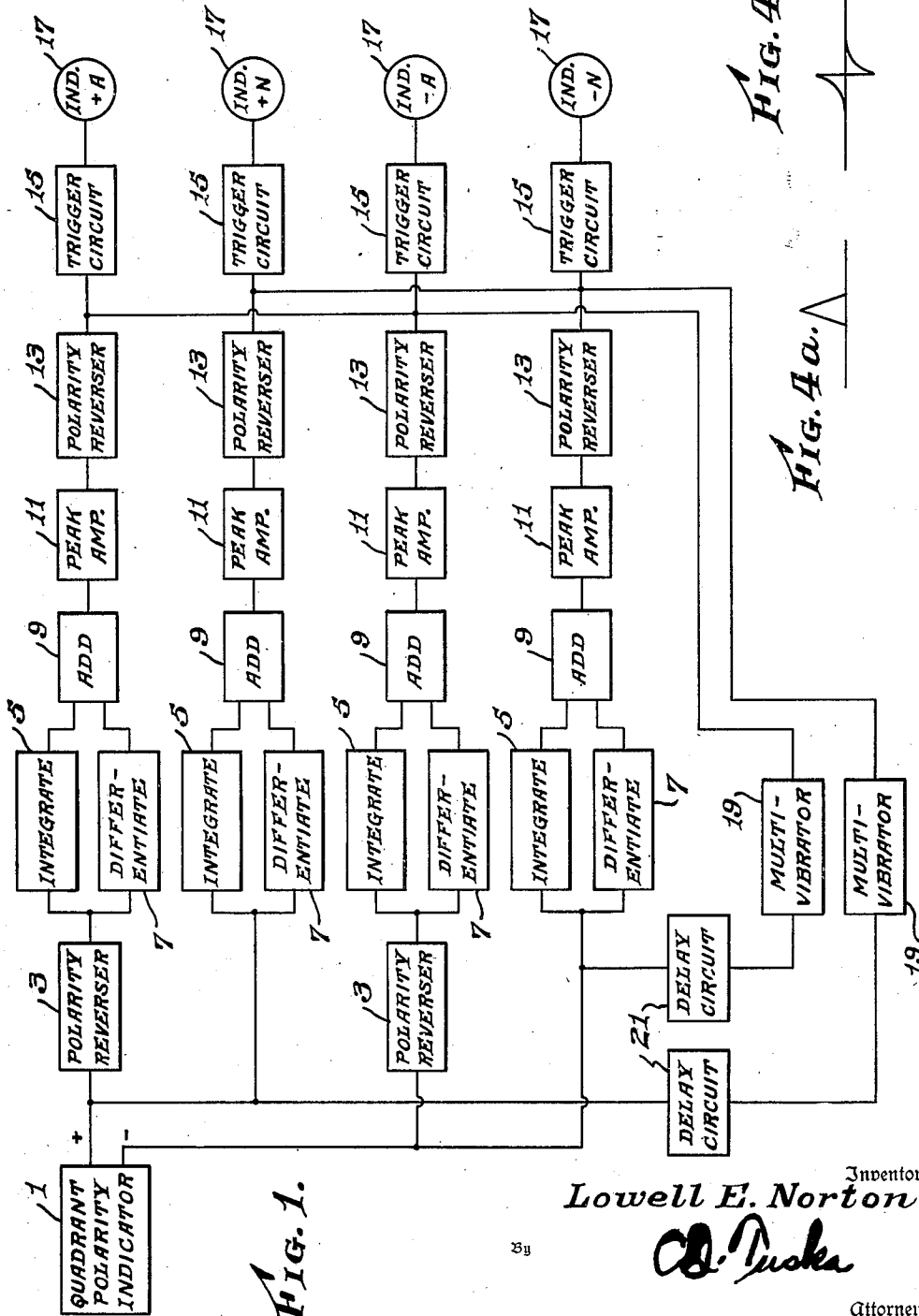
L. E. NORTON

2,379,739

RANGE QUADRANT IDENTIFICATION CIRCUIT

Filed March 31, 1942

2 Sheets-Sheet 1



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FIG. 4b.

FIG. 4a.

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FIG. 2.

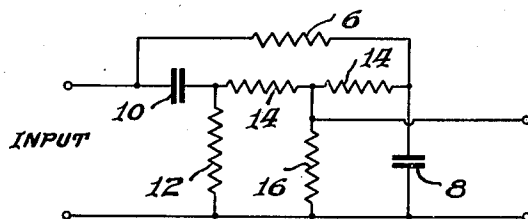


FIG. 3.

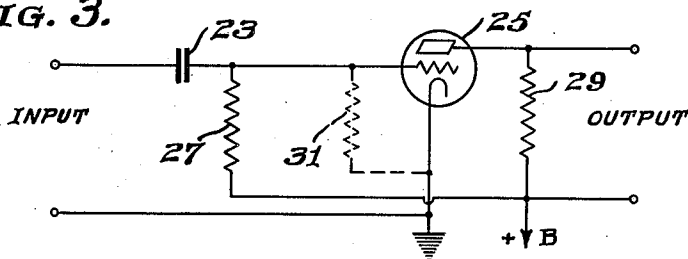


FIG. 5a.

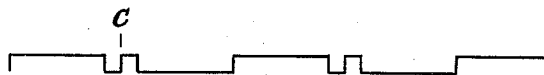


FIG. 5b.

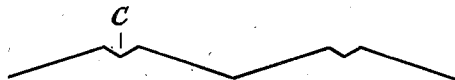


FIG. 5c.

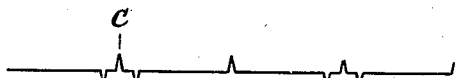


FIG. 5d.

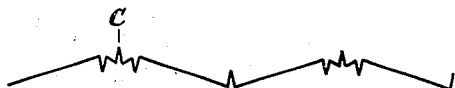


FIG. 5e.



FIG. 5f.

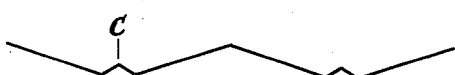


FIG. 5g.

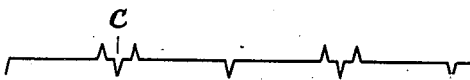
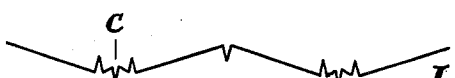


FIG. 5h.



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RANGE QUADRANT IDENTIFICATION
CIRCUITLowell E. Norton, Collingswood, N. J., assignor to
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Application March 31, 1942, Serial No. 436,942

4 Claims. (Cl. 250—11)

This invention relates to course and quadrant identification in a four course simultaneous radio range, and more particularly to means for giving a visual quadrant indication which is simple and unmistakable requiring very little interpretation by the pilot. Application Ser. No. 272,017, entitled Radio ranges, filed on May 5, 1939, by D. G. C. Luck and matured into Patent No. 2,314,795 describes a quadrant identification system in which an auxiliary reference phase tone is radiated non-directionally and compared in phase with the keyed course tone to indicate the quadrant in which the receiver lies. Application Serial No. 436,933, entitled Radio ranges, filed March 31, 1942, by D. G. C. Luck and matured into Patent No. 2,350,284 describes means for attachment to the output of a usual radio range receiver to provide visual indications in such a system by means of two flashing indicator lamps. Another such device, operating on a different principle, is described in application Serial No. 437,149 entitled Radio ranges, filed by L. E. Norton on April 1, 1942, and matured into Patent No. 2,364,748. A disadvantage of the indicator systems described in said applications is the requirement of interpretation of the keyed light flashes in terms of courses and quadrants. This has been found somewhat difficult, particularly when the attention of the user must be divided between the quadrant identification device and a number of other instruments. The object of the present invention is the provision of a device which interprets the quadrant identification signals of systems of the type described, and gives a direct indication requiring no mental operation to convert it into usable form. The visual indication is presented upon a circular screen, divided into quadrants corresponding to the quadrants of the radio range; the quadrant on the screen corresponding to the range quadrant, in which the receiver is operating, is illuminated by rhythmic flashes. On course, the two quadrants defining the particular course are illuminated.

The invention will be described with reference to the accompanying drawings, of which Figure 1 is a schematic block diagram of the circuit of the device; Figure 2 is a schematic diagram of an adding network forming a part of the circuit of Figure 1, Figure 3 is a schematic diagram of a trigger circuit forming a part of the circuit of Figure 1, Figure 4a is a graph of a voltage pulse of the type occurring in the operation of the system, Figure 4b is a graph of the pulse of Figure 4a after differentiation, Figure 5a is a graph representing radio range "N" signal, Figure 5b is a

graph representing the signal of Figure 5a after integration, Figure 5c is a graph representing the signal of Figure 5a after differentiation, Figure 5d is a graph representing the sum of the integrated and differentiated signals of Figures 5b and 5c, respectively, Figure 5e is a graph representing radio range "A" signal, Figure 5f is a graph representing the signal of Figure 5e after integration, Figure 5g is a graph representing the signal of Figure 5e after differentiation, and Figure 5h is a graph representing the sum of the integrated and differentiated signals of Figures 5f and 5g, respectively.

Referring to Fig. 1, the quadrant polarity indicator 1 is a device of the type described in the above-mentioned Patent No. 2,350,284 and Patent No. 2,364,748. As described in said applications, the four course range transmitter is arranged to radiate non-directionally an auxiliary reference modulation harmonically related to the course tone modulation. In Ser. No. 436,933 the two modulation frequencies are separated by filters at the receiver. The lower of the two frequencies is multiplied to a frequency equal to that of the other, and the two voltages of the same frequency are compared in phase by means of rectifiers arranged to energize one of two circuits, depending on whether said voltages are in phase or out of phase. In Ser. No. 437,139 the combined course tone and reference tone modulation is applied to two tubes which are biased by means of a rectifier to a voltage proportional to the average modulation amplitude. The modulation is applied to one of these tubes directly, and to the other tube through a phase shifter which shifts the higher frequency component a predetermined amount with respect to the lower frequency component. Thus when the ratio of peak to average amplitude of the combined modulation is above a predetermined value, the first tube only will conduct; when said ratio is below the predetermined value, the second tube only will conduct. The circuit designated "+" in Fig. 1 is energized when the receiver is in one of the quadrants arbitrarily chosen as positive, and the "-" circuit is energized in the negative quadrants. This energization is in the form of keyed impulses A (—) or N (—), depending on whether the receiver is in an "A" quadrant or an "N" quadrant. Thus, in a positive "A" quadrant, dot-dash impulses applied to the receiver are transmitted along the + wire, while nothing is transmitted along the — wire. The output from each of the terminals of the quadrant polarity indicator 1 is divided, and goes along one path directly to devices 5, 7, 9,

which separately perform the operations of integration and differentiation of the signal, and addition of the resulting waves. The other path from each terminal of the polarity indicator 1 leads through a polarity reverser 3 to a second group of integration, differentiation, and addition devices 5, 7, 9. The polarity reversers 3, as well as the polarity reversers 13 are simply single-stage amplifiers, which produce a 180 degree phase shift between their input and output, corresponding to a reversal of polarity.

The circuits of the integration, differentiation and addition devices 5, 7 and 9 are shown in detail in Fig. 2. A signal applied to the input is conducted through a resistor 6 to a capacitor 8. The voltage developed across the capacitor 8 is proportional to the time integral of the current flowing into it through the resistor 6. This is very nearly proportional to the time integral of the voltage applied to the input of the circuit if the magnitude of the resistor 6 is large as compared to the reactance of the capacitor 8 at the repetition frequency of the applied potential. The input signal voltage is also applied through the capacitor 10 to the resistor 12, and hence the voltage across it is substantially proportional to the time differential of the input voltage if the magnitude of resistor 12 is small as compared to the reactance of the capacitor 10 at the repetition frequency of the applied potential. The voltages across the capacitor 8 and the resistor 12 are applied through resistors 14 to a resistor 16. Resistors 14 are much higher in resistance than the resistor 16; the current through 16, and hence the voltage across it, is substantially proportional to the sum of the voltage across the capacitor 8 and the resistor 12. Thus, the voltage at the output terminals, across the resistor 16, is approximately proportional to the sum of the time integral and the time differential of the signal voltage applied to the input.

Referring again to Fig. 1, the output of each of the addition circuits 9 is conducted to a peak amplifier 11. The peak amplifiers 11 are merely single-stage amplifiers biased beyond cut-off, so that they transmit nothing but the peaks of the signals applied to their inputs.

The output of each of the peak amplifiers 11 goes to a polarity reverser 13, thence to a trigger stage 15. The circuit of one of the trigger stages is shown in Fig. 3. The signal is applied through a coupling condenser 23 to the grid of a tube 25. The grid is also connected through a resistor 27 to a positive terminal of the "B" supply. A load resistor 29 is connected between the "B+" terminal and the plate of the tube 25. The effective grid-to-cathode resistance of the tube is represented by the resistor 31, shown in dotted lines. The reactance of the capacitor 23 is very large, as compared to the magnitude of resistor 31, at the repetition frequency of the applied impulses, so that a signal pulse of the general shape shown in Fig. 4a will be substantially differentiated with respect to time and produce a diphasic pulse like that shown in Fig. 4b. The resistor 27 and capacitor 23 together have a relatively long time constant so for useable values of capacitor 23, resistor 27 will be very large.

In operation, a pulse applied to the input first renders the tube 25 conducting, and immediately afterward the tube is cut off by the high negative voltage of the second part of the wave shown in Fig. 4b. The capacitor 23 is charged with this negative voltage, which slowly leaks off through the resistor 27 and the B supply so that by the

time the next pulse arrives, the tube will conduct momentarily and cut off again. During the time the capacitor 23 is charged negatively, the resistance 31 is very high, but when the grid end of the condenser 23 is positive, the resistance 31 is low. Thus, any small impulses arriving while the condenser 23 is charged negatively will have no effect at the output. Pulses applied at timed intervals, however, will cause corresponding pulses in the output circuit.

Each of the trigger stages is connected to an indicator 17, which may be an electron ray tube, a neon lamp, or any voltage operated visual indicating device. The devices 17 are arranged in relative positions corresponding to the four quadrants of a radio range, so that flashing of any one of them shows in which of the range quadrants the receiver is located.

The operation of the organization of Figure 1 is as follows: Depending on the range quadrant, one of the output leads of the polarity indicator 1 is energized with a keyed A or N signal. First, assuming that the N signal is received, refer to Fig. 5. Fig. 5a represents the conventional "N" signal used in radio range systems. The dash is of one second duration, the space is one-quarter, the dot is one-quarter second and is followed by a pause of one second. Fig. 5b shows the result of integrating this signal with respect to time. Fig. 5c shows the result of differentiating the signal with respect to time. Fig. 5d shows the sum of the differentiated and the integrated waves. Similarly, Figs. 5e through 5g show an A signal, and the steps resulting in the wave of Fig. 5h. The N signal is seen to produce a positive peak at the point c in each cycle, while the A signal produces negative peaks at the corresponding points. This difference forms a basis for separating the A and N signals. Thus an A signal on the output + of the polarity indicator will be conducted to the +A and +N channels in the diagram of Figure 1; it will be integrated, differentiated, and the resultant potentials added by the several devices 5, 7 and 9 in the +N channel, resulting in negative peaks as shown in Fig. 5h. Since the peak amplifiers 11 can pass only positive peaks, the signal will go no further in the +N channel. However, due to the polarity reverser 3 in the +A channel, the signal will be inverted to an N signal, resulting in the production of positive peaks at the amplifier 11 in this channel, which will pass to the polarity reverser 13, the trigger 15, and the indicator 17. The polarity reverser 13 is necessary to compensate the 180 degree phase shift, or polarity reversal, caused by the single-stage peak amplifier 11.

A negative A or N signal will be selected in the same manner by one of the negative channels, causing operation of the corresponding indicator. Thus a unique signal is actuated in each quadrant of the radio range.

When the receiver is located on one of the course lines, the interlocking A and N signals together form a continuous tone; if both the A and N components are of the same polarity, the devices 5, 7 and 9 cannot separate them; and no indication is given. This difficulty is resolved by using a pair of multivibrators 19, or other relaxation oscillators which are biased so as to be normally non-oscillating. The + and - output circuits of the polarity indicator 1 are each connected through a time delay network 21 to a control point in the corresponding multivibrator 19. As long as there is no signal, or a keyed signal in either channel, the multivibrators remain

quiescent. However, when there is a continuous un-keyed signal in either circuit, enough energy gets through the delay circuit 21 to start the corresponding multivibrator 19, which is connected in each case to inject its output in the trigger stages 15 corresponding to the two quadrants which overlap to define the course, thus actuating the corresponding indicators.

Thus the invention has been described as a device for interpreting the keyed A and N signals of a four course radio range by flashing one of a group of lights arranged in positions corresponding to the range quadrants. The A and N signals are separated by deriving waves of like shapes but opposite polarities from said signals, and passing the derived waves through positive peak amplifiers to trigger circuits controlling the indicators.

While a particular embodiment of the invention has been described it is not intended to limit the scope of the claims to this specific arrangement. For example, an examination of Fig. 5 shows that the wave forms of Figs. 5b and 5f differ only in polarity and hence may be used to distinguish A and N keying in substantially the manner disclosed above by omitting the differentiating circuits. A possible disadvantage is the difficulty of adjustment of the apparatus, because the peaks of the waves of Figs. 5b and 5f are much less sharp than those of Figs. 5d and 5h. It is also theoretically possible to omit the integrator circuits, retaining the differentiators, and distinguish curves like those shown in Figs. 5c and 5g. However, the energy content of the extremely sharp peaks of these wave forms is so slight that they are not conveniently usable for controlling the peak amplifiers.

I claim as my invention:

1. In a system for course and quadrant identification of a four course simultaneous radio range, quadrant polarity indicator means having two output circuits and responsive to the phase relationship between the signals radiated by said range to provide output in one of said output circuits in response to the field of said range in a quadrant thereof arbitrarily designated as positive and output in the other of said output circuits in response to the field of said range in a quadrant arbitrarily designated as negative, said output being keyed in one of two complementary sequences in accordance with the signals emitted by said range, means connected to each of said output circuits and responsive to output of one of said sequences and an indicator connected thereto, means in each of said channels for converting output of the second of said sequences into output of the first of said sequences, and means connected to each of said converting means and responsive to said converted output and an indicator connected thereto.

2. In a system for course and quadrant identification in a four course simultaneous radio range arranged to emit a non-directional reference phase modulation, quadrant polarity indicator means having two output circuits and responsive to the phase relationship between the signals radiated by said range to provide output in one of said output circuits in response to the field of said range in a quadrant thereof arbitrarily designated as positive and output in the

other of said output circuits in response to the field of said range in a quadrant arbitrarily designated as negative, said output being keyed in one of two complementary sequences; means connected to each of said output circuits to convert said output into voltages of peaked wave forms having shapes independent of the keying sequence and polarities depending on the keying sequence, means responsive to said peaked wave form voltages in one polarity and an indicator connected thereto; further means connected to each of said output circuits for converting output keyed in one of said sequences into output keyed in the other of said sequences, means connected to each of said converters for converting the outputs thereof into voltages of peaked wave form having polarities dependent upon the keying sequence of said converted output, means responsive to said second peaked wave form voltages in one polarity, and an indicator connected thereto.

3. The method of distinguishing radio range signals keyed in complementary sequences including the steps of deriving from said signals voltages which vary in accordance with the keying thereof, integrating said voltages with respect to time, differentiating said voltages with respect to time, adding the results of said integrating and differentiating operations to produce an impulse having a peaked wave form and a polarity dependent upon the keying sequence of the signal from which it is derived, and producing an indication when said impulse is of a predetermined polarity.

4. A system for course and quadrant identification of a simultaneous radio range of the type arranged to emit a constant non-directional reference modulated signal and two further signals keyed in complementary sequences, said keyed signals being radiated directionally in overlapping figure of eight patterns each having two lobes of opposite polarities arbitrarily designated respectively as positive and negative, including quadrant polarity indication means having two output circuits and responsive to the phase relationship between the fields produced by said non-directional signal and said directional signals to provide output in one of said output circuits in response to the field of said range in a positive lobe and output in the other of said channels in response to the field of said range in a negative lobe, said outputs being keyed in accordance with the keying of the signals radiated by said range, four keying sequence responsive circuits, one pair connected to each of said output circuits and each including a differentiating circuit, an integrating circuit, and an adding circuit connected to combine the outputs of said differentiating and integrating circuits to produce a resultant voltage of peaked wave having a shape independent of the keying sequence and a polarity depending upon the keying sequence, four indicator means responsive to voltage peaks of only one polarity, one connected directly to one of each of said pairs of keying sequence responsive circuits, two polarity reversing means, one connected to the other of each of said pairs of keying sequence responsive circuits and to one of the other two of said indicators, respectively.

LOWELL E. NORTON.