Nov. 30, 1948. E. LABIN 2,454,810

RADIO TRANSMITTING AND RECEIVING SYSTEM

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Fig. 1.

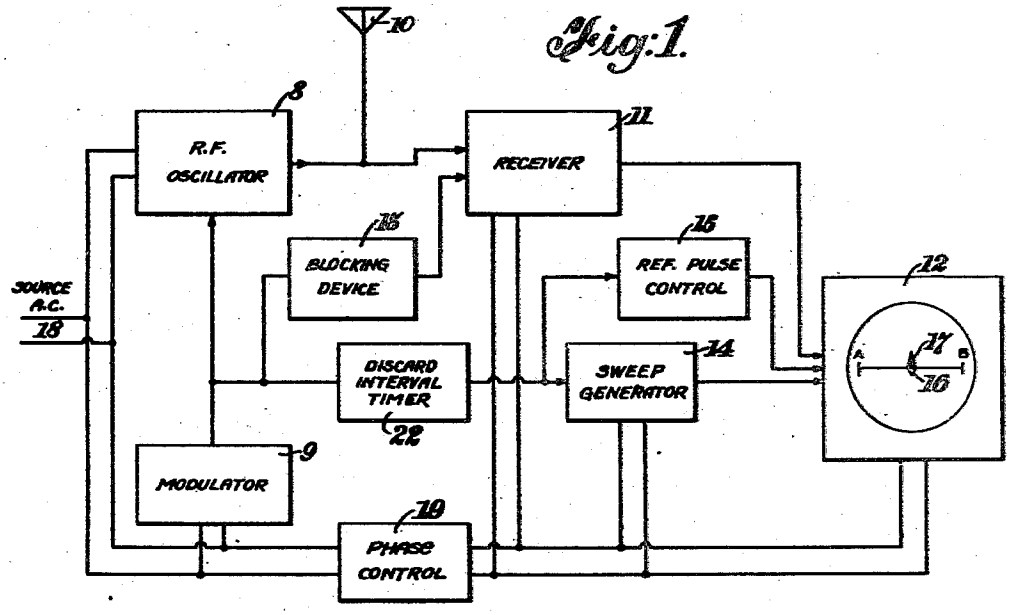


Fig. 2.

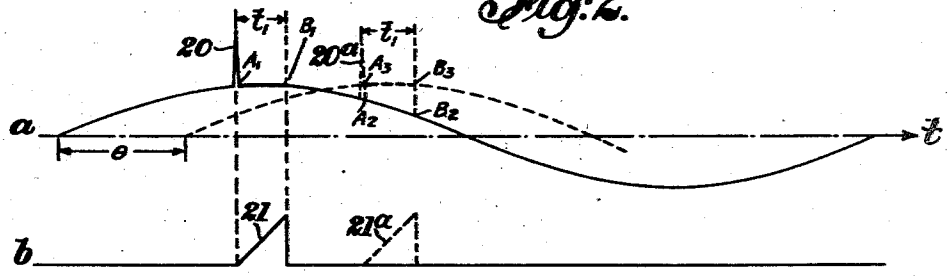
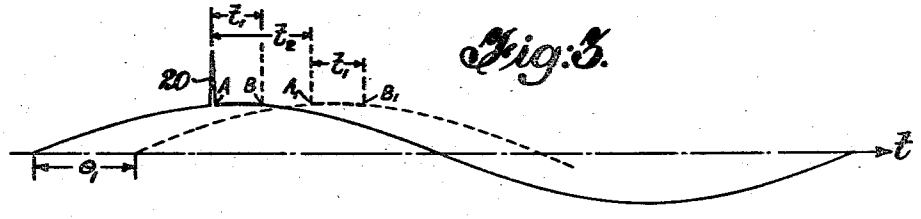


Fig. 3.



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Fig: 4.

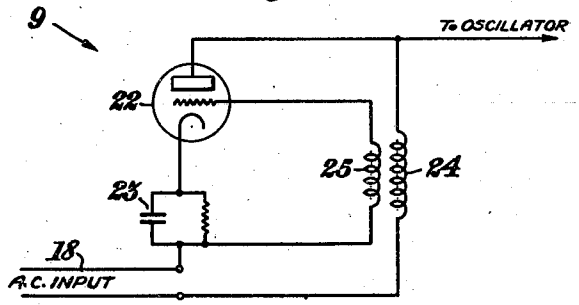


Fig: 5.

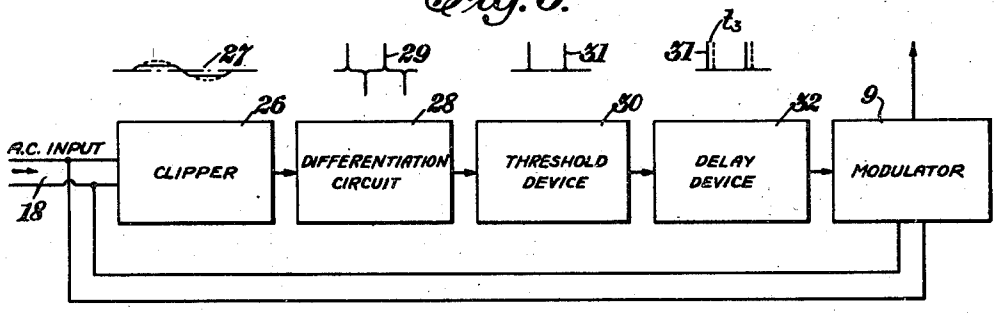
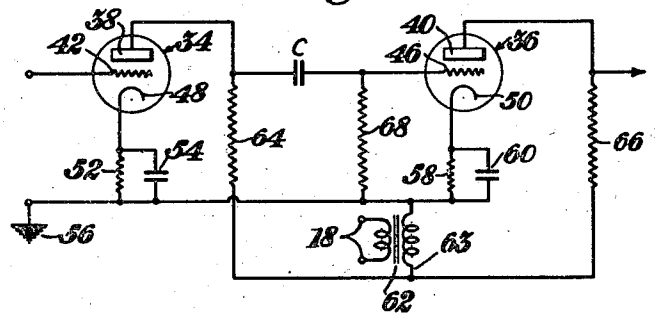


Fig: 6.



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Fig: 7.

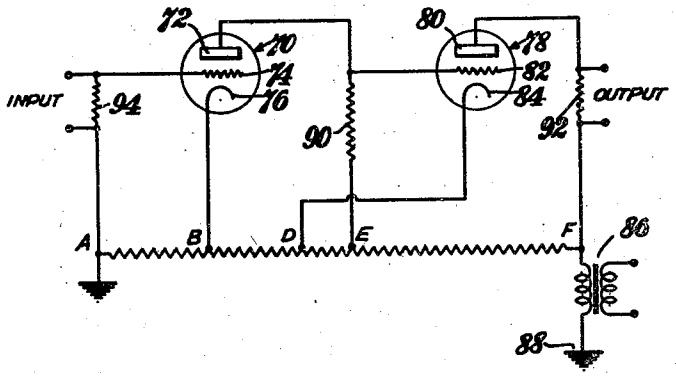
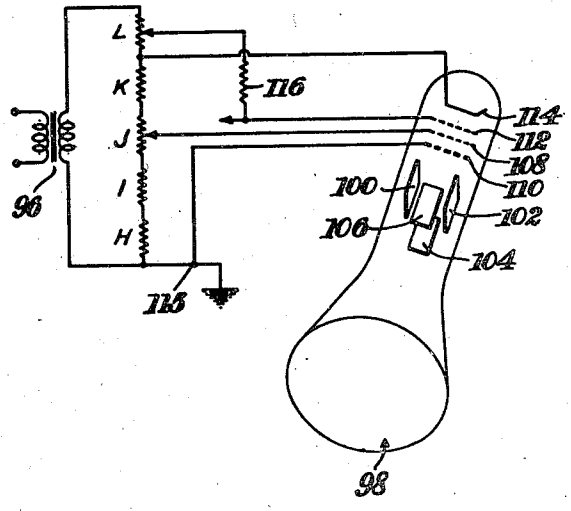


Fig: 8.



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Patented Nov. 30, 1948 2,454,810

UNITED STATES PATENT OFFICE

2,454,810

RADIO TRANSMITTING AND RECEIVING SYSTEM

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Application January 23, 1943, Serial No. 473,310

18 Claims. (Cl. 343—5)

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This invention relates to radio transmitter-receiver systems and more particularly to systems of the character which operate for brief recurring intervals.

It is customary in radio detection systems and other transmitter and/or receiver systems to use direct current. The supply of direct current for these systems requires considerable equipment in the way of rectifiers, filters, chokes, condensers, etc. Where the systems are to be made portable the equipment for supplying direct current takes up valuable space and adds considerably to the weight of the apparatus.

It is an object of this invention to eliminate much of the bulk, weight and cost of equipment heretofore believed necessary for transmitter and/or receiver systems which operate for brief recurring intervals.

Another object of this invention is to provide a method and means for operating transmitter and/or receiver systems such as radio detection systems directly on an alterating current source in place of the usual source of direct current.

Generally speaking, my invention involves the application of non-rectified, non-filtered, raw alternating current of a given frequency in lieu of direct current, to vacuum tube circuits normally in operation for brief recurring periods. Heretofore, transmitter-receiver systems have depended on vacuum tube circuits having direct current supplied to the various tube electrodes. I discover that by making modifications in circuit design and/or the inclusion of means to control the alternating current for the different portions thereof I can use directly a source of alternating current as the power supply for such systems.

The nature of my invention may be best understood from the following detailed description when read in connection with the accompanying drawings, in which:

Fig. 1 is a block diagram of a radio detection system employing an alternating current source in accordance with this invention;

Figs. 2 and 3 are graphical illustrations showing how alternating current is used in the place of direct current in the system;

Fig. 4 is a schematic wiring diagram of a modulating control circuit;

Fig. 5 is a block diagram of another modulating control circuit;

Fig. 6 is a schematic illustration of a two-stage radio circuit employing stage coupling elements for use with alternating current;

Fig. 7 is a schematic illustration of a two-stage radio circuit in which the design principles of

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direct current amplifiers are employed with alternating current; and

Fig. 8 is a schematic illustration of a voltage divided circuit supplying the electrodes of the cathode ray oscillograph.

Referring to Fig. 1 of the drawings, I show, for purposes of illustration, a radio detection system comprising a pulse transmitter composed of a radio frequency oscillator 8, a pulse modulator 9 and an antenna 10 for transmission of recurring impulses. A receiver 11 and a cathode ray oscillograph 12 are included to receive and indicate echo pulses caused by an obstacle in response to the transmission of impulses. Connecting the output of the pulse modulator 9 to the receiver 11 is the usual blocking circuit 13 arranged to block the receiver during the transmission of impulses. If desired, the circuit 13 may comprise an R.-C. blocking circuit such as disclosed in my copending application, Serial No. 471,228, filed January 4, 1943. A sweep generator 14 is also connected to the output of the modulator 9 whereby the sweep A—B of the oscillograph 12 is synchronized with the transmission of impulses. A reference pulse control 15, such as an adjustable passive retardation network or other circuit capable of providing a reference marker pulse delayed selectively relative to the transmission of an impulse, is connected to the output of the pulse modulator 9 to provide a reference pulse on the oscillograph 12 whereby the interval of time between a transmitted pulse and its echo 17 can be determined by coincidence of the reference pulse 16 and the echo pulse.

To the circuits of the radio detection system, I apply directly an alternating current source 18. While this source of current is applied directly to the oscillator 8 and the modulator 9, I preferably pass energy from the same source through a phase control 19 prior to application of the current to the receiver 11, sweep generator 14 and the oscillograph 12. By controlling the phase of the alternating current applied to the receiver side of the system, a desired portion of a period of the alternating current can be selected for the brief operating period of the receiver means.

Any alternating current source having a frequency such that the interval of receiver operation will cover but a small fraction of the period of the alternating current whereby the amplitude of the current during the interval has negligible percentage variation is satisfactory. That is to say, a small percentage variation in the current applied during the operating interval is not objectional and if the peak portion of the positive

half of a cycle is used this variation may be maintained at a minimum of about one percent. A maximum percent variation up to six or seven percent to both sides of a mean value is not objectionable for most receiver operations. Such variation in the applied power is analogous to a permissible like variation in the direct current supply heretofore believed necessary.

When alternating current is applied to the pulse modulator 9, the modulator which may be of the spark type or any other pulse producing circuit desired will, depending upon the time constants of the circuit, produce an impulse at some point along the positive half of an alternating current cycle. The particular location of the impulse with respect to the alternating current period may be selected as hereinafter more particularly described.

The modulator is arranged to produce and cause transmission of an impulse 20 in the relation shown in Fig. 2. The receiver 11 will be blocked temporarily by the device 13 during transmission of the impulse and thereafter permitted to receive echoes caused by obstacles in response to the transmitted impulse. A desirable range for portable radio detection apparatus may be selected so that the maximum time interval t_1 of receiver operation for a given alternating current is about three per cent of a cycle thereof and should this operating interval occur at the peak portion of the cycle as indicated by the sweep A_1—B_1 in Fig. 2 very little variation will occur in the amplitude of the current.

Assuming that the transmitted impulse occurs at 20*a* on the decreasing portion of the curve, the interval directly following it A_2—B_2 will approach a maximum percentage variation. This variation can be reduced to a minimum by proper control of the phase of the alternating current source applied to the receiver side of the system. By adjusting the phase control 19 an amount θ the alternating current applied to the receiver side of the system will be retarded in phase so that the peak portion thereof will be used during the receiver operating interval. This interval is indicated by the broken lines as A_3—B_3.

The sweep A—B is produced by a saw-tooth wave 21 generated at 14 in synchronism with the pulse 20 as shown in Fig. 2. When the pulse 20 is varied in position relative to the cycle of the alternating current as shown at 20*a*, the saw-tooth wave is likewise moved in time as indicated by the broken line curve 21*a*.

In Fig. 3, the transmitted impulse 20 and the sweep A_1—B_1 is shown at the peak portion of an alternating current. Should it be desirable to introduce a discard interval t_2 and increase the speed of the sweep for the oscillograph thus magnifying the reception interval t_1 for vernier measurement, a discard interval timer 22*a* may be interposed between the output of the modulator 9 and the sweep generator 14. This interval timer may comprise any suitable adjustable delay device whereby the initiation of a sweep voltage can be delayed a desired time interval.

For radio detection operation, the sweep interval A—B indicates the interval of receiver operation desired. Since the phase of the alternating current source can be controlled by the phase control 19, this brief operating interval can be correlated with the peak portion of the alternating current. The receiver, of course, may be permitted to operate beyond the sweep interval A—B and any reception or interference beyond the sweep interval A—B will not appear on the oscillograph. In application of the invention to other radio receiving systems it may be desired to block out all of the receiver operation except for a selected brief period.

In Fig. 4, I have shown a form of modulator similar to the direct current-operated modulator disclosed in my copending application, Serial No. 406,499, filed August 12, 1941, which matured into Patent No. 2,408,076. The modulator comprises a vacuum tube 22 in which a cathode is self-biased to a desired cut-off level by a capacity-resistance circuit 23. The plate circuit of the tube includes an inductance coil 24 and the grid circuit for the tube is provided with a coil 25 inductively coupled with the coil 24, to provide a positive feedback between the plate circuit and the grid circuit. The alternating current source 18 is applied between the cathode circuit and the coil 24. This application of alternating current takes the place of direct current applied in the modulator or pulse generator disclosed in my aforesaid copending application, Serial No. 406,499, now Patent No. 2,408,076. In operation the plate circuit is adapted to build up to saturation at some point along the ascending portion of the alternating current cycle. This saturated condition causes the grid potential, due to the feedback circuit, to suddenly become negative. This blocks the current flow through the tube 22 and permits the coil 24 is discharge, thereby producing a high potential impulse of short duration. The time constant of the circuit 23 is such that the discharge of the condenser thereof prolongs the negative charge of the grid of the tube thereby providing an interval between the generation of impulses.

Besides the form of pulse generator described above other forms of pulse generators such as the spark type, for example, may be used for modulating purposes in the radio detection system of Fig. 1.

Should it be desirable to cause generation of an impulse at some point on the descending side or at any other portion of an alternating current wave, a control system such as illustrated in Fig. 5 may be used. This system comprises a clipper 26 adapted to clip the alternating current wave applied thereto from the source 18 substantially as indicated at 27. The resulting wave is substantially rectangular in form and when applied to a differentiating circuit 28 produces alternately positive and negative pulses as indicated at 29. Uni-directional pulses 31 may be obtained from the output of the differentiating circuit 28 by passing the energy through a threshold device 30 such as a class "C" amplifier. The uni-directional pulses 31 may be retarded any desired amount t_3 by passing the pulses through a time delay device 32 and thence to modulator 9, (for example the grid of the tube 22, Fig. 4). In this instance tube 22 is biased to such a level that the alternating current will not cause it to operate in the absence of the added pulses. The energy of these pulses when applied to the grid triggers the operation of the modulator so as to time the occurrence of the generated impulses. It will be clear therefore that a proper adjustment of the delay device 32 will provide the occurrence of the impulse 20 in the desired location along the alternating current cycle.

From the foregoing description it will be clear that by using the peak portions of the alternating current wave, I can provide a voltage which taken alone has substantially the characteristics of direct current for the operative intervals of the

devices. Also, since this peak portion will vary in potential a very small percent, such variation will have no adverse effect on the operation of a radio detection system constructed in accordance with my invention.

A radio detection system intended for use with a source of direct current will require certain alterations before it will satisfactorily operate on alternating current. I have therefore selected certain portions of the system to show specifically the kind of alterations required.

In Fig. 6 I have shown a multi-stage circuit fed by alternating current and designed with the proper time constants to pass high frequencies and to filter out low frequencies such as the source of alternating current used. This circuit comprises vacuum tubes 34 and 36 having respectively plates 38 and 40, grids 42 and 46, and cathodes 48 and 50. Tube 34 has a grid bias resistor 52 in its cathode circuit and the by-pass condenser 54 connected to a common ground 56. Likewise tube 36 has a grid bias resistor 58 in its cathode circuit by-passed by condenser 60 and connected to the common ground 56. The plate supply voltage is obtained through a transformer 62 fed from the alternating current source 18. One end 63 of the secondary is connected through a load resistance 64 to the plate 38 of tube 34 and also through load resistance 66 to plate 40 of tube 36. The other end of the secondary is connected to the common ground 56. A grid input resistor 68 is connected to the grid 46 and the other end is connected to a ground point. The two stages are coupled together by a condenser C. The size of condenser C and resistor 68 largely determines the time constants necessary to pass high frequencies and reject the lower frequency of the power used. When properly designed, a circuit as indicated in Fig. 6 may be responsive to signals received when the plates 34 and 36 are positive.

In operation of the multi-stage circuit of Fig. 6 assume that a pulse is applied to the grid 42 of tube 34 at an instant when the transformer 62 is providing a high positive plate voltage. The pulse will be amplified by tube 34 and the amplified pulse will be applied to the grid 46 of the tube 36 and further amplified therein. Ordinarily the application of alternating current may introduce undesired reactions in the grid circuit of tube 36. However, in accordance with my invention, I select the condenser C and the resistor 68 to provide a convenient time constant. If the duration of the input pulse is to be 5 microseconds, for example, I may select a time constant which will allow my circuit to pass any pulse having a duration up to, say of 10 microseconds, and which will offer a high impedance to a pulse lasting several thousand microseconds. Therefore, by proper design it will be clear that the low frequency supply voltage of the source 18 introduces negligible reactions in the circuit.

In Fig. 7 I have illustrated a known type of multi-stage direct current amplifier wherein no blocking condenser is employed between stages modified for operation with an alternating current supply. This circuit comprises a first vacuum tube 70 having a plate 72, a grid 74 and a cathode 76. A second vacuum tube 78 comprises a plate 80, a grid 82 and a cathode 84. Plate 72 of vacuum tube 70 is directly connected to the grid 82 of tube 78. A coupling resistor 90 has one end connected to the plate 72 of tube 70 and the other end connected to a point E about midway on a voltage divider A—F. The point A on the voltage divider A—F is connected to a ground as well as through

a resistor 94 to the grid 74 of tube 70. The point F is connected through resistor 92 to the plate 80 of tube 78. The cathode 76 is connected to the voltage divider A—F at a point B so that a voltage slightly above ground potential will be applied thereto. The cathode 84 is connected to a point D on the voltage divider A—F between points B and E. Alternating current voltage is supplied to the voltage divider through a transformer 86 having one end connected to the point F and the other end connected to a ground point 88.

In actual practice, points at which various taps may be made on the voltage divider may be selected so as to provide the necessary operating voltages. The grid bias on tube 70 may be the voltage drop between points A and B. That on tube 78, however, is equal to the difference between the voltage which may be developed across a resistance 90 by the plate current of tube 70 and the voltage between points D and E. The anode voltage for tube 70 may be equal to that between points B and E less the voltage drop through the resistor 90. The anode voltage on tube 78 will be that between points D and F minus the voltage drop through the output resistor 92.

The circuit of Fig. 7 comprises a type of resistance coupling in which the plate of one tube is conductively connected to the control grid of the following tube by a single coupling resistor. The action of this type of directly coupled amplifier depends upon the fact that in any one tube considered by itself, the performance is a result of potential difference between plate and cathode of the first tube and between control grid and cathode in the second tube. This performance is not affected with reference to ground or with reference to any other tube.

In Fig. 8 I have illustrated a voltage divider H—L having divider connections to cathode ray tube 98. The voltage divider comprises five resistors H, I, J, K and L arranged in series and fed by the secondary of a transformer 96. The cathode ray tube 98 comprises vertical deflecting plates 104, 106 and horizontal deflecting plates 100, 102, a first anode 108, a second anode 110, a grid 112, and a cathode 114. The second anode 110 is connected to the end of resistor H at the ground point 115. The first anode 108 is adjustably connected to the resistor J. The grid 112 is adjustably connected through a resistor 116 to the resistor L. The cathode 114 is connected to a point between resistors K and L.

The voltage divider H–L should be arranged either with no by-pass condensers as shown in Fig. 8 or with proportional by-pass condensers around each section thereof so that the time constants of all sections will be substantially alike. The reason for this is because when a condenser of more than negligible capacity is connected across one or more sections it may cause an undesirable shift of the phase relations of the various voltages applied to the cathode ray tube.

Although I have described the principles of my invention in connection with specific apparatus, I recognize that many modifications and adaptations thereof are possible. It is to be clearly understood, therefore, that this description is made only by way of example and not as a limitation on the scope of my invention as set forth in the objects of my invention and the appended claims.

What I claim is:

1. A method of operating a transmitter-receiver system comprising energizing a transmitter di-

rectly with alternating current, energizing the receiver simultaneously with the energization of the transmitter with the same alternating current and operating the receiver for a period which is a small fraction of the alternating current cycle, whereby only an inconsequential variation in the amplitude of the energizing current will occur during the operation of the receiver.

2. The method defined in claim 1 further including phasing the alternating current applied to the receiver to cause the operating interval of the receiver to occur during a portion of a period thereof having a minimum of variation in amplitude.

3. The method defined in claim 1 further including selectively controlling the timing of the brief interval of the receiver operation with respect to transmitter operation.

4. The method defined in claim 1 wherein the energization of the transmitter includes causing the transmitter to transmit impulses in a selected timed relation with respect to the periods of the current applied thereto, and the energization of the receiver includes controlling the phase of the current applied to the receiver to energize the receiver for the operating intervals thereof at the peak portions of said current.

5. A method of operating a radio detection system having a transmitter to transmit recurring impulses and a receiver to detect for brief intervals echoes of the transmitted impulses, comprising simultaneously energizing directly with alternating current all the circuits of the system, and operating the receiver for an interval which is such a small fraction of the alternating current cycle that less than a ±7% variation in the mean amplitude of the energizing current will occur during the operating interval of the receiver.

6. A method of operating a radio detection system having a transmitter to transmit recurring impulses and a receiver to detect for a brief interval echoes of the transmitted impulses, comprising supplying alternating current directly to the circuits of the system for simultaneous energization thereof, correlating the recurring impulses to occur in a given time relation with respect to the peak portions of the alternating current, operating the receiver for an interval which is a small fraction of the alternating current cycle and controlling the phase of the alternating current applied to the receiver to insure application thereto of the peak portions thereof during said brief intervals of echo detection.

7. A method of operating a radio detection system having a transmitter to transmit recurring impulses and a receiver together with a cathode ray oscillograph to receive and indicate echoes of the transmitted impulses, which method comprises energizing simultaneously directly the circuits of the system with alternating current, correlating the generation of a sweep potential for the oscillograph to occur in synchronism with the occurrence of said impulses, and causing the peak portions of said current to occur in the circuits of said receiver and said oscillograph during the sweep interval of said oscillograph.

8. A method of operating a radio receiver for brief intervals comprising energizing the receiver with alternating current and operating the receiver for a period which is sufficiently small to constitute a fraction of the alternating current cycle to insure an amplitude variation of the current during such periods of less than ±7% of the mean amplitude of the current.

9. A method defined in claim 8 further including the step of phasing the alternating current energizing the receiver to correlate the coincidence of the portion of the alternating current cycle having a minimum of amplitude variation with the operating interval of the receiver.

10. A method of operating a radio receiver and an oscillograph arrangement for visual indication of signals received during brief intervals, comprising energizing directly and simultaneously the circuits of the receiver and the oscillograph with alternating current, deriving sweep potentials from said alternating current for the oscillograph, operating the receiver for a brief period which is recurrent for each alternating current cycle and is such a small fraction thereof that the amplitude variation of the alternating current for the brief interval of receiver operation is less than ±7% of the mean amplitude of the current during such interval, and correlating the occurrence of said sweep potentials with said operating intervals.

11. A transmitter-receiver system comprising a transmitter, a receiver, means for applying alternating current to said transmitter and said receiver for the simultaneous energization thereof, and means for operating the receiver at least for an interval which is such a small fraction of the alternating current cycle as to limit the variation in the amplitude thereof during such interval to less than ±7% of the mean amplitude of the current.

12. The system defined in claim 11 wherein the means for supplying alternating current to the receiver means includes means for variably phasing the current to cause the operating interval of the receiver to occur during a portion of the period of the alternating current having a desired minimum of variation in amplitude.

13. The system defined in claim 11 wherein the transmitter includes means to control the occurrence of impulses with respect to the cycle of the alternating current.

14. The system defined in claim 11 wherein the receiver includes means providing a time constant between at least certain stages to pass radio frequency energy and to block passage of energy of the alternating current source.

15. In a radio detection system having means to transmit impulses and receiver means to detect and indicate for brief intervals echo pulses caused by obstacles in response to said impulses; the combination therewith of means to supply alternating current directly to the transmitting means and to the receiver means for simultaneous energization thereof, said current having a frequency to render each cycle thereof large relative to said interval and means for variably phasing the alternating current applied to the receiver means with respect to the application thereof to said transmitting means to insure application to said receiver means of a portion of the cycle of alternating current having a desired minimum of variation during said brief intervals of detection.

16. In a radio detection system having means to transmit impulses and receiver means to detect and indicate echo pulses caused by obstacles in response to said impulses; the combination therewith of means to supply alternating current directly to the transmitting means and to the receiver means, and means to effect retardation of the alternating current applied to the

receiver means to insure application thereto of a portion of the cycle of alternating current having a minimum of variation during reception of echo pulses, the receiver means including a receiver and an oscillograph in combination with means responsive to the transmission of impulses to generate a sweep potential for the oscillograph, and means to retard the timing of the sweep potential with respect to the impulse transmission to provide a discard interval between the occurrence of an impulse and initiation of a sweep for the oscillograph.

17. A receiver system, means to operate said system for brief intervals, means to supply the system with alternating current power, for overall energization thereof, the frequency of which is low so that each interval of operation is equal to a fraction only of a cycle of said current, and means providing a time constant between at least certain stages to pass radio frequency energy and to block passage of energy of said alternating current between stages of said system.

18. The method described in claim 1 wherein said variation in amplitude is held to be less than ±7% of the mean amplitude of the current during said period.

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