May 6, 1941. G. ULBRICHT 2,241,170

METHOD FOR RECEIVING PERIODIC IMPULSES

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FIG. 1.

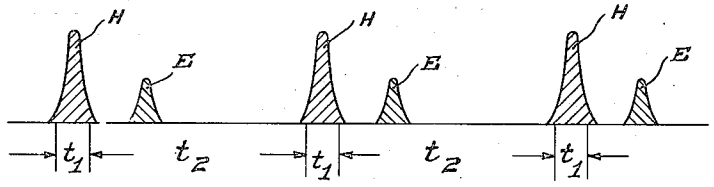
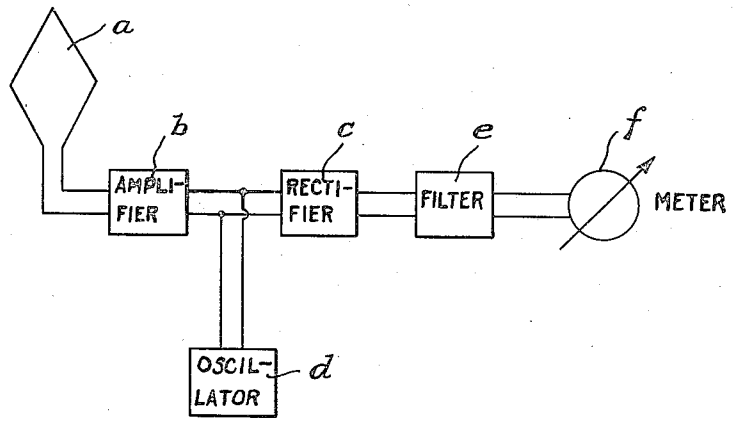


FIG. 2.



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METHOD FOR RECEIVING PERIODIC IMPULSES

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3 Claims. (Cl. 250—11)

This invention relates to impulse direction finders, and has for its principal object the provision of a method of and means for eliminating the error due to night effects.

Impulse direction-finding gives bearings free from night effects when a separation of the signal (main signal) H due to the ground wave and the signal reflected from the ionosphere, or echo signal is accomplished. This separation, as known from the prior art, is insured by rendering the two signals following each other a certain time interval apart, visible by time deflection upon the screen of a Braun tube. In order that the Braun tube, which is impractical in handling and use, may be replaced by a measuring instrument, the suggestion has been made in the earlier art to block reception, say, by a negative biasing potential or the like during the period of time t_2 between two consecutive main impulses and to open the receiver only for the period of time t_1 during which the main impulse arrives. Fig. 1 illustrates the relation of main and echo impulses and the times t_1 and t_2 referred to above.

The drawback residing in this method is that the blocking or the opening of the receiver must be effected by impulses which are synchronous in relation to the main impulses, yet the main impulses disappear in case of minimum signal strength direction-finding.

The invention will be better understood from the following description when considered in connection with the accompanying drawing. Its scope is indicated by the appended claims.

Referring to the drawing, Fig. 1 illustrates the time relation between the main impulses H and the echo impulses E which are picked up by a receiver, and Fig. 2 illustrates the components of a receiver arranged in accordance with this invention.

Now, according to the invention the following method is to be used for a separation of the main impulse and the echo. The incoming radio frequency energy is mixed in the receiver with another locally generated radio frequency current to produce an audio frequency beat. Presupposing that the impulser or impulse transmitter is so key-modulated that the phase of the radio frequency current in each successive impulse signal is the same as the phase which would be present at that time if the transmitter were oscillating uninterruptedly there is produced what will hereinafter be termed coherent oscillations. The radiated radio frequency energy comprises a carrier wave and a number of discrete side-bands separated from the carrier frequency by an amount equal to the impulse frequency, say, 300 cycles per second. Such keying is insured by causing the transmitter to oscillate permanently instead of causing it to resume oscillations upon each signal, while keying action is brought only upon the output tube connected as an amplifier. Now, at the receiving end, a constant radio frequency oscillation is superimposed upon the oscillations picked up by the aerial which is roughly equal to the carrier frequency. What thus results are beats between the locally produced and the incoming (or signal) radio frequency carrier. Thus, if the frequency of the local oscillator is, say, $h+n_1$, where h is the carrier frequency and n_1 is any low frequency, and if the impulse frequency be denoted by n_2 (300 cycles per second) so that the side-bands of first order of the incoming radio frequency carrier have these frequencies: $h-n_2$ and $h+n_2$, there is produced a beat frequency n_1-n_2 which corresponds to the combination of the frequency of the local oscillator $h+n_1$ and one side-band frequency $h+n_2$ of the radiation. By means of audio frequency filters this new beat frequency n_1-n_2 may be separated from the other audio frequency combination frequencies between the impulse frequency and harmonics thereof, and be then fed to a measuring instrument.

If the presupposition be made that the impulse transmitter is not keyed in a way so that it will oscillate at the correct phase for each impulse, but rather in a way resulting in any arbitrary phase at all (which, for instance, would occur if the oscillations of the transmitter after each signal were caused to discontinue and to be resumed anew upon the start of each new signal), then, contra-distinct from the first case, what are hereinafter termed incoherent oscillations are produced, and the transmitter will not radiate discrete side frequencies in addition to the carrier wave, but it will radiate a frequency spectrum which extends all the way from zero frequency to infinity. This may be explained by the fact that the first-named case (coherent oscillation), in first approximation, may be conceived of as a coherent sinusoidal oscillation subject to amplitude modulation at impulse frequency n_2. The radiation is then based upon a pure sinusoidal oscillation which is imparted with an additional frequency by the modulation. Hence, the frequency spectrum consists of the carrier wave with discrete side-band frequencies. In the second case, the cir-

cumstance that upon each and every new impulse the transmitter starts to oscillate at an indefinite phase makes the presence of a periodic feature in the frequency spectrum prohibitive. Hence, inasmuch as there is an infinite variety of chances, so far as the phase is concerned, upon resumption of oscillations by the transmitter upon each impulse, the radiation is not representable by a Fourier series (for this would lead to the spectrum of discrete frequencies), but rather by a Fourier integral. If, then, the combination frequencies which are produced in the receiver upon the combination of the carrier with the constant frequency $h+n_1$ are taken into consideration, it will be understood that it is not feasible to produce any constant beat frequency n_1-n_2 as in the preceding case, seeing that in the case first discussed the frequency $h+n_2$ constituted a preferential frequency (first side-band frequency), while in the second instance frequency $h+n_2$ plays no such part, nor, indeed, is there any arbitrary frequency at all in the continuous spectrum.

In close analogy to the instances hereinbefore examined, according to the invention a separation of the main impulse and the echo impulse is insured by utilization of the constant beat frequency n_1-n_2. For this purpose, it is necessary that the transmitter, as in the example first cited, should radiate coherent radio frequency impulses. Under such conditions it is possible, in the receiver, to obtain the desired beats by a combination of the locally generated current and the main impulse (or direct signal). However, the impulses of the echo do not represent any coherent oscillation trains. The phase of the radio frequency of the reflected radiation will be a function of the length of the path which has been covered by the radiation. The length of this path is governed by the altitude of the reflecting layer, and the latter is never constant, in fact, it is subject to uninterrupted brief fluctuations, and this results in a time shift of the phase which is inversely proportional to the wave-length. As a result, the reflected radiation has a similar characteristic to that radiated by a transmitter subject to incoherent oscillations. Hence, the audio frequency filter which is tuned to the frequency n_1-n_2 will be fed with energy only from the main impulse or direct signal, while the echo impulse (the reflected signal) will furnish practically no voltage of this frequency. Hence, by turning the direction-finding loop, it is possible to make the main impulse, in other words, the output obtained from the audio frequency filter and the rectifier, equal to zero without the echo signal having any influence upon the direction-finding work.

Fig. 2 shows the basic diagram of such a direction-finding outfit. The radio frequency energy picked up by the direction-finder frame *a* reaches the receiver *b* which may be a radio frequency amplifier or the intermediate frequency amplifier of a superheterodyne receiver. The radio frequency rectifier is specially and separately indicated in Fig. 2 by *c*. At *c* the local radio frequency current generated in the oscillator *d* is mixed with the carrier frequency. In the output of the rectifier *c* arises the beat n_1-n_2 which is filtered out in the audio frequency filter *e* and is indicated by the instrument *f*. The indicator instrument may consist of a telephone receiver or else of any desired alternating current instrument.

I claim as my invention:

1. In an impulse modulated direction finding system the method of reducing errors due to the interference of echo impulses with the reception of main impulses which includes the steps of receiving said main and echo impulses, generating local oscillations having a frequency differing from the carrier frequency of said impulses by a fixed amount, combining said received impulses and said local oscillations to produce a constant beat frequency current which corresponds to the combination of the frequency of the local oscillator and one side band frequency of the impulse-modulated carrier, and a varying beat frequency current which changes with changes in the phase of the echo carrier current, and selectively passing currents of the frequency of said constant beat frequency currents and rejecting currents of other frequencies.

2. In an impulse modulated direction finding system the method of reducing errors due to the interference of echo impulses with the reception of main impulses which includes the steps of receiving said impulse modulated main and echo impulses, generating local oscillations, combining said received main and echo impulses with said generated oscillations to produce modulated intermediate frequency currents, having upper and lower side band components, selecting only one of said side band components, and indicating the amplitude of said selected component.

3. In an impulse modulated direction finding system the method of reducing errors due to the interference of echo impulses with the reception of main impulses which includes the steps of receiving said main and echo impulses, generating local oscillations having a frequency differing from the carrier frequency of said impulses by a fixed amount, combining said received impulses and said local oscillations to produce a constant frequency beat frequency current which corresponds to the combination of the frequency of the local oscillator and one side band frequency of the main impulse-modulated carrier, and a varying frequency beat frequency current which changes with changes in the phase of the echo carrier current, selectively passing currents of the frequency of said constant beat frequency currents and rejecting currents of other frequencies, and indicating the amplitude of said selectively passed currents.

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