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IMPULSE DIRECTION-FINDING METHOD

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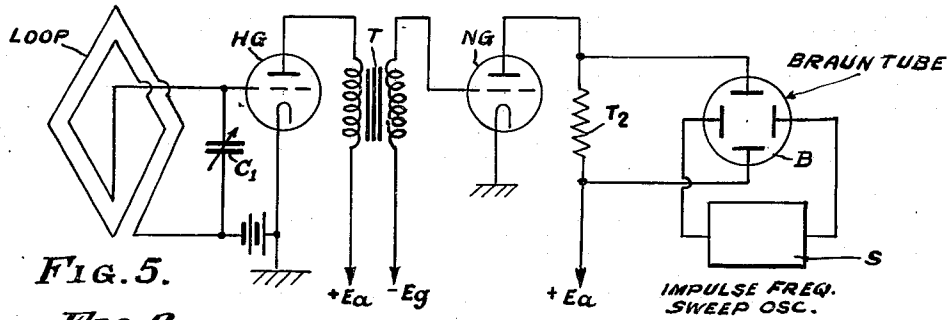


FIG. 5.

FIG. 2.

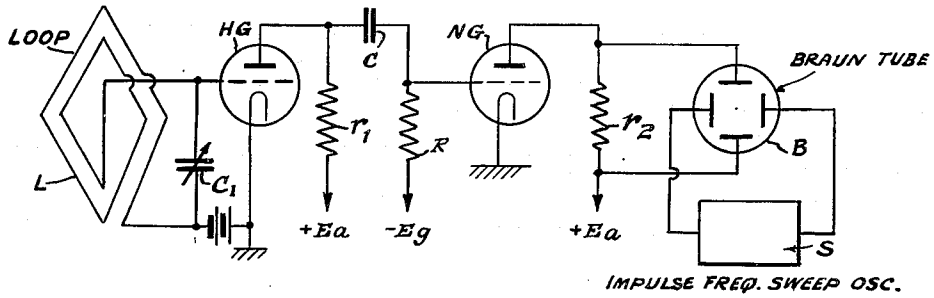


FIG. 3a.

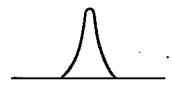


FIG. 3b.

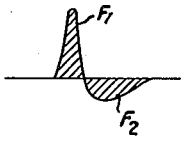


FIG. 3c.

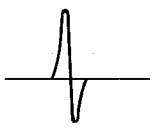


FIG. 4a.

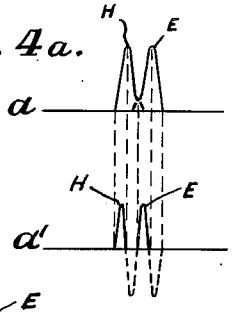
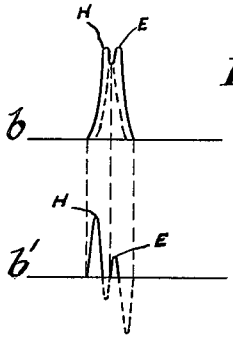


FIG. 4b.



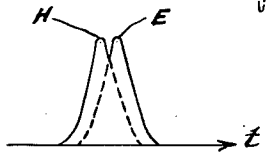


FIG. 1.

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IMPULSE DIRECTION-FINDING METHOD

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Application February 11, 1938, Serial No. 190,105
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4 Claims. (Cl. 250—11)

This invention relates to impulse direction finders and has for its object the provision of an apparatus for and a method of increasing the effective separation between two successive impulses, such as the ground and space wave impulses in a direction finder.

This invention will be better understood from the following description when considered in connection with the accompanying drawing, in which

Figure 1 illustrates the result of the overlapping of two successive impulses,

Figure 2 illustrates an embodiment of my invention which utilizes capacitive coupling between the radio frequency rectifier and the audio frequency rectifier,

Figures 3*a* and 3*b* represent, respectively, an impulse as received and the impulse which is derived therefrom. Fig. 3*c* is a special case of the impulse shown in Fig. 3*b*,

Figures 4*a* and 4*b* represent, respectively, received and derived ground and space wave impulses of substantial spacing and received and derived ground and space wave impulses of small spacing such as is shown in Fig. 1,

Figure 5 is a schematic drawing of an alternative embodiment of my invention which utilizes transformer coupling.

The working ranges obtainable with the impulse direction-finding methods are limited for the reason that when the major or original signals and the echo or space signals are received at a great distance from the transmitter it is no longer possible to separate the two as they occur in such rapid succession. In fact, they merge into one another and overlap partly as shown in Fig. 1 where the amplitudes of the main signal H and of the echo E are plotted against the time *t*.

According to the invention an increase in the working range or distance can be attained by reducing the time duration or width of the incoming space and ground wave impulses at the receiver, with a view to separating them more clearly as to their time of arrival. To accomplish this the radio frequency impulses are rectified and the resultant unipotential impulse signals are coupled through energy storing means to an audio-frequency rectifier.

Referring to Fig. 2, one embodiment of my invention is shown which utilizes a resistance-capacitance coupling system. A loop antenna L is used to receive the impulse signals. The signal is then impressed on the grid of a radio frequency rectifier tube HG. The rectified output of this tube appears across the plate load impedance r_1, and a voltage is impressed on the grid of the audio frequency rectifier NG by the coupling capacitor C. The rectified voltage which appears across the output impedance r_2 is impressed across the vertical deflecting plates of a Braun tube B. The horizontal deflecting plates of the Braun tube are connected to a sweep oscillator which is synchronized to the frequency at which the impulses occur. This provides a horizontal scanning line on which a mark appears whenever an impulse is received. Impulses arriving at different times appear in different positions on the line and may thus be identified. The use of a loop antenna and a Braun tube indicator for impulse direction finding are in themselves old.

The operation of my invention will now be explained.

After radio frequency rectification in rectifier HG the voltage across the resistance r_1 corresponding to one impulse has the form shown in Fig. 3*a*. The voltage appearing across the resistance R is the derived curve as shown in Fig. 3*b*. This will be understood when it is remembered that the voltage which is induced through a capacitor, or a transformer, is zero when the inducing voltage is constant, and a maximum when the rate of change of the inducing voltage or current is the greatest. Mathematically, the relation between the inducing and the induced voltage is expressed by the process of differentiation. Thus a sine wave voltage, or current, induces a voltage which follows a cosine curve. An impulse such as that shown in Fig. 3*a* is not the equivalent of one half of a sine wave cycle, for in the sine wave the rate of change is a maximum at the point of intersection with the abscissae while in the impulse the rate of change becomes zero at the point of intersection with the abscissae.

The width of the impulse is decreased because the derived voltage starts from zero, goes through a maximum and returns to zero in the time during which the original voltage is going from zero to maximum. The return of the original voltage to zero induces another impulse of opposite polarity. The two derived impulses are shown at F1 and F2 of Fig. 3*b*. The areas F1 and F2 above and below the neutral or zero line must be the same since no direct current will flow through the condenser C. The form of the areas is a function of the size of condenser C and of the resistance R.

In the impulse direction-finding method the

signals follow one another periodically, say, at a frequency of f_1=300 cycles per second. If the coupling means C and R are chosen so small that only the high harmonics of frequency f_1 are transmitted, then the signals which appear across R assume the shape shown in Fig. 3c.

Now, these signals are fed to the grid of the audio frequency rectifier NG. Owing to rectification, the negative portion below the neutral line drops out, and there is obtained in the output of the tube across the resistance r_2 signals of the original shape, though narrowed or constricted. In this manner both the ground wave impulse and the echo signal will be reduced in width.

If the ground wave and the echo impulses are received with as great a separation as that illustrated in Fig. 4a at *a*, their identification would be possible according to the usual methods, but by utilizing the method herein explained their separation would be improved as shown in Fig. 4a at *a'*. However, if the ground wave and the echo impulses are received in very close sequence as shown at *b* in Fig. 4b, or in Fig. 1, then, as noted above, direction finding would normally be quite inaccurate. By my invention, the two impulses are completely separated as shown at *b'* in Fig. 4b, and direction finding thus made accurate where it is otherwise inaccurate.

In Figs. 4a and 4b the vertical dotted lines are drawn in to show the relative time relation between the received impulses at *a* and *b* and the derived impulses at *a'* and *b'*. The dotted lines below the abscissae show that portion of the derived voltage which has been removed by the audio rectifier NG.

Referring now to Fig. 5, an alternative arrangement is illustrated which substitutes a transformer coupled stage for the impedance-capacitance coupling shown in Fig. 2. The theory of operation is the same as before, as it is well known that the voltage induced in the secondary of a transformer is the derivative of the primary current.

The basic idea of this invention is not confined to its use as here suggested and the energy storing means here disclosed. In fact, the disclosure is intended, in a general way, to cover reduction in width of two impulses arriving at the receiving end for the purpose of their exact separation.

I claim as my invention:

1. In an impulse direction finder, the method of operation which includes the steps of receiving ground wave and reflected impulses, rectifying the received impulses, obtaining a derived impulse from each rectified impulse, the time duration of said derived impulses being short with respect to the duration of received impulses, selecting high harmonics of said derived impulses, rectifying the selected harmonics, and determining the successive arrival of said ground wave and reflected impulses as indicated by the time interval between successive derived and rectified harmonic impulses.

2. The combination which includes means receptive to short radio frequency ground wave impulses, said means being receptive to undesired reflected impulses which arrive at a normally indistinguishable intervals after said ground wave impulses, means for rectifying said ground wave and said reflected impulses, a capacitor coupled to said rectifying means for obtaining an impulse which is the derivative of each of said rectified impulses, the time duration of said derivative impulse being small with respect to the duration of each of said received impulses, means for rectifying said derived impulses, and means for indicating the successive occurrence of said derived and rectified impulses to distinguish said ground wave impulse from said reflected impulse.

3. The combination which includes means receptive in short radio frequency ground wave impulses, said means being receptive to undesired reflected impulses which arrive at a normally indistinguishable interval after said ground wave impulses, means for rectifying said ground wave and said reflected impulses, a transformer coupled to said rectifying means for obtaining impulses which are the derivatives of said rectified impulses, the time duration of said derivative impulses being small with respect to the duration of corresponding received impulses, means for rectifying said derived impulses, and means for indicating the successive occurrence of said derived and rectified impulses to distinguish said ground wave impulses from said reflected impulse.

4. The combination which includes means receptive to short radio frequency impulses, means for rectifying said impulses to obtain unipotential impulses containing high order harmonics, means for obtaining derivative impulses from said high order harmonics of said rectified impulses, means for rectifying said derivative impulses, and means for visually indicating the successive occurrence of said rectified derived impulses.

GÜNTHER ULBRICHT.