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 [21] Appl. No. **807,626**
 [22] Filed **Mar. 17, 1969**
 [45] Patented **Sept. 7, 1971**
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[54] **RAILROAD GRADE CROSSING PROTECTION SYSTEM**
13 Claims, 2 Drawing Figs.

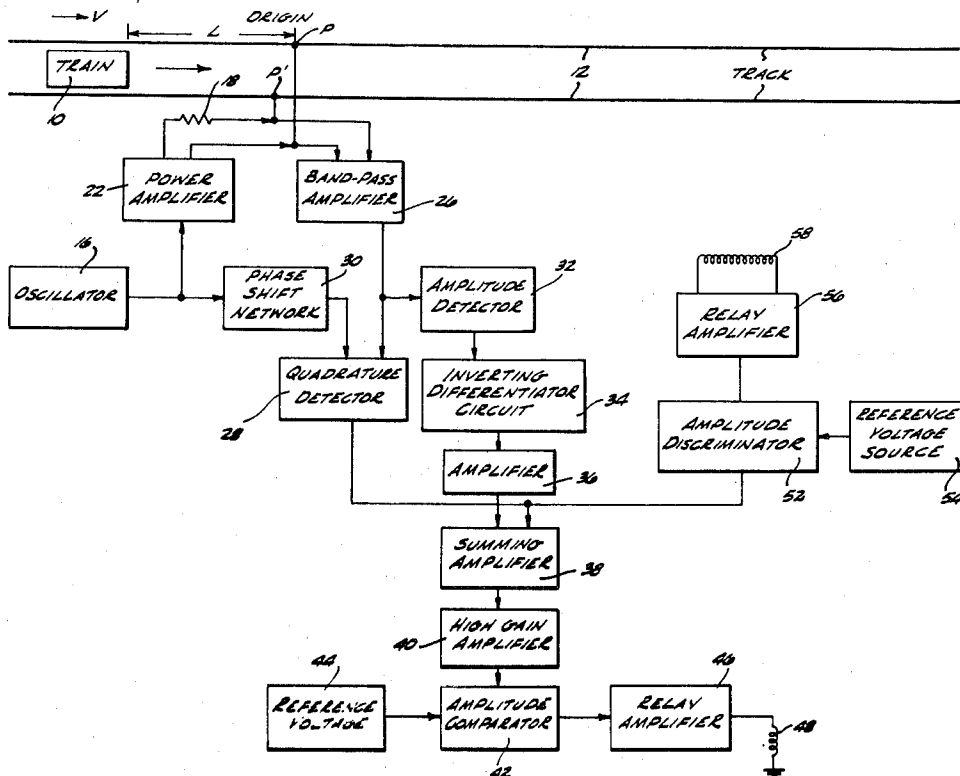
[52] U.S. Cl. **246/128**
 [51] Int. Cl. **B611 1/06,**
B611 29/32
 [50] Field of Search **246/128**

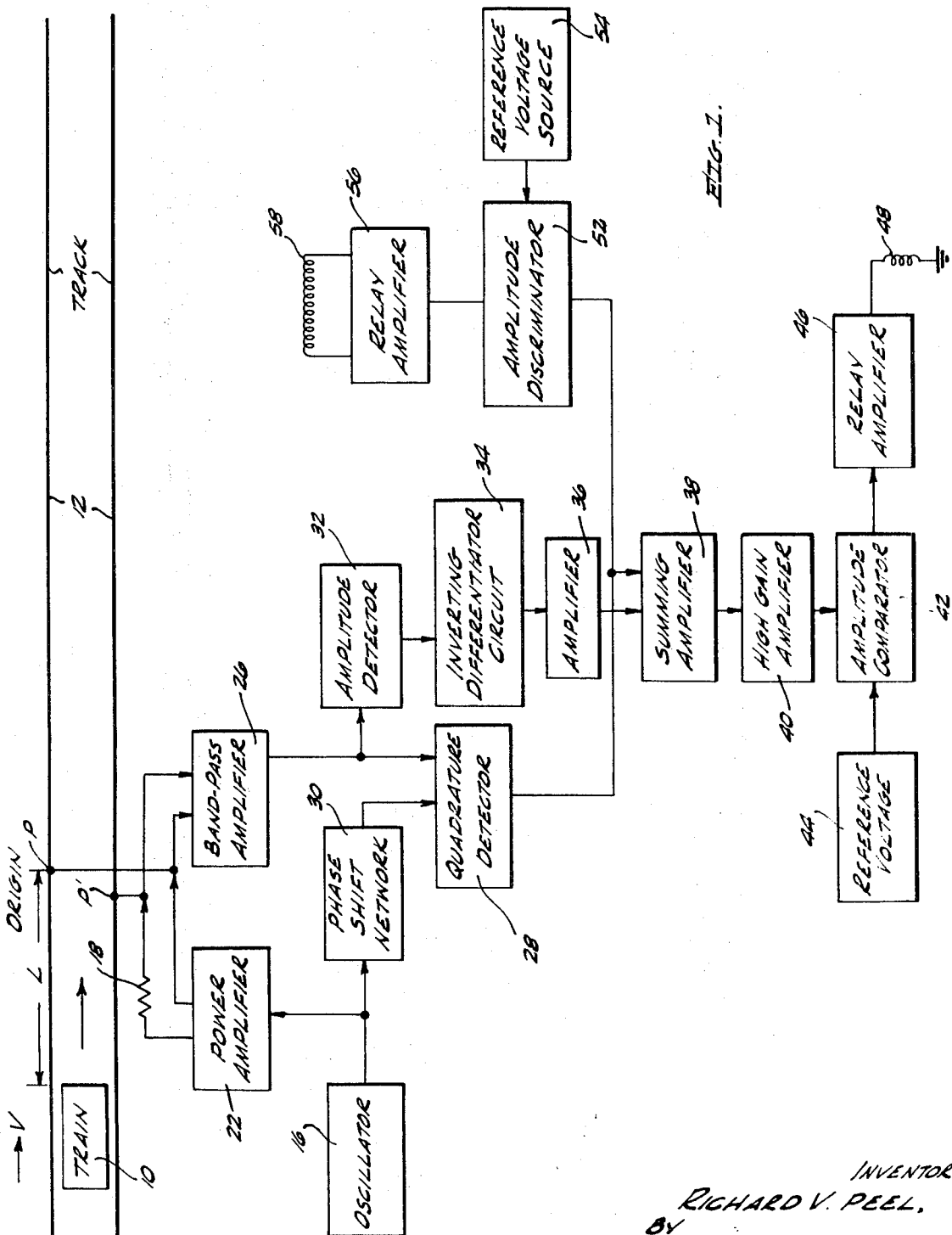
[56] **References Cited**

UNITED STATES PATENTS

3,246,143 4/1966 Steele et al. **246/128**

ABSTRACT: A railroad crossing warning indicator which predicts the time of arrival of trains to a grade crossing is described, which includes a quadrature detector which provides a distance voltage which is derived from the reactance magnitude, and an amplitude detector which provides a distance voltage derived from the impedance magnitude. The voltage derived from the impedance magnitude is applied to a differentiating circuit which provides the speed of the train. The reactance voltage from the quadrature detector and the impedance voltage derivative circuit from the differentiating circuit are then summed whereby the sum of the two voltages provides an improved estimate of the time of arrival of the train with the decrease in error.





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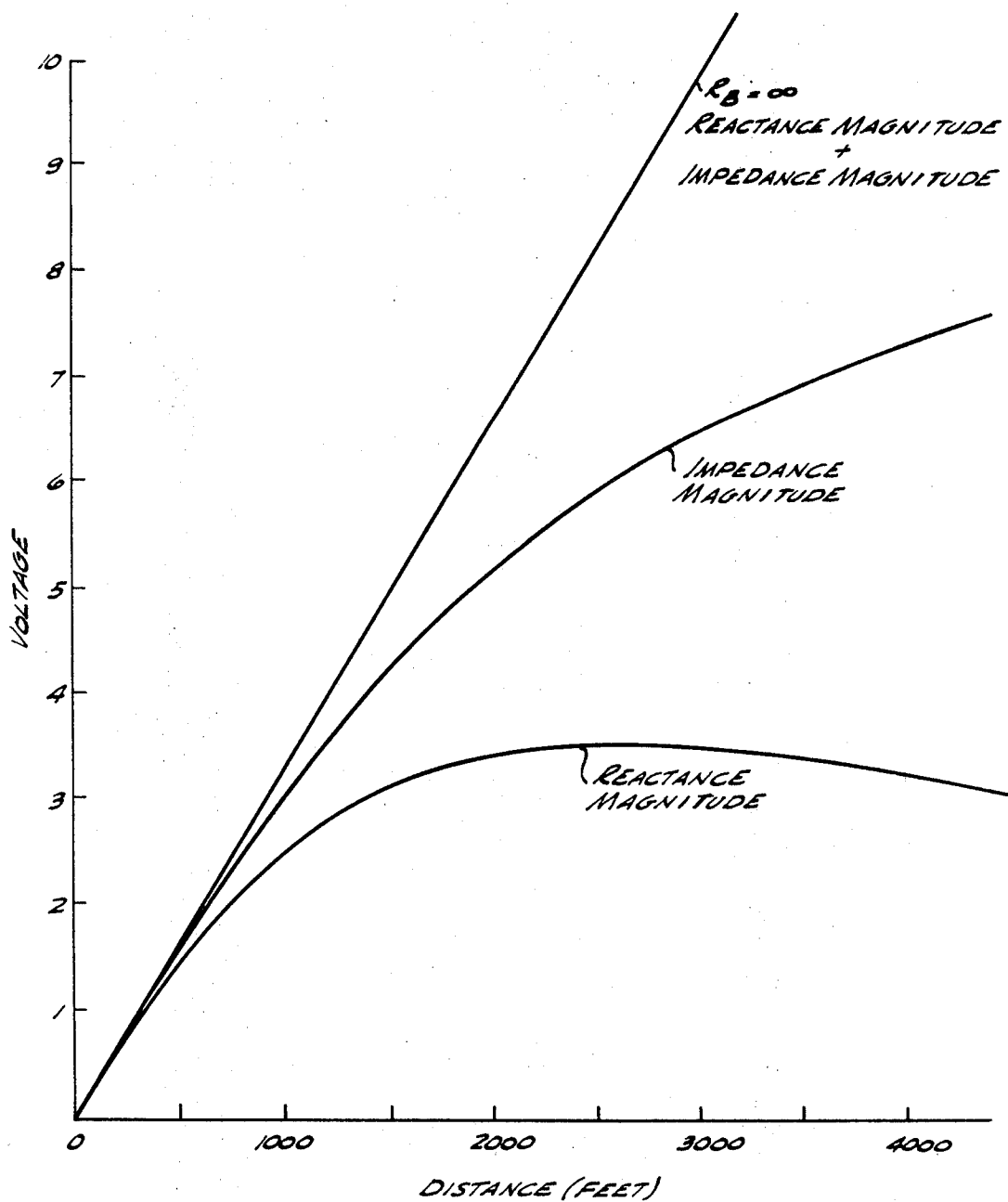


FIG. 2.

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RAILROAD GRADE CROSSING PROTECTION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to warning systems for railroad grade crossings and more particularly to an improvement in warning predictor systems used to predict the time of arrival of an approaching train.

2. Discussion of the Prior Art

A typical grade crossing predictor is set forth in U.S. Pat. No. 3,246,143. Much of the same system's electronics of that patent are used in the invention discussed herein.

The system of the patent provides a railroad crossing warning system whereby delay to cross traffic is minimized. This is achieved in an arrangement wherein the railroad track is considered as a shorted transmission line in which the short is provided by the train. An alternating current signal which is a substantially constant current level is applied to the tracks at the location of the grade crossing. The voltage existing across the tracks as the train, and therefore the short, approaches the grade crossing, will diminish. Thus, the amplitude of this voltage provides a measure of the distance of the train from the crossing while the rate at which this voltage diminishes provides a measure of the velocity of the train. With these parameters it becomes possible to estimate the time of the train's arrival at the crossing. Knowing the time of arrival, the system can start warning signals at such a time as will provide the least possible delay to cross traffic. The signal representative of distance and the derived signals therefrom representative of velocity are combined to provide a third voltage representative of the time required for the train to arrive at the railroad grade crossing.

It has been found that the input impedance of the shorted railroad track section, having infinitely high ballast resistance, varies linearly with track length. The grade crossing predictor, as set forth in the above patent, for example, uses this principle to develop a voltage which is the measure of the distance of the train to the predictor probe location. The voltage is derived from the reactance component of the input impedance. The rate at which this voltage diminishes as a train approaches, provides a measure of the speed of the train. These two voltages are then combined to estimate the time of the train's arrival at the crossing. Knowing the time of arrival of the train, the aforesaid system can initiate warning signals before the arrival thereof.

Since, in actual practice, ballast resistance is low enough to cause the input impedance, and in particular the reactance component, to vary nonlinearly with track length, an error is introduced into the distance voltage and thus the speed voltage. These two errors cause the predictor to err in the estimate of the arrival time of the train; as the ballast decreases, the error increases linearly. Thus, a need has arisen to reduce the error in the estimate of arrival time of a train when ballast resistance is low.

Briefly described, the present invention makes use of a second distance voltage which differs from the first in that it is derived from the impedance magnitude of the input impedance. It is this second voltage which is used to measure the speed of the train. The first distance voltage is used to measure the distance to a train.

DESCRIPTION OF THE DRAWINGS

These and other objects, features and advantages will become more apparent to those skilled in the art when taken into consideration with the following detailed description, wherein like reference numerals indicate like and corresponding parts throughout the several views, and wherein:

FIG. 1 is a block diagram of the preferred embodiment of the invention; and

FIG. 2 is a graph of the voltage versus distance and the error reduction linearity realized by this invention.

DESCRIPTION OF ONE PREFERRED EMBODIMENT

Turning now to FIG. 1, there is shown a block diagram of the preferred embodiment of this invention. The train 10 has a motion in a direction represented on a pair of track rails 12. The train is at a distance L from the origin point P, P', which represents the location of a grade crossing, for example. The train motion occurs from left to right. The velocity V and the acceleration A factors are, therefore, represented as going from left to right on the drawing. The method of computing the time of arrival is set forth fully in the aforesaid U.S. Pat. No. 3,246,143.

A computer, in accordance with the aforesaid, includes an oscillator 16 which oscillates at a suitable frequency. The output of the oscillator 16 is applied to excite a power amplifier 22. A resistor 18 connects one side of the power amplifier to one of the rails at a point P'. The other side of the power amplifier 22 connects to the other rail P. The power amplifier 22, together with the resistor 18, comprises a constant current generator. This delivers an input to the track at substantially a constant current.

It should be appreciated that as the train 10 approaches the points P, P' on the track to which current from the constant current generator is applied, the impedance of the tracks looking toward the train from these points is continuously being diminished. Thus, the train comprises a short across tracks 12, which is moved toward the points P, P'. With current being maintained constant, the voltage at the points P, P' will continuously decrease to a minimum when the train reaches the points P, P'. Therefore, by measuring the voltage across the tracks 12, an indication is obtained of the distance of the train 10 from the points at which the voltage is impressed. The change, with respect to time of this voltage, can provide velocity information and a second derivative of this voltage provides information as to the acceleration of the train 10.

Accordingly, a narrow band-pass amplifier 26 centered at the frequency of the oscillator 16, which is connected to the same points of the tracks 12 as the constant current generator, receives a voltage representative of length of track L or distance between the train 10 and the points P, P'. This voltage is an alternating current which is modulated by the motion of the train 10 toward the points P, P'.

The output of the band-pass amplifier 26 is applied to a quadrature detector 28 which also has a reference input applied from the oscillator 16 through a phase shift network 30. The output of the quadrature detector 28 is applied to a summing amplifier 38. The output of the band-pass amplifier 26 is also coupled to an amplitude detector 32 which, in turn, has an output coupled to an inverting differentiating circuit 34. The amplitude detector 32 provides a DC voltage proportional to the impedance of the track 12. Circuit 34 provides the rate of change of that impedance. The output of the circuit 34 is coupled through an amplifier 36 to a summing amplifier 38. The summing amplifier 38 receives the time rate of change of the impedance derived distance voltage from the output of the differentiating circuit 34 which is equal to the speed of the train 10. The output of the summing amplifier 38 is connected to a high gain amplifier 40. The output of the high gain amplifier is applied to an amplitude comparator 42 wherein it is compared with a signal from the reference voltage source 44. The output of the amplitude comparator 42 is connected to a relay amplifier 46 which operates the warning relay when the signal applied into it has a sufficient magnitude.

An override circuit is also provided, and this includes an amplitude discriminator 52 which receives the output from the quadrature detector 28 and compares it to the output of a reference voltage source 54. The output of the amplitude discriminator 52 is connected to a relay amplifier 56 which drives a minimum distance override relay 58. The input to the differentiator circuit 34 and summing amplifier 38 are voltages proportional to the distance L between the train and the excitation points P and P'. When differentiated, this voltage

gives a voltage proportional to train speed. The output of the quadrature detector 28 is a voltage proportional to the reactance component across the track which is a measure of the distance to a train from points P and P'.

FIG. 2 illustrates the difference between the distance voltage derived from the reactance magnitude provided by the quadrature detector 28 and the distance voltage derived from the impedance magnitude provided by amplitude detector 32. The sum of distance voltage derived from the reactance magnitude and the time rate of change of the distance voltage derived from the impedance magnitude is provided by the summing amplifier 38.

When the ballast resistance is very high ($R_B = \infty$) the two distance voltages have the same slope. When the ballast resistance is decreased ($R_B = 1.5$ ohms, for example, lumped at the predictor) it can be readily seen that the slope of the impedance magnitude is much improved over the slope of the reactance magnitude, as shown in the two graphs in FIG. 2. Thus, the error in estimate of the arrival of a train by the predictor is also much improved. As stated in U.S. Pat. No. 3,246,143, the reactance portion of the input impedance is unaffected by a bad bond which results in a lumped resistance in the track circuit. Therefore, the reactance component voltage is more satisfactory for obtaining a value which is a function of train distance. However, as illustrated in FIG. 2, the reactance voltage vs. train distance for a low ballast track section approaches substantially zero slope at a first train distance which is less than the desired prediction distance. On the other hand, the impedance voltage vs. distance curve maintains a slope substantially greater than zero over a greater train distance. Therefore, the impedance voltage can be differentiated over train distance greater than the first distance. Thus, the utilization of the reactive component for measuring distance and the impedance component for measuring velocity provide a more accurate prediction of time of arrival over a greater length of track. The reason that the impedance magnitude provided by amplitude detector 32 is less affected by low ballast resistance than the reactance magnitude is apparent in the following example:

$$Z_{in} = R + jX$$

If we assume that $R = 0.5X$, which provides a high ballast resistance condition, then

$$Z_{in} = 1.12X < 63.4^\circ$$

If we assume a low ballast resistance condition ($R_B = 2X$) where the ballast resistance is in parallel with Z_{in} then

$$Z_{in} = 0.83X < 41.6^\circ$$

therefore, the impedance magnitude

$Z_{in} = (0.83/1.12)$ or a 26 percent reduction in its magnitude while the reactance magnitude

$$X_{in} = \frac{.83 \sin 41.6^\circ}{1.12 \sin 63.4^\circ}$$

or a 45 percent reduction in its magnitude for the same given low ballast condition.

Thus, there has been provided by the improvements set forth herein a time of arrival predictor computer which has a lower error as compared to the prior art system. The output, as provided by this predictor from summing amplifier 38, is sent through a high gain amplifier 40 and compared in a comparator 42 to a reference voltage provided by 44. If the sum of these voltages is above the reference voltage, then the relay amplifier 46 enables a relay 48, which, in turn, either sounds an alarm or lowers a crossing gate, or the like.

Having thus described but one preferred embodiment of this invention, what is claimed is:

1. In a system for deriving from railroad tracks of low ballast information for predicting the time required for arrival at a given location of a distant train which is moving on said track towards said location, comprising:

means for applying an AC signal of a constant current level on said track from said location;

means for deriving a first voltage proportional to the reactance component across said tracks said first voltage

having an output vs. train distance curve approaching substantially zero slope in the vicinity of a first train distance from said location;

means for deriving a second voltage proportional to the impedance component across said tracks having a time rate of change indicative of the speed of said train approaching said location, said second voltage having an output vs. train distance curve of a slope substantially greater than zero over a train distance greater than said first train distance;

said first voltage being indicative of the distance of said train from said location over said greater train distance and being substantially free from the effect of lumped resistance in said track;

means for differentiating said second voltage to obtain a voltage representative of the instantaneous speed of said train at any train position over said greater train distance; and

means for combining said first voltage and said differentiated voltage to provide a third voltage which is a function of the time required for said train to arrive at said given location from any train position over said greater train distance.

2. The system as defined in claim 1 and further comprising means for utilizing said third voltage for operating a warning device at said location.

3. The system as defined in claim 1 wherein said means for deriving said first voltage is a quadrature detector.

4. The system as defined in claim 1 wherein said means for deriving said second voltage is an amplitude detector.

5. The system as defined in claim 1 wherein said means for differentiating is an operational amplifier differentiator.

6. The system as defined in claim 1 and further comprising: means for providing a reference voltage; and comparator means responsive to said reference voltage and said third voltage provided by said combining means, said comparator means being adapted to provide an output when said third voltage exceeds said reference voltage.

7. The system as defined in claim 6 and further comprising means for utilizing the output voltage of said comparator means for operating a warning device at said location.

8. In a system for predicting the time of arrival of a train on a track comprising:

a source of AC signals at a constant current level, said source being coupled across said tracks at a selected location;

a quadrature detector being coupled to receive signals from said track at said selected location, said quadrature detector being adapted to provide a first output voltage proportional to the reactance component across said track and having an output vs. train distance curve approaching substantially zero slope in the vicinity of a first train distance from said location;

an amplitude detector being coupled to receive signals from said track at said selected location and to provide a second output voltage proportional to the impedance component across said tracks, said second output voltage having an output vs. train distance curve of a slope substantially greater than zero over a train distance greater than said first train distance, said first output voltage being indicative of the distance of said train from said selected location over said greater train distance and being substantially free from the effect of resistance variations in said tracks;

a differentiator circuit being coupled to said amplitude detector, and being responsive to said second output voltage of said amplitude detector for providing a third output voltage indicative of the instantaneous speed of said train at any position over said greater train distance, and

a summing amplifier being coupled to said amplitude detector and to said differentiator circuit and being responsive to said third output voltage of said differentiator circuit and said first output voltage of said quadrature detector,

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said summing amplifier being adapted to provide a fourth output voltage which is a function of the time required for said train to arrive at said location from any train position over said greater train distance.

9. The system as defined in claim 8 and further comprising means coupled to said summing amplifier and to a warning device for utilizing said fourth output voltage of said summing amplifier for operating a warning device at said location.

10. The system as defined in claim 8 and further comprising: a reference voltage source adapted to provide an output voltage of a predetermined level; and an amplitude comparator being coupled to said summing amplifier and said reference voltage source and being responsive to said fourth output voltage of the said summing amplifier and to the output voltage of said reference voltage source and being adapted to provide an output signal when the voltage provided by said summing

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amplifier exceeds the voltage provided by said reference voltage source.

11. The system as defined in claim 8 wherein said source of AC signals includes:

an oscillator adapted to provide an output signal at a predetermined frequency; and a power amplifier coupled between said oscillator and said tracks.

12. The system as defined in claim 11 and further including a band-pass amplifier coupled between said track and said quadrature detector and said amplitude detector.

13. The system as defined in claim 12 and further comprising means coupled to said amplitude comparator for utilizing the output voltage of said amplitude comparator for operating a warning device on said location.

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