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Geiger

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[54] **RAILWAY SIGNAL SYSTEM WITH SPEED DETERMINED MOVEMENT DETECTOR**

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[52] **U.S. Cl.** .... **246/128,** 246/34 CT, 246/121

[51] **Int. Cl.** **B61l 23/04**

[58] **Field of Search**...... 246/125, 128, 130 R, 34 R, 246/34 CT, 40, 121

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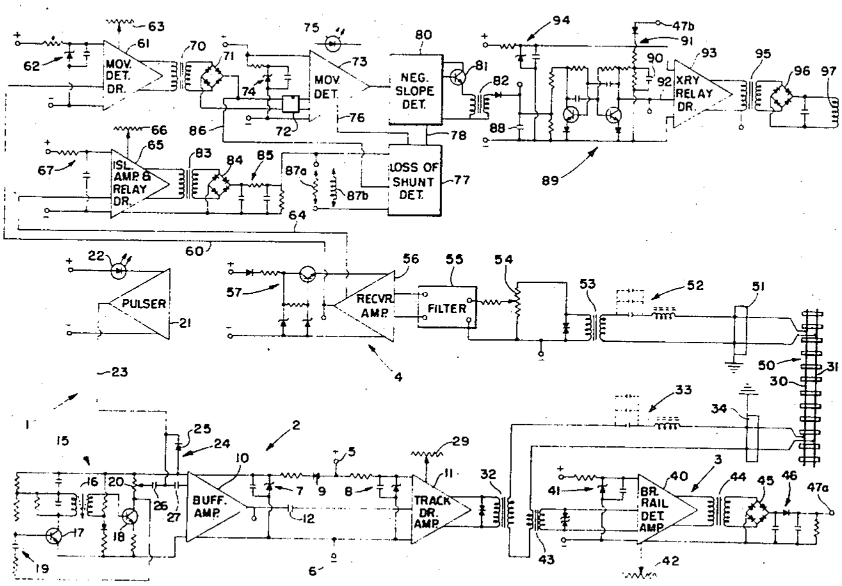
[57] **ABSTRACT**

A railway signal system for detecting a train approaching a railway crossing or track section transmits in the track a periodically interrupted carrier wave signal the amplitude of which is attenuated by an approaching train effecting a variable shunt across the track. A receiver converts the received signal to a DC level with an impressed AC pulse for application through a DC blocking differentiating capacitor to an amplifier, which produces an AC output used to effect pick up of a signal relay unless an approaching train is detected. The system is self-checking and fail-safe using an astable multivibrator to control power supplied to the relay driver, and the system provides for increased sensitivity with increased train proximity. Additional circuits including a broken rail detector power monitor, island amplifier, loss of shunt detector, and disabling circuit for the latter provide added capability for the system.

34 Claims, 5 Drawing Figures



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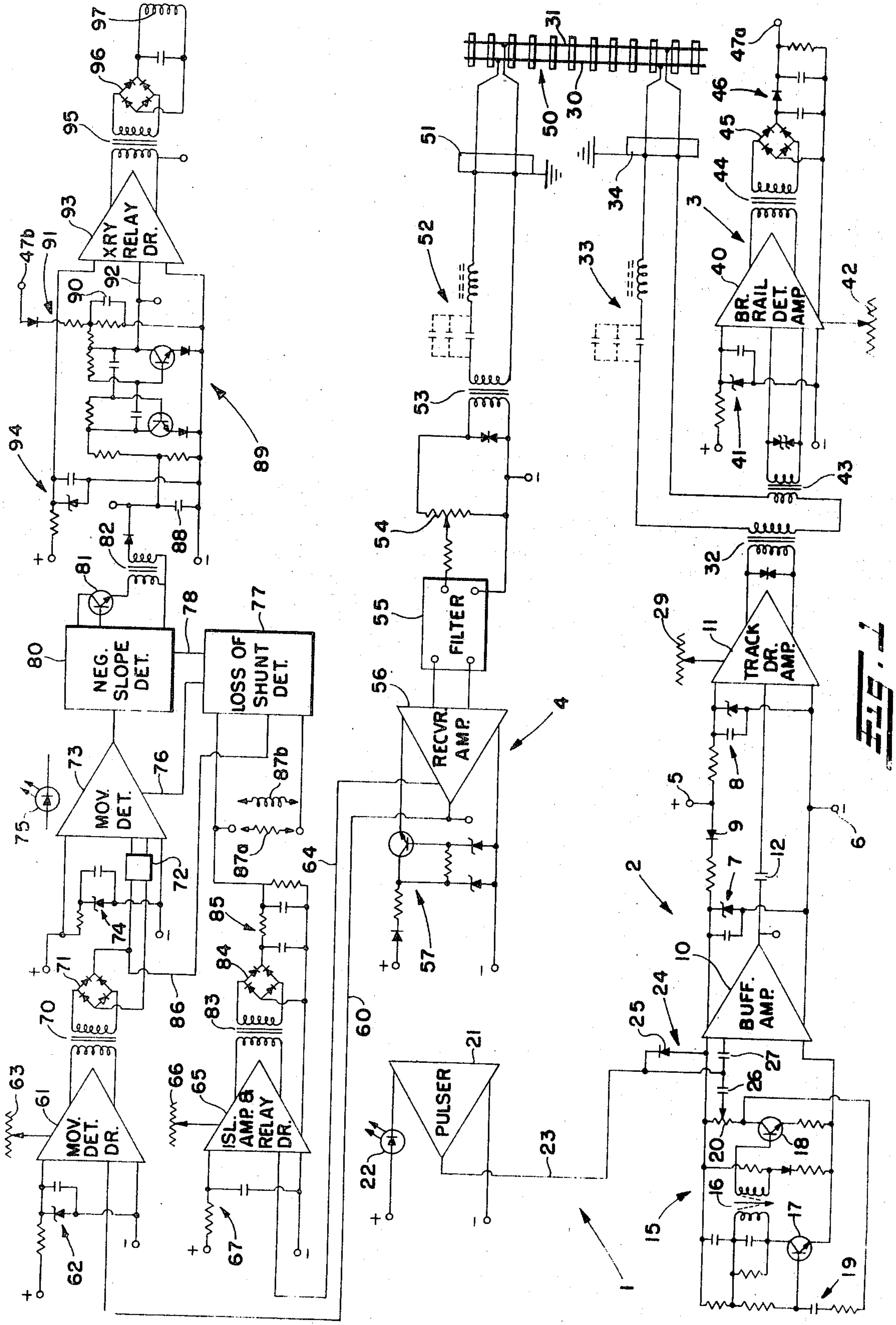

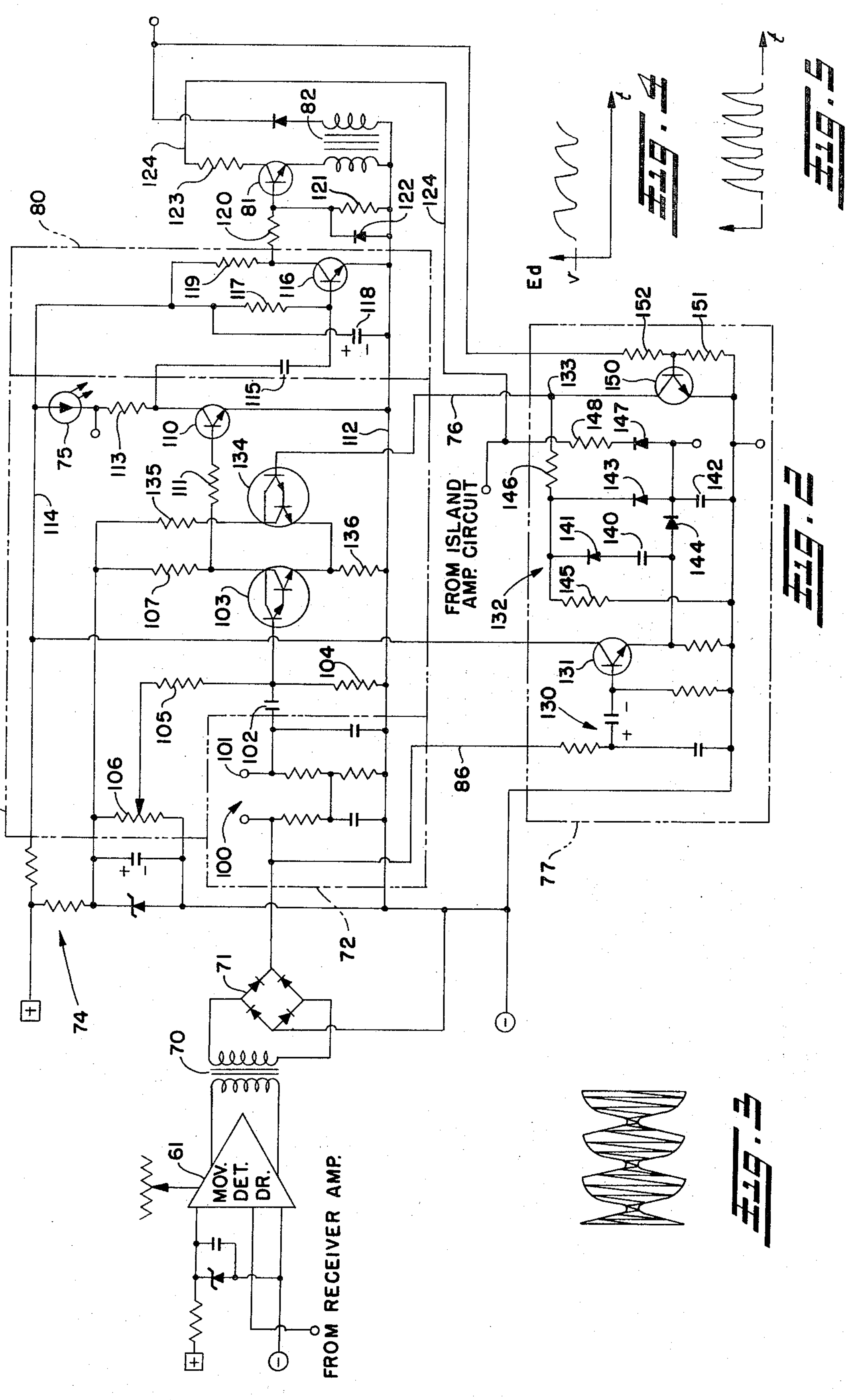
FROM ISLAND AMP. CIRCUIT
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MOV. DET. DR.
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RAILWAY SIGNAL SYSTEM WITH SPEED DETERMINED MOVEMENT DETECTOR

BACKGROUND OF THE INVENTION

This invention relates to a fail-safe railway signal system for detecting an approaching train and particularly to such a system having increased sensitivity with increased train proximity.

Prior art railway signal systems for detecting approaching trains have used various techniques to compensate for train approach and speed to achieve minimum down time during which a signal device is activated to provide an indication, for example, at a grade crossing or at another track section, when a train is approaching, existing in, or leaving a railway crossing area or a specific track section. The signal device may be coupled to provide a signal to a control system, for example, a computer, for automated train control.

Several already existing signal systems for detecting trains require long islands defined by the track connection points of the transmitter and receiver in order to provide adequate time for train detection. Other prior art devices are sensitive to train approach speed, but do not vary their sensitivity as the approach distance varies; and if a train were to slow gradually as it approached an island, the train would be nearly in the island before being detected.

Still further existing systems use signals of varying frequency with each frequency matched to the distance and time requirements to achieve a constant working time throughout the approach to the island, and one disadvantage of such systems is that there often is a speed below which detection will not occur.

A disadvantage to the prior art railway signal systems is that without sensitivity changes with respect to distance, a train consisting of only a single car and engine may suddenly accelerate after approach time prediction to put the engine almost in the crossing before gate actuation. A further disadvantage is the relatively long ring-by time, during which the presence of the train is indicated even when the train is actually leaving the island.

Some train detection systems use DC amplifiers to produce output signals indicative of train detection, and in such systems it is necessary to maintain a constant check on the DC portion of the amplifier, such as, for example, by the use of a checking pulse introduced at regular periods, for example, every five or six seconds. Such devices result in a loss of authenticity of the amplifier for each five or six second period, and train detection will not be credible until after a self-check pulse is initiated; but the five or six second delay in assuring train detection coupled together with inherent relay and other similar delays can be critical when the train is approaching at high speed.

SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the invention to provide a fail-safe railway signal system for indicating the presence of a train while assuring minimum down time of the railway signal relay.

Another object of the invention is to provide a railway signal system in which sensitivity increases as the train approaches.

An additional object of the invention is to provide a fail-safe railway signal system with maximum integrity, such system recognizing its own signal, being self-checking, and having low signal and low voltage monitoring capability.

A further object of the invention is to provide a railway signal system having broken rail detection, island control, and motion detection functions.

Still another object of the invention is to provide a railway signal system with minimum ring-by.

Still an additional object of the invention is to provide in a railway signal system loss of shunt protection which is disabled by a leaving train.

Still a further object of the invention is to provide a constant checking of track integrity and self-compensation for low ballast conditions in a railway signal system that indicates a train approaching or existing in an island.

Yet another object of the invention is to provide an amplifier with variable sensitivity.

Yet an additional object of the invention is to provide a fail-safe circuit for producing an AC output signal upon occurrence of plural DC input signals.

Yet a further object of the invention is to detect a slow or fast moving train approaching a railway crossing or a track section without requiring an extended island.

Even another object of the invention is to provide a railway signal system having continuous rapid self-checking capability to provide a credible indication of an approaching train.

These and other objects and advantages are realized in the instant invention which comprises a transmitter for transmitting an interrupted carrier signal in a track, a broken rail detection circuit for monitoring the track signal, a receiver for receiving and amplifying the track signal, a movement detector for determining changes in such signal indicative of an approaching train, a negative slope detector for providing noise immunity, signal regulation, and minimum ring-by, an island amplifier for detecting a train in the island, a loss of shunt detector for disabling the movement detector upon occurrence of a temporary loss of shunt and a circuit for disabling the latter upon occurrence of a leaving train, a multivibrator for providing an AC output in response to respective DC inputs, and a relay driver for providing a signal to energize or to pick up a relay when no trains are approaching or present and the entire railway signal system is properly operating and to drop or to release the relay when train motion or presence is detected or when the system malfunctions.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but several of the various ways in which the principals of the invention may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the annexed drawings:

FIG. 1 is a schematic electric circuit diagram partially in block form of a railway signal system in accordance with the invention;

FIG. 2 is a schematic electric circuit diagram of the movement detector and driver therefor, negative slope detector, and loss of shunt detector of the railway signal system;

FIG. 3 is a graph of an interrupted carrier wave signal produced in the transmitter of the railway signal system;

FIG. 4 is a graph of a DC signal with an impressed AC pulse applied to the movement detector; and

FIG. 5 is a graph of an AC signal having a negatively sloped portion applied to the negative slope detector.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The railway signal system has a transmitter and a receiver connected to a section of railroad track, for example, at a railroad grade crossing or on a specific track section in a block signal arrangement, with an island being defined between such connections. In the preferred embodiment a beginning of approach shunt is connected across the railroad tracks at a distance in either or both directions sufficient to provide adequate time for indicating a rapidly approaching train. The system compensates automatically for varying ballast conditions, which often change with temperature, moisture, and normal track wear, is self-checking at a rate of approximately five times per second, is insensitive to noise, and is sufficiently sensitive to detect motion as slow as several feet per second on a close approach.

Referring now more specifically to the drawings wherein like reference numerals refer to like elements in the several figures, the railway signal system generally indicated at **1** includes a transmitter **2**, a broken rail detector **3** and a receiver **4**. The transmitter **2** receives power at the input terminals **5, 6** and has a plural resistor, capacitor, and zener diode voltage regulation circuits **7, 8** and an isolating diode **9** connected between a buffer amplifier **10** and a track driver amplifier **11** with the output from the former being connected through a coupling capacitor **12** to the input to the latter.

A frequency or tone generator circuit generally indicated at **15** includes a conventional reed oscillator **16** having an energization circuit including the transistor **17** and a feedback circuit including the transistor **18** which is connected through an RC network **19** to the base of the former transistor. Additional resistors and capacitors are provided to effect resonant vibration in the reed oscillator **16**, thereby producing at the potentiometer **20** a carrier wave having a frequency depending on the oscillator and an amplitude depending on the setting of such potentiometer. A more detailed description of the tone generator circuit **15** may be found in my co-pending patent application Ser. No. 105,509, filed Jan. 11, 1971, and assigned to the same assignee as the instant application.

A pulser **21**, having a positive input connected through a light emitting diode **22** and a negative input, provides a pulse signal on the line **23** to a diode gating circuit generally indicated at **24** including a diode **25** and capacitors **26, 27**. The pulser circuit **21** may include, for example, a well known unijunction transistor oscillator circuit which produces a periodic pulse signal on the line **23** to effect interruption of the carrier wave, and a flashing of the diode **22** indicates proper pulser operation. The interrupted carrier wave is shown graphically in FIG. **3** and is provided through the capacitor **27** to the buffer amplifier **10**, which may include one or more stages for shaping such signal. The track driver amplifier **11** including a conventional potentiometer off-set circuit **29** provides the resulting interrupted carrier signal to the railroad tracks **30, 31** through a coupling transformer **32**, an impedance matching network **33**, and a surge protection apparatus **34**, such as, for example, a lightning arrester arrangement.

The broken rail detector **3** includes a broken rail detector amplifier **40** having a power input taken across input terminals and a resistor, capacitor, and zener diode voltage regulating network **41** with a conventional potentiometer off-set circuit **42**. A coupling transformer **43** provides to the broken rail detector amplifier **40** an input signal proportional to the power level of the interrupted carrier wave signal applied to the tracks **30, 31**, and the output from such amplifier is coupled through a transformer **44**, full wave rectifier **45**, and filter network **46** to an output terminal **47*a***. Thus, a DC signal representative of the power applied to the track is produced at terminal **47*a*** the purpose of which will be described in detail below. The broken rail detector amplifier **40** may include, for example, one or more buffer stages and a threshhold device, such as a schmitt trigger circuit, whereby the output signal from the broken rail detector amplifier is an AC signal having an amplitude, phase, and frequency characteristic indicative of the power applied to the track by the transmitter **2**.

The receiver **4** is connected to the tracks **30, 31**, defining an island **50** between such connection and the connection of the transmitter **2** to the tracks, and receives a signal therefrom through the surge protection apparatus **51**, impedance matching network **52**, coupling transformer **53**, potentiometer **54**, and highy selective filter **55**. The output from the filter **55** is applied to the receiver amplifier **56**, which receives a power input across appropriate terminals and a zener diode and transistor voltage regulation circuit **57**. A first output from the receiver amplifier **56** is connected by line **60** to the movement detector driver **61**, which has power input terminals and a voltage regulation circuit **62** with a conventional potentiometer off-set circuit **63**; and a second output is connected by line **64** to the island amplifier and relay driver **65**, which has an off-set circuit **66** and power input across an RC network **67**.

The movement detector driver **61** is coupled through a transformer **70** and a full wave rectifier **71** to the input of the wave shaping circuit **72**, the normal output signal E_d from which is a DC level v with an AC pulse impressed thereon as shown in FIG. **4**. The wave shaping circuit **72** provides an input to the movement detector **73**, which has a power connection at the terminals and a voltage regulation circuit **74**. A light emitting diode **75** connected in the movement detector emits light pulses as the latter produces an AC output indicating proper operation when no train is detected. Another input to the movement detector is made by the line **76** coupled to the loss of shunt detector **77** to be described in more detail below.

The movement detector **73** outputs, having a normal signal wave form as shown in FIG. **5**, is coupled to a negative slope detector **80**, which is responsive only to the negatively sloped portion of such signal and provides for noise immunity in the railway signal system **1** while minimizing ring-by when a train leaves the island **50**. The negative slope detector **80** has an additional input from the island amplifier and relay driver **65** by way of the loss of shunt detector **77**, which is shown in more detail in FIG. **2**; and the power transistor **81** and pulse transformer **82** provide an output from the negative slope detector.

The island amplifier circuit including an island amplifier and relay driver **65** is coupled to a coupling transformer **83**, full wave rectifier **84**, and filter **85** and to the loss of shunt detector **77**, which has another input taken on the line **86** from the full wave rectifier **71**. The island amplifier circuit and loss of shunt detector provide a power input to the negative slope detector **80** on the line **78**, whereby, if no output is produced by the former, the latter is incapable of producing an output. A resistor **87***a* and a relay coil **87***b* of comparable impedance are shown for optional connection across the island amplifier and relay driver output and the loss of shunt detector input.

The secondary of the coupling transformer **82** is connected to a capacitor **88**, which is coupled as one DC input to a conventional astable multivibrator **89**; and the other DC input to the astable multivibrator is taken across the capacitor **90** connected for charging through the resistor and diode network **91** by a signal at the terminal **47***b*, which is coupled to terminal **47***a* at the broken rail detector output. The astable multivibrator **89** output is supplied on the line **92** to the railroad signal relay driver **93** having a power input across the terminals and voltage regulation circuit **94**, and the output from the railroad signal relay driver is connected to a transformer **95**. A full wave rectifier **96** supplies an energization signal from such transformer to the railroad signal relay **97** to pick up the same. Of course, when no signal is supplied to the relay **97** it is dropped or released indicating detection by the railway signal system **1** of an approaching train, the presence of a train in the island, or a malfunction in the railway signal system.

In the preferred embodiment the receiver amplifier **56**, movement detector driver **61**, island amplifier and relay driver **65**, and railway signal relay driver **93** are conventional amplifier circuits having one or more stages of solid state design for accuracy, efficiency, durability, and longevity. In order to achieve an energization signal to pick up the relay **97** it is essential that both halves of the astable multivibrator **89** be energized which is achieved only when the signal transmitted in the tracks is of a sufficient level and the movement detector **73** and negative slope detector **80** produce respective AC outputs to provide a signal through the pulse transformer **82** to charge capacitor **88**.

In operation of the railway signal system **1** the transmitter **2** transmits the interrupted carrier wave in the tracks **30, 31**, and the broken rail detector **3** produces at the terminal **47***a* a DC voltage representative of the power delivered to the tracks by sensing the current flow. The receiver **4**, amplifies the filtered signal from the tracks and applies an AC signal on the line **60** to the movement detector driver **61** for further amplification with the output from the latter being transformed, rectified, filtered, and provided to the wave shaping circuit **72** to produce the signal wave form illustrated in FIG. **4**.

Each time the pulsed signal applied to the movement detector **73** goes negative, simulated movement is detected, and as the pulse again recovers in the positive direction movement detection ceases. The light emitting diode **75** produces light flashes indicative of proper functioning of the railway signal system when no train

is detected and the diode **22** indicates the pulser **21** is operating. As long as railway signal system **1** is operative and the power of the track signal is sufficient, the capacitors **88, 90** drive the astable multivibrator **89** to produce an AC signal, which is amplified in the railway signal relay drive **93** to pick up the relay **97**.

If a broken rail condition or an unusual ballast condition occurs on the tracks **30, 31** to cause the current applied to the tracks by the transmitter **2** to drop below a prescribed minimum, the voltage level at the terminal **47***a* in the broken rail detector **3** drops and is inadequate to charge the capacitor **90**, and the relay **97** is dropped. The railway system **1** is fail-safe. If the pulser **21**, tone generator circuit **15**, or any other part of the transmitter **2** malfunctions, then no AC signal will be coupled through the receiver amplifier **56**, movement detector driver **61**, movement detector **73**, and negative slope detector **80** to the transformer **82**; and the capacitor **88** will not charge. Thus, the astable multivibrator **89** will not run, and the relay **97** will drop indicating a circuit malfunction.

When a train crosses one of the beginning of approach shunts in a direction toward the island **50**, the voltage level of the signal in the tracks begins to decrease, although the current increases since the train as a travelling shunt reduces the effective ballast seen by the transmitter **2**, and the E_d signal level v as well as the pulse impressed thereon decreases proportionately. A train in the island **50** shunts the entire track signal, and the input to the receiver **4** is effectively zero. In the latter case the island amplifier and relay driver **65** produces a zero or DC output and no signal is produced in the transformer **83** secondary, thus releasing the relay coil **87***b* if used, which may be coupled to effect firm lock out of the railway signal, and/or preventing conduction in the negative slope detector **80**.

Referring now to FIG. **2** the wave shaping circuit **72**, movement detector **73**, loss of shunt detector **77**, and negative slope detector **80** are shown in detail. The movement detector driver **61** is connected through the transformer **70** and full wave rectifier **71** to provide a signal to the wave shaping circuit **72** which includes an RC network **100** for normally producing at the node or terminal **101** a signal having a wave shape as indicated in FIG. **4**. A DC blocking differentiating capacitor **102** is coupled between the wave circuit **72** and a darlington pair amplifier **103** base bias circuit, which includes resistors **104, 105** and a potentiometer **106** for determining the sensitivity of the movement detector **73**, such circuit being coupled across the voltage regulation circuit **74**. The effective gain over the operational range of the amplifier **103** is variable, determined by the amplitude of the DC part of the E_d signal normally blocked by the capacitor **102** and the proportional pulse thereof. The collector output of the amplifier **103** is connected to a resistor **107** and to the base of a transistor **110** through a voltage dropping resistor **111**, the emitter of the latter transistor being connected to the negative line **112** and the collector thereof coupled through a resistor **113** and the light emitting diode **75** to the positive line **114** serving as the output of the movement detector **73**.

The negative slope detector **80** has a control input connected through a coupling capacitor **115** to the movement detector output. A transistor **116** forming the active element in the negative slope detector **80** is connected at its base to the coupling capacitor **115** and through a resistor 117 to the positive line 114, normally maintaining the transistor 116 in saturation, and a capacitor 118 is connected between the positive line 114 and the negative line 112. The emitter of transistor 116 is connected to the negative line 112, and the collector is connected through a resistor 119 to the positive line. The output from the negative slope detector is connected through a resistor 120 to the base of the transistor 81 which controls current flowing to the primary winding of the pulse transformer 82, and a bias resistor 121 and clamping diode 122 connect the base of the transistor 81 to the negative line 112. Power is supplied to the collector of the transistor 81 through the resistor 123 and the line 124 connected to the island amplifier circuit, whereby when no train is in the island the latter produces a signal at the output of the filter 85 (FIG. 1) to provide such power.

The loss of shunt detector 77 receives an input signal on the line 86 through an RC network 130 coupled to control a transistor 131, which is connected between the positive line 114 and the timing circuit 132. The output 133 from the timing circuit 132 is connected by the line 76 to the base of a darlington pair amplifier 134, which is connected between the resistor 135 and the emitter of the amplifier 103. A resistor 136 connects the emitters of the amplifiers 103, 134 to the negative line 112. Thus, a control signal to the base of the amplifier 134 causes the emitters of both amplifiers to go positive to assure cut-off of the amplifier 103.

The timing circuit 132 includes a first capacitor 140 and diode 141 combination and a second capacitor 142 and diode 143 combination with an isolating diode 144 connected between switch combinations. A large resistor 145 is connected between the negative line and the cathodes of the diodes 141, 143, and a resistor 146 connects such cathodes to the output 133 of the timing circuit to the island amplifier circuit, whereby when the latter is off, for example, when a train is in the island, any potential accumulated in the timing circuit 132 is discharged through the diode 147, resistor 148 and the island amplifier circuit.

A disabling circuit for the timing circuit 132 in the loss of shunt detector 77 includes a transistor 150, coupled at its base by a resistor 151 to the negative line and by resistor 152 to the secondary winding of the transformer 82. Thus, whenever a signal is induced in the secondary winding of the transformer 82, the transistor 150 will conduct to discharge any potential accumulated in the timing circuit 132 of the loss of shunt detector 77 and disabling the same from any effect on the amplifier 134 or the amplifier 103. 0

Operation of the wave shaping circuit 72, movement detector 73, loss of shunt detector 77, and negative slope detector 80 is described in detail below. When the railway signal system 1 has been connected to the track and adjusted, the track signal transmitted by the transmitter 2 is amplified in the receiver amplifier 56 and coupled by the line 60 to the movement detector driver 61, which effects the production of an unfiltered rectified signal at the output of the full wave rectifier 71, such signal being coupled to the wave shaping circuit 72 and by the line 86 to the loss of shunt detector 77. The wave shaping circuit 72 operates on the unfiltered rectified signal and produces at the node 101 the E_d signal shown in FIG. 4, the transistor 131 in the loss of shunt detector being maintained non-conducting at this time. In one embodiment when no train is within the beginning of approach shunts, the E_d signal has a 40 volt DC level v and a proportional 2.5 volt peak to peak pulse. When a train is at a certain location between one of the beginning of approach shunts and the island 50 effecting a shunt across the tracks and reducing the total track ballast seen by the transmitter 2 and receiver circuit 4, the E_d signal is reduced, for example, to a 20 volt DC level and a 1.25 volt pulse.

The differentiating capacitor 102 normally blocks the DC part of the E_d signal and provides through the pulses impressed on such DC part a constant self-checking of the railway signal system, for example at the rate of approximately five times per second. The differentiating capacitor 102 should be considered in a zero state or charged state, i.e. it charges back to zero state condition at a constant charging rate. Each time an E_d pulse goes negative, simulated motion is detected by the movement detector 77 and the amplifier 103 is cut off; and as the pulse recovers in the positive direction, the differentiating capacitor 102 is recharged and the amplifier conducts. When a continued slow drop of the DC part of the E_d signal occurs, for example, due to a slowly approaching train far from the island 50, the differentiating capacitor 102 maintains itself only a slight amount away from the zero state, drawing very little current from its recharging circuit, the base biasing network 104, 105, 106 of the amplifier 103. Thus, the E_d pulses will effect an AC output from the amplifier 103.

A train on the track inside a beginning of approach shunt travelling in a direction toward the island is a travelling shunt that reduces the track signal and, of course, the E_d signal at the node 101, such signal reductions being non-linear with respect to distance from the island due to the non-linearity in the approach of the accumulated track ballast resistance. It t to distance from the island due to the non-linearity in the approach of the accumulated track ballast resistance. It has been found that signals having frequencies of from 20 to 65 Hz exhibit some semblance of linearity of attenuation over a given length of rail, whereas higher frequencies of from 300 to 3,000 Hz are substantially non-linear throughout the entire approach.

The approaching train causes the E_d signal to drop, and in one embodiment when the DC part of the E_d signal is at 40 volts with a 2.5 volt pulse, a drop of E_d signal in excess of approximately 0.4 volt per second will bias the amplifier 103 in a negative direction preventing it from passing the pulses through the succeeding stages allowing the relay 97 (FIG. 1) to drop. Similarly, when the E_d signal is at 20 volts with a 1.25 volt pulse, a 0.2 volt per second drop in the DC part will maintain the amplifier 103 cut-off. Once cut-off by an appropriate E_d signal drop rate, the amplifier 103 is maintained cut-off due to such E_d drop since the differentiating capacitor 102 cannot recharge instantaneously and the base of the amplifier 103 is held negative due to the travelling shunt effect of the approaching train.

The railway signal system 1 becomes increasingly more sensitive to E_d drop as the train approaches the island because the reduced E_d pulses require less of an E_d signal drop to bias the amplifier 103 toward cut-off. Since the track ballast resistance is non-linear, a train 3,000 feet from the island must effect reduction of the E_d signal at a rate of approximately 0.4 volt per second, whereas a train several hundred feet from the island need only effect reduction of the E_d signal at a rate of, for example, 0.011 of a volt per second.

The AC output produced by the amplifier **103** when no train is detected is coupled through the transistor **110** to provide an input signal to the negative slope detector **80,** such input signal being illustrated in FIG. **5.** Each time the transistor **110** conducts the light emitting diode emits light to indicate that the movement detector **73** is operating properly.

The transistor **116** in the negative slope detector **80** is maintained in saturation by the potential applied to the base through the resistor **117.** The transistor **116** is cut-off, however, each time the signal illustrated in FIG. **5** reaches its negatively sloped portion. Therefore, the output from the negative slope detector **80** is a square wave applied to the input of the transistor **81,** which effects production of an AC signal in the transformer **82** coupled at the terminal **160** to the multivibrator **89** (FIG. **1**) and to the base of the disabling transistor **150** in the loss of shunt detector **77.**

Since the negative slope detector **80** is operated alternately at saturation and at cut-off, it is relatively immune to noise and provides circuit isolation and uniform regulation of signals applied to the multivibrator **89.** Also, the negative slope detector **80** reduces ring-by time as the train leaves the island because it is operated in saturation and cut-off, the AC output therefrom being a strong broad square wave signal which assures energization of the transformer **82.**

The transistor **131** in the loss of shunt detector **77** is normally maintained cut-off due to the blocking effect of the capacitors in the RC network **130.** However, when an approaching train has caused the E_d signal to drop to a point where motion has been detected and the transistor **150** in the disabling circuit is maintained cut-off, a rapid increase in E_d voltage, due, for example, to the train running over a rusty rail, causes the transistor **131** to conduct charging the capacitors **140, 142** in the timing circuit **132.** The capacitor **140** rapidly discharges through the diode **141** and resistor **146** to effect conduction in the amplifier **134,** which raises the potential at the output of the amplifier **103** maintaining the latter cut-off. When the E_d signal has dropped again as the approaching train passes the rusty rail, the transistor **131** is cut-off, and the capacitor **142** discharges through the resistor **146** to maintain conduction in the amplifier **144** until the charge on the capacitor **142** has been dissipated. When the approaching train has entered the island, any charge retained on the capacitor **142** will be discharged by the diode **147** and the resistor **148** through the island amplifier circuit.

A train leaving the island causes a relatively slow increase in E_d voltage although the pulses thereof are quickly recognized by the amplifier **103.** The transistor **116** in the negative slope detector **80,** which was formerly operating only in saturation, then begins to be periodically cut-off, effecting production of an AC signal at the terminal **160** to power the multivibrator **89** and to effect conduction in the transistor **150** in the disabling circuit of the loss of shunt detector **77.** Conduction of the transistor **150** causes a rapid discharge of the capacitors **140, 142** and assures that any conduction by the transistor **131** will not effect operation of the amplifier **134.**

It will now be appreciated that the railway signal system operates in a fail-safe mode to provide indications of a train approaching or existing in an island or of a defect in the system itself. The system also has variable sensitivity, is constantly self-checking, and continuously monitors track conditions.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track comprising a transmitter and a receiver; said transmitter including means for producing an AC signal, means coupling said means for producing to said track for transmitting said AC signal in said track, means for monitoring the power level of said AC signal; and said receiver including receiver means coupled to said track for receiving said AC signal, said receiver means including means for detecting said AC signal to effect production of said output signal in response to changes in said AC signal occurring upon the approach of a train, said means for detecting including means for responding to changes in said AC signal effected by an approaching train located beyond the island defined between connections of said means for transmitting and said receiver means to said track; and said means for monitoring being also coupled to said receiver means and including means for causing at least a portion of said receiver means to produce said output signal when the power level of said AC signal coupled to said track drops below a minimum level.

2. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track as set forth in claim **1,** wherein said means for producing comprises tone generator means for producing an interrupted carrier signal as said AC signal.

3. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track as set forth in claim **2,** wherein said means for producing further comprises oscillator means coupled to said tone generator means for effecting interruption of said carrier signal.

4. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track as set forth in claim **3,** wherein said means for producing further comprises switching diode means and capacitor means coupled to said oscillator means for interrupting said carrier signal.

5. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track as set forth in claim **1,** wherein said means for coupling comprises impedance matching circuit means for matching the output impedance of said means for producing to the input impedance of the track to which the latter is coupled, said impedance matching circuit means including a coupling transformer.

6. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track as set forth in claim **1,** wherein said means for monitoring comprises means for producing a voltage output signal in response to said AC signal current produced in said track by said means for producing.

7. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track as set forth in claim **1,** wherein said receiver means comprises highly sensitive filter means for passing a signal having the frequency of said AC signal, and amplifier means coupled to said filter means for amplifying the output thereof.

8. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track as set forth in claim **1,** wherein said receiver means comprises amplifier means having a variable effect gain over the major extent of the operational range thereof, the magnitude of such effective gain being determined by the characteristics of a received input signal.

9. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track as set forth in claim **8,** wherein said receiver means further comprises wave shaping circuit means for producing from said received AC signal an output signal having a DC signal component and a proportional AC pulse component impressed thereon, and capacitor means for normally blocking said DC signal component from said amplifier means and for normally passing said AC pulse component to said amplifier means, whereby upon receipt of said AC pulse component said amplifier means produces an AC output signal and upon decrease of said DC signal component at a rate greater than the rate of increase of said AC pulse said amplifier means produces a DC output signal.

10. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track as set forth in claim **9,** further comprising negative slope detector means coupled to said amplifier means for producing an AC output signal when a portion of the amplifier means output signal has a negatively sloped portion.

11. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track as set forth in claim **1,** further comprising means coupled to said receiver means and responsive to the presence of a train in at least a portion of said island for effecting production of said output signal.

12. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track comprising means for producing an AC signal; means coupling said means for producing to said track for transmitting said AC signal in said track; means for monitoring the power level of said AC signal; receiver means coupled to said track for receiving said AC signal, said receiver means including means for detecting said AC signal to effect production of said output signal in response to changes in said AC signal occurring upon the approach of a train; and said means for monitoring comprising means for causing at least a portion of said means for receiving to produce said output signal when the power level of said AC signal coupled to said track drops below a minimum level, including means for producing a voltage output signal in response to the AC signal current produced in said track by said means for producing an AC signal, said means for producing a voltage output signal comprising amplifier means for amplifying a signal proportional to the AC signal current produced in said track, and trigger circuit means coupled to said amplifier means for producing output pulses having a duration proportional to the output from said amplifier means.

13. A railway signal system for producing an output signal indicative of the occurrence of an approaching train in a track as set forth in claim **12,** wherein said means for monitoring further comprises rectifier means coupled to said trigger circuit means for producing a DC output signal proportional to the duration of said pulses.

14. A railway signal system for producing an output signal indicative of the occurrence of an approaching train on a track comprising means for producing an AC signal, means coupling said means for producing to said track for transmitting said AC signal in said track, means for monitoring the power level of said AC signal, receiver means coupled to said track for receiving said AC signal to effect production of said output signal in response to changes in said AC signal occurring upon the approach of a train, said means for monitoring including means for causing at least a portion of said means for receiving to produce said output signal when the power level of said AC signal coupled to said track drops below a minimum level, and a utilization circuit including astable multivibrator means having first and second input circuits providing separate DC power signals therefor, one of said input circuits being responsive to the power level of said AC signal coupled to said track and the other one of said input circuits being responsive to receipt of an AC output signal from said means for receiving.

15. A railway signal apparatus for detecting a train approaching a location on a railroad track comprising means for producing a detectable signal along such track such that a train approaching such location causes a change in the level of such detectable signal, means for receiving said detectable signal for sensing changes in the level of such detectable signal and producing a first output when no changes occur and a second output when changes occur in a given direction from a first level, said second output being indicative of an approaching train, means for preventing said means for receiving from changing to said first output when said means for receiving is producing said second output and said detectable signal temporarily changes toward said first level, and means for disabling said means for preventing when said means for receiving is producing said first output whereby upon occurrence of a train leaving such location on such railroad track said means for disabling is ineffective.

16. A railway signal apparatus for detecting an approaching train as set forth in claim **15,** wherein said means for producing comprises tone generator means for producing an interrupted AC carrier signal.

17. A railway signal apparatus for detecting an approaching train as set forth in claim **16,** wherein said means for producing further comprises oscillator means for interrupting said carrier signal.

18. Railway signal apparatus for detecting an approaching train as set forth in claim **15,** wherein said means for receiving comprises means sensitive to the rate at which said detectable signal changes in said given direction including wave shaping means for producing in response to receipt of said detectable signal a DC signal with a proportional AC pulse impressed thereon.

19. Railway signal apparatus for detecting an approaching train as set forth in claim **18,** further comprising an amplifier having an input and an output and capacitor means for coupling said amplifier input to said wave shaping means, whereby said capacitor means normally blocks said DC signal from said amplifier input and normally passes said AC pulse to said amplifier input.

20. Railway signal apparatus for detecting an approaching train as set forth in claim 19, wherein said means for preventing comprises further amplifier means having an input and an output, said output of said further amplifier means being coupled to said amplifier means for disabling same upon receipt of an input signal at said input of said further amplifier means, and time delay circuit means coupled for energization upon such temporary changes for providing an input signal to said further amplifier means.

21. Railway signal apparatus for detecting an approaching train as set forth in claim 15, wherein said means for preventing comprises further amplifier means having an input and an output, said output of said further amplifier means being coupled to said amplifier means for disabling same upon receipt of an input signal at said input of said further amplifier means, and time delay circuit means coupled for energization upon such temporary changes for providing an input signal to said further amplifier means.

22. Railway signal apparatus for detecting an approaching train as set forth in claim 21, wherein said means for disabling comprises means for disabling said output of said further amplifier means upon receipt of said first output from said means for receiving.

23. Railway signal apparatus for detecting an approaching train as set forth in claim 15, further comprising monitoring means for producing a power level signal indicative of the power level of said detectable signal.

24. Railway signal apparatus for detecting an approaching train as set forth in claim 23 further comprising utilization circuit means coupled to said means for receiving and said monitoring means for producing an AC output signal indicative of no approaching train when said first output occurs from said means for receiving and said power level signal is produced by said monitoring means, and a DC output signal indicative of an approaching train upon receipt of said second output or an insufficient power level signal conditions, whereby the latter condition is indicative of a defect in said track or said apparatus.

25. Railway signal apparatus for detecting an approaching train as set forth in claim 24, wherein said utilization circuit means comprises an astable multivibrator circuit, and said means for receiving and said monitoring means are coupled to said astable multivibrator circuit for providing respective first and second DC power inputs thereto.

26. A railway signal system comprising means for providing an interrupted carrier wave, means for receiving said interrupted carrier wave, and means responsive to an output from said means for receiving for providing an indication of an approaching train, said means for receiving including means for producing from said received interrupted carrier wave a signal normally having DC and AC parts, amplifier means for producing from an input signal a corresponding output signal, and differentiating capacitor means coupled to said amplifier means for normally blocking said DC part and passing thereto said AC part of said signal, an AC output from said amplifier means coupled to said means responsive being indicative of no approaching train and a DC output from said amplifier means occasioned by a drop in the level of said DC part at a rate at least approximately equal to the rate at which said AC part increases being indicative of detection of an approaching train.

27. A railway signal system as set forth in claim 26, wherein said means for providing an interrupted carrier wave comprises an oscillator for producing said carrier wave and a pulser circuit for periodically interrupting said carrier wave.

28. A railway signal system as set forth in claim 26, wherein said means for producing comprises a resistance and capacitor wave shaping circuit.

29. A railway signal system as set forth in claim 26, further comprising a normally saturated negative slope detector means coupled to the output of said amplifier means for producing an AC output signal when a portion of said corresponding output signal is negatively sloped.

30. A railway signal system as set forth in claim 29, wherein said means responsive comprises an astable multivibrator.

31. A railway signal system as set forth in claim 29, further comprising means for maintaining an indication of an approaching train after such has been detected and such detection has been temporarily lost, said last mentioned means including timing circuit means for determining the duration of such maintained indication.

32. A railway signal system comprising means for providing an interrupted carrier wave; means for receiving said interrupted carrier wave; negative slope detector; and astable multivibrator means responsive to an output from said negative slope detector for providing an indication of an approaching train; said means for receiving including means for producing from said received interrupted carrier wave a signal normally having DC and AC parts, amplifier means for producing from an input signal a corresponding output signal, and differentiating capacitor means coupled to said amplifier means for normally blocking said DC part and passing thereto said AC part of said signal; said negative slope detector being normally driven at saturation and coupled to the output of said amplifier means for producing an AC output signal when a portion of said corresponding output signal is negatively sloped driving said negative slope detector out of saturation; and said astable multivibrator having a first input coupled to said negative slope detector output and a second input responsive to the power level of said interrupted carrier wave; whereby an AC output from said amplifier means coupled to said astable multivibrator means is indicative of no approaching train and a DC output from said amplifier means occasioned by a drop in the level of said DC part at a rate at least approximately equal to the rate at which said AC part increases is indicative of detection of an approaching train or of insufficient power of said interrupted carrier wave.

33. A railway signal system as set forth in claim 32, further comprising means for sensing the power level of said interrupted carrier wave.

34. A railway signal system comprising means for providing an interrupted carrier wave; means for receiving said interrupted carrier wave; negative slope detector; and means responsive to an output from said negative slope detector for providing an indication of an approaching train; said means for receiving including means for producing from said received interrupted carrier wave a signal normally having DC and AC parts,

amplifier means for producing from an input signal a corresponding output signal, and differentiating capacitor means coupled to said amplifier means for normally blocking said DC part and passing thereto said AC part of said signal; said negative slope detector being normally saturated and coupled to the output of said amplifier means for producing an AC output signal when a portion of said corresponding output signal is negatively sloped driving said negative slope detector out of saturation; whereby an AC output from said amplifier means coupled to said means responsive is indicative of no approaching train and a DC output from said amplifier means occasioned by a drop in the level of said DC part at a rate at least approximately equal to the rate at which said AC part increases is indicative of detection of an approaching train; means for maintaining an indication of an approaching train after such has been detected and such detection has been temporarily lost, said last mentioned means including timing circuit means for determining the duration of such maintained indication; and means for disabling said means for maintaining upon occurrence of a leaving train.

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