

Jan. 26, 1937.

H. CHIREIX ET AL
RAILWAY SIGNALING SYSTEM

2,068,655

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3 Sheets-Sheet 1

Fig. 1.

Fig. 5.

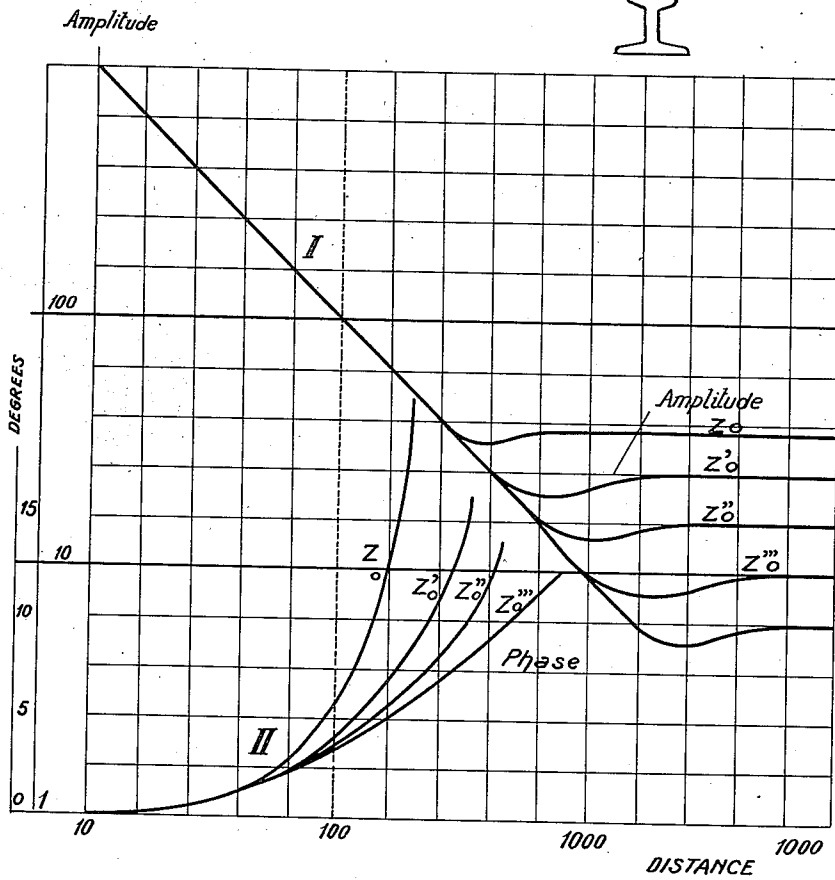
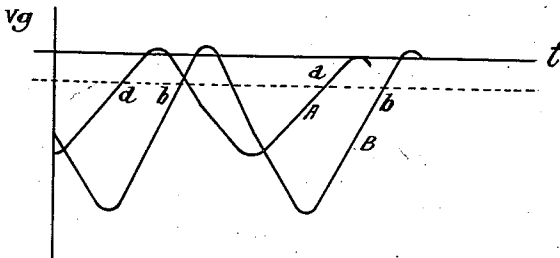


Fig. 4.



HENRI CHIREIX
AND PAUL NICOLAS
INVENTORS
BY *Haseltine, Lake & Co.*
ATTORNEYS

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Fig. 2a

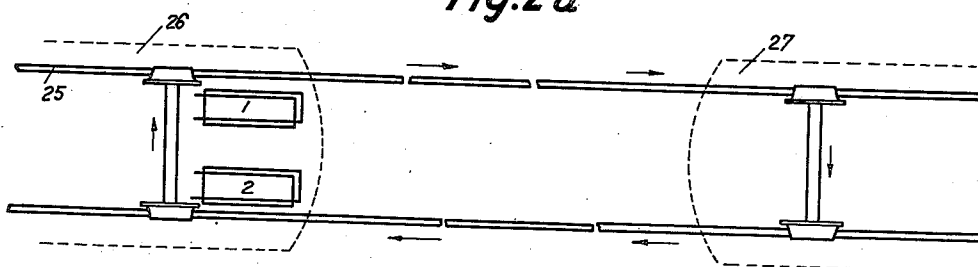


Fig. 2b

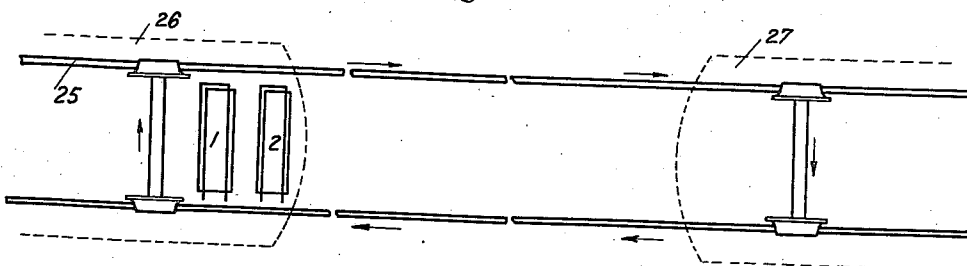
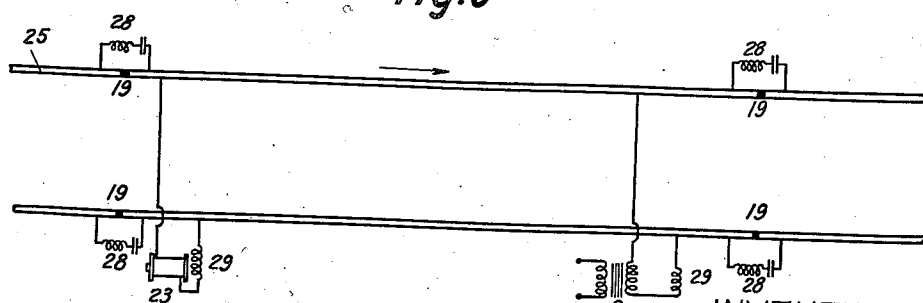


Fig. 6



INVENTORS
HENRI CHIREIX
PAUL NICOLAS
BY *Haseltine, Lake & Co.*
ATTORNEYS.

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Fig. 7

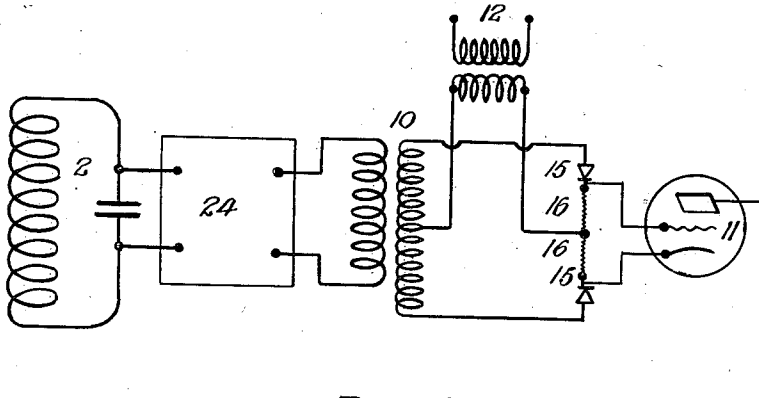


Fig. 3a

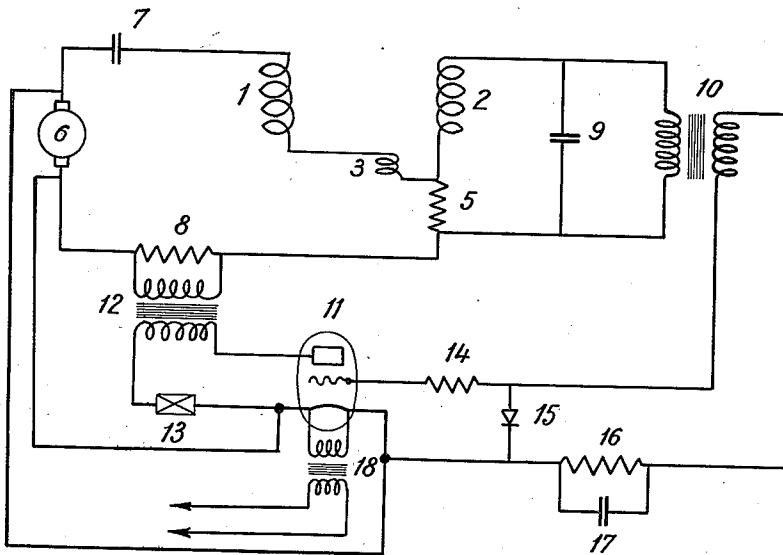
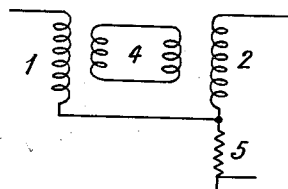


Fig. 3b



HENRI CHIREIX
AND PAUL NICOLAS
INVENTORS.
BY *Haseltine, Lake & Co.*
ATTORNEYS

UNITED STATES PATENT OFFICE

2,068,655

RAILWAY SIGNALING SYSTEM

Henri Chireix and Paul Nicolas, Paris, France,
assignors to Société Française Radio Electrique,
a corporation of France

Application April 12, 1935, Serial No. 15,962

In France May 18, 1934

11 Claims. (Cl. 246—63)

The present invention is for improvements in railway signaling systems and has for its object the provision of a signaling arrangement for trains in motion which is operated either independently of the signals disposed along the track or by these signals and which indicates to the driver that the train should be slowed down or stopped when the track is not clear, for example, when the train approaches too closely a train in advance thereof on the same track. The signaling arrangement is of an electrical character and utilizes the rails as conductors; consequently the rails must be arranged in such a manner as to ensure electric continuity therein.

In front of the first axle of the train is placed an inductive device for alternating currents (wound frame with or without an iron core) which is arranged to induce a current of a comparatively high frequency in the rails together with a second inductive device, for example of similar construction, arranged to collect the induced currents. When the currents collected by the second inductive device are sufficiently strong (this occurs when the distance from the train in advance or from a point where the track is short-circuited by mechanical means operated from a stationary position, becomes less than a certain value), the release of a relay is effected which causes the slowing down or the stopping of the train. It is possible to use apparatus which effects the slowing down of the train at a certain predetermined distance from the short circuit and the stopping of the train at a different predetermined distance from the short circuit; this can be effected by using two different frequencies and differentiating between them by means of any convenient known kind of selecting apparatus.

The invention will be hereinafter more particularly described with reference to the accompanying drawings in which like devices are indicated by like reference numerals.

Figure 1 illustrates a graph showing the characteristics of the current as a function of distance,

Figure 2a illustrates a general schematic diagram of an arrangement in accordance with the invention,

Figure 2b is a slight modification of the same, Figure 3a illustrates a detailed circuit of apparatus with which a train is equipped,

Figure 3b illustrates a modification of a detail of construction shown in Figure 3,

Figure 4 illustrates a graph of the grid current on the reception of a signal,

Figure 5 illustrates a detail of construction of coils used on the train,

Figure 6 illustrates schematically a signaling circuit arranged along the track, and

Figure 7 illustrates a modification of the circuit shown in Figures 3a and 3b.

Although the principle of the invention appears fairly simple, difficulties are experienced in actual practice, and it is necessary first to refer to the general theory of transmission lines used in railway signaling.

In the case of the railway track, the determining factor is the insulation between the rails, which insulation will vary according to the state of the track and the weather. Unless, therefore, very high frequencies (for example, higher than 20,000 cycles per second) are used, which would not be convenient owing to the fact that they give rise to stationary waves of too short a wave length, the capacity between the rails may be neglected.

It is possible, alternatively, to neglect the ohmic resistance in comparison with the self-inductance as soon as the frequency exceeds a few hundred cycles per second, in view of the comparatively large dimensions of the cross-section of the rails. Consequently, it is only necessary to consider seriously, the self-inductance per unit of length L and the leakage S . Although the rails are formed of a magnetizable metal, the self-inductance may be considered as constant within the range of frequencies mentioned in consequence of the superficial penetration of the currents.

Under these conditions, a calculation shows that if an electromotive force proportional to the frequency is induced in the rail, the current varies with the distance, as illustrated by the curve I of Figure 1, where the scales are logarithmic. It will be observed that the current at first diminishes according to a law inversely proportional to the distance, then less rapidly to pass through a minimum and finally becomes stabilized (long line condition) at a value corresponding to the characteristic impedance (Z_0 , Z_0' , Z_0'' or Z''') of the line constituted by the rails, the value depending both upon the frequency and upon the insulation. It is, furthermore, shown that a similar characteristic impedance is obtained when the frequency varies inversely with the insulation (low frequency and high insulation, or vice versa).

A frequency of working according to the distance at which it is desired to obtain the signaling effect will consequently be chosen, the value

thereof being such that the rectilinear portion of the curve is still in operation even under the most unfavourable conditions from the point of view of insulation. The line may then be considered as a line of medium length. One will thus be certain, under these conditions, of always working in the portion of the curve satisfying the condition of the current varying inversely with the distance, while having as high a value as possible of the frequency. By way of example, it may be mentioned that a frequency of the order of 1,000 cycles per second appears to be a mean frequency satisfying these conditions.

It is also possible to calculate the phase of the induced current. It will be observed that at very short distances, the phase of the induced current is substantially displaced by 90° behind the inducing current (actually less in practice owing to the resistance of the rail which has been neglected) and that as the line becomes longer, the lag diminishes in such a manner that at long distances the phase displacement is only about 45°. These results are illustrated by the curve II of Figure 1, where the phase corresponding to a near-by short-circuit has been taken as the origin of the phases.

Consequently, by conveniently selecting the frequency of working, as has been explained, it is found that the presence of an obstacle short-circuiting the track causes the following effects:

1. The current induced at the start is increased, this becoming progressively greater as the distance from the obstacle diminishes.

2. The induced current is caused to lag in phase.

These variations in the intensity and the phase may be utilized in the following manner:

Two frames or inductor coils 1 and 2 comprising windings are disposed underneath the train and close to the track, the frame 1 serving as a transmitter of induced currents to the track, and the frame 2 as a collector of induced currents from the track. These frames may be arranged in either of the positions illustrated in Figure 2a or 2b. In these figures, the track is shown at 25, the rear of the train at 26 and the front of the train at 27. The arrows indicate the circulation circuit of the induced current through the first axle of train 26, the rails and the last axle of the train 27 short-circuiting the track. These frames 1 and 2 are also illustrated diagrammatically in Figure 3.

It is necessary that the direct action of one frame on the other should be perfectly compensated so as not to interfere with the controlling effect. To effect this compensation an auxiliary winding 3, having a small number of turns as compared with the number of turns of the main winding, is arranged on one of the frames; the mutual induction of this auxiliary winding is employed to compensate the mutual induction of the frames. A precise adjustment may, furthermore, be effected by slightly displacing one frame relatively to the other. Another method of compensation would be to employ a circuit 4 arranged in the manner illustrated in Figure 3b.

It is usually found that with these precautions only, the compensation is not perfect, and that instead of obtaining a zero effect, only a minimum effect greater than zero is obtained. This may be caused by defective insulation, or more frequently, by inductive effects in metallic masses close to and in the ground.

These inductive effects give rise in the receiving frame to currents which are out of phase with respect to the currents caused by a simple mutual inductive coupling. One of the objects of the present invention is to eliminate these undesirable effects, this being effected by coupling the frames through a very weak common resistance 5. It will be readily observed that if the inlet and outlet terminals of the frame 1 are reversed, the effects of mutual induction are reversed without changing the sense of the coupling through the resistance 5; consequently, the direction of the effect of this resistance is under control. It is also possible to effect compensation by means of a winding such as 4 having an interposed resistance; this method is not however, so accurate owing to the fact that the inductive coupling and the coupling by resistance are both varied at the same time.

Finally, in order to avoid having to compensate too great a resistance effect, it is preferable to arrange between the frames and the body of the train, a screen formed of a good conducting metal, for example copper; this screen will reduce the losses due to Foucault currents.

The direct action of one frame upon the other having been perfectly or almost perfectly compensated, it will be possible to use the arrangement in the manner hereinafter described. The transmitting frame 1 is tuned to the frequency of the alternator 6 by means of a condenser 7, the circuit in addition comprising a resistance 8 which has the effect of making the circuit less sensitive to variations of speed. The alternator 6 is furthermore, preferably provided with a sensitive speed regulator.

The receiver frame 2 is also tuned (or slightly de-tuned) by means of a condenser 9, and the potential developed (by the action of the track) is collected at the secondary terminals of the transformer 10.

The indicator apparatus preferably comprises a relay 13 connected in the output circuit of an ionized gas relay 11 commonly known as a gas filled ignition electrode tube or device. The current collected by the transformer 10 flows in the grid circuit of the electrode tube or device while the plate circuit of the electrode tube or device is connected to the transmitter frame by means of the transformer 12, which is also connected in series with the relay 13. The advantage obtained by connecting the transformer 12 at the terminals of the resistance 8 is as follows:

If for any cause whatever, such for example as a variation in the speed of the alternator, the phase of the current in the transmitting frame varies, it will correspond with that of the plate potential of the discharge relay 11, and the relative ratios of the two phases will therefore be unchanged.

A high ohmic resistance 14 (for example, a hundred thousand ohms) is used for the purpose of limiting the grid current of the discharge relay 11 when it has started to operate. A further important fact is that the grid of the relay 11 is polarized negatively by an auxiliary rectifier 15 of the copper oxide type which feeds current to a resistance 16 having a condenser 17 connected in parallel thereto. A transformer 18 fed from the same source of current as the alternator 6 is used to supply heating current to the filament of the relay 11.

It is known that the output of an ionized gas relay having a control grid, may be controlled in a uniform and continuous manner by influencing

the phase and the amplitude of the grid potential. For example, when the phase of the grid potential is retarded or the grid is polarized more negatively, the output is reduced; it is in fact possible to stop this output when the variation of one or other of these quantities, or of the two quantities jointly, is sufficient.

The circuit hereinbefore described complies with these conditions and the operation is as follows: When the track is clear, the alternating grid potential of the relay 11 has a particular value and phase, as also the negative polarization thereof (potential at the terminals of condenser 17), and these values can be altered by preliminary adjustments, more particularly adjustments of the tuning.

It will be arranged, by means of these preliminary adjustments, that the discharge relay 11 is actuated with a current which is less than that corresponding to the maximum (region of control). The electromagnet 13 is then attracted and indicates that the track is clear. If now the train equipped with the signaling device approaches another vehicle located in front of it, the grid alternating potential will increase simultaneously with the increase in the negative polarization developed at the terminals of the condenser 17. It will furthermore, be noted that with the circuit illustrated the grid cannot become positive with respect to the filament except by an amount corresponding to the amount of the internal drop in the rectifier 15; in other words, the positive grid potential will only vary very slightly. This is illustrated in Figure 4, where the positive grid potential is plotted on a graph as a function of the time. In this figure, A is the grid potential when the track is clear and B is the grid potential when the track is short-circuited. If the dotted line represents the critical ignition potential of the discharge relay 11, the moment of ignition is thus retarded by the period of time equivalent to the length *ab*, and this time will be sufficient for a convenient adjustment of the phases of the plate and grid alternating potentials for the purpose of causing the complete release of the gas relay and the release of the armature of the relay 13.

It is evident that if the signal corresponding to the occupied condition of the track effects, by means of a convenient mechanical arrangement which can be readily designed, a short circuiting of the track, the apparatus carried by the train will operate as regards this short-circuit in the same manner as regards the short circuit produced by the axles of the train. The driver will thus receive an indication that signals at a distance are against him and consequently he will be able to stop the train before it actually reaches the signal set to the "stop" condition.

It will furthermore be noted that if, during the period of braking, the track again becomes clear, the indicator apparatus on the train will change so as to give an indication that the track is clear. A simple method is thus provided for reproducing on the locomotive the "stop" signals given along the track.

As the system hereinbefore described operates by reason of loss of current, it is therefore, safeguarded from the majority of the working faults, the most important of which are that the alternator may lose excitation or the gas valve may deteriorate.

Nevertheless, if the circuits of the receiver frame are disconnected, the signaling may be faulty. This defect is easily remedied by observing the fact of the disappearance of the nega-

tive polarization and that the anode current of the gas relay increases (rate outside the control region). The relay 13 may therefore be made to operate at maximum and minimum values, or a fuse or cut-out may be inserted in the anode circuit.

It will also be observed that instead of effecting an exact compensation of the frames 1 and 2 illustrated in Figure 3, in the absence of the track, means may be provided which effect the compensation in the presence of the track when the latter is not short-circuited. Under these conditions, the variations due to the short circuit between the rails will be increased.

Various modifications in the details of the invention can be effected; thus, instead of a gas valve or relay 11, a high vacuum valve, for example a triode or pentode can of course be used, this valve being supplied with anode potential either by means of alternating current as illustrated or by means of direct current obtained from a small supplementary rectifier. It is also possible to amplify the current passing through the receiving frame before it reaches the valve 11. The circuit illustrated in Figure 3 is simply given by way of example for various modifications can be made therein by one skilled in the art without departing from the spirit and scope of the invention.

Instead of transmitting to or receiving from the rails by means of frames wound without an iron core, it is possible to use inductive circuits such as illustrated in Figure 5 in which iron is used. In Figure 5, receiving plates 21 are provided with a coil 22 and the arrangement extends axially with respect to the track. In this case, one of the assemblies illustrated in Figure 5, which acts as an inductor is placed, for example, in the vicinity of the left-hand rail, while another similar assembly acting as a receiver is placed in the vicinity of the right-hand rail.

Figure 6 illustrates a track 25 equipped as track circuit and provided with insulating joints 19. The signal circuit includes a source of current for the operation of the signals at the point 20 and a signal relay at the point 23. With this arrangement it is necessary in accordance with the usual current practice, to shunt the insulating fish plates by means of shunts 28 tuned to the frequency induced in the track (these shunts possibly comprising simple capacities in the form of condensers), and to protect the connections 20 and 23 by stopper circuits connected to the wires, these latter circuits being in the form of simple self-inductances 29. The arrow in the figure indicates the direction of movement of the trains.

It has also been found very satisfactory if the mounting of the receiver is sensitive to the variations of phase, as has hereinbefore been mentioned. An advantageous modification of the receiver arrangement will consist in the use of the well-known principle of the watt-meter, the indications of which change in direction when the phases of the current and of the potential pass through the points of quadrature. The circuit illustrated in Figure 7 may be employed. Referring to this figure, 2 is a receiving circuit tuned or approximately tuned to the frequency to be received, 24 is a convenient amplifier, 10 is a first transformer with a centre tapping on the secondary winding, 12 is a second transformer the primary winding of which is fed with current by the alternator which feeds the current to the track, 15 are rectifiers or detectors which may con-

veniently be of the copper oxide type, 16 are equal resistances, and 11 is an ionized gas valve the plate of which is fixed with alternating current. The devices 10, 12, 15, 16 comprise a known circuit which permits the variations of phase to be tested. If in fact, the phases of the potentials developed at the terminals of transformers 10 and 12 are at quadrature the rectified potentials in the resistances 16 will be equal, and consequently there will not be a potential difference between grid and cathode of the gas valve 11. If, on the contrary, the quadrature is upset, the outputs of the detectors will be unequal owing to the unequal potentials developed between the extremities of the transformer 10 and the centre point between the resistances 16, and a potential will exist between the grid and cathode of the valve 11; the polarity of this potential will depend upon the direction in which the quadrature of the phases has been upset. By suitably regulating the circuit 2 or the phase of the current arriving at the transformer 12, it is possible to arrange so that if the track is free, the potential between the cathode and grid of the gas valve 11 is always slightly positive or at the most, zero, in the most unfavourable case (quadrature). When the track is short circuited, the potential of the transformer 10 will lag behind in phase and the potential between the grid and cathode of the gas valve will be reversed, the lag or advance of the phase of the potential corresponding to the phase which prevailed before the short-circuit. This lagging behind of the phase will cause a sufficient amplitude to effect the release of the gas valve 11.

The circuit comprising the devices 10, 12, 15, 16 and 11 may be modified in various known manners, provided these modifications do not affect the characteristic of the circuit that a continuous potential is created, the direction of which is reversed for a definite phase displacement. It is also possible to reverse the grid and filament of the gas valve 11 and to regulate the whole circuit in such a manner that the grid is negative when the track is clear, and becomes positive when the track is short circuited. The valve 11 under these circumstances would normally be inactive. This method of operation is however, simply mentioned as a possible modification, for it is preferable from the point of view of reliability, to operate by loss of current.

What we claim and desire to secure by Letters Patent of the United States is:—

1. A railway signaling system comprising apparatus installed on a train to be protected and a circuit formed by the first axle of the said train which short circuits the rails and by a section of the rails located between the said first axle and a position along the track in advance of the train where another short-circuit of the rails is completed, the said apparatus comprising means for inducing in the rails an alternating current of sufficiently low frequency to cause the capacitive admittance between the rails to be small in comparison with the leakage conductance, separate means for collecting the current energy circulating in the said rails and distinct means actuated by the current collected for indicating that the length of the section of the rails in which the current flows, is below a predetermined value.

2. A railway signaling system as claimed in claim 1, in combination with means for suppressing the mutual induction between the said means for inducing the current in the rails and the said means for collecting the current energy.

3. A railway signaling system comprising ap-

paratus installed on a train to be protected and a circuit formed by the first axle of the said train which short-circuits the rails and by a section of the rails located between the said first axle and a position along the track in advance of the train where another short circuit of the rails is completed, the said apparatus comprising a frame operable to induce in the rails an alternating current of such frequency that the capacitive admittance between the rails is small in comparison with the leakage conductance, another frame operable to collect the current energy flowing in the said rails, an inductance interposed between the said two frames, of a predetermined value for suppressing the mutual induction between the frames, and means fed by the current in the collecting frame for indicating that the length of the section of the rails in which the current flows, is below a predetermined value.

4. A railway signaling system comprising apparatus installed on a train to be protected and a circuit formed by the first axle of the said train which short-circuits the rails and by a section of the rails located between the said first axle and a position along the track in advance of the train, where another short-circuit of the rails is completed, the said apparatus comprising a frame for inducing in the rails an alternating current of such frequency that the capacitive admittance between the rails is small in comparison with the leakage conductance, another frame for collecting the current energy flowing in the said rails, a resistance in the coupling circuit of the said two frames for suppressing the mutual induction between the frames, and means fed by the current in the collecting frame for indicating that the length of the section of the rails in which the current flows, is below a predetermined value.

5. A railway signaling system comprising apparatus installed on a train to be protected and a circuit formed by the first axle of the said train which short-circuits the rails and by a section of the rails located between the said first axle and a position along the track in advance of the train where another short-circuit of the track is completed, the said apparatus comprising a source of alternating current of such a frequency that the capacitive admittance between the rails is small in comparison with the leakage conductance, a coil arrangement coupled with the rails and fed by the said source so as to induce current in the rails, a second coil arrangement coupled with the rails so as to collect the current energy flowing therein and connected to an ionized gas relay having a control grid, and an indicator connected in the plate circuit of the said relay and operable to indicate that the length of the section of the rails in which the current flows, is below a predetermined value.

6. A railway signaling system comprising apparatus installed on a train to be protected and a circuit formed by the first axle of the said train which short circuits the track and by a section of the rails located between the said first axle and a position along the track in advance of the train where another short-circuit of the track is completed, the said apparatus comprising a source of alternating current of such a frequency that the capacitive admittance between the rails is small in comparison with the leakage conductance, a coil arrangement coupled with the rails and fed by the said source so as to induce current in the rails, a second coil arrangement coupled with the rails so as to collect the current energy flowing therein and con-

nected to an ionized gas relay having a control grid, and an indicator connected in the plate circuit of the said relay and operable to indicate that the length of the section of the rails in which the current flows, is below a predetermined value, the said plate circuit being fed by the said source of alternating current.

7. A railway signaling system comprising apparatus installed on a train to be protected and a circuit formed by the first axle of the said train which short-circuits the track and by a section of the rails located between the said first axle and a position along the track in advance of the train where another short-circuit of the track is completed, the said apparatus comprising a source of alternating current of such a frequency that the capacitive admittance between the rails is small in comparison with the leakage conductance, a coil arrangement coupled with the rails and fed by the said source so as to induce current in the rails, a second coil arrangement coupled with the rails so as to collect the current energy flowing therein and connected to an ionized gas relay having a control grid, means for polarizing the said grid so as to vary the phase of the effect thereon when the length of the signaling section varies, and an indicator connected in the plate circuit of the said relay and operable to indicate that the length of the section of the rails in which the current flows, is below a predetermined value.

8. A railway signaling system comprising apparatus installed on a train to be protected and a circuit formed by the first axle of the said train which short-circuits the track and by a section of the rails located between the said first axle and a position along the track in advance of the train where another short-circuit of the track is completed, the said apparatus comprising a source of alternating current of such a frequency that the capacitive admittance between the rails is small in comparison with the leakage conductance, a coil coupled with the rails and fed by the said source so as to induce current in the rails, a second coil coupled with the rails so as to collect the current energy flowing therein and connected to an ionized gas relay having a control grid, means for polarizing the said grid comprising a detector connected in shunt and operable to vary the phase of the effect on the said grid when the length of the signaling section varies, and an indicator connected in the plate circuit of the said relay and operable to indicate that the length of the section of the rails in which the current flows, is below a predetermined value.

9. A railway signaling system comprising apparatus installed on a train to be protected and a circuit formed by the first axle of the said train which short-circuits the track and by a section of the rails located between the said first axle and a position along the track in advance of the train where another short-circuit of the

track is completed, the said apparatus comprising a source of alternating current of such a frequency that the capacitive admittance between the rails is small in comparison with the leakage conductance, a coil coupled with the rails and fed by the said source so as to induce current in the rails, a second coil coupled with the rails so as to collect the current energy flowing therein and connected to an ionized gas relay having a control grid, and an indicator connected in the plate circuit of the said relay and operable to indicate that the length of the section of the rails in which the current flows, is below a predetermined value, the said plate circuit being fed by the said source of alternating current and containing means operable to disconnect the circuit at a predetermined value of the current.

10. A railway signaling system comprising apparatus installed on a train to be protected and a circuit formed by the first axle of the said train which short-circuits the rails and by a section of the rails located between the said first axle and a position along the track in advance of the train where another short-circuit of the rails is completed, the said apparatus comprising means for inducing in the rails an alternating current of such frequency that the capacitive admittance between the rails is small in comparison with the leakage conductance, separate means for collecting the current energy flowing in the said rails and means operable by the current collected to indicate that the length of the section of the rails in which the current flows, is below a predetermined value, the latter means comprising a circuit sensitive to the variations of phase of the current collected relatively to the current induced.

11. A railway signaling system comprising apparatus installed on a train to be protected and a circuit formed by the first axle of the said train which short-circuits the rails and by a section of the rails located between the said first axle and a position along the track in advance of the train where another short-circuit of the rails is completed, the said apparatus comprising means for inducing in the rails an alternating current of such frequency that the capacitive admittance between the rails is small in comparison with the leakage conductance, separate means for collecting the current energy flowing in the said rails and means operable by the current collected to indicate that the length of the section of the rails in which the current flows, the latter means comprising a bridge circuit, the arms of which comprise inductances, detectors and resistances, the said inductances and one diagonal of the bridge being supplied respectively by the collected and the induced currents, while an indicator is connected in the other diagonal of the bridge.

HENRI CHIREIX,
PAUL NICOLAS.