

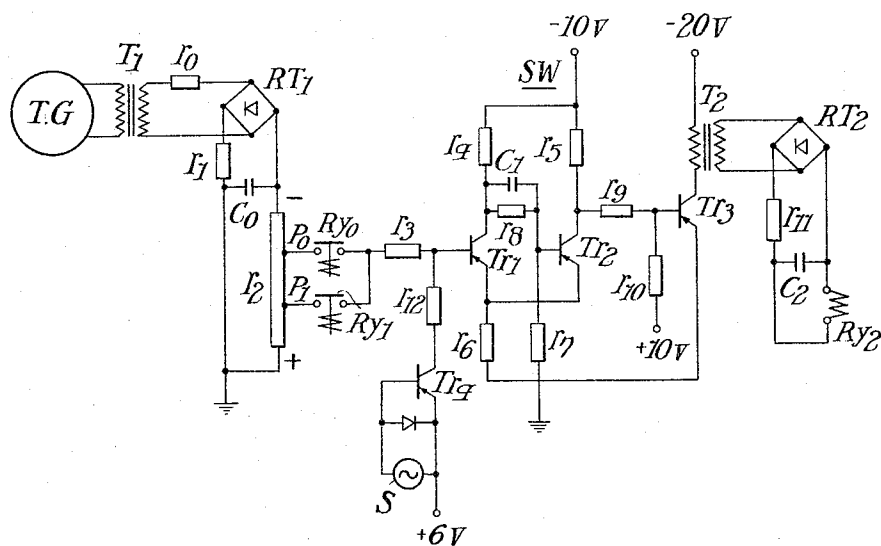
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KEIICHI HAYASHI ET AL

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SAFETY DEVICE FOR TRAINS

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SAFETY DEVICE FOR TRAINS

Keiichi Hayashi and Junichi Watanabe, Tokyo-to, Japan,
assignors to Tokyo Shibaura Denki Kabushiki Kaisha,
Kawasaki-shi, Japan, a joint-stock company of Japan

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This invention relates to a safety device for trains and more particularly to an improved safety device for automatic train control devices which are automatically controlled by instruction signals from the ground.

In high speed trains running at a normal running speed exceeding 100 kilometers per hour or more it is difficult to control the trains safely and accurately by depending solely upon the visual judgement of the driver. Therefore it has been proposed to provide for such a high speed train or electric car with a control device which is arranged to receive instruction signals emitted from signal emitting devices such as radio transmitting apparatus, super-sonic transmitters and light ray transmitters which are located at suitable positions along the travelling section of the train instead of ordinary visual indexes, said control device is also arranged to determine whether the speed of the train during an interval in which it passes through preselected points coincides or not with the predetermined speed given by a predetermined running schedule and when the actual speed is higher than said predetermined value said control device will actuate a suitable control device to decelerate the train whereas when the actual speed is lower than the predetermined speed, will cause inoperative the control device. In such a control device an electromagnetic type operating relay movable between two positions has been provided in order to apply or release braking force. This relay, when energized will move to one position to release braking force whereas, when deenergized, will move to the other position to apply the braking force. By arranging this relay in such a manner, discontinuity in the conductor of the operating coil or its energizing circuit will result in the deenergization of the coil, thus applying the braking force. In other words, fault of the operating coil of the relay or its energizing circuit will cause the control device to safeguard the train. However, in order to operate positively said operating relay it is necessary to apply sufficiently large input power to its electromagnetic coil, and in order to attain this object it has been provided a power amplifier comprising a logical circuit, switching circuit or the like between a receiver which receives said signals and said operating relay. In this regard, it is advantageous to use a transistor as the amplifier or switching element to increase the reliability of the control device.

However, even with logical circuits or switching circuits utilizing transistors are still certain defects, more particularly, such circuits will provide two types of output signals depending upon the type of the faults occurring therein. Thus, when the conductor of a source of supply is broken these circuits will not produce any output causing the relay to drop out, thus applying a braking force. In other words, the control device will operate to safeguard the train in response to an internal fault as above described. On the other hand faults of the transistor itself such as short circuit between the emitter and base electrodes thereof or breakage in the coupling circuit may result in the application of erroneous input to the relay which causes releasing of the braking force, depending upon the type or location of the fault. Thus the control device will operate in the non-safety side in response to such internal faults. Upon occurrence of such internal faults, the automatic train control device will not actuate the braking device even when the train is running at a

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dangerous speed exceeding the predetermined value, which, of course, is very dangerous.

Accordingly, it is an object of this invention to provide a safety device for an automatic train control device which can positively eliminate such dangerous condition and cause said control device to automatically apply braking force to the train, thus safeguarding it, in response to any predictable faults.

It is another object of this invention to provide an automatic train control device wherein coded signal inputs are applied to a control relay to release braking force only when the speed of a train is above a predetermined limit.

It is a still further object of this invention to provide a safety device for an automatic train control device which applies braking force in response to any fault in various components of the control device such as a tachometer generator, electromagnetic relays, transistors, a switching circuit, and source of electricity.

Briefly stated, and in accordance with this invention a safety device is provided for a train, comprising means for obtaining a direct current voltage corresponding to the speed of said train, a source of reference voltage, a plurality of means responsive to speed limiting signals which are successively transmitted to said train from the ground in the travelling sections of said train to successively close a circuit which compares said direct current voltage with said reference voltage, a circuit means to produce an output corresponding to said difference voltage, means provided on the input side of said circuit means to convert said difference voltage into codes, means to derive out only said coded output from said circuit means and means responsive to said coded output to detect the abnormal condition of said train.

For a complete understanding of the invention, reference may be had to the accompanying drawing in which a single drawing illustrates a connection diagram of one embodiment of this invention.

Referring now to the accompanying drawing, there is shown an alternating current tachometer generator T.G which is driven directly or indirectly from an axle of a car. As the tachometer generator, an alternator having a rotating field driven by an axle to generate an alternating current output having a frequency proportional to the speed of the car may be used. Alternatively, an inductor generator comprising a stator energized from an alternating current source of a definite frequency and a wound rotor driven by the axle may be used wherein the rotor is rotated in the same direction as the rotating field produced by the stator to produce across the terminals of the rotor winding an output of the frequency inversely proportional to the speed of the train. In the following description the alternator is assumed to be one that produces an output frequency which is inversely proportional to the speed of the train. It is advantageous to use a tachometer generator whose output voltage varies in inverse proportion to the speed of the train because higher control voltage is available at low speed when it is desired to decelerate and finally stop the train running at a high speed. In order to eliminate the effect of variations in the magnitude of the output voltage, a transformer T_1 including a saturable core (not shown) is connected across the output terminals of the pilot generator T.G, whereby to produce a voltage across the secondary winding, which is substantially unaffected by the magnitude of the primary voltage but is proportional to the frequency alone. The secondary voltage of the transformer T_1 is rectified by a bridge rectifier RT_1 and the direct current output thereof is applied through a filter circuit including a resistor r_1 and a capacitor C_0 to a potentiometer r_2 with one terminal grounded. In this embodiment various voltages corresponding to different speeds with

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which the trains successively passes a number of predetermined points or sections are compared with a reference voltage of a fixed value. Thus to obtain a substantially constant voltage for different speeds, in the embodiment shown, a plurality of taps $P_0, P_1 \dots$ are provided at different positions along the potentiometer r_2 . Thus, for example when the train is passing through a section between two points at a low speed, the voltage of the tachometer generator is high so that, at this time, the lower tap P_1 is used whereas when the train passing through a section between another two points at a high speed, the voltage is low so that the upper tap P_0 is used. Thus, voltages of substantially the same magnitude can be produced when the train passes through respective points. Receiving relays Ry_0 and Ry_1 are provided to selectively respond to different speed limit signals which are sent from the ground when the train is passing through respective sections, and the contacts of these relays which are closed when the associated relay is energized are connected to said contacts $P_0, P_1 \dots$, respectively. Thus, when the train is passing through a certain section, the relay Ry_1 will operate to select the tap P_1 while the train is passing through another section at a different section the relay Ry_0 will operate to select the tap P_0 . For the sake of brevity only two receiving relays have been shown, but it should be understood that, in practice, a substantial number of relays are to be installed.

As can be noted from the drawing the polarity of the output voltage of the bridge rectifier is selected such that it will produce a voltage drop across the potentiometer r_2 that makes positive its lower terminal and negative its upper terminal. In this manner, when the relay Ry_0 or Ry_1 is closed, a fractional voltage which is negative with respect to the grounded terminal is impressed upon the right hand terminal of the relay. The right hand terminals of the contacts of relays Ry_0 and Ry_1 are connected together and then connected through a resistor r_3 to the base electrode of a PNP junction transistor Tr_1 which constitutes the element of the first stage of a switching circuit Sw to be described later. One terminal of a resistor r_{12} is connected to a conductor which interconnects the resistor r_3 and the base electrode of the transistor Tr_1 and the other end of the resistor r_{12} is connected to the collector electrode of a PNP junction transistor Tr_4 , the emitter electrode of which being connected to a positive source of direct current of about 6 volts. A source of alternating current S is connected between the base and emitter electrodes of the transistor Tr_4 thus periodically turning on and off the collector circuit of the transistor. Periodic on and off operations of the transistor Tr_4 will result in the periodic application of the positive potential from the plus 6 volts source to the base electrode of the transistor Tr_1 .

As shown in the drawing, the emitter electrode of the transistor Tr_1 included in the first stage of the switching circuit Sw is grounded via an emitter resistor r_6 while its collector electrode is connected to a minus 10 v. terminal of a direct current source through a collector resistor r_4 . The emitter electrode of the transistor Tr_1 is also directly connected to the emitter electrode of a PNP junction transistor Tr_2 of the second stage. The collector electrode of the transistor Tr_2 is connected to said minus 10 volts terminal via a collector resistor r_5 whereas its base electrode is grounded through a base electrode r_7 and is also connected to the emitter electrode of the transistor Tr_1 in the first stage via a parallel combination of a capacitor C_1 and a resistor r_8 . During the off period of the transistor Tr_1 a negative potential will be impressed to the base electrode of the transistor Tr_2 through resistors r_4 and r_8 to render more negative the base potential than the emitter potential, thus turning on this transistor Tr_2 . When the transistor is turned on its collector-emitter circuit will be closed through resistors r_5 and r_6 to produce a voltage drop across the resistor r_6 which biases negatively the emitter electrode and positively the base elec-

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trode of the transistor Tr_1 . This voltage maintains the transistor Tr_1 in the off condition and also serves as a reference voltage. Assume now that the transistor Tr_4 is in off condition so that the base electrode of the transistor Tr_1 is interrupted from the plus 6 volts source. When the negative voltage provided by the potentiometer r_2 is larger than said reference voltage, then the base potential of the transistor Tr_1 will be more negative than its emitter potential causing it to turn on. On the other hand if the negative voltage provided by the potentiometer r_2 is smaller than the reference voltage, the transistor Tr_1 will continue its off condition and the transistor Tr_2 its on condition, thus producing no change in conditions. Periodic application of plus 6 volts upon the base electrode of the transistor Tr_1 by the periodic on off operations of the transistor Tr_4 as described above, will turn off the transistor Tr_1 even when a sufficiently negative voltage to turn on the transistor Tr_1 is supplied to the base electrode thereof from the potentiometer r_2 . Stated in another way, during the safe cycles of the alternating current source S in which the transistor Tr_4 is in on condition, the transistor Tr_1 will not be affected by the input from the potentiometer r_2 . Thus, the circuit comprising the transistor Tr_4 and the source S will act as a chopper to periodically interrupt the inputs to the transistor Tr_1 from the potentiometer r_2 whereby to convert these inputs into codes.

A PNP transistor Tr_3 is provided in the third stage with its emitter electrode grounded and its collector electrode connected to a source of minus 20 volts through the primary winding of a transformer T_2 . The base electrode of this transistor is connected to the collector electrode of the transistor Tr_2 through a resistor r_9 and also to a plus 10 volts source through a resistor r_{10} , as shown in the drawing. The resistance values of resistors r_5, r_6, r_9 and r_{10} are suitably elected such that when the transistor Tr_2 is on, the transistor Tr_3 is off, while the transistor Tr_2 is off, the transistor Tr_3 is on. When the transistor Tr_3 becomes on and off alternately, a pulsating current flowing therethrough will induce a voltage across the terminals of the secondary winding of the transformer T_2 which is rectified by a bridge rectifier RT_2 and the direct current output thereof is applied to the coil of a relay Ry_2 via a filter comprising a resistor r_{11} , and a capacitor C_2 . This relay is a brake control relay, for instance, and serves to release the brake when actuated and apply the brake when deenergized. It will be clear to those skilled in the art that this relay may be substituted by any suitable device which operates to supervise or to give warning of the overspeed condition.

The overall operation of the safety device shown is as follows. As described before, the track between stations are divided into a plurality of sections and in each section a suitable speed limiting signal transmitter is located on the ground along the track. As previously described, this transmitter may be in the form of a wireless transmitter, supersonic transmitter or a light ray transmitter. While a train is running through the first section, it will receive the speed limiting signal transmitted from said signal transmitter located in said section to operate the relay Ry_1 , to connect the tap P_1 of the potentiometer to the base electrode of the transistor Tr_4 . As already explained, since the value of the negative voltage at the potentiometer tap P_1 varies inversely proportional to the speed of the train, this voltage will be larger than the reference voltage produced across the resistor r_6 as long as the train speed does not exceed a preselected limit. At this time the voltage difference impressed upon the base electrode of the transistor Tr_1 will make more negative its base potential than the emitter potential thus turning the transistor Tr_1 on. This will turn off the transistor Tr_2 in the next stage, and turn on the transistor Tr_3 in the last stage. On the other hand periodic on off operations of the transistor Tr_4 included in the chopper circuit will turn on the transistor Tr_1 irrespective of the presence

or absence of another input while the transistor Tr_4 is in on condition. On the other hand the transistor Tr_1 will be turned on by the action of said difference voltage input while the transistor Tr_4 is in the off condition. Accordingly, if the train speed is below a predetermined limit the switching circuit comprising transistors Tr_1 , Tr_2 and Tr_3 will repeat periodic on off operations corresponding to the frequency of the source S. Thus, the current flowing through the primary winding of the transformer T_2 will be interrupted periodically to induce a voltage in its secondary winding to energize the relay Ry_2 , whereby the relay is actuated to release the brake.

However, whenever the train speed exceeds said limit, the negative voltage appearing at the tap P_1 of the potentiometer r_2 will become smaller than the reference value thus applying a positive difference voltage to the base electrode of the transistor Tr_1 to turn it off. It will be clear that this off condition of the transistor Tr_1 continues as long as the train speed is above said predetermined limit. By this reason the switching circuit will remain unchanged when the transistors Tr_1 and Tr_3 are off, and the transistor Tr_2 is on. Hence no voltage will be induced in the secondary circuit of the transformer T_2 and the relay Ry_2 will drop out. When the relay Ry_2 drops out a suitable braking device, such as electric brake, pneumatic brake, or similar braking device is actuated to decelerate the train. When the train speed is decreased below the predetermined limit, the negative voltage appearing at the tap P_1 of the potentiometer will become larger than the reference voltage, again causing the switching circuits Sw to effect periodic on off operations to actuate the relay Ry_2 , thus releasing the braking force.

When the train enters into the next section the relay Ry_0 will be operated by the speed limiting signals transmitted to the train from the transmitter located on the ground in that section. Although not shown in the drawing, it should be understood that, between a plurality of relays Ry_0 and Ry_1 , there is provided a well known interlocking circuit which positively maintains one relay in inoperative position while the other is operated. Thus, the respective relays will operate successively in response to the signals transmitted from the ground. For the sake of simplicity only two relays have been shown, but in practice, a substantial number of such relays should be used. Also it will be obvious that it is possible to substitute static type relays such as transistors or electronic tubes for the electromagnetic type relays shown in the drawing. Operation of the safety device of this invention when the relay Ry_0 is actuated is just the same as that when the relay Ry_1 is actuated so that its detailed explanation is believed unnecessary excepting to mention that since it is assumed that the train speed is higher in the section in which the relay Ry_0 operates than in the previous section thereby decreasing the voltage impressed upon the potentiometer r_2 and since the reference voltage is constant, the other tap P_0 which is at a higher point than P_1 is selected in this case whereby to maintain at a substantially equal value the voltages corresponding to different speeds in various running sections which are to be compared with the reference voltage.

In the illustrated embodiment, the safety device of this invention is constructed and arranged in such a manner that only when the speed of the train is below the predetermined limit, coded signal inputs are applied to the operating relay of a braking device to release the braking force and that when the coded signal is not applied, said relay is deenergized or apply a braking force. By this arrangement there are following advantages. Thus when the voltage to be compared can not be obtained owing to a fault of the pilot generator T.G, the switching circuit will not perform on off operations and hence the relay Ry_2 will be deenergized to apply the braking force. Also when the contacts of the receiving relays Ry_0 and Ry_1 are not closed owing to their fault the switching circuit Sw will not operate to deenergize the

relay Ry_2 to apply the braking force. In the case of a fault such as a short circuit between base and emitter electrodes of any of the transistors Tr_1 , Tr_2 and Tr_3 included in the switching circuit or of the transistor Tr_4 in the chopper circuit, the transistor Tr_3 in the last stage will be in either on or off condition thus ceasing its on and off cycles so that the braking force is applied. Furthermore, breakage of the coupling conductor in the switching circuit Sw or the failure of the source of electric supply will also cause the transistor Tr_3 to cease its on and off cycles to apply the braking force. In addition, failure of the last relay Ry_2 , such as breakage of its winding conductor will also result in the application of the brake. In this way, any fault in any portion of the circuit or circuit components will assure application of braking force, that is the device of this invention always operates in the safety side.

While the invention has thus been described in connection with a preferred embodiment, but instead many modifications will occur to those skilled in the art which will lie within the spirit and scope of the invention. For example, the switching circuit may be substituted by a logical circuit and the relay Ry_2 may be replaced by a suitable supervisory or alarming device. It is thus intended that the invention be limited in scope only by the appended claims.

What is claimed is:

1. A safety device for a train running on a roadbed, comprising means for obtaining a direct current voltage inversely proportional to the speed of the train, a reference voltage source, a comparing circuit adapted to compare said direct current voltage with said reference voltage, a plurality of speed selecting means actuated selectively by speed limiting signals transmitted to said train from ground positions along said roadbed, each of said speed selecting means being adapted to close an electric circuit to compare a selected portion of said direct current voltage with said reference voltage, means including transistor means, rectifying means and an alternating current source for superposing a pulse signal on to said direct current voltage corresponding to the speed of the train so as to convert said direct current voltage into a pulsating voltage, a control device and a switching circuit connected to the output of said speed selecting means and responsive to said pulsating voltage when within selected voltage limits as determined by said reference voltage to supply current to energize said control device.

2. A safety device according to claim 1, in which said switching circuit comprises a plurality of transistors connected in cascade to provide a circuit in which conduction of one transistor renders a succeeding transistor non-conducting.

3. A safety device according to claim 1, in which said switching circuit comprises a means for passing alternating current while blocking direct current to said control device.

4. A safety device for a train running on a roadbed, comprising generator means for producing a direct current voltage in reverse proportion to the speed of the train, a voltage divider excited by said direct current voltage and having a plurality of voltage taps, a reference voltage source, a voltage comparing circuit adapted to compare said reference voltage and a voltage from said generating means, a plurality of relay devices responsive to speed limiting signals transmitted from ground positions along said roadbed for selectively connecting one or another of said taps to said comparing circuit, means for superimposing a pulse signal having a repetition frequency on the direct current voltage fed by one of said relay devices to said comparing circuit so as to convert said direct current voltage into a pulsating voltage, a control device and a switching circuit responsive to said pulsating voltage when within limits as determined by said reference voltage to supply current to energize

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said control device, said switching device comprising a plurality of transistors connected in cascade and means passing said pulsating voltage but blocking direct current.

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ARTHUR L. LA POINT, *Primary Examiner.*

LEO QUACKENBUSH, *Examiner.*

S. B. GREEN, *Assistant Examiner.*