

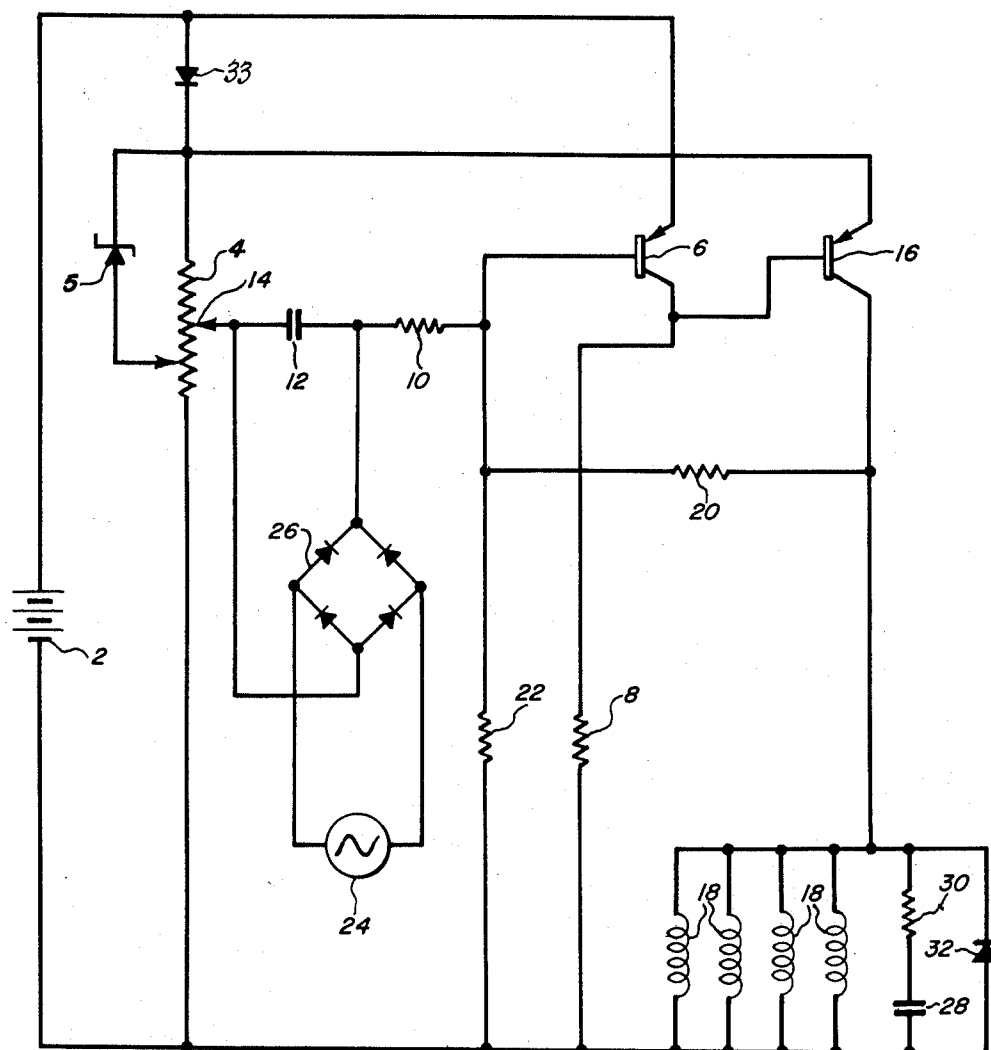
July 6, 1965

R. M. HENDERSON ET AL

3,193,698

TRANSISTOR CONTROLLED SPEED SHUNT

Filed May 27, 1960



INVENTORS
Robert M. Henderson
Richard Zechlin
By *George G. Woodruff*
Atty.

1

3,193,698

TRANSISTOR CONTROLLED SPEED SHUNT
Robert M. Henderson, Williams Bay, and Richard Zechlin, Beloit, Wis., assignors, by mesne assignments, to Fairbanks Morse Inc, New York, N.Y., a corporation of Delaware

Filed May 27, 1960, Ser. No. 32,243

4 Claims. (Cl. 307—88.5)

This invention relates to locomotives and is particularly directed to novel means for controlling the field shunting of the motor of a diesel electric locomotive.

As a diesel electric locomotive accelerates, the voltage across the traction motor gradually increases, while the current through the motor gradually decreases. This phenomenon is a function of the inherent characteristics of the prime mover's generator and the associated traction motors. Eventually a point is reached where any further voltage increase is not possible from the prime mover's generator, or any further increase of voltage on the traction motor is not desirable.

In order to produce further increase in speed of the locomotive, some change must be made in the electrical circuit of the traction motors in order that they may operate at a lower voltage. By providing a resistive shunt across the field windings, the motor may be made to operate at a lower point on its characteristic curve. This has the effect of "shifting gears" and permits the voltage across the motor to be again increased. Thus, the locomotive may be further accelerated until a maximum potential is approached once more. By providing a plurality of resistive shunts which may be successively connected across the field windings, the locomotive may be accelerated to speeds limited only by mechanical and other electrical factors of the traction motors.

The resistive shunts may be successively connected across the field winding manually. However, for smoother, more reliable operation, it is preferable to provide automatic means for controlling the connection of the shunts. Numerous types of devices have been proposed heretofore for automatically controlling the shunts. However, none of these have been entirely satisfactory. Many of the control systems proposed heretofore have been extremely complicated and costly to install and maintain. Moreover, some of the prior art control systems have employed electron tubes. However, locomotives are frequently subjected to severe mechanical shock, as when coupling cars, starting or stopping with a train of cars attached and travelling over rough roadbeds. Unfortunately, electron tubes are subject to failure due to high physical shock. Consequently, control systems employing electron tubes require considerable maintenance and still may fail during operation of the locomotive.

These disadvantages of prior art control systems are overcome with the present invention and a novel control system is provided which is simple in construction and economical while being virtually insensitive to physical shock and requiring little or no maintenance.

The advantages of the present invention are preferably attained by providing novel means for controlling the successive connection of shunting resistances across the field windings of the diesel electric locomotive motors comprising a source of fixed voltage, a first transistor having collector, emitter and base electrodes, the emitter of said first transistor being connected to the positive terminal of said fixed voltage source, resistance means connecting the collector of said first transistor to the negative terminal of said fixed voltage source, a generator establishing a variable voltage functionally related to the speed of the locomotive, means applying said variable voltage to the base of said first transistor, a second transistor having collector, emitter and base electrodes, means connecting

2

the emitter of said transistor to the positive terminal of said fixed voltage source, means connecting the base of said second transistor to the collector of said first transistor, means connecting a relay in series between the collector of said second transistor and the negative terminal of said fixed voltage source, means actuated by energization of said relay for controlling the connection and disconnection of a resistive shunt for the field winding of a diesel electric locomotive motor, and resistance means connecting the base of said first transistor with the collector of said second transistor.

With this arrangement, no electron tubes are used and all moving parts between the generator and the relay are eliminated. Thus, the device of the present invention is virtually insensitive to physical shock. Moreover, the device of the present invention draws so little generator current that it may readily be provided in several stages to permit higher speeds for the locomotive.

Accordingly, it is an object of the present invention to provide novel means for controlling the connection and disconnection of resistive shunts for the traction motor fields of the diesel electric locomotive.

Another object of the present invention is to provide novel means requiring no electron tubes for controlling the connection and disconnection of resistive shunts for the traction motor fields of a diesel electric locomotive.

A further object of the present invention is to provide novel means requiring no moving parts for controlling the connection and disconnection of resistive shunts for the traction motor fields of a diesel electric locomotive.

An additional object of the present invention is to provide novel means for controlling the connection and disconnection of resistive shunts for the traction motor fields of a diesel electric locomotive and which is virtually insensitive to physical shock.

Still another object of the present invention is to provide novel means for controlling the connection and disconnection of resistive shunts for the traction motor fields of a diesel electric locomotive and which requires virtually no maintenance.

A specific object of the present invention is to provide novel means for controlling the connection and disconnection of resistive shunts for the traction motor fields of a diesel electric locomotive, said means comprising a source of fixed voltage, a first transistor having collector, emitter and base electrodes, the emitter of said first transistor being connected to the positive terminal of said fixed voltage source, resistance means connecting the collector of said first transistor to the negative terminal of said fixed voltage source, a generator establishing a variable voltage functionally related to the speed of the locomotive, means applying said variable voltage to the base of said first transistor, a second transistor having emitter, collector and base electrodes, means connecting the emitter of said second transistor to the positive terminal of said fixed voltage source, means connecting the base of said second transistor to the collector of said first transistor, means connecting a relay in series between the collector of said second transistor and the negative terminal of said fixed voltage source, means actuated by energization of said relay for controlling the connecting and disconnecting of resistive shunts for the traction motor fields of a diesel electric locomotive, and resistance means connecting the base of said first transistor with the collector of said second transistor.

These and other objects and features of the present invention will be apparent from the following detailed description wherein reference is made to the figures of the accompanying drawing.

In the drawing:

FIG. 1 is a schematic diagram of a typical control device embodying the present invention.

In that form of the present invention chosen for purposes of illustration in the drawing, FIG. 1 shows a control device which is energized by a suitable source 2 of fixed voltage having a voltage divider 4 connected in series therewith. If desired, a Zener diode 5 or the like may be connected in parallel with voltage divider 4 to provide regulation. A first transistor 6 is provided having the emitter thereof connected to the positive terminal of the fixed voltage source 2 and the collector connected to resistor 8 to the negative terminal of the source 2. The base of transistor 6 is connected through biasing resistor 10 and capacitor 12 to a suitable tap 14 on the voltage divider 4. A second transistor 16 is also provided having the emitter thereof connected to the positive terminal of the fixed voltage source 2 and having the collector connected through one or more suitable contactor relays 18 to the negative terminal of source 2. The contactor relays 18 control the opening and closing of resistive shunt circuits, not shown, across the field windings of the locomotive traction motors. The base of transistor 16 is connected to the collector of transistor 6. Moreover, the resistor 20 is connected between the base of transistor 6 and the collector of transistor 16 and a biasing resistor 22 is connected between the base of transistor 6 and the negative terminal of the fixed voltage source 2.

A variable voltage source 24, such as an axle generator, is provided to produce a voltage which is functionally related to the speed of the locomotive. The output of the variable voltage source 24 is applied to a rectifier bridge 26 to establish a variable voltage direct current which is applied across capacitor 12.

In operation, with the locomotive standing still, transistor 6 is biased to conduct by means of voltage divider 4 and biasing resistors 20 and 22. Thus, the potential drop between the emitter and collector of transistor 6 will be low and the potential applied to the base of transistor 16 will be negative with respect to the emitter because of the voltage drop of rectifier 33. Consequently, transistor 16 will be cut off. As the locomotive starts to move, axle generator 24 begins to develop a voltage having a value functionally related to the speed of the locomotive. This voltage is converted to a variable voltage direct current by rectifier bridge 26 and is applied through resistor 10 to the base of transistor 6.

As the speed of the locomotive increases, the voltage of the generator increases. The generator voltage subtracts from the bias voltage applied to the base by the setting of tap 14. At a predetermined voltage, and therefore a predetermined speed, the emitter to base voltage of transistor 6 reaches a very low level. The current that is flowing in the emitter to base circuit of transistor 6 is reduced. A reduction of base current reduces the emitter to collector current in transistor 6. A reduction in emitter to collector current in transistor 6 reduces the current from transistor 6 that flows in resistor 8 and allows emitter to base current of transistor 16 to flow to resistor 8. Allowing emitter to base current to flow in transistor 16 thus permits emitter to collector current to flow in transistor 16 by the relationship of the current gain in the transistor. As collector current starts to flow in transistor 16, the voltage at its collector becomes more positive. A more positive potential at the collector reduces the flow of current through resistor 20. A reduction of current in resistor 20 reduces the current flow in the base of transistor 6. This action drives transistor 6 farther toward non-conduction and thus accelerates the action started by the generator. This positive feedback action provides bistable operation of transistors 6 and 16 and therefore provides positive switching action. The current in coil of contactor 18 is increased very rapidly, as though 16 were closed as a switch. The contactor 18 closes a circuit which places a resistor, not shown, in parallel with the traction motor field. If a plurality of contactors 18 are used, each inserts a resistance in the field of its respective traction motor. The circuit closed by

contactor 18 is conventional and it is not believed necessary to show or describe this circuit in detail as it would be well known to those skilled in the art.

The closing of a contactor and the insertion of its respective resistance in each motor circuit of the locomotive permits an increase in locomotive speed without exceeding motor design parameters.

As the locomotive slows down, the output of the axle generator will decrease. At a predetermined speed, usually just below the speed at which the transistors 6 and 16 switched in the increase speed direction, the potential at the base of transistor 6 will become such as to permit current to flow in the emitter-base circuit. Current flows in the emitter to collector circuit and in resistor 8 from transistor 6. This action reduces the transistor 16 emitter to base current that can flow in resistor 8. A reduction in emitter to base current of transistor 16 reduces the emitter to collector current of transistor 16. The voltage of the collector of transistor 16 becomes more negative. A reduction in the voltage from the collector of transistor 16 to the negative side of fixed voltage source 2 increases the current that can flow through resistor 20 from the base of transistor 6. Thus the combination of transistor 16 acts as a switch in the "turn off" direction.

If the current through the contactor coils 18 is reduced instantaneously, the induced potential of the coils will attempt to produce a voltage at the collector of transistor 16 in opposition to the applied voltage and thus produce undesirably high voltages across the emitter to collector of transistor 16. The circuits containing capacitor 28, resistor 30 and rectifier 32 provide means for preventing the current through the coils 18 from changing instantaneously and thus avoid undesirable potentials.

It will be apparent to those versed in the art that the control circuit hereinabove described could, if desired, be produced to provide a multistage circuit wherein each stage would control the operation of a single respective relay. It is believed that such multiplication of the basic circuit is within the skill of the ordinary engineer and, consequently, it is not deemed necessary to show or describe such a multistage circuit in detail.

In addition, numerous other variations and modifications may obviously be made without departing from the invention. Accordingly, it should be clearly understood that the form of the present invention described above and shown in the figure of the accompanying drawing is illustrative only and is not intended to limit the scope of the invention.

What is claimed is:

1. A switching circuit comprising first terminal means for connecting a source of fixed voltage thereto, a first transistor having collector, emitter, and base electrodes, the collector and emitter electrodes of said first transistor being connected in series with said first terminal means, electrically passive biasing means connected between said fixed voltage at said first terminal means and the base electrode of said first transistor, said biasing means and said fixed voltage operating to furnish a potential to bias said first transistor into an initial state of conduction, a second transistor having collector, emitter, and base electrodes, first electrically passive means connecting the base electrode of said second transistor to the collector electrode of said first transistor, whereby the emitter-collector current through said second transistor is controlled by the emitter-collector current through said first transistor, means connecting the emitter of said second transistor to a positive terminal of said fixed voltage source, whereby said second transistor is initially biased to cut-off, second terminal means for connecting a current controlled device in series between the collector electrode of said second transistor and a negative terminal of said fixed voltage source, third terminal means for connecting a source of variable voltage thereto, and second electrically passive means connected across a portion of said first biasing means for applying said source of variable voltage

5

to the base of said first transistor, whereby said variable voltage is applied in opposition to the initial bias potential on said first transistor, and the conduction of said first transistor is varied at a predetermined amplitude of said variable voltage to cause an opposite variation in the conduction of said second transistor.

2. The switching circuit of claim 1 wherein said second electrically passive means comprises: a bridge rectifier means, said bridge rectifier means operating to convert said variable voltage applied to said third terminal means into a varying D.C. potential opposite in sign to the initial bias potential applied to said first transistor.

3. The switching circuit of claim 1 wherein said passive biasing means includes a variable voltage divider connected across said first terminal means.

6

4. The switching circuit of claim 1 wherein resistance means are connected between the base of said first transistor and the collector of said second transistor, said resistance means acting to provide a positive feedback potential to the base electrode of said first transistor upon the conduction of said second transistor.

References Cited by the Examiner

UNITED STATES PATENTS

10	2,617,970	11/52	Justus	-----	318—249
	3,011,076	11/61	Paradise	-----	307—88.5

JOHN W. HUCKERT, *Primary Examiner*.

15 MILTON O. HIRSCHFIELD, *Examiner*.