

[54] ELECTRIC RAILWAY SPEED CONTROL

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[22] Filed: Nov. 24, 1972

[21] Appl. No.: 309,061

[30] Foreign Application Priority Data

Feb. 10, 1972 Canada 134456

[52] U.S. Cl. 318/270, 318/376

[51] Int. Cl. H02p 1/20, H02p 3/14

[58] Field of Search 290/3, 9, 45; 318/87, 139, 318/269, 270, 272, 273, 275, 376, 396, 397, 420-422, 462

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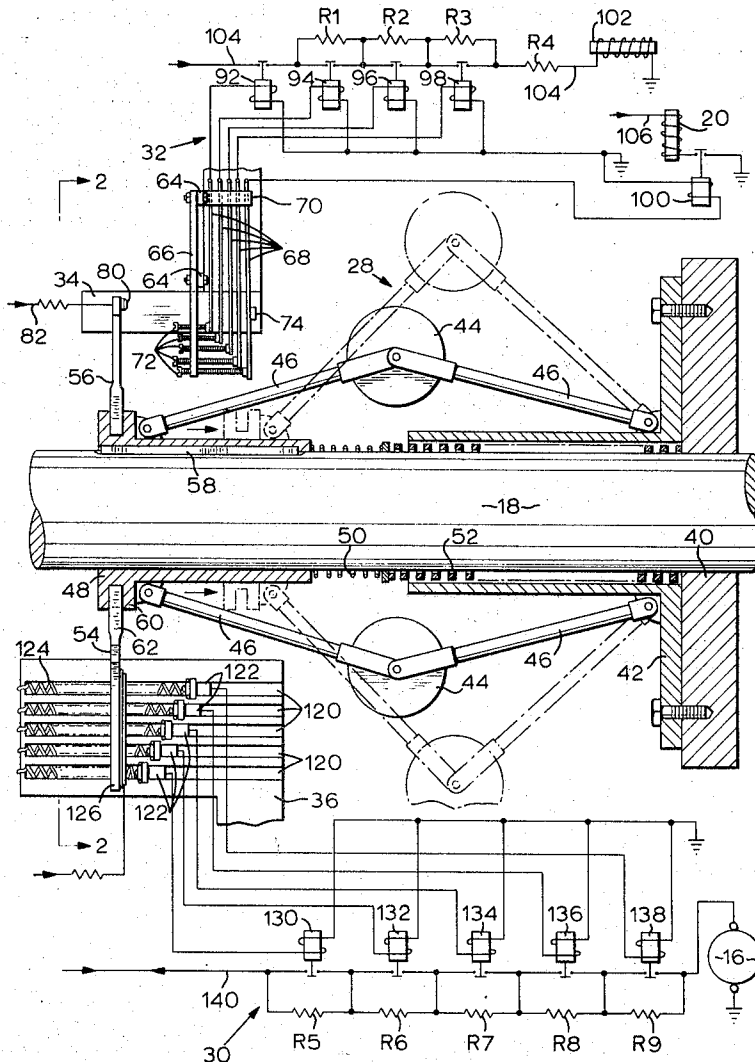
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[57] ABSTRACT

Regenerative braking systems which have previously been used in association with electrically driven vehicles have been manually controlled whereas the present invention provides a governor which automatically controls the starting resistance of the series winding of the motor and the regenerative braking resistance of the motor in proportion to the speed of the vehicle. The starting resistance means and the braking resistance means vary in a series of steps which progressively decrease the starting and braking resistance as the speed of the vehicle increases and progressively decreases the starting and braking resistance as the speed of the vehicle decreases within predetermined limits so that the variation in the starting resistance is effective in the low speed range while the variations in the braking resistance are effective in the high speed range. In addition, the governor of the present invention is mounted directly onto the output drive shaft of the motor so that there is no danger of failure of the governor as a result of a failure of any transmission used to transmit power to the governor which might otherwise permit the motor to rotate at high speed while the governor is inoperative.

6 Claims, 3 Drawing Figures



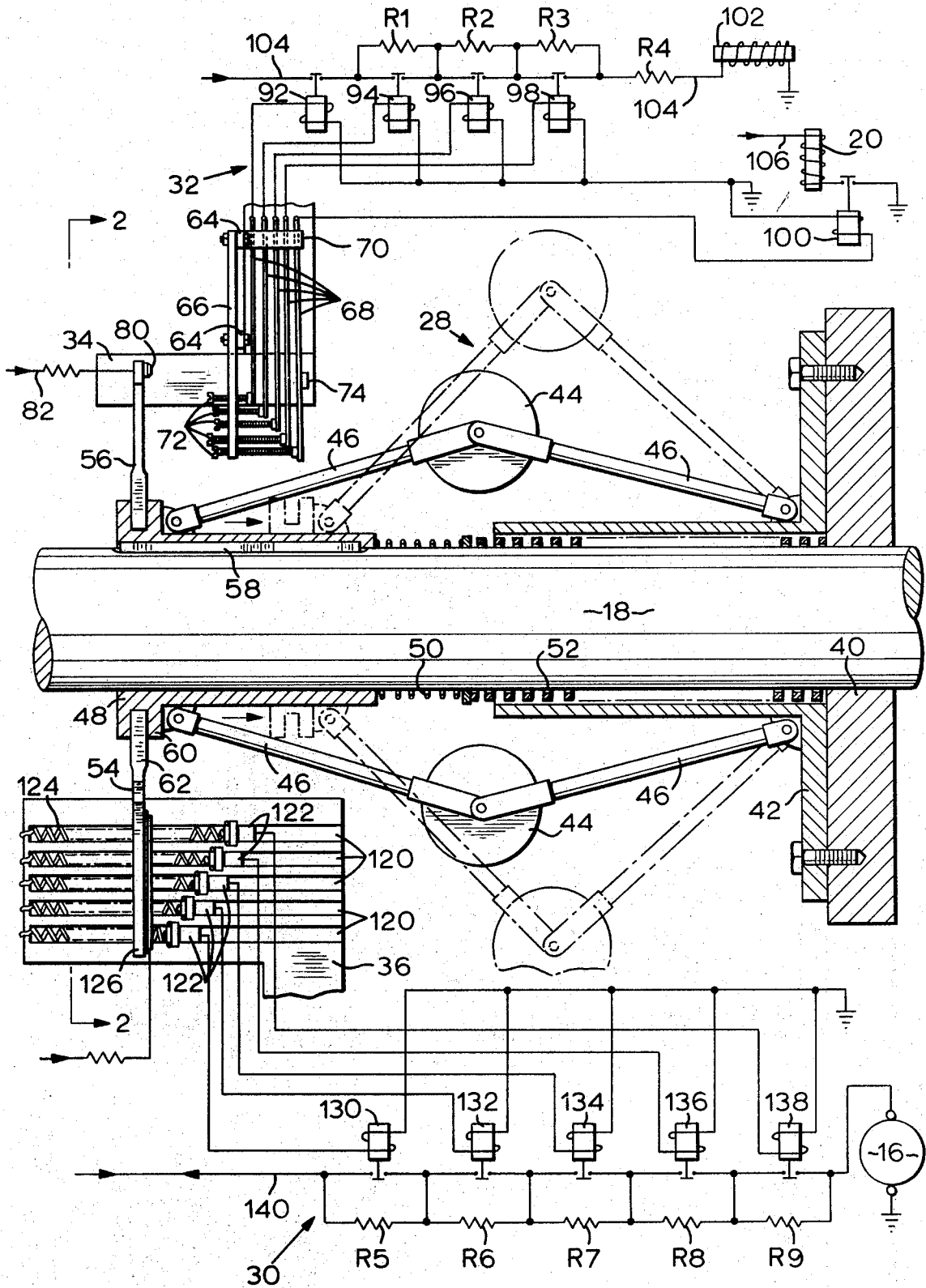


FIG. 1

ELECTRIC RAILWAY SPEED CONTROL

This invention relates to self-propelled electric railway cars. In particular, this invention relates to improvements in self-propelled electric railway cars incorporating a regenerative braking motor and a governor for controlling the operation of the motor.

In my prior Canadian Pat. No. 647,365, dated Aug. 28, 1962, I described an electric railway apparatus wherein the individual cars are driven by an electric motor which is directly connected to the wheel axle. I have also described the method of supplying power to the motor and the method of insulating the motor relative to the power supply. In my prior patent I have described electric railway apparatus which is suitable for use without the assistance of an operator. One of the problems associated with the operation of vehicles without the assistance of an operator is to ensure that the vehicle will start, brake and stop in a manner which will permit the safe operation of the vehicle. It is important to ensure that when an unmanned electric vehicle slows down as a result of an increased load applied when the vehicle encounters an upward incline, the power supplied to the motor is adjusted accordingly and also it is important to adjust the power supplied to a motor when travelling at high speed in order to prevent damage to the motor resulting from over-driving the motor.

It is well known to use various resistances in a starter for an electric motor and regenerative braking systems have also been provided for electric locomotives and the like to effect braking and to prevent over-running of the motor. However, the known regenerative braking systems are controlled by the operator of the vehicle and no system has yet been provided which will operate automatically without an operator. A further problem with the known starter series resistance systems and regenerative braking systems has been in attempting to provide for the operation of these systems in direct response to the rotation of the motor drive shaft so that failure of a gear transmission system disposed intermediate the drive motor and the control mechanisms for controlling the operation of the starter system and the regenerative braking system cannot occur.

The present invention overcomes the difficulties of the prior art described above and provides a governor which automatically controls the speed of the car by automatically regulating the starting resistance and regenerative braking resistance in a predetermined manner with respect to the speed of the car.

In addition, the present invention provides a governor for use in association with a self-propelled electric railway car or the like wherein the power supplied to the drive motor and the regenerative braking of the motor is provided in a series of steps which are balanced against an appropriate speed of the motor.

Furthermore, the governor of the present invention may be mounted directly on the drive shaft of the motor so that the dangers associated with the usual transmission of power to the governor are eliminated.

The present invention also provides a braking system which is operable by means of the governor at excessive speeds of the motor to apply a conventional brake to the vehicle.

According to an embodiment of the present invention, there is provided, in a self-propelled electric railway car or the like which has a series winding and a regenerative field winding which are not directly connected to one another, starting resistance means for the series winding and regenerative braking resistance means for the regenerative field winding of the motor, the improvement of governor means operative in response to a predetermined speed of said car to control the starting resistance means and the braking resistance means as required in use.

The invention will be more clearly understood after reference to the following detailed specification read in conjunction with the drawings, wherein

FIG. 1 is a partially sectioned view of a governor and starting resistance means and braking resistance means according to an embodiment of the present invention;

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1; and

FIG. 3 is a partially sectioned view illustrating the manner in which the apparatus of the present invention is mounted on a vehicle.

As shown in FIG. 3 of the drawings, a vehicle having a frame generally identified by the reference numeral 10 has a pair of wheels 12 which support the vehicle on rails 14 and 14a. The wheels 12 are mounted on a common axis. A regenerative motor 16 is mounted on the frame 10 by suitable means (not shown) so that the housing of the motor is stationary relative to the frame. The motor 16 has output drive shafts 18 extending from opposite ends thereof and a pair of solenoid operated brakes 20 are mounted on the shafts 18. The brakes 20 may be of the well known type operated by a solenoid in order to effect braking of the motor drive shaft 18. The rail 14a is connected to a dc power supply and in order to insulate the motor 16 from the power supply, an insulated coupling 22 is provided in the shaft 18. A contactor wheel 24 is provided on the shaft 18 outwardly from the coupling 22 and contactor 26 is mounted on the shaft 18 on the opposite side of the motor and adjacent to the governor 28. A rheostat 30, which will be described hereinafter, is connected in the series circuit of the motor 16 and rheostat 32 is connected in the field winding circuit of the motor 16. Support arms 34 and 36 are mounted on the motor 16 and project outwardly therefrom towards the rail 14 so as to overlie the governor 28.

The governor 28 and associated rheostats 30 and 32 form a principal feature of the present invention and are more clearly illustrated in FIGS. 1 and 2.

With reference to FIG. 1 of the drawings, it will be seen that the governor which is generally identified by the reference numeral 28 consists of a base plate 40 which is secured to the shaft 18 for rotation therewith, a collar plate 42, a pair of governor balls 44 mounted on arms 46, a sleeve 48, springs 50 and 52, and a pair of laterally projecting arms 54 and 56 extending outwardly from the slip ring 62. The sleeve 48 is rigidly keyed to the shaft 18 by means of a key 58 so that the sleeve 48, governor balls 44, arms 46, collar plate 42 and base plate 40 will rotate with the shaft 18 in use. The arms 54 and 56 are connected by means of a slip ring 62 which is a sliding fit in the annular recess 60 formed in the sleeve 48. An important feature of the rotating governor assembly is the provision of springs 50 and 52 of different compressive strengths so that the

initial movement of the governor will be primarily controlled by the lightweight compression spring 50 while the later movement of the governor will be primarily controlled by the heavier compressive spring 52. As shown in FIGS. 1 and 2 of the drawings, the support arm 34 has a pair of upright supports 64 which are connected at their upper ends to a transverse support bar 66. A plurality of spring-like arms 68 are mounted in a bracket 70 which extends laterally from the support 64 so as to extend outwardly towards the shaft 18. The spring-like arms 68 increase in length in a direction towards the governor balls. Adjustment screws 72 are provided at the inner end of the arm 66 so as to adjust the spacings between the arms 68 to control the timing of the operation of the device as will be described hereinafter. An anvil-like member 74 is mounted on the bracket 34 and projects upwardly therefrom behind the arms 68. The support block 70 and the inner ends of the adjustment screws 72 are made from an insulating material so that each of the spring-like arms 68 is insulated from one another when in the spaced position shown in FIG. 1 of the drawings. The arm 56 which projects outwardly from the slip ring 62 has a contact member 80 at the outer end thereof which is insulated with respect to the remainder of the arm and which is connected to a power source by means of the line 82. The first, second, third and fourth arms 68 are connected to solenoids 92, 94, 96 and 98, respectively, and the last arm 68 is connected to solenoid 100, as shown in FIG. 1. The field winding 102 of the motor is connected to a power source by way of line 104 and resistances R1, R2, R3 and R4, depending upon the operation of the solenoids 92, 94, 96 and 98. The emergency brake 20 is connected to a power source by way of line 106 and the power supplied to the brake is interrupted by the solenoid 100 when braking is not required.

The arm 36 on the other side of the shaft 18 is formed with a plurality of recessed channels 120 within which sliding contact members 122 are reciprocally mounted. The sliding contact members 122 are connected to the end wall of the arm 36 by springs 124 and the contact members 122 are longitudinally spaced relative to one another on the arm 36. The arm 54 which projects outwardly from the slip ring 62 has an electrical contact 126 extending transversely over a substantial length thereof so as to be alignable with each of the contacts 122. The power supply to the series winding of the motor is controlled by the rheostat, diagrammatically illustrated at 30 in FIG. 1, which includes solenoids 130, 132, 134, 136 and 138, each of which is connected to a contact 122. The power supply to the series winding of the motor is supplied directly through line 140 or through resistances R5, R6, R7, R8 and R9, depending upon the position of the solenoid switches 130, 132, 134, 136, 138.

To start the forward motion of the vehicle, power is supplied to the series winding by way of the rail 14a, wheel 12, contact wheel 24, line 140 and resistances R5, R6, R7, R8 and R9. As the vehicle begins to move, the governor balls are rotated and as the vehicle gathers speed, the governor balls move outwardly causing the collar 48 to move towards the sleeve member 42. The contact 126 will eventually make contact with the first contact 122, thereby activating the solenoid 130 to remove resistance R5, thereby increasing the power supplied to the motor. As the vehicle picks up more speed, the first contact 122 is moved within the slide

passage 120 towards the second contact 122. When contact is made with the second contact 122, the second solenoid 132 will be activated removing the resistance R6, with the result that both the resistances R5 and R6 will be removed from the circuit thereby further increasing the power supplied to the motor. A further increase in speed will remove the resistances R7, R8, R9 from the circuit. The movement of the governor over the period during which contact is made with the various contacts 122 is primarily controlled by the lightweight spring 50. However, after all of the contacts 122 have been brought into use, the spring 50 is substantially fully compressed and the further movement of the collar is controlled by the heavier compressive spring 52. The use of this double spring assembly permits the starting resistance means to operate in response to a substantial movement of the contact arm 54 for a relatively low increase in speed of the vehicle. All of the starting resistances will be removed from the series circuit by the time the vehicle has reached a relatively low starting speed in the range of about 5 to 18 miles per hour for a self-propelled electric railway car or the like.

With full power being supplied to the motor and the car running on a level track, the car will gather speed until at a predetermined maximum speed the governor will operate to bring the contact 80 of the arm 56 into contact with the first of the spring-like contact arms 68. When this first contact is made, the solenoid 92 will be activated to connect the regenerative circuit 102 of the motor to the power supply by way of line 104 and resistances R1, R2, R3 and R4. The regenerative braking circuit, being operative, will then tend to apply braking force to the motor serving to slow the forward speed of the vehicle. If the vehicle continues to accelerate, as will occur when running downhill, the governor will continue to operate to cause the arm 56 to move so as to cause the contact 80 to make contact with both the first and second arm 68, thereby activating the solenoid 94 to remove resistance R1 from the regenerative braking circuit. Further acceleration of the vehicle will activate solenoids 96 and 98, removing resistances R2 and R3 from the regenerative braking circuit, thereby increasing the braking effect of the regenerative braking circuit on the motor. If the vehicle continues to accelerate, the contact 80 will eventually be placed in contact with all of the arms 68 so that eventually the solenoid 100 will be activated which will connect the emergency brakes 20 to the power source by means of the line 106, thereby applying a direct braking force to the axle of the vehicle.

As the vehicle begins to slow down, the operation of the governor will be the reverse to that previously described above so that if initially the governor is in a position to apply the emergency braking system as described above, slowing will initially release the emergency brake system and subsequently remove the regenerative braking load from the motor until the required cruising speed is obtained. Generally the motor will have sufficient power to drive the vehicle up any predetermined incline in its path. As the vehicle slows down below the cruising speed, the operation of the starting circuit will be reversed from that previously described in that the resistances R9, R8, R7, R6 and R5 will be added to the power supply line as a result of disengagement of the contact 126 with successive contacts 122.

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From the foregoing it will be apparent that the present invention provides a simple and inexpensive governor system which will be used on self-propelled electrically driven track vehicles such as railway cars and the like and which may be employed to operate the vehicle without manual control so as to regulate the maximum speed of the vehicle and prevent overloading of the drive motor.

It is believed that the system of the present invention may be particularly suitable for use in railway vehicles for use in northern areas wherein railway cars may be transported over long distances without requiring an operator. There are considerable advantages resulting from the use of a railway system as opposed to, for example, a pipe line in northern areas due to the fact that a failure in a pipe line conveying oil or the like may result in spillage of enormous quantities of oil before the leakage is detected whereas in the event of a failure in a track vehicle, the only damage likely to occur will be as a result of a derailment of a number of tank cars and techniques for controlling and preventing derailments of railway cars are well known and highly developed.

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

1. In a self-propelled electric railway car or the like having drive wheel means for driving the car along a track and mechanical brake means for braking the car, the improvement of: regenerative braking motor means having output shaft means drivingly connected to said drive wheel means of said car, said regenerative motor means having a series winding and a regenerative field winding which are not directly connected to one another, starting resistance means for said series winding of said motor, regenerative braking resistance means for said regenerative field winding of said motor, mechanical governor means mounted on said drive shaft of said motor and operative in response to rotation of said drive shaft to control said starting resistance means and said braking resistance means as required in use.

2. In a self-propelled electric railway car which has a regenerative braking motor means having a series winding and a regenerative field winding which are not directly connected to one another, starting resistance means for said series winding of said motor, regenerative braking resistance means for said regenerative field winding of said motor, the improvement of mechanical governor means operative in response to a predetermined speed of said car to control said starting resistance and said braking resistance as required in use,

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said mechanical governor being a two-stage governor, the first stage being operative at slow speeds to effect a step variation in said starting resistance which is balanced against the appropriate speed of said car, the second stage being operative at high speed to effect a step variation in the regenerative braking resistance which is balanced against the appropriate speed of the car.

3. A self-propelled railway car as claimed in claim 1 having mechanical braking means, said governor means being operative to activate said mechanical braking means for said car at a predetermined speed of said car.

4. In a self-propelled electric railway car or the like having drive wheel means for driving the car along a track and mechanical brake means for braking the car, the improvement of: regenerative braking motor means having output shaft means drivingly connected to said drive wheel means of said car, said regenerative motor means having a series winding and a regenerative field winding which are not directly connected to one another, starting resistance means for said series winding of said motor, regenerative braking resistance means for said regenerative field winding of said motor, mechanical governor means mounted on said drive shaft of said motor and operative in response to rotation of said drive shaft to control said starting resistance means and said braking resistance means as required in use, said governor being a two-stage governor, the first stage being operative at slow speeds to effect a step variation in said starting resistance which is balanced against the appropriate speed of said motor, the second stage being operative at high speed to effect a step variation in the regenerative braking resistance which is balanced against the appropriate speed of the motor.

5. A self-propelled railway car as claimed in claim 4 wherein said governor means is operative to activate said mechanical braking means for said car at a predetermined speed of rotation of said shaft.

6. A self-propelled electric railway car having a propulsion unit comprising regenerative braking motor means having a series winding and a regenerative field winding which are not directly connected to one another, starting resistance means for said series winding of said motor, regenerative braking resistance means for said regenerative field winding of said motor, mechanical governor means operative in response to a predetermined speed of said car to control said starting resistance and said braking resistance as required in use.

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