

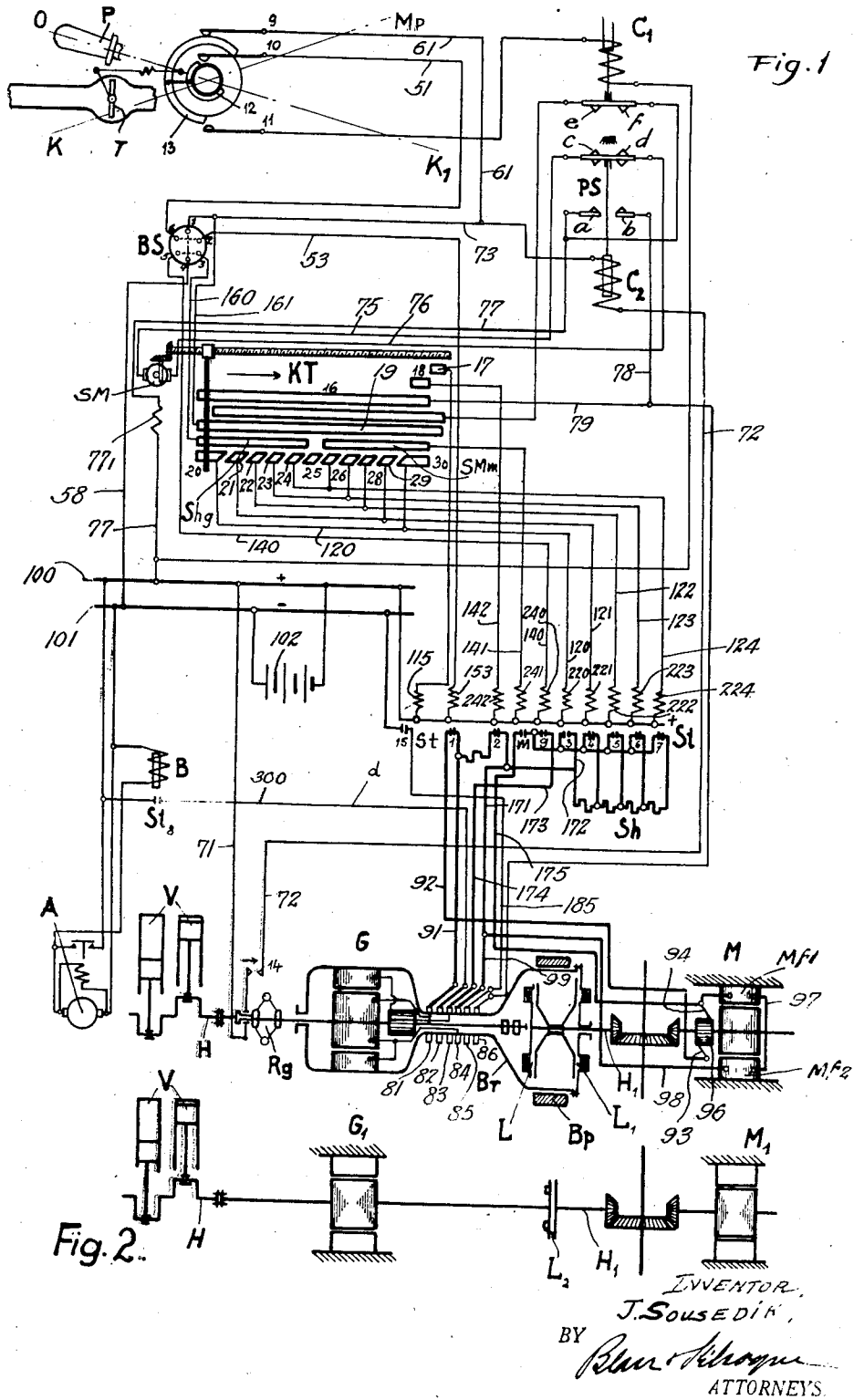
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ELECTRICAL TRANSMISSION GEAR, IN PARTICULAR FOR TRACTION MACHINES

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ELECTRICAL TRANSMISSION GEAR, IN PARTICULAR FOR TRACTION MACHINES

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This invention relates to an electrical transmission gear, in particular for traction machines, of the kind in which the speed regulation of a unit, which consists of an internal combustion engine, an electrical generator and an electric motor, is effected by varying the energisation of an auxiliary regulating device of the electrical system of the gear.

The object of an arrangement of this kind for driving the vehicle both by means of an internal combustion engine as well as by means of an electric motor, is to distribute the forces and torques which act on the driving shaft in such a way that the internal combustion engine is not overloaded either at first when the vehicle is started-up in overcoming high starting torques and frictional resistance or if a sudden increase in load occurs, and therefore the power of the engine can be fully utilised with little loss for increasing the acceleration. For this purpose the driving shaft of the vehicle is driven, in the circumstances mentioned, not only by the internal combustion engine, by the reaction of the armature of the generator, but is simultaneously driven by the electric motor.

The object of the present invention is to simplify the arrangement in such a way that the regulation takes place automatically and with the aid of means which are normally available and without any special supervision by the driver being required. Further, with the arrangement of the invention, when the engine is controlled by the driver, there is no danger of a part of the unit which is defective or stops moving owing to the bearings heating up or for other reasons being kept in movement by the remaining parts which are still running, in which case the entire unit might be destroyed. Also, the working of the generator is not confined only to starting the engine and to times when the vehicle is ascending a gradient, but the generator also comes into operation during normal running, being usefully employed for various purposes.

The desired result is obtained in one arrangement constructed in accordance with the invention by controlling simultaneously with the throttle the electrical controlling circuits of an automatically rotatable controller and the contact devices, namely by the arrangement of a reversing device for reversing the servomotor which drives the controller and by arranging, in the circuit of the reversing device, contacts which are actuated from the governor which is mounted on the shaft of the internal combustion engine. A faulty part of the unit is prevented from being ro-

tated by connecting the circuit of the coupling by means of an auxiliary relay belonging to the part in question, the contacts of which are situated in series with the circuit of the coupling and which may be energised, for example, by a lighting dynamo.

According to a further feature of the invention the generator is utilised for other purposes than for starting, and in two different ways. In the first place the stator of the generator is provided with two couplings for changing over the mechanical connection of the stator and rotor directly to the driving shaft, and the motor is provided with a brake which holds the stator fast when the rotor is mechanically connected to the driving shaft. In a second form of construction the generator has a stationary stator but its rotor is connected to the driving shaft by means of a clutch.

Two forms of construction of an arrangement in accordance with the invention are illustrated diagrammatically and by way of example in the accompanying drawing, in which

Figure 1 is a diagram showing the arrangement of the first form and

Figure 2 is a diagram showing a different arrangement of the generator.

Referring to Figure 1 of the drawing, the throttle lever P can be moved in succession into four different basic positions. In the normal position O the fuel is entirely cut off at the throttle T and the circuit to the main switch I in the circuit of the generator and motor is broken. This lever can be rotated out of its normal position either clockwise into the position Mp for the maximum supply of fuel or still further into the position K₁ for connecting the electrical transmission; it can also be rotated in the reverse direction into the position K for connecting the controlling device.

When the vehicle is started and the lever is moved from the position O, an auxiliary circuit is connected, by way of the contacts 9 and 10 and the segments 12 and 13, for the main switch St₁, which connects the main circuit of the generator G (or G₁ in Fig. 2) to the motor M (or M₁ in Fig. 2). The energizing circuit for this connection may be traced from the negative main 101 of the battery system 102, by way of conductor 58, contacts BS₄ and BS₁ of switch BS, conductor 73, conductor 61, contactor 9, segment 13, jumper 104, segment 12, contactor 10, conductor 51, contacts BS₆ and BS₂, conductor 53, relay 153 to the positive main 100. This circuit closes contactor St₁ which completes the circuit from the slip ring 81 of the generator through

conductor 91, switch St_1 , conductor 92, brush 93 of the motor M, commutator 96, brush 94, field winding Mf_1 , conductor 97, field winding Mf_2 , conductor 98, conductor 99, and slip ring 84. On rotating the lever P in a clockwise direction further towards the position Mp more fuel is admitted to the internal combustion engine V; thus, when fuel is admitted, the circuit of the machines G and M is also closed. The maximum ratio of the electrical transmission is thereby obtained, since, at the same time, by means of the controller KT, which is in the position O when the vehicle is ready to start, the auxiliary or battery circuit is closed by the switches St_g through the contacts 20 and the segment Sh_g , that is to say the generator G (or G_1) is shunted by way of the switch St_3 which short circuits the main magnets of the generator. The controller KT is operated by a bridging conductive element extending along the dot and dash line indicated in this figure which experiences relative movement with respect to the conductive segments indicated in the drawing by moving one or the other of the parts. Switch St_g is closed by the energization of relay 240 in the circuit from the positive main 100, relay 240, conductor 140, contacts BS_5 and BS_3 , conductor 160, segment Sh_g , the conductive bar of the controller to segment 19, conductor 161, contacts BS_1 and BS_4 , conductor 58, to negative main 101.

Switch St_3 is also closed by the energization of relay 220 in the circuit from the positive main 100, relay 220, conductor 120, contact segment 20, contact segment 19 and to the negative main as outlined above.

The closing of switches St_g and St_3 operate to complete a circuit from slip ring 84, conductor 99, conductors 171, 172, switch St_3 , switch St_g , conductor 173, conductor 174 to slip ring 83, between which and slip ring 84 are connected the main windings of the generator. The generator is now energized only by means of a separate winding for the production of a definite maximum current for starting-up the vehicle, so that the vehicle is set in motion.

The further starting of the vehicle takes place automatically owing to the fact that the load on the internal combustion engine is not so great after starting and its centrifugal governor Rg is set in operation and, after a definite speed of revolution has been reached, closes the contacts 14 and therefore the circuit of the switch PS which connects the servomotor SM of the controller KT. The bar 19 of the controller is connected through a blocking switch BS to the minus pole of the battery. The circuit for the servomotor SM is energized from the positive main 100, conductor 71, contacts 14, which have been closed by the centrifugal governor, conductor 72, relay winding C_2 , conductor 73, contactors BS_1 and BS_4 , and conductor 58 to the negative main 101. The actuation of the armature of the switching device PS serves to connect the mains 75 and 76 connected to the opposite terminals of the servomotor and terminating at contacts c and d with the lower set of contacts a and b respectively of the switching device PS. The contact b of the switch PS is connected by way of conductor 78 and conductor 79 to segment 16 of the controller, which is connected to the negative main 101 by way of the conductive element of the controller and the continuous segment 19. The contact a of the switch PS is connected by way of conductor 77, to the positive main 100 with the interposition of a resistance 77r in the con-

necting line. The blocking switch BS enables the connections indicated in dotted lines to be broken and can therefore block any connections which can be made by the lever P. The end connection of the servomotor SM in the end positions of the controller KT is made possible owing to the bars 16 and 17. As long as the speed of revolution of the internal combustion engine V does not fall below the normal speed, the controller displaces, according to the acceleration of the vehicle by reducing the shunting of the generator, the contacts stepwise along the row of contacts 20—25. At each one of these steps, the switch St_g remains closed by the continuous energization of coil 240 through segment Sh_g . The conductive element of the controller brushing across the contact segments 21, 22, 23, and 24, serves to energize the relays 221, 222, 223 and 224 by way of conductors 121, 122, 123 and 124, respectively, to selectively close switches 4, 5, 6 and 7 of the switch mechanism St to adjust the resistance shunted across the slip rings 83 and 84 of the generator G. On sliding over the contact 26 of the controller KT, the shunt resistance Sh is changed over to the driving motor by means of the segment SH_m by closing the switch ST_m and St_r . The switch ST_m is closed by the energization of relay 241 by a circuit extending from the positive main 100, relay 241, conductor 141, contact segment Sh_m , segment 19, to the negative main 101 as outlined above. The closing of switch ST_m completes a circuit from the field winding Mf_2 of the motor M through conductor 98, conductor 171, resistances Sh , switches St_r and ST_m , conductor 175 to the field winding Mf_1 of motor M. The operation of segments 27, 28 and 29 closes switches 6, 5 and 4, respectively, and decreases the amounts of resistance inserted in the circuit. Consequently, owing to the further reduction in the degree of energization of the electromagnets owing to the connection of St_6 , St_5 and St_4 , the driving motor continues to drive the vehicle until finally, on passing over the contact 30, the auxiliary circuit is closed by way of the contact 17 at the contact St_{15} . At the time of this connection, the relay 115 is energized by the completion of a circuit extending from the positive main 100, relay 115, segment 17, the conductive element of the controller, and segment 19, to the negative main 101, as outlined above. The operation of relay 115 effectuates the closing of switch 15 and the consequent connection of the negative main 101 to the slip ring 85 by way of conductor 185. By this means an electrical plate coupling L (or L_2 in Fig. 2) is engaged, and the two shafts K and K1 are connected together and the electrical part is put out of action since the driving motor M is provided with a free wheel device. The coupling is effectuated by the energization of the magnetic winding upon the completion of a circuit from the positive main 100, through safety switch St_6 , conductor 300, slip ring 82, the magnetic winding of the clutch device, slip ring 85, conductor 185 and switch 15, to the negative main 101. Previously, after contact 18 on the controller KT was reached the switch St_2 was connected by which the armature of the generator is short circuited through a small resistance. By this means before the plate coupling is engaged the minimum difference in speed between the rotating magnet body and the armature of the generator is obtained. The switch St_2 is closed upon the bridging of the conductive element of the controller of segments 19 and 18 by way of a circuit extending from the positive main 100, relay 75

242, conductor 142, segment 18, the conductive element of the controller, and segment 19 to the negative main 101 as outlined in detail above. The closing of switch St_2 serves to insert the small resistance 2_r across the armature of the generator which extends between slip rings 81 and 84. This circuit may be traced from slip ring 84, conductors 99 and 171, switch St_2 , resistance 2_r, and conductor 91, to slip ring 81.

If the vehicle reaches a steep part of the road, for climbing which the power of the internal combustion engine with direct drive is not sufficient and its power would decrease as the speed of revolution decreased, the driver can connect the electrical transmission by rotating the throttle lever P beyond the position M_p . As soon as the lever P reaches the position K_1 the maximum supply of fuel is obtained and the auxiliary circuit is connected to the coil C_1 of the switch PS by means of the segment 13 through the contacts 9 and 10. The switch PS connects the servomotor SM to a current of the opposite direction. The contacts a, b and the double contacts c, d, of the switch PS have flexible leads and, when the coil C_1 is connected, they enable the connection a—c and b—d to be made, or, when the coil C_2 is connected, they enable the connection c—e and d—f to be made. In this way the reversal of the servomotor SM is effected.

The servomotor thereby returns the controller KT, corresponding to the transmission ratio of the electrical transmission, until the internal combustion engine V attains its normal speed of revolution, the centrifugal governor Rg closes the contact 14 and the pre-connected switch PS reverses the direction of flow of the current by means of the coil C_2 owing to the lever P being set in a position K_1 even if the coil C_1 is connected. As long as the lever P is not moved out of a position between the position M_p and K_1 into the limiting position M_F , the ratio of the electrical transmission is automatically adjusted by the rotation of the controller according to the load on the internal combustion engine or on the whole unit by means of the controlling switch St and the shunt resistance S_h .

The throttle lever P together with its circuits which are connected by means of the contact segments, the pre-connected switch PS, the speed governor Rg and the controlling contact 14 forms an entirely automatic controlling device for regulating the power of the internal combustion engine and ensuring the best conditions for driving the vehicle. The driver can apply this automatic control of the vehicle at any time by turning the lever P out of the position O in counter-clockwise direction into the position K, whereby the electric transmission is set automatically by means of the controller KT to the best ratio for the fresh start.

Within the range O to M_p of the lever P one can drive, even at small speeds, with the internal combustion engine V connected directly to the shaft H_1 , as long as the torque of this motor is not completely utilised for obtaining the best efficiency of the output of the driving unit. Within the range M_p to K_1 an automatic electrical transmission with maximum fuel supply for great acceleration is obtained. In this range M_p to K_1 the circuits for the servomotor SM of the controller KT are closed with the aid of the pre-connected switch PS. The controller KT is adjusted automatically to the best ratio of transmission under the control of the servomotor when

the contact 14 is controlled by means of the governor Rg.

In the case of the driving units with a large number of individual parts and having at the same time automatic control of the system, an additional safety device is provided in accordance with the invention for protecting the individual parts of the unit, by means of which a mechanical closure of the plate couplings belonging to these parts is prevented if one of these parts becomes inoperative owing to some fault.

For this purpose there is employed as the source of current a light dynamo A which is directly driven by the internal combustion engine V and an intermediate relay B for energizing the switch St_s for the circuit 300 of the plate coupling L or L_2 of the generator G and motor M of the system. This will now be described.

In the arrangement illustrated in Fig. 1 a driven part of the generator G namely the rotor is directly coupled to the internal combustion engine V while the stator of the generator is freely revoluble and is combined with a brake drum Br. On the side of the brake drum is provided the above-mentioned plate coupling L_1 which effects a direct connection between the stator and a Cardan of driving shaft H_1 and is electrically influenced by way of the circuit 300 from the safety device B with the switch St_s . This direct connection is also obtained when the internal combustion engine V is running light because the dynamo A is rotated with it, the relay B is energized and therefore the switch St_s is closed. The rotor shaft of the generator G is also provided with an electrical plate coupling L for the direct mechanical engagement of the internal combustion engine V with the driving shaft H_1 by way of this rotor.

In order when the driving shaft H_1 is driven directly by the internal combustion engine V to obtain the source of electrical energy, the stator of the generator G is braked by means of the brake band Bp. By this means the generator is connected to the normal source of current, the current produced in it can be used for heating or for driving the motor of an attached coach for obtaining greater adhesion of the vehicle.

In the modified form of construction shown in Fig. 2, the ordinary generator G_1 is provided with the fixed stator and its rotor is directly connected to the internal combustion engine V. This generator supplies the motor M_1 with current when starting up the vehicle after which when the vehicle has attained a certain speed, the shaft H_1 can be directly connected by means of the coupling L_2 of the driven shaft H of the internal combustion engine and the source of the current can be disconnected so that loss of current is avoided.

What I claim is:

1. An electric transmission gear for traction machines comprising a prime mover, a control lever therefor, an electric generator and an electric motor coupled to said prime mover and controlled by said control lever, electrical resistance in circuit with said generator and motor, switching means for controlling varying proportions of the resistance in circuit with said generator and motor, a controller for governing the operation of said switching means, and an auxiliary electric motor for automatically operating said controller following the attainment of a predetermined speed by the prime mover.

2. An electric transmission gear for traction machines comprising a prime mover, a control

lever therefor, an electric generator and an electric motor coupled to said prime mover and controlled by said control lever, electrical resistance in circuit with said generator and motor, switching means for controlling varying proportions of the resistance in circuit with said generator and motor, a controller for governing the operation of said switching means, an auxiliary reversible electric motor for automatically operating said controller following the attainment of a predetermined speed by the prime mover, and a reversing switch for controlling the direction of rotation of said last-mentioned motor.

3. An electric transmission gear for traction machines comprising an internal combustion engine, a control lever therefor having a plurality of settings, electric circuits conditioned by said control lever, an electric generator and an electric motor coupled to said internal combustion engine and controlled by said control lever, electrical resistance in circuit with said generator and motor, switching means for controlling varying proportions of the resistance in circuit with said generator and motor, a controller for governing the operation of said switching means, an auxiliary reversible electric motor for automatically operating said controller, and a reversing switch for controlling the direction of rotation of said last-mentioned motor, controlled by the operation of said internal combustion engine beyond a predetermined speed and by the predetermined setting of said control lever.

4. An electric transmission gear for traction machines comprising a prime mover, a transmission shaft, electrical coupling means and mechanical coupling means for connecting the prime mover and said transmission shaft, said electrical

coupling means comprising an electric generator having a rotor connected to said prime mover, and a stator connected to the transmission shaft through the intermediary of an electric motor, a control lever for operating said prime mover and simultaneously adjusting electric circuits associated with said generator and motor, electric resistance in circuit with said generator and motor, switching means for controlling varying proportions of the resistance in circuit with said generator and motor, a controller for controlling the operation of said switching means, an auxiliary reversible electric motor for automatically operating said controller and a reversing switch for controlling the direction of rotation of said last-mentioned motor.

5. The combination set forth in claim 4 wherein said mechanical coupling means is energized by an electromagnet, and a safety switch operated by an independent dynamo driven by said prime mover in the energizing circuit of said electromagnet.

6. The combination set forth in claim 4 wherein said generator operates as a driving medium upon starting and upon loading by armature reaction, braking means for the stator of the generator, and electromagnetic means for executing the mechanical coupling between the prime mover and transmission shaft in the braked position of the stator.

7. The combination set forth in claim 4 wherein the stator of said generator is stationary and the rotor thereof is connected with the prime mover and the transmission shaft by mechanical means only, while the electrical windings are disconnected to avoid electrical losses.

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