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 [21] Appl. No. **849,480**
 [22] Filed **Aug. 12, 1969**
 Continuation-in-part of Ser. No. 746,110,
 July 19, 1968, abandoned
 [45] Patented **Dec. 15, 1970**
 [32] Priority **Aug. 18, 1967, Aug. 22, 1968**
 [33] **France**
 [31] **Nos. 118,235 and 163,743**

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[54] **TRAINS FOR CARRYING OUT MAINTENANCE
 WORK ON RAILWAY TRACKS**
 22 Claims, 11 Drawing Figs.

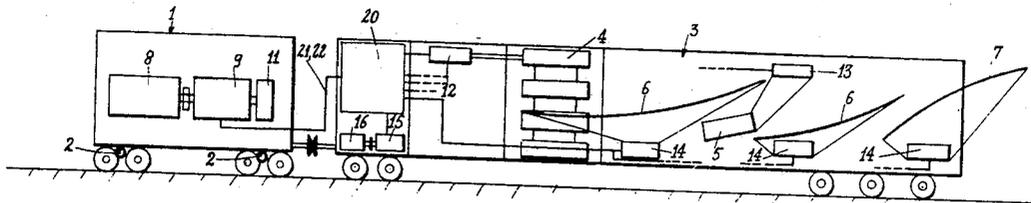
[52] U.S. Cl..... **105/1,**
 105/49; 290/17
 [51] Int. Cl..... **B60I 15/42**
 [50] Field of Search..... 290/3, 11,
 32, 17, (Inquired); 318/(Inquired); 104/12; 105/1,
 35; 37/(Inquired)

[56] **References Cited**

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ABSTRACT: A train for carrying out maintenance work on railway tracks and comprising a diesel-electric-type field locomotive and a work unit. The locomotive is equipped with electric traction motors and an electric power generating set driven by a diesel motor and the work unit comprises electric motors to drive at least a part of the tool equipment. According to the invention, the train comprises a power switching device whereby a part of the electric power supplied by the generator set of the locomotive is directed to the motors of the work unit for the working periods of the train. The remainder of the available electric power serves to supply the traction motors of the locomotive to haul the train for the working periods. In a first version of the invention, the work unit comprises an auxiliary electric power generating set to supply the traction motors for the working periods of the train. In a second version, the work unit comprises separate electronic power regulators for the motors driving the tool equipment and the traction motors. Means are provided to control the traction motors for the working periods in dependence upon the load of the tool equipment driving motors.



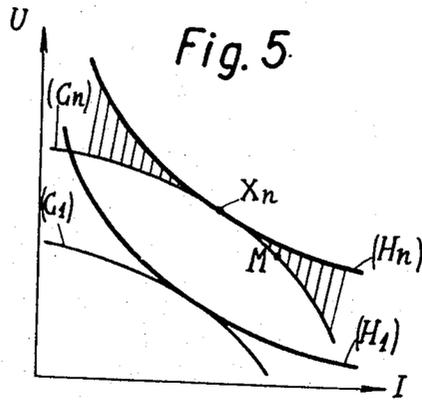
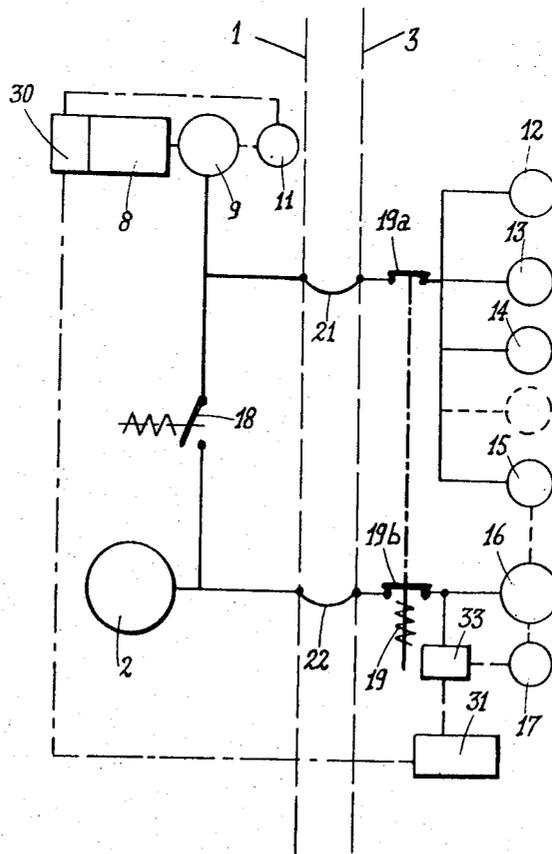


Fig. 3



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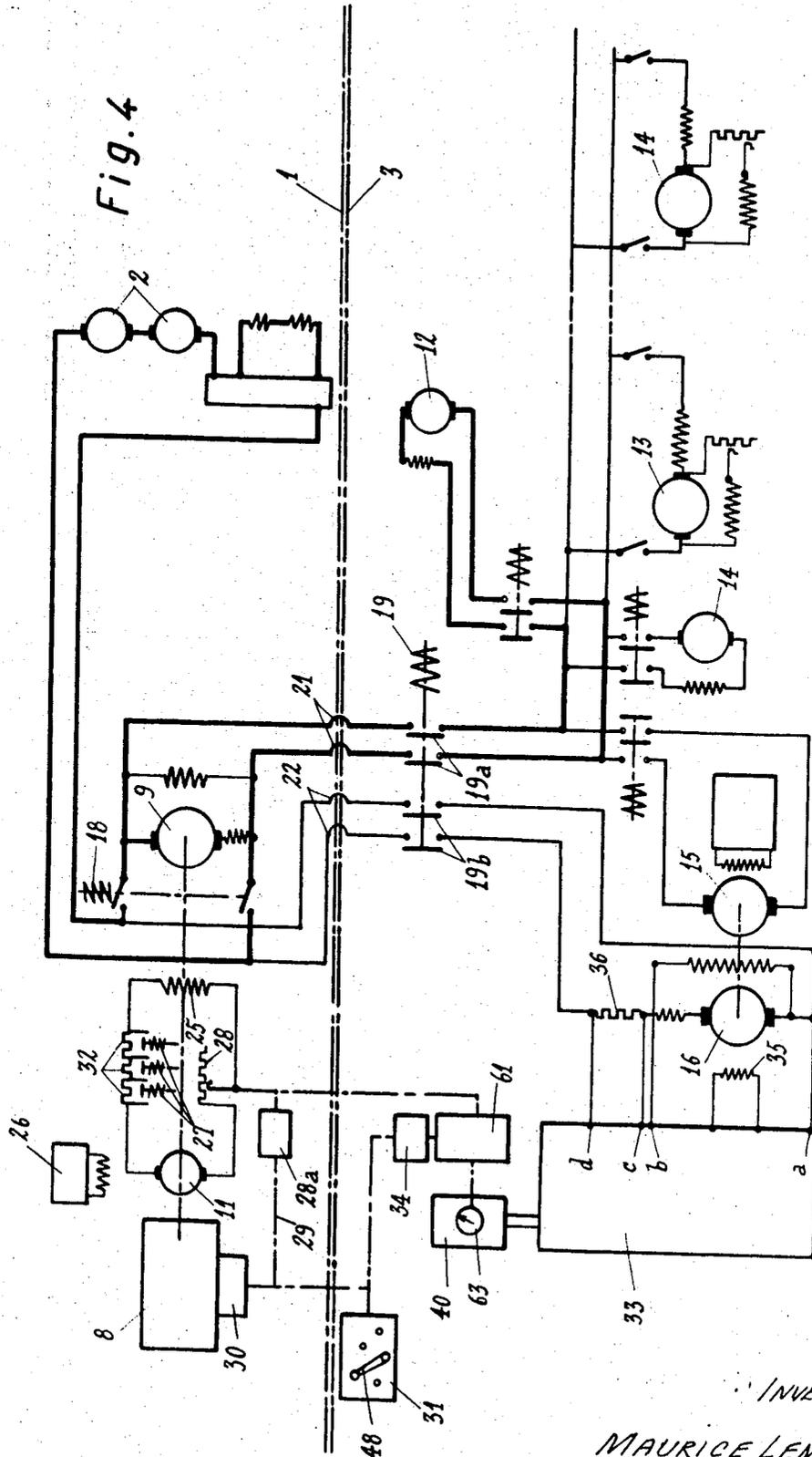


Fig. 4

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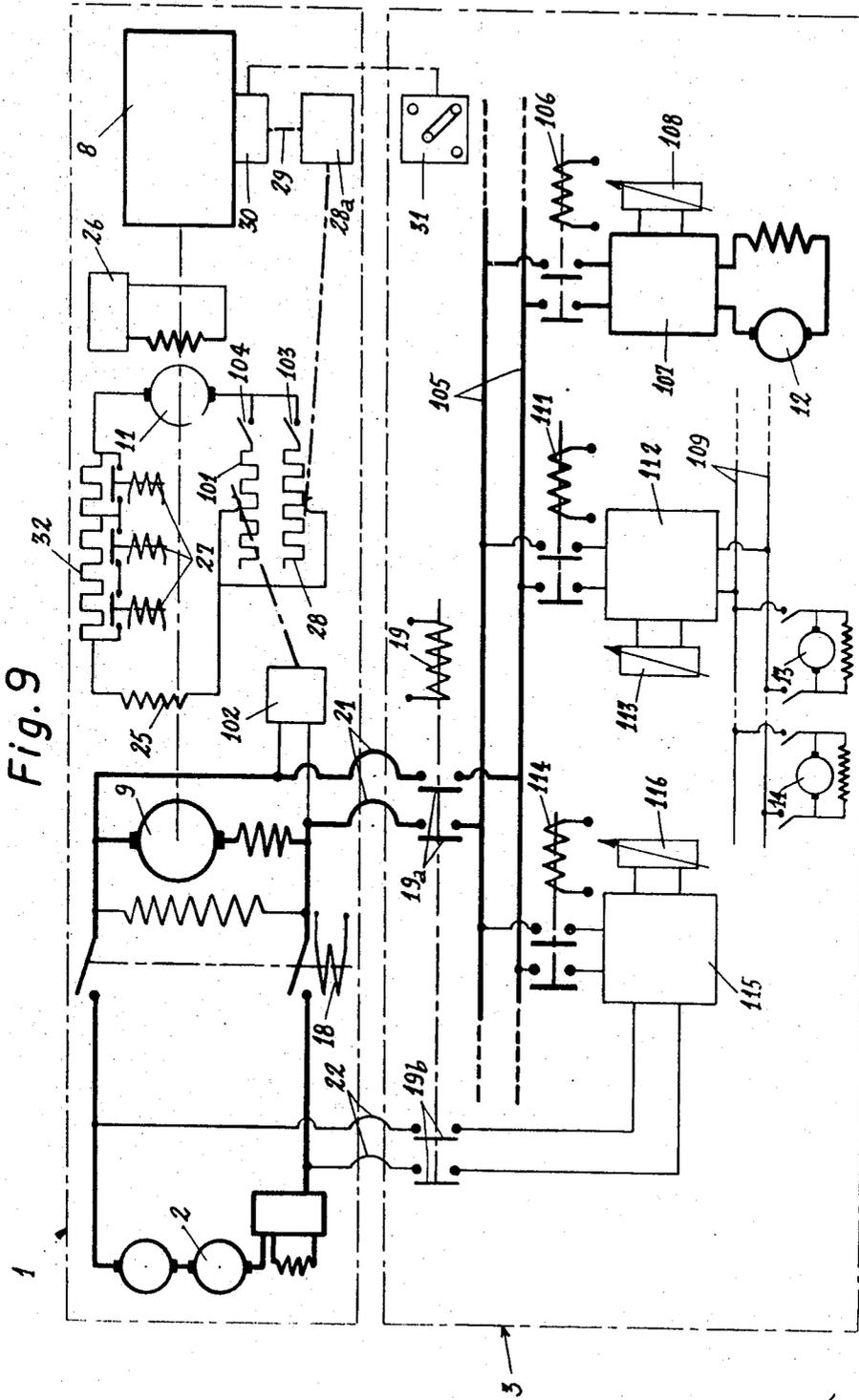


Fig. 9

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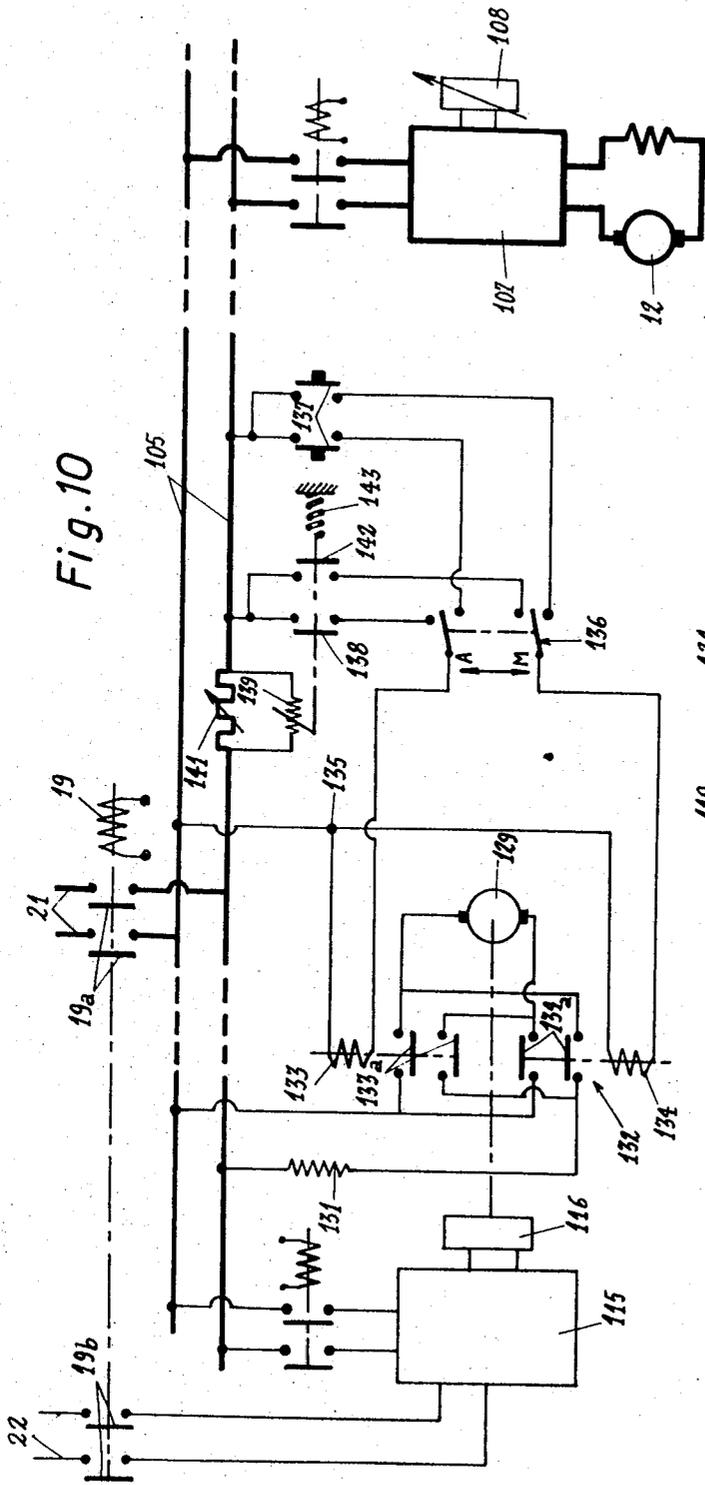


Fig. 10

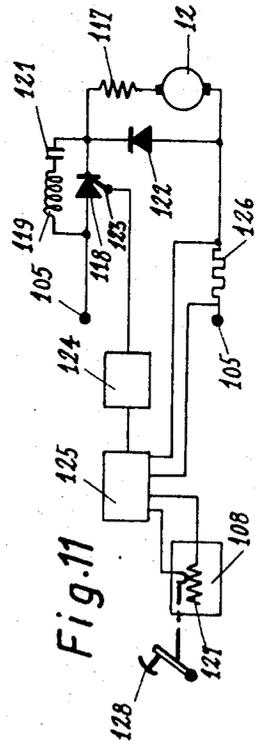


Fig. 11

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TRAINS FOR CARRYING OUT MAINTENANCE WORK ON RAILWAY TRACKS

This application is a continuation-in-part of my copending patent application Ser. No. 746,110 filed on Jul. 19, 1968 and now abandoned. In the following, the latter application will be referred to as the "Parent Application."

In the Parent Application, there were described trains which travel on railway tracks for the purpose of carrying out various maintenance operations on such tracks and particularly renewal work such as clearing and screening old ballast, dismantling tracks, laying new tracks or placing additional ballast.

Maintenance trains of this type usually comprise a field locomotive, a work unit and in some cases loading cars. In the majority of cases, the field locomotive is of the diesel-electric type and is equipped with traction motors mounted on the driving axles and a generator set with its regulating and transmission systems. The field locomotive serves to haul the train during transportation of equipment from the yard or siding to the site location.

In addition, the work unit is equipped with motors for driving the tools and an electric generator set with transmission and regulating systems. In some designs, the work units themselves are capable of carrying out the displacement of tools along the track as the work proceeds.

It is therefore apparent that the technique at present in use calls for two generator sets with transmission and regulation which never work simultaneously. The power capacity factor, or ratio of average load to installed capacity, is therefore of a very low order and the capital cost of the work units is unnecessarily high.

The aim of the present invention is to overcome the disadvantages referred to in the foregoing.

According to the invention, the train for carrying out maintenance work on railway tracks which comprises a field locomotive of the diesel-electric type equipped with an electric generator set and a work unit hitched thereto in which at least a part of the tool equipment is driven by electric motors is characterized in that it comprises a switching device whereby a part of the electric power supplied by the generator set of the field locomotive is directed to the motors of the work unit during the work performed by the train whilst the remainder of the available power serves to supply the traction motors of the field locomotive.

The combination of means thus provided by the invention increases the coefficient of utilization of the field locomotive generator which is employed both during work and during haulage. It is thus no longer necessary to mount a second electric generator set and corresponding transmission systems on the work unit and the cost price of the unit is reduced to an appreciable extent.

As a preferable feature, the power switching device comprises within the generator circuit a contactor which is mounted on the field locomotive, the contacts of which are closed during transportation, and a contactor mounted on the work unit, the contacts of which are closed while work is in progress.

In a first version of the invention, the work unit is equipped with an auxiliary motor-generator set equipped with a regulator of the preset speed type. This set supplies the necessary power to the traction motors of the field locomotive in order to ensure low-speed traction of the train while work is in progress.

In a particular embodiment of this first version of the invention, the track maintenance train comprises an automatic servosystem whereby the low-speed traction during maintenance work is regulated as a function of the railway track gradient and of the load torque applied to one of the tools of the work unit.

In a second version of the invention, the generator of the field locomotive motor-generator set comprises a dual regulating device. The first device is put into service while the train is being hauled from the yard or siding to the site location and is designed in a manner known per se to maintain the power

delivered by the generator at a substantially constant level. The second device is put into service while work is being performed by the train and is designed to maintain the terminal voltage of said generator at a constant level.

In a particular embodiment of this second version, the work unit comprises electronic power regulators which are respectively assigned to the motors of said work unit and a power regulator which is assigned to the traction motors of the field locomotive and serves to control the power delivered to said traction motors by the generator of the field locomotive at the time of low-speed traction of the train while work is in progress.

It is possible by this means to achieve substantial flexibility of control of the different motors and to dispense with any special auxiliary generator set for supplying the traction motors during periods when the train is working on the track.

In accordance with a preferred embodiment of the second version of this invention, the work train comprises a servomechanism for controlling the regulator assigned to the traction motors in dependence on the power absorbed by the motors of the work unit.

One of the most important applications of the invention is the clearing of railway tracks which consists in removing and screening ballast. In this case, the work unit is a clearing and screening car and its main tool is the excavator which removes the ballast. The low traction-speed of the train is then controlled in dependence on the load torque which is encountered by the excavator.

Further properties and advantages of the invention will become apparent from the description which follows below.

A number of different embodiments of the invention are shown in the accompanying drawings which are given solely by way of nonlimitative example, and in which:

FIG. 1 is a general view in elevation showing a ballast clearing train;

FIG. 2 is a diagram showing the general arrangement of the ballast clearing train of FIG. 1 in accordance with the invention;

FIG. 3 is a block diagram showing a first version of the electrical equipment of the train of FIG. 1;

FIG. 4 is the corresponding circuit diagram;

FIG. 5 is an operational diagram corresponding to one embodiment of the invention;

FIG. 6 is an operational diagram corresponding to a preferred embodiment of the invention;

FIG. 7 is a diagrammatic sectional view of a servosystem for controlling the low-speed traction in the version shown generally in FIGS. 3 and 4;

FIG. 8 is a diagram showing an element of the servosystem shown in FIG. 7;

FIG. 9 is a circuit diagram of a second version of the invention;

FIG. 10 is a partial circuit diagram showing the electrical equipment of the work unit in a preferred embodiment of the version shown in FIG. 9; and

FIG. 11 is a block diagram of an electronic power regulator used in the version shown in FIG. 9.

There will hereinafter be described one application of the invention to a track maintenance train comprising a clearing and screening car which is intended to renew the ballast of a railway track.

Referring to FIGS. 1 and 2, there is shown the field locomotive 1 together with its electric traction motors 2 and the ballast clearing car 3 which comprises in particular an excavator 4, a screen 5, belt conveyors 6 and a belt conveyor 7 for discharging waste rubble. When operations are in progress, the buckets of the excavator pass beneath the crossties or sleepers of the track 10 which has been previously lifted for this purpose as shown diagrammatically in FIG. 1.

The field locomotive 1 comprises a diesel engine 8 which drives a main direct current generator 9 and the exciter 11 of this latter (shown in FIGS. 3 and 4). The ballast clearing car or unit 3 comprises a motor 12 for driving the excavator 4, a

motor 13 for actuating the screen 5 and motors 14 for driving the belt conveyors. In addition, in a first version of the invention which will now be described, an auxiliary motor 15 which is preferably an electric motor but could equally well be a heat engine, is adapted to drive a direct current generator 16 and its exciter 17 (as shown in FIG. 3).

The circuits of the field locomotive 1 are connected to a bicycle 20 for controlling the circuits of the ballast clearing unit 3. More specifically, as is apparent from the diagram of FIG. 3, the main generator 9 is connected either to the traction motors 2 of the field locomotive via the contactor 18 whose contacts are closed during haulage of the train from the yard to the site location or vice versa or, alternatively, to the utilization motors 12, 13, 14 of the ballast clearing unit via the contactor 19 whose contacts 19_a are closed while work is in progress. The contactor 19 is additionally provided with a second pair of contacts 19_b which are also closed while work is in progress and serve to connect the output circuit of the auxiliary generator 16 to the traction motors 2. The electric connection between the field locomotive and the ballast clearing unit is provided by the connections 21 and 22.

The general operation can readily be understood. For the purpose of hauling the train from the yard to the site, the contactor 18 is closed and the contactor 19 is open. The main generator 9 which is driven by the diesel engine 8 supplies the traction motors 2. The motors of the ballast clearing unit are cut out of circuit.

During clearing operations (condition of FIG. 3), the contactor 18 is open and the contactor 19 is closed. The main generator 9 then supplies current on the one hand to the motors 12, 13, 14 via the contacts 19_a and drives the different components of the ballast clearing unit and, on the other hand, to the motor 15 which drives the generator 16. Said generator supplies the necessary power to the traction motors 2 across the contacts 19_b and the connection 22, thereby ensuring the low-speed forward motion of the train as the work proceeds.

It is therefore apparent that, by virtue of this arrangement, the motor-generator set which comprises the diesel engine 8 and the generator 9 is continuously in use, thus ensuring good economic performance and dispensing with the need to add a similar generator set to the ballast clearing unit.

The resultant economy in rated power capacity which is achieved by the invention can readily be appreciated by considering the example of a modern ballast clearing unit which is capable of clearing and screening at a depth of 0.2 meter and a mean forward speed of 650 meters per hour. The power which is necessary for the excavator, for the screen, for the belt conveyors and ancillary elements is of the order of 1,000 h.p. and the power which is necessary for slow traction while work is in progress is 200 h.p. The total rated capacity of the ballast clearing unit is therefore 1,200 h.p. Furthermore, the field locomotive must be capable of hauling the ballast clearing car together with a train of approximately thirty boxcars filled with rubble and at a speed of 30 kilometers per hour. The corresponding power is also of the order of 1,200 h.p. It is evident that, in this case, the system in accordance with the invention makes it possible in the case of the ballast clearing unit to achieve a saving of an electric generator set having a power rating equal to that of the field locomotive.

Consideration being again given to the case of a ballast clearing train, the applications of the invention to the problem of regulation will now be described in detail.

In a ballast clearing unit, the power absorbed by the excavator constitutes the major part of the total power required. The load torque encountered by the excavator is extremely variable since the ballast underneath the track exhibits very different degrees of hardness. It is therefore essential to ensure that the motor which drives the excavator operates at constant power whereas its speed varies as a function of the load torque. In fact, these operating conditions are wholly comparable with those of the traction motors of the field locomotive and, in the present invention, it is especially intended to

employ for the excavator the traction motor regulating system which is installed on the locomotive. This makes it possible to dispense with a regulator while employing all the available power and preventing any overload.

It is known that, in the case of generator sets of the Ward-Leonard type which consist of a direct current generator as shown at 9 and a series excitation motor as shown at 2, there are in existence two classes of regulation which will be recalled for the sake of greater clarity.

In the so-called internal regulation method, one characteristic of the generator 9 is made to correspond to each position of the controller of the diesel engine 8. The characteristic of the generator 9 will be understood hereinafter to mean the curve which represents the terminal voltage U of said generator as a function of the current intensity I which is delivered by said generator in respect of a given value of its excitation current. In the graph of FIG. 5 in which the voltage developed across the terminals of the generator and the current delivered by the generator are related to the coordinates U and I respectively, the ideal curves at constant power which correspond to each position of the diesel engine controller form a family of equilateral hyperbolae $H_1 \dots H_n$. Furthermore, the external characteristics of the generator corresponding to different values of its excitation form the family of curves $C_1 \dots C_n$. In this system of regulation and in each position of the diesel engine controller which corresponds to a hyperbola H_n , the excitation of the generator is adjusted so that the corresponding external characteristic C_n is tangent at X_n to the hyperbola H_n . In consequence, the power of the diesel engine is fully utilized only if the load torque is such that the operating point corresponds to the tangential point X_n . In the case of any other value of load torque, the operating point comes to a point such as M on the curve C_n and the power of the diesel engine is not fully employed, whilst the power loss corresponds to the shaded portion of the FIG.

The system of the so-called external regulation has the object of reducing said power loss. In this system (as shown in FIG. 6), in respect of a given position of the diesel engine controller which corresponds to a hyperbola H_n , the regulator causes the excitation of the generator to vary as a function of the load torque so that the operating point remains practically on the hyperbola H_n . If the load torque is, for example, such that the operating point is at M_n on the curve C_n and if the load torque decreases, the operating point tends to be displaced along the curve C_n in the direction corresponding to a reduction of intensity and to come to a point such as M' . This point is thus above the hyperbola H_n , the diesel engine is overloaded and tends to slow down. This reduction in speed of the diesel engine produces a reduction in excitation by means of a servomotor which controls the exciting rheostat of the generator, thereby displacing the operating point to M_{n+1} which is practically at the intersection of the hyperbola H_n with another curve C_{n+1} . The variable-torque operation is accordingly represented by a stepped curve which conforms to the hyperbola H_n , the steps being correspondingly smaller and more numerous as there is a greater number of control positions on the exciting rheostat.

The change in excitation characteristics of the generator is carried out, for example, by a device referred to as a servomotor field rheostat consisting of a contact-stud rheostat whose rotary slide is controlled by an oil actuated servomechanism controlled by the link rod system of the diesel engine governor.

One object of the invention is precisely to make use of the servomotor field rheostat of the locomotive 1 for the purpose of controlling the excitation of the generator 9 even in the case in which a preponderant part of the electric power of said generator is employed for ballast clearing work.

The corresponding circuit diagram is shown in FIG. 4 in the case of a regulation of the external type which is thus employed both for haulage of the train and for operation of the ballast clearing unit. In this FIG., the same elements as those shown in FIG. 3 are provided with the same reference nu-

merals. The terminals of the exciter 11 whose field circuit comprises a voltage regulator 26 are connected to the field windings 25 of the main generator 9 through a series of resistors 32 and a field rheostat 28 with servomotor 28a. The servomotor 28a is coupled with the governor 30 of the diesel engine 8 by means of the link rod system 29. A controller 31 comprising a regulating lever 48 is installed within the ballast clearing unit 3 and intended to control by means of servomechanisms (not shown) on the one hand the governor 30 of the diesel engine 8 and, on the other hand, a series of contactors 27 which short circuit the resistors 32.

During haulage of the train, the regulation is carried out in a well-known manner which will be outlined briefly:

At the time of startup, the field rheostat 28 is eliminated by the governor 30 and the servomotor 28a, the operating regime being accordingly that of internal regulation. Each position of the controller 31 determines on the one hand a given speed of the diesel engine 8 which corresponds to a power hyperbola H_n and, on the other hand, as a result of the action of the contactors 27, a given value of excitation of the main generator 9 corresponding to a curve C_n .

During normal operation, all the resistors 32 are cut out of circuit and the rheostat 28 is put in circuit. Any variation in load torque which is encountered by the traction motors 2 during haulage of the train results in a change of speed of the diesel engine 8 whilst the position of the controller 31 remains unchanged. The governor 30 then actuates the servomotor 28a which modifies the position of the field rheostat 28, thus displacing the operating point from the curve C_n to an adjacent curve C_{n+1} . The action of the governor 30 stops when the diesel engine has returned practically to the same speed, that is to say when the operating point is again located on the same power hyperbola H_n .

During the work performed by the ballast clearing unit, the greater part of the power delivered by the main generator 9 is absorbed by the excavator motor 12.

In accordance with the invention, the regulation is carried out in the same manner and by means of the same elements as during haulage of the train, the function performed during haulage by the traction motors 2 being performed during ballast clearing operations by the motor 12. It can thus be readily understood that a saving is achieved, not only of a generator set in the ballast clearing unit, but also of regulation components such as contactors 27, the field rheostat 28 and its servomotor 28a.

In the case of low-power units, the field locomotive 1 may comprise only one regulation of the internal type. In this case, in respect of a given position of the controller 31, the operating point (as shown in FIG. 5.) remains on the same curve C_n of the main generator 9. The ballast clearing unit still operates satisfactorily but the power of the diesel engine is less efficiently utilized. However, taking into account the low power outputs employed, the degree of efficiency is less critical in this case. Aside from its low capital cost, the main advantage of a regulation of this type lies in the fact that the diesel engine is never overloaded irrespective of the nature of the ballast. The curve C_n is in fact always located below the hyperbola H_n .

There will now be described the regulation of low-speed traction of the train during the work performed by the ballast clearing unit. It is intended in accordance with the invention to utilize the characteristics of external regulation hereinabove set forth for the purpose of controlling the low-speed traction in dependence on the value of the load torque applied to the excavator and on the variations in resistance to forward motion.

To this end, the auxiliary generator 16 which supplies the necessary power to the traction motors 2 when work is in progress is equipped with a self-excited regulator which is controlled by the diesel engine governor by means of an amplifying servomechanism.

FIG. 4 shows the field winding 35 of the auxiliary generator 16 which is connected to an electronic regulator 33. In addition,

the output voltage of the generator 16 is applied to the terminals *a* and *b* of the regulator 33 whilst the terminals *c* and *d* of this latter are connected to the terminals of a shunt 36 which is mounted in series in the load circuit of the generator 16. The regulator 33 is of known type and maintains a constant ratio *K* between the terminal voltage of the generator 16 and the current delivered by said generator. The regulator 33 additionally comprises a panel 40 for the resetting of the speed of the traction motors 2, on which is mounted a control knob 63 for varying the value of the ratio *K*. In the usual applications of the regulator 33, the control knob 63 is operated by hand. In the application of the invention now under consideration, the control knob 63 is coupled to the governor 30 of the diesel engine 8 through the intermediary of an amplifying servomechanism 34 and changeover unit 61 which will be described hereinafter. The servomechanism 34 is additionally connected to the controller 31 of the diesel engine. The changeover unit 61 which serves to change the direction of transmission of motion of the servomechanism 34 to the control knob 63 is actuated by an auxiliary current source (not shown in the FIG.) in whose circuit is inserted a limit contact of the field rheostat 28.

The operation of the device is as follows:

When the value of the speed indicated on the panel 40 by the control knob 63 remains stationary, the regulator 33 maintains a constant ratio between the terminal voltage of the generator 16 and the current delivered by this latter, thereby ensuring constant speed of the series excitation traction motors 2.

If the load torque encountered by the excavator motor 12 is such that the operating point is at M_n (as shown in FIG. 6) beyond the tangential point X_1 in the direction of increasing current intensities, it has been seen earlier that, when the load torque decreases, the governor 30 reacts in such a manner as to cause the displacement of the operating point from M_n to M' , then to M_{n+1} . The diesel engine is then overloaded and its speed decreases. The reduction in speed of the diesel engine is transmitted to the servomechanisms 34. By means of the changeover unit 61 which is in the direct coupling position in this region of operation, the servomechanism 34 causes the control knob 63 of the indicator panel 40 to rotate in the direction of increasing speeds. The speed of haulage of the train is accordingly increased by the regulator 33.

When the operating point passes beyond the tangential point X_1 (shown in FIG. 6) in the direction of decreasing current intensities, the field rheostat 28 which is in its position of maximum resistance actuates its limit contact, thereby producing a change of position of the changeover unit 61.

When the operating point is located beyond the tangential point X_1 in the direction of decreasing current values, for example at N_n (as shown in FIG. 6) and when the load torque continues to decrease, the operating point first comes immediately to N' . The diesel engine is then underloaded inasmuch as N' is located beneath the hyperbola H_m and the diesel engine accordingly accelerates. The governor 30 then acts on the servomotor 28a of the field rheostat 28 so as to bring the operating point to N_{n+1} . At the same time, the increase in speed of the diesel engine is transmitted to the servomechanism 34 by the governor 30. The servomechanism 34 is actuated in the opposite direction with respect to the case considered above. However, inasmuch as the changeover unit 61 is now in the reverse coupling position, the control knob 63 will again be moved in the direction of increasing traction speeds. Thus, by virtue of the combination of the servomechanism 34 and changeover unit 61, a reduction in the load torque applied to the excavator always produces an increase in the traction speed of the train.

By virtue of the system just described for controlling the low-speed traction in dependence on the load torque, both the power of the diesel engine and the regulation of the main generator 9 can be fully utilized with maximum effectiveness.

If a servosystem of this type is not provided and the excavator encounters ballast which offers less resistance after a

steady operative speed has been established, the governor 30 of the diesel engine causes the displacement of the operating point from M_n to M_{n+1} (FIG. 6). The excavator motor 12 is supplied with current which has a lower intensity and a higher voltage, with the result that it develops a lower torque and its speed accelerates. The chain of buckets progresses at a faster rate and, since the traction speed has not been modified, the buckets are only partially filled. Conversely, if the ballast offers greater resistance, the chain of buckets slows down and the buckets are overfilled.

On the contrary, by virtue of the servosystem hereinabove described, the speed of forward motion of the train and the speed of rotation of the bucket chain are automatically combined so that the output is always at a maximum, taking into account the available power and the hardness of the ballast.

In the case when the motor 15 which drives the auxiliary generator 16 is an electric motor supplied from the main generator 9, the servosystem also adapts the low-speed traction either to the railway track profile or to the load being hauled. When the resistance to forward motion increases, the intensity absorbed by the motor 15 also increases, thereby displacing the operating point (FIG. 6) along the curve C_n of the main generator 9 in the direction of increasing current values. The governor 30 of the diesel engine reacts in the manner which has been described earlier and produces a decrease in the traction speed by means of the servosystem.

FIG. 7 shows one form of construction of the servomechanism 34. This latter comprises a hydraulic amplifier 39 which has proportional plus derivative action and which, in accordance with the invention, is controlled by a flyweight governor 42. The control knob 63 of the indicator panel 40 of the low-speed traction regulator hereinabove described is driven in rotation from the output shaft 75 of the hydraulic amplifier aforesaid through the intermediary of the changeover unit 61 which will be described hereinafter and a clutch unit 62. The flyweight governor 42 is driven in rotation by the shaft 41 by means of the gear train 79. The shaft 41 is in turn driven in rotation by means of a mechanism which has not been shown in the FIG. at a speed which is proportional to that of the diesel engine 8.

A further object of the invention is to couple the output shaft 43 of the flyweight governor 42 to a spring 44 which is in turn coupled by means of the link rod 46 to a plate 45, said plate being positionally controlled by a cam 47 which is rigidly fixed to the operating lever 48 of the diesel engine controller 31.

The hydraulic amplifier 39 comprises a first stage 52 comprising a piston 54 and a slide valve 53 which is slidably fitted in a cylinder 78. The cylinder 78 is connected to an oil supply pipe 76 and to the two faces of the piston 54 by way of the ports 64 and 65. The slide valve 53 is coupled to the output shaft 43 of the flyweight governor 42 by means of a lever 49 which is pivotally mounted at 51.

The piston 54 is adapted to drive through the intermediary of the lever 55 which is pivoted at 56 a second amplification stage 57 comprising a slide valve 58 which is connected to the oil supply pipe 76. Said slide valve is intended to actuate via the ports 66 and 67 a hydraulic motor 59 which is constituted, for example, by a vane pump. The motor 59 is adapted to drive the output shaft 75 in rotation. The second stage additionally comprises a damping system consisting of a piston 71 which is fitted with a restoring spring 72 and coupled to the lever 55 by means of the link rod 73. The two faces of the piston 71 are in communication with the slide valve 58 via two ports or ducts 68 and 69.

The operation of the device is as follows: If the diesel engine 8 is overloaded and tends to slow down, the speed of the shaft 41 decreases and the flyweights of the governor 42 draw closer together and initiate a displacement of the slide valve 53 in the direction of the arrow f . The port 64 is accordingly freed, thereby causing a movement of the piston 54 in the direction of the arrow g and a correlative displacement of the slide valve 58 in the direction of the arrow h . The oil is then

supplied to the motor 59 through the duct 66 and the output shaft 75 is driven in rotation. It has been seen earlier that the position of the changeover unit 61 is so determined that the control knob 63 is driven in the direction of increasing speeds.

In order to guard against pumping oscillations which could be caused by the time of response of the system, the slide valve 58 also admits oil in onto the face 77 of the piston 71. The piston is accordingly displaced in the direction of the arrow i and compresses the spring 72. There is thus obtained a derivative action which, as is already known, eliminates oscillations when it is added to the proportional action which has just been described.

When the train driver modifies the power of the diesel engine 8 by means of the lever 48 which produces action on the controller 31, the cam 47 displaces the plate 45 and the link rod 46, thereby modifying the tension of the spring 44. This modification of tension balances the variation in centrifugal force which is exerted on the flyweights of the regulator 42 as a result of the change in speed of the diesel engine.

The clutch unit 62 makes it possible to disconnect the automatic servosystem and to determine by hand the low-speed traction which results in the most effective operation of the excavator in respect of a given ballast. The clutch unit 62 is then engaged and the automatic servosystem adapts the traction speed to variations in the ballast.

FIG. 8 shows a simple form of construction of the changeover unit 61. The output shaft 75 of the hydraulic amplifier 39 is adapted to drive a bevel pinion 81 in rotation. Said pinion is capable of engaging with either of two bevel gears 82 or 89 which are slidably mounted on splines 83 of an output shaft 84 and coupled for rotation with this latter. The shaft 84 is coupled to the speed preindication knob 63 by means of the clutch unit 62. A fork 85, each arm of which is pivotally attached to the gears 82 or 89, is pivoted about an articulation 86 and carries at the lower extremity thereof a block 87 of soft iron. An electromagnet 88, the coil of which is supplied with current through the limit contact of the field rheostat 28 is adapted to attract the block 87. A spring 91 restores the fork 85 when the electromagnet is not energized. In addition, the limit contact of the rheostat 28 is designed in known manner to change position each time it is acted upon by the sliding contact of the rheostat and, between two control actions, to remain in the position in which it has been set; for example, said limit contact is actuated by means of a ratchet and pawl system.

The operation is as follows: if it is assumed that the electromagnet 88 is not energized and the contact of the rheostat 28 is open, the spring 91 restores the fork 85 which engages the gear 89 with the pinion 81. If the shaft 75 of the amplifier 39 rotates in the direction of the arrow j , there consequently takes place a movement of rotation of the output shaft 84 in the direction of the arrow k . If the field rheostat 28 arrives in the position of maximum resistance, the sliding contact of the rheostat 28 closes the limit contact which then remains closed until it is again actuated by the sliding contact. The electromagnet 88 is energized and attracts the mass 87 while overcoming the restoring force of the spring 91. The fork 85 pivots about the articulation 86 and brings the gear 82 into engagement with the pinion 81. In this new position, if the amplifier 39 causes the shaft 75 to rotate in the direction j , the output shaft 84 accordingly rotates in the direction m opposite to k .

Referring now to FIGS. 9 to 11, there will be described a second version of the invention.

In this version the separate excitation windings 25 of the generator 9 are supplied by the exciter 11 through a dual regulating device:

A first device as described hereinabove comprises the field rheostat 28 which is controlled by the governor 30 of the diesel motor 8 by means of the oil actuated servomotor 28a.

A second device comprises a field rheostat 101, the slider of which is actuated by an electric servomechanism 102. This servomechanism is connected to the terminals of the main generator 9 and designed in a manner known per se to

produce a variation in the resistance of the rheostat 101 so as to maintain the terminal voltage of the generator 9 at a substantially constant level.

Contacts 103, 104 which are mounted in series respectively with the rheostats 28 and 101 make it possible to put either of these regulating devices into service. The contact 103 is closed during high-speed haulage of the work train from the yard to the site location or conversely. The contact 104 is closed while work is being performed by the train. The contacts 103 and 104 can be of the manual control type or can be constituted by contacts of the contactors 18 and 19 respectively which form part of the power switching device described hereabove.

While maintenance work is being carried out by the work unit 3, the power delivered by the generator 9 is diverted to the work unit 3 via the contacts 19a of the contactor 19 and distributed on bus bars 105. The motors of the work unit 3 are supplied from said bus bars 105 and controlled by means of separate electronic power regulators. There is shown in FIG. 9 a main motor 12 which drives the excavator in the case in which the work unit 3 is a ballast clearing car and auxiliary motors 13, 14 which, in this same case drive the screens and the ballast conveyor belts.

The main motor 12 is connected to the bus bars 105 by means of a contactor 106 and is controlled by an electronic power regulator 107 of a type known per se which will be described hereinafter. The regulator 107 comprises a manual control device 108 which enables the operator to vary the power delivered to the motor 12.

The auxiliary motors 13 and 14 which are of the shunt excitation type in the example shown are supplied in parallel from a set of auxiliary bars 109. These bars 109 are connected to the bus bars 105 through a contactor 111 and the power supplied thereto is controlled by an electronic regulator 112 which is similar to the regulator 107 and comprises a manual control device 113.

Other motors of the work unit 3 can be connected to the auxiliary bars 109 and other groups of motors can be supplied from bus bars 105 through contactors and separate regulators which are similar to the contactor 111 and to the regulator 112, respectively.

For the supply and control of the traction motors 2 during work periods, the present invention makes provision for a contactor 114 and an electronic regulator 115 which transmit and regulate the electric power from the bus bars 105 to the contacts 19b of the contactor 9 and the line 22 which connects the motors 2 to the work unit 3. In the embodiment which is illustrated in FIG. 9, the regulator 115 comprises a manual control device 116.

There is shown in FIG. 11 a simplified diagram of the electronic power regulator 107 which supplies the motor 12.

Said motor 12 is of the series type and its field winding is shown at 117. The regulator comprises a thyristor 118 mounted in series in the circuit which connects the motor 12 to the bus bars 105. A quenching oscillating circuit is connected in parallel with the thyristor 118 and comprises an inductance coil 119 and capacitor 121 which are connected in series. A diode 122 for recovering the inductive energy is mounted in parallel with the armature and the field winding of the motor 12. The gate 123 of the thyristor 118 is connected to a pulse generator 124 having a variable and adjustable frequency. The frequency of the generator 124 is controlled by an electric comparator 125, one input of which is connected to the terminals of a shunt 126 mounted in series in the supply circuit of the motor 12 and one other input of which is connected to the manual control device 108. This device 108 comprises, for example, a potentiometer 127 having a slider which is actuated by a foot pedal 128.

At the time of rapid haulage of the train from the yard to the site location, the contactor 18 is closed and the contactor 19 is open. The contact 103 is also closed so that the field rheostat 28 is in service. Under these conditions, the governor 30 of the diesel motor 8 controls the field rheostat 28 by means of the

servomotor 28a in order to ensure that the power delivered by the main generator 9 to the traction motors 2 is maintained at a substantially constant level as was described hereinbefore.

During the periods of operation of the work unit 3, the contactor 18 is open and the contactor 19 is closed, with the result that the bus bars 105 are supplied directly from the generator 9. The contact 103 is open and the contact 104 is closed in order that the excitation of the generator 9 should be controlled by the rheostat 101. Said rheostat is actuated by the servomechanism 102 and the terminal voltage of the generator 9 is consequently maintained substantially constant. The regulators 107, 112, 115 control the power which is delivered respectively to the motors of the work unit and to the traction motors 2. The power level in each case can be modified separately by the operator of the work unit 3 by producing action on the manual control devices 108, 113, 116.

The operation of the electronic regulator as illustrated in FIG. 11 is as follows: As each trigger pulse is delivered by the generator 124, the thyristor 118 switches into conduction and the voltage applied to the bus bars 105 induces a current into the motor 12. At the same time, the capacitor 121 of the quenching circuit discharges through the thyristor 118 according to a substantially sinusoidal law. This discharge current has initially the same direction as the main current supplied by the bars 105, then changes polarity until the moment when said discharge current is equal and opposed to the main current. The thyristor 118 then switches off and remains switched off until a further pulse is delivered to the gate 123. The motor 12 therefore receives current pulses and the duration of these latter is determined by the natural frequency of the quenching circuit whereas the frequency of said pulses is that of the generator 124. The mean value of the current in the motor 12 is consequently proportional to this frequency. The frequency of the generator 124 is determined by the comparator 125 which produces a control signal, this signal being proportional to the difference between the signals which are applied to its two inputs. One of these signals delivered by the control device 108 is proportional to the reference value of the current whilst the other signal which is delivered by the shunt 126 is proportional to the instantaneous mean value of said current. The control signal which is delivered by the comparator 125 is consequently proportional to the difference between the instantaneous mean value of the current and its reference value. The device operates in such a manner as to reduce this difference to zero, that is to say to maintain the mean value of the current within the motor 12 at its reference value.

The preferred embodiment which is illustrated in FIG. 10 comprises a servomechanism, the function of which is to ensure that the regulator 115 which serves to control the traction motors 2 is controlled in dependence on the power absorbed by the motors of the work unit 3.

Instead of being actuated by means of a foot pedal as shown in FIG. 11, the device 116 which controls the regulator 115 is operated by a servomotor 129. Said motor 129 is supplied from bus bars 105 through a resistor 131 and a reversing switch 132. In the embodiment which is illustrated the reversing switch comprises a coil 133 which actuates a pair of contacts 133a and a second coil 134 which actuates another pair of contacts 134a. The coils 133 and 134 have a common terminal 135 which is connected directly to one of the bus bars 105. The other terminals of the coils 133 and 134 are connected to a changeover switch 136 having two poles and two positions. In the position M or so-called manual control position, the changeover switch 136 connects the terminals of the coils 133 and 134 to pushbuttons 137, one pole of which is connected to the other bus bar 105. In the automatic control position A, the changeover switch 136 connects the coils 133 and 134 respectively to a rest contact 138 and to a work contact 142, one pole of which is also connected to said bus bar 105. The contacts 138 and 142 are actuated by means of a coil 139 which is connected to the terminals of an adjustable shunt 141 which is inserted in one of the bus bars 105 in series with

the combined assembly of motors of the work unit 3. The shunt 141 can also be fixed and provision is made in this case for a variable resistor connected either in series or in parallel with the coil 139. An oppositely acting spring 143 urges the contacts 138 and 142 towards their rest position.

When the changeover switch 136 is in position M, the operator of the work unit 3 controls the low-speed traction of the train by pressing one of the pushbuttons 137. One of the coils 133 or 134 is then supplied and the motor 129 is thus caused to rotate either in one direction or the other. The reference value of the regulator 115 is thus either increased or decreased and the train is accordingly accelerated or slowed down.

When the changeover switch 136 is in position A, the motor 129 is controlled by the coil 139. In the case of a value I_0 of the total current absorbed by the motors of the work unit which depends on the setting of the shunt 141, the attraction exerted by the coil 139 on the contacts 138 and 142 balances the opposing force of the spring 143 and none of these contacts is closed. The motor 129 is then at a standstill.

If the total input current exceeds the value I_0 , the attraction of the coil 139 is preponderant and the work contact 142 closes, thereby supplying current to the coil 134 of the reversing switch 132. The motor 129 starts up in the direction corresponding to a reduction of the reference value which is imposed on the regulator 115. In consequence, said regulator produces a reduction in the mean value of the current supplied to the traction motors 2 and thus causes the train to slow down. This deceleration is accompanied by a reduction in the current absorbed by the work tools and this current decreases to the value I_0 at which the contact 142 opens once again.

On the contrary, if the current absorbed by the motors of the work unit 3 is lower than the value I_0 , the spring 143 closes the rest contact 138 which supplies the coil 133. The motor 129 then produces an increase in the reference value of the regulator 115, thereby causing an acceleration of the train. This acceleration in turn results in an increase in the power to be applied by the work tools and the input current increases to the value I_0 at which the contact 138 opens.

Under these conditions, it is apparent that the servocontrol device adjusts the speed of slow progression of the train in order that the total current absorbed by the motors of the work unit 3 or input current should be substantially constant. In the particular case in which the work unit is a ballast clearing unit, the greater part of the current is absorbed by the excavator. In practice, the servomechanism then adjusts the rate of forward motion of the train according to the load torque encountered by the excavator and in dependence on the speed of rotation of the bucket chain of said excavator. Maximum output of the excavator with respect to available power is thus ensured.

The second version of the invention shown in FIGS. 9 through 11 ensures a very high degree of flexibility in the control of the train and of the work unit. Each motor or group of motors can be controlled and regulated separately while taking its particular characteristics into account.

Moreover, all the motors including the traction motors are supplied by the main generator of the field locomotive and no auxiliary motor-generator set is necessary.

The speed of forward motion of the train is controlled in dependence on the power absorbed by the tools by virtue of very simple and inexpensive means and does not call for any additional connection between the field locomotive and the work unit. It will readily be understood that the invention is not limited to the forms of construction hereinabove described and that a large number of alternative forms may be contemplated without thereby departing from the scope of this invention. It accordingly follows that the main direct current generator 9 can be replaced by an alternator combined with a rectifier unit. The field locomotive can also be supplied directly from a direct current or alternating current power line by means of a pantograph. The electronic regulators can be of any type known or available in the present state of the art. The

coil 139 and the corresponding spring can also be replaced by an electric comparator which delivers to the reversing switch 132 a control signal having a suitable polarity and amplitude. On the other hand the ballast clearing unit 3 can be replaced by any other work unit which runs on a railway track and the tools of which are driven by electric motors. The electric motor 15 which drives the low-speed traction auxiliary generator 16 can also be replaced by a diesel engine or any other heat engine. The contactors 18 and 19 can also be replaced by any other switching elements such as power rectifiers with control grids. In addition, the servomotor 28a and the field rheostat 28 can be replaced by an electronic device for regulating the excitation of the main generator 9.

I claim:

1. A train for carrying out maintenance work on railway tracks and comprising:

a field locomotive having electrical traction motors, an electrical generator mechanically connected to a prime diesel motor, a governor adapted to control said diesel motor and a regulating device to control said generator;

a work unit comprising tool equipment and a plurality of electrical motors adapted to drive at least some of said tool equipment;

a power switching device comprising a first contactor whose contacts are connected in a first circuit from said generator in the locomotive to said traction motors and a second contactor whose contacts are connected in a second circuit from said generator to said motors in the work unit; and

means in the work unit adapted to control the flow of power from said second circuit to said traction motors when the contacts of said first contactor are open.

2. A train in accordance with claim 1 wherein said regulating device for controlling the electrical generator in the locomotive comprises a first and a second field rheostat for said generator, mechanical coupling means between said first rheostat and the governor of said diesel engine, a voltage sensing device connected across the terminals of said generator, mechanical coupling means between said second field rheostat and said voltage sensing device, and switching means adapted to switch alternatively first or second rheostat in the field circuit of said generator.

3. A train in accordance with claim 1, characterized in that the two power switching contactors are controlled from the work unit.

4. A train in accordance with claim 1, characterized in that the work unit comprises an auxiliary motor-generator set which delivers the necessary power to the traction motors of the field locomotive for low-speed traction while work is in progress.

5. A train in accordance with claim 4, characterized in that the auxiliary motor-generator set is coupled with the traction motors of the field locomotive through a circuit controlled by said second contactor which controls the connection between the locomotive generator and the motors of the work unit.

6. A train in accordance with claim 4, characterized in that the auxiliary generator of the work unit is driven by a motor of said work unit which is supplied with current by the locomotive generator.

7. A train in accordance with claim 1, characterized in that the device for regulating the generator of the field locomotive which is employed for the running of the train also serves to operate the work unit of which at least one motor is supplied with current from said locomotive generator.

8. A train in accordance with claim 7, characterized in that the work unit comprises a controller with a regulating lever which controls the governor of the diesel engine of the field locomotive.

9. A train in accordance with claim 1, characterized in that it comprises an automatic servosystem for controlling the low-speed traction of the field locomotive during the course of the work in dependence on the load torque applied to one of the tools of the work unit.

10. A train in accordance with claim 9, characterized in that the servosystem applies a law of regulation of the external type.

11. A train in accordance with claim 9, characterized in that the generator of the auxiliary set is provided with a regulator and means for indicating the speed of the traction motors of the field locomotive and that the servosystem for controlling the low-speed traction comprises a hydraulic amplifier controlled by a device whose position is a function of the speed of the diesel engine of the field locomotive and the output member of which controls the aforesaid speed indicating means.

12. A train in accordance with claim 11, characterized in that the connection between the hydraulic amplifier and the speed indicating means is carried out by means of a mechanical changeover unit for reversing the transmission of motion.

13. A train in accordance with claim 11, characterized in that the device for controlling the hydraulic amplifier is a flyweight governor which is driven at a speed which is proportional to that of the diesel engine.

14. A train in accordance with claim 13, characterized in that the position of the flyweight governor is controlled in dependence on the position of the manual controller for controlling the diesel engine of the field locomotive.

15. A train in accordance with claim 11, characterized in that the hydraulic amplifier is of the type which has proportional plus derivative action.

16. A train in accordance with claim 12, characterized in that the position of the changeover unit for reversing transmission of motion is modified when the excitation of the generator of the field locomotive set is at a minimum.

17. A train in accordance with claim 4, characterized in that the engine which serves to drive the auxiliary generator for low-speed traction while work is in progress is a heat engine.

18. A train for carrying out maintenance work on railway tracks and comprising:
a field locomotive having electrical traction motors, an elec-

trical generator mechanically connected to a prime diesel motor;

a work unit comprising tool equipment and at least one electrical motor adapted to drive at least some of said tool equipment;

a power switching device comprising a first contactor whose contacts are connected in a first circuit from said generator in the locomotive to said traction motors and a second contactor whose contacts are connected in a second circuit from said generator to at least one motor in the work unit; and

means in the work unit adapted to control the flow of power from said second circuit to said traction motors when the contacts of said first contactor are open.

19. A train in accordance with claim 2, characterized in that it comprises electronic power regulators respectively assigned to the motors which drive the tools of the work unit.

20. A train in accordance with claim 2, characterized in that it comprises an electronic power regulator which is assigned to the traction motors of the field locomotive and serves to control the power delivered to said traction motors by the generator of the field locomotive at the time of low-speed traction of the train while work is in progress.

21. A train in accordance with claim 20, characterized in that it comprises a servomechanism for controlling the aforesaid regulator of the traction motors in dependence on the power absorbed by the motors of the work unit.

22. A train in accordance with claim 20, characterized in that the regulator of the traction motors is similar to the regulators of the work unit tools and comprises a thyristor which is connected in series with the motors, a quenching oscillating circuit connected in parallel with said thyristor, a variable-frequency pulse generator for controlling the triggering of the thyristor and means for varying the frequency of a said generator.

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