PATENT SPECIFICATION

(11) 1 567 641

1 567 641

(21) Application No. 39582/76 (22) Filed 23 Sept. 1976
(23) Complete Specification filed 14 Sept. 1977
(44) Complete Specification published 21 May 1980
(51) INT. CL.[3] E21C 31/00
H02P 7/36 // 5/40 7/62
(52) Index at acceptance
H2J 12N 1L 1N2 CA
E1F 17 3A2
G3R A42 B389 B399 B424 BN33

(72) Inventor PAUL GREENHOUGH

(19)

(54) MINING MACHINE

(71) We, BRESSER EUROPE S.A., a limited liability company incorporated in Belgium of Boulevard du Souverain 191-197 (B-3) 1160 Brussels, Belgium, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a mining machine.

It is known practice to drive the haulage winch of a mining machine by a fluid operated driving mechanism which usually comprises a hydraulic pump and a hydraulic motor. The pump and motor are employed so that an infinitely variable speed output can be obtained and hence the feed rate from the pump to the motor is adjusted to suit changes in the hardness of the material which is being cut by the mining machine. Similarly, the rotary cutter(s) of the mining machine can be driven by such a hydraulic drive. However, hydraulic drives in use underground present difficulties as regards the risk of environmental dust at the coal face entering the hydraulic system, thereby increasing the need for maintenance. Electric motor drives are more suitable for use especially in situations where high quantities of dust are present but motor speed control requirements can give rise to complex and costly control circuitry.

According to the invention there is provided a mining machine having drive unit means operative to drive a haulage winch of the machine and a cutting tool of the machine, the drive unit means comprising at least a multi-phase induction motor with a wound rotor, the motor being provided with a circuit connected across the rotor windings and with means for varying the effective impedance presented by the said circuit to the rotor windings.

In this way, the motor speed over the full range of operating torques can be varied over the higher speed ranges up to maximum speed as well as over the lower speed ranges through which the motor passes transiently on starting up. The effective impedance presented to the rotor windings may be varied in discrete or infinitesimal steps.

Preferably, the effective impedance varying means comprises a feedback loop including control means arranged to control the effective impedance presented by the said circuit to the rotor windings in accordance with a predetermined criterion set in the control means. Alternatively, however, the effective impedance can be varied manually from a controller.

The drive unit means preferably comprises respective drive units arranged to drive the haulage winch and the cutting tool, at least one of the drive units comrising a multi-phase induction motor with a wound rotor, provided with the aforesaid circuit and the aforesaid effective impedance varying means. However, it could alternatively comprise a single such drive unit arranged to drive both the winch and the cutting tool.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:—

Figure 1 illustrates diagrammatically a mining machine having an electric cutter motor and an electric winch motor, the latter being an induction motor with a wound rotor,

Figure 2 shows, diagrammatically, a speed control circuit provided for the winch motor, and

Figure 3 is a graph of the winch motor torque speed characteristics, illustrating operation of the control circuit.

Referring to Figure 1, a mining machine 1 comprises a body 2 mounted for movement along a face conveyor 3 and having at each end a cutting drum 4. The body 2 houses an electric cutter motor 5, driving the two drums through cutting unit gearboxes 6, and an electric winch motor 7, which by means of a winch motor gear box 8 hauls the machine along the conveyor.

With reference to Figure 2, the winch motor is a three-phase induction motor comprising a stator winding 19, which is fed from the multiphase alternating current source *via* switchgear 10, and a wound rotor 17 having respective phase windings, across which is connected a circuit 100 having a three phase, full wave, rectifier bridge 11 which rectifies the rotor voltages, two parallel connected branches, one of which includes an impedance shown in the form of a resistor unit 12, and a filter consisting of an inductor 14 and a capacitor 15. Normally, the connection between the phase windings and the rectifier bridge will be by way of slip rings in order to keep the bulk of the rotor circuit (i.e. the rotor windings in combination with the circuit 100) separate from the rotor and stationary but this is not essential. The resistor unit 12 is connected in series with a direct current thyristor chopper unit 13 and the branch incorporating these two series-connected components is connected to the rectifier bridge output *via* the filter comprising the inductor 14 and the capacitor 15. A further direct current thyristor chopper unit 16 is connected in the other branch so as to be in parallel with the chopper unit 13 and resistor unit 12 in series.

The speed of the winch motor is governed by the effective impedance presented by the circuit 100 to the rotor windings, this effective impedance being controlled by a feedback branch from the wound rotor 17 comprising an overall logic unit 18. When neither thyristor is fired, the rotor winding is on open circuit. When the thyristor of chopper unit 13 is fired, the resistor unit 12 is connected into the rotor circuit which then has an effective resistance of R_R (see Figure 3). When the other thyristor alone is fired, the rotor winding 17 is on short-circuit, the effective impedance presented by the circuit 100 then being R_{SC}. In addition, other effective impedance values, that is R_- between R_{SC} and R_R and R_+ between R_R and infinite resistance can be selected by supplying square wave control pulses to one or other of the thyristors of the chopper units 13, 16, the value of R_- or $R+$ depending on the ratio of the conducting to the non-conducting times of the thyristors. In a modification only one branch with a chopper unit, and with or without an impedance, is incorporated in the circuit 100.

The feedback loop is arranged to maintain the winch motor speed to within limits of a pre-set value, set in a speed controller 20. Denoting this value by S_p, the motor is then operating at the point A (see Figure 3) on the torque-speed characteristic which corresponds to the torque T_E required from the motor, this characteristic corresponding to the effective resistance R_R. If the torque required from the motor increases the speed drops and the motor is then operating at the point B. The logic unit 18 monitors the frequency of the rotor current or voltage, or the rotor voltage, which are related to the speed of the winch rotor, and responds to the detected drop in rotor speed to adjust the effective impedance presented by the circuit 100 to the nearest possible value of R_- to restore the winch motor speed to S_p. The motor is then at the operating point C.

It is preferred from the practical point of view to adjust the effective impedance in discrete steps but it would be possible for the logic unit 18 to be arranged to control the chopper units in such manner that the effective impedance can be varied in infinitesimal steps. In either case the effective impedance can be varied over the full operating range of the motor.

Instead of obtaining values of R_- and R_+ by supplying square wave pulses to the thyristors, the rotor circuit could be modified by using at least one branch, and preferably several parallel-connected branches, each comprising a resistor unit and a chopper unit connected in series and each having a different resistive value for the resistor unit. The logic unit would then be arranged to fire the appropriate thyristor or combination of thyristors so as to provide the desired effective impedance. Clearly the larger the number of branches the greater is the number of discrete effective impedances which can be presented to the rotor windings.

It is preferred to arrange the control circuit such that a predetermined full-load torque cannot be exceeded. Thus, up to that torque, the motor speed can be maintained constant but when the full-load torque is reached, the presented effective impedance for increasing load is varied to allow the motor speed to drop correspondingly. In another arrangement, the motor could be arranged to operate at a predetermined constant torque and to adjust its speed according to the load. Where the motor is operated at constant torque, this has the advantage that because the rotor current is then substantially constant, the heat generated in the rotor windings is constant and this simplifies the cooling requirements of the rotor.

In the Figure 1 embodimen, the cutter motor does not employ the speed control arrangement described with reference to Figures 2 and 3 for the winch motor, but in a modification the cutter motor could be a three-phase induction motor whose speed is controlled by the described control system, and another electric motor drive used for powering the winch. In both cases it is not essential that the motor not employing the described speed control arrangement be an electric motor although this is in many cases to be preferred in view of the presence of environmental dust during mining at the coal face. In a further modification, the winch and cutter motors are each induction motors whose speed is controlled by the described speed control arrangement.

It is to be noted that the inductor 14 and/or the capacitor 15 of the filter connected to the output of the rectifier bridge 11 may be omitted under certain circumstances. Thus, where the inductance provided by the rotor phase windings is sufficient to provide a satisfactory current rise rate characteristic for the current through the thyristors once fired, no inductor is required in the filter. Moreover, the capacitor 15 may be left out of the circuit if the current fluctuations in the rotor circuit can be tolerated.

In a modification, the feedback from the wound rotor can be by way of a tachogenerator. Moreover, whilst feedback control of the motor speed is to be preferred, it would be possible to dispense with these and to control the logic unit from a manual controller.

In another possible modification the rectfier bridge 11 can be dispensed with. Then each phase will have its own circuit connected across the phase winding, each such circuit comprising one or more branches and preferably also an LC filter.

Advantages of the described motor speed control arrangement are that it is simple constructionally and also is unlikely to be affected by environmental dust at the coal face.

WHAT WE CLAIM IS: —

1. A mining machine having drive unit means operative to drive a haulage winch of the machine and a cutting tool of the machine, that drive unit means comprising at least a multi-phase induction motor with a wound rotor, the motor being provided with a circuit connected across the rotor windings and with means for varying the effective impedance presented by the said circuit to the rotor windings.

2. A mining machine according to claim 1, wherein the effective impedance varying comprises control means in a feedback branch, said control means being arranged to control the said effective impedance in accordance with a predetermined criterion set in the control means.

3. A mining machine according to claim 1, wherein the effective impedance varying means is manually operated.

4. A mining machine according to claim 1, wherein the said circuit comprises polyphase rectifier means arranged to receive the phase outputs and to combine them to form a single unidirectional voltage output, and at least one branch connected to be supplied by the rectifier means.

5. A mining machine according to claim 4, wherein the effective impedance varying means comprises switch means, connected in the or each branch of the said circuit, and control means for selectively controlling operation of the switch means of the branch or branches.

6. A mining machine according to claim 1, wherein the said circuit comprises a plurality of branches which are connected to be supplied from the rotor windings such that at least one branch is provided for each rotor winding, the effective impedance varying means comprising switch means, connected in each branch of the said circuit, and control means for selectively controlling operation of the switch means of the branches.

7. A mining machine according to claim 4, 5 or 6, wherein the the or at least one branch includes an impedance.

8. A mining machine according to claim 5, 6 or 7, wherein the control means is manually operated.

9. A mining machine according to claim 5, 6 or 7, wherein the control means is incorporated in a feedback loop and is arranged to control operation of the switch means to satisfy a predetermined criterion set in the control means.

10. A mining machine according to claim 2 or 9, wherein the criterion is that the motor speed is to remain constant within given limits.

11. A mining machine according to claim 2 or 9, wherein the criterion is that the full-load torque is not to exceed a predetermined torque, at which the motor-speed for increasing load is reduced so that said predetermined full-load torque is not exceeded.

12. A mining machine according to claim 2 or 9, wherein the criterion is that the motor speed is to remain constant within given limits up to a predetermined full-load torque, at which the motor speed for increasing load is reduced so that said predetermined full-load torque is not exceeded.

13. A mining machine according to claim 2 or 9, wherein the criterion is that

the motor is to operate at a predetermined constant torque.

14. A mining machine according to any one of claims 5 to 9 or 10 to 13 when appended to claim 9, wherein the or each switch means is in the form of a thyristor chopper unit and the control means incorporates a logic circuit arranged to supply control pulses selectively to the or each chopper unit.

15. A mining machine according to claim 4, 5 or 6 or any dependent claim thereof, when appended thereto, wherein the said circuit includes an inductance connected in series with the said branch or branches.

16. A mining machine according to claim 4, 5 or 6 or any dependent claim thereof when appended thereto, wherein the said circuit includes a further branch connected in parallel with said first mentioned branch or branches and comprising a capacitance.

17. A mining machine according to any preceding claim, wherein the said circuit and the effective impedance varying means are stationary in the machine and in connection with the rotor windings by way of slip rings.

18. A mining machine according to any preceding claim, wherein the induction motor is coupled to drive the said haulage winch alone and the drive unit means further comprises a separate drive unit operative to drive the said cutting tool.

19. A mining machine according to any one of claims 1 to 17, wherein the induction motor is coupled to drive the said cutting tool alone and the drive unit means further comprises a separate drive unit operative to drive the said haulage winch.

20. A mining machine according to any one of claims 1 to 17, wherein the induction motor is coupled to provide respective drives to the said haulage winch and the said cutting tool.

21. A mining machine according to any one of claims 1 to 17, wherein the drive unit means comprises two multi-phase induction motors with wound rotors, each provided with its own circuit connected across its rotor winding and with means for varying the effective impedance presented by the said circuit to the said rotor windings, the two motors being coupled to drive the said haulage winch and the said cutting tool respectively.

22. A mining machine substantially as hereinbefore described with reference to the accompanying drawings.

HASELTINE, LAKE & CO.,
Chartered Patent Agents,
Hazlitt House,
28, Soutampton Buildings,
Chancery Lane, London WC2A 1AT,
also
Temple Gate House, Temple Gate,
Bristol B81 6PT.
and
9, Park Square, Leeds LS1 2LH, Yorks.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1980
Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained

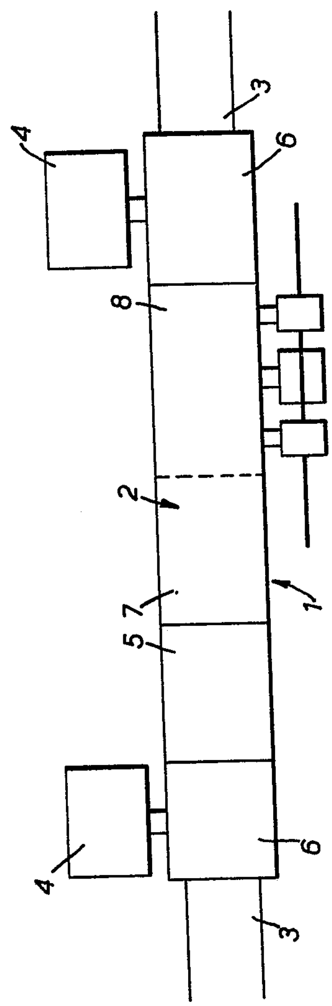

FIG. 1.

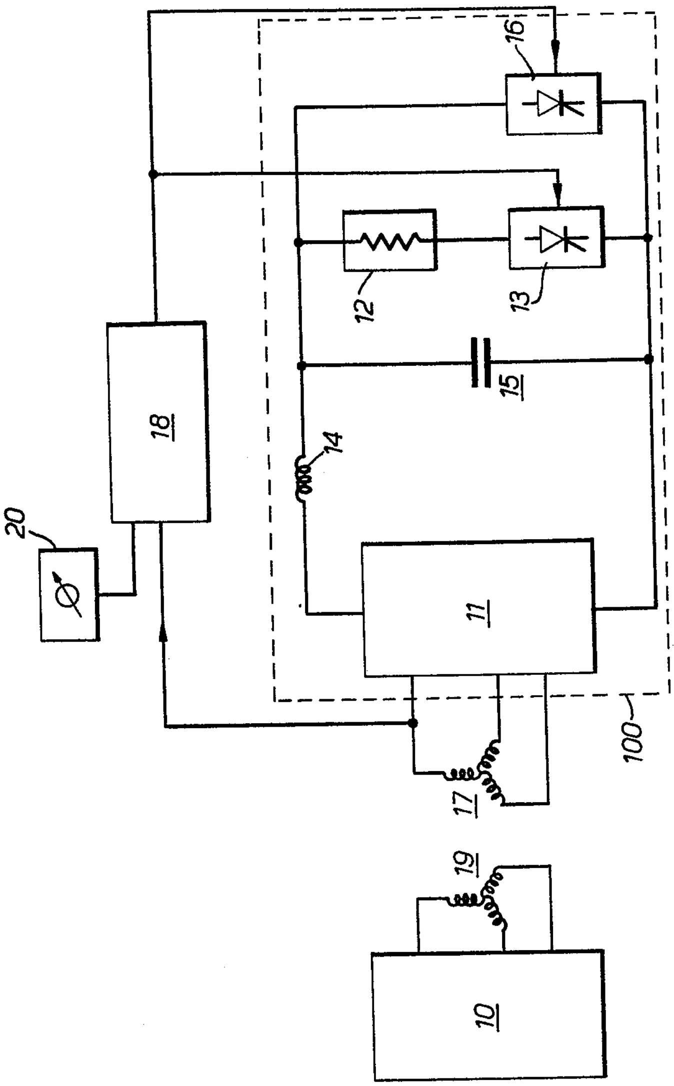

FIG. 2.

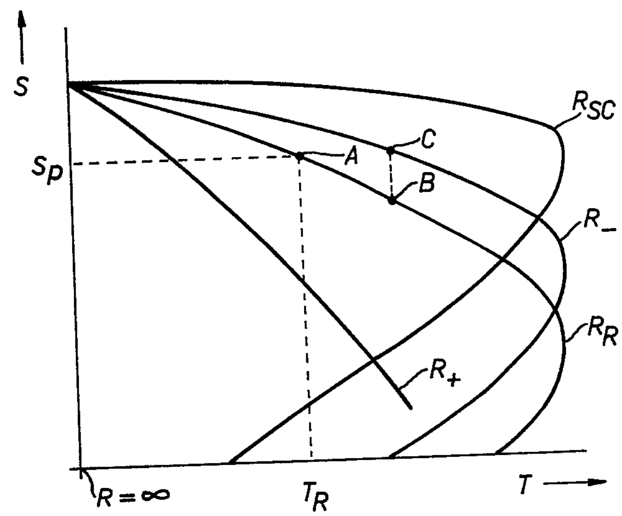

FIG. 3.