PATENT SPECIFICATION (11) 1 574 160

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(21) Application No. 34275/77 (22) Filed 16 Aug. 1977 (19)
(31) Convention Application No. 51/127 719U
(32) Filed 22 Sept. 1976 in
(33) Japan (JP)
(44) Complete Specification published 3 Sept. 1980
(51) INT. CL.³ H02P 5/06
(52) Index at acceptance
G3R A33 A42 A623 A625 B399 B424 B58 BN34

(54) A PROTECTIVE MEANS FOR A DC-MOTOR

(71) We, TOYOTA JIDOSHA KOGYO KABUSHIKI KAISHA, a Corporation organized under the laws of Japan, of 1, Toyotacho Toyota, Aichi, Japan, 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:—

The invention relates to a protective means for a DC-motor, and more particularly to an improvement of a means for protecting the armature of the DC-motor against excessive current.

Feeders for shifting a work-table of machinery are generally driven by a hydraulic cylinder mechanism. A hydraulic cylinder mechanism is advantageous in being readily controllable and able to exercise greater driving power; therefore, it is suited for a means to create thrust to shift a work-table. However, a hydraulic cylinder mechanism suffers some drawbacks such as inexact positioning of the work-table and a short life as well as insufficient productivity due to changes in temperature or quality of liquid to be used. In addition, it will easily cause pollution problems such as oil leakage and noisy operation.

In place of the conventional hydraulic cylinder mechanism mentioned above, it has been proposed to move the work-table by driving a motor. However, this does not enjoy all the advantages provided by the hydraulic cylinder mechanism. Particularly in the case of an AC-motor, it is not easy to change the revolution speed quickly and accurately; thus it is necessary to have a complex gear box and the like which will render the total cost very expensive. In addition, because of the gear box, it is difficult to maintain the exact positioning of the work-table; therefore, the work-table must be repeatedly moved back and forth when being positioned, thereby shortening its life because of friction.

In an attempt to resolve those drawbacks mentioned above, DC-motors have been introduced to replace AC-motors, since DC-motors are advantageous in controlling the positioning of the work-table by adjusting the current in the armature, and particularly suited for compact type feeders. However, there exists a serious disadvantage in using a DC-motor for this purpose, namely the current tends to change too much in the armature thereby causing damage to the DC-motor due to unavoidable excessive current once in a while.

This invention has been developed in an attempt to solve the problem discussed above. Accordingly, the primary object of this invention is to provide a protective means for feeders with a DC-motor, whereby the armature of the DC-motor is protected against current which otherwise would damage the armature when being excessive.

To achieve this object, this invention provides a protective means for a DC-motor when driving a worktable, comprising detection means for sensing revolution speed of a main shaft of said DC-motor, a comparator means for transmitting control signals based upon a difference measured by comparing the revolution speed thus sensed to a predetermined speed value, a current control circuit for limiting said control signals to a predetermined speed value when said control signals are above said predetermined value and an armature current control means for adjusting current to an armature of the DC-motor according to the control signals, in which the current control circuit has means respectively for setting up a first value and a second value as predetermined values, it being arranged that either one of said first and second values be selected as said predetermined value, said first value corresponding to a maximum allowable value of said armature current while said second value corresponds to a value smaller than said maximum allowable value.

This means that a speed detecting means is provided to sense the revolution speed of the rotating shaft of the DC-motor, said revolution speed being to be compared to a predetermined speed, thereby obtaining a signal on the differential therebetween. This

signal is to pass to a control means checking if the signal is below a permitted value. Any signal above such a value will be so modified by the control means as to be below the permitted value. The signal from the control means will be sent to another control means to adjust current in the armature.

There now follows a detailed description of a means according to the invention. It will be understood that the description, which is to be read with reference to the accompanying drawings, is given by way of example only, and not by way of limitation.

In the drawings:—

Figure 1 shows a circuit of a preferable embodiment of the protective means of this invention; and

Figure 2 shows an example of a current control circuit.

Figure 1 shows a circuit of the protective means to control a DC-motor which drives a worktable of a machine. The driving shaft of a DC-motor 10 is coupled to a known worktable (not shown). The armature of the DC-motor 10 is supplied with current through a forward-reverse switching circuit 12. The direct current stored at input ends 16 and 18 is supplied to the DC-motor 10 in such a manner that said current is controlled by the ON-OFF action of a control transistor 20, whereby the armature will receive a desired amount of current. The output wave shape obtained at the output end of the transistor 20 will be a pulse wave shape, whose pulse depends upon the duty-ratio; said pulse wave is to be modified to be smoothed by an inductance 22. Thus, the armature will receive smoothed direct current. A zener diode 24 is provided between the end 16 and the collector of the transistor 20 so that excessive voltage can be avoided at the ends of the transistor 20 even at sudden changes of the current in the armature. The forward-reverse switching circuit 12 comprises a relay circuit where the contacts 12*a* and 12*b* and the contacts 12*c* and 12*d* are alternately switched according to forward-reverse signals.

In this embodiment, the speed control of the feeder of the machinery is performed by adjusting the current supplied to the armature. There is provided a tacho-generator 26 next to the motor 10 so that the revolution speed of the main shaft of the motor 10 is continuously measured by said tacho-generator 26. The out-put voltage from the tacho-generator will be supplied to one of the input ends of a comparator 28 comprising a differential amplifier. A pre-determined speed signal is sent to the other input end from an end 30, whereby the revolution speed of the DC-motor 10 is modified so as to be at the predetermined speed. The predetermined speed is dependent upon the movement of the work-table and the value thus determined is either intermittently or continuously varied.

The output of the comparator 28 is supplied to one of the input ends of a current comparator 34 comprising a differential amplifier through a current control circuit 32. The current control circuit 32 comprises a selection circuit including diodes, where one selection branch thereof is coupled to the output end of the comparator 28 and the other branch is coupled to the end 36 which receives the predetermined value for current. The end 36 is connected to a voltage divider (not shown); thus, the selection branch receives control signals which transmit the desired current value for the armature. In this embodiment, the output control signals from the comparator 28 is so controlled to be below the predetermined value due to the control circuit 32, thereby protecting the armature against excessive current. In other words, if the output from the comparator 28 is below the predetermined value from the end 36, such output is allowed to get to the comparator 34; on the other hand, if the output is over the predetermined value, such output is reduced so as to be always below the predetermined value. Therefore, even when the actual speed of the motor is far beyond the predetermined value given at the end 36 and accordingly the comparator 28 would send an output to permit excessive current to the armature, the output will be checked and limited to hte predetermined value by the control circuit 32.

Thus, the control signals are kept below the predetermined value when being led to the driving transistor 20. In this embodiment, an armature current comparator circuit is provided in an attempt to improve the accuracy of the positioning of the worktable. This comparator circuit includes the comparator 34 where the other input is to receive the armature current signals from a shunt resistor 38 contained in the armature circuit. The comparator 34 will compare the armature current signals to the output signals from the current control circuit and then transfer the output to one of the inputs of a threshold circuit 40. To the other input of the threshold circuit 40, the output from a triangular wave generator circuit 42 is supplied and the output is transferred to a transistor driving circuit 44.

As discussed above, the speed control signals are supplied to the base of the transistor 20, thereby controlling the revolution speed of the DC-motor 10 to a desired value. In the embodiment a transistor is employed to control the current to the armature; however, a thyristor may also be preferable.

Figure 2 shows one example of the above described current control circuit 32. This

control circuit 32 as its predetermined values has a first predetermined voltage $-V_1$ determinable by voltage divider 46 and a second predetermined voltage $-V_2$ determinable by a voltage divider 50, functioning to compare those values with the output ($-V$) of comparator 28.

The voltage $-V_1$ is connected to point A through a diode 48, while the voltage $-V_2$ is in connection to the point A by way of contact element 52 adapted to be made "on" when the machinery is at dwell (upon completion of cutting stroke, the slide rest stops at its extreme forward position) and thence via diode 54. The comparator 28 has its output connected to the point A through diode 56. The voltage at the point A is applied to comparator 34 through a reverse diode 58. The voltage $-V_1$ is to determine a value of instantaneous maximum current of the armature while on the other hand the voltage $-V_2$ is to determine that of allowable current at the dwell time; and the relation between the two is $-V_1 <= V_2$. In this control unit 32, the voltage at A assumes the highest one of the outputs from the diode 48, 54 and 56. Accordingly, as in the normal case the contact element 52 is "off", there appears either one of the outputs $-V_1$, $<V$ from diodes 48, 56, whichever higher. For example, when DC-motor starts, $-V$ shows a considerably great negative voltage ($-V < -V_1$), and on that occasion the output $-V_1$ of the diode 48 becomes the output of the control unit 32. Hence, the occurrence of excessive current at the time of motor start will be prevented. Because of the relation $-V > -V_1$ existent at the time of normal operation of the DC-motor, the output $-V$ from the diode 56 becomes an output from the control circuit 32. And, at the dwell the contact 52 is made "on" the output $-V$ from diode 56 is compared with $-V_2$, and $-V_2$ becomes an output from the control circuit 32 ($-V < -V_2$. Occurrence of excessive current at the dwell time likewise will be avoided.

As seen above, this invention provides advantages over the prior art such as a longer life and greater security.

In other words, the armature is protected against excessive current by controlling the current to be sent to the DC-motor. This invention enjoys those advantages by installing a very simple and compact current control circuit as a protective means for the feeders of the machines; therefore, this invention is particularly suited for use in the compact type feeding devices with a DC-motor.

WHAT WE CLAIM IS:—

1. A protective means for a DC-motor when driving a worktable, comprising detection means for sensing revolution speed of a main shaft of said DC-motor, a comparator means for transmitting control signals based upon a difference measured by comparing the revolution speed thus sensed to a predetermined speed value, a current control circuit for limiting said control signals to a predetermined speed value when said control signals are above said predetermined value and an armature current control means for adjusting current to an armature of the DC-motor according to the control signals, in which the current control circuit has means respectively for setting up a first value and a second value as predetermined values, it being arranged that either one of said first and second values be selected as said predetermined value, said first value corresponding to a maximum allowable value of said armature current while said second value corresponds to a value smaller than said maximum allowable value.

2. A protective means according to claim 1 wherein said armature current control means comprises a triangle wave generator circuit, a threshold circuit to transmit pulse waves by modifying triangular waves from said generator circuit in accordance with control signals from said control means, and ON-OFF switching elements container in the armature current circuit for switching according to out-put signals from said threshold circuit.

3. A protective means according to claim 1, wherein at the dwell time of the machinery, said control means is adapted to select said second value as its predetermined value.

4. A protective means for machinery with a DC-motor to drive a work-table, arranged and adapted to operate substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1980.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.

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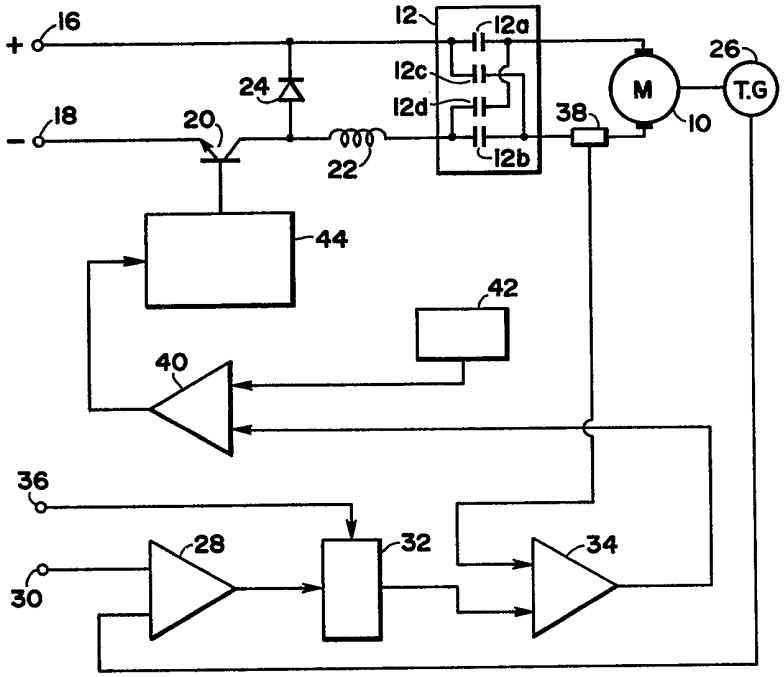

FIG. 1

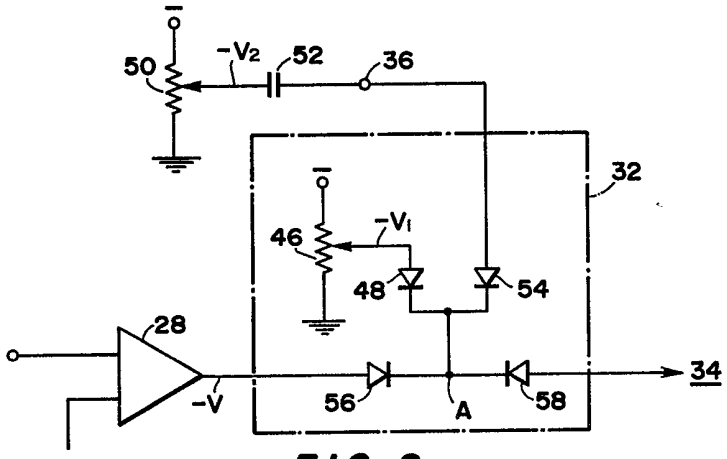

FIG. 2