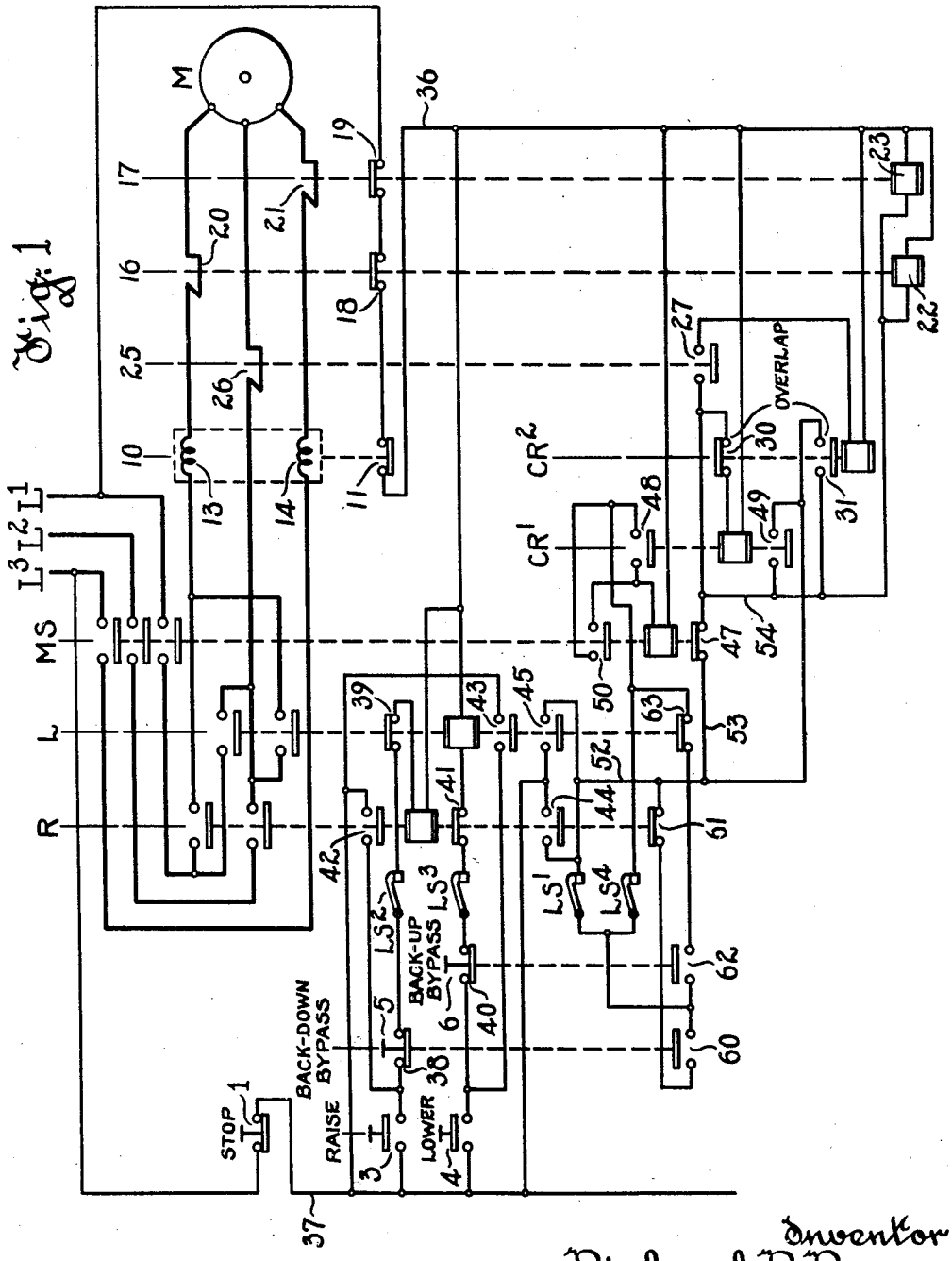
March 30, 1948. R. R. RANSON 2,438,647

CONTROLLER FOR ELECTRIC MOTORS

Filed April 22, 1946 2 Sheets-Sheet 1



Inventor
Richard R. Ranson
By Fowler & Hubbard
Attorneys

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Filed April 22, 1946 2 Sheets-Sheet 2

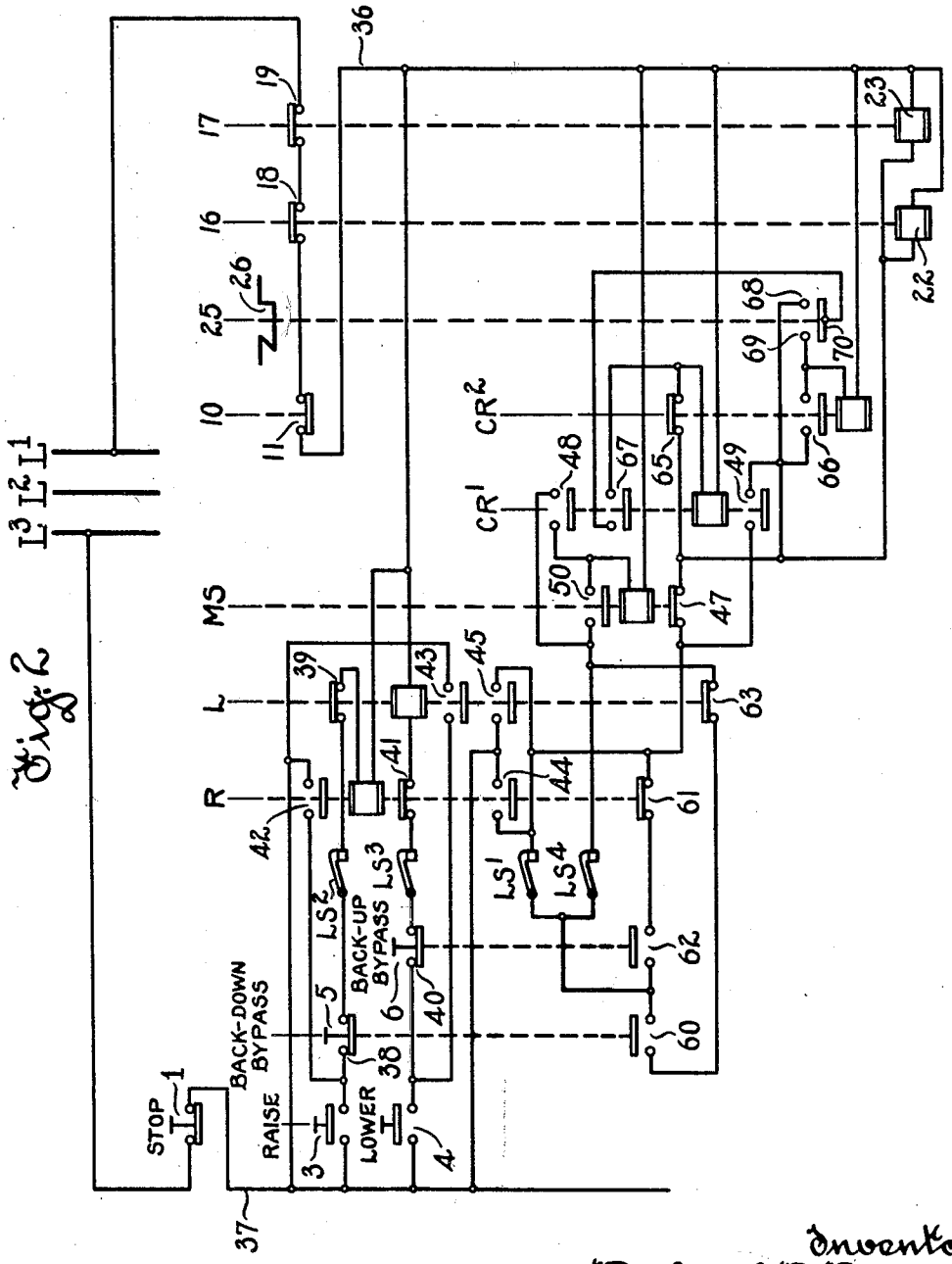


Fig. 2

Inventor
Richard R. Ranson
By Fauver & Hubbard
Attorney

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CONTROLLER FOR ELECTRIC MOTORS

Richard R. Ranson, Whitefish Bay, Wis., assignor to Cutler-Hammer, Inc., Milwaukee, Wis., a corporation of Delaware

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8 Claims. (Cl. 318—447)

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This invention relates to improvements in controllers for electric motors, and more particularly to controllers of the type affording so-called jam protection.

Controllers of such type comprise one or more devices sensitive to excessive motor current to effect disconnection of the motor from circuit or to otherwise protect the motor while jam conditions obtain. In some instances such controllers heretofore have been provided with means which in starting of the motor render ineffective for a definite transient period the device or devices responsive to excessive motor current. This enables a heavy inrush of motor current for starting which is often required or desirable but which according to starting conditions may or may not be safe for the transient period required under certain conditions. The current and time required to effect starting and acceleration in certain classes of service, as in operation of gates for dams and locks, may vary so widely as to render unsafe reliance upon a timing device of the definite time element type, at least without a setting of the timing device such as to preclude utilization of the maximum available torque of the motor in starting.

The present invention has among its objects to afford a safe and very reliable controller for use where such widely varying starting conditions are likely to be encountered such controller enabling utilization of the full motor torque for starting.

Another object is to afford such improvement by simple and reliable means.

More specifically the invention has among its objects to provide for rendering the jam responsive means ineffective in starting by means effective for a varying period determined by the electrical condition of the motor, but ineffective for repeated action during continued motor operation.

Various other objects and advantages of the invention will hereinafter appear.

The accompanying drawing diagrammatically illustrates certain optional embodiments of the invention which will now be described, it being understood that the embodiments illustrated are susceptible of various modifications without departing from the scope of the appended claims.

In the drawings:

Figure 1 shows diagrammatically one embodiment of the invention and Fig. 2 shows diagrammatically a modification of the embodiment shown in Fig. 1.

The controllers selected for illustration are of

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a type especially advantageous for motor operated dam gates and the controllers are in the main of a well known form.

Referring to Fig. 1 of the drawings, the same shows a 3 phase alternating current motor M such as is commonly employed for the service aforementioned. Such motor is commonly provided with an electromagnetic brake which has been omitted for simplicity of illustration.

For connection of the motor M to supply lines L^1, L^2, L^3 there is shown a triple pole electromagnetic main switch MS and double pole electromagnetic reversing switches R and L to effect respectively raising and lowering operations of the motor. The reversing connections controlled by switches R and L are obvious and are so well known as to require no description.

In accordance with the usual practice the switches aforementioned are under the control of push button switches including a stop push button switch 1. Switch R has for effecting energization thereof a push button switch 3, while switch L has for effecting energization thereof a push button switch 4. The main switch MS has provisions for its automatic response following response of switch R or switch L. Also the main switch MS has for effecting its energization in conjunction with the switches R and L selectively push button control switches 5 and 6, the former constituting a back-down bypass switch, and the latter a back-up bypass switch.

Also in accordance with usual practice the controller includes limit switches LS^1, LS^2, LS^3 and LS^4. Switch LS^2 may be considered as the raise limit, and switch LS^3 may be considered as the lowering limit, while switches LS^1 and LS^4 may be considered as respectively overtravel raise and overtravel lowering limits.

Referring now to the protective means for the motor, the same comprises an electrothermal overload relay 10 which may be considered as of well known form, having normally engaged contacts 11 and having thermally responsive means (not shown) under the control of windings 13 and 14 in series with different terminals of the motor, whereby either winding may effect tripping or disengagement of contacts 11. As will be understood, this electrothermal overload relay has an inherent time element rendering it responsive only if overload conditions persist for an appreciable safe length of time. Additionally the protective means comprises quick acting overload relays 16 and 17 of the electromagnetic type. Relays 16 and 17 are respectively provided with normally engaged contacts 18 and 19 in series

with the contacts 11 of the electrothermal relay in a control connection to line L^1. The relays 16 and 17 are operable by windings 20 and 21, respectively, which are connected in series with different terminals of the motor, whereas said relays are respectively provided with windings 22 and 23 which are energizable to hold their respective relays against response. The windings 22 and 23 are under the control of means including a series relay 25 having an operating winding 26 connected in series with a terminal of the motor circuit and also having normally disengaged contacts 27 connected in circuit as later described.

Additionally the controller illustrated comprises an electromagnetic relay CR^1 and an electromagnetic relay CR^2, the latter being under the control of contacts 27 of the series relay 25. These relays CR^1 and CR^2 render the lockout windings 22 and 23 of the overload relays 16 and 17 effective in starting, assuming response of the series relay 25, whereas upon release of series relay 25 they provide for deenergization of windings 22 and 23 and prevent reenergization thereof during continued motor operation. The relay CR^2 has normally engaged contacts 30 and normally disengaged contacts 31 which for a purpose later appearing preferably have an overlapping characteristic such that the normally disengaged contacts engage slightly in advance of disengagement of the normally engaged contacts.

As will later be explained in further detail, relay CR^1 responds following energization of either switch R or switch L, and in responding energizes main switch MS to start the motor, the main switch being self-maintaining. Also relay CR^1 in responding completes an energizing circuit for the lock-out windings 22 and 23 and partially completes an energizing circuit for the relay CR^2, the latter circuit being completed by response of series relay 25. Thus assuming response of series relay 25, relay CR^2 responds and completes a circuit for the lockout windings 22 and 23 independent of that provided by relay CR^1. Thereupon relay CR^1 may be and is deenergized by relay CR^2 to render continued energization of lockout windings 22 and 23 dependent upon continued closure of series relay 25. Relay CR^2 in responding establishes for itself a maintaining circuit independent of the relay CR^1, but dependent upon continued closure of series relay 25. Thus when series relay 25 releases it deenergizes relay CR^2 which in turn deenergizes lockout windings 22 and 23. Thereupon both relays CR^1 and CR^2 remain unresponsive pending release of main switch MS, with the result that lockout windings 22 and 23 are insured against reenergization during continued motor operation.

As will be understood, the overload relays 16 and 17 may be adjusted for any desired jam protection, whereas the series relay may be adjusted for response under any and all starting conditions and for release upon reduction of the inrush current to any desired value.

Thus the period during which the overload relays 16 and 17 are rendered ineffective will vary according to variations in starting conditions, such a variable period being obviously preferable to a fixed period which may be of greater duration than that needed under some conditions, or which may be too short for acceleration of the motor under extreme conditions where the motor could without danger stand a heavy surge a little longer. On the other hand, with the control illustrated

danger to the motor through failure of the series relay to release within a safe time limit may be guarded against by proper adjustment of the electrothermal overload relay 10, which as aforeindicated is to be set for response if and when a given overload persists for a given length of time, and which upon response affords the motor the same protection as that afforded by response of either of the overload relays 16 and 17.

Also with the control disclosed electrothermal relay 10 provides means to prevent telegraphing if after response and release of either quick acting overload relay restarting is attempted while overload persists for then the series relay will remain closed to continue energization of the lockout windings 22 and 23 of the quick acting overload relays until the electrothermal relay responds. Thus as relay 10 when tripped requires manual resetting, the low voltage relay usually employed to prevent telegraphing may be dispensed with.

Considering in further detail the controller shown in Fig. 1, there is provided a control circuit 36—37. Conductor 36 is connected to line L^1 through overload relay contacts 11, 18 and 19 in series. Conductor 37 is connected to line L^3 through push button stop switch 1.

Depression of the raise push button switch 3 completes a circuit through normally engaged contacts 38 of push button switch 5 and through limit switch LS^2 and normally engaged contacts 39 of switch L, to and through the winding of switch R to conductor 36. Alternatively, depression of lowering push button switch 4 completes circuit from conductor 37 to and through normally engaged contacts 40 of push button switch 6, through limit switch LS^3 and through normally engaged contacts 41 of switch R, to and through the winding of switch L to conductor 36. Switch R has normally disengaged contacts 42 which upon response of said switch establish a maintaining circuit therefor, shunting push button switch 3, and switch L has contacts 43 which upon response of switch L establish a maintaining circuit therefor shunting push button switch 4.

Switches R and L are respectively provided with parallel connected contacts 44 and 45 which have a common connection to conductor 37 and a common connection through normally engaged contacts 47 of main switch MS, and normally engaged contacts 30 of relay CR^2 to and through the winding of relay CR^1, to conductor 36. Thus response of either switch R or switch L effects energization of relay CR^1 and said relay through its contacts 48 completes an energizing circuit for the main switch MS, having through its contacts 49 completed a maintaining circuit for itself shunting contacts 47 of main switch MS. The energizing circuit for the main switch extends from the parallel connected contacts of switches R and L to and through the limit switches LS^1 and LS^4 in series, to and through the contacts 48 of relay CR^1, to the winding of the main switch which has a permanent connection to conductor 36. Main switch MS in responding engages its contacts 50 to establish for itself a maintaining circuit shunting contacts 48 of relay CR^1.

An energizing circuit for lockout windings 22 and 23 is established by response of either of the switches R, L and extends from the parallel connected contacts 44 and 45 of switches R and L by conductors 52 and 53 to and through the contacts 47 of main switch MS, by conductor 54, to and through windings 22 and 23 to conductor 36. Then upon response of relay CR^1 its contacts 49 parallel the normally engaged contacts 47 of the

main switch MS and hence the lockout windings 22 and 23 are maintained energized upon response of main switch MS to start the motor. Then the inrush motor current effects response of the series relay 25 to energize relay CR^2. The energizing circuit of relay CR^2 extends from conductor 52 through the contacts 49 of relay CR^1, to conductor 54, and thence through the contacts 27 of series relay 25 to and through the winding of relay CR^2 to conductor 36. Relay CR^2 then responds and through its contacts 31 establishes for itself a maintaining circuit shunting the contacts 49 of relay CR^1 and contacts 47 of main switch MS, but this maintaining circuit includes the series relay contacts 27. Also the contacts 31 of relay CR^2 establish a maintaining circuit for lockout windings 22 and 23 shunting contacts 49 of relay CR^1.

Also relay CR^2 in responding disengages its contacts 30, thereby deenergizing relay CR^1. Relay CR^1 then drops out but without any immediate effect, as meanwhile main switch MS, relay CR^2 and lockout windings 22 and 23 have become independent of relay CR^1.

When series relay 25 releases upon reduction of inrush motor current its contacts 27 interrupt the maintaining circuit of relay CR^2 which releases and deenergizes lockout windings 22 and 23. The relay CR^2 then becomes dependent for reenergization upon reenergization of relay CR^1, whereas the relay CR^1 becomes dependent for reenergization upon release of main switch MS to reengage its contacts 47.

While the aforedescribed results may be readily provided for through the medium of the means illustrated, especially if relay CR^2 be provided with the contact overlap characteristic aforementioned it will be apparent to those skilled in the art that other known means may be utilized in accomplishing like results.

As will be apparent, the backout switches 5 and 6 and their functions are in nowise essential to jam protection but may be incorporated without difficulty or any sacrifice of jam protection. Such switches and their functions being well known, description thereof appears unnecessary. However, it may be pointed out that contacts 60 of switch 5 together with contacts 61 of switch R provide means for bypassing at will the limit switch LS^1 for backout, while contacts 62 of switch 6 together with contacts 63 of switch L provide means for bypassing at will the limit switch LS^2 for backout.

Referring to Fig. 2 which discloses one of the other ways of accomplishing equivalent results, the instrumentalities shown are except in respect of certain contacts thereof like the instrumentalities shown in Fig. 1 and have been given the same reference characters except where new reference characters are employed to indicate changes.

The differences in contacts are as follows: Contacts 65 and 66 of relay CR^2 differ from the contacts of the corresponding relay of Fig. 1 only in that they do not involve the overlap aforementioned, this difference being the only reason for applying different reference characters. Relay CR^1 of Fig. 2, like the corresponding relay of Fig. 1, has the aforementioned contacts 48 and 49, whereas in Fig. 2 it has an additional normally open set of contacts 67. The series relay 25 of Fig. 2 has in lieu of the simple set of contacts of Fig. 1, contacts forming a so-called 3-point switch. These contacts comprise stationary contacts 68—69 and a movable contact 70 common to contacts 68 and 69, all three contacts having circuit connections. Contact 68 has a connection to the winding of relay CR^2 and contact 70 has a connection to the winding of relay CR^1 through contacts 67 of relay CR^1, whereas contact 68 has a feed connection for contacts 69 and 70. Thus the arrangement is such that contact 70 will always be energized at the same time or before contact 69 is energized, regardless of any small variations in setting of the contacts.

In the controller of Fig. 2 the control circuits for switches R and L and also for main switch MS are the same as in Fig. 1. More specifically, the push button switches 3 and 4 afford energization selectively of switches R and L and response of either of the switches R, L energizes relay CR^1 through normally engaged contacts 47 of the main switch MS and normally engaged contacts 65 of relay CR^2, whereas relay CR^1 upon response effects through its contacts 48 energization of main switch MS, said main switch through its contacts 50 shunting the contacts 48 of relay CR^1. Meanwhile as in the controller of Fig. 1, the lockout coils 22 and 23 are energized first through the contacts 47 of the main switch and then through contacts 49 of relay CR^1, and when the motor is started by closure of main switch MS series relay 25 responds.

With the modified contact arrangement of Fig. 2, when the series relay 25 responds it energizes the winding of relay CR^2 and also completes a maintaining circuit for the winding of relay CR^1 which defeats deenergization of relay CR^1 by disengagement of the contacts 65 of relay CR^2. Thus in contrast to the disclosure of Fig. 1, the relay CR^1 of Fig. 2 is maintained energized subject to deenergization by release of series relay 25. More specifically, response of series relay 25 completes circuit from conductor 37 through one of the parallel connected sets of contacts 44, 45 of switches R, L to and through contacts 49 of relay CR^1 to contact 68 of the series relay, and thence through contacts 68, 70 and 69 to and through the winding of relay CR^2 to conductor 36. Also circuit is then completed from series relay contact 68 through contact 70 to and through the contacts 67 of relay CR^1 to and through the winding of said relay to conductor 36. Relay CR^2 in responding engages its contacts 66 to establish for itself a maintaining circuit shunting contacts of the series relay 25.

The lockout coils 22, 23 of the quick-acting overload switches are maintained energized through the contacts 49 of relay CR^1 so long as said relay remains energized. When series relay 25 releases it deenergizes relay CR^1 which deenergizes lockout coils 22 and 23, and which also deenergizes relay CR^2 through disengagement of contacts 49 of relay CR^1. Both relays CR^1 and CR^2 then remain deenergized, for before the cycle described can be repeated the main switch MS must relase for reengagement of its contacts 47.

What I claim as new and desire to secure by Letters Patent is:

1. The combination with an electric motor, of protective means therefor responsive to an abnormal rise in motor current, and starting means for said motor rendering said protective means ineffective regardless of rise in motor current but only for a transient period, said starting means including for variation of such transient period electroresponsive means responsive to motor starting current and releasable to terminate such period when the motor starting current drops to a given value, and said starting means further including means which upon said

protective means becoming free for action frees said protective means from further influence by said electroresponsive means during continued motor operation.

2. The combination with an electric motor, of protective means therefor responsive to rise in motor current but only when the motor current exceeds a given value for a substantial period of time, additional quick acting protective means for said motor responsive to rise in motor current to a given value, and starting means for said motor controlling said quick acting protecting means to render the same ineffective in motor starting only and for only a transient period, said starting means including means to vary such transient period automatically with varying electrical conditions in starting.

3. The combination with an electric motor, of protective means therefor responsive to rise in motor current but only when the motor current exceeds a given value for a substantial period of time, additional quick acting protective means for said motor responsive to rise in motor current to a given value, and starting means for said motor controlling said quick acting protecting means to render the same ineffective in motor starting only and for only a transient period, said starting means including a series relay responsive to motor starting current and releasable upon drop in motor current to a given value thereby to terminate the aforementioned transient period.

4. The combination with a motor, of protective means therefor responsive to rise in motor current to a given value and having electroresponsive means to hold the same against response, and starting means for said motor inclusive of a series relay responsive to the motor starting current and releasable when the starting current recedes to a given value, said motor starting means energizing said electroresponsive holding means for a transient period terminated by release of said series relay.

5. The combination with a motor, of protective means therefor responsive to rise in motor current to a given value and having electroresponsive means to hold the same against response, and starting means for said motor inclusive of a series relay responsive to the motor starting current and releasable when the starting current recedes to a given value, said motor starting means energizing said electroresponsive holding means for a transient period terminated by release of said series relay, and said starting means upon release of said series relay maintaining said holding means deenergized throughout continued motor operation.

6. The combination with a motor, of protective means therefor responsive to rise in the motor current to a given value and having a holding winding to be energized to restrain the same against response, and control means for starting said motor and energizing said holding winding for a transient period, said control means

comprising an electroresponsive main switch for effecting motor starting, an electroresponsive control switch for said holding winding, a series relay responsive to the motor starting current and releasable when the starting current recedes to a given value, and an electroresponsive control relay controlling initial energization of said main switch and jointly with said series relay also controlling energization of the other of said switches, and said control means additionally comprising connections rendering said main switch self-maintaining, rendering release of said main switch essential to reenergization of said control relay after deenergization of the latter, and providing for deenergization of said control relay as an incident to a single full cycle of operation of said switches and relays to start said motor and deenergize said holding winding as a function of release of said series relay, thereby to render said protective means free from interference during continued motor operation.

7. The combination with an electric motor, of quick acting overload protective means for said motor, starting means for said motor, and means inclusive of a series relay, to render said protective means ineffective in starting, of said motor, the third mentioned means further including means acting independently of said series relay to render said protective means ineffective at the time the motor circuit is initially completed by said starting means and then rendering said series relay effective to determine the duration of the period of ineffectiveness of said protective means.

8. The combination with an electric motor, of quick acting overload protective means for said motor, starting means for said motor and means inclusive of a series relay, to render said protective means ineffective in starting of said motor, the third mentioned means further including means acting independently of said series relay to render said protective means ineffective at the time the motor circuit is initially completed by said starting means and then rendering said series relay effective to determine the duration of the period of ineffectiveness of said protecting means, and said third mentioned means after acting as stated being inactive during continued running of said motor and being dependent for repeated action upon restarting action of said starting means.

RICHARD R. RANSON.

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