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[54] **MOTOR AND HOIST CONTROL ARRANGEMENT**

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[58] **Field of Search**........................318/447; 317/13; 187/29

[56] **References Cited**

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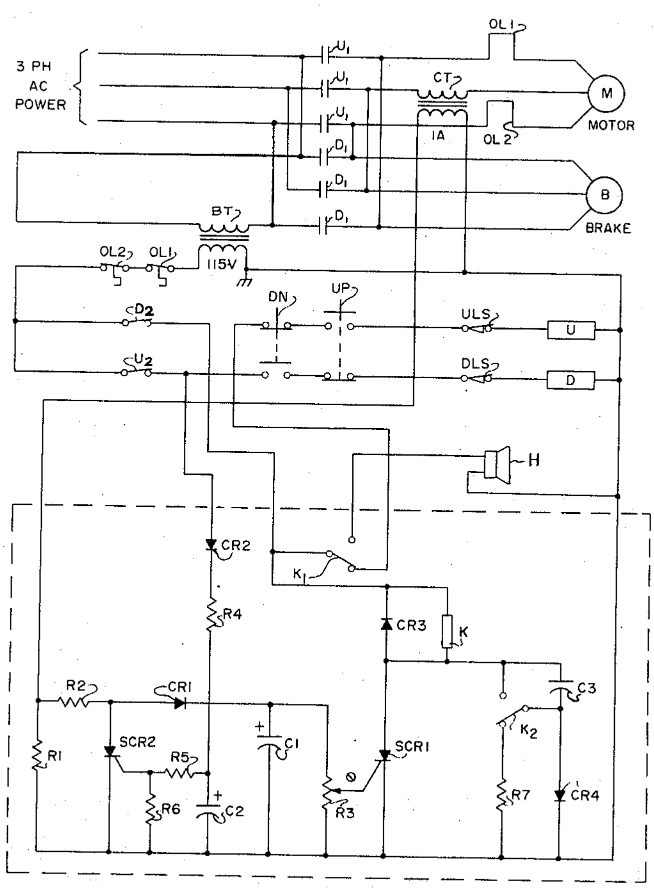
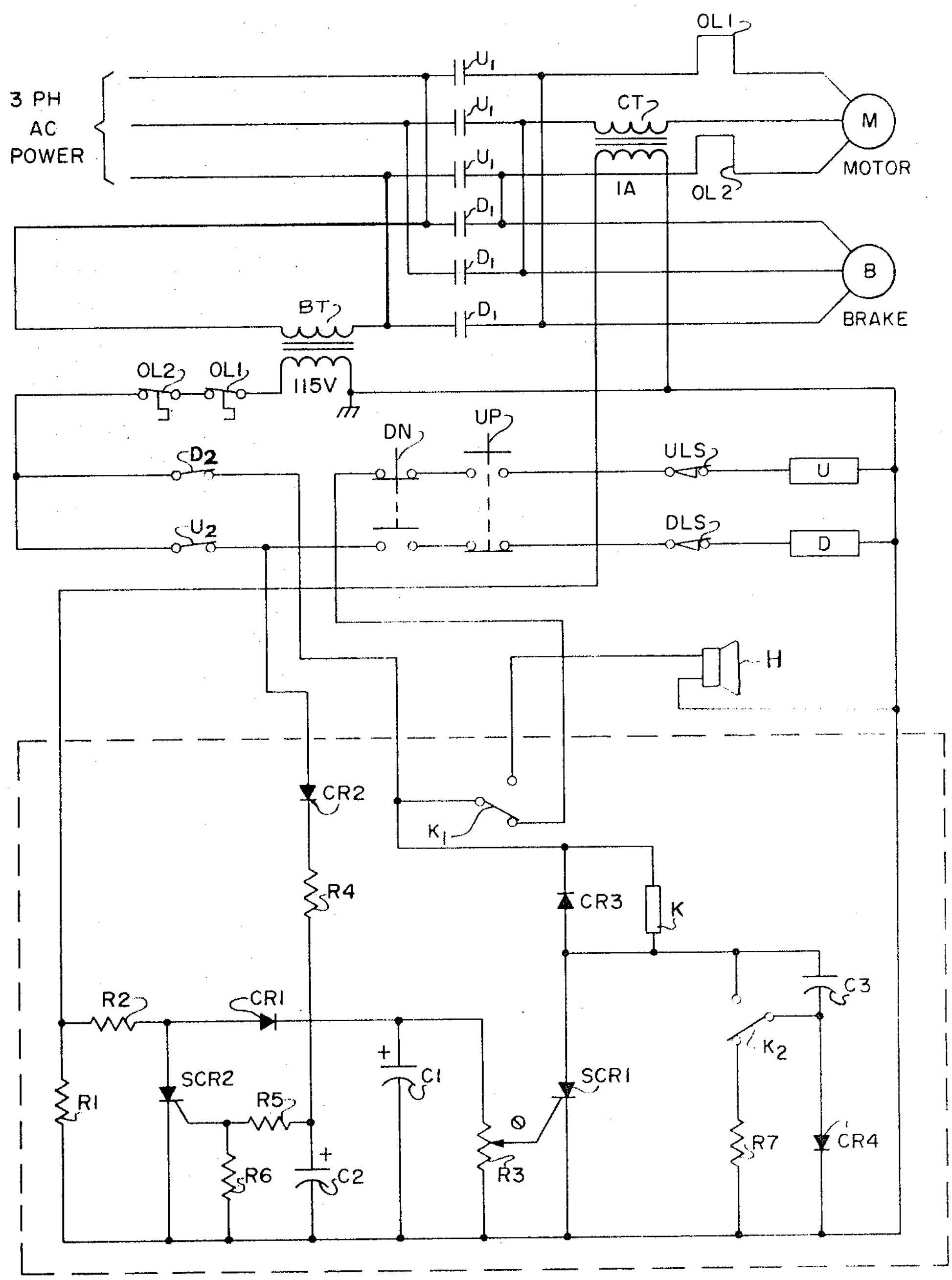
[57] **ABSTRACT**

A motor and hoist control arrangement having a motor energization circuit, with a motor current sensitive power disconnect network operative only after a time delay after motor start-up, to prevent undesired power disconnect due to motor surge current, and motor-current signal by-pass means for preventing motor current sensing action during start-up of the motor for a selected predetermined period to prevent power disconnect action during such period.

16 Claims, 1 Drawing Figure





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MOTOR AND HOIST CONTROL ARRANGEMENT

This invention relates to a motor control arrangement, and in particular to a control arrangement which is specifically useful and adapted to use as a hoist drive control for a hoist having an AC drive motor.

In the operation of motor driven hoists, as well as various other motor drive arrangements, a continuing problem is the prevention of damage to the hoist or other driven mechanical equipment, in its various drive or take-up parts, when such is attached to transmit motion to a substantially fixed object or to one which imposes a harmful overload condition on the hoist or other drive arrangement. For instance, in utilizing a hoist, it is not uncommon for an operator to secure the hoist lift rope, cable or chain to an anchored unit or to a unit which is grossly overweight for the rated hoist capacity. While motors are conventionally provided with built-in current overload responsive cut-off switches which operate after a given length of time on the basis of heat build-up or other abnormal operation indicators, such relatively slow acting motor overload protectors do not satisfy the requirements which must be met in order to prevent damage to the remaining hoist drive equipment, such as the clutch or clutches and the gears, as such remaining drive train equipment, as well as other portions of the hoist, may be very quickly damaged if the hoist is not relatively quickly stopped upon the attempt to lift or pull a grossly overloading weight or act against some other grossly overloading resistive force.

It will therefore be seen that it is desirable to provide a hoist arrangement which will prevent damage to the various parts of the hoist in the event that the hoist is inadvertently or otherwise connected so as to place an undue overload on the hoist. However, from the standpoint of the drive motor for the hoist, this poses a substantial problem in that if one attempts to derive a signal indicating that an overload condition is present based upon motor power consumption, as for instance by a motor current signal, a false indication of hoist overload will be given during the motor start-up, as the motor draws a substantial surge current at this time.

It is accordingly a major feature of the present invention to provide a motor control arrangement which is particularly useful on hoist or other power drive arrangements where quickly destructive overload conditions may be encountered, which motor control arrangement includes means for disconnecting power to the motor as a result of encountering such a destructive overload condition, while also preventing undesired disconnect of power during a brief period after motor start-up when large surge currents are encountered.

Still a further feature of the invention is the provision of such a motor control arrangement as applied to a practical hoist drive, in which a power disconnect means is operative during the operation of the hoist motor drive, but is rendered inoperative during the lowering of the hoist, when the motor and hoist are in different operating mode.

Still other objects, features and attendant advantages will become apparent to one skilled in the art from a reading of the following detailed description of one preferred and illustrated embodiment constructed in accordance therewith, taken in conjunction with the accompanying drawing, therein:

The FIG. is a schematic electrical circuit of a hoist motor control arrangement according to the invention.

Referring now in detail to the drawing, a motor and brake control arrangement is provided for a three phase AC motor M and a brake B, the motor being suitably mounted on a hoist and driving a take-up reel or drum, as through a suitable clutch and gear train drive of conventional construction (not shown). The hoist may also be provided with a brake B which is required to be energized to release the brake during the operation of the motor M, as is conventional practice. The motor M and brake B may be energized from any suitable source of three phase AC power, and it will also be appreciated that other AC power may be employed, including single phase power.

Conventional relatively slow acting overload switches OL1 and OL2 may be provided for the motor, as generally indicated in the circuit diagram, although such are not required for operation of the present invention. Such are illustrated primarily as an optional feature in view of the normal provision of such switch or switches as a built-in operating feature of conventional commercial motors. The present circuit does make arrangement for enabling the utilization of this optional additional overload disconnect arrangement. To this end, the overload switches OL1 and OL2, being in series circuit relation with the motor M, have conventional latching contacts OL1 and OL2, respectively, which are arranged to effect disconnection of power to the motor M and the brake B in the event of overload sensing by these overload detectors OL1 and OL2. However, inasmuch as such overload detectors are normally relatively slow acting as heretofore noted, further additionally relatively fast acting overload protection is provided according to the invention.

The motor M and brake B are energized in either the up or down modes through the medium of push button switches UP and DN, respectively, the actuation of which push button switches is effective to energize power contactors U or D, respectively, which contactors are provided with normally open contacts U_1 and D_1, and which contacts U_1 or D_1 are thereby closed to supply power to the motor M and brake B as a direct function of closing the respective up or down switch UP or DN. Thus, the motor M is driven in one direction by closing of the switch UP, and phase reversal is effected to the motor by closing of the switch DN, to thereby drive the motor in the opposite direction. The brake B operates in the conventional fashion during either phase condition.

A power disconnect network is provided to prevent undue damage to the hoist or other drive mechanism upon the encountering of abruptly acting overload such as where the hoist is connected to a grossly excessive weight or to a fixed object, such as a bulkhead. This power disconnect circuit includes a power disconnect relay and a relay operating switch in the form of a silicon controlled rectifier SCR1 which is normally in the cut-off state under normal motor operating conditions, as well as prior to energization of the motor M.

An AC signal indicative of motor drive current is picked off as through the medium of a suitable transformer CT, the output of which transformer is connected through current limiting resistor R2 and diode CR1 to the gate or control electrode of the silicon controlled rectifier SCR1. Variation of sensitivity of the rectifier SCR1 to the current indicating signal from transformer CT is effected through the medium of variation of pick-off at the potentiometer R3, the pick-off arm of which is connected to the control electrode or gate of SCR1.

AC anode voltage is supplied to SCR1 from an auxiliary transformer BT, through a line connection including overload contacts OL1, OL2, contactor D and its contact D_2, and power disconnect relay K. It will thus be seen that in the quiescent condition of the circuit, anode current is supplied to the SCR1, and this current continues to be supplied until some portion of the supply line thereto is broken, as by opening of contact D_2, as will be discussed later.

Although anode current is supplied to SCR1 in the quiescent and normal up motion operating condition of the motor M, the SCR1 is normally in the cut-off condition during this quiescent period, as well as in the normal operating condition, as the sensitivity control potentiometer R3 is set to a value such that the normal signal from the transformer CT, and resulting from normal motor operation, will be such as to maintain the SCR1 in the cut-off condition, as will the absence of signal from CT in the quiescent condition of the motor M before start-up.

A power-disconnect-defeat network is provided in order to prevent actuation of the SCR1 to conduction and power disconnect condition during a brief preselected period, commencing at motor start-up in the up mode and continuing for such brief predetermined period thereafter. This power-disconnect-defeat network takes the form of a bypass or shunting arrangement for the control signal from transformer CT and which is otherwise applied to the gate or control electrode of the SCR1. The shunting or bypass arrangement includes a second silicon controlled rectifier switch SCR2 biased at its control electrode or gate to the conduction state prior to motor drive actuation by the closing of the up switch UP, as well as prior to actuation of the motor, and during its actuation by closing of the down switch DN. This conduction state bias to the control electrode of the SCR2 is effected through a line connection from the secondary transformer BT, including overload switch contacts OL1, OL2, up contact U_2, diode CR2, resistor R4, and discharge time delay resistant-capacitance circuit C2, R5, R6.

Thus, in the quiescent condition preceeding operating of the motor M, the capacitor C2 will be charged from the transformer BT through diode CR2, to a full charged value, thereby effecting an on condition bias on the gate of the SCR2. Upon closing of the up switch UP, power is applied to the drive motor M and brake B through contacts U1, and an AC signal is derived from transformer CT and applied through resistor R2 to the anode of SCR2, thereby effecting full signal bypass conduction of SCR2, diode CR1 (which is also preferably a silicon diode) being clamped in a cut-off condition by the prior conduction of SCR2.

In energizing the contactor U by closing of the up power switch UP, the contact U_9 is opened, thereby removing the charging source BT from the capacitor C2, and enabling the commencing of a time delay period during which discharge of C2 through resistors R5 and R6 and the gate of SCR2 will be effected. Upon the discharge of capacitor C2 to a value beneath the conduction bias condition for SCR2, the SCR2 will go to cut-off upon the next succeeding reverse negative half-cycle of the AC signal from transformer CT, and will remain cut-off until such time as contactor U_2 is again closed. It will be apparent, of course, that contactor U_2 remains open during the up mode of operation of the motor M, and is only reclosed upon release of the switch UP and de-energization of the contactor U, at which time the capacitor C2 will again be charged to full value through the charge connection line from transformer BT.

The period of bypass or shunting condition of SCR2 may be selected to be of any desired relatively short (or long, if desired) value, such as for instance 200–300 milliseconds, which will be sufficiently long to prevent actuation of the power disconnect network, including SCR1 and relay K, as a result of the normal motor surge current during motor start-up. As will be readily apparent, this time delay period is primarily a function of the selected values of C2, R5 and R6.

The voltage clamping action of SCR2 in the bypass or shunt conduction state maintains the diode CR1 in the cut-off condition during this bypass period, thereby preventing the effective passage of the signal from transformer CT to the gate of SCR1 during such time. Upon the subsequent cut-off of SCR2 at the conclusion of this time delay period after start-up, the signal from transformer CT will be applied through current limiting resistor R2 and diode CR1 across capacitor C1 and selective bias potentiometer R3. The primary purpose of the capicator C1 is to prevent undesired actuation of the power disconnect switch SCR1 upon the occurrence of normal very brief transient power spikes which conventionally occur in power lines, and which are normally of insignificant effect in causing any harm to the drive train of a hoist.

Upon the encountering of a heavy resistive torque by the motor M, the current through the primary transformer CT will increase proportionately and the signal from the secondary transformer CT will likewise increase, and by setting the sensitivity of bias potentiometer R3 to a desired value, the SCR1 will be triggered to conduction in response to a given current overload condition at the motor M. There will be some small delay in actuation of the switch SCR1, in view of the filtering energy absorbing action of the filter capacitor C1, this time delay being for instance of the order of 100–200 milliseconds after the occurrence of the overload indicating signal from transformer CT. This brief period is acceptable, as the hoist will normally absorb, with no appreciable damage, a serious overload condition for the total combined period of the shunting action by SCR2 and the smoothing delay period of capacitor C1, which total period may be of the order of 400–500 milliseconds, under the worst case condition of pre-overload before start-up of the motor.

Upon conduction of SCR1, the relay K is energized, thereby moving double throw contacts K1 and K2 to their opposite throw conditions. Contactor K1 may suitably be employed to energize an alarm such as a horn H, and contactor K2 serves to effect enclosing of a holding circuit through diode CR4 in parallel with SCR1, to thereby hold relay K in its energized condition, independent of subsequent cut-off of SCR1, which cut-off of CR1 occurs as a result of actuation of relay K, de-energization of contactor U, and opening of power contacts U_1 in the power circuit to the motor M and transformer CT.

The coil of relay K may be suitably connected in parallel with a free-wheeling diode CR3, to maintain the relay K in actuated condition during both half cycles of the AC signal.

As an aid in preventing damage to and false operation of the SCR1, as may result from power surges through BT, a capacitor C3 and resistor R7 are connected in series relation with the coil of relay K, through relay contact K2 which is normally in series closed ground return connection through capacitor C3 and resistor R7. Thus, inductive or other abrupt power surges at the anode of SCR2 are absorbed by capacitor C3 prior to movement of the contact K2 to its alternate throw condition, thereby affording protection for the SCR1.

The breaking of the relay holding circuit through contact K2 and diode CR4, and the consequent resetting of the circuit to its normal pre-power-disconnect condition is effected through the releasing and opening of the up switch UP and the subsequent depressing and closing of the push button down switch DN. Closing of down switch DN effects energization of contactor D, thereby closing the contactor contacts D_1 to energize the motor M and brake B and drive the motor in the opposite direction, and likewise opens contactor normally closed contact D_2, thereby breaking the holding circuit for relay K. This same operation of opening of normally closed contact D_2 likewise removes the anode voltage from power disconnect switch SCR1, thereby effectively preventing any power disconnect action during the down mode of operation of the motor M, as it is not normally required to protect the hoist drive against any unexpected overload conditions in this direction of operation.

It will, of course, be apparent that if so desired, the circuit may be modified to permit similar power disconnect control action for the motor M in either or both directions of motion of the motor.

Suitable upper and lower travel limit switches may be provided, such as indicated generally at ULS and DLS respectively, and which may be suitably connected in series with the respective power control contactors U and D, respectively, for upper and lower limit de-energization of the motor M. In this respect, as well as with respect to other de-energization of the motor M and brake B, it is to be noted that hoists are normally provided with a further auxiliary brake which is operational upon the stopping of the drive motor, and as such is conventional practice the provision of such auxiliary brake is not specifically shown or indicated on the circuit arrangement. Such may, in fact, constitute only a clutch/brake arrangement of the mechanical variety and which is operative to prevent reverse or down motion of the motor and hoist except when the motor M is energized.

In general summary of operation, the motor M and brake B may be energized in either the up or down directions by pressing of push button switches UP or DN, respectively, thereby energizing contactors U and D respectively to effect closing of power contacts U_1 and D_1 respectively and the opening of normally closed contacts D_2 and U_2, respectively, the closing of either of the sets of power contacts U_1 or D_1 being effective to energize the motor M and brake B in each instance for effective motion of the motor in the requisite direction.

Opening of contact U_2 by the closure of push button contact UP and concomitant energization of contactor U, removes charging power from capacitor C2, thereby initiating a time delay period for discharge of capacitor C2 through resistor R5, R6 and the gate of SCR2. The current indicating signal from transformer CT is thus bypassed through SCR2 during the initial motor start-up time in the up motor direction, until bias voltage at the gate of SCR2 is below the cut-off value. During this conduction of the SCR2, the diode CR1 is clamped below cut-off by the conduction of SCR2, thereby preventing the signal from transformer CT from effecting actuation of the power disconnect switch SCR1 during such period. Upon the termination of the time delay period, at which time SCR2 goes to cut-off in view of the AC nature of the signal applied across its anode and cathode. The subsequent occurrence of overload indicative signals from sensing transformer CT will be effective to effect conduction of SCR1, dependent upon the sensitivity setting of R3.

Conduction of SCR1 effects actuation of relay K to switch contacts K1 and K2, thereby energizing alarm H and shunting SCR1 to effect a holding of relay K in the energized condition, which energized condition will be maintained until the down switch DN is subsequently depressed to close the circuit to contactor D and thereby open the normally closed contact D_2 of contactor D. Opening of contact D_2 removes the power to the coil of relay K, thereby resetting the relay K to the deenergized condition, which will turn off the alarm H, and restore the contacts K1 and K2 to their initial throw positions as indicated in the drawing.

Upon release of the down push button switch DN, the control arrangement will be restored to its full initial condition, with AC power applied to the anode of the SCR1, and with the capacitor C2 charged to conduction biasing condition for sCR2, the SCR1 being in the cut-off condition in view of the absence of an abnormal motor current flow indicating signal from the transformer CT. The circuit is thus in readiness for the up actuation of the motor M and power disconnect control as heretofore described, or for further down mode operation of the motor M without power disconnect control, also as heretofore described.

While the invention has been illustrated and described with reference to a particular illustrative embodiment, it will be apparent to those skilled in the art that various modifications and improvements may be made without departing from the scope and spirit of the invention. Accordingly, the invention is not to be limited by the illustrative embodiment, but only by the scope of the appended claims.

What is claimed is:

1. A load-limiting motor control circuit arrangement comprising:

means for sensing AC current flow to an AC motor,

power disconnect means responsive to a power disconnect switching signal which is a function of the quantum value of said current flow for disconnecting power to said motor,

and signal-gating means operative during motor start-up to gate said signal to prevent actuation of said current-sensing means during a selected period commencing with and terminating after start-up,

said signal-gating means comprising a current-shunting circuit,

said power disconnect switching signal being a current which is a direct function of the quantum value of the AC current flow to said motor,

said power disconnect means comprising:

a first normally cut-off electrical switch having a control electrode,

a signal flow connection between said signal-gating current-shunting circuit and said control electrode,

and a power disconnect relay responsive to cut-on of said normally cut-off electrical switch to disconnect power to said motor,

said signal-gating means comprising:

a second electrical switch having a control electrode, an anode and a cathode,

an enabling circuit effecting an enabling signal and connected in control-biasing relation to said control electrode,

means connecting said switch anode and cathode in controlled series shunt relation with said power disconnect switching signal,

said power disconnect switching signal being AC,

time-controlling means operative as a function of the passage of a selected time period after removal of said enabling signal at said control electrode to effect reduction of control bias to said second electrical switch control electrode below cut-off and to maintain said control bias in the below-cut-off condition during continued running of said motor thereafter,

and means connecting said power disconnect switching signal in switch-controlling relation to said power disconnect normally cut-off first electrical switch.

2. The improvement according to claim **1**,

said signal gating second electrical switch and said power disconnect normally cut-off first electrical switch each comprising a respective controlled rectifier.

3. In a motor control circuit for an AC electric motor having an AC power source, the improvement comprising:

motor current responsive means for detecting, and providing an electrical signal as a function of, current input to said motor,

power disconnect means operating to disconnect electrical power to said motor in response to values of said signal indicating overload of said motor,

and signal bypass means effectively shunting said signal away from said power disconnect means during initial current surge as a function of motor start-up,

and predetermined time interval time delay bypass disabling means effective to disable said bypass means after a selected predetermined time period from start-up.

4. In a motor control circuit for an AC electric motor having an AC power source, the improvement comprising:

motor current responsive means for detecting, and providing an electrical signal as a function of, current input to said motor,

power disconnect means operative to disconnect electrical power to said motor in response to values of said signal indicating overload of said motor,

and signal bypass means effectively shunting said signal away from said power disconnect means during initial current surge as a function of motor start-up,

and time delay means effective to disable said bypass means after a selected time period from start-up,

said power disconnect means comprising a first controlled rectifier and a motor power control relay responsive to actuation and deactuation of said controlled rectifier,

said relay having power control contacts in power control relation to said motor,

said signal bypass means comprising a bypass switch in controlled signal-shunting relation to said first controlled rectifier,

said time delay means being connected in shunt-controlling relation to said bypass switch.

5. A motor control circuit according to claim **4**,

said time delay means comprising a resistance-capacitance discharging circuit,

charging means selectively connecting capacitor-charging power to said discharging circuit,

and charge-disconnect means responsive to start-up actuation of said motor to effectively disconnect said discharging circuit from said charging means and thereby initiate a discharge period for said resistance-capacitance discharging circuit,

the operative condition of said bypass switch being controlled by the effective charge of said resistance-capacitance discharging circuit.

6. A motor control circuit according to claim **5**, and a filter circuit between said motor current responsive means and said power disconnect means to prevent undesired actuation of said power disconnect means due to momentary signal fluctuations.

7. A motor control circuit according to claim 6,

and a normally quiescent alarm responsive to actuation of said power disconnect to the power disconnect mode.

8. A motor control circuit according to claim 5, and motion enabling means enabling rotation of said motor in one mode of motor operation beyond the control of said power disconnect means.

9. In a motor control circuit for an AC electric motor having an AC power source, the improvement comprising:

motor current responsive means for detecting, and providing an electrical signal as a function of, current input to said motor,

power disconnect means operative to disconnect electrical power to said motor in response to values of said signal indicating overload of said motor,

and signal bypass means effectively shunting said signal away from said power disconnect means during initial current surge as a function of motor start-up,

and time delay means effective to disable said bypass means after a selected time period from start-up,

said power disconnect means comprising a first controlled rectifier and a motor power control relay responsive to actuation and deactuation of said controlled rectifier,

said relay having power control contacts in power control relation to said motor,

said power disconnect means further comprising a protective filtering network normally connected in parallel relation to said first controlled rectifier,

relay-holding circuit means responsive to actuation of said first controlled rectifier to power disconnect state to thereby shunt both of said first controlled rectifier and said filtering network,

and reset means for resetting said relay-holding circuit means.

10. A motor control circuit according to claim 9,

said relay holding circuit means including a normally inactive rectifier in shunt-connectable relation to said first controlled rectifier and being operatively connected in shunting and similarly polarized rectification relation to said first controlled rectifier in response to said actuation of said controlled rectifier to power disconnect relation.

11. A motor control circuit according to claim 10,

said relay holding circuit means comprising switch contacts operated as a function of actuation of said power disconnect relay,

said switch contacts including a double throw contact arm normally connecting said filter network in operative protective filtering relation to said first controlled rectifier and movable in response to actuation of said relay to shunt said filter network and controlled rectifier and to connect said normally inactive rectifier into series holding relation with said relay.

12. A motor control circuit according to claim 9,

said power disconnect means including a free-wheeling diode in parallel with an actuating coil of said relay to insure continued holding operation thereof during succeeding AC cycle reversals.

13. A lift-weight-restricting hoist arrangement comprising a hoist having a lift drive arrangement, said lift drive arrangement comprising: an AC drive motor in lift-driving relation to said hoist, to apply a lifting power to the hoist, means for sensing current flow to said motor and effecting a power disconnect signal as a function of the quantum value of said current flow, power disconnect means responsive to said power disconnect signal for disconnecting power to said motor, and signal control means operative during motor start-up to to prevent effective application of said power disconnect signal to said power disconnect means for effective operation of said power disconnect means during a selected period commencing with and terminating after start-up.

14. An arrangement according to claim 13,

said signal gating means being operative to prevent effective operation of said current sensing means through prevention of actuation thereof during said period.

15. A load-limiting motor control circuit arrangement comprising:

means for sensing AC current flow to an AC motor,

power disconnect means responsive to a power disconnect switching signal which is a function of the quantum value of said current flow for disconnecting power to said motor,

and signal-gating means operative during motor start-up to gate said signal to prevent actuation of said current-sensing means during a selected period commencing with and terminating after start-up,

said signal-gating means comprising a current-shunting circuit,

said power disconnect switching signal being a current which is a direct function of the quantum value of the AC current flow to said motor,

said power disconnect means comprising:

a first electrical switch having a control electrode and two controlled current-conducting electrodes controlled by said control electrode and being normally in one electrical-conducting condition,

a signal flow connection between said signal-gating current-shunting circuit and the said control electrode,

and a power disconnect relay responsive to change of the electrical conducting-condition of said two controlled current-conducting electrodes from normal to disconnect power from said motor,

said signal-gating means comprising:

a second electrical switch having a control electrode, an anode and a cathode,

an enabling circuit effecting an enabling signal and connected in control-biasing relation to said control electrode,

means connecting said switch anode and cathode in controlled series shunt relation with said power disconnect switching signal,

time-controlling means operative as a function of the passage of a selected time period after removal of said enabling signal at said control electrode to effect reduction of control bias to said second electrical switch control electrode below cut-off and to maintain said control bias in the below-cut-off condition during continued running of said motor thereafter,

and means connecting said power disconnect switching signal in switch-controlling relation to said power disconnect first electrical switch.

16. A load-limiting motor control circuit arrangement comprising:

means for sensing AC current flow to an AC motor,

power disconnect means responsive to a power disconnect switching signal which is a function of the quantum value of said current flow for disconnecting power to said motor,

and signal-gating means operative during motor start-up to gate said signal to prevent actuation of said current sensing means during a selected period commencing with and terminating after start-up,

said signal-gating means comprising a current-shunting circuit,

said power disconnect switching signal being a current which is a direct function of the quantum value of the AC current flow to said motor,

said signal-gating means comprising:

an electrical switch having a control electrode, an anode and a cathode,

an enabling circuit effecting an enabling signal and connected in control-biasing relation to said control electrode,

means connecting said switch anode and cathode in controlled series shunt relation with said power disconnect switching signal, time-controlling means operative as a function of the passage of a selected time period after removal of said enabling signal at said control electrode to effect reduction of control bias to said electrical switch control electrode below cut-off and to maintain said control bias in the below-cut-off condition during continued running of said motor thereafter,

and means connecting said power disconnect switching signal in switch-controlling relation to said power disconnect means.

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