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CONTROLLER FOR POLYPHASE ALTERNATING CURRENT MOTORS

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Fig. 1

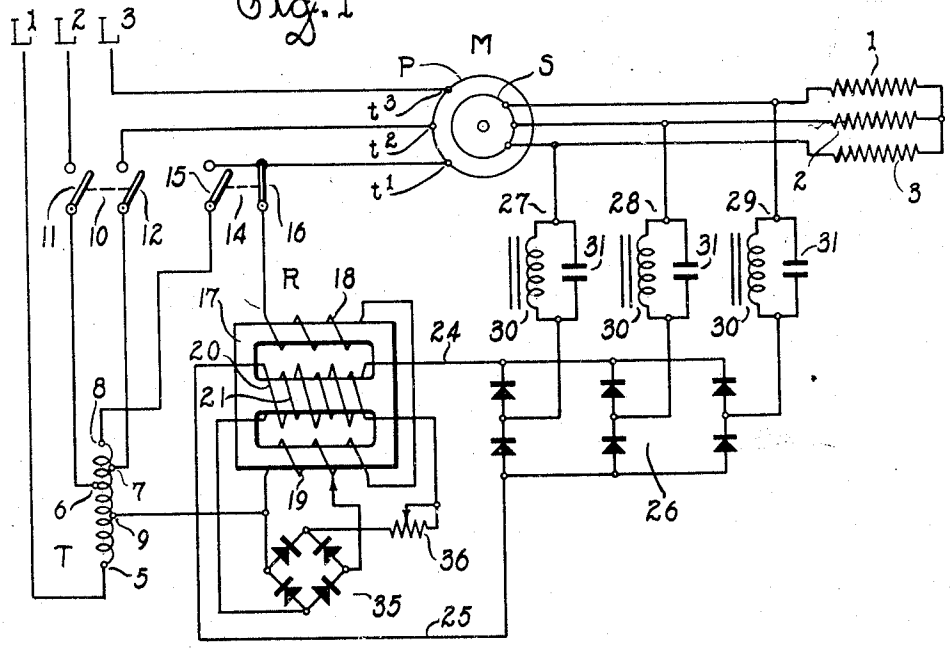
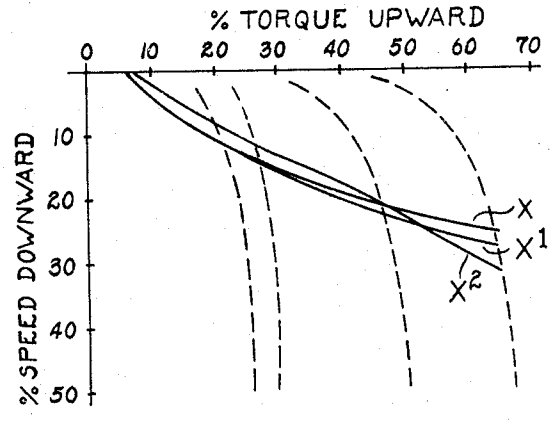


Fig. 2



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CONTROLLER FOR POLYPHASE ALTERNATING CURRENT MOTORS

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8 Claims. (Cl. 172—152)

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This invention relates to controllers for polyphase alternating current motors, controllers embodying the invention being especially advantageous for motors employed in hoisting and lowering widely varying loads.

Heretofore it has been proposed to obtain a slow lowering speed through the medium of a saturable reactor connected in the primary circuit of the motor, the degree of saturation of the reactor being made a function of the motor speed.

An object of the present invention is to provide improved saturable reactor control for slow speed lowering.

Another object is to provide for varying reactor saturation as desired without need of a tachometer machine.

Another object is to minimize the size of the required saturable reactor.

Other objects and advantages of the invention will hereinafter appear.

An embodiment of the invention is illustrated in the accompanying drawing, such embodiment being susceptible of various modifications without departing from the scope of the appended claims.

In the drawing,

Figure 1 is a diagrammatic showing of a motor and control means therefor, and

Fig. 2 is a chart showing certain characteristic curves.

Referring to Fig. 1 of the drawing, it shows a polyphase alternating current motor M having a primary P and a secondary S, which motor it will be assumed is employed in hoist service. The primary of motor M is shown as supplied with power from lines L^1, L^2, L^3 and the secondary of the motor is shown as provided with resistors 1, 2 and 3, individualized to the phases of the secondary circuit.

For simplicity of illustration the control means shown for motor M has been reduced to the elements employed for slow speed lowering as such control means may obviously be incorporated in a now well known type of hoisting and lowering controller. Such type of controller employs for effecting voltage unbalance of the motor primary and for enabling torque reversals of the motor in lowering an autotransformer such as the autotransformer T shown in the drawing. The autotransformer T has a portion between terminal 5 and a tap 6 connected across lines L^1 and L^2, and in addition has an extended portion and commutatable connections to afford variation of the degree of voltage unbalance of the motor primary and to enable reversals of the motor torque.

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A two-pole switch 10 through the medium of its contacts 11 connects across lines L^1 and L^2 the portion of the autotransformer T between points 5 and 6, while contacts 12 of switch 10 connect transformer tap 7 to terminal t^2 of the motor primary. A two-pole double throw switch 14 through the medium of its contacts 15 connects autotransformer terminal 8 to motor terminal t^1, whereas the contacts 16 of switch 14 alternatively connect motor terminal t^1 to tap 9 of the autotransformer T through coils of a saturable reactor R.

The reactor R is of conventional form comprising a magnetic frame 17 having on its outer legs series connected alternating current windings 18 and 19, and on its central leg a direct current winding 20. The series connected windings 18 and 19 are included in circuit between contacts 16 of switch 14 and the autotransformer tap 9, the contacts of the switch 14 being, as aforeindicated, interlocked for closure thereof selectively whereby the reactor windings 18 and 19 are included in circuit only when the contacts 15 of switch 14 interrupt the circuit between motor terminal t^1 and autotransformer terminal 8. As will be understood, the direct current winding 20 affords varying degrees of saturation of the magnetic frame 17 to vary the reactance value of reactor R, the reactance value being at a maximum with the direct current winding deenergized. Also the reactor, for a purpose hereinafter set forth, has on its center leg a compensating winding 21.

The direct current winding 20, as aforeindicated, is to be energized to varying degrees as a function of the frequency of the secondary circuit of the motor, and to this end it is subjected to rectified current supplied to conductors 24 and 25 by a two-way rectifier 26 which is supplied with alternating current from the motor secondary through tuning devices 27, 28 and 29. Each of these tuning devices comprises a reactor 30 paralleled by a condenser 31, said tuning devices being connected between the rectifier 26 and different terminals of the motor secondary. Because of the primary voltage unbalance due to the autotransformer and the saturable reactor, the motor secondary will produce voltages and currents of positive and negative sequence. With the motor running at a given slip (S) the frequency of the former will be proportional to (S) and that of the latter to (2—S). At standstill of the rotor the frequencies of the two sequences will thus be equal and the same as that

of the primary. The tuned circuit is designed and adjusted to reduce to a minimum the energization of winding 20 at zero speed of the motor, or in other words, when the sequence frequencies of the motor secondary are equal to that of the primary, whereas as the motor accelerates, with deviation in the sequence frequencies from that of the primary, winding 20 is energized to a degree varying with the motor speed.

Although the tuned circuit is designed for minimum current at zero speed there is some current flow even under such conditions, due to the leakage of the condensers and the resistance of the associated reactors, and the purpose of the compensating winding 21 is to neutralize the direct current thus supplied to the winding 20 at standstill of the motor. As shown the winding 21 is connected across a portion of winding 19 through a two-way rectifier 35 and an adjustable resistor 36. This connection of the compensating winding is a preferable one, having been found effectively to neutralize the undesired residual direct current aforementioned and to have other advantage. With this connection the neutralizing direct current decreases as the load begins to move and the reactor becomes saturated. Consequently its bucking effect is less at full load, which is desirable as permitting better utilization of the controlling direct current. In a test the compensating or neutralizing winding was found to have at full load less than half its standstill bucking effect, with consequent tendency to reduce the standstill-full load ratio of the required controlling direct current.

Assuming switch 14 to be positioned as illustrated and switch 10 to be closed, the motor will be supplied wtih power from lines L^1, L^2, L^3, through the autotransformer T in respect of certain of its terminals, for voltage unbalance of the motor primary and a torque of the motor in hoisting direction. However, the motor torque at standstill will be low because of the high reactance value of reactor R due to the high impedance of the tuned circuits 27, 28, 29 at the standstill frequencies and consequent deenergization of the saturating winding 20. On the other hand, as the motor accelerates, with consequent variation in secondary frequency, the saturating winding 20 will become energized to decrease the reactance value of reactor R for increased torque of the motor, the effect of the saturating coil varying as a function of variations in secondary frequency of the motor.

With the motor so controlled it has been found possible with relatively small circuit components to hold the speed of the motor to about 25% in lowering under heavy load conditions at the same time holding the motor torque in hoisting direction at zero speed within a 10% limit, as indicated by the chart, Fig. 2. The chart shows the speed torque curves obtained with different numbers of turns per set of reactor coils and with different voltages measured between transformer tap 9 and line L^2. Thus, for example, curve X was obtained with forty turns per set of reactor coils and a transformer voltage of 230 between tap 9 and line L^2, whereas curve X1 was obtained with the same number of turns and a lower voltage, while curve X2 was obtained by reducing both the number of turns and the voltage. The different loads imposed upon the motor in the tests from which the aforementioned curves were obtained are indicated by the other curves shown and varied from a light load to a heavy load.

By combining the reactor with the autotransformer type of lowering control it is possible to obtain better control and to employ a smaller saturable reactor than would be possible should the autotransformer be omitted.

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

1. The combination with a polyphase alternating current motor for load hoisting and lowering, of voltage unbalancing means for the primary of said motor comprising a saturable reactance having a winding in circuit with a terminal of the motor primary, and also having a saturating winding, means for rectifying current obtained from the secondary circuit of said motor for supplying said saturating winding and automatic means rendering the rectified current thus supplied to said saturating winding variable as a function of speed of said motor.

2. The combination with a polyphase alternating current motor for load hoisting and lowering, of voltage unbalancing means for the primary of said motor comprising a saturable reactance having a winding in circuit with a terminal of the motor primary and also having a saturating winding, and a compensating winding, means for rectifying current obtained from the secondary circuit of said motor for supplying said saturating winding, automatic means rendering the rectified current thus supplied to said saturating winding variable as a function of speed of said motor, and means supplying rectified current to said compensating winding to neutralize the effect of said saturating winding at zero speed of said motor.

3. The combination with a polyphase alternating current motor for load hoisting and lowering, of slow speed lowering control means therefor comprising a saturable reactor in circuit with certain of the terminals of the primary of said motor, and means for supplying to said reactor, to effect saturation thereof, rectified current derived from the secondary current of said motor, the last mentioned means comprising tuning means rendering such rectified current a function of frequency condition of the secondary of said motor.

4. The combination with a polyphase alternating current motor for load hoisting and lowering, of means to afford voltage unbalance of the primary of said motor comprising a saturable reactor having certain of its windings in circuit with certain of the terminals of the primary of said motor, means to supply to a saturating winding of said reactor rectified current derived from the secondary circuit of said motor and so derived as a function of frequency condition of the secondary of said motor, and means effective at standstill of said motor to neutralize saturating tendency, if any, of said saturating winding.

5. The combination with a polyphase alternating current motor for load hoisting and lowering, of voltage unbalancing means for the primary of said motor comprising a saturable reactor having certain of its windings in circuit with certain of the terminals of the primary of said motor, means to supply to a saturating winding of said reactor direct current as a function of speed of said motor, and means effective at standstill of said motor to neutralize saturating tendency, if any, of said saturating winding, said neutralizing means comprising a winding for said reactor and a rectifying circuit connecting the last mentioned winding across a portion of a winding of said reactor included in circuit with said motor.

6. The combination with a polyphase alternating current motor, of means comprising an auto-

transformer and a saturable reactor, affording voltage unbalance of the motor primary and variation of the voltage on certain of the terminals of the motor primary, and means to saturate said reactor to varying degrees as a function of changes in speed of said motor.

7. The combination with a polyphase alternating current motor for load hoisting and lowering, of means comprising an autotransformer and a saturable reactor jointly controlling the voltage on certain of the terminals of the primary of said motor and affording voltage unbalance of the motor primary, said reactor having a saturating winding, and means for supplying said saturating winding of said reactor with rectified current derived from the secondary current of said motor, the last mentioned means comprising tuning means rendering such rectified current a function

of frequency condition of the secondary of said motor.

8. The combination with a polyphase alternating current motor for load hoisting and lowering, of means comprising an autotransformer and a saturable reactor jointly controlling the voltage on certain of the terminals of the primary of said motor and affording voltage unbalance of the motor primary, means supplying to said reactor for saturation thereof rectified current derived from the secondary of said motor and so derived as a function of frequency condition of the motor secondary, and means effective at standstill of said motor to neutralize the saturating effect of any such rectified current supplied under such conditions.

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