INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

SLIPSYN®

Synchronous Motor Control

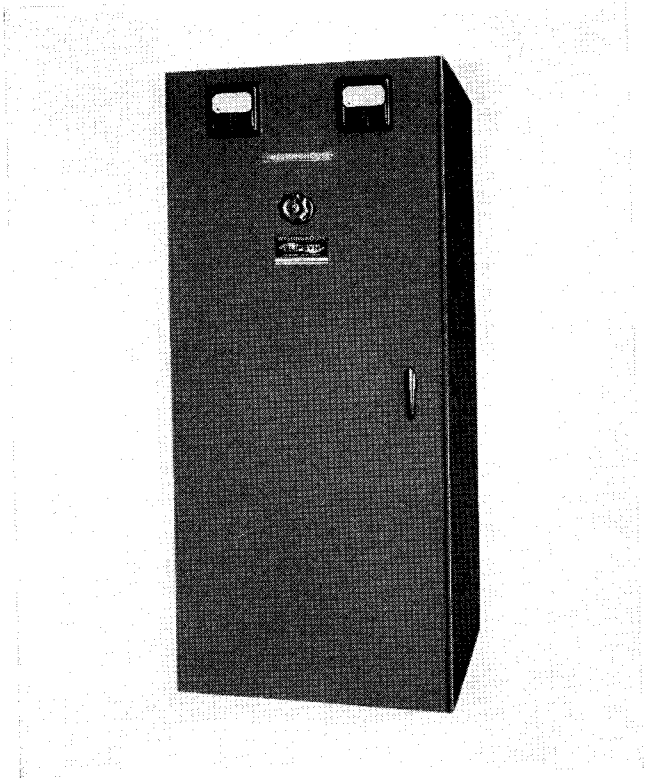

FIG. 1. Typical Class 14-250 Full Voltage Starter

SLIPSYN SYNCHRONOUS MOTOR CONTROL units to which this leaflet applies are listed with their apparatus class numbers in table below.

APPARATUS CLASS NO.	SLIPSYN SYNCHRONOUS MOTOR CONTROL UNIT
14-040	Semi-Magnetic Reduced Voltage Starters, Autotransformer Type.
14-100	Field Application Panel for use in conjunction with Separate Starters.
14-200	Magnetic Full Voltage Starters.
14-202	Magnetic Full Voltage Starters, Combination Type.
14-600	Magnetic Reduced Voltage, Autotransformer Starters.
14-602	Magnetic Reduced Voltage, Autotransformer Starters, Combination Type.
14-502	Magnetic Reduced Voltage Reactor Starters, Combination Type.

These instructions have been prepared specifically for guidance in the operation and adjustment of standard Slipsyn starters for synchronous motors. The standard Class 14-250 a-c full voltage starter is used as an illustration since it is the basic type. Combination and reduced voltage types differ only in the power circuit components used.

The information herein may also be used to advantage for special and nonstandard designs which differ from the standard only in minor electrical or mechanical modifications.

This leaflet and the diagram of connections should be carefully studied before attempting to install and operate the equipment.

Note: General instructions for installation and inspection of this equipment are contained in leaflet I. L. 1477-D, Controllers—General Instructions.

INSTALLATION

Before installation, the customer should determine whether the controller is to operate (1) to resynchronize the motor or (2) to trip the line switch on pull-out. If resynchronizing after pull-out is desired, the user must be sure that the motor has sufficient torque to reaccelerate under load conditions or that a satisfactory form of automatic unloader is provided. Standard controllers are shipped with connections arranged to trip the main switch on pull-out. Connections may be easily changed for the alternate scheme of operation by reconnecting the jumpers on the panel. (See directions on controller wiring diagram).

If an unloader is used with the driven machine, connections for its operation are shown on the controller wiring diagram. The contacts provided for this service have a current-carrying capacity of 5 amperes and an interrupting capacity of 200 volt-amperes at a maximum of 600 volts a-c or d-c.

FUNCTIONS OF CONTROLLER DEVICES

The general operation of the various devices used on the controller is indicated in their individual

SUPERSEDES I.L. 14-000-1A

instruction leaflets. The functions of these principal devices as used on Class 14-250 starters are as follows:

1. *The Line Contactor* operates to connect the motor to the a-c line. (This contactor is replaced by starting and running contactors in reduced voltage starters to connect and short out the autotransformer or reactor).

2. *The Thermal Overload Relay* protects the synchronous motor from damage due to overload, single-phase operation, and field failure. It operates to trip out the line contactor.

3. *The Field Contactor* connects the motor field windings to the source of d-c excitation. It also connects the starting-field discharge resistor in series with the motor field during the starting period, and again when field excitation is removed.

4. *The Starting-Field Discharge Resistor* is used to improve the motor starting torque and to limit the induced field voltage during starting or when the field excitation is removed.

5. *The Damper Winding Protection Relay* protects the damper winding of the synchronous motor against burn-out in the event the motor fails to start and accelerate. It operates to trip out the line contactor.

6. *The Synchronizing Relay* controls the field contactor, so that it closes when the motor has reached a sufficiently high speed and the poles are in a favorable relationship for synchronizing.

7. *The Rectox* rectifies the component of the induced field current thereby polarizing the holding circuit of the synchronizing relay.

8. *The Pull-Out Relay* operates on pull-out of the synchronous motor to trip the line contactor, thus shutting down the motor; or to energize the synchronizing relay, thereby initiating a resynchronizing sequence, depending upon connections used. (See first paragraph under "Installation").

9. *The Auxiliary Sequence Relay* controls the sequence of the field application equipment and nullifies the pull-out relay during synchronizing.

10. *The Field Rheostat,* while usually supplied separately with the motor or exciter, ordinarily may be mounted on the control panel. It is used for adjusting the current flowing to the synchronous motor field. With individual exciters, this is usually accomplished by varying the exciter voltage.

11. *The Master Switch,* whether a pushbutton station, float switch, pressure switch, or other device, operates to start and stop the motor.

12. *Ammeters,* both a-c and d-c are supplied for use in adjusting the excitation and to give an indication of the currents flowing. Additional meters may be supplied on order.

13. *Current Transformers,* where necessary, supply current in direct ratio to line current, to the overload relay, and to the various meters.

14. *A Control Transformer* is used on all high-voltage starters to supply power at a low voltage to the various control devices. Secondary fuses are provided for this transformer.

15. *An Auxiliary Relay* is used with the larger contactors interposed between the master switch and the contactor coil. This is necessary to handle the larger coil current. A similar contactor, together with an anti-pumping relay, is provided to energize the circuit breaker solenoid, when used.

16. *Instantaneous A-C Undervoltage Trip* is provided on all starters which use contactors for the line switch. This standard feature is obtained by action of the line contactor, or auxiliary relay if used.

17. *Time Delay Undervoltage Protection* may be provided if specified. An auxiliary relay is used with time-opening contacts to maintain the holding circuit for a short time, ½ to 1½ seconds, after voltage failure and thus will initiate a new starting cycle without attention from the operator, provided voltage returns to normal within the time delay period of the scheme. An additional relay is used to provide permanent shutdown on operation of the "Stop" pushbutton.

18. *A Time Delay Undervoltage Trip Device* is provided for use with all high-voltage starters which use circuit breakers for the line switch. This device operates in conjunction with the regular breaker undervoltage trip attachment, and delays the tripping action for a period of approximately 2 seconds. This time delay is obtained from energy stored in a condenser which continues to supply power to the trip attachment for a short time after failure of voltage. Instantaneous tripping occurs when the "Stop" control switch or button is depressed.

19. *Class 14-040 Semi-Magnetic Reduced Voltage Starters* incorporate an autotransformer and a manually-operated starting and running switch in place of the line contactor, paragraph (1) above.

20. *Class 14-200 Field Application Panels* contain only the field control equipment and must be used in conjunction with some type of separate primary motor control.

21. *Class 14-410* magnetic reduced voltage starters incorporate an autotransformer, starting and running contactors, and a definite time relay for the motor primary control.

22. *Class 14-252* magnetic full voltage starters, combination type, embody all the features of the standard Class 14-250 starter plus disconnecting type power fuses for short-circuit protection of both starter and motor.

23. *Class 14-412* magnetic reduced voltage starters combination type, embody all the features of the standard Class 14-410 starter plus disconnecting type power fuses same as those used in the Class 14-252.

24. *Class 14-452* magnetic reduced voltage starters combination type, incorporate a reactor and closed transition starting. Other features are the same as Class 14-412.

CONTROLLER OPERATION

Referring to the typical wiring diagram (Fig. 2), closure of the "Start" pushbutton energizes the line contactor and the motor is connected to the line and is accelerated as an induction motor with its field connected across a starting and discharge resistor through a damper winding protection relay.

At the same time the synchronizing relay "ASR" and auxiliary sequence relay "T" are energized thus nullifying the pull-out relay, setting up the coil circuit of the field contactor, and making the drop-out of the synchronizing relay dependent upon its holding coil.

Operation of the synchronizing relay is based on the variable frequency of the motor induced field current during starting. (See Fig. 3). A rectified half wave portion of this current is used as a means of holding the relay closed during starting, the time intervals of the no current half of the wave increasing as the frequency of the motor field current decreases with acceleration of the motor. When the time interval between rectified current half waves exceeds the time delay of the relay, the relay operates to close the field contactor and apply excitation to the motor. The polarity of the half wave Rectox rectifier is arranged to apply excitation when the motor rotor is in a favorable position for good synchronizing performance.

The synchronizing relay can be adjusted to operate over a motor induced field current frequency range of 1 to 3.5 cycles—corresponding to 98 to 94 percent motor speed based on a 60-cycle machine. (See Fig. 4). This adjustment is made by varying the adjusting nut in the front of the relay. A calibration plate is provided to simplify this setting. The relay should be set to operate at the lowest frequency (highest motor speed) the motor will attain under the most severe starting condition, so that the maximum usable pull in torque is available. This is of special importance in applications involving high inertia loads

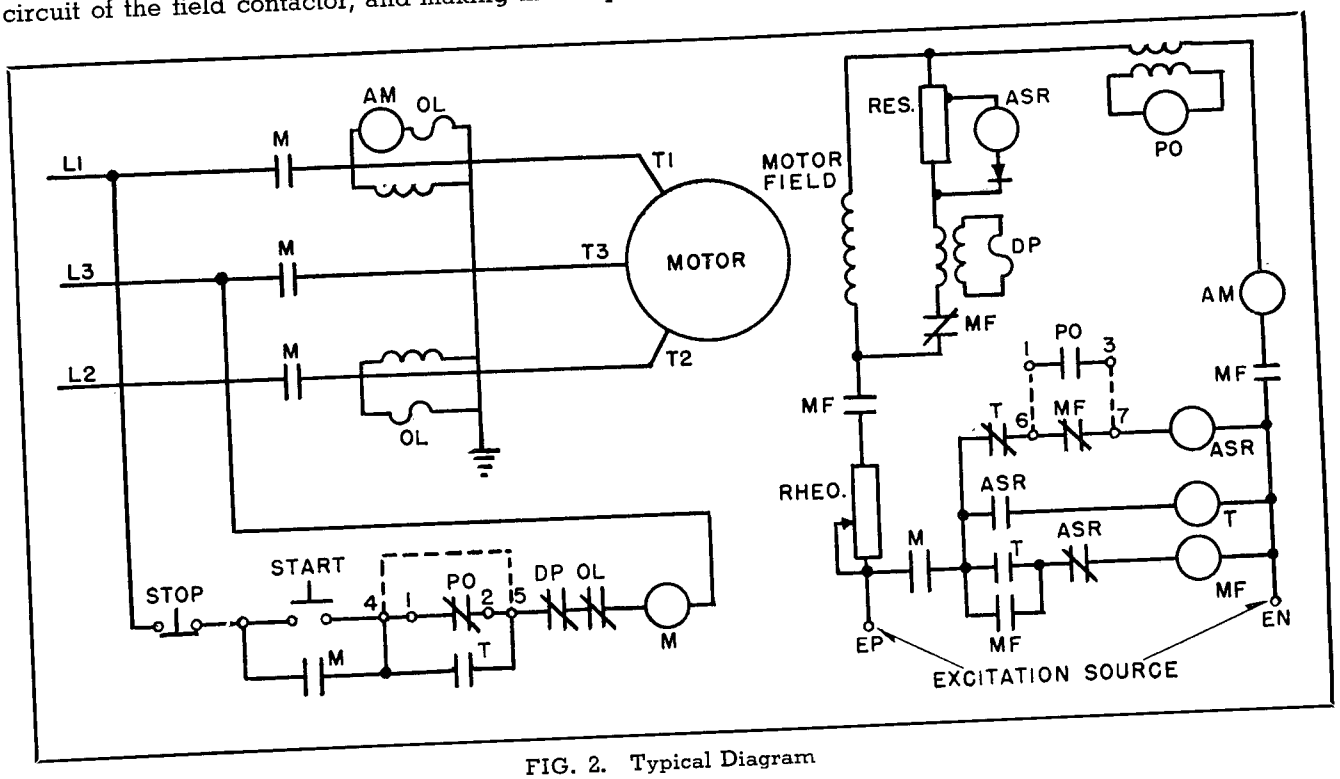

FIG. 2. Typical Diagram

d. Check load at starting. Does motor accelerate to a speed from which it can pull in?

3. If overload relay trips:

a. Check a-c supply. Is voltage correct? Is line single phased?

b. Check field current and supply. Is d-c available? Does a proper value of current flow through field current?

c. Check load. Is machine overloaded?

d. Did overload relay trip from normal synchronized condition, when pulled out of step or in starting condition.

e. Check relay calibration. Setting may be too low. Ordinarily should be about 120 percent of full load which will roughly correspond to 100 percent relay setting. Advance if necessary. Are heaters tight?

f. Check machine operation to make sure motor is synchronizing properly.

g. Inspect carefully, relay, control equipment, motor and driven load for any abnormal condition. Correct such before restarting.

h. Reset relay and attempt new start, observing carefully operation of equipment.

4. If controller fails to go through starting operation completely, check contacts, connections, and operation of the various devices.

Each equipment is designed for controlling one particular motor. Before applying it to some other motor, check the application with the nearest Westinghouse Sales Office.

Likewise, if any major repairs become necessary, contact the Sales Office for recommendations.

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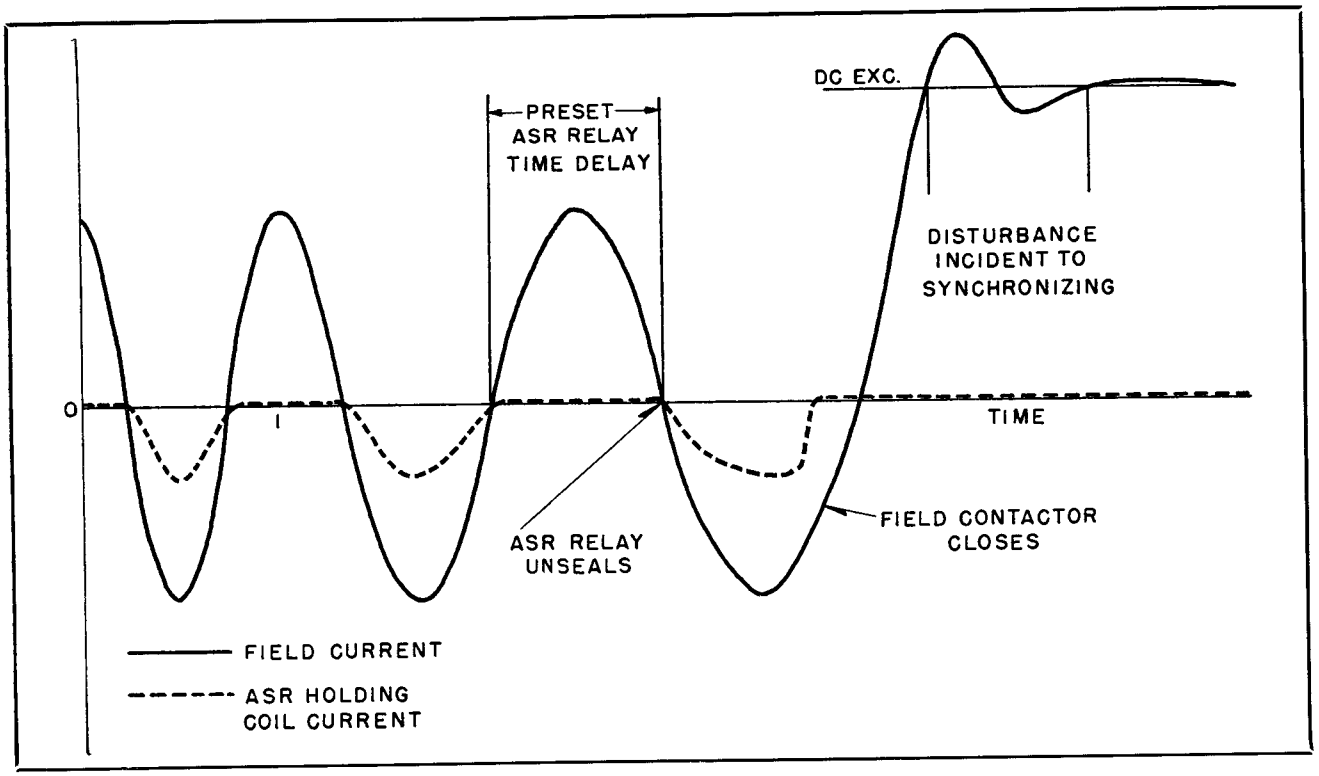

FIG. 3. Operation of ASR Relay

Closure of the field contactor places in the circuit a transformer coupled high speed, highly sensitive pull-out relay for protection against failure to synchronize, or for protection in case the motor pulls out of synchronism after being in step. The contacts of the relay are arranged to accomplish either of two functions (1) stop the motor by opening the line contactor (Jumpers 4-1 and 2-5 connected) or (2) remove excitation by opening the field contactor and initiate the resynchronizing action, as for a normal start (Jumpers 4-5, 1-6, 3-7 connected), (See Fig. 2). The fast action of the relay is of special importance for resynchronizing the motor under load, since the faster excitation is removed, the less the loss of speed, and the more rapidly the motor can again pull in. Transient load and voltage variations may cause an a-c current component in the d-c field circuit, which may cause operation of the pull-out relay should the relay be set for high sensitivity. The sensitivity of the relay may be reduced by increasing the armature spring pressure by means of the thumb screw provided. This relay cannot be adjusted to an inoperative position by means of this spring, for with maximum obtainable spring pressure the relay will still operate at approximately 6 percent slip on 60-cycle machines and 12 percent slip on 25-cycle machines. The fast action of the relay is purposely delayed during the period the motor is pulling into step, so that the transient disturbances incident to synchronization do not cause premature operation of the pull-out relay. This time delay is provided by the "inductive time delay on opening" of the auxiliary sequence relay.

The damper winding protection relay is provided to trip the line switch and remove the motor from the line should the motor fail to start. Should the

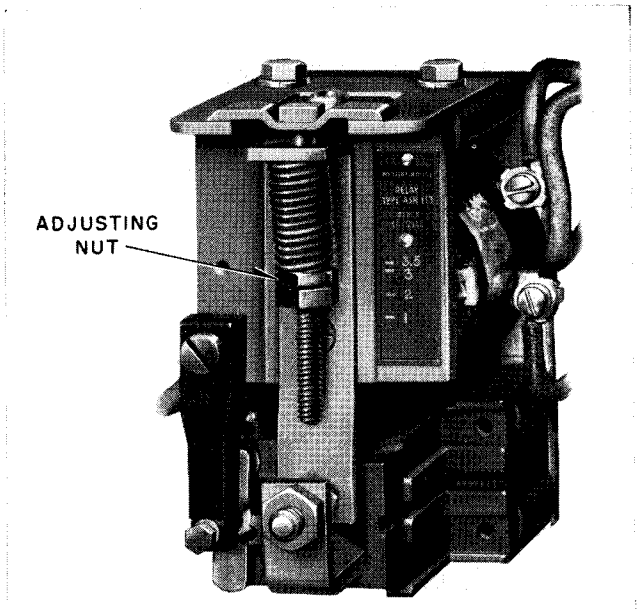

FIG. 4. Type ASR Synchronizing Relay

motor start but fail to accelerate to the speed from which it could pull in, or should the motor while running receive a sustained overload, the thermal overloads would trip the line switch before the motor would be damaged.

TESTS AND ADJUSTMENTS

Make a careful check of the controller with all motor leads disconnected to insure that the equipment is in good operating condition. In particular check the following:

1. Does controller go through complete sequence properly?

2. Trip overload relay. Does it remove equipment from the line?

3. Manually operate the pull-out relay. Does it trip the line switch, or if so connected, close the synchronizing relay and initiate a new starting cycle?

4. Does the pushbutton station (or other master switch) operate to control the equipment as expected?

After making tests as above, make temporary connections to the motor, disconnect the field contactor coil lead, and make adjustments and further tests as given below.

Important: Do not restart motor successively without allowing starting and discharge resistor to cool.

5. Set the synchronizing relay for 1-cycle operation.

6. Check the direction of rotation of the motor and correct, if necessary.

7. Start the motor and allow to accelerate to the maximum speed it will attain with normal starting load. Increase the frequency setting of the synchronizing relay until this relay drops out. Repeat start to be sure relay will drop out. (This is the minimum frequency setting which can be used for this motor and load combination. It is recommended that this setting be increased ½ cycle to provide for lower line voltage and increased bearing friction.)

8. If the relay fails to drop with the relay increased to the 3.5 cycle setting, measure the voltage across the holding coil—Rectox circuit and the current in the starting and discharge resistor. Reset the permanent tap setting on the resistor to this circuit so as to reduce this voltage approximately 10 volts, readjust the relay setting to the 1-cycle position and repeat procedure paragraph (7) and, if necessary, paragraph (8). (The permanent tap setting was made at the factory on the basis of calculated motor data. Differences between calculated and actual data may make this adjustment necessary.)

9. If the relay drops out too soon in paragraph (7) with the relay set in the 1-cycle position, proceed as outlined in paragraph (8) except reset the tap on the resistor to increase the voltage approximately 10 volts. Most motors starting without load will pull into step without applying the field. Therefore, care should be taken not to increase the holding circuit voltage if this condition exists.

10. Check overload relay operation. The heating elements are so chosen that the 100 percent adjustment is usually satisfactory. If the relay trips during the starting period, advance the setting somewhat. If the motor accelerates rapidly, the relay setting may be decreased slightly to provide quicker tripping in case of field failure, repeated pull-outs, or overload conditions.

11. Set field rheostat so that the field excitation (hot) is the value stamped on the motor nameplate. This should be considered a permanent setting in order to assure stable operation under various load conditions.

12. With the motor synchronized and normal load applied, open the field contactor coil circuit momentarily and allow the motor to decelerate to approximately 95 percent speed, and reclose the field contactor coil circuit (apply the field). The motor may pull in, in which case repeat the test at a lower motor speed. If the motor speed falls off on reclosing of the field contactor, the pull-out relay should operate and trip the line contactor or start the resynchronizing cycle depending upon the circuit. Adjustment of this relay is made by means of the armature spring adjusting screw.

After tests are completed, make permanent connections taping joints and otherwise insulating as necessary to make a permanent installation.

Trouble Checking.

1. If control fuses blow, (on high-voltage controllers), check carefully for shorted or damaged coils or wires; repair equipment and replace fuse.

2. If machine fails to synchronize properly:

a. Repeat procedure in paragraph (7) under "Tests and Adjustments."

b. Decrease the frequency setting on the synchronizing relay.

c. Check a-c voltage conditions and d-c field current.