Westinghouse

SLIPSYN®

SYNCHRONOUS MOTOR CONTROL

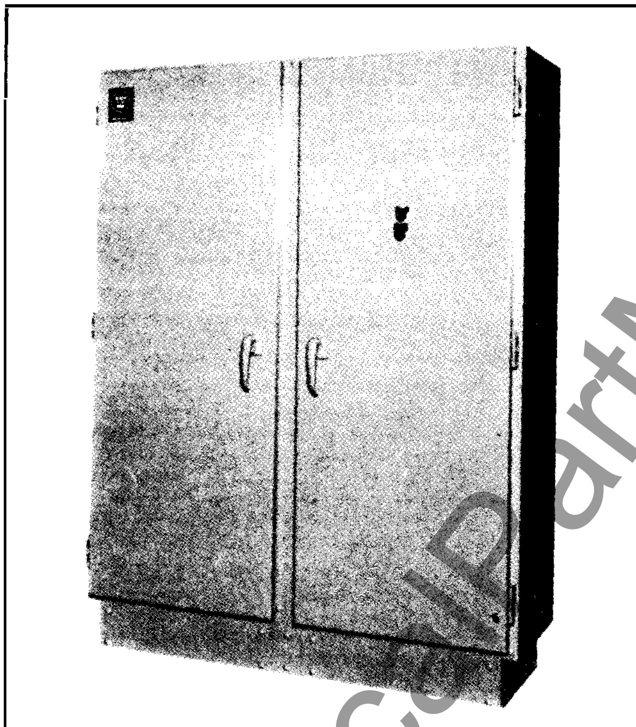

Fig. 1 A (Photo 70-0691)
Typical Class 14-200 Low Voltage Synchronous Starter

Fig. 1 B (Photo 70-0448)
Typical Class 14-202 High Voltage Synchronous 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
	LOW VOLTAGE
14–100	Field Application Panel for use in conjunction with Separate Starters.
14–200	Magnetic Full Voltage Starters.
14–600	Magnetic Reduced Voltage, Autotransformer Starters.
	HIGH VOLTAGE
14–202	Magnetic Full Voltage Starters, Combination Type.
14–502	Magnetic Reduced Voltage Reactor Starters, Combination Type.
14–602	Magnetic Reduced Voltage, Autotransformer 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 AC full voltage starters are used as an illustration of the basic types. 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.

SUPERSEDES I.L. 14–000–1 B

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 AC or DC.

FUNCTIONS OF CONTROLLER DEVICES

The general operation of the various devices used on the controller is indicated in their individual instruction leaflets. The functions of these principal devices as used on Class 14-200 starters Fig. ② are as follows:

1. The Line Contactor "M" operates to connect the motor to the AC line. Additional contactors are required in reduced voltage starters to short out the reactor or to connect and disconnect the autotransformer in the circuit. The "M" contactor may be a high voltage or low voltage depending on the class number of the starter.

2. The Overload Relay protects the motor from damage due to over current conditions such as an overload, single phase or field failure. It operates to trip the line contactor. The standard relay is thermally activated, however induction types are available as options.

3. The "FC" Field Contactor is a type "M", DC activated device with two normally open and one normally closed poles when the field current does not exceed 150 amperes. Above this range three single pole type M contactors are used. Normally the rated coil voltage is half that of the supply to accelerate the operation and cover a wider field voltage range. A series dropping resistor is used to keep from exceeding rated coil voltage.

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. The resistor current and ohmic values are determined by the motor designer.

5. The "DP" 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 is thermally activated and operates to trip out the line contactor, and the relay must be hand reset in event it trips. **Note:** This is a transformer operated thermal relay and maximum sensitivity is on initial starting when the induced field frequency is maximum. See Instruction Leaflet DP—15—827—DP—1 for more detailed information.

6. The "ASR" Synchronizing Relay, shown in Figure ④ controls the field contactor, so that it closes when the motor has reached sufficient speed and the poles are in favorable relationship for synchronizing. The relay has two independent windings. The main winding energizes the relay while the holding winding keeps it activated by the voltage drop across the starting and discharge resistor and the polarity of the two windings must be additive. The rectifier in the holding winding produces half wave direct current, and when the off time between pulses is longer than the inherent dropout time of the "ASR" relay it drops out to energize the field contactor. This is shown in Figure ③ and more fully described in controller operation under tests and adjustments.

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 contactors, thus stopping the motor; or to energize the synchronizing relay "ASR", thereby initiating a re-synchronizing sequence, depending upon connections used. (See first paragraph under Installation.) The pull out transformer is not affected by DC but pulses of AC in the field is transformed to the secondary to operate the relay. Additional information is covered in Tests and Adjustments.

9. The Auxiliary Sequence Relay "TR" is a type "AZ" timing relay with 2 to 3 seconds maximum timing range. It controls the sequence of the field application equipment and nullifies the pull-out relay during synchronizing and the two seconds delay allows the field time to stabilize. The "AZ" relay is more fully described in IL 15—827—AZ—A.

10. The Field Rheostat, while usually supplied separately with the motor or exciter, ordinarily is mounted on the control panel. It is used to control the exciter field which in turn affects the exciter voltage and motor field. When motor excitation is from a fixed bus a tapped permanent resistor with a higher rated rheostat is required. On static exciter supplies, transformer taps are provided for adjustment in place of the rheostat, however variacs may be supplied on order for ease of adjustment.

11. AC and DC Ammeters are supplied for use in adjusting the excitation and to give an indication of the currents under operating conditions. Additional meters may be supplied on order.

12. Current Transformers are furnished on all high voltage starters to supply current to the overload relay and various meters in direct ratio to the line current. On low voltage applications current transformers are supplied as necessary.

13. A Control Transformer is used on all high voltage starters and as specified on low voltage starters to furnish a control supply. Fuses are supplied on both primary and secondary.

14. Instantaneous AC Undervoltage Protection is provided on all starters, as standard which use line contactors. Time delay undervoltage may be supplied when ordered.

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 "TR" 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 Hertz—corresponding to 98 to 94 percent motor speed based on a 60—Hertz 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.

Closure of the field contactor places in the circuit a transformer coupled high speed, highly sensitive "PO" 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

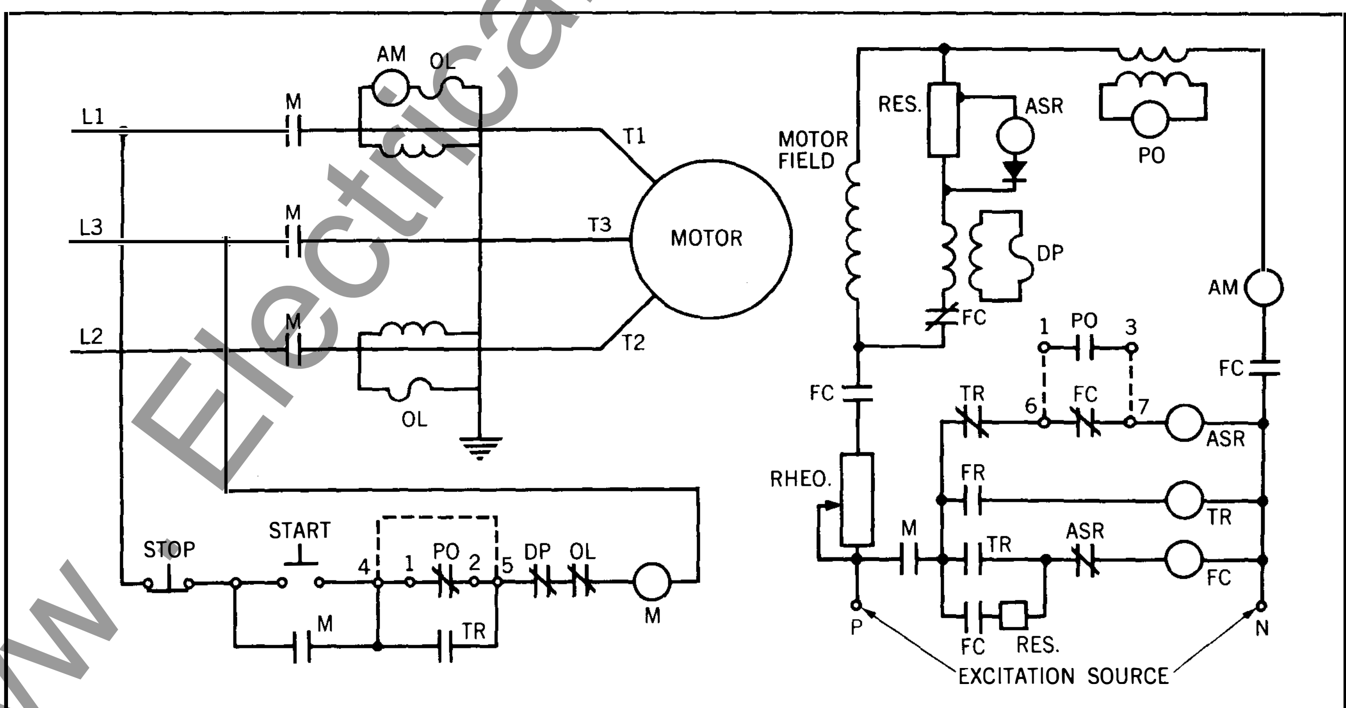

Fig. 2 Typical Diagram

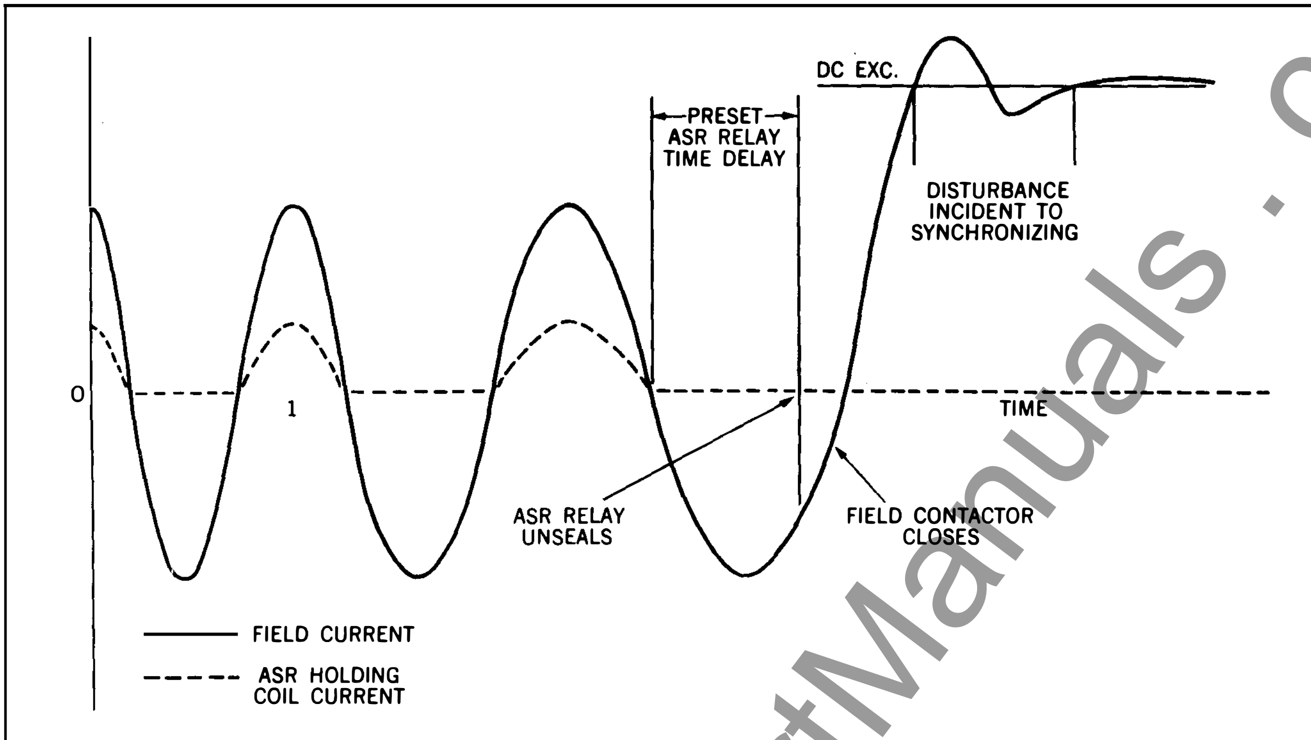

Fig. 3. Operation of ASR Relay

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 AC current component in the DC 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–Hertz machines and 12 percent slip on 25–Hertz 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 "DP" 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 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. Note: This is a transformer operated thermal relay and maximum sensitivity is on initial starting when the frequency is maximum.

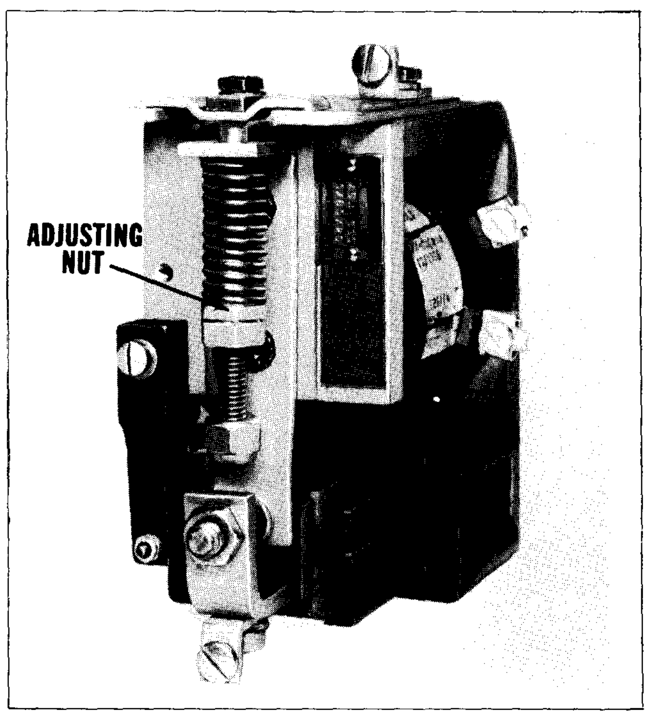

Fig. 4. Type ASR Synchronizing Relay (Photo 70-0827)

TESTS and ADJUSTMENTS

Make a careful check of the controller sequence with motor leads disconnected, except on high voltage autotransformer starters, to insure that the equipment is in good operating condition and adjusted to suit the application. In particular check the following:

1. Does the controller go through complete sequence properly?

2. Trip the overload relay, if practical, to be certain it removes the equipment from the line.

3. Manually operate the "PO" pull-out relay. Does it trip the line contactor or initiate a re—synchronizing cycle?

After making above checks, reconnect the motor and disconnect the field contactor coil lead and proceed with tests as follows:

CAUTION: Do not restart motor successively without allowing starting and discharge resistor and Motor damper winding time to cool.

4. Check direction of motor rotation and correct if necessary.

5. In order to check the (ASR) synchronizing relay, set the adjusting nut ring to decrease calibration line and start the motor. Allow it to accelerate to the maximum speed it will attain with normal starting load. Increase the frequency setting (spring tension) until the relay drops out. Allow motor to cool, then 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.) If the relay fails to drop when set on increase cycles line measure the AC voltage drop to the relay and rectifier, and move the resistor tap so as to produce 10 volts less. Reset adjusting nut to decrease cycles line and proceed as described above. Should the relay drop out too soon move resistor tap to increase AC voltage drop approximately 10 volts then restart and proceed as described above. It is recommended that the final relay adjustment be increased one full turn to provide for lower line voltage and increased bearing friction. The synchronizing relay is factory set to drop out at 2-½ cycles with the AC voltage applied, on the relay and rectifier, as stamped on the top of the relay. This corresponds to the calculated motor induced field current at 95% speed. Differences between the actual and calculated data may make adjustments necessary.

NOTE: 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.

6. Check overload relay. The heating elements are so chosen that the 100% adjustment is usually satisfactory. If the relay trips occasionally on starting, advance the setting slightly. Relays have plus or minus 15% adjustment and normally may be decreased slightly to provide quicker tripping in case of overload conditions. Overload setting should be kept as low as practical for protection and yet not produce nuisance tripping.

7. To check the (PO) pull out relay, with the motor synchronized and normal load applied, open the field contactor coil circuit momentarily and allow the motor to decelerate to approximately 95% speed then re—energize the field contactor. When Field Loss (FL) is supplied block so it cannot trip on (PO) test. This should produce a pulse and the pull out relay should operate to trip the line contactor, or initiate a re—synchronizing cycle depending on the circuit. The pull out relay is high sensitive, low power, fast operating transformer actuated relay. It is adjusted to pick up around 100 milliamperes at 3 Hertz per second with spring tension minimum. Minimum tension is when the adjusting screw is flush with the adjusting nut, and with an air gap of 1/16" on the hinge side of the armature when it is held against the pole piece.

If the relay trips occasionally on starting increase the spring tension a turn or two. There is approximately 9 turns from minimum to maximum setting and the frequency range changes from 1 to 6 Hertz maximum to trip. Cut the adjusting screw if it interferes with the glass cover.

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 (5) under "Tests and Adjustments."

   b. Decrease the frequency setting on the synchronizing relay.

   c. Check AC voltage conditions and DC field current.

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

3. If overload relay trips:

   a. Check AC supply. Is voltage correct? Is line single phased?

   b. Check field current and supply. Is DC available? Does a proper value of current flow through field circuit?

   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.

5. When tripping occurs during a start and the pull-out or field loss relay appears to be at fault, block so the contacts cannot operate then observe during starting. Remove blocking and reset the relay if it appears to be set too low.

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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