SECTION 159-410-301
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SYNCHRONOUS MOTORS
WITH DIRECT CONNECTED EXCITERS
PER KS-5123
DESCRIPTION AND OPERATION

SECTION 1 - GENERAL

1.1 Synchronous motors may be used in place of induction motors for driving charging generators in telephone power plants where it is desired to raise the power factor of the office load. These motors are equipped with direct connected exciters for furnishing the motor field current. Section 159-410-701 covers the installation and maintenance requirements for these motors.

1.2 Section 2 of this specification describes these motors and will be called "Description".

1.3 Section 3 of this specification describes the operation of these motors together with their control equipment and will be called "Operation".

1.4 Section 4 of this specification describes the various conditions which may interfere with the proper operation of this equipment and will be called "General Troubles".

SECTION 2 - DESCRIPTION

2.1 Synchronous motors consist of a stationary armature with a revolving field and are designed to operate on polyphase circuits. Current is supplied to the field coils from a direct connected exciter, through slip rings on the rotor shaft, to produce the necessary operating torque. A squirrel cage winding is imbedded in the face of the field poles in order to permit starting as an induction motor, and to prevent "hunting" of the motor while in operation. These motors require starting compensators similar to those used with induction motors, and in addition have an arrangement for automatically shunting the motor field circuit through a resistor connecting it to the exciter. The motor is always started with the field contactor open. With the field contactor in the open position, the motor field discharge resistor is connected across the field coils. When the motor is practically up to speed, the field contactor closes automatically removing the resistor from the field circuits, and connecting the exciter across the field windings. The motor then pulls into synchronism. The field current may be adjusted manually by means of the exciter field rheostat to change the office power factor.

2.2 The motor frame is a cast iron skeleton frame with feet cast integral with the frame. Laminated steel punchings having slots for the armature windings are assembled under high pressure, accurately aligned and keyed to the frame. The coils of the armature windings are form wound, and are held in place in the slots by wedges. The leads are brought out on the right side of the motor frame as viewed from the coupling end. End shields are mounted on each end of the frame and support the bearings for the rotor shaft. For the smaller motors each end shield is cast in one piece; making it necessary to remove the end shield in order to replace the bearings. The end shields of the larger motors on the end opposite the coupling are solid, while the end shields on the coupling end are split to facilitate the removal of the bearing.

2.3 The rotor consists of a shaft with a rigidly attached spider supporting the field poles, field windings and squirrel cage winding. Two collector rings for bringing current to the field windings are also mounted on, but insulated from, the shaft. The spider and pole-pieces are made of steel laminations rigidly fastened together. Fins are attached to the spider which circulate air through the windings for cooling purposes.

2.4 The exciter is a small DC generator with its frame mounted on one of the motor end shields and its armature mounted on the end of the motor shaft. The exciter output is controlled by a manually operated rheostat mounted separately. During starting, this rheostat is shunted by a back contact on the field contactor, insuring that the exciter voltage will build up to full strength during the starting of the motor. When the field contactor is closed, this shunting contact is opened, and the resistance may be cut in or out of the exciter field circuit as desired by operating the rheostat hand-wheel.

2.5 The compensators used with these motors are of the auto-transformer type having a "Start", "Off" and "Run" position. The desired starting voltage is obtained by connecting the motor to one of four taps on the transformer winding. It is necessary to hold the starting lever arm in the "Start" position manually, but in the "Run" position the lever arm is held by means of a catch controlled by a voltage coil. Any interruption of the power service releases this catch and the lever arm is returned to the "Off" position by means of a spring. A mechanical interlock prevents throwing the lever arm to the "Run" position until after it has been thrown to the "Start" position and the lever can then be thrown only with a rapid unhesitating movement. There is also a thermal over-load relay which operates to open the circuit of the voltage coil in case the motor becomes over-loaded, shutting down the set before damage is done to the motor.

2.6 The automatic control for the motor field consists of a field contactor and field relay, and is mounted in an enclosed sheet metal box on the framework to which the compensator is fastened. The field contactor is closed automatically upon the

closing of the contacts of the field relay. The field relay contacts close only when the motor is thrown directly across the line and the voltage induced in the motor field winding is at a minimum.

2.7 Theory of Motor and Field Control - See Fig. 1 With the compensator in the open position, the motor is disconnected from the power supply, the under voltage coil of the compensator is not energized, the field control relay and the field contactor of the automatic field control panel are released, the field discharge resistor is connected across the motor field and the exciter field rheostat is shunted. When the starting compensator is thrown manually to the "Start" position the power supply is connected to the motor through the compensator which steps down the voltage so as to reduce the starting current taken by the motor. The motor starts as an induction motor by means of its squirrel cage winding. During the starting period a high voltage induced in the motor field sends current through the discharge resistor and the auxiliary coil of the field control relay which prevents the relay from operating. As the motor comes up to speed the voltage induced in the motor field approaches zero. After the motor reaches its maximum speed at the reduced voltage the compensator is thrown manually to the "Run" position. In this compensator position full line voltage is applied to the motor and the holding coil of the field control relay is energized. If the motor is up to speed the current through the auxiliary coil of the field control relay approaches zero, the field control relay operates applying line voltage to the field contactor winding which operates the field contactor. If the motor is not up to speed an induced current flows through the auxiliary coil and prevents the field control relay from operating. When the field contactor operates the shunt around the exciter field rheostat is broken, the resistor circuit is opened and the exciter armature is connected to the motor field. As soon as the exciter armature is connected to the motor field the motor pulls into step and operates as a synchronous motor. The power factor of the motor is varied by adjusting the exciter voltage by means of the exciter field rheostat. In case of an overload sufficient to operate the overload relay, or of too low line voltage, or in case the stop button is pushed, releasing the voltage coil, the compensator drops back to the open position and disconnects the motor from the power supply. When the compensator drops back to the open position the field control relay and the motor field contactor of the automatic field control panel release, disconnecting the exciter armature from the motor field, shunting the exciter field rheostat and connecting the motor field discharge resistor across the motor field.

SECTION 3 - OPERATION

3.1 Preparation for Starting Before starting these motors a general inspection should be made to see that nothing is in or on the set which will interfere with its starting.
The height of the oil in the oil gauges should be noted and oil added if necessary.

3.2 Starting Make sure that the motor disconnect switch is closed. Throw the compensator lever to the "Start" position and hold it there until the sound of the motor indicates that the motor is practically up to speed, then throw the compensator lever rapidly through the "Off" to the "Run" position.

Caution During the starting of the motor the operator should be careful not to touch any part of the motor field circuit, such as slip rings, brushes, and automatic field switch circuit. The box enclosing the automatic field control panel should be kept closed during the starting period.

3.3 Running Adjust the exciter field rheostat until the desired office power factor is obtained or the motor field is at maximum condition. The rheostat setting at which the motor operates at 0.8 power factor leading under the full load hot condition is marked by means of a black line painted on the rheostat. A stop is provided to prevent cutting out the resistance in the rheostat beyond this point. After starting, an inspection should be made to make certain that the oil rings are turning on the shaft and delivering oil to the shaft and bearing.

3.4 Stopping Remove the load from the driven machine. Push the "Stop" button on the compensator. This releases the catch holding the arm in the running position and allows the compensator switch to return to the "Off" position.

SECTION 4 - GENERAL TROUBLES

4.01 Failure to Start

Cause	Action
Fuses open	Replace
No voltage on one or more phases of the power service	Notify supervisor
Rotor blocked	Remove obstruction
Defective motor winding	Repair or replace motor

4.02 Failure to Come up to Speed

Cause	Action
Low voltage or frequency, or both	Notify supervisor
Open phase in motor	Notify supervisor

4.03 Motor Stops

Cause	Action
Overload relay on compensator operated	Reset and start again avoiding overload
Overload relay out of adjustment	Check and adjust relay setting
No voltage on one or more phases of power service	Notify supervisor
Fuses blown	Replace
Undervoltage relay releases due to momentary interruption of service	Start again

4.04 Failure of Field Contactor

Cause	Action
Contacts stuck together	Pry open, smooth or replace
Binding	Adjust or replace
Defective winding or open connections	Repair or replace

4.05 No Motor Field

Cause	Action
Poor contact of exciter brushes or brushes binding in holders	Clean or replace if too short
Exciter field circuit open	Repair open
Failure of exciter to build up	Remove exciter brushes, apply DC voltage to field coils with proper polarity for few seconds. Replace brushes and start set again. Repeat if necessary.
Defective exciter winding	Repair or replace exciter
Defective motor field circuit	Repair or replace rotor
Failure of field contactor	Adjust or replace
Poor connections	Repair

4.06 Overheating of Bearings

Cause	Action
Oil rings not functioning	Adjust or replace
Bent shaft	Replace rotor and shaft
Rough bearing surface	Smooth or replace bearing
Improper alignment	Realign
Insufficient oil	Add oil
Improper grade of oil or dirt in oil	Clean out bearing and lubricate with proper oil
Improper fitting of babbit lining	Repair or replace

NOTE In case a hot bearing develops, the load on the machine shall be taken off. The bearing should then be flushed with Dynamo oil until cool. The set should, in no case, be stopped until the bearing is cool unless the rotor is striking the stator. Stopping a motor with a hot bearing before the bearing is cooled may result in the shaft adhering to the bearing lining and make the replacement of the bearing more difficult. After cooling the bearing, the set shall be stopped and an inspection made to determine the cause of the heating , and the condition corrected before again placing load on the machine.

4.07 Overheating of Exciter Commutator

Cause	Action
Excessive brush tension	Reduce tension
Excessive sparking	See paragraph 4.08
Short circuited or grounded winding	Repair or replace armature
High, low or loose commutator bars	Repair or replace armature
Defective armature winding such as open or short circuit	Repair or replace armature

NOTE If the commutator appears excessively heated the load should be thrown off and the machine stopped at once, the temperature checked with a thermometer, and the condition corrected, if necessary, before again operating the machine.

4.08 Excessive Sparking of Exciter

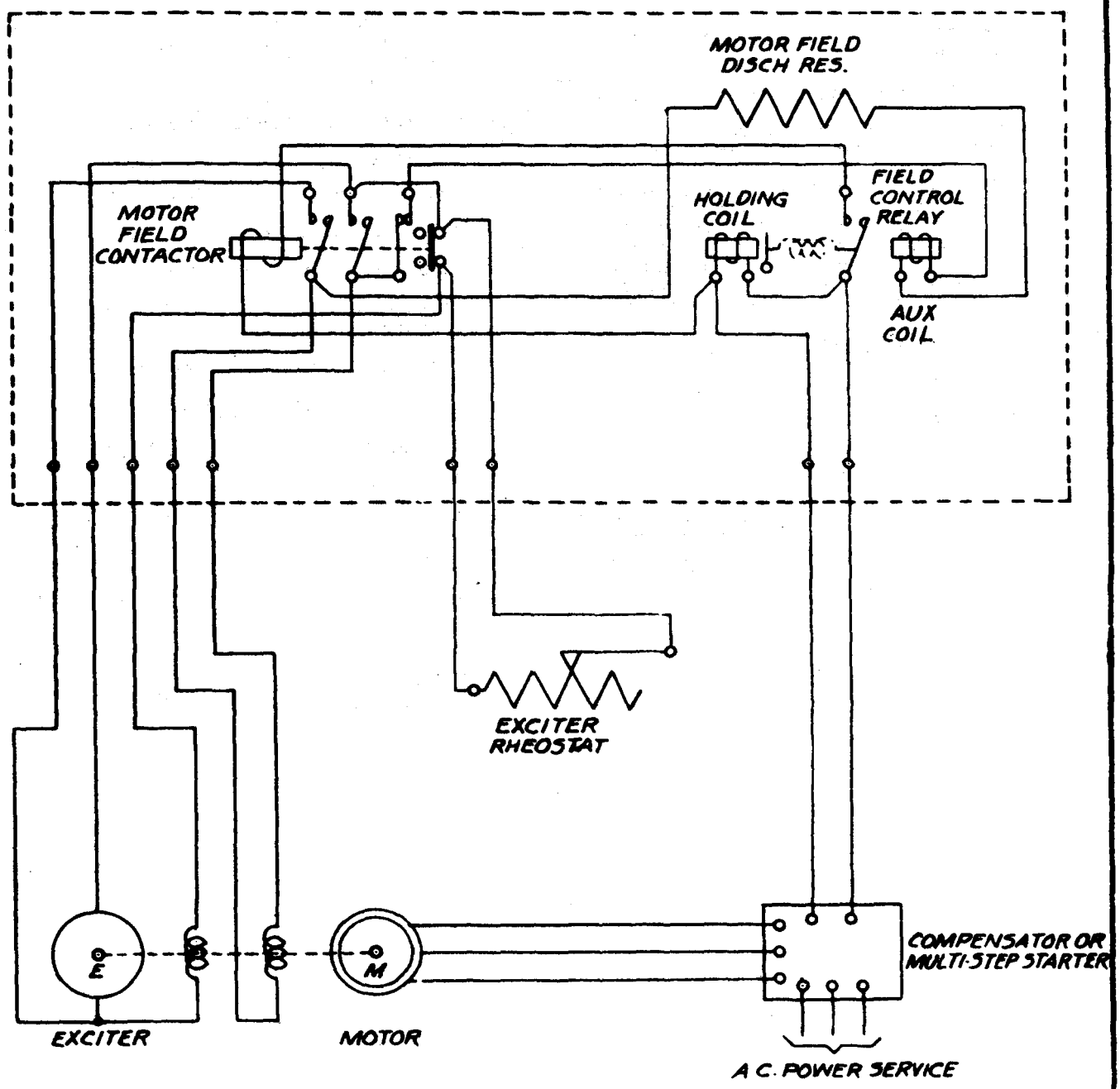
Cause	Action
Brushes not seated properly	Refit
Brushes too short	Replace
Incorrect brush tension	Adjust tension or replace brush and spring as required
Oily or dirty commutator	Clean
Rough or pitted commutator	Smooth

4.09 Excessive Noise and Vibration

Cause	Action
Set not level	Level set
Improper alignment	Realign set
Loose bolts or nuts	Tighten
Loose commutator segments in exciter	Replace armature
Worn bearings	Replace

4.10 Overheating of Motor Windings

Cause	Action
Overload	Reduce load
No voltage on one phase of power service	Shut down and notify supervisor
Open phase, grounded or short-circuited winding in motor	Repair or replace motor
Low or high service voltage or frequency or both	Report to supervisor



SCHEMATIC WIRING FOR FIELD CONTROL OF SYNCHRONOUS MOTORS

FIG. 1