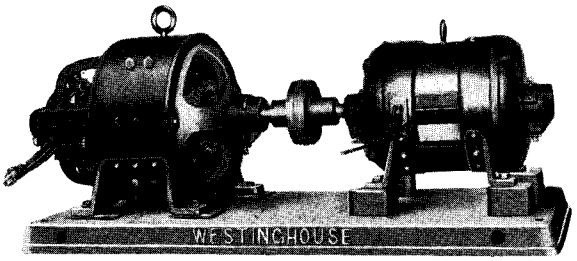
Westinghouse
Motor-Generator Equipment For Motion Picture Projection

INSTRUCTION BOOK



Motor-Generator with Polyphase Alternating-Current Motor

Westinghouse Electric & Manufacturing Company
East Pittsburgh Works East Pittsburgh, Pa.

I. B. 5164-C

INDEX

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IMPORTANT

Keep the motor-generator clean. The finest machine and the most expensive plant may be shut down by accident if they do not have protection and care. The insulation must be kept clean and dry. Oil and dirt in the insulation are as much out of place as grit or sand in a cylinder or bearing.

Before installing or operating an equipment, read this Instruction Book carefully.

General Information

1. **Unpacking**—When uncrating the equipment protect the various units against severe shocks and blows, especially if the temperature of the air is very low. Do not remove the blocking between the generator and motor frames until the set is finally installed at its permanent location. Furthermore, these sets should never be moved from their permanent location unless suitable blocking is placed between the motor and generator frames. This is important so as to prevent bending the bearings out of alignment. Be sure to protect all the equipment from moisture and make certain that all windings of the motor and generator are dry before subjecting them to operating voltage.

2. **Location**—All of the electrical equipment should be finally installed in a clean, dry well ventilated place and in such a manner as to be easily accessible for inspection and cleaning. The room or enclosure for the equipment should be sufficiently well ventilated so that the air temperature will never be in excess of 104° Fahrenheit.

3. **Foundation**—A foundation should be provided for the motor-generator so that the the bottom of the bedplate will be approximately two feet above the level of the surrounding floor. To prevent the magnetic hum and vibration of the set being transmitted to the surrounding supports such as floor and walls of the building, it is desirable to build a vibration and sound-absorbing base.

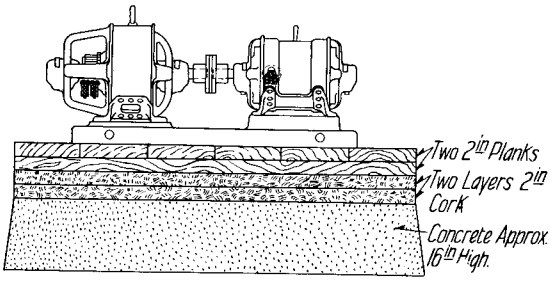


Fig. 1—Sketch Showing Foundation for Motor-Generator.

4. Such a base as shown in (Fig. 1), may be constructed readily with solid planking two inches thick and layers of solid cork each layer two inches thick. The supporting foundation should preferably be made of hollow concrete. The cork should be placed in two layers on the concrete foundation. On top of the cork should be placed the plank frame constructed of the two layers of two-inch plank. The planks of one layer should be laid at right angles with the plank in the other, both layers to be bolted or nailed together securely. The motor generator may then be mounted on the plank frame and, if desirable, the bedplate may be bolted down to the plank frame as holes are provided for this purpose. If so desired, heavy felt may be substituted for the cork but cork is much more resilient and will remain elastic indefinitely, whereas felt will not.

5. When constructing the foundation and sound-absorbing base it is essential that the top of the plank platform be made level so

that the oiling system of the motor-generator will not fail after the set is installed.

6. For installations where it is not expedient or advisable to build such an elaborate foundation very satisfactory, results can be obtained by mounting the bedplate on fairly heavy helical compression springs. These springs should be not less than 3″ external diameter, and sufficiently long to raise the bottom edge of the bedplate one-half inch above the floor. The upper ends of the springs should be securely bolted to the under side of the bedplate by suitable bolts passing through the usual foundation bolt holes. These springs should be sufficiently heavy to keep the set from being "wobbly", and yet not too stiff, so as to defeat their purpose.

Multiple or Parallel Arc Equipment

7. Equipments for two typical types of installations will be considered under the captions of single light, and two-light equipments or installations.

The single-light equipment is required for each installation wherein only one motion picture machine is to be used.

The two-light equipment is required for each installation wherein two motion picture machines are to be operated alternately, for "change over" or "continuous picture service". For this latter service one lamp is "warmed up" for a period of approximately one minute when another motion picture machine is in operation.

EQUIPMENT REQUIRED

8. The complete equipment for a single light installation consists of a motor-generator, field rheostat, motor starter, control panel, and one ballast rheostat, the short-circuiting switch being optional; for a two light installation, two ballast rheostats, one for each arc, and two short-circuiting switches are necessary.

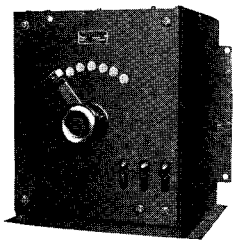


Fig. 2—Ballast Rheostat

INSTRUCTIONS

9. **Foreword**—For all cases wherein the instructions are equally applicable to both types of installations, namely, two-light and single-light, no distinction will be necessary. However, when the instructions apply to only one of these types, then the type which is involved will be clearly indicated.

Fig. 3—Type A Auto-Starter

10. A **short-circuiting switch** is a single-pole single-throw knife switch, which must be mounted on the frame of a motion picture machine and be protected by a suitable cover.

11. **Motor-Generator**—Install the motor-generator either in the operating booth, or as near the booth as possible.

12. **Control Panel**—Install the control panel (Fig. 4) in the projection room in any convenient place, preferably between the two projection machines.

13. **Generator Field Rheostat**—Install the field rheostat, for the generator, on the control panel.

14. **Motor Starting Equipment**—Install the motor control equipment, for the motor-generator, in the booth, if permissible, or as near the booth as possible.

15. **Ballast Rheostats**—Install the ballast rheostats either in or near the operating booth. Each ballast rheostat should be mounted so as to allow a free circulation of air vertically between the grids (Fig. 2).

16. **Short Circuiting Switches**—The short-circuiting switch for each ballast rheostat should, preferably, be mounted on the frame of the motion picture machine, with which the ballast rheostat is to be used, beside the cut-out switch.

WIRING AND CONNECTING MOTOR-GENERATOR

TYPE CS POLY-PHASE MOTOR

17. **Connect the motor** and auto-starter by referring to the diagram furnished with the auto-starter. If the circuit is 2-phase, 4-wire, connect leads from one phase to motor terminals A1 and A2 and leads from other phase to terminals B1 and B2. If circuit is 2-phase, 3-wire, connect outside leads to terminals A1 and B1 and middle lead to A2 and B2. If circuit is 3-phase connect any lead to any terminal. To obtain proper direction of rotation see instructions as follows. If fuses are used in

running circuit they should carry current in excess of current indicated in nameplate as follows:

2-phase, 4-wire circuit, all leads, 25 per cent.

2-phase, 3 wire circuit { outside leads, 25 per cent. middle lead, 75 per cent.

3-phase, 3-wire circuit, all leads, 25 per cent.

18. If circuit-breakers are used in the running circuit they should be adjusted to open the circuit with the above overload capacities.

19. Fuses in the starting circuit should carry four to five times the rated current.

TYPE AR SINGLE-PHASE MOTOR

20. Voltages—This motor can be connected for operation on either 110 or 220-volt circuits.

TYPE SK DIRECT-CURRENT MOTOR

21. Connections—Refer to the diagram (Fig. 6) and make the following connections for counterclockwise rotation looking at the commutator end:

Connect A2 to terminal marked "Arm" on Starting Rheostat.

Connect A1 to S1.

Connect S2 to F2 to terminal marked "Fld" on Starting Rheostat.

Connect F1 to + line.

TYPE SK GENERATOR

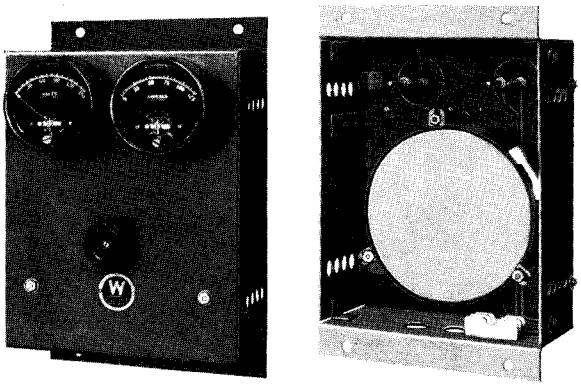
22. Connections—The diagram (Fig. 7) and directions show the connections for clockwise rotation looking at the commutator end:

Connect A1 to + line.

Connect A2 and F2 to S2.

Connect S1 to — line.

Connect F1 to field rheostat, thence to + line.



Front View of Control Panel **Rear View of Control Panel**

Fig. 4

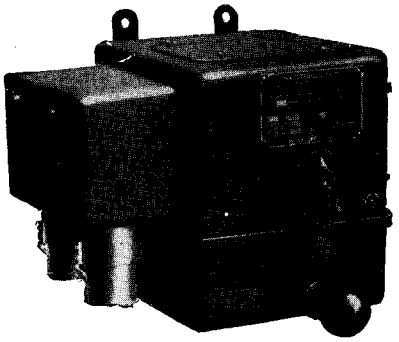


Fig. 5—Type 815 10-Horsepower Maximum Motor Starting Switch

MINIMUM SIZE OF WIRE FOR INSTALLATION

23. Single-light—For each single-light installation, wherein the distance from the generator terminals to the cut-out switch on the motion picture machine, measured along the route of the wiring or conduit, is 150 feet

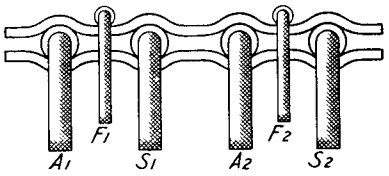


Fig. 6—Diagram of Type SK Motor Terminals

or less, the size of the wire is determined by the current to be carried. (See the "National Electric Code".) If the distance is over 150 feet, the exact distance should be referred to the Company for recommendations as to the proper size of wire to be used.

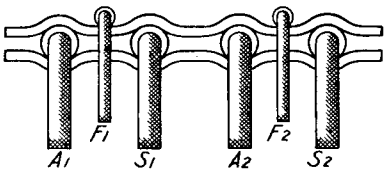


Fig. 7—Diagram of Type SK Generator Terminals

24. Two-Light—The minimum size of wire to be used for the circuit, which must carry current for both lamps for a two-light installation, is indicated in Table on Page 7. The column headed "Length in Feet of Circuit Which Must Carry Current for Both Arc Lamps," represents the distance from the generator terminals to the generator switch, or to the point where the circuit, which must carry current for both lamps, branches or

divides into separate circuits, one for each lamp. The distance must be measured along the route of the wiring or conduit. If this distance is greater than 300 feet, the exact distance should be referred to the Company for recommendations as to the proper size of wire to be used. The size of all wires which carry current for one lamp only, will be governed by paragraph 23, but the distance is measured along the route of the wiring or conduit from the cut-out switch on each motion picture machine, to the generator switch or to the point where the branch circuit for each lamp joins the main generator circuit. For example, assume an installation, wherein the length of the circuit, which must carry current for both lamps is 130 feet, and the length of each branch circuit to each lamp is 130 feet, then if a 2¾-kilowatt, 75-volt, 36.7-ampere set is used, it will be observed by reference to Table on Page 7, that No. 00 wire must be used for the main circuit, whereas No. 6 wire may be used for the branch circuit to each lamp.

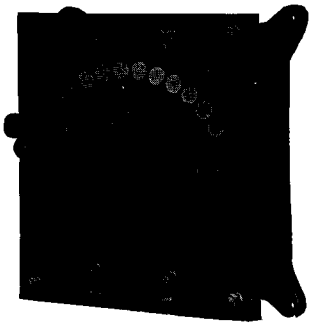


Fig. 8—Type D Starting Rheostat

25. For **each two-light** installation, wherein the length of the main circuit, which must carry current for both lamps or wherein the length of the branch circuit to either lamp, is greater than 150 feet, a diagram should be prepared which represents the wiring and the length of each wire should be accurately indicated thereon. This diagram should be referred to the Company for recommendations as to the proper size of wire to be used for each circuit.

26. Emergency Service—For each installation, wherein alternating current is to be used for emergency service, we strongly recommend that all wiring and switches, which will be used for carrying this current to each lamp, be made of sufficient capacity to carry the alternating current, bearing in mind the fact that, in order to produce the same volume, or candle-power, of light, the alternating current (measured in amperes) must be approximately three times as great as the direct current ordinarily used.

27. Motor Circuits—The wiring for the circuit of each direct-current or alternating-current motor should be of a capacity such that the speed of the motor will not be appreciably affected by the line voltage drop at any load up to and including 30 per cent overload for a few minutes or 100 per cent overload momentarily.

LUBRICATION

28. Before starting, fill the oil reservoirs with the best quality of clean dynamo oil; overflow plugs must always be kept open. The old oil should be withdrawn occasionally and fresh oil substituted. The old oil can be filtered and used again.

STARTING THE MOTOR-GENERATOR

29. General—After the apparatus is properly installed and all wiring is correctly connected, open all of the switches in the generator and lamp circuits; turn the contact arm, on the generator field rheostat to the contact marked "in", and then start the motor as explained below.

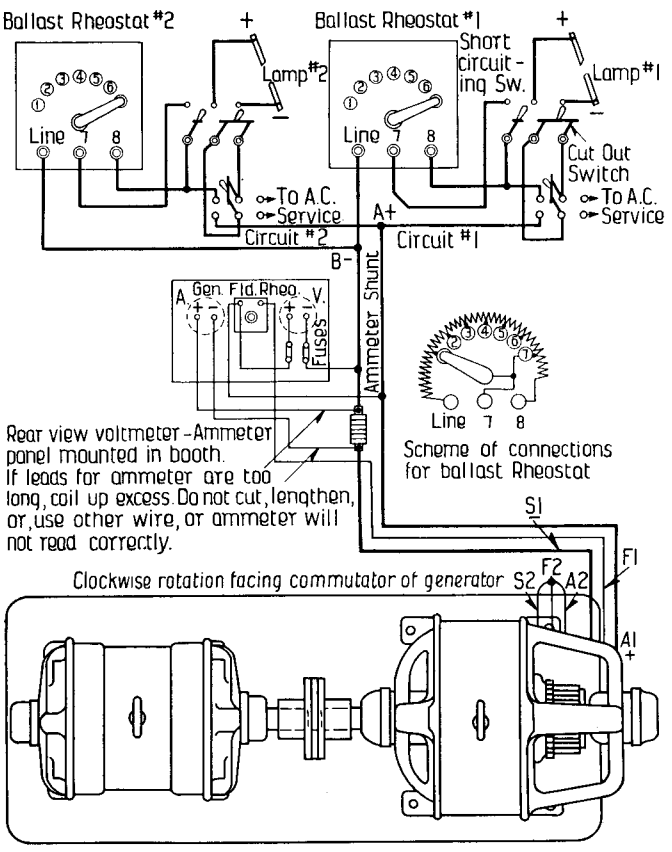
TYPE CS POLY-PHASE MOTOR

30. To Start Motor—See that the auto-starter handle is in the "off" position. Close the circuit-breaker, if one is used, then close the main switch. Move the auto-starter handle from the off to starting position. When the motor attains practically full speed, move handle of auto-starter to running position. Do not leave the auto-starter handle in starting position.

31. If an auto-starter is not required, the starting switch must be thrown to the starting position until the set operates at almost full speed and then the switch may be thrown to the running position.

TYPE AR SINGLE-PHASE MOTOR

32. To Start Motor—Close the line switch. The motor starts as a repulsion motor with current flowing through the brushes and commutator. At nearly full speed, a centrifugal governor inside the armature automatically short-circuits the armature windings, thus causing the motor to run as a squirrel-cage induction motor. The brushes are thrown off by the end thrust of the armature. If the motor does not come to full speed, which is shown by continued sparking at the brushes, the



Multiple or Parallel Arc Equipment

Diagram of Connections

Length in Feet of Circuit Which Must Carry Current for Both Arc Lamps	Size of Wire Required B. and S. Gauge or Circular Mils Rating of Generator in Amperes			
	36.7 or 40	55	70 or 72	90
10	No. 6	No. 3	No. 3	No. 2
20	6	5	3	2
30	6	4	3	2
40	5	3	2	1
50	4	2	1	0
60	3	1	0	00
70	2	2	1	00
80	2	0	00	00
90	1	0	00	000
100	1	00	000	0000
110	0	00	000	0000
120	0	000	0000	2500000*
130	00	000	0000	2500000
140	00	000	0000	3000000
150	00	0000	250000*	3000000
160	000	0000	250000	3000000
170	000	0000	300000	3500000
180	000	0000	300000	3500000
190	000	250000*	300000	4000000
200	0000	250000	300000	4000000
210	0000	250000	350000	4000000
220	0000	300000	350000	4500000
230	0000	300000	350000	4500000
240	0000	300000	400000	4500000
250	250000*	300000	400000	5000000
260	250000	350000	400000	5000000
270	250000	350000	450000	5500000
280	250000	350000	450000	5500000
290	250000	350000	450000	5500000
300	250000	350000	450000	5500000

*CM

Table of Wire Sizes

motor is overloaded and will overheat. Apparently there is an overload on the generator. Look over the generator circuit and make sure that all load is removed by opening all cut-out switches.

TYPE SK DIRECT-CURRENT MOTOR

33. To Start Motor—See that all instructions for connecting and installing the motor have been complied with and that the handle of the starter or controller is in the "off" position. Close the line switch or circuit-breaker and move the starter or controller handle step by step to the running position. Motors of less than 10 horsepower can usually be brought to full speed in 15 seconds, and the larger motors in about 30 seconds; the time, however, varies with the torque required. If the motor does not start when the third step is reached, first open the line switch or circuit-breaker, then move the handle of the controller to the "off" position, and look for overload or faulty connections.

INSPECTION OF OILING SYSTEM

34. After the motor-generator is started, raise the covers of all bearings and see that all oil rings are rotating properly and carrying oil up on the journals.

STOPPING THE MOTOR GENERATOR TYPE CS POLY-PHASE MOTOR

35. To Stop Motor—Open circuit-breaker or main switch. Move the handle of auto-starter to the "off" position. If neither circuit-breaker nor main switch is used, the auto-starter may be used to close and open the main circuit.

TYPE AR SINGLE-PHASE MOTOR

36. To Stop Motor—Open the line switch or circuit breaker.

TYPE SK DIRECT-CURRENT MOTOR

37. To Stop Motor—When a starting rheostat is used, open the line switch or circuit-breaker. Never force the starter handle to

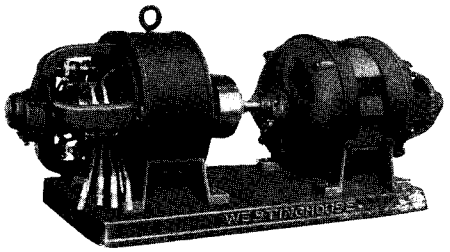


Fig. 9—Motor-Generator Single-Phase Alternating-Current Motor

the "off" position, but allow it to return automatically.

If the motor is to be shut down for a considerable period, open the line switch or breaker.

REVERSING MOTOR-GENERATOR

38. The rotating element of the motor-generator should revolve in a clockwise direction as observed by viewing the generator end of the set. If this is not the case when the motor is started, then the wiring connections for the motor must be changed.

TYPE CS POLY-PHASE MOTOR

39. To Reverse Motor—To reverse a two-phase, four-wire motor, the two leads of one phase should be interchanged. To reverse a two-phase, three-wire motor, the two outside leads should be interchanged. To reverse a three-phase motor, any two leads should be interchanged.

TYPE AR SINGLE-PHASE MOTOR

40. To Reverse Motor—The direction of rotation is determined by the position of the brushes and is indicated by a scale on the rocker ring and a pointer on the front bearing bracket. The scale consists of three lines marked RR, N, and RL, respectively. When the rocker ring is turned so that the pointer is opposite RR, the motor will run in a right-hand or clockwise direction (facing the commutator). and when the pointer is opposite RL, the rotation will be left-hand or counter-clockwise. N, is the neutral point; the armature will not turn if the pointer is opposite this line. To reverse the motor, therefore, loosen the rocker ring set screw and turn the rocker ring until the pointer is opposite the line for the reverse direction of rotation.

ADJUSTING THE EQUIPMENT

41. After the set is running properly, gradually adjust the generator field rheostat until the potential between the generator terminals, as indicated by the voltmeter, is approximately as follows:

75 volts for	2¾ Kw.	36.7	amp. generator
75 volts for	4⅔ Kw.	55	amp. generator
80 volts for	5¼ Kw.	70	amp. generator
80 volts for	5¾ Kw.	72	amp. generator
90 volts for	8 1/10 Kw.	90	amp. generator
100 volts for	11 Kw.	110	amp. generator

42. Size of Carbons—The carbon sizes recommended by the National Carbon Company for various arc currents are as follows:—

25 to 50 amps.	⅝"x12" National Cored upper 5/16"x 6" Silvertip Solid lower
51 to 65 amps.	¾"x12" National Cored upper 11/32"x 6" Silvertip Solid lower
66 to 70 amps.	⅞"x12" National Cored upper 11/32"x 6" Silvertip Solid lower
71 to 85 amps.	⅞"x12" National Cored upper ⅜"x 6" Silvertip Solid lower
86 to 100 amps.	1"x12" National Cored upper 7/16"x 6" Silvertip Cored lower

43. Single Light—For single-light equipments the short-circuiting switch should always be opened before striking the arc. After the arc is struck and the carbons have been separated, close the short-circuiting switch and then re-adjust the carbons until the potential across the arc, as indicated by a reliable voltmeter, the terminals of which are connected directly to the terminals of the lamp is approximately the value given in the following table:

Arc Amps.	Approximate Arc Volts	Arc Amps.	Approximate Arc Volts
36	55	90	65
55	60	110	67
72	63		

If under these conditions, the current through the lamp, as indicated by the ammeter, is less than required, and not greater than the full load rating of the generator, then the contact arm of the ballast rheostat should be shifted to button 6 or button 5 and so on, until the proper current does flow, when the arc potential is the value given in table. This button should be marked for future use.

44. Two Light—For two-light equipments the short-circuiting switch connected to the ballast in the circuit of either lamp, must always be opened before striking the arc in the lamp.

With lamp No. 2 cut off the circuit, open the short-circuiting switch No. 1 move contact arm

of ballast rheostat No. 1 to button No. 7, and strike the arc in lamp No. 1. After the carbons have been separated, close the short-circuiting control switch No. 1, and then readjust the carbons until the potential across the arc is in line with table in paragraph 43, as indicated by a reliable voltmeter, the terminals of which are connected directly to the terminals of lamp No. 1. If, under these conditions, the current through lamp No. 1, as indicated by the ammeter, is less than required or less than the full-load rating of the generator, then the contact arm of ballast rheostat No. 1, should be shifted to button 6, or button 5, and so on, until the proper current does flow, when the arc potential is at proper value. This button should be marked for future use.

45. With lamp No. 1 cut off the circuit,open the short-circuiting switch No. 2, move contact arm of ballast rheostat No. 2 to button No. 7 and strike the arc in Lamp No. 2. After the carbons have been separated, close short circuiting switch No. 2, and then readjust the carbons until the potential across the arc is in line with table in paragraph 43, as indicated by a reliable voltmeter, the terminals of which are connected directly to the carbons in lamp No. 2. If, under these conditions, the current through lamp No. 2, as indicated by the ammeter, is less than required or less than the full load rating of the generator, then the contact arm of ballast rheostat No. 2, should be shifted to button 6, or button 5, and so on, until the proper current does flow, when the arc potential is at proper value. This button should also be marked for future use.

OPERATING THE EQUIPMENT

46. Single Light—After the adjustments, specified in paragraph 43, have been made, the equipment is operated in the usual manner, which needs no further explanation.

47. Two Light—After both ballast rheostats have been properly adjusted, as specified in paragraphs 44 and 45, and the crater in the positive or upper carbon in each lamp is properly formed, the entire equipment is ready for operation as hereinafter given.

48. Insert reel No. 1 in machine No. 1; open short circuiting switch No. 1; strike the arc in lamp No. 1, and then separate the carbons; close short-circuiting switch No. 1; adjust the carbons properly and then project pictures in the usual manner.

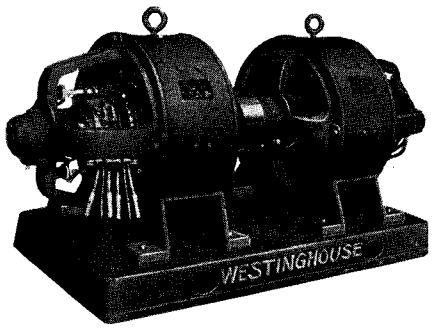


Fig. 10—Motor-Generator with Direct-Current Motor

49. Reel No. 2, should be inserted in machine No. 2. About one minute before the end of reel No. 1, is reached, open short-circuiting switch No. 2; strike the arc in lamp No. 2, and adjust the carbons properly. A few seconds before the end of reel No. 1, is reached, close short-circuiting switch No. 2, and if necessary make a final adjustment of the carbons. At the proper time, as the end of reel No. 1 is reached, begin projecting pictures with machine No. 2, and cut lamp No. 1 off the circuit.

50. Reel No. 3 should be inserted in machine No. 1. About one minute before the end of reel No. 2 is reached, open short-circuiting switch No. 1; strike the arc in lamp No. 1, and adjust the carbons properly. A few seconds before the end of reel No. 2 is reached close short-circuiting switch No. 1, and if necessary, make a final adjustment of the carbons. At the proper time, as the end of reel No. 2 is reached begin projecting pictures with machine No. 1, and cut lamp No. 2 off the circuit.

51. The cycle of operation, as specified in paragraphs 48, 49 and 50, may be carried out indefinitely at the rate of three, four, or five 1000-foot reels per hour, without injury to the electrical equipment, provided each lamp does not require more than the full-load rated current from the generator operating at the potential of 75-80 volts.

Series Arc Equipment

52. Equipment Required—The complete equipment comprises a motor generator, a control panel, a field rheostat motor starter, and a short circuiting switch for each projection lamp. The generator is marked 65/130 volts and is designed to supply current to one arc at the lower voltage or two arcs at the upper voltage.

INSTRUCTIONS

53. A **short-circuiting switch** is a single-pole, single-throw knife switch, which must be protected by a suitable cover if mounted on the frame of a motion picture machine. If the short-circuiting switch is mounted on a switchboard panel, then the individual cover is not required for this switch.

54. Motor-Generator—Install the motor-generator either in the operating booth, or as near the booth as possible.

55. Control Panel—Install the control panel (Fig. 4) in the projection room in any convenient place, preferably between the two projection machines.

56. Generator Field Rheostat—Install the field rheostat, for the generator, on the control panel.

57. Motor Starting Equipment—Install the motor control equipment, for the motor-generator, in the booth, if permissible, or as near the booth as possible.

WIRING AND CONNECTING MOTOR-GENERATOR

TYPE CS POLY-PHASE MOTOR

58. Connect the motor and auto-starter by referring to the diagram furnished with the auto-starter. If the circuit is 2-phase, 4-wire, connect leads from one phase to motor terminals A1 and A2 and leads from other phase to terminals B1 and B2. If circuit is 2-phase, 3-wire, connect outside leads to terminals A1 and B1 and middle lead to A2 and B2. If circuit is 3-phase connect any lead to any terminal. To obtain proper direction of rotation see instructions below. If fuses are used in running circuit they should carry current in excess of current indicated in nameplate as follows:

2-phase, 4-wire circuit all leads, 25 per cent.

2-phase, 3-wire circuit { outside leads, 25 per cent. / middle lead, 75 per cent.

3-phase, 3-wire circuit, all leads, 25 per cent.

59. If circuit-breakers are used in the running circuit they should be adjusted to open the circuit with the above overload capacities.

60. Fuses in the starting circuit should carry four to five times the rated current.

TYPE AR SINGLE-PHASE MOTOR

61. Voltages—This motor can be connected for operation on either 110 or 220-volt circuits.

TYPE SK DIRECT-CURRENT MOTOR

62. Connections—Refer to the diagram (Fig. 6) and make the following connections for counterclockwise rotation looking at the commutator end:

Connect A2 to terminal marked "Arm" on Starting Rheostat.

Connect A1 to S1.

Connect S2 to F2 to terminal marked "Fld" on Starting Rheostat.

Connect F1 to + line.

TYPE SK GENERATOR

63. Connections—The diagram, (Fig. 7), and following directions show the connections for clockwise rotation looking at the commutator end:

Connect A1 to + line.

Connect A2 and F2 to S1.

Connect S2 to — line.

Connect F1 to field rheostat, thence to + line.

MINIMUM SIZE OF WIRE FOR INSTALLATION

64. The minimum size of wire to be used for connecting the generator to the motion picture projectors is shown by the following table:—

Length in Ft. of Circuit from Gen. to Projectors	Size of Wire B & S Gauge	
	75 Amp. Gen.	100 Amp. Gen.
1 to 100	✱3	✱1
110	✱2	✱1
120	✱2	✱1
130	✱1	✱0
140	✱1	✱0
150	✱1	✱0
160	✱1	✱00
170	✱0	✱00
180	✱0	✱00
190	✱0	✱000
200	✱0	✱000
210	✱00	✱000
220	✱00	✱000
230	✱00	✱000
240	✱00	✱0000
250	✱00	✱0000
260	✱000	✱0000
270	✱000	✱0000
280	✱000	✱0000
290	✱000	✱0000
300	✱000	✱0000

65. Emergency Service—For each installation, wherein alternating-current is to be used for emergency service, we strongly recommend that all wiring and switches, which will be used for carrying this current to each lamp, be made of sufficient capacity to carry the alternating current, bearing in mind the fact that, in order to produce the same volume, or candle-power, of light, the alternating current (measured in amperes) must be approximately three times as great as the direct current ordinarily used.

66. Motor Circuits—The wiring for the circuit of each direct-current or alternating-current motor should be of a capacity such that the speed of the motor will not be appreciably affected by line voltage drop at any load up to and including 50% overload for a few minutes.

LUBRICATION

67. Before starting, fill the oil reservoirs with the best quality of clean dynamo oil; overflow plugs must always be kept open. The old oil should be withdrawn occasionally and fresh oil substituted. The old oil can be filtered and used again.

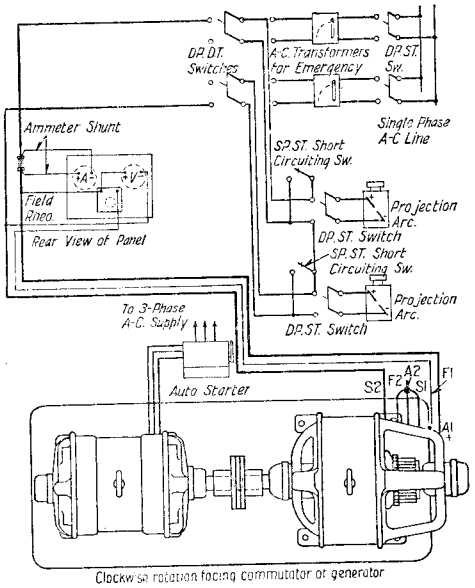


Fig. 11—Series Arc Equipment Diagram of Connections

STARTING THE MOTOR-GENERATOR

68. General—After the apparatus is properly installed and all wiring is correctly connected, close all the switches in the generator line and also the short circuiting switch on each projection machine, see (Fig. 11). Turn the contact arm of the field rheostat to the extreme position marked "lower voltage", and then start the motor as explained below.

TYPE CS POLY-PHASE MOTOR

69. To Start Motor—See that the auto-starter handle is in the "off" position. Close the circuit-breaker, if one is used, then close the main switch. Move the auto-started handle from the off to starting position. When the motors attains practically full speed, move handle of auto-starter to running position. Do not leave the auto-starter handle in starting position.

70. If an auto-starter is not required, the starting switch must be thrown to the starting position until the set operates at almost full speed and then the switch may be thrown to the running position.

TYPE AR SINGLE-PHASE MOTOR

71. To Start Motor—Close the line switch. The motor start as a repulsion motor with current flowing through the brushes and commutator. At nearly full speed, a centrifugal governor inside the armature automatically short-circuits the armature windings, thus causing the motor to run as a squirrel-cage induction motor. The brushes are thrown off by the end thrust of the armature. If the motor does not come to full speed, which is shown by continued sparking at the brushes, the motor is overloaded and will overheat. Apparently there is an overload on the generator. Look over the generator circuit and make sure that all load is removed by opening all cut-out switches.

TYPE SK DIRECT-CURRENT MOTOR

72. To Start Motor—See that all instructions for connecting and installing the motor have been complied with and that the handle of the starter or controller is in the "off" position. Close the line switch or circuit-breaker and move the starter or controller handle step by step to the running position. Motors of less than 10 horsepower can usually be brought to full speed in 15 seconds, and the larger motors in about 30 seconds; the time, however, varies with the torque required. If

the motor does not start when the third step is reached, first open the line switch or circuit-breaker, then move the handle of the controller to the "off" position, and look for overload or faulty connections.

INSPECTION OF OILING SYSTEM

73. After the motor-generator is started raise the covers of all bearings and see that all oil rings are rotating properly and carrying oil up on the journals.

STOPPING THE MOTOR GENERATOR

TYPE CS POLY-PHASE MOTOR

74. To Stop Motor—Open circuit-breaker or main switch. Move the handle of auto-starter to the "off" position. If neither circuit-breaker nor main switch is used, the auto-starter may be used to close and open the main circuit.

TYPE AR SINGLE-PHASE MOTOR

75. To Stop Motor—Open the line switch or circuit breaker.

TYPE SK DIRECT-CURRENT MOTOR

76. To Stop Motor—When a starting rheostat is used, open the line switch or circuit-breaker. Never force the starter handle to the "off" position, but allow it to return automatically.

If the motor is to be shut down for a considerable period, open the line switch or breaker.

REVERSING MOTOR-GENERATOR

77. The rotating element of the motor generator should revolve in a clockwise direction as observed by viewing the generator end of the set. If this is not the case when the motor is started, then the wiring connections for the motor must be changed.

TYPE CS POLY-PHASE MOTOR

78. To Reverse Motor—To reverse a two-phase, four-wire motor, the two leads of one phase should be interchanged. To reverse a two-phase, three-wire motor, the two outside leads should be interchanged. To reverse a three-phase motor, any two leads should be interchanged.

TYPE AR SINGLE-PHASE MOTOR

79. To Reverse Motor—The direction of rotation is determined by the position of the brushes and is indicated by a scale on the rocker ring and a pointer on the front bearing bracket. The scale consists of three lines marked RR, N, and RL, respectively. When the rocker ring is turned so that the pointer is opposite RR, the motor will run in a right-hand or clockwise direction (facing the commutator), and when the pointer is opposite RL, the rotation will be left-hand or counter-clockwise. N, is the neutral point; the armature will not turn if the pointer is opposite this line. To reverse the motor, therefore, loosen the rocker ring set screw and turn the rocker ring until the pointer is opposite the line for the reverse direction of rotation.

OPERATING THE EQUIPMENT

80. After the Series Arc set is running properly, be sure to close the double pole, single throw switch on the projection machine to be used first.

81. When ready to start the arc in this projector #1, open its short circuiting switch and when the voltmeter builds up to about 150 volts, strike the arc in the usual manner.

82. Adjust the arc gap until the voltmeter indicates about 60 to 65 volts and then if the current indicated by the ammeter is not more than the rating of the generator, it can be either increased or decreased to that desired by adjusting the generator field rheostat.

83. The approximate values of arc current and voltage which give the best operating results are as follows:

Arc Amperes		Arc Volts
60	75 Amp. Gen.	61
65		62
70		63
75		64
80	100 Amp. Gen.	65
90		66
100		67

84. After the crater in the upper or positive carbon is properly formed, insert reel No. 1 in machine No. 1 and project pictures. Then insert reel No. 2 in machine No. 2.

85. A short time before reaching the end of reel No. 1, close the two pole cut-out switch on machine No. 2, and turn the carbon adjusting knob until the carbon ends are firmly against each other. Adjust the carbons in machine No. 1 until correct voltage is shown by voltmeter. Then open the No. 2 short circuiting switch slowly. If an arc appears at the switch jaws as it starts to open be sure to close it quickly because the carbon ends are not making good contact and if switch is opened the circuit will be broken and the arc in machine No. 1 will go out. If the carbons in machine No. 2 are making good contact, its short circuiting switch can be opened without any flash.

86. Now separate the carbons in machine No. 2 slowly, draw out the arc until the voltmeter shows double the arc voltage given in the table in paragraph 83. Both lamps are now burning at full intensity and the arcs are in series.

87. At the proper time start the projector No. 2, dousing projector No. 1 at the same time. Then turn the carbon adjusting knob in machine No. 1 until carbons are in contact and then close short circuiting switch on this machine. This method of shutting down a machine will cause much less disturbance in the arc of the operating machine than if the short circuiting switch is closed before the carbons are brought into contact.

88. It must be understood that if no arc is being operated that the first arc must be struck relatively quickly after the generator builds up to about 150 volts, whereas if one arc is in operation the second arc must be drawn out rather slowly to preclude interrupting the circuit.

89. When the motor-generator is running idle, it is advisable to keep both of the short circuiting switches closed which prevents the generator voltage from building up to a high value, thereby preventing overloading the voltmeter and decreasing the heating of the generator field windings.

90. Emergency Service—(Fig. 11), shows provision for emergency service in case of trouble with the motor-generator. Before connecting the lamp circuits to the emergency service (by throwing the two pole, double throw switches to the right) be sure to open the short circuiting switches on each machine. If this is not done, the emergency circuit will be short circuited by these switches and fuses may possibly be blown.

REPAIR PARTS FOR MOTOR-GENERATOR

91. Repair Parts for this motor-generator should be obtained from the Westinghouse Electric & Manufacturing Company. When ordering give the name of the part wanted and the serial number of the unit on which the parts is to be used. The serial number will be found plainly stamped on the end of the shaft and on the nameplate. The omission of the serial number from your order will positively cause delay.

92. Bearings—New bearings to replace those worn out can be obtained by application to the nearest district office of this Company. It is advisable to have spare bearings on hand.

93. If the bearings overheat, the cause is probably one of the following: (1) Poor lubrication, which may be owing to poor grade or insufficient quantity of lubricant or failure of the oil rings to revolve; (2) poor alignment or leveling causing excessive end thrust or binding; (3) rough bearing surface; (4) bent shaft.

94. If a bearing becomes hot, feed a heavy lubricant copiously. If the relief is not thus afforded shut down the motor-generator keeping the armature revolving slowly until the bearing is cool, in order to prevent sticking or "freezing."

CARE OF MOTOR-GENERATOR TYPE SK GENERATOR AND MOTOR

95. Commutator—The commutator must be kept clean and the brushes properly adjusted and fitted to the commutator. Wipe the commutator at frequent intervals, depending on the character of the service, with a piece of clean canvas cloth free from lint. Apply lubricant sparingly; a piece of paraffin rubbed lightly across the commutator surface will furnish sufficient lubrication. No other attention is required by the commutator which is taking on a polish and shows no sign of wear. A rough, raw, copper-colored surface should be smoothed with a piece of sandpaper or fine sandstone ground to fit. In any case the final smoothing should be with fine (No. 00) sandpaper. When using the paper or stone lift the brushes and do not replace them until all grit is removed. Never use emery cloth or emery paper on the commutator.

96. Brushes—The brushes are set in the neutral position at the factory and the bracket to which they are attached is doweled in position. This adjustment should not be altered as it is correct for either direction of rotation.

97. New brushes should be of the same make and grade as those shipped with the machine. Brushes should have only sufficient clearance in the box to slide easily.

TYPE AR SINGLE-PHASE MOTOR

98. Renewing Brushes—To remove brushes from the holder, turn the rocker ring so that the brushes are brought between the arms of the bearing bracket. Remove the screws of the clips that hold the brushes in place. After inserting new brushes, turn the rocker ring so that the pointer is opposite the line for the proper direction of rotation.

99. The front bracket of the motor should not be removed unless unavoidable. If the bracket is removed, when replacing make sure that the steel pin in the brush-raising ring enters the corresponding slot in the brush-holder casting. Failure to observe this may result in poor operation.

GENERAL POINTERS

100. Generator Excitation—When a generator is started, it may fail to build up its voltage properly. This may occur even though the generator operated perfectly during the preceding run. This may be due to one or more of the following causes:

(a) Slow speed.

(b) Open shunt-field circuit, caused by faulty connections or defective field coil or field rheostat.

(c) Open armature or commutating-field circuit.

(d) Incorrect setting of brushes.

(e) Reversed series or shunt coils.

(f) Poor brush contact due to dirty commutator or brushes sticking in holders.

(g) Loss of residual magnetism.

101. Examine all connections, try a temporarily increased pressure on the brushes; look for a broken or burned out resistor coil in the rheostat. An open circuit in the field winding may sometimes be traced with the aid of a magneto and bell; but this is not an infallible test as some magnetos will not ring through a circuit of such high resistance as some field windings have, even though the winding be intact. If no open circuit is found in the rheostat or in the field winding, the trouble is probably in the armature. But if it be found that nothing is wrong with the connections or the winding it may be necessary to excite the field from another generator or some other outside source. Calling the generator that we desire to excite, No. 1, and the other machine from which the current is to be drawn, No. 2, the following procedure should be followed:

102. Open all switches and remove all brushes from generator No. 1; connect the positive brushholder of generator No. 1 with the positive brushholder of generator No. 2; also connect the negative holders of the machines together (it is desirable to complete the circuit through a switch protected by a fuse of about 5 amperes). Close the switch. If the shunt winding of generator No. 1 is all right, its field will show considerable magnetism. If possible, reduce the voltage of generator No. 2 before opening the exciting circuit; then break the connections. If this cannot be done, set the field rheostat contact arm of generator No. 1 on button marked "IN", then open the switch very slowly and gradually lengthen the arc, which will be formed, until it breaks.

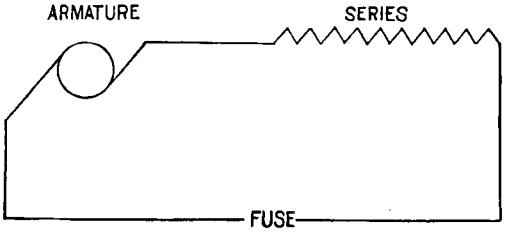


Fig. 12—Showing Convenient Method of Making a Compound-Wound Generator Pick Up Voltage

103. A very simple means for getting a compound-wound machine to pick up is to short-circuit it through a fuse having approximately the current capacity of the generator. (See Fig. 12). If sufficient current to melt this fuse is not generated, it is evident that there is something wrong with the armature, either a short circuit or an open circuit. If, however, the fuse has blown, make one more attempt to get the machine to excite itself. If it does not pick up, it is evident that something is wrong with the shunt winding or connections.

104. If a new machine refuses to build up voltage and the connections apparently are correct, reverse the field connections; i. e., interchange the field wires which are connected to the positive and negative terminals of the generator. If this interchange of connections does no good, re-establish the original connections and locate the fault as previously advised.

Fig. 13—Grinding Brushes

105. Brushes—All brush faces resting on the commutator should be fitted to the commutator so that they make good contact over the entire area. This can be most easily accomplished after brushholders have been adjusted and the brushes inserted. Lift one set of brushes so that they will not be forced against the commutator. Place a piece of sandpaper against the commutator with the sanded side towards the brushes. Replace one brush in its holder and allow the spring to force it against the sandpaper. Draw the sandpaper in the direction of rotation under the brush, as shown in (Fig. 13), releasing the pressure as the paper is drawn back being careful to keep the ends of the paper as close to the commutator surface as possible and thus avoid rounding the ends of the brush. After the first brush is properly ground, it should be lifted sufficiently to prevent it being forced against the commutator, after which the remaining brushes of the set may be similarly ground one at a time.

106. By this means a satisfactory contact is quickly secured, each set of brushes being similarly treated in turn. If the brushes are copper plated, their edges should be slightly beveled, so that the copper does not come in contact with the commutator.

Make frequent inspection to see that:

(a) Brushes are not sticking in holders.

(b) Pig-tail shunts are properly attached to brushes and holder.

(c) Tension is readjusted as the brush wears.

(d) Copper plating is cut back so it does not make contact with commutator.

(e) Worn-out brushes are replaced before they reach their wearing limit and break contact with the commutator.

(f) Any free copper picked up by the face of the brushes is removed.

107. Commutator—The commutator is perhaps the most important part of the machine in that it is most sensitive to abuse. Under normal conditions, it should require little attention beyond frequent inspection. The surface should always be kept smooth, and if, through extreme carelessness, neglect or accident, it becomes badly roughened, the armature should be removed and the commutator turned down in an engine lathe.

108. Sparking at the brushes may be due to any one of the following causes:

(a) The machine may be overloaded.

(b) The brushes may not be set exactly on the neutral position. If so, the neutral should be determined by running the machine in both directions of rotation and obtaining the same voltage at full load current in both directions.

(c) The brushes may be welded in the holders or have reached their limit of wear.

(d) The brushes may not be fitted to the surface of the commutator.

(e) The brushes may not bear on the commutator with sufficient pressure.

(f) The brushes may be burned on the ends.

(g) The commutator may be rough. If so, it should be smoothed.

(h) A commutator bar may be loose or may project above the others.

(i) The commutator may be dirty, oily or worn out.

(j) The carbon brushes may be of an unsuitable grade.

(k) The brushes may not be equally spaced around the periphery of the commutator.

(l) Some brushes may have extra pressure and may be taking more than their share of the current.

(m) The contact between some brush pigtails and brushholders may be poor, forcing the other brushes to carry too much current.

(n) High mica.

(o) Vibration or chattering of the brushes.

109. These are the more common causes, but sparking may be due to an open circuit or loose connection in the armature. This trouble is indicated by a bright spark which appears to pass completely around the commutator, and may be recognized by the scarring of the commutator at the point of open circuit. If a lead from the armature winding to the commutator becomes loose or broken it will draw a bright spark as the break passes the brush position. This trouble can be readily located, because the insulation on each side of the disconnected bar will be more or less pitted.

110. The commutator should run smoothly and true, and have a dark glossy sruface.

111. Heating—Many persons not familiar with permissible operating temperatures of electrical apparatus become unduly alarmed when they find that the various parts of a motor-generator feel very hot to the fingers. However, it is extremely inadvisable to permit the equipment to operate above certain temperatures because the insulation will become charred and the current will break through burning out the windings. The only safe and certain way to determine temperatures is to use centigrade thermometers the bulbs of which can be applied directly against the parts, which are suspected of being too hot, by means of putty over and around the bulb.

The standardization rules of the American Institute of Electrical Engineers specify a maximum actual temperature of 90°C (194°F) as the limit of safe temperature for such motor-generator equipments. In other words a temperature rise of 50°C (90°F) above a maximum permissible room temperature of 40°C (104°F). Obviously a temperature of 194° Fahrenheit would feel hot to the hand having a blood temperature of only about 98° Fahrenheit.

It is not uncommon for projection room temperatures especially in hot weather to reach a value of 35°C (95°F) to 40°C (104°F) but even if the room temperature was only 22°C (72°F) and the motor-generator operates at a temperature rise of 50°C (90°F) the actual temperature of the motor generator would be 72°C (162°F) which would also feel hot to the hand or fingers. Therefore unless the room temperature exceeds, 40°C (104°F) and unless the actual temperature of the hottest part of the motor generator as indicated by a reliable thermometer exceeds 90°C (194°F) the equipment will not be damaged.

To reduce centigrade temperature to Fahrenheit temperature multiply the degrees Centigrade by 1.8 and add 32. For example projection room temperature of 40°C corresponds to what temperature Fah. 40 x 1.8 = 72; 72 + 32 = 104° Fahrenheit.

112. Heating of Field Coils—Heating of field coils may result from any of the following causes.

(a) Too low speed.
(b) Too high voltage.
(c) Too great forward or backward lead of brushes.
(d) Partial short-circuit of one coil.
(e) Overload.

113. Heating of Armature—Heating of armature may result from any of the following causes:

(a) Too great load.
(b) A partial short-circuit of two coils heating the two particular coils affected.
(c) Short-circuits or grounds in armature windings or commutator.
(d) Bad commutation with consequent large circulating currents in armature coils undergoing commutation.

114. Heating of Commutator may result from any of the following causes:

(a) Overload.
(b) Sparking.
(c) Too high brush pressure.

115. Bucking is the very expressive term descriptive of the arcing between adjacent brush arms. In general, bucking is caused by excessive voltage between commutator bars, or by abnormally low surface resistance on the commutator between brushholders of opposite polarity. Any condition tending to produce poor commutation increases the danger of bucking. Among other causes are the following:

(a) Rough or dirty commutator.
(b) A drop of water on the commutator from the roof, leaky stream pipes or other source.
(c) Short-circuits on the line producing excessive overloads.