A LABORATORY MANUAL

FOR

STUDENTS OF ELECTRICAL ENGINEERING

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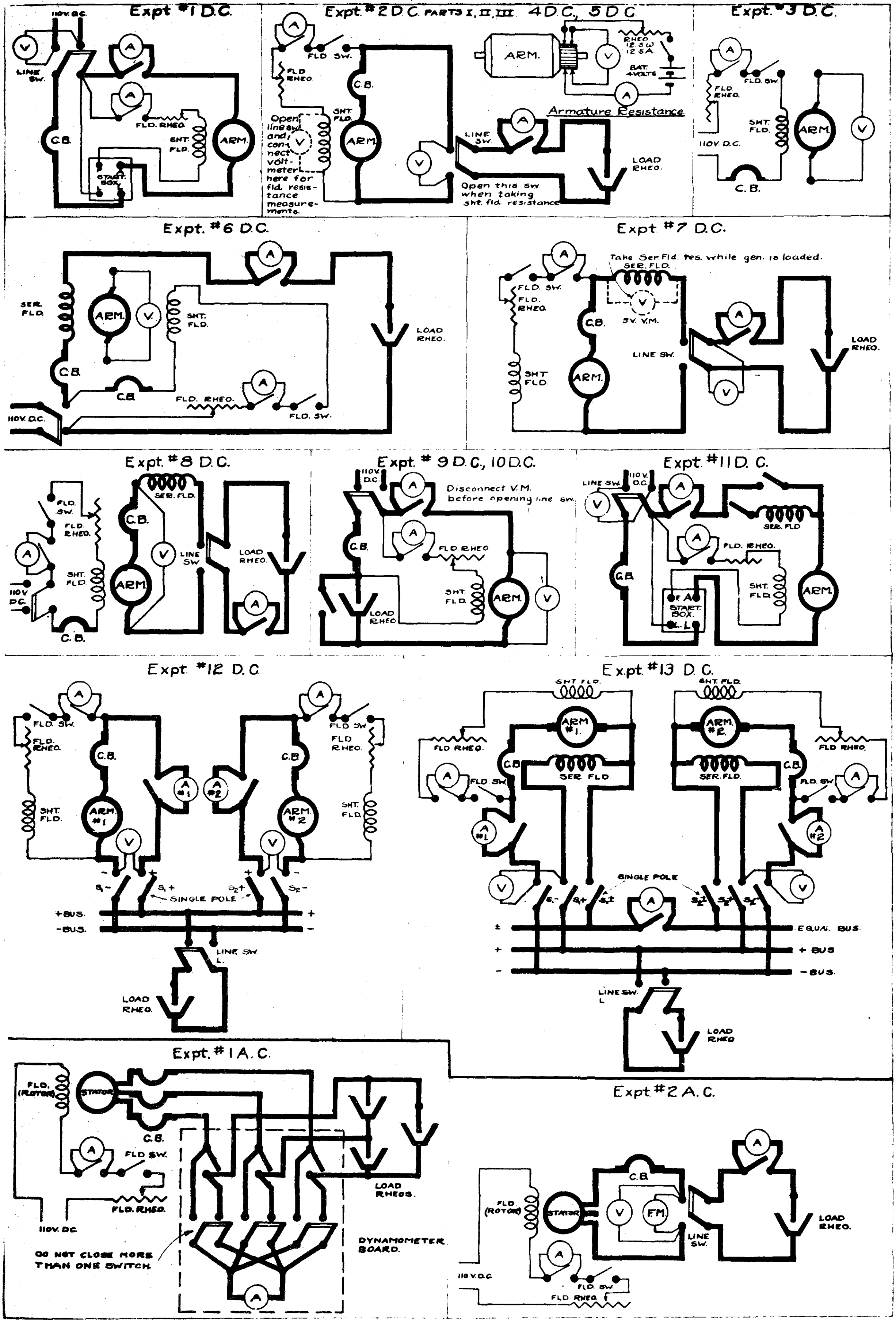
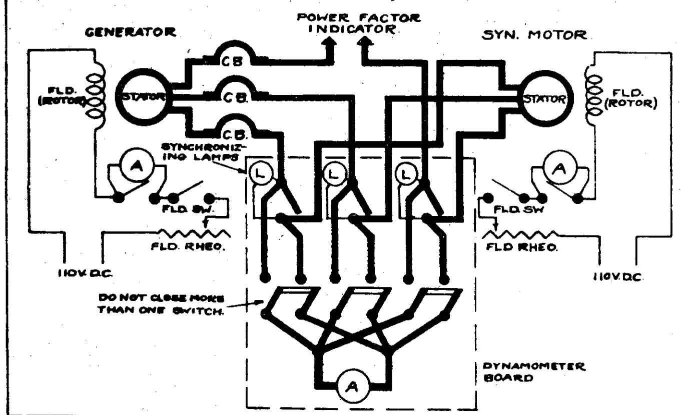
George Forster

Presented as partial fulfillment
of the requirements for the degree
of Master of Science, at the
California Institute of Technology,
May 26, 1926.

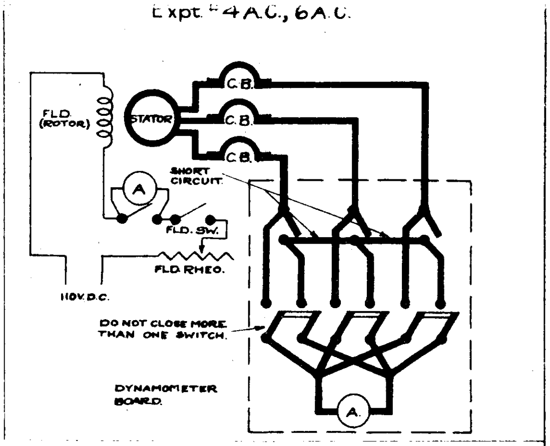


Expt #1 D.C.
110V. D.C.
LINE SW.
C.B.
FLD. RHEO.
SHT. FLD.
ARM.
START. BOX.
Expt #2 D.C. PARTS I, II, III 4 D.C., 5 D.C.
FLD. SW.
FLD. RHEO.
C.B.
SHT. FLD.
Open line sw. and connect voltmeter here for fld. resistance measurements.
ARM.
RHEO. 12 SW. 12.5 A.
BAT. 4 VOLTS
Armature Resistance
LINE SW.
LOAD RHEO.
Open this sw when taking sht. fld. resistance
Expt #3 D.C.
FLD. SW.
FLD. RHEO.
SHT. FLD.
110V. D.C.
C.B.
Expt #6 D.C.
SER. FLD.
SHT. FLD.
LOAD RHEO.
C.B.
FLD. RHEO.
FLD. SW.
110V. D.C.
Expt #7 D.C.
Take Ser. Fld. res. while gen. is loaded.
SER. FLD.
FLD. SW.
FLD. RHEO.
C.B.
5V. V.M.
LINE SW.
LOAD RHEO.
SHT. FLD.
ARM.
Expt #8 D.C.
SER. FLD.
FLD. SW.
FLD. RHEO.
C.B.
SHT. FLD.
LINE SW.
LOAD RHEO.
110V. D.C.
ARM.
Expt # 9 D.C., 10 D.C.
110V. D.C.
Disconnect V.M. before opening line sw.
FLD. RHEO.
C.B.
SHT. FLD.
LOAD RHEO.
ARM.
Expt #11 D.C.
LINE SW.
110V. D.C.
SER. FLD.
FLD. RHEO.
SHT. FLD.
START. BOX.
ARM.
Expt #12 D.C.
FLD. SW.
FLD. RHEO.
C.B.
SHT. FLD.
ARM. #1
ARM. #2
SINGLE POLE
+BUS.
-BUS.
LINE SW.
LOAD RHEO.
Expt #13 D.C.
SHT. FLD.
ARM. #1.
ARM. #2.
FLD. RHEO.
C.B.
SER. FLD.
FLD. SW.
SINGLE POLE
EQUAL BUS.
+ BUS
- BUS.
LINE SW.
LOAD RHEO.
Expt #1 A.C.
FLD. (ROTOR)
STATOR
C.B.
FLD. SW.
FLD. RHEO.
110V. DC.
LOAD RHEOS.
DYNAMOMETER BOARD.
DO NOT CLOSE MORE THAN ONE SWITCH.
Expt #2 A.C.
C.B.
FLD. (ROTOR)
STATOR
F.M.
LINE SW.
LOAD RHEO.
110V. D.C.
FLD. SW.
FLD. RHEO.

Expt #3 A.C., 5 A.C.



Expt #4 A.C., 6 A.C.



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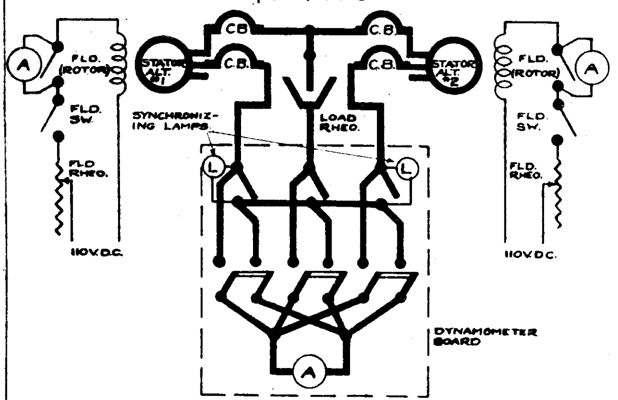
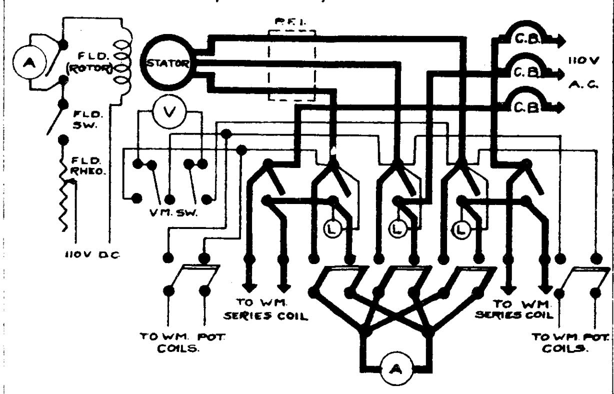
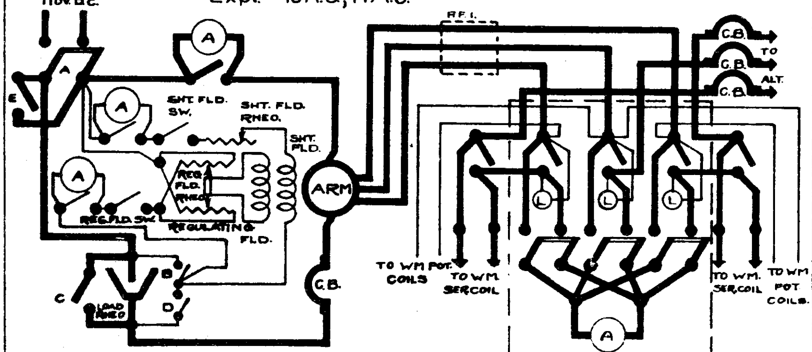


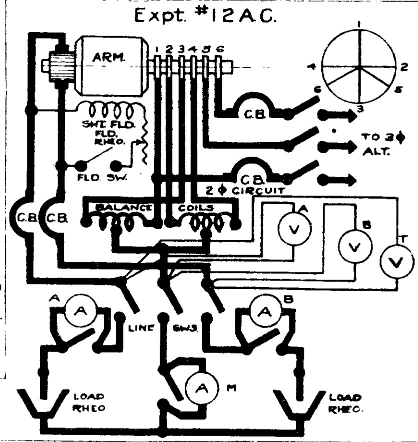
Expt #8 A.C., 9 A.C.



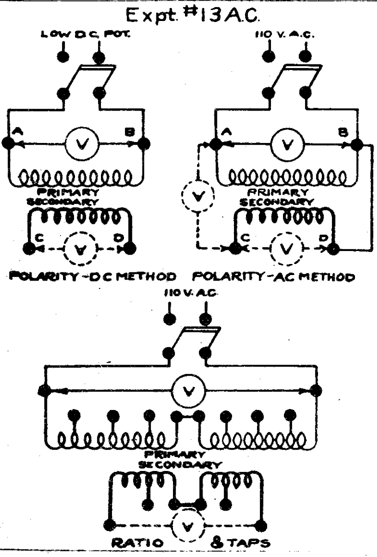
Expt #10 A.C., 11 A.C.



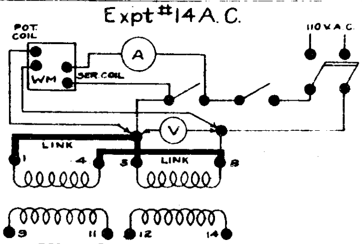
Expt #12 A.C.



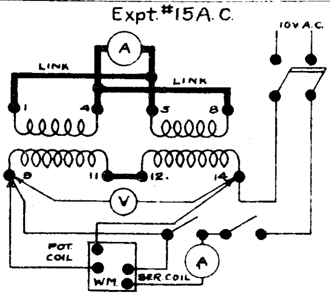
Expt #13 A.C.



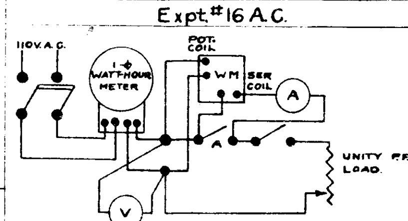
Expt #14 A.C.



Expt #15 A.C.



Expt #16 A.C.



Close voltage switches on WM and V only when taking readings.

Close switch A only at start, for protection.

DIRECT-CURRENT LABORATORY EXPERIMENTS

1-DC General study of a Direct-Current Generator, and Motor. Operation of a Shunt Motor.

2-DC Operation of a Shunt Generator, Measurement of Field and Armature Resistance.

3-DC Saturation Curve of a Shunt Generator.

4-DC External and Total Characteristics of a Shunt Generator.

5-DC Armature Characteristic of a Shunt Generator, Armature Reaction in a Shunt Generator.

6-DC Saturation Curve of a Compound Generator.

7-DC External and Total Characteristic of a Compound Generator.

8-DC Armature Reaction in a Compound Generator.

9-DC Speed Regulation of a Shunt Motor.

10-DC Efficiency of a Shunt Motor by the Stray Power Method.

11-DC Speed Regulation of a Compound Motor (Differential & Cumulative).

12-DC Operation of Shunt Generators in Parallel.

13-DC Operation of Compound Generators in Parallel.

REFERENCES

A.I.E.E.	Standardization Rules.
F. & E.	"Elements of Electrical Engineering" Vol. 1, Franklin & Esty.
Franklin	"Dynamo Laboratory Manual".
Foster	"Foster's Handbook", 7th Edition, 1913.
Gray	"Principles & Practice of Electrical Engineering".
Karapetoff	"Experimental Electrical Engineering". Vol. I Third Edition. Vol. II Second Edition
Langsdorf	"Principles of Direct Current Machines".
Morecroft	"Short Course in Electrical Testing".
S. & T.	"Laboratory & Factory Tests in Electrical Engineering", Sever & Townsend.
S. & F.	"Testing of Electro-Magnetic Machinery," Swenson & Frankenfield.
Smith	"Testing Dynamos & Motors".
Std. Hdbk.	"Standard Handbook for Electrical Engineers".
Pender	"Direct Current Machinery".
Dawes	"Electrical Engineering" Vol. I "Direct Currents".
R. & T.	"Electrical Engineering Laboratory Experiments", Ricker & Tucker.

SUPPLEMENT

Additional References

M. & H. "Continuous Current Circuits and Machinery"

"Electrical Circuits and Machinery"

Vol. I, II, III. Morecroft & Hehre.

Expt. #1-DC. M. & H. Vol. 1, p. 403-412, 385, 386,
Vol.III p. 20-31

Expt. #2-DC. M. & H. Vol. I, p. 390-399
Vol.III p. 3-14

Expt. #3-DC. M. & H. Vol. I, p. 396-399, 238-251.
Vol.III p. 10-14

Expt. #4-DC. M. & H. Vol. I, p. 396-399, 251-253;
Vol.III p. 10-14

Expt. #5-DC. M. & H. Vol. I, p. 253, 228-238.

Expt. #6-DC. M. & H. Vol. I, p. 400-402, 253-257;
Vol.III p. 15-19

Expt. #7-DC. M. & H. Vol. I, p. 400-402, 253-257;
Vol.III p. 15-19.

Expt. #8-DC. M. & H. Vol. I, p. 400-402, 253-257;
Vol.III p.15-19.

Expt. #9-DC. M. & H. Vol. I, p. 403-407, 280-287, 293-310;
Vol.III p. 20-25.

Expt.#10-DC. M. & H. Vol. I, p. 413-418, 322-332;
Vol.III p. 32-38.

Expt.#11-DC. M. & H. Vol. I, p. 290-316, 422-425;
Vol.III p. 42-46.

Expt.#12-DC. M. & H. Vol. I, p. 426-430, 263-267;
Vol.III p. 47-52.

Expt.#13-DC. M. & H. Vol. I, p. 263-271, 431-435;
Vol.III p. 53-58.

M. & H. "Electrical Circuits and Machinery" Vol. I, II, III
Morecroft & Hehre

Gherkins "Regulators"

Expt. #1-AC. M. & H. Vol. II p. 264-265;
Vol.III p. 100-109.

Additional References (contd)

Expt. #2-AC.	M. & H.	Vol. II	p. 263-264;	
		Vol.III	p. 100-109	
Expt. #3-AC.	M. & H.	Vol. II	p. 263-266;	
		Vol.III	p. 100-109.	
Expt. #4-AC.	M. & H.	Vol. II	p. 265-273;	
		Vol.III	p. 100-109.	
Expt. #7-AC.	M. & H.	Vol. II	p. 276-286;	
		Vol.III	p. 147-153.	
Expt. #8-AC.	M. & H.	Vol. II	p. 345-359;	
		Vol.III	p. 127-138.	
Expt. #9-AC.	M. & H.	Vol. II	p. 345-359;	
		Vol.III	p. 127-138.	
Expt. #10-AC	M. & H.	Vol. II	p. 360-381;	
		Vol.III	p. 139-146.	
Expt. #11-AC	M. & H.	Vol. II	p. 360-381;	
		Vol.III	p. 139-146.	
Expt. #12-AC	M. & H.	Vol. I	p. 92-99, 257-258, 316-319.	
Expt. #13-AC	M. & H.	Vol. II	p. 289-324;	
		Vol.III	p. 110-118.	
Expt. #14-AC	M. & H.	Vol. II	p. 289-324;	
		Vol.III	p. 110-118.	
Expt. #15-AC	M. & H.	Vol. II	p. 289-324;	
		Vol.III	p. 110-118.	
Expt. #16-AC	M. & H.	Vol. I	p. 125-147, 447-449;	
		Vol. II	p. 175-209;	
		Vol.III	p. 72-74, 160-165.	
Expt. #17-AC	M. & H.	Vol. I	p. 343-350;	
		Vol. II	p. 273-276;	
	Gherkin's Regulators.			
Expt. #18-AC	M. & H.	Vol. I	p. 125-147;	
		Vol. II	p. 175-209.	
Expt. #19-AC	M. & H.	Vol. II	p. 289-324.	
Expt. #20-AC	M. & H.	Vol. II	p. 289-324.	
Expt. #21-AC	M. & H.	Vol. II	p. 289-324.	

Expt. #________ Title: ____ Date__________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#1-DC I. GENERAL STUDY OF A DIRECT-CURRENT GENERATOR & MOTOR

This sheet is to help you get acquainted with the apparatus you will use most frequently in your laboratory work. Check and fill in all the required blank spaces as quickly as possible. If in doubt about one or another, proceed with the rest, omitting that one until assistance can be given you.

Type of Dynamo:

Direct Current_____ Double-Current_____ Shunt______ Series______
Compound_______ Commutating-pole_______.

Armature:

Ring______ Drum______ Lap______ Wave______ No. of slots_______
Conductors per slot______ E.M.E.______ Current_______
Watts Output______ Active length______ Circumference in feet______ Speed, r.p.m.______ Peripheral speed, ft. per minute______

Commutator:

Active length______ Total length______ Circumference in ft.______
Peripheral speed, ft. per min.______ Total No. of bars______
No. of bars between brushes of opposite polarity_______
Average voltage between bars______ Width of bars______ Width of insulation______.

Brushes:

Material______ Bare?______ Copper coated?______ Width______
Thickness______ No. per set______ No. of sets______
Brush area per set______ Current density in brushes, amp./in^2______ Tension of springs on brushes, lbs.______

Field:

No. of coils______ Form-wound?______ Hand-wound?______ No. of poles______ Pole pitch (inches)______ (mech. degrees)______ (elec. degrees)______ Pole width______ Pole length (axial)______
Width of pole shoe______ Length of pole shoe (axial)______
Width of commutating pole______ Length of commutation pole (axial)______

#1-DC II. OPERATION OF A SHUNT MOTOR

Procedure:

1. This test is to teach you four important and essential things concerning a direct-current motor and three concerning the use of ammeters and voltmeters. They are for the motor, (a) the method of connection, (b) starting, (c) changing speed, and (d) reversing the direction of rotation, and for the meters, (a) the proper method of interchanging ammeter lead connections, (b) protecting ammeters by means of a short-circuiting switch, and (c) protecting voltmeters and yourself by properly interchanging lead connections when necessary. As you will use d.c. motors and meters in practically every experiment you perform, it is to your advantage to memorize these seven points immediately.

2. Use a low-range ammeter in the field circuit, a high-range ammeter in the line, and a high-range voltmeter across the terminals of the line switch.

3. Adjust the field rheostat so that all resistance is out. See that all ammeter short-circuiting switches are closed.

4. Observe if the voltmeter is reversed. If so, interchange its lead connections at the line-switch. Never reverse lead connections at the voltmeter terminals.

5. Close the line switch, raise the starting-box handle to the first notch, and note the direction of rotation of the motor. If the rotation is incorrect, pull the line switch immediately and before releasing the starting-box handle. Then reverse either the lead connection at the field terminals, or those at the armature terminals, and proceed as before.

6. If the rotation is correct, proceed to move the starting-box handle gradually from one notch to the next until it engages the catch and stays in the upright position.

7. Before opening the ammeter short-circuiting switches see if the meters are indicating in the proper sense. If not, the lead connections at the meter terminals may be interchanged while the short circuiting switch is closed.

8. Take readings of the line voltage or electro-motive force, armature current, field current, and speed, for field resistance out and also in. Do not permit the motor to speed up excessively.

9. Reverse the direction of rotation of the motor. While starting, observe the fluctuations of the armature current as the starting resistance is cut out.

#1-DC Procedure Cont'd.

Data:

Tabulate all observations on a standard data sheet.

Questions:

Answers to questions 1-6 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. State the function of a motor.

2. What is (a) a shunt motor?
   (b) a series motor?
   (c) a compound motor?
   (d) a differential motor?

3. Compare the field resistance of a shunt motor with respect to its armature resistance. Why are they different?

4. Why is a starting resistance necessary and where is it placed?

5. State two methods for reversing the direction of rotation of a shunt motor.

6. How can you regulate the speed of a shunt motor?

7. If the motor gave trouble in starting, to which of the following causes was it due?

(a) Great overload preventing the turning of the armature.
(b) Excessive friction in some part.
(c) External or internal circuit open.
(d) Wrong connections.
(e) Armature revolved at excessive speed.
(f) Armature revolved in wrong direction.
(g) State any other cause.

8. Did the results check your answers to (4), (5) and (6)?

References:

S. & T.	pp. 3-6, 27-29, 64-66, 68-69.
Langsdorf	Art. 31, 60, 127.
Gray	Art. 32-38, 86, 93-96, 100-101, 104, 401-404.
Smith	pp. 116-121
E. & E.	Art. 26, 59.
A.I.E.E.	Definitions
Std. Hdbk.	Definitions in Standardization Rules section.
Pender	p. 40, 198.
Dawes	p.309.
Karapetoff	p. 340 Vol. I.
R. & T.	p. 107, 128.

#1-DC

DATA SHEET

Station______

		A	B	C	D=B+C	E=AD
Field Rheo.	R.P.M. #	Volts #	Arm. Amp. #	Fld Amp. #	Total	Watts
Out						
In*						

*Do not permit the motor to speed up to excessive values.

Approved________________

Expt. #_______ Title:____________________________________ Date__________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt._______ Title____ Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________
2. Are the brushes badly worn?_______ Incorrectly set?__________
3. Is commutator rough or pitted?________
4. Does armature turn easily?________
5. Are all connections correct?________
6. Are couplings or belted connections properly made?________
7. Is machine clear of tools and foreign particles?________
8. Have your wiring inspected and OK'd by instructor________
9. Do oil rings turn and provide sufficient lubrication after machine is running?________
10. Are there any defects, and any unusual noises in the machine after it is running?________
11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#2-DC OPERATION OF A SHUNT GENERATOR
MEASUREMENT OF FIELD AND ARMATURE RESISTANCE

Procedure:

I. Operation of a Shunt Generator.

1. This test is to teach you five important and essential things concerning a direct-current generator. They are: (a) the method of connection, (b) building-up the voltage, (c) correcting one of the most common hindrances to building-up, (d) varying the voltage, and (e) a common method of loading. As you will use a d.c. generator frequently in all your laboratory work, it is to your advantage to memorize these five points immediately.

2. Use a low-range ammeter in the field circuit, a high-range voltmeter across the armature terminals, and a high-range ammeter in the line.

3. Have your connections checked & OK'd by instructor_______.

4. Adjust the generator field rheostat so that all resistance is in. See that all ammeter short-circuiting switches are closed.

5. Record the voltage due to residual magnetism.

6. Close the field switch, gradually decrease the field circuit resistance and note the voltmeter carefully. If the voltage does not increase, insert all the resistance, open the field switch and reverse the leads at the field terminals. Refer to question (11).

7. Adjust the voltage until its value is about 110 volts, or the rated voltage of the machine, and record.

8. With the water rheostat plates out, close the line switch, and carefully lower the rheostat plates into the water until the line ammeter indicates full-load current. Record the voltage.

9. If possible adjust the field resistance until the voltage is the same as it was at no-load, and record.

10. With the generator running at constant speed and steady load, shift the brushes a short distance around the commutator. Note the results. Do not permit the commutator to spark excessively.

11. Reverse the field connections after removing the load and opening the field switch, and note the effect on the possibility of bringing up the voltage.

#2-DC Procedure contd.

II. Measurement of Field Resistance.

1. Use a low-range ammeter and high-range voltmeter.

2. Have your wiring inspected and OK'd by instructor.________

3. See that meters are properly protected and external field resistance is in.

4. Close the field switch, adjust the rheostat for a certain value of current and read the voltage.

5. Repeat for at least two different current values.

III. Measurement of Armature Resistance.

This test is made frequently and should be memorized.

a. Lap Winding.

1. Lift all the brushes from the commutator. Do not change the brush-holder settings, but release only the springs.

2. Use a low-range ammeter and voltmeter and the special leads provided for the purpose.

3. Have your connections checked & OK'd by instructor.________

4. Hold the ends of the special leads on diametrically opposite segments of the commutator, adjust the rheostat for a certain value of current and read the voltage.

5. Repeat for at least two different current values.

6. Calculate the resistance from the data by Ohm's Law, multiply this by four and divide by the number of poles squared. This is the true running resistance.

b. Wave winding.

1. Lift the brushes from the commutator. Do not change the brush-holder settings, but release only the springs.

2. Use a low-range ammeter and voltmeter, and the special leads provided for the purpose.

3. Have your connections checked & OK'd by instructor.________

#2-DC Procedure contd.

4. Hold the ends of the special leads on commutator segments 180 electrical degrees apart, i.e. on segments separated a distance equal to that between adjacent positive and negative brushes.

5. Adjust the rheostat for a certain value of current and read the voltage.

6. Repeat for at least two different current values.

7. Calculate the resistance by Ohm's Law. This is the true running resistance.

Data:

Tabulate all observations on a standard data sheet.

Questions:

Answers to questions 1-10 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. State Ohm's Law in words.

2. Why is the armature resistance made low, and the shunt field resistance high?

3. What is meant by brush contact resistance and how does it vary with the current for carbon brushes?

4. How would you obtain the resistance of several different parts of a series circuit?

5. Why should the armature remain stationary while measuring its resistance?

6. State the function of a generator.

7. Name the three types of direct-current generators and show their differences by diagrams.

8. Why should all the resistance of the field circuit be in before closing the field switch?

9. What method of resistance measurement is generally most convenient for motors or generators?

#2-DC Questions contd.

10. Explain a second method, stating its principle, the procedure, and its advantages.

11. If the generator failed to excite to which of the following causes was it due?

(a) Residual magnetism weak or not present.
(b) Reversed field connections.
(c) Short-circuit, either in the machine or external circuit.
(d) Field coils opposed to each other.
(e) Open circuit in the field coils or connections.
(f) Brushes not in proper position on the commutator.
(g) Rheostat in the field circuit of too great resistance.
(h) State any other cause.

12. Explain the variation in the voltage obtained at full-load and no-load.

13. Explain why adjustment of the field current enabled you to bring the voltage to a value equal to that at no-load. In case you were unable to bring the voltage back to normal explain why.

14. What occured when you closed the field switch and gradually cut out the resistance in the field circuit? Explain this action. What prevents its continuing indefinitely?

References:

S. & T.	pp. 3-6, 21-25, 29-31.
Langsdorf	Art. 51-56, 58-59.
Gray	Art. 69, 74, 82, pp.370-371
Smith	pp. 7-13, 54, 73.
F. & E.	Art. 31, 49.
A.I.E.E.	Definitions.
Std. Hdbk.	Definitions in Standardization Rules Section
Pender	p.34, 147.
Dawes	p. 48, 215.
Karapetoff	p. 3, 287, Vol.I; pp. 188-207, Vol.II.
R. & T.	p. 74, 77.

#2-DC

DATA SHEET

Station:_______

Field Resistance		
Amp. #	Volts #	Res. ohms
	Av.	

Armature Resistance (Wave Winding)		
Amp. #	Volts #	Res. ohms
	Av.	

Armature Resistance (Lap Winding)				
A	B	C=B/A	D	E=4C/D2
Amp.	Volts	Res. ohms	No. poles	True Res. ohms
			Av.	

	Volts #	Line Amp. #	Field Amp. #
Due to residual magnetism			
No-load voltage			
Full-load voltage before adjustment			
Full-load voltage after adjustment			
Brushes on neutral			
Brushes maximum forward *			
Brushes maximum back *			

* Do not permit commutator to spark excessively.

Approved:_______________

Expt.#________ Title:____ Date____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#3-DC SATURATION CURVE OF A SHUNT GENERATOR

Procedure:

1. Use a low-range ammeter, a high range voltmeter, and a high resistance in the field circuit. Do not use a field rheostat with a current capacity less than the field current used.

2. Connect the generator for separate excitation and start it as per instructions in #1 & #2-DC.

3. Before closing the field switch record the voltage due to residual magnetism.

4. Turn in all of the field circuit resistance, close the field switch and read the field current, and corresponding armature voltage.

5. Keeping the speed constant throughout the test, decrease the field resistance in about ten steps, taking simultaneous readings of field current and corresponding armature voltages. Always bring the magnetizing current up to the value; do not carry it above and then reduce it. If the speed varies, corrections for voltage readings should be made.

6. If you should unavoidably reduce the current, it is necessary to insert all the resistance, open and close the field switch, and bring the current up to the desired value again.

7. After all the field resistance is out, insert it again in about ten steps, taking readings as before. This time approach the current value from one higher up and do not raise it at any time during the descent. Your last reading should be the voltage due to residual magnetism.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot the saturation or magnetization curve on a standard curve sheet, using volts as ordinates and field currents as abscissae. Follow instructions given in the general directions.

#3-DC Procedure contd.

Questions:

Answers to questions 1-7 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. What is meant by "characteristic curves" of a generator? What are their functions?

2. What is the magnetization or saturation curve of a generator? Name two of its functions.

3. What is the internal characteristic or building-up curve of a generator? Name its function.

4. What is meant by self- and separate excitation? By ampere-turns? By magnetic saturation? By magneto-motive-force?

5. Does the flux increase proportionately with the voltage?

6. If the speed varies, how can the voltmeter readings be corrected?

7. Suppose too great an increase is made in the field current and then it is reduced directly to the required value, what effect is produced on the curve and why? How would you attain the required value without producing this effect?

8. Explain why the curve first runs up straight, then bends over.

9. Explain why the curve cuts the vertical axis above the origin, and the important bearing this has on the operation of self-excited generators.

10. At what point on the curve should the no-load voltage usually come? What is the effect on the action of the generator of having it lower? What is the effect of having it higher?

11. What is meant by hysteresis? How are its effects shown?

12. State two effects of temperature rise on the voltage of a generator. Which effect is greater? Are they additive or subtractive? Explain.

#3-DC Procedure contd.

References:

S. & T.	pp. 3-6, 32-37.
Langsdorf	Art. 54, 59, 78-79.
Gray	Art. 78-79, p. 371.
Smith	pp. 41-53.
F. & E.	pp. 384-386.
Foster	p.336.
A.I.E.E.	Definitions.
Std. Hdbk.	Definitions in Standardization Rules Section.
Pender	pp. 83, 84, 299.
Dawes	pp. 258-262.
Karapetoff	pp. 289-294.
R. & T.	p. 77.

#3-DC

DATA SHEET

Station: ________

Magnetization Curve							
Going Up				Coming Down			
Volts		Fld. Amp.	R.P.M.	Volts		Fld. Amp.	R.P.M.
Read #	Correct	#	#	Read #	Correct	#	#

Approved: __________

Expt.#________ Title:____ Date__________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #_________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date_____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#4-DC EXTERNAL & TOTAL CHARACTERISTICS OF A SHUNT GENERATOR

Procedure:

I. External Characteristic

1. Use a low-range ammeter in the field circuit, a high-range ammeter in the line, and a high-range voltmeter.

2. Start the generator and bring the voltage up to rated value as per instructions in #1 & #2-DC.

3. Keeping the speed and the field resistance (not field current) constant throughout the test, take simultaneous readings of the terminal voltage, line current, field current, and speed for zero output and for increasing values of load. Try increasing the load until the machine fails to generate.

II. Total Characteristic

1. Use a low-range ammeter and voltmeter.

2. Determine the armature resistance by the voltage-drop method of #2-DC.

3. To the drop due to armature resistance add one volt per brush (total 2 volts) to account for brush contact drop and armature leads, and calculate the values for the total characteristic. See A.I.E.E. Standardization Rules 440, 442-444, 454, 819.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot the external and total characteristics on the same standard curve sheet, using external or terminal volts as ordinates and line currents as abscissas for the external characteristic, and total volts as ordinates and total armature currents as abscissae for the total characteristic. Follow instructions given in the general directions.

Questions:

Answers to questions 1-6 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. What is the external characteristic curve of a shunt generator?

#4-DC Questions, contd.

2. What is the total characteristic curve of a shunt generator?

3. What causes the terminal voltage of a shunt generator to decrease as its load is increased?

4. When do both the current and the terminal voltage rapidly decrease? Why? How does this affect short-circuiting a shunt generator?

5. Why should the field resistance be kept constant during the test?

6. Why should the brushes be kept stationary during the test?

7. Give two reasons why the total characteristic departs from a horizontal line.

8. How is the external characteristic affected by reducing the armature conductors to one-half the original cross section? Why?

9. Explain why the voltage corresponding to a given current cannot be corrected proportionally to speed.

References:

S. & T.	pp. 3-6, 38-40.
Langsdorf	Art. 114-116.
Gray	Art. 81-82, p. 372.
Smith	pp. 76-82.
F. & E.	p. 149.
Pender	pp. 147, 292.
Dawes	pp. 288-295.
Karapetoff	pp. 299-303.

#4-DC

DATA SHEET

Station________

External Characteristic				
Line Amp. #	Field Amp. #	Total Amp. #	Volts #	Speed Const. #

Total Characteristic (calculated)					
Total Amp.	Ext. E.M.F. Volts	Arm. Res. Ohms	Arm.RI Drops Volts	Brush Con. Drop Volts	Total E.M.F. Volts

Armature Resistance (Lap Winding)				
A	B	C=B/A	D	$E=4C/D^2$
Amp. #	Volts #	Res. Ohms	No. Poles	True Ohms
			Av.	

Armature Resistance (Wave Winding)		
Amp #	Volts #	Res. Ohms
	Av.	

Approved:________________

Expt.#________ Title:____________________________________ Date__________

<u>Diagram of Connections:</u> Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

<u>Apparatus:</u> Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

<u>Instruments:</u> Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#5-DC ARMATURE CHARACTERISTIC OF A SHUNT GENERATOR
ARMATURE REACTION IN A SHUNT GENERATOR

Procedure:

I. Armature Characteristic.

1. Use a low-range ammeter in the field circuit, a high-range ammeter in the line, and a high-range voltmeter.

2. Start the generator and bring the voltage up to rated value as per instructions in #1 & #2-DC.

3. Keeping the speed and the voltage constant throughout the test, take simultaneous readings of the terminal voltage, line current, field current, and speed for zero output and for increasing values of load.

II. Armature Reaction:

1. Repeat Part I, but with this difference. Use separate excitation for the field, allow the voltage to change, but keep the speed and the field current constant throughout the test.

2. Determine the armature resistance by the voltage drop method of #2-DC, calculate the total armature and brush-contact RI drops, and hence, the voltage drops due to armature reaction.

Data:

Tabulate all observations on a standard data sheet.

Curves:

On a standard curve sheet plot the armature characteristic curve, using field currents as ordinates and line currents as abscissae.

On a second standard curve sheet, plot four curves, using line currents as abscissae in each case, and as ordinates:

(1) the observed terminal volts.
(2) the total volts developed (terminal volts plus armature and brush-contact RI drops).
(3) the volts due to a constant magnetomotive-force (a horizontal line at a value equal to the no-load voltage).
(4) the voltage drops due to armature reaction (the difference in voltages between curves (3) and (2)).

Follow instructions given in the general directions.

#5-DC Procedure contd.

Questions:

Answers to questions 1-5 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. What is the armature characteristic of a shunt generator? What is its function?

2. What is meant by flat-compounding? By over-compounding?

3. How could you determine the series turns required for compounding by means of added turns?

4. How would you determine the number of turns actually in the shunt or series winding by the use of added turns?

5. Define armature reaction. How does it affect the E.M.F.?

6. If the machine you tested has 1200 shunt field turns per pole, how many series turns per pole should be added to change it into a flat-compounded generator?

7. What causes the slope of the armature characteristic to increase with increased currents?

8. How would the number of turns required for 10% over-compounding compare with the number required for 5%? Why? What additional readings would be necessary to determine this?

References:

S. & T.	pp. 3-6, 40-41, 45-46, 49.
Langsdorf	Art. 91, 93, 109, 162.
Gray	Art. 75-77, 83, 92, 98.
Smith	pp. 54-62, 67-69, 105-109.
F. & E.	Art. 77, 78, App.B. Art. 34.
S. & F.	pp. 165-167.
A.I.E.E.	Definitions.
Std.Hdbk.	Definitions in Standardization Rules Section
Pender	pp. 159-161, 116-136.
Dawes	pp. 300-301, 267-276.
Karapetoff	pp. 305, 316, 441-446.

#5-DC

DATA SHEET

Station_______

Armature Characteristic			
Line Amp. #	Field Amp. #	Volts Const. #	Speed Const. #

Armature Reaction							
Fld. Amp. Const #	Line Amp. #	Volts #	Speed Const #	Arm. RI Drop Volts	Brush Con. Drp. Volts	Total RI Drop	Arm. Reaction

Armature Resistance (Lap Winding)				
A	B	C=B/A	D	$E=4C/D^2$
Amp. #	Volts #	Res. Ohms	No. Poles	True Res. Ohms
			Av.	

Armature Resistance (Wave Winding)		
Amp #	Volts #	Res. Ohms
	Av.	

Approved___________

Expt.#_______ Title:________________________________ Date__________

<u>Diagram of Connections:</u> Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

<u>Apparatus:</u> Note name plate data of all machines used:

Station #_________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

<u>Instruments:</u> Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#6-DC SATURATION CURVE OF A COMPOUND GENERATOR

Procedure:

1. Follow instructions 1-6 of #3-DC, Part I, bringing voltage only up to the normal rated value. Keep the series field circuit open.

2. Use a high-range ammeter and a load-rheostat in the series field circuit.

3. Keeping the maximum shunt field current obtained in (1) constant, close the series field circuit and gradually decrease the resistance of the load rheostat, taking readings of the series field current, shunt field current, terminal e.m.f. and speed for a range of currents up to the full-load value of the machine. If the e.m.f. falls with increase in series field current, reverse the series field connections. Observe the same precautions as in (1) about approaching the next value of em.f. from one below.

4. Decrease the current in the series field, taking observations as in (3) and approach values of e.m.f. from higher values.

5. After reaching zero current in the series field, open its circuit and then proceed as in (7) of #3-DC, Part I.

6. The ratio between the series and shunt turns is obtained as follows: (a) Operating the generator at normal speed excite only the series field bringing the armature terminal voltage to a suitable value. Record the series field current and the terminal voltage. (b) Then excite the shunt field alone bringing the armature terminal voltage to the value obtained in (a). Record the readings as before. Take at least three different sets of readings in each case.

The turn ratio is then equal to the shunt field current divided by the series field current which produced the same voltage.

The equivalent shunt field value of the series field current is equal to the product of the series field current and the turn ratio. This equivalent value should be added to the shunt field current to obtain the total magnetizing current.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot the saturation or magnetization curve on a standard curve sheet, using volts as ordinates and total magnetizing currents as abscissae. Follow instructions given in the general directions.

#6-DC Procedure contd.

Answers to questions 1-3 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. What is meant by equivalent shunt field value of the series field current? What constant should be determined in order to find this current? Explain in detail how to obtain it.

2. Compare the current ratings and resistance of the rheostat used in the shunt field circuit with that used in the series field circuit.

3. Could the series field be excited from a low-potential source in this test? State any advantages in doing so.

4. How can the value of current in the series winding be regulated under normal running conditions without changing the load? If so regulated, how might you determine its value?

5. How can the value of current in the shunt winding be regulated?

6. What happens when loading a compound generator if the series winding is reversed with respect to the shunt winding?

7. What is the advantage of a compound generator? What is the function of the shunt winding? Of the series winding?

8. What effect would a short-circuit on a compound generator produce compared with that on a shunt generator?

References:

S. & T.	pp. 3-6, 45-47, 49-52.
Langsdorf	Art. 53-56, 58-59, 78-79.
Gray	Art. 78-79, p. 371.
Smith	pp. 41-53.
F. & E.	pp. 80, 384.
Pender	pp. 83, 171.
Dawes	pp. 258, 295.
Karapetoff	p. 313.
R. & T.	p. 88.

#6-DC

DATA SHEET

Station____________

Saturation or Magnetization Curve						
Volts		Ser.Fld. Amp. #	Eq.Sht. Amp.	Sht.Fld Amp. #	Total Magnet Amp.	Speed Const. #
Read #	Correct	A	B=AK	C	D=B + C	

Ratio Data				
Volts #	Sht.Fld. Amp. #	Ser.Fld. Amp. #	Ratio	Speed Const. #
	E	F	K=E/F	
		Av.		

Approved____________________

Expt.#_______Title:_________________________________Date__________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #_________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date______________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#7-DC

EXTERNAL & TOTAL CHARACTERISTICS OF A COMPOUND GENERATOR

Procedure:

I. Compound or External Characteristic.

1. Use a low-range ammeter in the field circuit, a high-range ammeter in the line, and a high-range voltmeter.

2. Start the generator and bring the voltage up to rated value as per instructions in #1 & #2-DC.

3. Apply a load and note if the e.m.f. rises, remains constant, or falls. If it falls with load increase, remove the load, open the shunt field circuit and reverse the series field connection at its terminals.

4. Keeping the speed and the shunt field resistance constant throughout the test, take simultaneous readings of terminal e.m.f., line current, shunt field current, and speed for zero output and for a series of values of current output ranging from no-load to full-load value.

II. Total Characteristic.

1. Determine the armature and series field resistance by the voltage-drop method of #2-DC, calculate the total armature and brush-contact RI drop, and hence, the total characteristic values.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot the external and total characteristic curves on the same standard curve sheet, using terminal volts as ordinates and line currents as abscissas for the external characteristic, and total volts as ordinates and total armature currents as abscissas for the total characteristic. Follow instructions given in the general directions.

Questions:

Answers to questions 1-4 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. Explain the difference between long shunt and short shunt connections using diagrams.

#7-DC Questions contd.

2. What is wrong with a compound generator, if the voltage decreases rapidly as the load increases? What must be done to remedy this?

3. If the voltage is found to rise considerably with load increase how can it be remedied?

4. Explain the actions of shunt and series coils in producing the compound characteristic.

5. What would be an ideal "flat"-compound characteristic? How will the actual "flat" compound characteristic differ from the ideal and why?

6. Under what circumstances might a rising characteristic be required? What is a machine giving such a characteristic called?

7. What would be the effect on the characteristic of a flat-compound machine if it were operated
(a) with no-load voltage normal and speed 90% normal?
(b) with no-load voltage 90% normal and speed normal?
(c) with both no-load voltage and speed 90% normal?
(d) with no-load voltage normal and speed 110% normal?
(e) with no-load voltage 110% normal and speed normal?
(f) with both no-load voltage and speed 110% normal?

8. Compare the effects of long and short-shunt connections on the external & total characteristics of a given machine.

References:

S. & T.	pp. 3-6, 45-50.
Langsdorf	Art. 56, 118-119.
Smith	pp. 99-106.
F. & E.	pp. 47, 48, 407.
Pender	pp. 57, 153, 171, 176.
Dawes	pp. 295-301.
Karapetoff	pp. 313-319.
R. & T.	pp. 88-93.

#7-DC

DATA SHEET

Station__________

External Characteristic			
Line Amp. #	Field Amp. #	Term. Volts #	Speed Const. #

Total Characteristics (Calculated)										
Line Amp. #	Series Fld. Res.	Se.Fld. RI Drop Volts	Sh.Fld. Amp. #	Total Arm. Amp.	Arm. Res. Ohms	Arm. RI Drop Volts	Brush Con.Drp. Volts	Total RI Dp. Volts	Term. Volts	Total Volts
A	B	C=AB	D	E=A+D	F	G=EF	H	I=G+H	K	L =I+K

Armature Resistance (Lap Winding)				
A	B	C=B/A	D	$E=4C/D^2$
Amp. #	Volts #	Res. Ohms	No. Poles	True Res. Ohms

Armature Resistance (Wave Winding)		
Amp. #	Volts #	Res. Ohms
		Av.

Series Field Resistance		
Amp. #	Volts #	Res. Ohms
	Av.	

(e)

Approved__________

Expt. #________ Title:____ Date____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date______________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#8-DC ARMATURE REACTION IN A COMPOUND GENERATOR

Procedure:

1. This test should be made on the same generator used in #6-DC*. Use a low-range ammeter in the field circuit, a high-range ammeter in the line, and a high-range voltmeter across the armature terminals.

2. Start the generator as per instructions in #1 & #2-DC, adjust the speed to the value used in #6-DC* and bring up the armature terminal voltage until it equals the no-load (shunt field) value of #6-DC*.

3. Apply a load and check the series field connections.

4. Keeping the speed and the field current constant throughout the test, take simultaneous readings of the armature terminal voltage, line current, field current, and speed zero output and for increasing values of load.

5. Determine the armature resistance by the voltage-drop method of #2-DC, calculate the total armature and brush-contact RI drops, and hence, the voltage drops due to armature reaction.

Data:

Tabulate all observations on a standard data sheet.

Curves:

On a standard curve sheet plot four curves, using line currents as abscissae in each case, and as ordinates:

(1) the observed armature terminal volts.
(2) the total volts developed (armature terminal volts plus armature and brush-contact RI drops).
(3) the saturation curve voltages obtained in #6-DC due to the series field.*
(4) the voltage drops due to armature reaction (the voltage differences between curves (3) and (2).

Follow instructions given in the general directions.

Questions:

Answers to questions 1-2 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. Define armature reaction. Explain the cross-magnetizing effect; the demagnetizing effect.

* In case the generator used in #6-DC is not available the part of #6-DC necessary to give the required data should be repeated.

#8-DC Questions contd.

2. Explain the function of the armature reaction curve. Describe briefly the method of obtaining it.

3. Explain the effect of armature reaction on commutation.

4. How can its effect be overcome on non-interpole machines?

5. How do interpoles affect the armature reaction?

References:

S. & T.	pp. 3-6, 40-41, 54-56.
Langsdorf	Art. 90-103, 162-163.
Gray	pp. 65, 67-69, 162-163.
Smith	pp. 54-63.
F. & E.	pp. 151-164.
Pender	pp. 77, 116-144.
Dawes	pp. 267-276.
Karapetoff	pp. 441-446

#8-DC

DATA SHEET

Station: ________

Armature Reaction								
Fld. Amp. #	Speed Const. #	Arm. Term. #Volts	Line Amp. #	Arm Res. Ohms	Arm RI Drop Volts	Brush Contact Volts	Total RI Drop Volts	Arm. Reaction Volts
			A	B	C=AB	D	E=C+D	

Armature Resistance (Lap Winding)				
A	B	C=B/A	D	$E=4C/D^2$
Amp. #	Volts #	Res. Ohms	No. Poles	True Res. Ohms
			Av.	

Armature Resistance (Wave Winding)		
Amp. #	Volts #	Res. Ohms
	Av.	

Approved ______________

Expt.#________ Title:____ Date__________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________
2. Are the brushes badly worn?_______Incorrectly set?__________
3. Is commutator rough or pitted?________
4. Does armature turn easily?________
5. Are all connections correct?________
6. Are couplings or belted connections properly made?________
7. Is machine clear of tools and foreign particles?________
8. Have your wiring inspected and OK'd by instructor________
9. Do oil rings turn and provide sufficient lubrication after machine is running?________
10. Are there any defects, and any unusual noises in the machine after it is running?________
11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#9-DC

SPEED REGULATION OF A SHUNT MOTOR

Procedure:

1. Use a low-range ammeter in the field circuit, a high-range ammeter in the armature circuit, and a high-range voltmeter across the armature terminals.

2. Start the motor by closing the line switch, gradually inserting the plates of the water rheostat, and after the motor is up to speed, short circuiting the water rheostat.

3. Adjust the position of the brushes to the neutral point, and take simultaneous readings of the field current, armature current, armature voltage, and speed, for zero output and for increasing outputs up to a value corresponding to the rated full-load current input of the motor.

4. At no-load, shift the brushes a short distance to and fro about the commutator, noting the variations in speed. Do not permit excessive sparking.

5. At no-load and with brushes in the neutral position, increase the resistance in the field rheostat and note the changes in speed for a series of values of field current. Do not permit the speed to become excessive.

6. At no-load, vary the e.m.f. at the armature terminals by means of a variable resistance in the armature circuit and note the speed for a series of values of armature voltage.

7. Determine the armature resistance by the voltage drop method of #2-DC, calculate the total armature and brush-contact RI drops, and, hence, the counter e.m.fs. of the motor.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot four curves on a standard sheet, between:

(1)	speeds	as	ordinates	and	armature currents	as	abscissae.
(2)	"	"	"	"	" volts	"	"
(3)	"	"	"	"	field currents	"	"
(4)	e.m.fs.	as	"	"	armature currents	"	"

Follow instructions given in the general directions.

#9-DC Procedure contd.

Questions:

Answers to questions 1-4 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. What is the function of a starting box? The over-load release? The no-voltage release?

2. What factor aids the starting resistance as soon as the armature begins turning?

3. State two methods for reversing the direction of rotation of a shunt motor.

4. Why should the field rheostat be cut out before starting a motor? Will a shunt motor start without a field current? What happens if the field circuit is opened when the motor is running light? When loaded? Why? Is it good practice to place a switch in a motor field circuit? Why?

5. Define the speed regulation of a motor.

6. Discuss the effect of line resistance upon the speed regulation.

7. How will heating affect the speed of a shunt motor? State two effects. Which is greater? Are they additive or subtractive? Explain fully.

8. What other method of speed control is used besides those you studied?

9. Give two reasons why the speed of a motor changes when the brushes are shifted.

10. What effect has armature reaction on the speed of a motor?

11. What is the counter e.m.f. of a motor? Explain its production and show how it automatically adjusts the current to the power demand.

12. Why will a motor spark badly with a weak field and heavy armature current? What remedies have been devised?

#9-DC Procedure contd.

References:

S. & T.	pp. 3-6, 59-70.
Langsdorf	Art. 127, 129, 132-134.
Gray	pp. 80-83, 87, 91, 105-121, 371.
Smith	pp. 112-133.
F. & E.	Art. 56-59.
Franklin	pp. 19-22, 32-35.
S. & F.	pp. 106-111, 208-219.
Morecroft	pp. 32-39, 45-52.
A.I.E.E.	Definitions
Std. Hdbk.	Definitions in Standardization Rules Section.
Pender	pp. 202, 222, 293.
Dawes	pp. 339-343.
Karapetoff	pp. 347-359, 699-715.
R. & T.	p. 107.

#9-DC

DATA SHEET

Station________

Effect of Loading										
Fld. Amp. #	Arm Amp. #	Total Line Amp.	Line Volts #	Watts Input	Arm. Res. Ohms	Arm RI Drop Volts	Brush Con. Dp. Volts	Total RI Drop Volts	Counter E.M.F. Volts	Speed #
A	B	C=A+B	D	E=CD	F	G=BF	H	I=G+H	K	

Armature Resistance (Lap Winding)				
A	B	C=B/A	D	$E=4C/D^2$
Amp. #	Volts #	Res. Ohms	No. Poles	True Res. Ohms
			Av.	

Armature Resistance (Wave Winding)		
Amp. #	Volts #	Res. Ohms
	Av	

Effect of Brush Shifting*		
Speeds #		
With Rotation.	Neutral	Against Rotation

Effect of Changing Field Flux**	
Fld. Amp #	Speed #

Effect of Changing Impressed Armature Voltage	
Arm. Volts #	Speed #

* Do not permit excessive sparking
** " " " " speed.

(f)

Approved________

Expt.#_______ Title:____ Date__________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#10-DC EFFICIENCY OF A SHUNT MOTOR BY THE STRAY POWER METHOD

Procedure:

1. Use a low-range ammeter in the field circuit, a high-range ammeter in the armature circuit, and a high-range voltmeter.

2. Start the motor as in #9-DC and take simultaneous readings of the speed, line voltage, field current and armature current for zero output and for increasing outputs up to a value corresponding to the rated full-load current input.

3. Run the motor without load at the speed and field current values corresponding to those obtained under (2), and take simultaneous readings of speed, armature current, field current, line voltage and armature terminal voltage. Speed adjustment is obtained by means of the water rheostat in the armature circuit. Field current is adjusted with the field rheostat.

4. Determine the armature resistance by the voltage drop method of #2-DC, and hence, calculate the armature copper losses.

Data:

Tabulate all observations on a standard data sheet.

Curves:

On a standard curve sheet plot nine (9) curves using watts output as abscissae and as ordinates:

(1) watts lost in the motor field.
(2) watts lost in the field plus watts lost in stray power.
(3) watts field loss plus watts stray power plus armature watts loss.
(4) watts input (total losses plus output)
(5) speed.
(6) percent efficiency.
(7) percent efficiency plus percent of input lost in stray power.
(8) percent efficiency plus percent stray power plus percent input lost in the armature.
(9) percent efficiency plus percent stray power plus percent armature loss plus percent field loss.

Indicate the various losses in each case.
Follow instructions given in the general directions.

#10-DC Procedure contd.

Questions:

Answers to questions 1-3 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. Give three expressions for the commercial efficiency of a dynamo in terms of watts input, watts output and watts lost.

2. Give a tabular classification of all sources of loss in a dynamo. Indicate whether they are constant or how dependent upon speed or load, in the case of a shunt motor.

3. What losses are included under stray power? Are these constant for all loads and speeds? Why?

4. Why is the method used in this test particularly useful for very large shunt machines?

5. In the case of a machine having 80% efficiency, what error in determining the losses would give ½% error in the efficiency? What with 90% efficiency?

6. At what temperature should efficiency be calculated?

References:

S. & T.	pp. 3-6, 74-80.
Langsdorf	Art. 170-180.
Gray	Art. 105-112.
Smith	Chap. X & XI
F. & E.	pp. 127-132, 138-143.
S. & F.	pp. 258-263.
A.I.E.E.	420-455.
Std. Hdbk.	Sec. 24, 420-455.
Morecroft	pp. 53-59.
Karapetoff	pp. 391-419.
Pender	pp. 2, 261-282.
Dawes	pp. 348-359.
E. & T.	pp. 141-148.

#10-DC

DATA SHEET

Station________

Motor Running Under Load								
A	B	C	D	E	F	G	H	I
R.P.M. #	Line Volts #	Fld. Amp. #	Arm. Amp. #	Total Amp.	Arm. Res. Ohms	Brush Con. Drp. Volts	Watts Lost Arm.	Watts Lost Field
				C + D			FD^2+GD	BC

J	K	L	M	N	O	P	Q	R
Stray Power Loss	Total Losses Watts	Watts Input	Watts Output	% Eff.	% Input Lost In Arm.	% Input Lost In Fld.	%Lost In Stray Power	Total % Input =100
	H+I+J	BE	L-K	100M/L	100H/L	100 I/L	100 J/L	N+O+P+Q

Motor Running Light											
A	C	S	T	U	F	G	V	W	X	Y	J
R.P.M. #	Fld. Amp. #	Arm. Amp. #	Line Volts #	Arm. Volts #	Arm. Res. Ohms	Brush Drop Volts	Watts Lost Arm.	Watts Lost Fld.	Total Copper Losses	Total Watts Input	Stray Power Loss
							FS^2+GS	CT	V+W	CT+SU	Y-X

Armature Resistance (Lap Winding)				
A	B	C=B/A	D	$E=4C/D^2$
Amp. #	Volts #	Res. Ohms	No. Poles	True Res. Ohms
			Av.	

Armature Resistance (Wave Winding)		
Amp. #	Volts #	Res. Ohms
	Av.	

Approved__________

Expt. #________ Title: ____ Date ____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date_____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#11-DC SPEED REGULATION OF A COMPOUND MOTOR

Procedure:

1. Use a low-range ammeter in the field circuit, a high-range ammeter in the armature circuit, and a high-range voltmeter.

2. Start the motor with the series field disconnected and ammeters short-circuited. After it is up to speed close the series field switch first, then open the switch in the shunt around the series field.

3. Keeping the applied voltage constant, take simultaneous readings of field current, armature current, line voltage, and speed, for zero output and for increasing outputs up to a value corresponding to the rated full-load current input. If the speed of the motor remains constant or increases with load increase, the motor is connected differentially, otherwise it is connected cumulatively.

4. Repeat (3) after reversing the series field connections.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot curves on the same standard sheet between watts input as abscissae and speeds as ordinates for both the differential and the cumulative connections. Follow instructions given in the general directions.

Questions:

Answers to questions 1-3 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. State and explain the difference in the starting characteristics of a differential compound and a cumulative compound motor. What can be done to improve the starting characteristic of the former?

2. Power is applied to the pulley of a cumulative compound motor until it is driven above normal no-load speed. Does it operate as a cumulative generator? Why?

3. State some of the applications of cumulative and differential motors.

#11-DC Questions contd.

4. Why does the differential motor spark on overload and the cumulative motor as a rule not spark?

5. Explain any difficulties encountered in the operation of the differential motor. Also state and explain the remedy.

6. Can a constant speed for all loads be maintained by differential compounding? Why?

7. Calculate the percent speed regulation from your data.

8. How could the number of series turns necessary to give zero speed regulation be obtained experimentally?

References:

S. & T.	pp. 3-6, 81-82.
Langsdorf	Art. 131-133.
Gray	Art. 104.
Smith	pp. 154-160.
F. & E.	Art. 60.
S. & F.	pp. 238-239.
Karapetoff	pp. 374-377.
Pender	pp. 59, 199, 212-214, 202, 222, 293.
Dawes	p. 328.

#11-DC

DATA SHEET

Station:________

Differential Motor Speed Regulation					
Fld. Amp. #	Arm. Amp. #	Total Line	Line Volts #	Watts Input	Speed #
A	B	C=A+B	D	E=CD	

Cumulative Motor Speed Regulation					
Fld Amp. #	Arm. Amp. #	Total Line Amp.	Line Volts #	Watts Input	Speed #
A	B	C=A+B	D	E=CD	

Approved:____________

Expt.#_______ Title:____________________________________ Date__________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #_________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date______________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#12-DC OPERATION OF SHUNT GENERATORS IN PARALLEL

Procedure:

1. Use low-range ammeters in the field circuits, high-range ammeters in the lines, and a high-range voltmeter.

2. Bring each generator up to its proper speed, all line and field switches being open, and ammeters short-circuited.

3. Close the field switches and adjust the field rheostats of the generator until the voltage of each is equal to its normal rated value.

4. With the voltmeter, check the polarities of switches S_1 and S_2. If these are correct, proceed with (5), otherwise correct the polarity by making the proper changes in connections.

5. Close switches S_1 and L and apply normal load to generator #1.

6. Check polarities of the bus bars and generator #2, and adjust the voltage of generator #2 until it is equal to that of the bus bars.

7. Close switch S_2+ and note the voltage across the open switch S_2-. If the voltmeter reads zero, or very nearly so, switch S_2- may be closed and the two machines are paralleled.

8. Adjust the field rheostats of both generators, inserting resistance in #1 field circuit, and taking it out of #2 circuit, keeping the bus-bar voltage constant, and at the same time shifting part of the load from generator #1 to generator #2, until they divide the load in proportion to their rated outputs. This will be indicated by the respective ammeters.

9. Shift all the load from generator #1 to generator #2 by field rheostat adjustment as in (8), then open switches S_1. Repeat the operation of paralleling several times.

10. Parallel the generators, then decrease the field strength of generator #1 until it is seen to be operating as a motor taking power from generator #2. This will be the case when its ammeter indicates in a negative sense.

11. Adjust the field rheostats until generator #1 takes all the load and generator #2 runs as a motor.

12. With no-load on either generator, connect them in parallel, and keeping the speeds of each constant, increase the current in uniform steps, until full load for the two machines is obtained. Keep the e.m.f. of the system constant, and current equally divided between the two machines. Record the data.

(c)

#12-DC Procedure contd.

Data:

Tabulate all observations on a standard data sheet.

Questions:

Answers to questions 1-6 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. Why are generators operated in parallel?

2. With a loaded shunt generator and an unloaded one, give full directions for putting the latter in parallel with the former, and causing them to share the load as desired, without changing the voltage of the load.

3. Give directions for removing a loaded generator from parallel operation with others.

4. What will occur if the field current of a machine running in parallel is reduced beyond the point where it takes zero load. Explain.

5. What will occur if the positive terminal of one generator is connected to the negative terminal of the other?

6. What will occur if a field circuit is opened while the machine is in parallel with others?

7. What must be true of the characteristics of two shunt generators in order that they will automatically share all loads equally when paralleled?

8. What must be true of the characteristic of generators of unequal capacities in order that they will automatically share all loads proportionally?

#12-DC Questions contd.

9. If a pair of shunt generators do not properly share the load, what must be done to one of the generators, and to which one?

References:

S. & T.	pp. 3-6, 94-98.
Langsdorf	Art. 122.
Gray	Art. 191-197.
Smith	pp. 109-110.
F. & E.	Art. 86, 87.
S. & F.	p. 304.
Franklin	pp. 123-125.
Pender	p. 185.
Dawes	p. 272.
Karapetoff	p. 325.
R. & T.	p. 94.

#12-DC

DATA SHEET

Station________

Generator #1					
A	B	C	D	E	F
E.M.F. #	Ext. Amp. #	Fld. Amp. #	Arm. Amp. B+C	Speed #	K.W. Output AB

Generator #2					Totals	
Ext. Amp. #	Fld. Amp. #	Arm. Amp. G+H	Speed #	K.W. Output AG	Load Amp. B+G	K.W. Output F+K
G	H	I	J	K	L	M

Approved________

Expt.#_______ Title:__________________________________ Date__________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #_________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt._______ Title____ Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______ Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#13-DC OPERATION OF COMPOUND GENERATORS IN PARALLEL

Procedure:

1. Use low-range ammeters in the field circuits, high-range ammeters in the equalizer and lines, and high-range voltmeter.

2. Bring each generator up to its proper speed, all line and field switches being open, and ammeters short-circuited.

3. Close the field switches and adjust the field rheostats of the generators until the voltage of each is equal to the normal rated value.

4. With the voltmeter, check the polarities of switches S_1 and S_2. If these are correct, proceed with (5), otherwise correct the polarity by making the proper change in connections.

5. Adjust the voltage of generator #1 to normal value, apply full load, after closing switches S_1+ , S_1- , and L, and note the full load voltage. If this is less than no-load voltage your series field is reversed. Remove the load, open the switches and correct the series field connections if necessary.

6. Repeat (5) on generator #2. If the change in voltage from no-load to full-load (voltage regulation) is the same for each machine, proceed with (8), otherwise with (7).

7. Across the series field of the generator showing the greater change in voltage between no-load and full-load, connect a shunt lead which will divert enough current from the series field to make the voltage regulation of this generator equal to that of the other. The total resistance of the series fields and their shunts should also be such that they are respectively inversely proportional to the full-load current outputs of the respective generators. This adjustment is called compounding and is necessary to insure successful paralleling.

8. Close switches S_1+ , S_1- , and L, and apply normal load to generator #1.

9. Close the equalizer switches $S_1\pm$ and $S_2\pm$, and also S_2+ , and adjust the voltage of generator #2 until it is equal to that of the bus bars.

10. Note the voltage across S_2-. If the voltmeter reads zero or very nearly so, switch S_2- may be closed and the two machines are paralleled.

#13-DC Procedure contd.

11. Adjust the field rheostats of both generators, inserting resistance in #1 field circuit, and taking it out of #2 circuit, keeping the bus-bar voltage constant, and at the same time shifting part of the load from generator #1 to generator #2, until they divide the load in proportion to their rated outputs. This will be indicated by the respective ammeters.

12. Shift all the load from generator #1 to generator #2 by field rheostat adjustment as in (11), then open switch S_1-, and after this switches $S_1\pm$ and $S_2\pm$. Repeat the operation of paralleling several times.

13. With no-load on either generator, connect them in parallel, and keeping the speeds of each constant, increase the current in uniform steps until full-load for the two machines is obtained. Keep the e.m.f. of the system constant, and current equally divided between the two machines. Record the data.

Data:

Tabulate all observations on a standard data sheet.

Questions:

Answers to questions 1-5 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. Explain the action of two compound generators in parallel without an equalizer. How does the equalizer operate to make satisfactory parallel running possible? Discuss fully.

2. Explain how differences in the over-compounding of two machines affects the division of load between them.

3. Why should the equalizer circuit be as short as possible? Why of large cross-section? What is the effect of resistance in the equalizer circuit?

4. Show how the series coil resistance must be related to the capacity of the machines, in order to give proper division of load, and just what happens if this relation does not hold. In such a case how may proper automatic division of load be obtained? Why can a shunt around the series field be used for this adjustment and what would be the function of such a shunt?

#13-DC Questions Contd.

5. Describe and explain the operation of throwing an unloaded generator in parallel with a loaded one, and dividing the load. Also of relieving the machine of the load and disconnecting it.

6. Compound generators sometimes have their series fields connected continuously to the equalizer and one of the other bus-bars. What is the effect on the action of a generator in operation when the series field of a dead machine is so connected?

7. Why should no circuit breaker or fuse be put in the equalizer circuit?

8. Why should no single-pole circuit breaker be put between the series coil and the bus bars?

9. If a flat-compound generator and a shunt generator are paralleled at no load how will they share a load? Explain using curves.

References:

S. & T.	pp. 3-6, 98-103.
Langsdorf	Art. 122.
Gray	Art. 191-197.
Smith	pp. 110.
F. & E.	Art. 86-87.
Franklin	pp. 125-128.
Morecroft	pp. 79-84.
Pender	pp. 57, 152, 171, 176, 185.
Dawes	pp. 295-299, 374.
Karapetoff	pp. 317-329.
R. & T.	pp. 88, 98.

#13-DC

DATA SHEET

Station:________

Generator #1						
A	B	C	D	E	F	G
E.M.F. #	Ext. Amp. #	Fld. Amp. #	Arm. Amp. B+C	R.P.M. #	K.W. Output AB	Equalizer Amp. #

Generator #2					Totals	
H	I	J	K	L	M	N
Ext. Amp. #	Fld. Amp. #	Arm. Amp. H+I	R.P.M. #	K.W. Output AH	Load Amp. B-H	K.W. Output F-L

(f)

Approved____________

ALTERNATING CURRENT LABORATORY EXPERIMENTS

1-AC Alternator Field Compounding.
2-AC External Characteristic of an Alternator with Non-inductive Load.
3-AC External Characteristic of an Alternator at Constant Power Factor.
4-AC Alternator, Open-circuit Saturation, Short-circuit Saturation, and Synchronous Impedance Tests.
5-AC Alternator, Zero-Power-Factor Saturation Test.
6-AC Alternator Short-Circuit and Open-Circuit Core Loss Tests.
7-AC Parallel Operation of Alternators.
8-AC Synchronous Motor V-Curves.
9-AC Synchronous Motor Current and Power-Factor Curves.
10-AC Efficiency of Rotary Converter.
11-AC Rotary Converter, Relation between Field Current & D.C.Volts.
12-AC Three-wire Generator with Unbalanced Loads.
13-AC Transformer, Ratio and Polarity.
14-AC Transformer Resistance, and Core Loss Tests.
15-AC Transformer Copper Losses, Impedance and Regulation.
16-AC Watt-hour Meter Calibration.
17-AC Boost and Lower Test on Induction Regulator.
18-AC Curve Tracing with the Oscillograph.
19-AC Transformer Connections
- (a) Three-phase Connections with Two Transformers.
- (b) Three to Two-phase Transformation.
- (c) Two to Six-phase Transformation.

20-AC Transformer Connections - Y delta and delta-Y.
21-AC Effect of Unbalancing in Polyphase Transformer Banks.
22-AC High Tension Transformer Tests.
23-AC Induction Motor Tests
- (a) Running Light Saturation.
- (b) Locked Saturation.
- (c) Circle Diagram & Characteristic Curves.
- (d) Efficiency Determination by Prony Brake.

24-AC Thermionic Vacuum Tube Characteristics.

REFERENCES

A.I.E.E.	Standardization Rules of the American Institute of Electrical Engineers.
Collins	"Commercial Electrical Testing."
Dawes	"Electrical Engineering" Vol. II. Alternating Currents.
Edgecumbe	"Industrial Electrical Measuring Instruments".
Elec. Jour.	"Electric Journal".
Fact. Test.	"Factory Testing"
Foster	"Pocket Book"
Franklin	"Dynamo Laboratory Manual" Vol. I, Franklin & Esty.
F. & E.	"Elements of Electrical Engineering", Vol. I, II, Franklin & Esty.
Gray	"Principles & Practice of Electrical Engineering"
G.E. Rev.	"General Electric Review"
Hay	"Alternating Currents"
Jour. Elect.	"Journal of Electricity, Power & Gas"
Karapetoff	"Experimental Electric Engineering" Vol. I (3rd edition) Vol. II (2nd edition)
Langsdorf	"Principles of Direct Current Machines"
Lawrence	"Principles of Alternating Current Machinery".
Magnusson	"Alternating Currents"
Mtr. Hdbk.	"Meterman's Handbook"
R. & T.	"Electrical Engineering Laboratory Experiments" Ricker & Tucker.
S. & F.	"Testing of Electro-Magnetic Machinery" Swenson & Frankenfield.
S. & T.	"Laboratory & Factory Tests in Electrical Engineering" Sever & Townsend.
Smith	"Practical Alternating Currents"
Std. Hdbk.	"Standard Handbook for Electrical Engineers"
Steinmetz	"Theoretical Elements of Electrical Engineering"
Thomalen	"Textbook of Electrical Engineering" 2nd Edition, 1910.
Thompson	"Dynamo-Electric Machinery"
Westinghouse	"Instruction Books"
Weston	"Instruction Books"

Expt.#________ Title:____ Date____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#1-AC DETERMINATION OF EXCITATION REQUIRED TO MAINTAIN CONSTANT VOLTAGE ON AN ALTERNATOR (FIELD COMPOUNDING)

Procedure:

1. Use a low-range DC ammeter, a high-range AC ammeter and a high-range AC voltmeter.

2. Run the AC generator three-phase at constant frequency or speed, and constant terminal voltage and take readings of field and armature currents, terminal voltage and speeds for a series of water-rheostat loads ranging from zero to about 25% overload. Take six readings.

3. Repeat (2) using a single-phase load.

4. Repeat (2) using an induction-motor load.

Data:

Tabulate all observations on standard data sheet.

Curves:

Plot on the same standard sheet the field compounding curves from the data obtained. Use load currents as abscissae and field currents as ordinates. Follow instructions given in the general directions.

Questions:

Answers to questions 1-4 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. What is the nature of the loads in (2) and (4) of procedure?

2. May compounding be resorted to in the case of a generator? Why is it not generally used?

3. What method is usually used to keep the voltage of an alternator constant for varying loads?

4. What factors contribute to the fall of potential of an alternator on non-inductive load? On inductive load?

5. Compare the field compounding curves for lagging and non-inductive loads.

#1-AC Questions contd.

6. If the E.M.F. of the exciting current is 125 volts, what must be the current and resistance rating of the field rheostat in order to maintain constant voltage for the readings you obtained?

7. What change would have to be made in the field rheostat in order to maintain constant voltage with a load of leading power-factor?

8. An alternator has the following characteristics: Field current required to produce 110 volts at no-load, 2 amp. Field current required to produce 110 volts at full non-inductive load, 3 amp., field current to produce 110 volts at full load, 0.60 power factor, 4.5 amp. Field resistance 50 ohms. Can constant voltage be maintained if the field is excited from 125 volt mains? What must be the voltage of the exciting circuit?

References:

S. & T.	pp. 123-125.
Magnusson	pp. 211-220, 226-230.
Gray	Art. 259-263, 266, 268-271, 276.
F. & E.	Art. 1-9, 48-56.
Smith	pp. 182-184.
Dawes	pp. 99-171.
Karapetoff	pp.532, Vol.I; pp. 129-150, Vol.II.

#1-AC DATA SHEET

Field Compounding											
Fld. Amp. #	Armature Amp. #				Armature Volts Const. #				Speed Const. #	Remarks
	1	2	3	Av	1-2	1-3	2-3	Av		
										3-Ønon-inductive
										S-Ønon-inductive
										3-Ø inductive

Approved____________

Expt.#________Title:____Date___________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

Expt.________Title____Date______________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#2-AC

EXTERNAL CHARACTERISTIC OF AN ALTERNATOR WITH NON-INDUCTIVE LOAD

Procedure:

Data taken in this test is used in #3-AC and should be preserved.

1. Use a low-range DC ammeter, a high-range AC ammeter and a high-range AC voltmeter.

2. Run the alternator single-phase at a frequency of 60 cycles and rated no-load voltage. Keeping the field current constant, note the terminal voltage for a series of water-rheostat loads ranging from zero to 25% overload. Take six readings.

3. Repeat (2) running the alternator at 50 cycles and rated no-load voltage.

4. Repeat (2) using the same normal excitation but at a constant frequency 50% below normal, or as low as possible.

5. Repeat (2) running the alternator at rated frequency but with excitation 50% below normal.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot on the same standard sheet the external characteristic curves from the data obtained, using load currents as abscissae and voltage as ordinates. Follow instructions given in the general directions.

Questions:

Answers to questions 1-4 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. What is the relation between frequency and speed of an alternator?

2. What factors contribute to the drop in voltage of an alternator at non-inductive load?

3. How does the current in an armature conductor of a DC generator vary with respect to time?

#2-AC Questions contd.

4. How does the current in an armature conductor of an alternator vary with respect to time?

5. What is meant by reactance of an alternator and upon what does it depend?

6. Why cannot the total characteristic be easily determined from the external in case of alternators?

7. Why is the drop of voltage in an alternator greater than in a separately excited direct current generator?

8. Why are alternators usually separately excited?

References:

S. & T.	pp. 131-132.
Magnusson	pp. 216-226.
Gray	Art. 272-274.
F. & E.	Art. 62-64.
Smith	pp. 171-182.
Dawes	pp. 99-117.
Karapetoff	p. 332, Vol.I; pp. 129-150, Vol.II.

#2-AC

DATA SHEET

External Characteristic				
Field Amp. Const. #	Arm. Amp. #	Arm. Volts #	Freq. Const. #	Remarks
				60 Cycles
				50 Cycles
				50% rated freq. normal fld.
				50% normal fld. rated freq.

Approved____________

Expt. #________ Title: ____ Date ____________

<u>Diagram of Connections:</u> Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

<u>Apparatus:</u> Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

<u>Instruments:</u> Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#3-AC EXTERNAL CHARACTERISTIC OF AN ALTERNATOR AT CONSTANT POWER FACTOR

Procedure:

This experiment should be performed on the alternator used in #2-AC. *

1. Use two low-range DC ammeters, a high-range AC ammeter, a high-range AC voltmeter, a power-factor indicator and a frequency meter.

2. Connect the direct-current machines of each of two sets to operate as motors and the alternating current machines, one to operate as an alternator and the other as a synchronous motor.

3. With all the switches in the field circuits of the alternators and those on the dynamometer-board open, bring each set up to speed.

4. Close the field switch of the alternator and bring its voltage, as measured across one phase, up to normal frequency and to the no-load value used in (3) of Exp't #2-AC. * Check and record the voltages across all phases. Note and record the field current. This value should be maintained constant throughout the test.

5. Close the field switch of the synchronous motor, bring its speed up to such a value that the synchronizing lamps become bright and dark slowly, and adjust the field rheostat until the voltage as measured across each phase is equal to that across each phase of the alternator.

6. If all three synchronizing lamps become dark and bright simultaneously, then the phase-rotation is correct and you may proceed with (7). If the lamps become dark and bright successively, or in rotation, then the phase-rotation is incorrect and two of the leads from one of the machines to the dynamometer board must be interchanged.

7. The lamps as connected give the proper phase-relation when they are dark and if they become dark very slowly, then the frequencies of the two machines about to be connected together or synchronized are very nearly equal, and the three single-phase switches on the dynamometer board may be closed at the instant the lamps become dark. After synchronizing the two machines, the DC driving motor of the synchronous motor set may be disconnected.

8. Check the power-factor meter for leading or lagging currents as follows: Vary the synchronous motor field and observe the effect on the reading of the AC ammeter. If the current is leading, increasing

* In case the alternator used in #2-AC is not available that part of #2-AC necessary to give the desired data should be repeated. See curve instructions on next page.

#8-AC Procedure contd.

the field strength of the synchronous motor will increase the current, but if the current is lagging, it will decrease it. At unity power-factor the current will be a minimum. The ammeter may be inserted into any one of the three lines by means of the dynamometer board. To do this, close only one of the three two-pole switches on the board and then open the single-pole switch immediately above it. To remove the ammeter reverse the operation, i.e. close the single-pole switch and then open the double-pole switch. Never close more than one of the double-pole switches at any one time.

9. Load the alternator through the synchronous motor, making the latter drive its DC machine as a generator, and with the power-factor kept constant at 0.7 leading and alternator field current kept constant at the value obtained in (4), take readings of the alternator field current and voltage, the synchronous motor field current, the AC line current, power-factor and frequency for a series of five values from zero to full-load value of the DC motor driving the alternator. Keep the frequency, alternator field current and power-factor constant.

10. Repeat (9) for constant power-factors of 0.9 leading, and 0.9 and 0.7 lagging, keeping the alternator field current constant at the value used in (9). Vary the power-factor with the motor field.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot, on the same standard sheet, the external characteristic curves for the various power-factors used in the test, line currents as abscissae and voltages as ordinates. Plot also on the same sheet, the curve for unity power-factor from the data obtained in (3) of #2-AC.* Follow instructions given in the general directions.

Questions:

Answers to questions 1-5 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. Define voltage regulation of an alternator. Upon what factors will the regulation depend?

* See note on preceding page.

#3-AC Questions, Contd.

2. What is meant by the external characteristic of an alternator?

3. What is meant by synchronizing?

4. In synchronizing alternators, what conditions must the E.M.F. of the machines fulfill?

5. What three things do synchronizing lamps indicate and what are the conditions under which the lamps give correct indications?

6. What is the effect of a lagging load on the external characteristic and why?

7. What is the effect of a leading load on the external characteristic and why?

8. Explain the effect of a lagging and leading load on the kilowatt capacity of an alternator.

9. Is it possible to have a negative regulation? Under what conditions?

10. Is it possible to operate an alternator without any field excitation? With a negative excitation? If so, under what conditions?

References:

S. & T.	pp. 131-137.
Magnusson	pp. 216-220, 237-241, 245-246, 256.
Gray	Art. 274, 279, 284-299.
F. & E.	Art. 62, 63, 68, 70-77.
Smith	pp. 171-182.
Dawes	pp. 99-171.
Karapetoff	p. 532, Vol.I; pp. 129-150, Vol.II.
R. & T.	pp. 227-239.

#3-AC

DATA SHEET

Station:________

D.C.Motor		Alternator											Syn.	
Volts #	Amp. #	Fld. Amp. Const.	Volts #				Amperes #				Freq. Const. #	Pow. Fac. Const.	Mot. Fld. Amp. #	Remarks
			1-2	1-3	2-3	Av.	1	2	3	Av.				
														0.7Lead'g
														0.9Lead'g
														0.9Lagg'g
														0.7Lagg'g

Approved:____________

Expt. #_______ Title: ____________________________________ Date __________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station # _________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#4-AC OPEN-CIRCUIT SATURATION CURVE, SHORT-CIRCUIT SATURATION CURVE AND SYNCHRONOUS IMPEDANCE CURVE

Procedure:

Data taken in this test is used in #5-AC and should be preserved.

1. Use a low-range DC ammeter, and a high-range AC ammeter and voltmeter, also a high-resistance field rheostat.

2. With all switches in the alternator field and stator circuits open, bring the machine up to speed.

3. Record the voltage due to residual magnetism, then with all the field resistance turned in, close the field switch and take simultaneous readings of field current, frequency and voltage for a series of ascending values of field current up to the maximum. Keep the frequency constant and take about eight readings. Always bring the field current up to the desired value to prevent inaccurate results due to hysteresis.

4. Reduce the field current in about eight steps, taking readings as in (3) and always bring the field current down to the desired value. The last voltage reading should be that due to residual magnetism.

5. With all the field resistance turned in, short circuit the stator of the alternator through the dynamometer board, take readings of the field current, and each line current, then open the three single-pole switches on the dynamometer board and read the voltage across each phase corresponding to the values of short-circuit current obtained. One set of readings should be taken with the field switch open.

6. Repeat (5) for a series of short-circuit currents up to 125% full-load current value of the alternator. Take six readings including one set with field switch open.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot on one standard sheet the open-circuit and short-circuit saturation curves using as ordinates, for the former, terminal volts, for the latter, short-circuit currents, and as abscissae, the field currents. Follow instructions given in the general directions.

Plot on a second standard sheet the synchronous impedance curve, using short-circuit currents as abscissae, and as ordinates, the terminal volts obtained when the stator circuit is opened.

#4-AC

Questions:

Answers to questions 1-5 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. What is meant by the open-circuit saturation curve?

2. How may a slight speed variation be corrected for if it occurs in making the test for this curve and why?

3. What is meant by the short-circuit saturation curve?

4. Why is the current in the short-circuit test practically independent of the speed?

5. What is meant by synchronous impedance and how is it obtained?

6. Explain the form of the open-circuit saturation curve you obtained.

7. Explain the form of the short-circuit saturation curve you obtained.

8. Why will the current in a short-circuit saturation curve run much lower than on a direct current curve of the same sort?

9. What determines the power factor in this case?

10. Calculate the synchronous impedance for the rated value of current.

11. Armature reaction is sometimes spoken of as a counter magnetomotive force. Why?

12. The E.M.F. of self-induction is often referred to as a counter E.M.F. Why?

References:

S. & T.	pp. 125-126, 130-131.
Magnusson	pp. 216-236.
Gray	Art. 272, 275.
F. & E.	Art. 62-64.
Smith	pp. 161-171, 185-193.
Dawes	pp. 142-155.
Karapetoff	pp. 537-541, Vol.I; pp. 129-150, Vol.II.
R. & T.	pp. 227-245.

#4-AC

DATA SHEET

Open Circuit Saturation.						
Fld. Amp. #	Arm. Volts #				Freq. Const. #	Remarks
	1-2	1-3	2-3	Av.		
						Ascending
						Descending

Short Circuit Saturation & Synchronous Impedance									
Fld. Amp. #	Short Circuit Amp. #				Syn. Imped. Volts #				Freq. Const. #
	1	2	3	Av	1-2	1-3	2-3	Av.	

Approved____________

Expt #_______ Title:____ Date__________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #_________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt. ________ Title ____ Date ____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings? ________

2. Are the brushes badly worn? ______ Incorrectly set? ________

3. Is commutator rough or pitted? ________

4. Does armature turn easily? ________

5. Are all connections correct? ________

6. Are couplings or belted connections properly made? ________

7. Is machine clear of tools and foreign particles? ________

8. Have your wiring inspected and OK'd by instructor ________

9. Do oil rings turn and provide sufficient lubrication after machine is running? ________

10. Are there any defects, and any unusual noises in the machine after it is running? ________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#5-AC ZERO POWER-FACTOR SATURATION CURVE

Procedure:

This test should be made on the alternator used in #4-AC. In case this machine is not available that part of #4-AC required for this test should be repeated. See curve instructions below.

1. The prime mover M_s used in synchronizing the a.c. motor (see Expt. #3-AC) should be a DC motor which can be started with a water rheostat in its armature circuit. After synchronizing, the load due to the stray power and other losses of the synchronous motor should be transferred from the alternator to the DC motor M_s as follows:

2. Adjust the alternator for unity power-factor (see Expt. #3-AC), check the connected wattmeters for proper indication (see Expt. #8-AC) and by proper adjustment of the water rheostat in the armature circuit of M_s, the wattmeter readings can be reduced to zero indicating that the alternator is operating at no-load. Note the current and voltage supplied to M_s and keep their product constant throughout the test.

3. Starting with the alternator field as low as consistently possible, underexcite the synchronous motor field until the line current is equal to the rated full-load current value of the alternator, the power-factor at the same time being as near zero as possible. Take readings of all meters. Keep the line current and frequency constant and the power-factor as near zero as possible throughout the test.

4. Raise the excitation of the alternator in steps and correspondingly decrease the excitation of the synchronous motor keeping the line current and frequency constant and the power-factor as near zero as possible, and take readings as in (3) for a series of field current values up to the maximum possible alternator excitation.

Data:

Tabulate all observations on a standard data sheet.

Curves:

1. Plot on a standard sheet the zero power-factor saturation curve, using alternator field currents as abscissae and corresponding voltages as ordinates. Follow instructions given in the general directions.

2. On the same sheet plot the ascending values of the open-circuit saturation curve obtained in #4-AC.

#5-AC

Questions:

Answers to questions 1-3 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. What is the object of taking a zero-power factor curve?

2. Describe briefly three methods for making tests and computations of the regulation of alternators.

3. Which is the most preferable and why is it not generally used?

4. Explain why the full load zero power-factor saturation curve is more easily taken, and more reliable, than that for unity power-factor.

5. Show how at zero-power-factor the three sources of voltage drop and the terminal volts are related vectorially.

6. Show how the optimistic zero power-factor saturation curve may be deduced from the no-load curve and the short-circuit characteristic.

7. Show how the pessimistic curve may be obtained from the same curves.

8. Show how to derive the zero power-factor saturation curve from the no-load curves by the Potier method, when the zero and one other point on it are known.

9. What component of voltage drop is neglected in the pessimistic method? In the optimistic method?

10. With what sort of a saturation curve would the pessimistic and optimistic methods give the same results?

11. Is it possible to obtain a power-factor of zero?

12. Why is a power-factor of 20% as good as a power-factor of zero for all practical purposes?

References:

Std.Hdbk.	Sect. 24, Art. 585-586, 4th ed.; 4390, 4394, 5th ed.
A.I.E.E.	Art. 585-586.
Thomalen	pp. 96-101.
Karapetoff	pp. 563-569, Vol.I, pp. 120-150, Vol.II.
Hay	Art. 80, 81, 84-87.
S. & F.	Vol.II, pp.125-131, Nos. 53-55, 59.
Thompson	Vol.II, pp.253, 292.
Lawrence	Chapter V.
Dawes	pp. 128-159.
R. & T.	pp. 227-242.

#5-AC

DATA SHEET

Station:_______

Alternator												Motor
Fld. Amp. #	Armature Volts #				Armature Amp. #				Freq. Const. #	Power Factor #		Fld. Amp. #
	1-2	1-3	2-3	Av.	1	2	3	Av.				

Approved:___________

Expt.#________ Title:____________________________________ Date____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt. ________ Title ________________________________ Date __________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?________

2. Are the brushes badly worn?______ Incorrectly set?________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#6-AC SHORT-CIRCUIT AND OPEN-CIRCUIT CORE LOSS OF AN ALTERNATOR

Procedure:

1. Use two low-range DC ammeters, a high-range DC ammeter and voltmeter, a high-range AC ammeter and voltmeter, and a high resistance field rheostat.

2. Couple the small (special) D.C. motor and the alternator together and bring the alternator up to normal speed. Short-circuit the stator of the alternator by connecting together the line (not alternator) sides of the S.P.S.T. switches on the dynamometer board and closing these switches. With the alternator field switch open read all instruments. With a high resistance in the alternator field circuit, close its field switch and read instruments.

3. Keeping the alternator speed and the motor excitations constant, raise the excitation of the alternator and take readings as in (2) for about five values of short-circuit current up to the maximum normal rated full-load current of the machine.

4. Open the short-circuit on the alternator and take a set of readings on all instruments for a series of about ten values of field current from zero to the maximum. Keep the alternator speed and the motor excitation constant at the values used in the short-circuit test.

5. Keeping the alternator speed and the motor excitation constant at the values used in (3) and (4), obtain the friction loss of the alternator by driving it with field and line switches open.

6. Run the motor disconnected from the alternator, with the same excitation and speeds as it had in (3), (4) and (5), and take readings as before.

7. Measure the resistance of the motor armature.

8. Determine the equivalent resistance of the alternator stator as follows: Measure the RI drop between each pair of terminals, using the same equipment and method as in (7), add the three values thus obtained and divide the sum by 2. The quotient is the resistance desired.

9. Calculate the motor stray-power loss, the alternator friction loss, and the short-circuit and open-circuit core losses.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot on the same standard curve sheet, the short-circuit core losses and load losses as ordinates against short-circuit currents as abscissae. Plot also the open-circuit core losses as ordinates against corresponding

(c)

#6-AC Curves contd.

alternator field currents as abscissae. Follow instructions given in the general directions.

Questions:

Answers to questions 1-8 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. What is meant by the core loss of an alternator?

2 What are the hysteresis losses? Eddy current losses?

3. What is the object of the short-circuit core loss test?

4. What is meant by the load loss? How is it determined? Is the value thus obtained correct? What assumption is made? Why?

5. What causes the load losses?

6. What losses remain constant during the test? What losses vary?

7. What conditions govern the motor speed and excitation? Why?

8. Why should a small alternator excitation be used when the stator is short-circuited?

9. Express in the form of equations the following: Motor stray power, alternator friction loss, the short-circuit core-loss and the open-circuit core-loss. Explain each equation.

10. Explain the method of obtaining the equivalent resistance in instruction (8), stating why it applies equally well to both Y- and delta-connected stators.

11. Knowing that the stator is either Y- or delta-connected, and impossible to separate into its phases, explain how the resistance per phase can be determined, from the RI drop measured across any pair of stator terminals.

References:

S. & T.	pp. 126-129.
Smith	pp. 194-200, 228-235, 284, 285.
Magnusson	pp. 115-122, 231-232.
Gray	Art. 105-110, 227.
Karapetoff	pp. 541-542 Vol.I pp. 120-150 Vol.II.
R. & T.	pp. 246-249.
Lawrence	p. 123.

#6-AC

DATA SHEET #1

Observations D.C. Motor					
Read. No.	Fld. Amp. Const. #	Arm. Volts # A	Arm. Amp # B	Speed Const. #	Remarks
1					Motor Stray Power Loss
2					Alternator Friction Loss
3					Short-circuit Core Loss
4					" " " "
5					" " " "
6					" " " "
7					" " " "
8					" " " "
9					Open-circuit Core Loss
10					" " " "
11					" " " "
12					" " " "
13					" " " "
14					" " " "
15					" " " "
16					" " " "
17					" " " "
18					" " " "

Motor Armature Resistance Lap Winding				
A	B	C=B/A	D	$E=4C/D^2$
Amp. #	Volts #	Res. Ohms	No. Poles	True Res. Ohms
			Av.	

Approved: ____________

#6-AC

DATA SHEET #2

Observations Alternator										
Rdg. No.	Fld. Amp. #	Line Amp. #				Terminal Volts #				Speed Const. #
		1	2	3	Av.C	1-2	1-3	2-3	Av.D	
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										

Stator Resistance										
Volts #			Line Amp #			Resistance per phase ohms				Equivalent Resistance
1-2	1-3	2-3	1	2	3	1-2	1-3	2-3	Sum	M=Sum/2
									Av.	

Approved:____________

#6-AC

DATA SHEET #3

Reading No.	D.C. Motor Calculations					
	Arm. Input Watts	Arm. Res. Ohms	Arm. Copper Loss Watts	Brush Contact Loss Watts	Total Copper Loss Watts	Stray Power Loss (Const.) Watts
	E=AB	F	$G=FA^2$	H=2B	I=G+H	K=E-I
1						*
2						" " "
3						" " "
4						" " "
5						" " "
6						" " "
7						" " "
8						" " "
9						" " "
10						" " "
11						" " "
12						" " "
13						" " "
14						" " "
15						" " "
16						" " "
17						" " "
18						" " "

*Calculate K for reading #1 and use this value for all other readings

Approved: ____________

#6-AC

DATA SHEET #4

Station:_______

Read. No.	Alternator Calculations					
	Friction Loss Watts. Const.	Equiv. Stator Res. Ohms	Stator Copper Loss Watts	Short Circ. Core Loss Watts	Load Loss Watts Assumed	Open Circuit Core Loss Watts.
	L=E-K-I	M	$N=MC^2$	O=E-K-L-I-N	P=O/3	S=E-K-L-I
1	*					
2	" " "					
3	" " "					
4	" " "					
5	" " "					
6	" " "					
7	" " "					
8	" " "					
9	" " "					
10	" " "					
11	" " "					
12	" " "					
13	" " "					
14	" " "					
15	" " "					
16	" " "					
17	" " "					
18	" " "					

* Calculate L for reading #2 and use this value for all other readings

Approved:__________

Expt. #_______ Title:____ Date__________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

Expt. ________ Title ____ Date ______________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings? __________

2. Are the brushes badly worn? ________ Incorrectly set? __________

3. Is commutator rough or pitted? ________

4. Does armature turn easily? ________

5. Are all connections correct? ________

6. Are couplings or belted connections properly made? ________

7. Is machine clear of tools and foreign particles? ________

8. Have your wiring inspected and OK'd by instructor ________

9. Do oil rings turn and provide sufficient lubrication after machine is running? ________

10. Are there any defects, and any unusual noises in the machine after it is running? ________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#7-AC PARALLEL OPERATION OF ALTERNATORS.

Procedure:

1. Use two low-range DC ammeters, a high-range AC ammeter, a high-range AC voltmeter and a frequency indicator.

2. Bring one of the alternators A_1 up to its rated speed and voltage and apply a load to it. Bring the other alternator A_2 up to its rated speed and voltage and synchronize it with A_1 (see Expt. #3-AC). In order to divide the load equally between the machines it is necessary to increase the torque of A_2 by lowering the excitation of its d.c. driving motor. To keep the frequency and bus-bar voltage constant at the same time the torque of A_1 should be reduced correspondingly by raising the excitation of its prime mover. Equal loads will be indicated by equal ammeter readings.

Cross-currents between the two machines can be practically reduced to zero by adjusting the alternator field excitations until the sum of the machine ammeter readings is a minimum, raising the excitation of one alternator while lowering that of the other, thus keeping the bus-bar voltage constant.

3. Keeping the bus-bar voltage and load current constant throughout take readings of all meters under the following conditions:

(a) A_1 operating alone at rated voltage and full-load.

(b) A_1 as before and A_2 at no-load in parallel with the line.

(c) A_1 and A_2 supplying equal power to the load and the sum of the machine ammeter readings equal to the load current or nearly so (cross-current practically zero).

(d) A_1 and A_2 sharing the load unequally. Adjust the alternator excitation so that the sum of the machine ammeter readings is a minimum (cross-current a minimum).

(e) A_1 and A_2 sharing the load equally but with unequal excitations (fairly large cross-current).

4. Try synchronizing with a 300-volt voltmeter across the line switch in place of the lamp.

Data:

Tabulate all observations on a standard data sheet.

Questions:

Answers to questions 1-7 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. State four conditions that must be fulfilled before two alternators can be connected in parallel.

2. Draw a diagram showing how one synchronizing lamp is used to synchronize two single phase alternators.

#7-AC Questions contd.

3. When should the switch be closed in this case? What must be the voltage rating of the lamp?

4. If two lamps are used, show two ways in which they can be connected and tell when the line switch should be closed in each case.

5. Discuss the relative merits of using lamps with crossed and direct connections.

6. Show the way in which synchronizing lamps may be connected three-phase to synchronize dark; to synchronize light.

7. If the phase rotation of the incoming machine is wrong, how may it be changed?

8. How may synchronizing lamps on a three-phase machine or system be connected to show whether the incoming machine is too slow or fast? Explain the action in this case.

9. In a permanent three-phase installation how many synchronizing lamps would ordinarily be used, and why?

10. Explain briefly the operation of synchroscopes or synchronism indicators and their advantages over lamps.

11. Explain the action of the circulating current upon both alternators.

12. If the field excitation of one alternator is reduced, what is the effect of the circulating current on that machine? Upon the other machine?

13. If the torque of the prime-mover of one set is reduced, what is the effect of the reduction upon the alternator of that set?

14. If both alternators are driven by DC shunt motors, explain the effect of raising the excitation of M_1, M_2, of A_1, A_2.

15. Compare the method of shifting loads on parallel-operated DC generators with that used on alternators.

References:

S. & T.	pp. 142-147.
Magnusson	pp. 233-256.
Gray	Art. 279-288.
F. & E.	Art. 68-77.
Smith	pp. 200-206.
Dawes	pp. 125, 163.
Karapetoff	pp. 570-581 Vol.I; pp. 120-150 Vol.II.
R. & T.	pp. 250.

#7-AC

DATA SHEET

Station:________

Alternator #1		Alternator #2		Line			
Stator Amp. I' #	Fld. Amp. #	Stator Amp. I" #	Fld. Amp. #	Volts Const. #	Amp. I_L Const. #	Freq. Const. #	Remarks
							#1 alone Full Ld.
							#1 Fl. Ld. #2 No Ld.
							#1 Hlf. Ld. #2 " " $I' + I'' = I_L$
							#1 - #2 Unequal Ld. $I' + I''$ min.
							#1 ½ Load #2 ½ Load Unequal Excitat.

Approved:____________

Expt. #________ Title:____ Date____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#8-AC SYNCHRONOUS MOTOR "V" CURVES

Procedure:

1. Use a low-range DC ammeter, a high-range DC ammeter and voltmeter, a high-range AC ammeter and voltmeter, a frequency indicator, a power-factor indicator, two wattmeters, and special test table.

2. Bring the motor up to speed and synchronize with the 100-volt AC mains. Check the power factor indicator as in Expt. #3-AC.

In order that wattmeters indicate correctly it is necessary to connect them in a definite phase relation. It is also necessary to know when using two watt-meters in a three-phase circuit whether their readings should be added or subtracted. For example, at unity power-factor the two wattmeters should each indicate the same if the load is balanced; at 50% power-factor one of the watt-meters should read zero, while below 50% it should indicate negatively and its reading (obtained after reversing either the series or potential coil connections) should be subtracted from that of the other meter to obtain the correct total power.

If connection diagrams are available they should be followed carefully. A check on the proper connection of two wattmeters on a three-phase balanced circuit whose power factor can be controlled may be made as follows:

If the wattmeters have reversing switches (potential coil) set these for direct reading. Bring the power factor to unity as in Expt. #3-AC, the line current at this value being a minimum. Both wattmeters should now read alike (taking account of their multiplying constants). If one of them is negative, do not touch the reversing switch, but reverse either the series or the potential coil connections taking proper precautions to protect yourself and the meter. Both wattmeters will then be connected so that their readings are positive and should be added. If one of the wattmeters indicates negative at any time during the test use the reversing switch and subtract the reading from the other wattmeter reading to get the correct result.

3. Operate the machine at no-load, keep the impressed E.M.F. and the frequency constant, and take ammeter and wattmeter readings for successive values of field current ranging from minimum possible to maximum possible values. If motor falls out of step, pull line switches on dynamometer board immediately.

4. Repeat (3) running the motor at full load.

Data:

Tabulate all observations on a standard data sheet.

Curves:

1. Plot on one standard sheet curves showing the relation between power factors, line currents and watts at no-load as ordinates, and field currents as abscissas. Follow instructions given in the general directions.

2. On a second standard sheet plot curves for full-load, similar to those in (1).

#8-AC

Questions:

Answers to questions 1-4 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. Why must the motor always revolve in synchronism with the frequency of the line?

2. What is meant by a synchronous motor "V" curve?

3. Why does a DC generator, giving current, form a particularly convenient load for this test?

4. Explain several methods of starting synchronous motors.

5. Discuss the shape of the "V" curves for different loads.

6. Why are the two sides of the curve not symetrical?

References:

S. & T.	pp. 139-141.
Magnusson	pp. 245-260.
Gray	Art. 279-288.
F. & E.	Art. 68-77.
Smith	pp. 207-216, 219-227.
Dawes	pp. 305-332.
Karapetoff	p. 580 Vol.I; pp. 120-150 Vol.II.
R. & T.	pp. 258-265.

#8-AC

DATA SHEET #1

Station:________

D.C. Generator			Synchronous Motor								
Read. No.	Line Amp. Const.	Volts Const. #	Terminal Volts E Constant. #				Line Amp. I #				Volt Amps.
			1-2	1-3	2-3	Av.	1	2	3	Av.	$P=EI\sqrt{3}$
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

Approved____________

#8-AC

DATA SHEET #2

Station:__________

Read. No.	Synchronous Motor: Watts Input W: #1	K	#2	K	Total	Power Factor #: W/P	Read.	Fld. Amp. #	Freq. Const. #	Remarks
										No Load
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										Full Load
12										
13										
14										
15										
16										
17										
18										
19										
20										

K = multiplying factor

Approved:__________

Expt. #________ Title: ____ Date____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#9-AC SYNCHRONOUS MOTOR CURRENT AND POWER-FACTOR CURVES WITH CONSTANT EXCITATION

Procedure:

1. Use a low-range DC ammeter, a high-range DC ammeter and voltmeter, a high-range AC ammeter and voltmeter, two wattmeters, a power-factor indicator and a frequency indicator.

2. Synchronize the motor, check the power factor indicator and the wattmeter connections as in Expt. #3-AC and #8-AC.

3. Adjust the power factor to 0.6 lagging and keep the impressed e.m.f., the frequency and the motor field constant. Take eight sets of readings of all the meters for motor loads ranging from zero to approximately 125% full load.

4. Repeat (3) after adjusting the power factor to 0.6 leading.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot on the same standard sheet curves showing the relation between currents, watts and power-factors as ordinates, and DC watts output as abscissae. Follow instructions given in the general directions.

Questions:

Answer the following in the final report.

1. Explain with the revolving vector or circle diagram how, by changing its phase relation, the synchronous motor takes increased current, when its load is increased.

2. What other phenomenon combines with this to take the place of the drop in speed of other types of motors, as a means of increasing the current as the load increases?

3. Show by the vector diagram the effect of increasing load upon the phase relation of line current and voltage.

4. Discuss the bearing of this upon the loading of motors used to supply leading current for the purpose of improving the line power-factor.

5. By the circle diagram, explain the sudden stopping of the motor when too much overloaded, and the effect of excitation upon the load it will carry.

References:

S. & T.	pp. 132-135, 141-142.
Magnusson	pp. 260-266.
Gray	Art. 279-287, 319-321.
F. & E.	Art. 68-88.
Smith	pp. 216-227.
S. & F.	Vol. II, No. 67.
Dawes	pp 305-332.
Karapetoff	p. 580 Vol.I; pp. 120-150 Vol.II.
R. & T.	pp. 258-265.

#9-AC

DATA SHEET #1

Station:________

Read No.	DC Generator				Synchronous Motor								
	Line Amp. #	Volts #	Watts Output	Fld. Amp. Const.	Terminal Volts E # Const.				Line Amps # I				Volt. Amp.
					1-2	1-3	2-3	Av.	1	2	3	Av.	$P=EI\sqrt{3}$
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													

Approved:____________

DATA SHEET #2

Station:_______

Synchronous Motor									
Read. No.	Watts Input W					Power Factor #		Freq. Const. #	Remarks
	#		#						
	1	K	2	K	Total	W/P	Read		
1									Mot. Fld. Underexcited.
2									
3									
4									
5									
6									
7									
8									
9									Mot. Fld. Superexcited.
10									
11									
12									
13									
14									
15									
16									

K = Multiplying factor

Approved__________

Expt.#________Title:____Date____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

Expt.________ Title____ Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______ Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#10-AC EFFICIENCY AND EXTERNAL CHARACTERISTIC OF A ROTARY CONVERTER

Procedure:

1. Use a low-range DC ammeter, a high-range DC ammeter and voltmeter, a high-range AC ammeter and voltmeter, a power-factor indicator, frequency meter and wattmeters.

2. Start and synchronize the rotary converter to a three-phase source as follows:

Refer to the given wiring diagram.
Open all switches and the water rheostat circuit.
Close switches A and B and bring the converter up to speed, using the water rheostat.
Close switch C after converter is running.
Synchronize the converter with the AC source provided.
Close switch D and open B.
Open switch C and the water rheostat circuit.
Open switch A and close switch E.
The converter is now ready to load by means of the water rheostat.
Check the power-factor indicator and wattmeter connections as in Expt. #3-AC and #8-AC

3. Adjust the field current until the current input is a minimum at no-load, and keeping this field current, the frequency and impressed voltage constant, take readings of all meters for a series of eight values of DC amperes from zero to normal rated full-load current.

4. Repeat (3) running the converter single-phase.

5. Repeat (3) running the converter from a six-phase source.

Data:

Tabulate all observations on a standard data sheet.

Curves:

1. Plot on the same standard sheet the efficiency curves for six-phase, three-phase and single-phase operation, using efficiencies in % as ordinates and watts output as abscissae. Follow instructions given in the general directions.

2. Plot on another standard sheet the external characteristic for six-phase, three-phase and single-phase operation, using DC voltages as ordinates, and DC currents as abscissae.

#10-AC

Questions:

Answers to the following questions should be approved before starting the test:

1. Discuss the various methods of starting a rotary converter.

2. Discuss the possibility of loading back on the d.c. starting source in making this test. State the merits of such a method and also some of its disadvantages.

3. Name all the possible uses for a synchronous converter, and state which one finds most frequent application, also where it is used in such a case.

References:

S. & T.	pp. 185-189.
Magnusson	pp. 268-290.
Gray	Art. 345-354.
F. & F.	Art. 75, 84-96.
Smith	pp. 243-270.
Dawes	pp. 342-376.
R. & T.	p. 269.
Karapetoff	pp. 120-163 Vol. II.

#10-AC **DATA SHEET #1**

Station ______

Read. No.	Term.Volts E Const. #				Line Amps. I #				A.C End Volt Amp.	Watts Input W #		#			Power Factor #		Freq. Const. #
	1-2	1-3	2-3	Av.	1	2	3	Av.	$P=EI\sqrt{3}$	1	K	2	K	Tot.	W/P	Read	
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20																	

K = Multiplying Factor

Approved: ______________________

#10-AC

DATA SHEET #2

Station:________

D.C. End						
Read No.	Field Amp. Const. #	Volts #	Line Amps. #	Watts Output	Eff. %	Remarks
1						Three-phase
2						
3						
4						
5						
6						
7						
8						Single-phase
9						
10						
11						
12						
13						
14						Six-phase
15						
16						
17						
18						
19						
20						

Approved:____________

Expt. #________Title:____________________________________Date__________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#11-AC RELATION BETWEEN D.C. VOLTS AND FIELD CURRENT OF A ROTARY CONVERTER

Procedure:

1. Use the same range instruments and start and synchronize the converter as in Expt. #10-AC.

2. Load the converter up to normal rated full-load direct current output, and keeping the impressed AC terminal volts, the frequency and the direct current line amperes constant, vary the field strength of the converter for different values and take corresponding readings of all the meters.

3. Run the converter at no-load. Insert the regulating field into the circuit and with its rheostat contact arm set at a point midway between the limiting stops, adjust the shunt field rheostat for the value corresponding to minimum AC line current.

4. Keeping the field current constant at the value obtained in (3), as well as the AC terminal voltage, and frequency, take readings of all meters for a series of values of regulating field current varying from that giving maximum to that giving minimum DC voltage. Do not permit the commutator to spark excessively.

Data:

Tabulate all observations on standard data sheet.

Curves:

Plot on a standard sheet two curves using DC voltages as ordinates and shunt field currents and regulating field currents as abscissae. Follow instructions given in the general directions.

Questions:

Answer the following questions in the final report:

1. Draw a diagram, showing the ratios between the AC voltage for single, three, four and six phase converter connections, and, hence construct a table showing the voltages referred to the DC voltage as unity. Give also the corresponding virtual alternating current ratios in the lines and in the armature conductors.

#11-AC

Questions contd:

2. Explain how the voltage ratios are affected by loading and by the power-factor.

3. Discuss the effect of excitation upon the voltage ratios, (a) with no inductance between the converter and the AC supply, (b) with inductance.

4. Explain why the power capacity of the converter increases with the number of phases used. List the capacities of single, two, three, six, and twelve-phase converters in terms of the same machine operated as a d.c. generator.

References:

S. & T.	pp. 189-190.
Magnusson	pp. 268-290.
Gray	Art. 345-354.
F. & E.	Art. 75, 84-96.
Smith	pp. 243-270.
Dawes	pp. 342-376.
R. & T.	p. 269.
Karapetoff	pp. 120-163 Vol.II.

#11-AC

DATA SHEET #1

Station ________

A.C. End.																	
Read. No.	Term. Volts E Const. #				Line Amps I #				Volt. Amp.	Watts Input W. #		#			Power Factor #		Freq. Const. #
	1-2	1-3	2-3	Av.	1	2	3	Av.	$P=EI\sqrt{3}$	1	K	2	K	Tot.	W/P	Read	
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20																	

K = Multiplying Factor.

Approved: ________________

(c)

#11-AC

DATA SHEET #2

Station:________

D.C. End						
Read. No.	Sht. Fld. Amp. #	Reg. Fld. Amp. #	Volts #	Line Amps. Const. #	Watts Output Const. Full Load	Remarks
1						Varying Sht.Field
2						
3						
4						
5						
6						
7						Varying Reg Field
8						Sht. Field Const.
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Approved:______________

Expt. #_______ Title: ______________________________________ Date ___________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station # __________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#12-AC THREE WIRE GENERATOR WITH UNBALANCED LOAD

Procedure:

1. Connect the rotary converter as a three-wire generator with three-phase AC supply and two balance coils connected to the two-phase terminals. Refer to connection diagram.

2. Adjust the two receiving circuits of the three-wire system so that each takes full-load current, and adjust the field rheostat of the generator to give its normal voltage (sum of the voltages across the circuits), at the same time adjusting the AC voltage so that the AC line current is a minimum (unity power factor).

3. Reduce the current taken in circuit A step by step until it is zero, keeping the total voltage of the generator constant, and AC line current at a minimum, and take simultaneous readings of the current in each line and the voltage across each circuit of the system.

4. Repeat (3) reducing the current in circuit B, step by step, to zero, the current in circuit A being zero.

Data:

Tabulate all observations and other data neatly on a standard data sheet.

Curves:

Plot on a standard sheet two curves from the data obtained in (3), using volts across circuits A and B as ordinates, and currents on the A side as abscissae. Follow instructions given in the general directions.

Plot similar curves from the data obtained in (4) using the current on the B side as abscissae.

Questions:

Answers to questions 1-7 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. Explain the theory of the Dobrowolsky three-wire generator.

2. What are the advantages of a three-wire system as compared with those of a two-wire system?

3. What is the object of the neutral wire?

4. Need it be as large in cross-section as the outside wires? What is the usual practice?

5. What would be the effect of a large unbalanced load on the system if the neutral wire should be disconnected?

#12-AC

Questions Contd.

6. Is it advisable to fuse the neutral wire? Why?

7. State the relative amounts of copper required on the two-wire and three-wire systems.

8. Describe the Edison three-wire system.

9. Describe the split-pole three-wire generator.

10. Describe the Dettmar three-wire generator.

11. Describe the motor-generator balancer and its use.

12. Describe the method of balancing a three-wire system by the use of rheostats.

References:

Elec.Jour	Vol. 10, pp. 600-602.
Franklin	pp. 85-88.
Langsdorf	Chap. XI
Magnusson	Chap. XV-XVI
F. & E.	Vol.I, Chap. IX; Vol.II, Chap. IX.
Dawes	pp. 375-376.
Karapetoff	pp. 331-335, 506-508, Vol.I; pp. 130-163, Vol.II.
R. & T.	p. 160.

#12-AC

DATA SHEET

Station:________

Three-Wire Generator						
Read. No.	Amp. A #	Amp. B #	Amp. (middle main) #	Volts A #	Volts B #	Volts Total Const. #

Approved___________

Expt.#________ Title:____ Date___________

<u>Diagram of Connections:</u> Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

<u>Apparatus:</u> Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

<u>Instruments:</u> Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#13-AC TRANSFORMER RATIO AND POLARITY

Procedure:

DC Polarity Method:

1. For the DC method, use the storage battery and a high-range DC voltmeter.

2. Refer to the given diagram of connections. Close the switch S and connect the voltmeter to the terminals A and B on the high or primary side of the transformer, so as to deflect in the proper direction.

3. Note which transformer terminal is connected to the positive lead of the voltmeter. Designate this terminal as positive.

4. Transfer the voltmeter leads to the terminals on the low or secondary side of the transformer, connecting the A lead to C and the B lead to D.

5. Open switch S and note the direction of kick of the voltmeter needle at the instant the primary circuit is broken. A positive kick of the needle indicates that the secondary terminal connected to the positive lead of the voltmeter is negative, and the other terminal is positive, in other words, adjacent terminals A and C will have unlike relative polarities, as will also adjacent terminals B and D. A negative kick reverses the above designations. Note the polarities of the transformers.

AC Polarity Method:

1. For the AC method, use a special high-range (300V.) AC voltmeter.

2. Connect one primary terminal B to one secondary terminal D. Excite the primary winding from a 110 volt AC source, and measure the voltage across each winding, and also across the terminals A and C. If the latter voltage is greater than that across the primary winding, then the adjacent terminals A and C, and likewise B and D, have unlike relative polarities, otherwise, the adjacent terminals have like polarities. Designate the letter you assign to each terminal.

Ratio Test:

1. Use two high-range AC voltmeters.

2. Impress across the primary winding 25%, 50%, 75%, 100% and 125% normal rated voltage, at normal rated frequency, and note the values of primary impressed volts and secondary induced volts. Take at least two sets of readings.

#13-AC

Procedure Cont'd.

3. Repeat (2) having interchanged voltmeters.

Checking Taps:

1. Use a high-range and a low-range AC voltmeter.

2. Apply 110 volts AC at normal rated frequency to the primary winding, and take readings of the voltage across the winding, and also between successive taps. The sum of the tap voltages should check within one percent of the total voltage applied.

3. Repeat (2) on the secondary windings, applying the 110 volt source to this winding. The sum of the tap voltages should check within one percent of the total voltage applied.

Data:

Tabulate all observations on a standard data sheet. Draw diagrams representing the transformer windings and indicating the polarities as you obtained them, together with the various terminal and tap numbers.

Questions:

Answers to questions 1-2 inclusive should be approved before starting the test , the remainder to be answered in the final report.

1. Show what ratios can be obtained with a transformer, having two primary and two secondary coils, there being in all ten times as many primary as secondary turns.

2. If each primary coil is designed for 1000 volts and 10 amperes, on what primary voltages can the transformer be used, what secondary voltages can be obtained, and what will be the primary and secondary currents and powers transformed in each case? Neglect losses. Make a tabular statement.

3. If the length of turn and the current density are the same in both coils, what will be the relation of the resistance in a ten-to-one transformer?

4. What will be the relation of watts lost in the two coils?

5. What will be the ratio of the volts lost by the resistance in the two coils?

#13-AC

Questions, Cont'd.

6. Tell how to test the polarity of two transformers which are to be connected in parallel by the use of a test lamp or light fuse wire.

References:

Magnusson	pp. 131-134, 150-158.
Gray	Art. 302-308.
F. & E.	Art. 97-113.
Smith	pp. 101-156.
Collins	pp. 175-179.
Dawes	pp. 172-224.
Karapetoff	pp. 466-531, Vol.I; pp. 1-118, Vol.II.

#13-AC

DATA SHEET

Station:________

Polarity Test						
Term. No.	D.C. Pol'ty #	AC Method				
		Term Design	Pol'ty	Volts #		
				AB	CD	AC
1						
4						
5						
8						
9						
11						
12						
14						

Check on Taps			
Taps	Tap Volts #	Imprest Volts #	% of Winding
1-2			
2-3			
3-4			
5-6			
6-7			
7-8			
Sum.			
9-10			
10-11			
12-13			
13-14			
Sum.			

Ratio Test.						
Term. Nos.	Imprest & Induced Volts # #					Remarks
	25%	50%	75%	100%	125%	
1-8						Meter #
1-8						
1-8						Meter #
1-8						
Ave.						
9-14						Meter #
9-14						
9-14						Meter #
9-14						
Ave.						
Ratio						

Approved:____________

Expt # ______ Title: ____ Date __________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station # __________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date______________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#14-AC TRANSFORMER CORE LOSSES

Procedure:

This experiment and Expt. #15-AC should be performed on the same transformer.

1. Connect the low-voltage winding of the transformer in conjunction with properly protected meters and line switch to an alternator. Determine proper meter ratings from the transformer name-plate and test requirements, and observe every possible precaution so as not to exceed the current ratings of ammeters and especially wattmeters to prevent overheating or burning them out. When opening or closing the line switch always be sure all voltmeter and wattmeter potential circuits are open.

2. Keeping the impressed voltage constant at normal rated value, take readings of all meters for frequencies of 0, 40, 50, 60, and 70 cycles. In reading ammeters all voltmeter and wattmeter potential switches should be open, as the current taken by these affect the readings. Likewise in reading wattmeters, all voltmeter switches should be open.

3. Keeping the frequency constant at normal rated value, take readings of all meters for impressed voltages of 0, 50, 75, 100, 125 and 150 volts. Observe same precautions with potential switches as in (2).

4. Determine the resistance of the separate coils of each winding by the voltage drop method, using a low voltage d.c. source and suitable meters.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot on a standard sheet the curves of watts, amperes and power-factors as ordinates with impressed volts as abscissae. Follow instructions given in the general directions.

On a second sheet plot corresponding curves using frequencies as abscissae.

Questions:

Answers to questions 1-2 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. What will happen if a transformer coil is used on a voltage much higher than that for which it was designed, and why?

2. Why is it usually preferable to make connections to the low tension rather than the high tension side for this test?

3. Using your data compare the losses and hence the heating of a 2200-volt, 60 cycle, transformer operating at the following voltages and frequencies: 2000-volts, 50 cycles; 2200-volts, 60 cycles; 2200-volts, 50 cycles; 2300-volts, 50 cycles; 2300-volts, 60 cycles.

4. Discuss the practice of operating standard 60 cycle apparatus on the mains of the Municipal Light Plant.

5. Tabulate representative core losses, copper losses and efficiencies of modern distribution transformers of the following KVA ratings: 1, 5, 7.5, 10, 20, 30 and 50.

References:

S. & T.	pp. 148-149	F. & E.	Art. 97-122.
Magnusson	pp. 131-163.	Smith	pp. 101-156.
Gray	Art. 289-308	Collins	p. 180
Std. Hdbk.		Dawes	pp. 172-224.
R. & T.	pp 199-223	Karapetoff	pp. 466-531 Vol.I. pp. 1-118 Vol.II.

#14-AC

DATA SHEET

Station:________

Freq. #	Volts E #	Amp. I #	Watts W #			Volt Amp. EI	Power Factor W/EI	Copper Loss $R''I^2$	Core Loss $W-R''I^2$
			Read	K	Correct				

K = Multiplying Factor

R" is the calculated resistance of the low-voltage series or parallel combination used.

Transformer Resistance					
Primary (high side Coil #1			Secondary (low side) coil #1		
Volts #	Amps #	Res. R'_1	Volts #	Amp. #	Res. R''_1
	Av.			Av.	
Coil #2			Coil #2		
Volts #	Amp. #	Res. R'_2	Volts #	Amp. #	Res. R''_2
	Av.			Av.	

Approved:________________

Expt. #________ Title: ____ Date ____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt. ________ Title ____ Date ____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings? __________

2. Are the brushes badly worn? _______ Incorrectly set? __________

3. Is commutator rough or pitted? ________

4. Does armature turn easily? ________

5. Are all connections correct? ________

6. Are couplings or belted connections properly made? ________

7. Is machine clear of tools and foreign particles? ________

8. Have your wiring inspected and OK'd by instructor ________

9. Do oil rings turn and provide sufficient lubrication after machine is running? ________

10. Are there any defects, and any unusual noises in the machine after it is running? ________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#15-AC TRANSFORMER COPPER LOSSES, IMPEDANCE AND REGULATION

Procedure:

This experiment should be performed on the same transformer used for Expt. #14-AC. If this transformer is not available that part of #14-AC necessary for this test should be repeated.

1. Connect the high-voltage winding of the transformer in conjunction with properly protected meters and line switch to an alternator. Short-circuit the low-voltage winding through a suitable ammeter. Determine the proper meter ratings from the transformer name-plate and test requirements. The voltage of the alternator should be reduced to at least six volts before closing the line switch, otherwise, the current in the transformer and the meters may be excessive and burn them out. Observe every possible precaution so as not to exceed the current ratings of ammeters and especially wattmeters to prevent overheating or burning them out. All potential circuits should be open when opening or closing the line switch.

2. Adjust the speed of the generator to give the rated frequency of the transformer under test and take readings of all meters for a series of applied voltages from the smallest possible (at least six volts) to that giving the normal rated (calculated for the particular connection, if necessary) current in the transformer windings. Observe precautions regarding meter readings as given in (2) of Expt. #14-AC.

Data:

Tabulate all observations on a standard data sheet.

Curves:

Plot on a standard sheet curves using wattmeter readings and calculated copper losses as ordinates and amperes as abscissae. Designate the load losses. Follow instructions given in the general directions.

Questions:

Answers to questions 1-6 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. Define regulation as applied to a transformer.

2. Discuss the relations of the primary and secondary resistances, as based on the turn ratio.

3. What is meant by "load losses" in a transformer?

4. Explain equivalent resistance and reactance.

5. Explain effective resistance and reactance.

#15-AC

Questions cont'd.

6. Why is it usually preferable to make connections to the high-tension rather than the low-tension side for this test?

7. Calculate the efficiency at normal voltage, unity power-factor and loads of 0, 1/4, 1/2, 3/4, 1, and 1 1/4 times normal. Make a tabular statement and plot curve.

8. Calculate the average value of impedance and determine the regulation at full-load for unity and for 0.7 power-factor, using the method of the A.I.E.E. Standardization Rules.

References:

S. & T.	pp. 140-152
Magnusson	pp. 115-163.
Gray	Art. 289-308.
F. & E.	Art. 97-122.
Smith	pp. 101-156.
Collins	p. 180
Std.Hdbk	Stand.,Rules.
Dawes	pp. 172-224.
Karapetoff	pp. 466-531, Vol.I; pp. 1-118, Vol.II.
R. & T.	pp. 199-233.

#15-AC

DATA SHEET

Station:________

Freq. Const. #	Volts E' #	Amps I' #	Watts W #			Amp I"	$R'I'^2$	$R''I''^2$	Cop. Loss Tot.	Load Loss	Imp. Z
			Read	K	Correct						

K = Multiplying Factor

R' is the calculated resistance of the high-voltage series or parallel combination used.

R" is the calculated resistance of the low-voltage series or parallel combination used.

Approved:______________

Expt. #_______ Title:______________________________________ Date___________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #_________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

16-AC WATT-HOUR METER CALIBRATION

Procedure:

1. Test by the indicating instrument method, a watt-hour meter at loads ranging from zero to normal rated value of the meter. Include readings for "creep" also, if there is any. In making connections include a line switch and properly protect all meters.

Data:

Tabulate all observations and other data neatly on a standard data sheet.

Curve:

Plot a curve showing the relation between the correct energy as obtained by the indicating instruments as ordinates, and the values obtained from the meter as abscissae. Follow instructions given in the general directions.

Questions:

Answers to questions 1-7 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. Explain the difference between power and energy and their units.

2. What is meant by (a) the test constant; (b) the watt-hour constant; (c) the watt-second constant; (d) the register constant?

3. Give detailed directions for obtaining the constants of a meter at different loads. Show how to adjust the meter to the correct test constant.

4. What would be the result if friction were not compensated for? Explain how this compensation is accomplished and adjusted. What happens if there is over compensation?

5. Explain the construction and operation of the Sangamo meter.

6. Explain the action of the induction type of watt-hour meter.

7. Explain why meters of the commutator and Sangamo types can be used on alternating current circuits.

8. Explain the phase angle or power-factor compensation.

#16-AC Questions contd.

9. Show how polyphase meters are constructed.

10. Discuss the rotating standard, and the calibrated resistance methods of watthour meter testing.

References:

Electrical Meterman's Handbook.
Trade Circulars.
Jansky "Electrical Meters".
Shepard & Jones "The Watt-Hour Meter".
Dawes pp. 51-75
Karapetoff pp. 36-171, Vol. 1

#16-AC

DATA SHEET

Station:__________

Observed								Calculated		
Watthour Meter #			Volts	Amp.	Stand. Watts #			Volt Amp.	Meter Watts	% Accuracy
Disc. Rev. R	Seconds S #	Test. Const. K_s	#	#	Read	K	Correct		K_sR/S	

K = Multiplying Factor.

Approved:______________

Expt.#_______ Title:____________________________________ Date____________

<u>Diagram of Connections:</u> Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

<u>Apparatus:</u> Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

<u>Instruments:</u> Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt. ________ Title ____ Date ____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings? ________

2. Are the brushes badly worn? ______ Incorrectly set? ________

3. Is commutator rough or pitted? ________

4. Does armature turn easily? ________

5. Are all connections correct? ________

6. Are couplings or belted connections properly made? ________

7. Is machine clear of tools and foreign particles? ________

8. Have your wiring inspected and OK'd by instructor ________

9. Do oil rings turn and provide sufficient lubrication after machine is running? ________

10. Are there any defects, and any unusual noises in the machine after it is running? ________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#17-AC BOOST & LOWER TEST ON AN INDUCTION REGULATOR

Procedure:

1. Turn the hand-wheel of the regulator, after blocking the brake open, until one of the limit switches just opens. Connect the primary leads (A,B,C) through line switches to the 110V A.C. source and take readings of voltage between each of the primary lines (A,B,C) and each of the secondary lines (A',B',C') for a series of positions of the regulator gear sector ranging from the open position of one limit switch to that of the other. Do not allow the segment to travel beyond the point where it just opens the limit switch.

2. Connect the regulator, together with its primary relay and resistance, according to the wiring diagrams on the blue-print provided with the test. Operate the primary relay by hand to change the voltage. Then release the contact lever and observe the action of the relay in correcting the voltage. Record what you observe.

Test the limit switches by allowing the segment to move until it opens one of the limit switches and the motor stops. If the motor fails to stop when the limit switch opens, pull the line switches immediately to prevent over-travel and breaking of the switch.

3. Connect a water rheostat to the load side of the regulator across the same phase to which you have connected the relay, and observe the action of the relay and regulator as the load is thrown on or off. Record what you observe.

Data:

Tabulate all observations and other data neatly on a standard data sheet.

Curve:

Plot the regulator characteristic curve on a standard sheet, using secondary volts as ordinates and positions of the rotating segment as abscissae. Draw also the line representing the voltage which is held constant by the regulator in normal operation. Follow instructions given in the general directions.

Questions:

Answers to questions 1-2 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. Discuss the theory and operation of an induction regulator.
2. State and discuss some of the applications of induction regulators.
3. Explain the operation of the primary relay.

References:

Collins	pp. 224-225.
Westinghouse	5137-B
Regulator Wiring Diagrams.	
Dawes	pp. 275-278.

#17-AC

DATA SHEET

Station:________

Hand Wheel Turn No.	Volts #							
	Primary				Secondary			
	A-B	A-C	B-C	Av	A'-B'	A'-C'	B'-C'	Av.

Approved:________

Expt. #________ Title:______________________________________ Date____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

Expt. ________ Title ________________________________ Date ____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings? ________

2. Are the brushes badly worn? ______ Incorrectly set? ________

3. Is commutator rough or pitted? ________

4. Does armature turn easily? ________

5. Are all connections correct? ________

6. Are couplings or belted connections properly made? ________

7. Is machine clear of tools and foreign particles? ________

8. Have your wiring inspected and OK'd by instructor ________

9. Do oil rings turn and provide sufficient lubrication after machine is running? ________

10. Are there any defects, and any unusual noises in the machine after it is running? ________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#18-AC CURVE TRACING WITH THE OSCILLOGRAPH

Procedure:

1. Using the optical method, obtain voltage and current curves of a synchronous motor under the following conditions:

(a) Field excited for unity power factor.
(b) Field under-excited.
(c) Field over-excited.

Connect the motor windings Y and take voltage measurements from line to neutral using the line in which the current curve is taken. In each case measure the power input with wattmeters and calculate the power factor. Check the results with a power-factor meter and also with the curves.

2. Obtain curves of a transformer under the following conditions:

(a) With secondary on open circuit obtain the curves of primary voltage and current and secondary voltage.
(b) With secondary loaded non-inductively obtain curves of primary and secondary voltage and current.
(c) With secondary connected to the primary of a second transformer (secondary of second transformer on open circuit) obtain curves of primary and secondary voltage and current.
(d) With the secondary of the second transformer loaded non-inductively, obtain curves as in (c).

Data:

Tabulate all observations and other data neatly on a standard data sheet.

Questions:

Answers to questions 1-4 inclusive should be approved before starting the test, the remainder to be answered in the final report.

1. Why must the moving parts of an oscillograph be very light in weight?

2. Explain with a diagram, the moving coil or Duddell type of oscillograph.

3. Also the iron-strip or Blondel type.

4. Also the hot-wire or Irwin type.

5. Describe all the essential features of the General Electric oscillograph.

6. Describe all the essential features of the Westinghouse oscillograph.

#18-AC

Questions, cont'd.

7. Explain the results of procedure (1).

8. Explain the results of procedure (2).

References:

Edgecumbe	pp. 169-179.
Std.Hdbk.	Sect. 3, 261-270.
Foster	pp. 50-54.
Tr.Circ.	G.E. & others.
Magnusson	Chap. VIII
Dawes	pp. 72-75.
Karapetoff	pp. 210-228, Vol.II.

Expt.#________Title:____Date____________

<u>Diagram of Connections:</u> Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

<u>Apparatus:</u> Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

<u>Instruments:</u> Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________ Title____ Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______ Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#19-AC TRANSFORMER CONNECTIONS

Procedure:

(a) Three to Two-Phase Transformation

Using the Scott-connection connect two transformers through line switches to a three-phase source so as to obtain a two-phase source on the secondary side. Measure and record all voltages on both the three-phase and two-phase circuits.

(b) Two to Six-phase Transformations

Using the connections of (a) to supply the two-phase source, connect up two other transformers according to Fig. 311, p. 284, Magnusson, omitting the neutral. Connect the high and low sides in such a manner that the six-phase voltages can be measured. Measure and record the voltage across each of the six phases, and also, as a check, measure the diametrical and the delta voltages. Show and explain all the connections in the report.

Data:

Tabulate all data neatly on a standard data sheet. Draw connection and topographic vector diagrams for each case.

Questions:

Answers to questions 1-5 inclusive should be approved before starting the test.

1. Explain the theory of transforming three-phase power using only two transformers. What is the principal use of this combination?

2. Discuss the T-connections of two transformers sometimes used on three-phase circuits.

3. Discuss the Scott system for transforming from two to three-phase, and vice versa.

4. Discuss the methods of transforming from two to six-phase, from three to six-phase, and from three to twelve-phase.

5. Discuss the use of the zig-zag transformer connections for a three-wire rotary converter.

References:

S. & T.	pp. 167-171.
Smith	pp. 155-156.
G.E. Rev.	Vol. 19, pp. 256-258.
Magnusson	pp. 150-160.
Dawes	p. 211.
Karapetoff	pp. 466-531, Vol.I; pp. 68-118, Vol.II.
R. & T.	pp. 217-223.

Expt.#________Title:____Date___________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

Expt. ________ Title ____ Date ______________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings? __________

2. Are the brushes badly worn? _______ Incorrectly set? __________

3. Is commutator rough or pitted? ________

4. Does armature turn easily? ________

5. Are all connections correct? ________

6. Are couplings or belted connections properly made? ________

7. Is machine clear of tools and foreign particles? ________

8. Have your wiring inspected and OK'd by instructor ________

9. Do oil rings turn and provide sufficient lubrication after machine is running? ________

10. Are there any defects, and any unusual noises in the machine after it is running? ________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#20-AC TRANSFORMER CONNECTIONS. Y-DELTA & DELTA-Y

Procedure:

I. Y-Delta, Y-Delta

1. Connect the primaries of each of two banks of three transformers Y and their secondaries in delta.

2. Connect the Y-connected primaries of the two banks in parallel to a 110-volt, 3-phase supply.

3. Connect an apex of the delta-connected secondary of #1 bank with an apex of the delta-connected secondary of #2 bank.

4. Measure and record the primary and secondary voltage across each phase, across each transformer and also between the remaining non-connected apexes of the delta-connected secondaries of both banks.

5. If the voltage between an apex of one bank and that of another is zero those two points may be connected. It is then necessary however to again check the voltage between the two remaining apexes before these may be connected. Record this voltage. If it is now zero, the two apexes may be connected and the two banks may be paralleled, otherwise they may not.

II. Delta-delta, Y-Delta.

1. Connect both the primary and secondary of one bank in delta; the primary of the second bank Y and its secondary delta. Choose the proper number of turns and transformation ratios so that the sides to be paralleled have the same voltage values.

2. Follow instructions 3-5 of Part I.

III. Delta-Y, Y-Delta.

1. Connect the primary of the first bank delta, and its secondary Y; also, connect the primary of the second bank Y and its secondary delta. Choose the proper number of turns and transformation ratios so that the sides to be paralleled have the same voltage values.

2. Follow instructions 3-5 of Part I.

Data:

Tabulate all observations neatly on standard data sheet. Draw to scale on standard curve paper the vector and connection diagrams illustrating the existing conditions in both primary and secondary of each transformer bank for each of the three above connections. Use designations similar to those on pp. 447-457 of the Journal of Electricity, Power & Gas of Nov. 11, 1911. In the report show why the two banks can or cannot be paralleled and explain the diagrams.

#20--AC

Questions:

1. Diagram the four methods by which the primaries and the secondaries of three transformers can be combined for three-phase transformation, and explain the voltage ratio obtained from each, in terms of the turn ratio.

2. Discuss the relative advantages of the different connections.

3. Discuss the advantages and disadvantages of three-phase transformers as compared to three single-phase transformers used for the same purpose. Discuss the methods of winding and connecting core-type and shell-type three-phase transformers.

References:

Jour. Elec.	Nov. 11, 1911, pp. 447-457.
G.E. Rev.	Vol. XXIII #5, May 1920, p. 374-385, Also April 1916 and October 1908.
Elec. World	November 11, 1908.
Dawes	pp. 172-224.
Karapetoff	pp. 466-531, Vol.I; pp. 71-118 Vol.II.
R. & T.	pp. 217-223.

Expt.#________ Title:____ Date____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#21-AC EFFECT OF UNBALANCED LOADS ON TRANSFORMER BANKS

Connect three single-phase transformers star-delta as shown in the diagram which will be furnished.

Take readings of currents in lines X, Y, Z, X', Y', Z', in each phase winding of the delta, and in load rheostat circuits A, B, C; also voltages between N-X, N-Y, N-Z, N-XI, Y-XI, Z-XI, X-Y, X-Z, Y-Z, X'-Y', X'-Z', Y'-Z', for the following conditions:

1. Apply a balanced load to the transformers.
2. With balanced load as in (1) open line X and take readings.
3. Remove the load from the transformers, open line X and take readings.
4. With line X closed, load phase A only, and take readings.
5. With load conditions as in (4), open line X and take readings.
6. With line X closed, load phase C only, and take readings.
7. With load conditions as in (6) open line X and take readings.

Plot topographic voltage vector diagrams for each of the above connections, discuss the results, and turn in with the data.

References:

Karapetoff pp. 466-531 Vol.I; pp. 71-118 Vol.II.
R. & T. pp. 217-223.

Expt.#________Title:____Date____________

<u>Diagram of Connections:</u> Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

<u>Apparatus:</u> Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

<u>Instruments:</u> Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

Expt.________Title____Date_____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#22-AC

HIGH-TENSION TRANSFORMER TESTS

The following tests will be made, two weeks being the time limit:

(a) Oil Testing, Filtering & Drying.

(b) Checking Transformer Ratios & Calibration of Measuring Voltmeter with the Sphere-Gap.

(c) Insulation Testing.

(d) Insulator Testing.

(e) Test of Effect on Breakdown of Using Air and Other Dielectrics in series.

(f) Horn-Gap Test.

(g) Corona Test.

(h) Effect of Frequency & Steep Wave Fronts on Sphere-Gap & Needle-Gap Discharge.

Connect the transformer as shown in the diagram, which will be furnished. Before closing the line switch be absolutely sure that all persons are a safe distance (at least five feet) from the high-tension load, and any apparatus connected to it.

(a) Oil Testing, Filtering & Drying.

Take a specimen of oil from the bottom of the testing transformer. It is to the bottom that most of the moisture, if there is any, will settle, and hence the oil in its worst condition is most likely to be found there. With the megger test the resistance of the oil in both the 1" and ½" oil cups after adjusting the gaps for a 0.1" spacing by means of the gauge. Likewise test the specimens in both cups by connecting to the test transformer and gradually bringing the voltage up to the break-down value. Record all data. The oil should take approximately 25000 volts or better. If it is in poor condition it should be filtered and dried.

Study the method of filtering and drying and also the means provided for performing this operation while the transformer is in use.

(b) Checking Transformer Ratio & Calibration of Measuring Voltmeter with the Sphere-Gap.

Adjust the spheres of the gap until they just touch, read the micrometer screw, and then separate the spheres a considerable distance. Bring the voltage of the transformer up to a chosen value, adjust the sphere gap until it arcs over, at which instant pull the line switch immediately. Read the micrometer screw again, calculate the distance between spheres and obtain the corresponding voltage value from the sphere-gap voltage curves.

Repeat for at least five different values ranging from 10,000 to 100,000 volts. Plot a curve for use in subsequent tests, using voltmeter readings as abscissae and deduced air-gap voltages as ordinates.

(c) Insulation Testing.

Place the specimen to be tested between the brass discs provided for the purpose, and after measuring resistance with the megger, apply the voltage gradually, increasing it to the value where breakdown occurs. Make a record of the break-down voltages for the various specimens used.

(d) Insulator Testing.

Measure the resistance of the insulator with the megger, then apply the voltage gradually and note the value of voltage and current when corona first appears, when static discharges take place, and when arc-over occurs. If the insulator breaks down, note the breakdown voltage.

(e) Test of Effect of Breakdown of Using Air and Other Dielectrics in Series.

Separate the metal plates of the apparatus one cm. apart and apply voltage up to a value just below breakdown. Record this value. Remove the potential, insert the glass plate in the space between the metal plates, leaving half the space filled with air, apply the voltage previously obtained and note the results.

(f) Horn-Gap Test

Apply a potential across the gap sufficient to cause it to break down. Note and explain the results.

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(g) Corona Test.

Stretch two fine wires parallel to each other and spaced about one foot apart. Connect one wire to ground and the second wire to the high-voltage lead of the transformer. Darken the room. Bring up the voltage gradually and observe its value when the corona first appears.

(h) Effect of Frequency & Steep Wave Fronts on Sphere-Gap and Needle-Gap Discharge.

Adjust one of the sphere gaps for 40,000 volts (approx. 1.95 cm.) by setting the gap and noting the arc-over voltage. In a similar manner adjust the needle-gap for 40,000 volts (approx. 6.1 cm.) Note the formation of corona on the needle points as the voltage is brought up.

Connect both needle- and sphere-gap in parallel and this combination in series with the second sphere-gap (set for about 60,000 volts) to the transformer. Make all leads as direct as possible avoiding all kinks and corners. Bring the voltage up gradually and note which gaps break down. Make a bend in the wire connected to the first sphere gap (the one in parallel with the needle-gap) and note if the same gaps break down when voltage is applied.

Remove the kink or corner in the wire so that conditions as before are obtained. Gradually reduce the distance between the needle points between successive voltage applications until the needle-gap arcs over in preference to the sphere-gap. Note this distance and the voltage corresponding to it.

Reference:

Karapetoff pp. 1-118, Vol.II.

Expt.#________ Title:____ Date____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Current Rating Min.

Note defects here: (Correct them, if possible)

#23-AC INDUCTION MOTOR TESTS - RUNNING & LOCKED SATURATION CIRCLE DIAGRAM & EFFICIENCY BY PRONY BRAKE

Procedure:

Follow instructions as given in Section 6 of Factory Testing, Westinghouse Electric & Manufacturing Co.

Data:

Tabulate all observations and other data neatly on a standard data sheet.

Curves:

Plot curves on standard sheets as given in the instructions.

Questions:

1. Discuss the slip of an induction motor, and its relation to increasing load.

2. Describe the different methods for measuring slip directly.

3. What determines the speed of an induction motor?

4. Explain the methods of starting induction motors.

5. Explain the low power-factor found in induction motors, when compared with transformers.

6. Explain why the secondary is usually the revolving part.

7. State how to determine the resistance per phase of a three-phase system, both Y and delta-connected.

8. Explain the equivalent single-phase resistance and current of an induction motor.

9. Discuss the losses that occur in an induction motor and their relation directly and indirectly to the load.

10. Explain the methods used in determining each of the above classes of loss.

11. Describe a method for determining the friction loss, as separated from the iron loss.

12. Explain how the torque may be calculated.

#23-AC

Questions contd.

13. Explain how and why the reactive effects of the revolving secondary of an induction motor can be replaced by those of an imaginary fixed winding, and show what the value of the current in this imaginary winding would be.

14. Explain the circle-locus current-vector diagram of a transformer.

15. Discuss the application of this circle-locus to an induction motor, and give complete directions for its experimental determination.

16. Show, by the circle-diagram, how to determine the current, power-factor, torque, slip, input, and efficiency, corresponding to any given output.

References:

Elec. Jour	Vol. II, pp. 100-107.	
Factory Testing W.E. & M.Co.		Section 6.
A.I.E.E.	Vol. XL, April 1921 #4 p. 326-332.	
Dawes	pp. 225-304.	
Magnusson	pp. 168-210.	
Lawrence	pp. 443-554.	
Karapetoff	pp. 584-627, Vol. I; pp. 166-186 Vol. II.	
R. & T.	pp. 276-288.	

Expt.#________Title:____Date____________

Diagram of Connections: Sketch neatly with pencil on a graph sheet the connections as actually used in experiment.

Apparatus: Note name plate data of all machines used:

Station #__________

Name	Make	Number	Type	Form

Volts	Amperes	K.W.	H.P.	Frequency	Speed	Phase

Instruments: Note make, number, etc., of all meters, instruments, and miscellaneous equipment used.

Meter	Make	Number	Model	Type	Range	Capacity	Remarks

Article	Number	Description	Article	Number	Description

(a)

Expt.________Title____Date____________

Inspection: This should be made for every experiment performed, defects noted and corrected whenever possible.

1. Is there sufficient oil in the bearings?__________

2. Are the brushes badly worn?_______Incorrectly set?__________

3. Is commutator rough or pitted?________

4. Does armature turn easily?________

5. Are all connections correct?________

6. Are couplings or belted connections properly made?________

7. Is machine clear of tools and foreign particles?________

8. Have your wiring inspected and OK'd by instructor________

9. Do oil rings turn and provide sufficient lubrication after machine is running?________

10. Are there any defects, and any unusual noises in the machine after it is running?________

11. Note here the maximum and minimum current ratings of all the field rheostats you used in the test.

No.	Make	Resistance Ohms	Current Rating Max.	Min.

Note defects here: (Correct them, if possible)

#24-AC THERMIONIC VACUUM TUBE CHARACTERISTICS

Connect the tube as shown in the diagram, which will be furnished.

1. Maintaining the filament current at the normal rated value and with normal rated plate voltage, take readings of all meters for a series of values of grid voltage ranging from -50% to 50% of normal plate voltage.

2. Repeat (1) with the plate voltage 50% above normal.

3. Repeat (1) with the plate voltage 50% below normal.

4. Plot characteristic curves of the vacuum tube using grid-potentials as abscissae and plate currents as ordinates. These curves should be similar to those shown in Fig. 134, p. 151, of "Radio Engineering Principles".

Vacuum Tube Ratings

	VT-1	VT-2
Plate Voltage	30V.	160V.
Plate Resistance	17000 ohms	5000 ohms
Filament Current	1.1 A.	1.3 A.
Filament Voltage	2.5 V	7 V.
Amplification Factor	6-7	6-7

References:

"Radio Engineering Principles" Lauer & Brown, pp. 150-165.
"Thermionic Vacuum Tube", Van Der Bijl, pp. 236-265.