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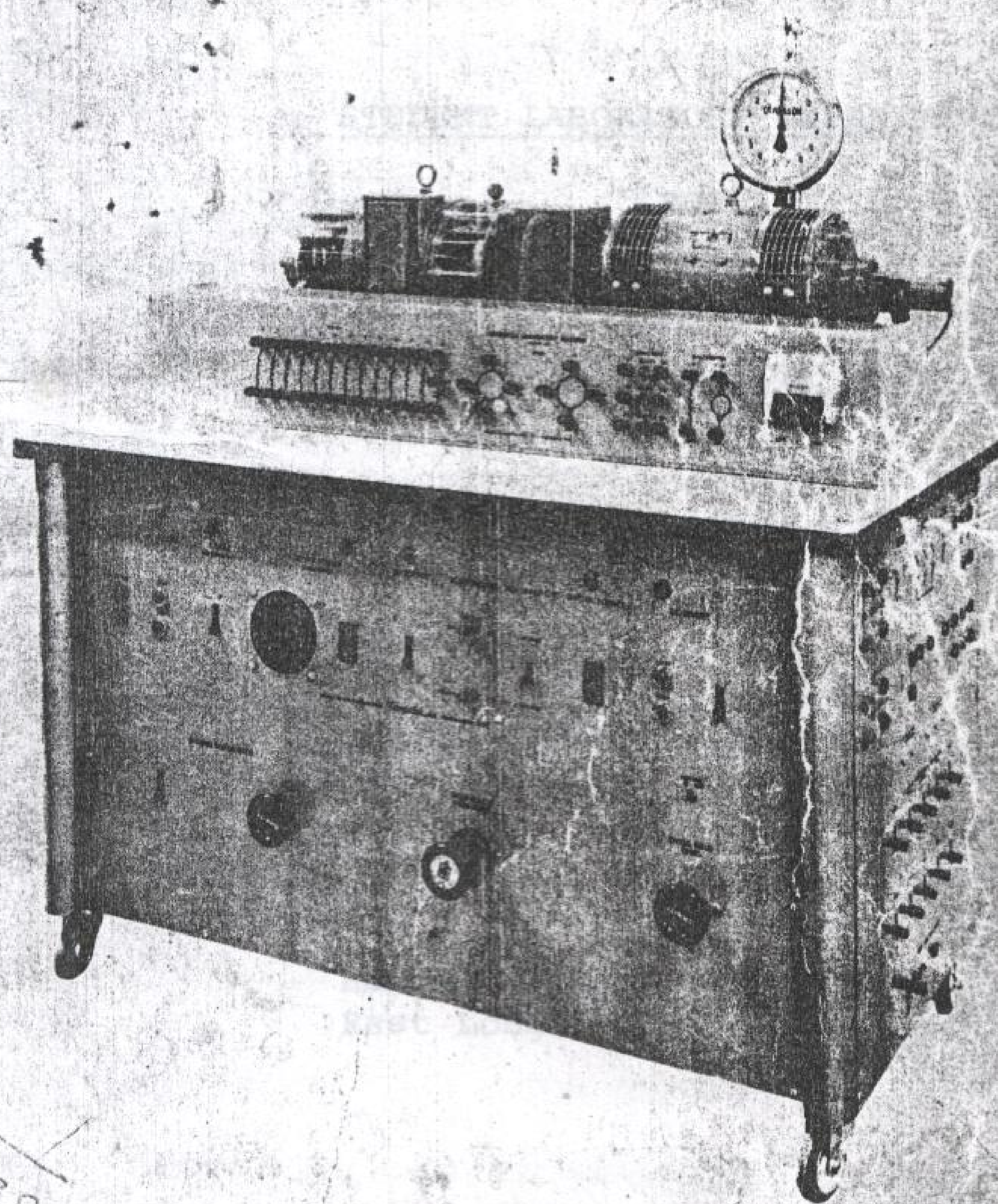
ESCUELA SUPERIOR POLITECNICA DEL LITORAL
ESPOL



STUDENT EXPERIMENTS
for
UNIVERSAL LABORATORY MACHINE

[redacted]

STUDENT LABORATORY EXPERIMENTS

FOR

HAMPDEN BULLETIN 120

UNIVERSAL LABORATORY MACHINE

Hampden Engineering Corporation
East Longmeadow, Massachusetts

[redacted]

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PREFACE

Since classroom instruction gains great strength when coordinate with laboratory experience and reports, a comprehensive laborato program is a valuable part of an electrical machinery course. However, very little published material in the form of workbooks or laboratory experiments has been available. This has placed t task of designing and preparing laboratory experiments on the individual instructor. The instructor, though experienced in th field of electrical machinery, has had to spend much time and effort designing experiments for use with new laboratory equip- ment with which he is unfamiliar. Thus, to lessen the instructo burden, Hampden has prepared the accompanying experiments to com pliment the Universal Laboratory Machine Set.

These experiments may be performed by the students without revis The instructor may, however, elect to use his own creativity to alter the scope or procedures of the experiments to suit his own individual needs.

SUGGESTED PROCEDURE FOR LABORATORY REPORT WRITING

GENERAL:

The formal laboratory report is an extremely effective part of the teaching and learning process. It is a form of recitation that demands an organized systematic approach and leads to a logical conclusion. Its educational value goes well beyond the absorption of facts and technical understanding. If properly used, it can promote straight thinking; it will strengthen the skills of communication and it can develop that most important of all motivation factors, personal pride.

The form suggested for the formal laboratory report follows accepted practices of technical reporting. It should be made clear to the student that the detailed information in the report is equal in importance to results and conclusion.

CHARACTERISTICS OF REPORTS:

Tests of equipment are usually summarized in the form of reports. In most cases, these reports are submitted to those who have not been actively engaged in the tests; hence, the reports must be clear and concise enough to leave no doubt concerning the method of test and the interpretation of the results.

The report should be written in the past tense and in the third person. It should be impersonal throughout, personal pronouns being avoided. The report must be complete in itself so that it can be followed by a reader without extensive knowledge of the test under consideration. A good report is thorough, orderly, neat, and grammatically correct.

REPORT SPECIFICATIONS:

1. Write with ink or use a typewriter.
2. Use 8½ x 11 inch paper. (Ruled paper for handwriting).
3. Write on one side of the paper only.
4. Draw illustrations, circuit diagrams, and curves neatly and carefully.
5. Letter or type all information on drawings, circuit diagrams and curves. Do not mix lettering styles.
6. Assemble the sheets in the order given in the following report outline. Submit the material in the standard report folder.

REPORT OUTLINE:

The material should be arranged in the following order:

I. Title Page

II. Introduction

III. Method of Investigation
   A. Procedure
   B. Circuit diagrams

IV. Results
   A. Data
      1. Nameplate data of equipment
      2. Observed and calculated data
   B. Sample calculations
   C. Curves

V. Analysis of Results

VI. Questions

(Not more than one of the above six divisions should be included on a single page. Omit Roman numerals.)

DISCUSSION OF REPORT OUTLINE:

I. Title Page
On this page should appear the name of the school, the course number and title, the date performed, the date submitted, the name of the student reporting, and the name of the co-worker(s). This page may be omitted if the form printed on the report includes these items.

II. Introduction
The introduction should be a concise statement setting forth the aim and scope of the investigation.

III. Method of Investigation
   A. Procedure
   In this section a general description of the procedure should be given. It should be comprehensive but brief. The enumeration and detailed description of routine mechanical

operations and their sequence - such as closing switches, reading instruments, turning knobs, and so forth - should, in general, be avoided. However, when a specific method of mechanical operation is necessary to assure validity or accuracy of the test data, it is important that the essential details be included in the description.

B. Circuit Diagrams

Each diagram should have a figure number, and should be referred to in the text material by that number. Each figure should have a descriptive title. Small diagrams may be included in the body of the description or several may be drawn on one separate sheet if the result is not crowded. Standard symbols should be used.

IV. Results

A. Data

The first item under results should be the nameplate data - or equivalent identification - of the apparatus tested. The original observed data should be presented in tabular form. If the observed data require corrections, these should be made before tabulation. Instrument identification numbers and ranges need not be copied from the original laboratory data sheet.

B. Sample calculations

This section should consist of a sample of a complete calculation of each type involved in the determination of calculated data and the solution of problems. When a succession of calculations is required in order to reach a final result, the same set of observed data should be used in carrying through the successive sample calculations, i.e. - the same sample figures that are selected from a data column should be used in all calculations involving that set of data.

C. Curves

All curve sheets should conform to the following specifications:

1. Use "Twenty to the inch" coordinate

paper, 8½ x 11 inches for rectangular plots.

2. Plot in the first quadrant where only one quadrant is needed.
3. In general, make the axes intersect within the sectioned part of the paper. Leave the curve sheet margins blank.
4. Plot the independent variable as abcissa and the dependent variable as ordinate.
5. In general, start the scale of the dependent variable, but not necessarily the scale of the independent variable, at zero.
6. Choose scales that are easy to use and that do not allow points to be plotted to a greater accuracy than that justified by the accuracy of the data.
7. Indicate points plotted from data by visible points or very small circles.
8. Draw a smooth average curve through the plotted points except in cases in which discontinuities are known to exist. Use a French curve in drawing the curves.
9. Place a title containing all pertinent information on each curve sheet. The title should be lettered or typed. Label the axes and show the units in which they are marked.
10. Draw only related curves on the same sheet.
11. Insert curve sheets in the report so that they can be read from the bottom or right side.
12. Use ink for everything on the sheet except the curves themselves; these should be drawn with a colored pencil.

V. Analysis of Results

The analysis of results is the most important section of the report. As the name implies, it should be a complete discussion of the results obtained. Part of the discussion should deal with the accuracy or reliability of the results. It is suggested, where applicable, that this section consist of a careful treatment of the effect on the results of the following:

1. Errors resulting from the necessity of neglecting

certain factors because of physical limitations in the performance of the test.

2. Errors in manipulation.
3. Errors in observation, and
4. Errors in instruments.

A very important part of the discussion should be a comparison of the results obtained with those which would reasonably have been expected from a consideration of the theory involved. When the theory is apparently contradicted, the probable reasons should be discussed. When results are given in graphical forms as curves, the shape of each curve should be carefully explained. Such an explanation should state the causes for the particular shape the curve may have. Any original conclusions drawn as a consequence of the laboratory procedure and a study of the results obtained should be included in this section.

IV. Questions

In this section should be included answers to any questions which are given as a part of the test.

EXPERIMENT NO. 1

INTRODUCTION TO THE UNIVERSAL LABORATORY MACHINE CONSOLE

PURPOSE:

The objective of the experiment is to gain familiarization with the ULM Set and its equipment console.

DISCUSSION:

In order that the greatest possible value is gained from the following experiments in this manual, one must have a basic understanding of the design features of the ULM Set and the operation of the equipment in the console. This information is found in the "Universal Laboratory Machine Set Instruction Manual" and the "Universal Laboratory Machine Console Instruction Booklet."

APPARATUS REQUIRED:

1 ULM Set and Console
1 ULM Set Instruction Manual - Bulletin 120MI
1 ULM Console Instruction Booklet - Bulletin 120CI

PROCEDURE:

1. Read pages 1 to 11 in the ULM Set Instruction Manual. Visually inspect the ULM Set to aid in understanding the material covered.
2. Read the ULM Console Instruction Booklet. Refer to the Console for the location of each set of controls.
3. Answer the following questions as an exercise in knowing where to find information on the ULM Set and its Console.
   - A. What is the purpose of the swamp resistor?
   - B. What is the resistance of a single stator coil?
   - C. Why must the starting capacitor (single-phase motor) be switched off as soon as possible?
   - D. What is the current rating of the rotor winding?

E. What are the ratings of the Dynamometer Field Rheostat?

F. Where are the search coils located?

G. Name two prerequisites for the proper operation of the automatic DC starter.

H. What is the purpose of the prewired plugs?

I. In what position should the brush lifting mechanism be for operation as an induction motor? Why?

EXPERIMENT NO. 2

OUTPUT POLARITY DETERMINATION OF A DC GENERATOR

PURPOSE:

The objectives of the experiment are to determine the relationship between the direction of rotation, the output polarity, and the direction of field flux in a DC generator.

DISCUSSION:

For any generator there exists a certain definite relationship between the direction of rotation, output polarity, and the flux in the magnetic circuit. In order for a self-excited generator to "build up", there must be some residual magnetism present in the frame structure and the flux produced by the field windings must be in such a direction as to aid this residual flux. Therefore, the field must be connected to the armature terminals in the proper manner, otherwise no build-up condition can exist. Since reversal of the direction of rotation results in a reversal of armature output polarity, the connections between the field and the armature must also be reversed if the flux produced by the field is still to aid the residual. In some cases, the residual flux is not present, or may be present in the wrong direction, in which case it can be restored or reversed by connecting the field to another source of power with the proper polarity. This process is known as "flashing the field".

Although any type DC generator will exhibit the above mentioned principles, they will be demonstrated in this experiment on the shunt generator.

APPARATUS REQUIRED:

- 1 ULM Set
- 1 ULM Set Instruction Manual - Bulletin 120MI
- 1 ULM Console Instruction Booklet - Bulletin 120CI
- 1 ULM Console containing,
  - 110 volt DC Power Supply
  - Dynamometer Field Rheostat (250Ω)
  - Three Phase Source
  - AC Starter
- 1 0-150 volt DC Voltmeter

PROCEDURE:

1. Connect the Universal Machine to operate as a 3Ø induction motor as shown in Figure 1.

2. Have the instructor check your machine connections before starting the Universal Machine.

3. Start the Universal Machine by switching on the main AC circuit breaker and pushing the start button of the AC starter. The set will run at approximately 3600 RPM in the counter-clockwise direction (as viewed from the slip-ring end of the Universal Machine). Should the rotation be in the opposite direction, stop the machine and swamp any two of the stator leads (to 1, 5, or 9).

4. Measure the DC voltage across the armature terminals of the Dynamometer. This voltage is due solely to residual flux. Record the magnitude and polarity of this voltage on the work sheet.

5. Connect the shunt field in series with the field rheostat (in the maximum resistance, fully cw position) and connect them to the armature. Slowly decrease the rheostat setting. If the armature voltage starts to rise, the correct connections have been made. If the voltage decreases, reverse the shunt field connections and proceed. Adjust the field rheostat to give a 110 volt DC generated voltage. Record the connections and polarity on the work sheet.

6. Stop the Universal Machine and reverse the direction of rotation by swapping any two stator leads. Start the machine and record the magnitude and polarity of the armature voltage for this direction of rotation.

7. In order to cause the generator to build-up with this direction of rotation, it will be necessary to reverse the connections between the armature and the field from that of Step 5. Make this connection, operate the set as in Step 5, and record the polarities and connections on the work sheet.

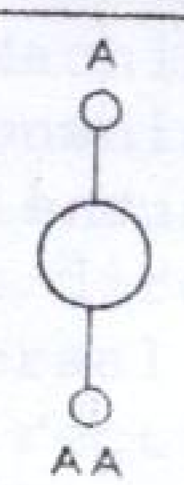
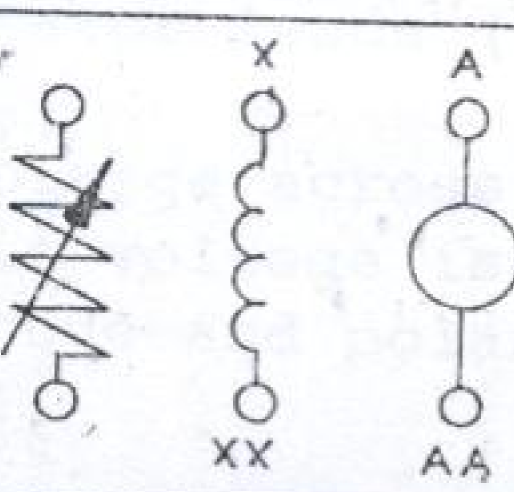
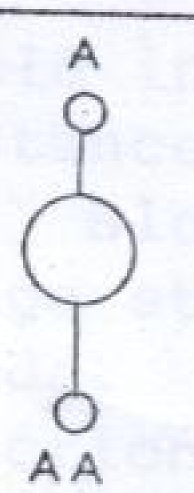
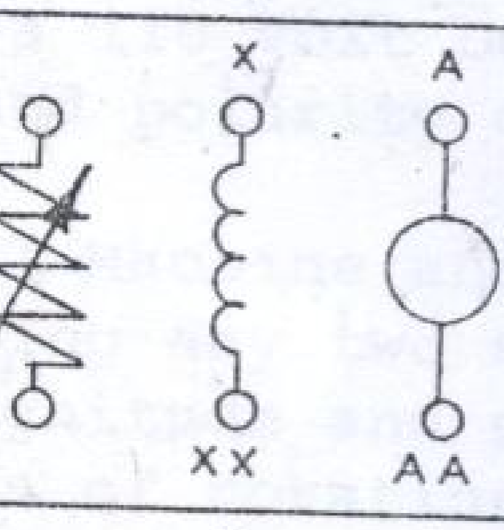
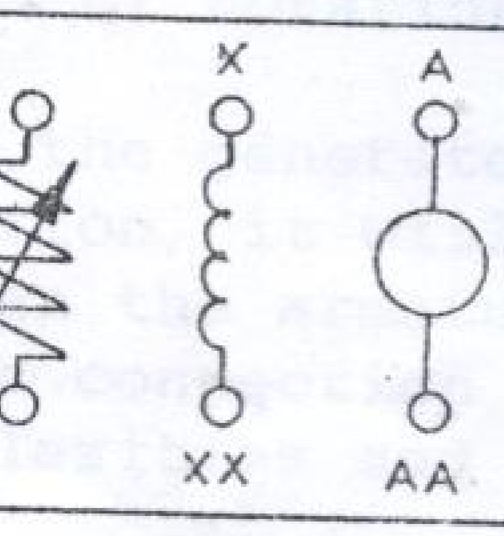
8. It is sometimes necessary to change polarity without changing the direction of rotation, as might be the case if the generator were driven by a non-reversible prime mover. This can

be done if the residual flux is reversed by "flashing the field". Connect the shunt field directly to the 110 volt DC power supply with a polarity opposite from that of Step 7. Switch on the DC supply for approximately 30 seconds. Now make the connections used in Step 5 and start the Universal Machine. Record the new polarity and connections on the work sheet.

REPORT:

Hand in the work sheet at the end of the lab period.

TABLE 1: WORK SHEET

STEP NO.	DIRECTION OF ROTATION	POLARITY, VOLTAGE AND CONNECTIONS	CONDITIONS OF TEST
4	CCW		Generated voltage due to residual magnetism.
5	CCW		Proper connection of shunt field to cause buildup.
6	CW		Generated voltage due to residual magnetism in the reversed direction of rotation.
7	CW		Proper connection of shunt field to cause buildup in reverse direction.
8	CW		Proper connection to cause buildup after flashing the field with reverse polarity.

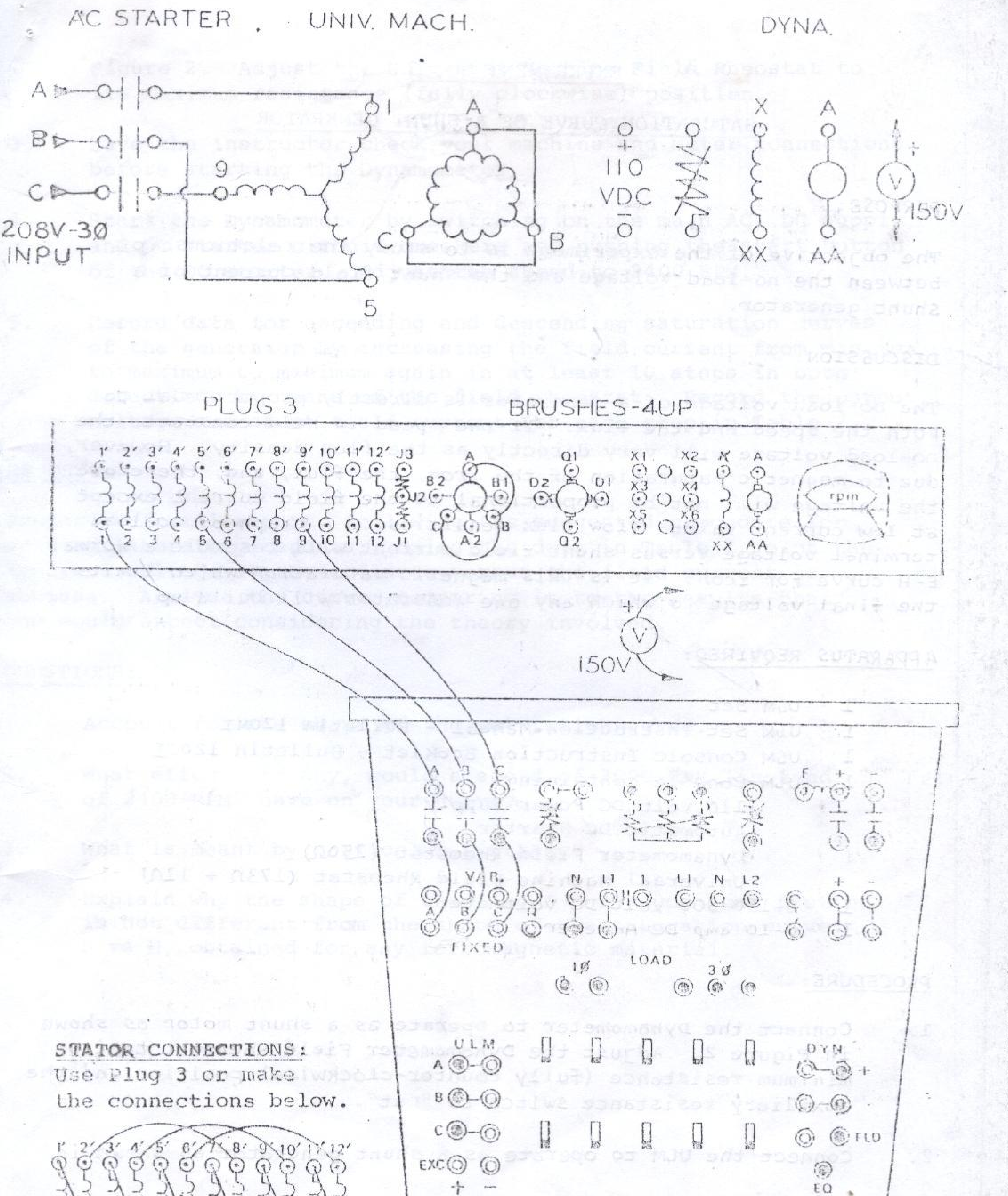

AC STARTER
UNIV. MACH.
DYNA.
A
B
C
208V-3Ø
INPUT
1
9
5
A
B
C
+
110
VDC
−
X
XX
A
AA
150V
PLUG 3
BRUSHES-4UP
1′ 2′ 3′ 4′ 5′ 6′ 7′ 8′ 9′ 10′ 11′ 12′ J3
1 2 3 4 5 6 7 8 9 10 11 12 J1
J2
A
B2
B1
A2
B
Q1
Q2
D2
D1
X1
X2
X3
X4
X5
X6
XX
AA
rpm
+
V
150V
A B C
F
+
−
VAR
N
L1
N
L2
FIXED
LOAD
1Ø
3Ø
STATOR CONNECTIONS:
Use Plug 3 or make
the connections below.
ULM
DYN
FLD
EXC
EQ
1′ 2′ 3′ 4′ 5′ 6′ 7′ 8′ 9′ 10′ 11′ 12′
1 2 3 4 5 6 7 8 9 10 11 12

FIG. 1

EXPERIMENT NO. 3

SATURATION CURVE OF A SHUNT GENERATOR

PURPOSE:

The objective of the experiment is to study the relationship between the no-load voltage and the shunt field current of a shunt generator.

DISCUSSION:

The no-load voltage of a generator is directly proportional to both the speed and the flux. If the speed is held constant, the no-load voltage will vary directly as the flux density. However, due to magnetic saturation of the iron, the flux, and, therefore, the voltage will not be proportional to the field current except at low current values (low flux densities). A graph of no-load terminal voltage versus shunt field current will resemble a normal B-H curve for iron. It is this magnetic saturation which limits the final voltage to which any one generator will build-up.

APPARATUS REQUIRED:

1 ULM Set
1 ULM Set Instruction Manual - Bulletin 120MI
1 ULM Console Instruction Booklet - Bulletin 120CI
1 ULM Console containing
  110 volt DC Power Supply
  Automatic DC Starter
  Dynamometer Field Rheostat (250Ω)
  Universal Machine Field Rheostat (173Ω + 11Ω)
1 0-150-300 volt DC Voltmeter
1 0-10 amp DC Ammeter

PROCEDURE:

1. Connect the Dynamometer to operate as a shunt motor as shown in Figure 2. Adjust the Dynamometer Field Rheostat to its minimum resistance (fully counter-clockwise) position and the auxiliary resistance switch to "out".

2. Connect the ULM to operate as a shunt generator as shown in

Figure 2. Adjust the Universal Machine Field Rheostat to its maximum resistance (fully clockwise) position.

3. Have the instructor check your machine and meter connections before starting the Dynamometer.

4. Start the Dynamometer by switching on the main AC, DC supply and DC starter circuit breakers and pushing the start button of the DC starter. Adjust the speed to 2400 RPM.

5. Record data for ascending and descending saturation curves of the generator by increasing the field current from minimum to maximum to minimum again in at least 10 steps in both directions by means of the field rheostat. Record the output voltage and shunt field current for each step in Table 2.

REPORT:

Prepare a formal report, following the suggested procedure for writing laboratory reports. Using the data in Table 2, plot the armature voltage as the ordinate versus the field current as abscissa. Analyze the curve; comparing it to the results that one would expect considering the theory involved.

QUESTIONS:

1. Account for the shape of the saturation curve.

2. What effect, if any, would a speed of 3000 RPM (instead of 2400 RPM) have on your curve?

3. What is meant by critical resistance?

4. Explain why the shape of the E vs I curve you just plotted is not different from the shape of the saturation curve, B vs H, obtained for any ferromagnetic material.

2

TABLE 2: . SATURATION CURVE

TERMINAL VOLTS	FIELD AMPS

18-

18

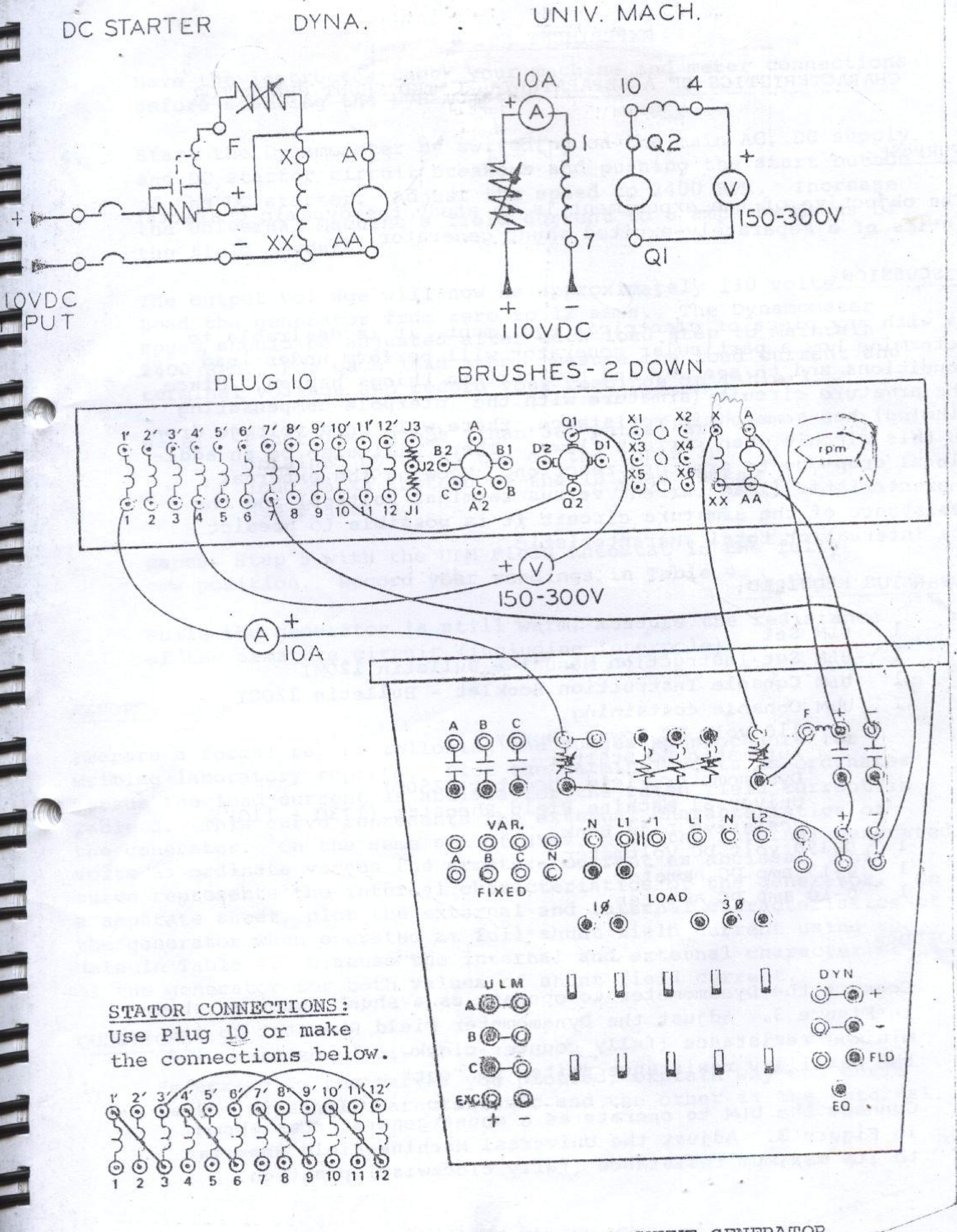


FIGURE 2: SATURATION CURVE OF A SHUNT GENERATOR