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NAVAL RESEARCH LABORATORY
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AIRCRAFT ELECTRICAL RESEARCH DIVISION
ELECTRICAL POWER SECTION

16 January 1946

INVESTIGATION OF AIRCRAFT ELECTRICAL SYSTEM USING GENERAL ELECTRIC 2CM73B7 AND ECLIPSE NEA-7 (1406-1-A) GENERATORS IN PARALLEL AND CONTROLLED BY ECLIPSE 1042-9-A VOLTAGE REGULATORS

By William Roberts--Project Engineer
Arthur T. McClinton--Group Leader

- Report E-2736 - [redacted]

FR-2736

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Approved by:

L. R. Larson, Head, Electrical Power Section

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Aircraft Electrical Research Division

Commodore H. A. Schade
Director, Naval Research Laborator

Preliminary Pages ...a-c
Numbered Pages 4
Figures 5
Distribution ..... d

NRL Problem No. 31E33

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ABSTRACT

An electrical system consisting of the General Electric 2CM73B7 and the Eclipse NEA-7 (1406-1-A) generators in parallel using Eclipse 1042-9-A regulators was investigated, in accordance with Project Directive TED No. NRL 31E33. Satisfactory parallel operation was demonstrated with the regulators adjusted on the generators used for the system, or on some other standard generator. It is recommended that the system be considered satisfactory for use on naval aircraft. However, the operation of the system would be improved, if the temperature compensation of the 1042-9-A regulator were improved. The operation of the single generator system using the General Electric 2CM73B7 generator with the Eclipse 1042-9-A regulator was also investigated. This regulator-generator has satisfactory regulation and recovery time characteristics, but the temperature compensation of the regulator is very poor.

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AUTHORIZATION

1. The investigation reported here was requested by the Bureau of Aeronautics in reference (a).

INTRODUCTION

2. The object of the investigation was as follows:

(A) To determine the system characteristics when a General Electric 2CM73B7 and an Eclipse NEA-7 (1406-1-A) generator, each controlled by an Eclipse 1042-9-A regulator, are operated in parallel. This investigation was to be conducted using regulators adjusted

1. on the generator it is controlling,
2. on some other standard navy generator, such as the Eclipse 1273-1-A.

(B) To determine the operation of the General Electric 2CM73B7 when controlled by an Eclipse 1042-9-A regulator. This investigation was to include regulation tests with the regulator adjusted

1. on the General Electric 2CM73B7 generator, and
2. on some other standard navy generator, such as the Eclipse 1273-1-A.

3. The investigation was conducted on the following equipment:

Mfg.	Type	Navy Type	Serial No.	Rated Speed	Full Load Amps.
G.E.	2CM73B7		2198728	4550/8000	300
Eclipse	1406-1-A	NEA-7	14	4000/8000	125
Eclipse	1273-1-A		A21868	2000/4000	75
Eclipse	1042-9-A		Y8100		
Eclipse	1042-9-A		Y8201		

DISCUSSION OF PROCEDURE AND RESULTS OBTAINED

4. The General Electric 2CM73B7 generator and the Eclipse NEA-7 generator were used in conjunction with Eclipse Type 1042-9-A regulators to determine the load division when used on a two-generator parallel system. Each regulator was adjusted on the generator it was used to control, in accordance with the procedure of reference (b). The procedure used to adjust the system for proper division of load is outlined in paragraph 6. Figure 1 shows the results of test, with deviation of the NEA-7 from its share of the load plotted as a function of total load current. Deviation of the 2CM73B7 is equal in value but opposite in sign. The maximum deviation of either generator from its share of the load was

2 amperes when the generators were operated at the same speed, and 9 amperes with the NEA-7 at 8000 r.p.m. and the 2CM73B7 at 4400 r.p.m.

5. In order to determine the effect of regulator adjustment on load division, the regulators were adjusted on an Eclipse Type 1273-1-A generator in accordance with the procedure of reference (b). Adjustment procedure used for parallel operation is outlined in paragraph 6 of this report. Figure 2 shows the results of the parallel operation, and is a graph of deviation of the NEA-7 from its share of the load. The maximum deviation of either generator from its share of the load was 3 amperes when the generators were operated at the same speed, and 9 amperes when the NEA-7 was operated at 8000 r.p.m. and the 2CM73B7 was operated at 4400 r.p.m.

6. The paralleling procedure was carried out at middle speed as follows:

(a) With the generator switches open and each generator carrying no load, the voltages were set equal with the voltage rheostats.

(b) The generator switches were closed, putting the generators in parallel. If any circulating current were shown by the ammeters (plus current on one, minus on the other), the voltage was raised on the generator with the negative-reading ammeter, until the ammeters read zero.

(c) Half load was placed on the system and the paralleling resistors adjusted so each generator took its share of the load. In this system, the 2CM73B7 should take 300/425ths of any load.

(d) Full load was placed on the system and the setting of the paralleling resistors was refined, if necessary.

(e) The load was removed and the system re-checked for a circulating current. If the voltage rheostats must be reset, steps (c) and (d) must be repeated. Shock loading was used throughout.

Note: The generator switch was a DPST switch and controlled the equalizer circuit and reverse current relay.

7. The voltage regulation obtained with the Eclipse Type 1042-9-A is determined largely by the adjustment of the mechanical stabilizer. As the compression of the spring in this element is increased, poorer regulation results. In addition, the minimum pile resistance is increased. It follows that the regulation resulting will depend upon what generator is used for adjusting the regulator. Figure 3 shows the regulation of the regulator-generator combination used in securing results for the parallel operation of Figures 1 and 2. Regulation on the 2CM73B7 generator was approximately the same for regulators adjusted on the 2CM73B7 or 1273-1-A generators. A difference in regulation was noted on the NEA-7, however. It is noticed that the regulator adjusted on the Eclipse 1273-1-A generator gave better regulation than one adjusted on the Eclipse NEA-7 generator. Comparison of Figures 1 and 2 will show that this change in

regulation has little effect on load division in a system that has been properly adjusted for parallel operation.

8. Figure 4 shows the results of the first study in the investigation of the characteristics of the Eclipse 1042-9-A regulator and General Electric 2CM73B7 generator combination. Voltage, field current, pile resistance and wattage are plotted as functions of load current at three generator speeds. Variation in voltage was 2.7%, or 0.75 volts when the regulator was operating in an ambient temperature of 25 degrees Centigrade. Figure 5 is a graph of voltage, field current, and regulator temperature as functions of time. Overall variation from the full load, no warm-up condition to the no load, ninety minute warm-up condition was 8.3%, or 2.3 volts. The generator was operated at 3/4 load and 4400 r.p.m., the conditions which Figure 4 shows to be that of maximum power dissipation in the pile. Recovery time was determined by a number of oscillograms to be approximately 0.033 second.

CONCLUSIONS

9. Parallel operation of the General Electric 2CM73B7 and the Eclipse NEA-7 generators is satisfactory when each regulator is adjusted on the generator it is to control. Adjusting the regulators on an Eclipse 1273-1-A generator will not affect the parallel operation.

10. The system containing these two generators in parallel can be operated so that each generator takes its share of the load at full load, within plus or minus 3 amperes when the generators are operated at the same speed.

11. Characteristics of the Eclipse 1042-9-A regulator-General Electric 2CM73B7 generator combination is as follows:

(a) Variation in voltage at an ambient temperature of 25 degrees Centigrade of 2.7%, or 0.75 volts.
(b) Overall voltage variation during a heat run of 8.3%, or 2.3 volts.
(c) Recovery time of approximately 0.033 seconds.

12. Poor temperature compensation of the Eclipse 1042-9-A regulator will cause erratic paralleling during warm-up in a system controlled by these regulators.

RECOMMENDATIONS

13. Parallel operation of the General Electric 2CM73B7 and the Eclipse NEA-7 generators controlled by Eclipse 1042-9-A regulators is recommended as suitable for use on naval aircraft.

14. Temperature compensation of the Eclipse 1042-9-A regulator should be improved to assure better load division during warm-up period of the regulator.

REFERENCES

15. (a) BuAer ltr Aer-E-3121 SHH, F36-1, dated 19 April 1945.

(b) NRL ltr to BuAer R-F42-1/21(316-1:ATM) R-310-62/45(mec), dated 4 April 1945.

(c) BuAer Spec. for regulators NavAer M-615, dated 1 June 1945.

PARALLEL OPERATION
DEVIATION OF NEA-7 GENERATOR FROM ITS SHARE
OF THE LOAD AS A FUNCTION OF TOTAL LOAD.
G.E. 2CM73B7 GENERATOR, SER. #2198728
ECLIPSE NEA-7 (1406-1-A) GENERATOR, SER. #14
ECLIPSE 1042-9-A REGULATORS, SER. #Y8100 AND #Y8201
CONDITIONS:
AMBIENT SEA LEVEL CONDITIONS
ONE-HALF HOUR WARM-UP OF EQUIPMENT
REGULATORS ADJUSTED ON GENERATOR WITH WHICH USED.
DEVIATION OF 2CM73B7 IS EQUAL IN VALUE
AND OPPOSITE IN SIGN

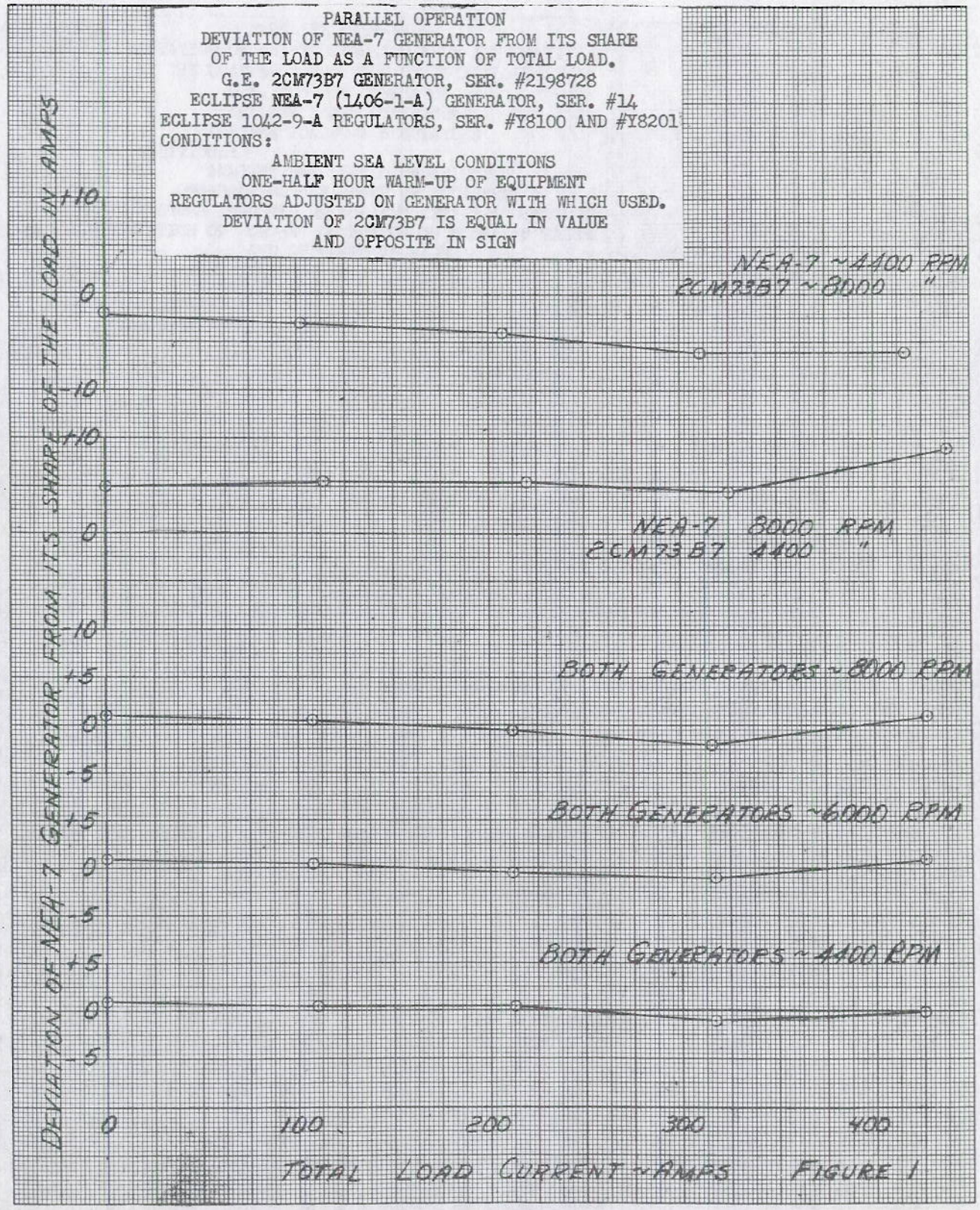

FIGURE 1

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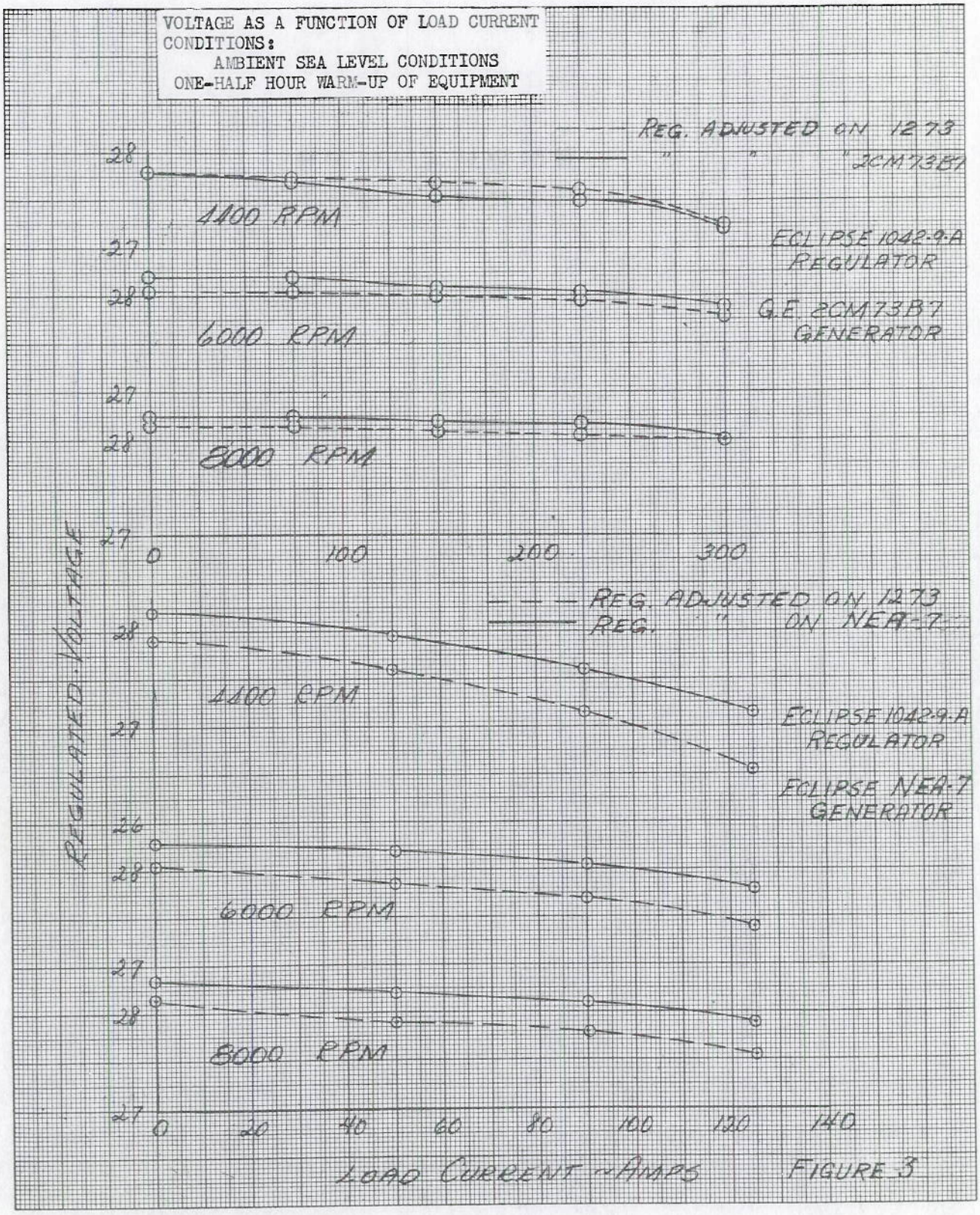

FIGURE 3

E-2736

VOLTAGE, FIELD CURRENT, PILE WATTS AND
PILE RESISTANCE AS A FUNCTION OF LOAD AT 3 SPEEDS.
G.E. 2CM73B7 GENERATOR
ECLIPSE 1042-9-A REGULATOR
CONDITIONS:
AMBIENT SEA LEVEL CONDITIONS
ONE-HALF HOUR WARM-UP OF EQUIPMENT

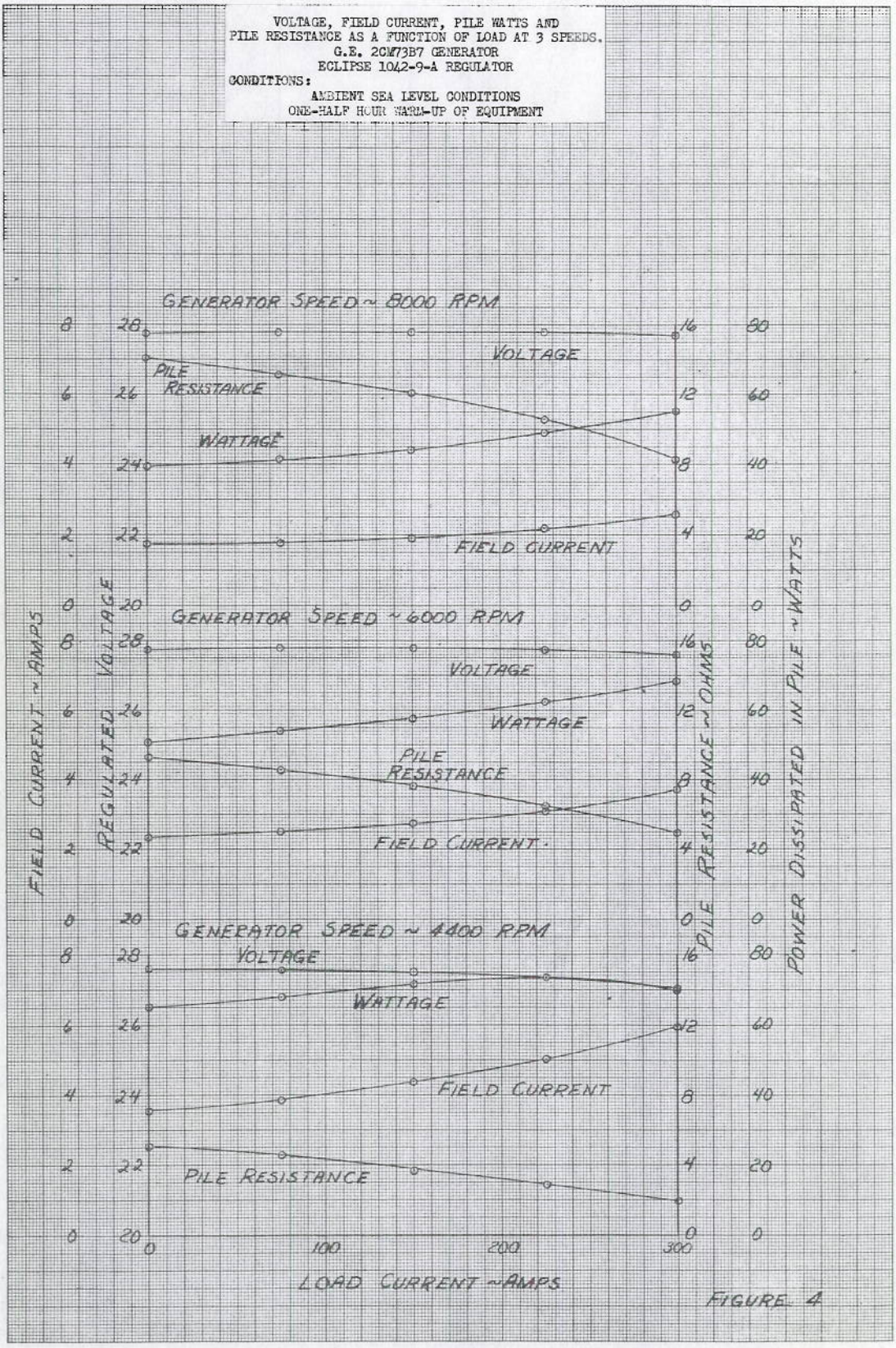

FIGURE 4

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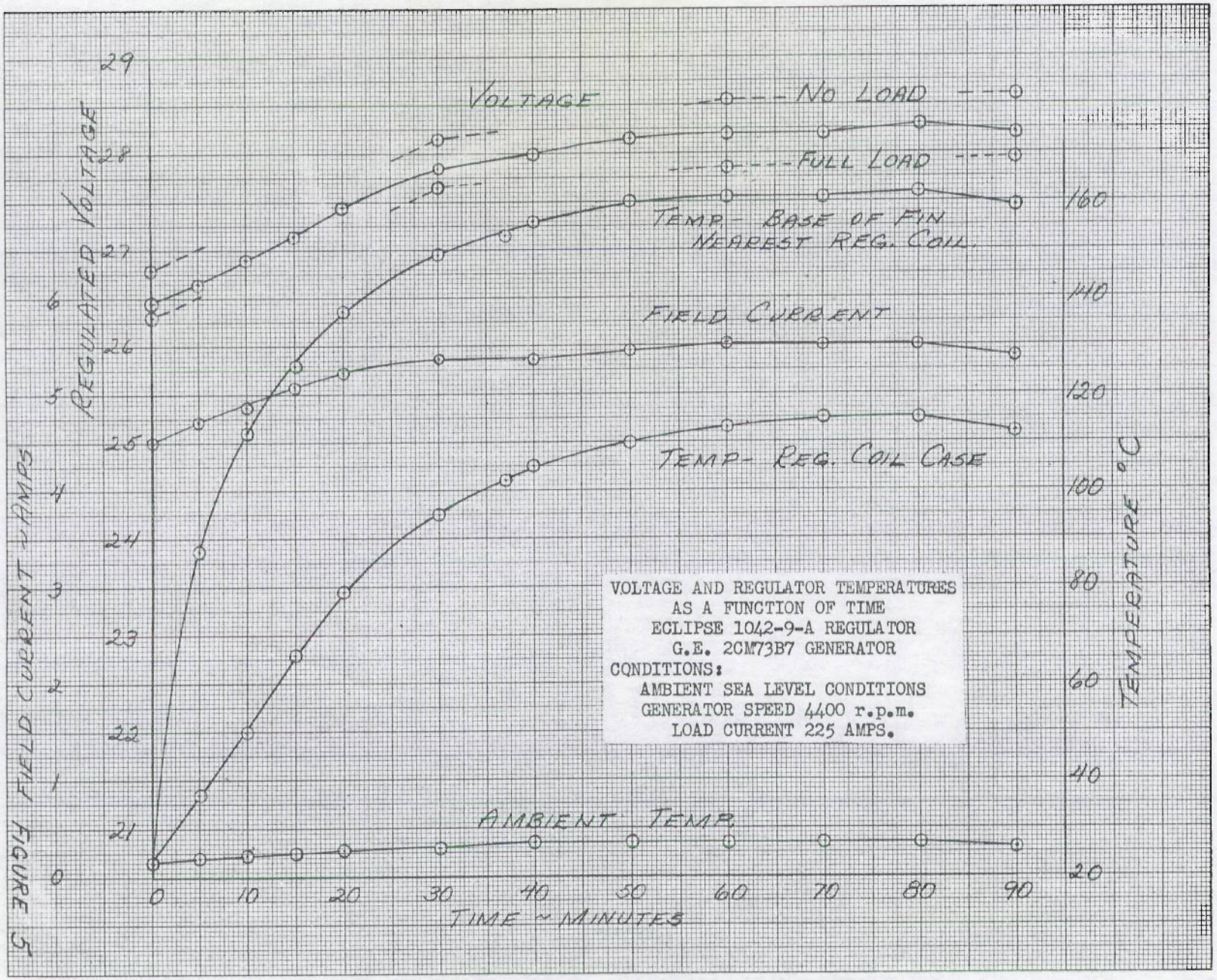

VOLTAGE AND REGULATOR TEMPERATURES
AS A FUNCTION OF TIME
ECLIPSE 1042-9-A REGULATOR
G.E. 2CM73B7 GENERATOR
CONDITIONS:
AMBIENT SEA LEVEL CONDITIONS
GENERATOR SPEED 4400 r.p.m.
LOAD CURRENT 225 AMPS.

FIGURE 5

E-2736