

# **NATIONAL BUREAU OF STANDARDS REPORT**

6337

Supplementary

Output Characteristics of Series-Series Transformers  
With Multiple Lamps as Loads

By

James E. Davis



**U. S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS**

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## NBS PROJECT

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March 1960

## NBS REPORT

6337

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Output Characteristics of Series-Series Transformers  
With Multiple Lamps as Loads

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Prepared for

Ship Aeronautics Division  
Bureau of Naval Weapons  
Department of the Navy  
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U. S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS



Output Characteristics of Series-Series Transformers  
With Multiple Lamps as Loads

James E. Davis

1. INTRODUCTION

The results of tests made of three 6.6/6.6-ampere, 200-watt runway lighting transformers using 120-volt, multiple-type lamps as loads are given in National Bureau of Standards Report 6337. Additional tests made using the same series-series transformers, but with 60- and 75-volt, multiple-type lamps as the loads are reported in this report.

2. TEST PROCEDURE

The tests were made using the airfield lighting circuit and regulator and procedure described in NBS Report 6337.

The tests were made by connecting the test transformer with its load into an airfield lighting circuit supplied by a type NC-3, 15-kilowatt regulator. The runway lighting circuit consisted of thirty-four 200-watt, series-series transformers and their lamps and three 200-watt series-series transformers with burned out lamps across their secondaries, and approximately 16,000 feet of No. 12, 3000-volt cable in metallic duct. The output voltage and current readings of the regulator when it was connected to this runway lighting circuit were as follows:

Step 1	440 volts	2.82 amperes	1.24 kva
Step 2	550 volts	3.40 amperes	1.87 kva
Step 3	670 volts	4.10 amperes	2.74 kva
Step 4	1000 volts	5.12 amperes	5.12 kva
Step 5	1440 volts	6.50 amperes	9.36 kva

Output voltage and current of the test transformers were measured for each intensity step using 75-volt and 60-volt lamps. Ten 75-watt and two 25-watt, 60-volt, PAR-38 lamps were used in combinations to obtain 100, 150, 200, 250, 300, 400, 500, 600, 700, and 800 rated watts as the load for one test. Thirteen 75-watt, 75-volt, PAR-38 lamps were used in combinations to obtain 75, 150, 225, 300, 450, 600, 750, 900, and 975 rated watts as the load for the other test.

All values of voltage and current were corrected for all significant losses in the measuring instruments.



# THE HISTORY OF THE

REIGN OF

CHARLES THE FIRST

BY JOHN BURNET

IN TWO VOLUMES.

LONDON, Printed by J. Streater, at the Sign of the Gun, in St. Dunstons Church-yard, 1679.

THE first of these two Volumes, contains the History of the Life and Reign of CHARLES THE FIRST, from his Birth to his Execution. The second Volume, contains the History of the same Life and Reign, from his Execution to his Restoration.

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### 3. RESULTS

The output characteristics of the test transformers and light output of the lamps as a function of the load are shown in figures 1 through 20, as listed in the following table.

<u>Lamp Voltage</u>	<u>Characteristic Curves</u>	<u>Figure No.</u>
60-volt	Secondary voltage-current	1, 2, 3*
75-volt	Secondary voltage-current	4, 5, 6*
60-volt	Output power versus rated wattage	7
75-volt	Output power versus rated wattage	8
60-volt	Relative light output	9, 10, 11
75-volt	Relative light output	12, 13, 14
60-volt	Lumen output	15, 16, 17
75-volt	Lumen output	18, 19, 20

\*In figures 1 through 6, the no-load, open-circuited, secondary voltage of the transformer for each intensity setting is shown by the dots at the bottom edge of the figure.

The secondary voltage-current characteristic curves of these 200-watt transformers using 60- and 75-volt lamps as loads are similar in shape to those of the 120-volt lamp loads. The curves indicate, for each of the three transformers tested, the minimum rated wattage of the load necessary for each intensity step to keep the applied voltage from exceeding the rated lamp voltage.

Figures 9 through 14 show the relative light output of one lamp of the 60- and 75-volt lamp loads as a function of rated connected load. The values of relative light output were computed using the intensity-voltage relation for 75-volt, 75-watt, PAR-38 lamps given in National Bureau of Standards Report 6190, figure 14b. To facilitate comparison of the light output of 60- and 75-volt lamp loads with the output of 120-volt lamp loads, the light output in lumens of the 60- and 75-volt lamp loads as a function of rated wattage of the load were computed and are shown in figures 15 to 20. The values of light output were obtained by multiplying the computed lumen output of the lamps at rated voltage by an applied-voltage factor. The lumen output at rated voltage was chosen as 15 lumens per watt. The applied voltage factors were obtained from National Bureau of Standards Report 6190, figure 14b, for a 75-volt, 75-watt, PAR-38 lamp.

CHAPTER I

The first part of the book is devoted to a general survey of the subject, and to a discussion of the various methods which have been employed for its treatment.

The second part is devoted to a detailed examination of the various methods which have been employed for the treatment of the subject, and to a discussion of the results which have been obtained.

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The curves of figures 15 to 20 are extended only to the minimum connected load used in this test at which the voltage applied to the lamps does not exceed the rated voltage of the lamps.

#### 4. DISCUSSION

For the 60-volt lamps, with 300 watts rated load, the ratio of relative light output is approximately 100 to 1 at intensity steps 5 and 1. For the 75-volt lamps at the same load, the ratio of relative light output is approximately 10 to 1 at intensity steps 5 and 1.

The data obtained from these tests indicate that the 60- and 75-volt lamps of certain loads may be useful for some special visual lighting aids if the transformer can be selected by manufacturer. If lamps of these voltages are used, care will have to be exercised in the selection of the number of lamps used with any transformer, except for 75-volt lamps with the Line Material transformer, to prevent exceeding the rated voltage of the lamps. Also note that with certain loads a single lamp failure will cause rapid failure of the rest of the lamps on that particular transformer.

A comparison of figures 15 to 20 with figures 5 to 7 of NBS Report 6337 shows that the maximum light output which can be obtained without exceeding rated voltage with a given transformer when 75-volt lamps are used is about 1.5 times the maximum light output that can be obtained when 120-volt lamps are used. The maximum output when 60-volt lamps are used is about twice the maximum output when 120-volt lamps are used.

Consideration has also been given to the use of 30/45-watt transformers to supply power to multiple lamps. The specified maximum open-circuit voltage of these transformers is 25 volts. Hence the 30/45-watt transformer is not a suitable source of power for lamps having a rated voltage much greater than 25 volts.

March 1960

US COMM NBS DC





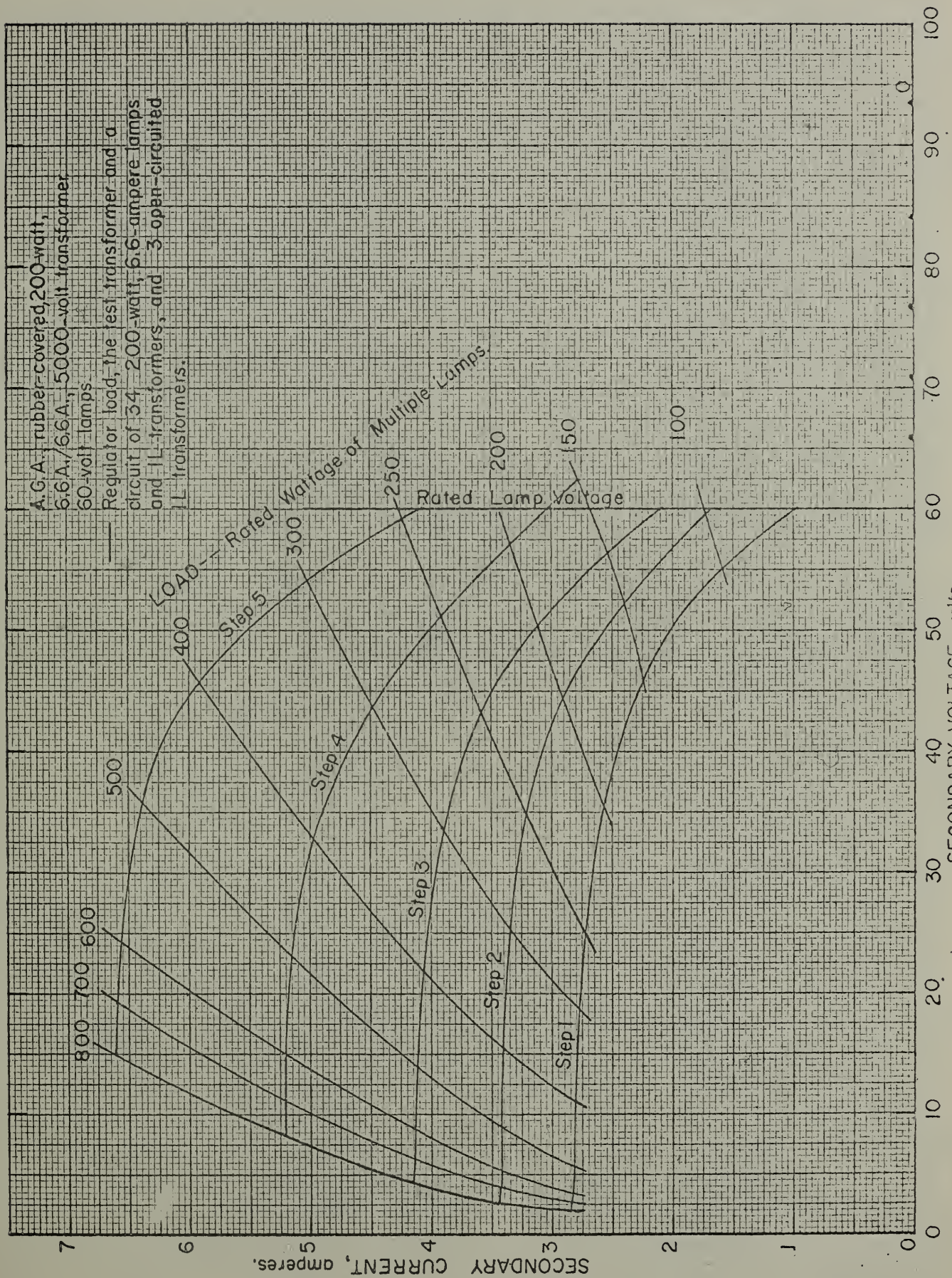


Figure 1. Output characteristics of series transformers, (with multiple-lamp loads)





JEFFERSON ELECTRIC CO., rubber-covered  
200-watt, 6.6A/6.6A., 5000-volt  
transformer.  
60-volt lamps.

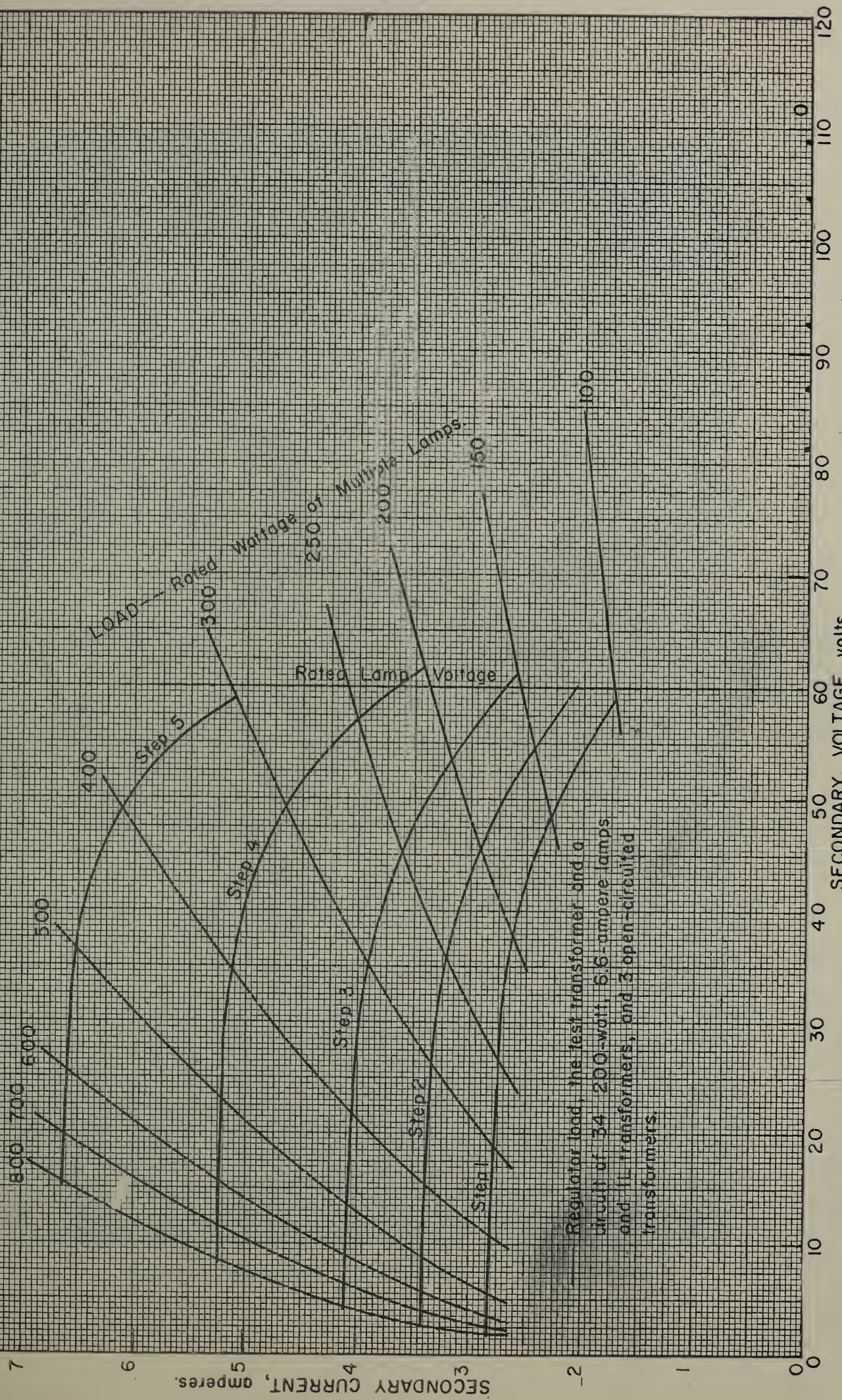


Figure 2. Output characteristics of series transformers, (with multiple-lamp loads).  
N.B.S. 6337 (Supplementary)





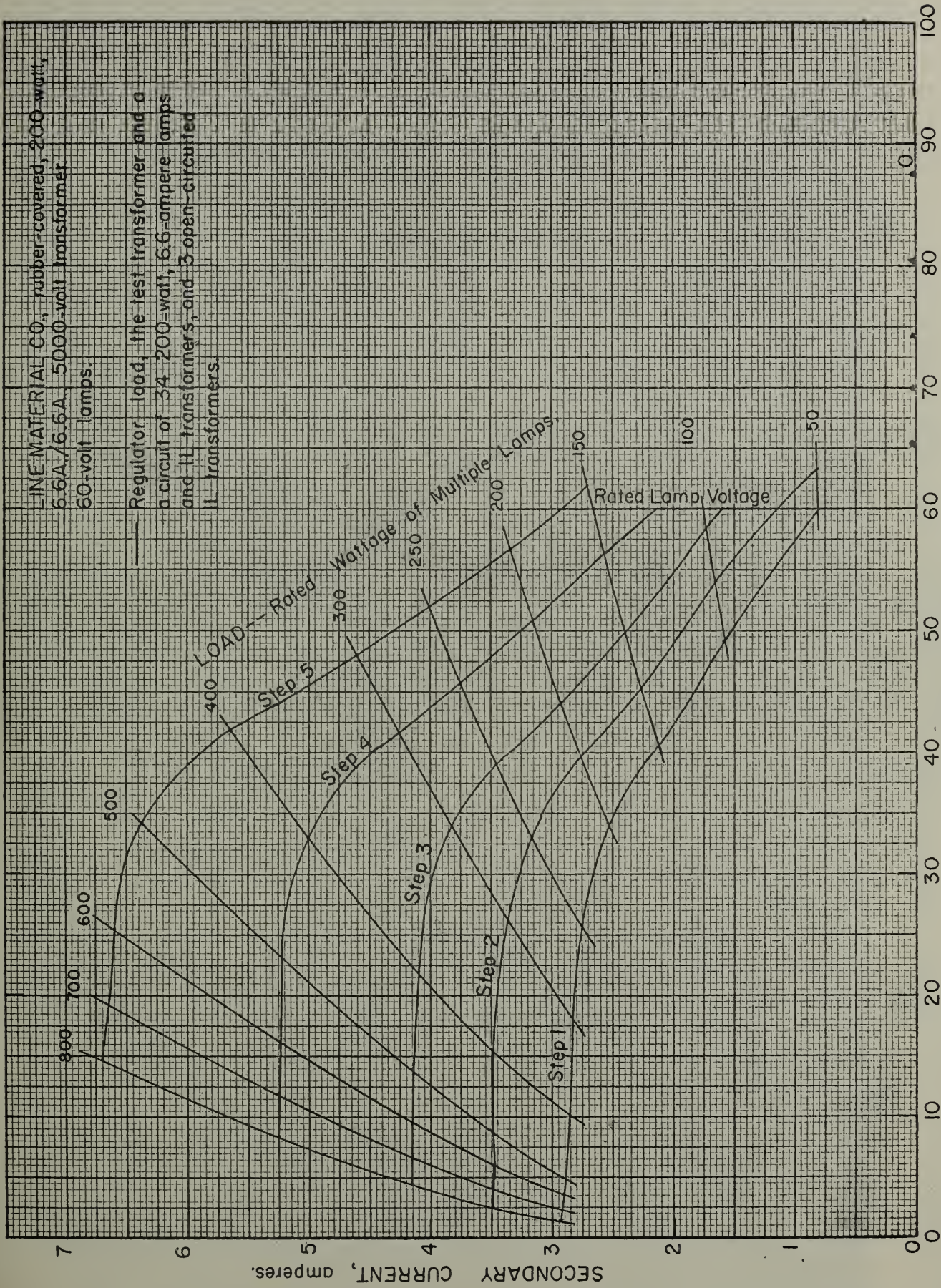
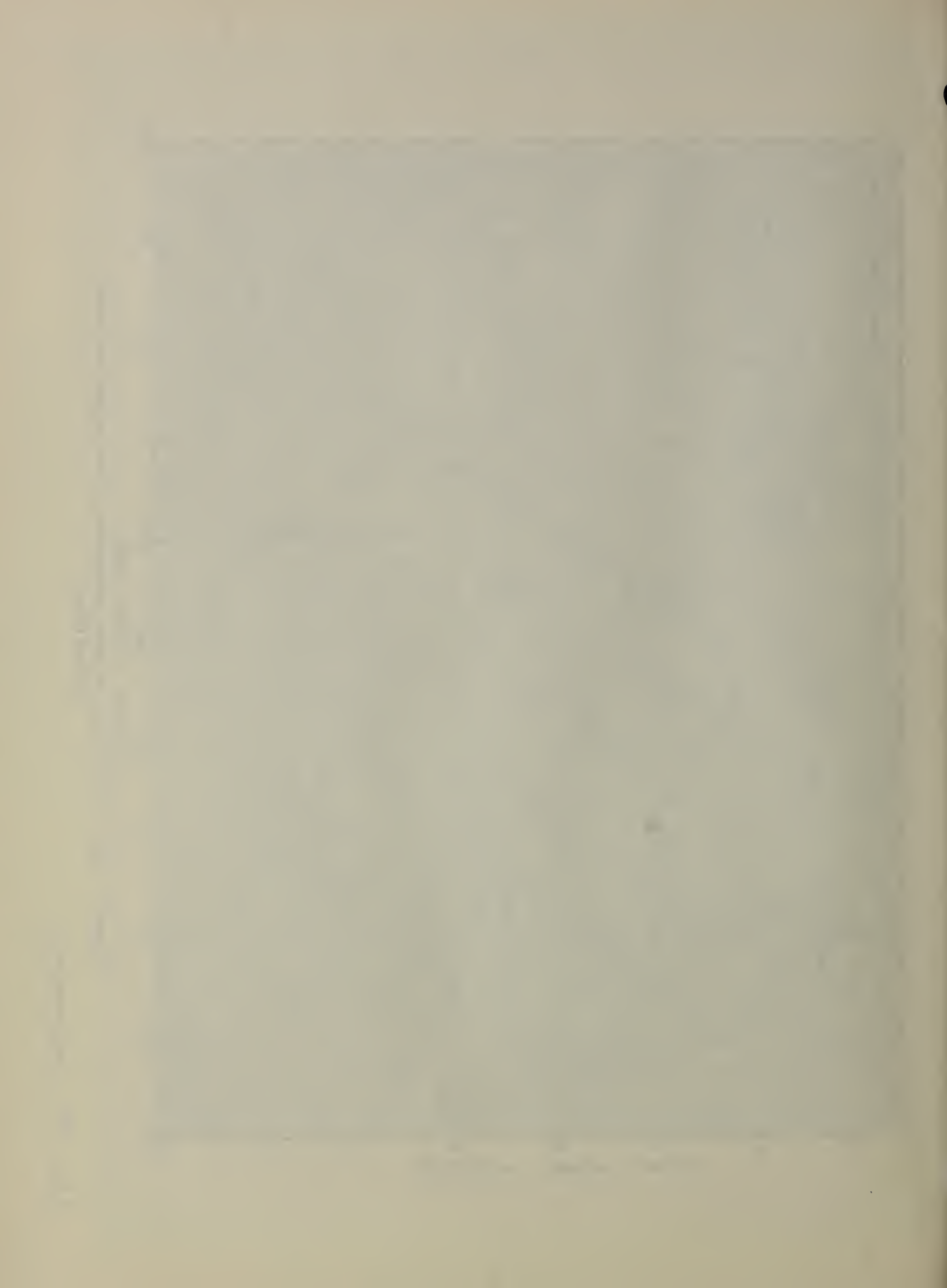


Figure 3. Output characteristics of series transformers, (with multiple-lamp loads).  
60-volt lamps.







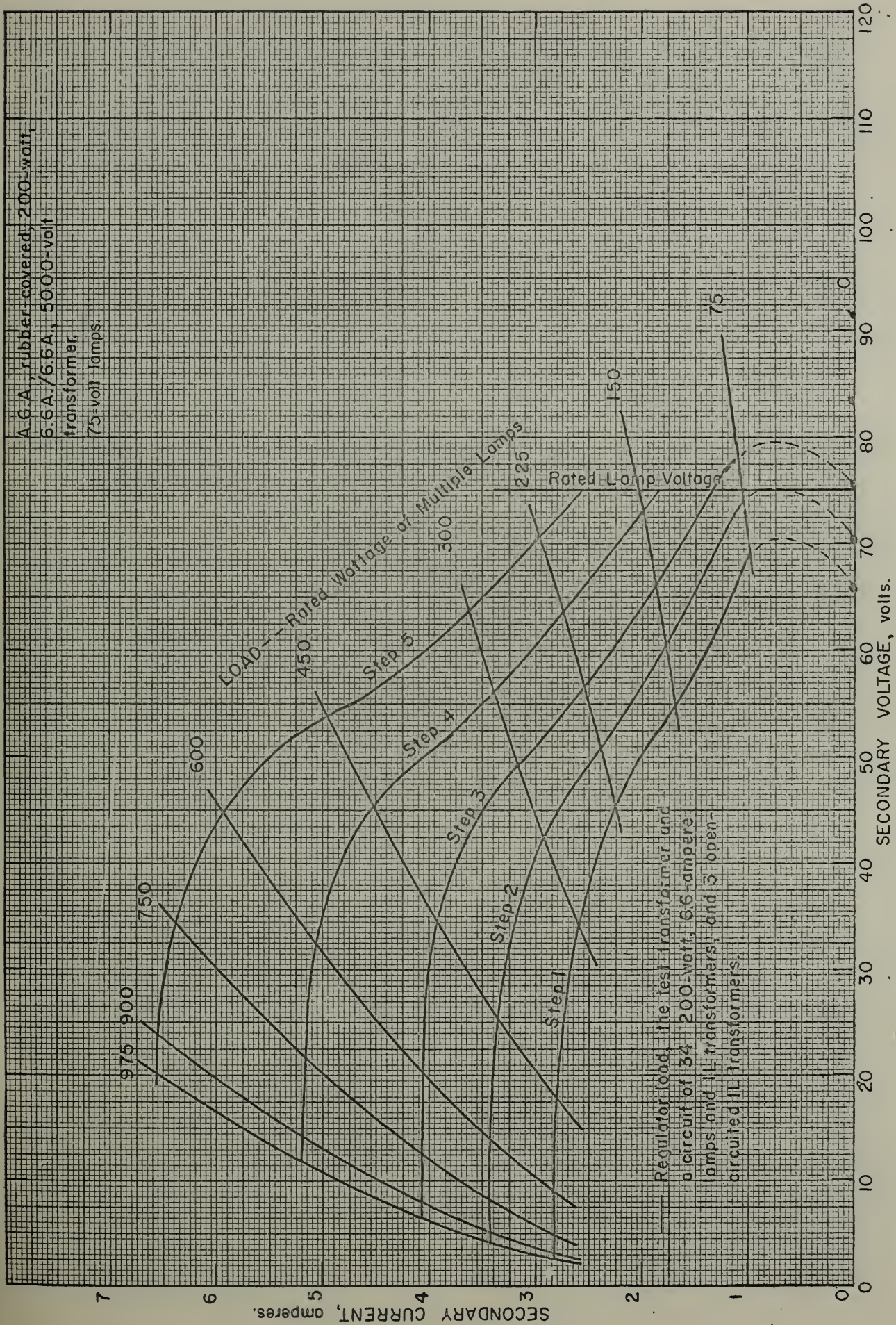


Figure 4. Output characteristics of series transformers, (with multiple-lamp loads).  
N.B.S. 6337 (Supplementary)







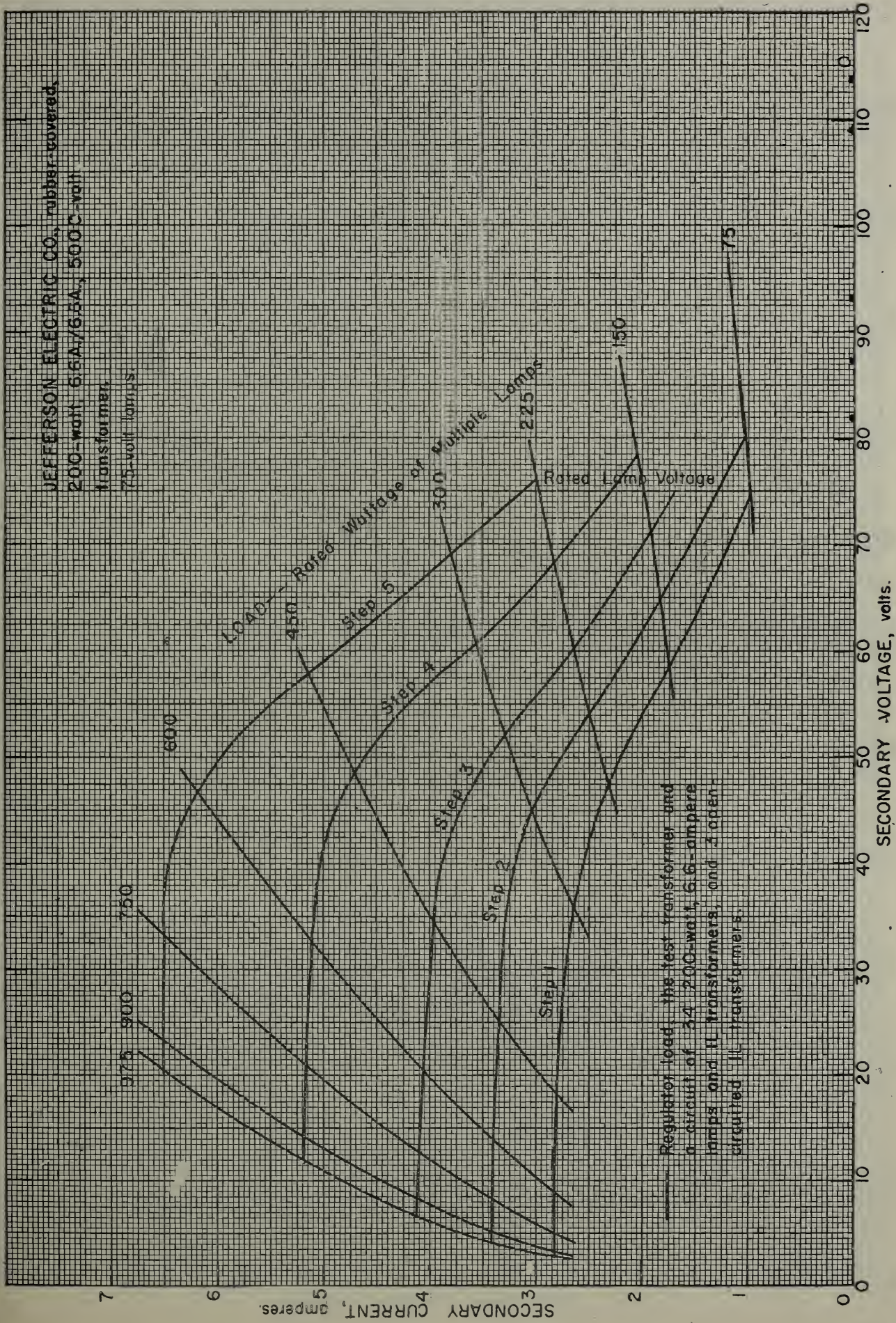


Figure 5. Output characteristics of series transformers (with multiple-lamp loads).  
75-volt lamps.

N.B.S. 6337 (Supplementary)







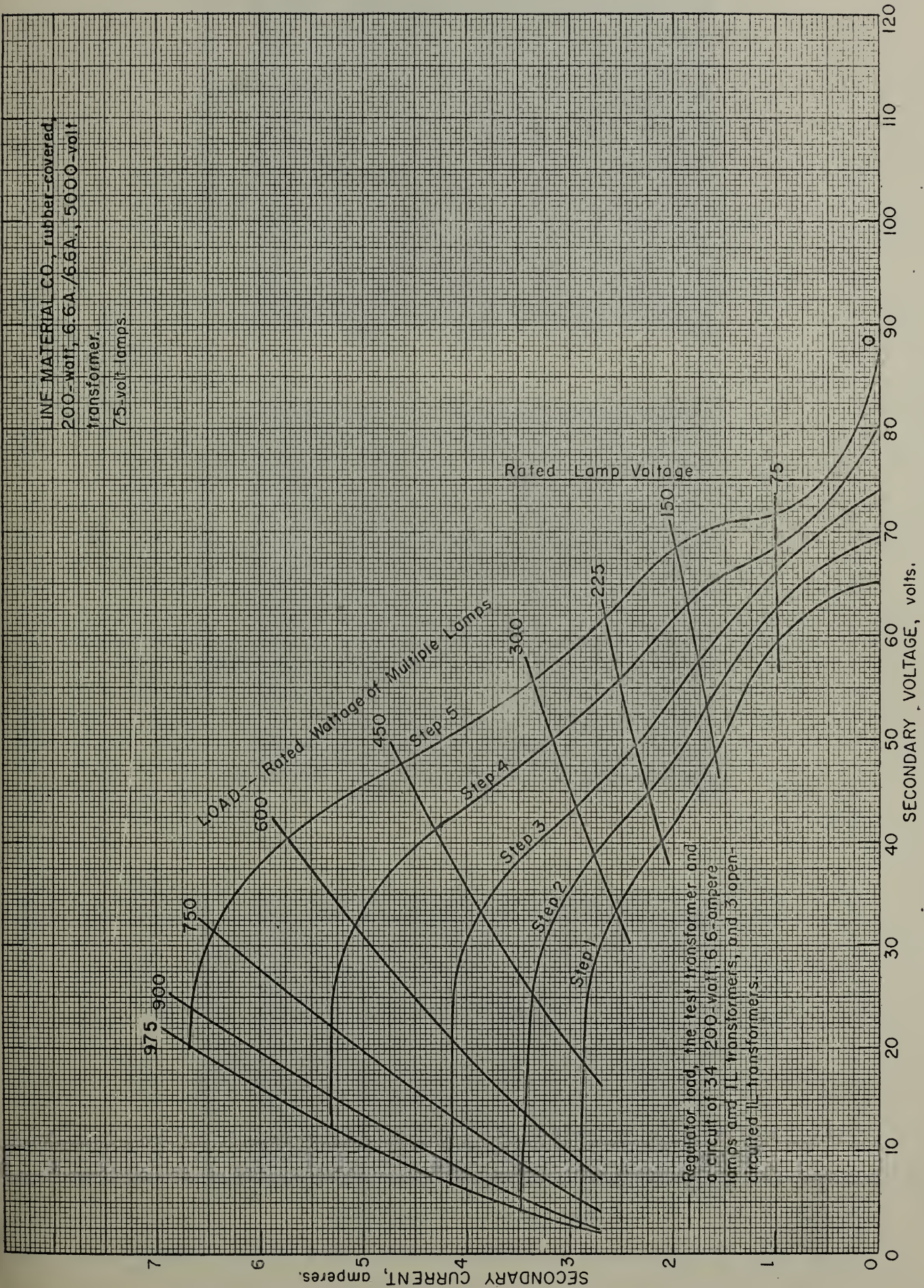


Figure 6. Output characteristics of series transformers, (with multiple-lamp loads).  
75-volt lamps.

N.B.S. 6337 (Supplementary)





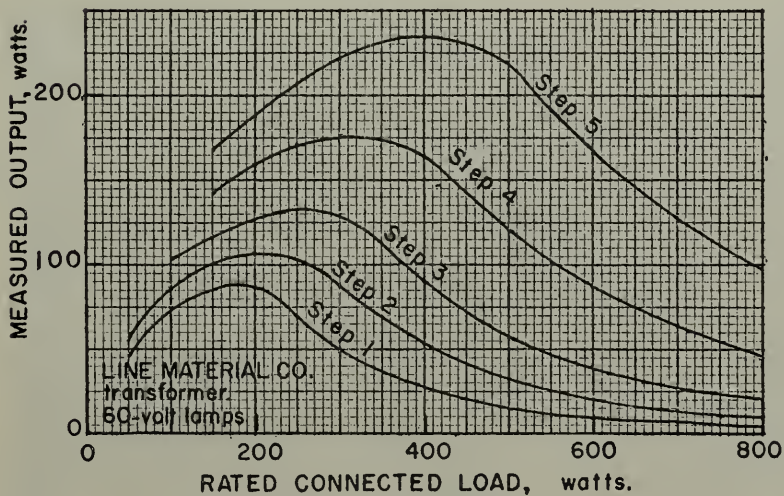
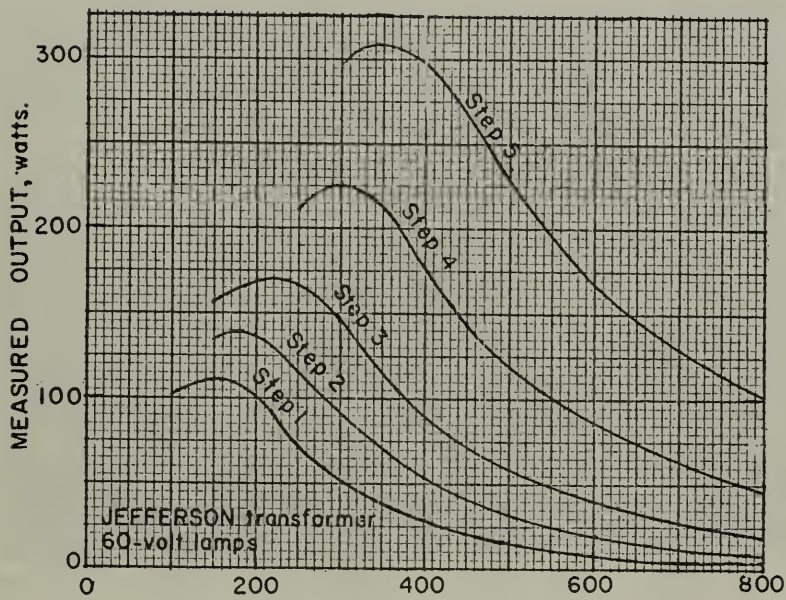
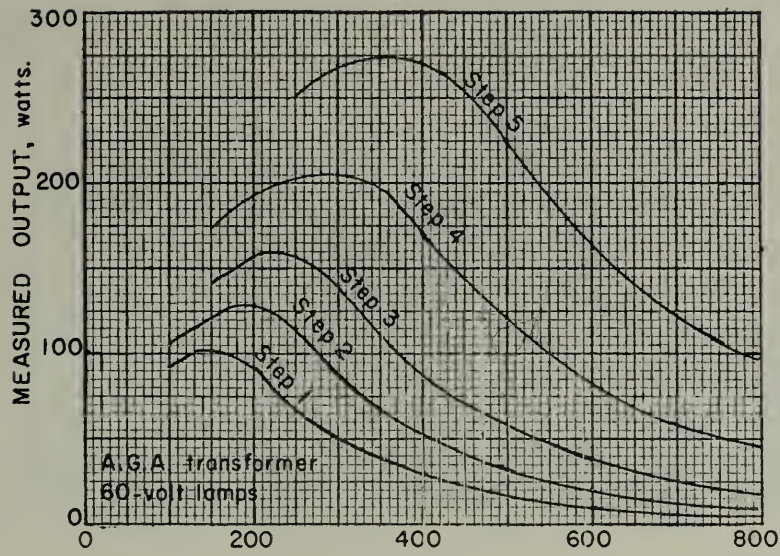


Figure 7. Output power of series transformers with multiple-lamp loads.





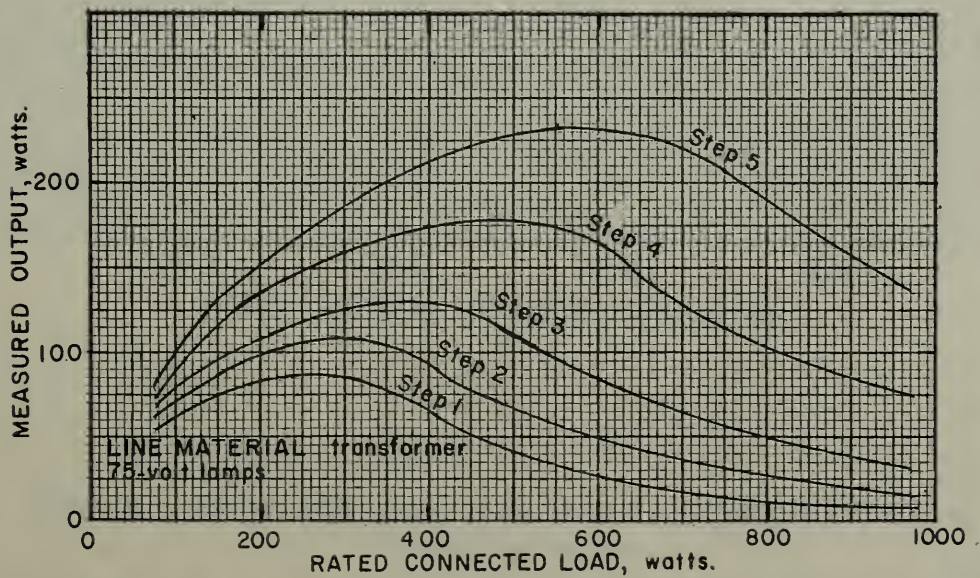
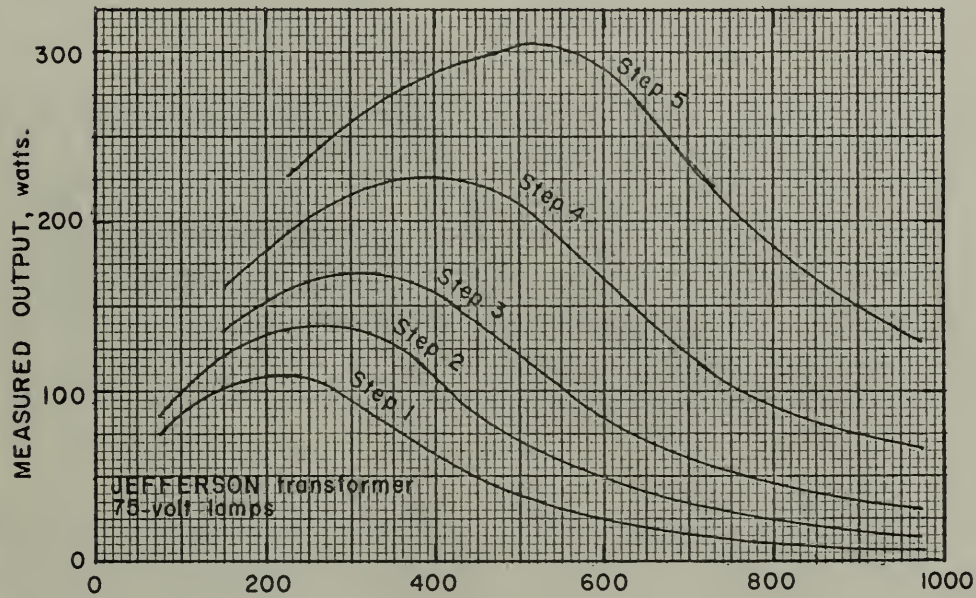
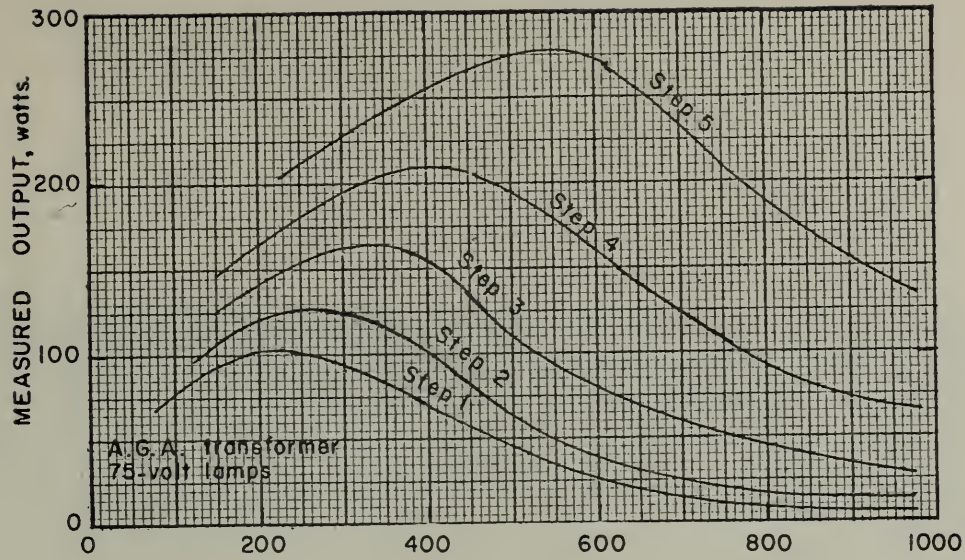


Figure 8. Output power of series transformers with multiple-lamp loads.





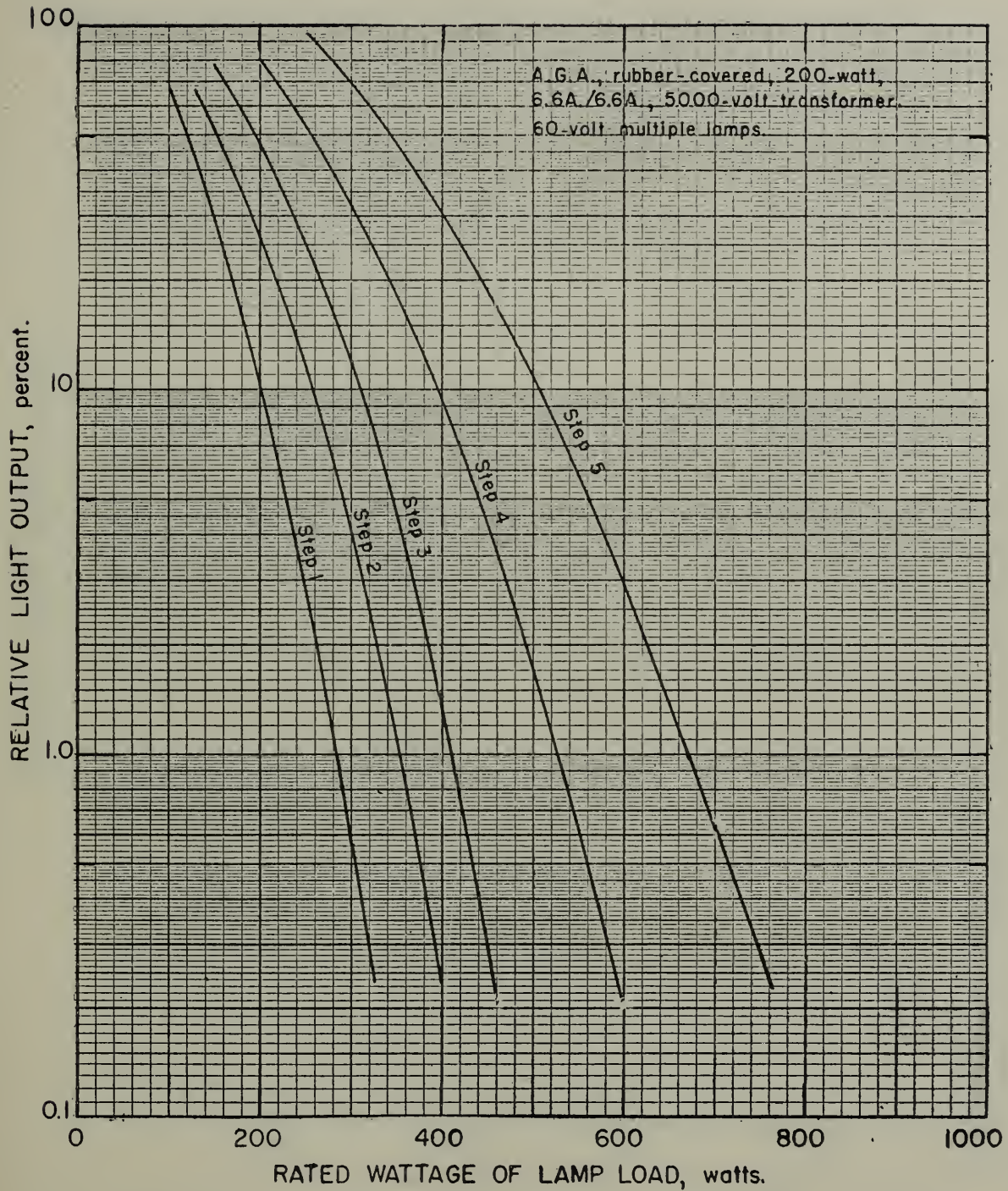


Figure 9. Relative light output of one lamp in a multiple lamp load of a series transformer.





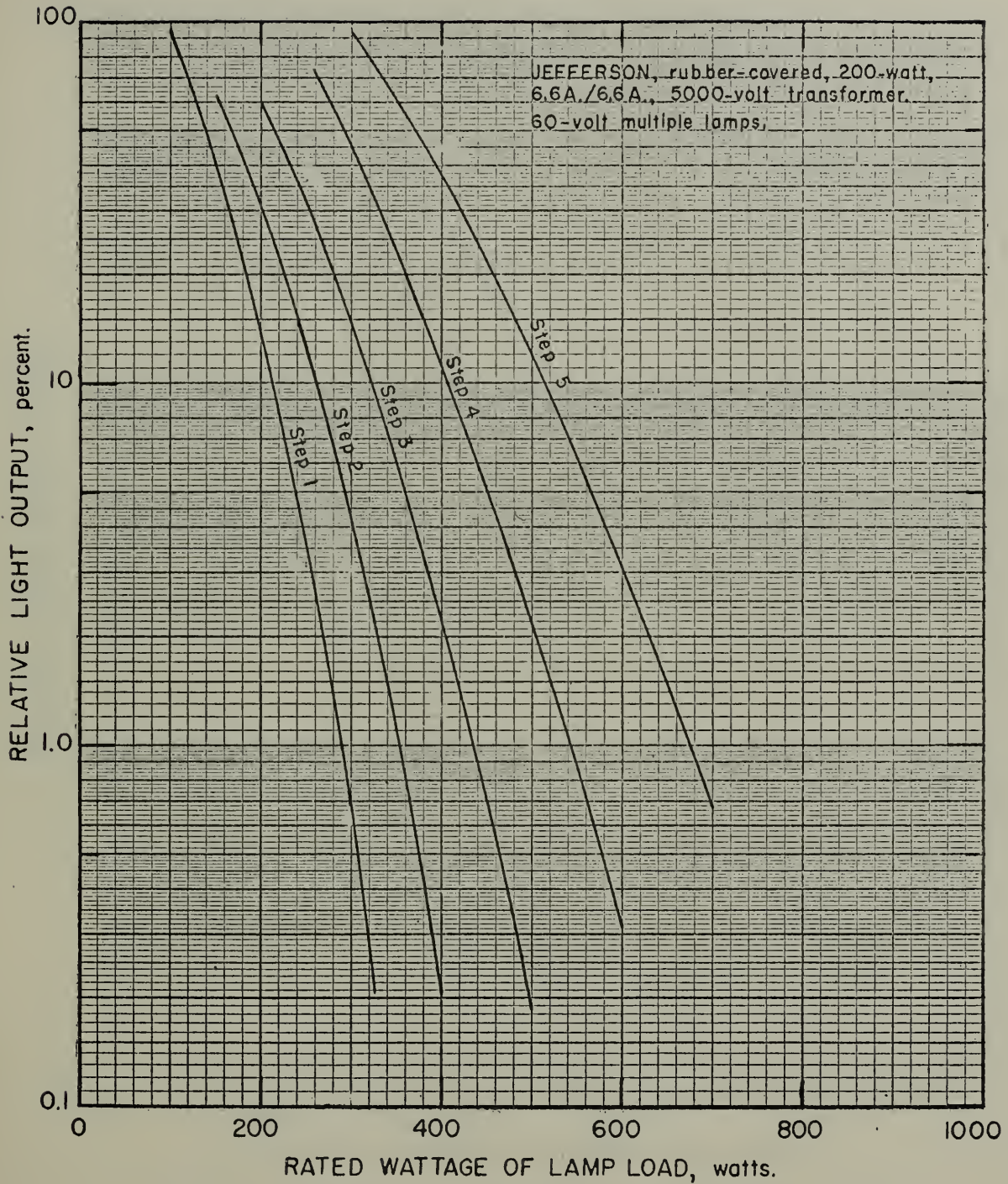


Figure 10. Relative light output of one lamp in a multiple lamp load of a series transformer.





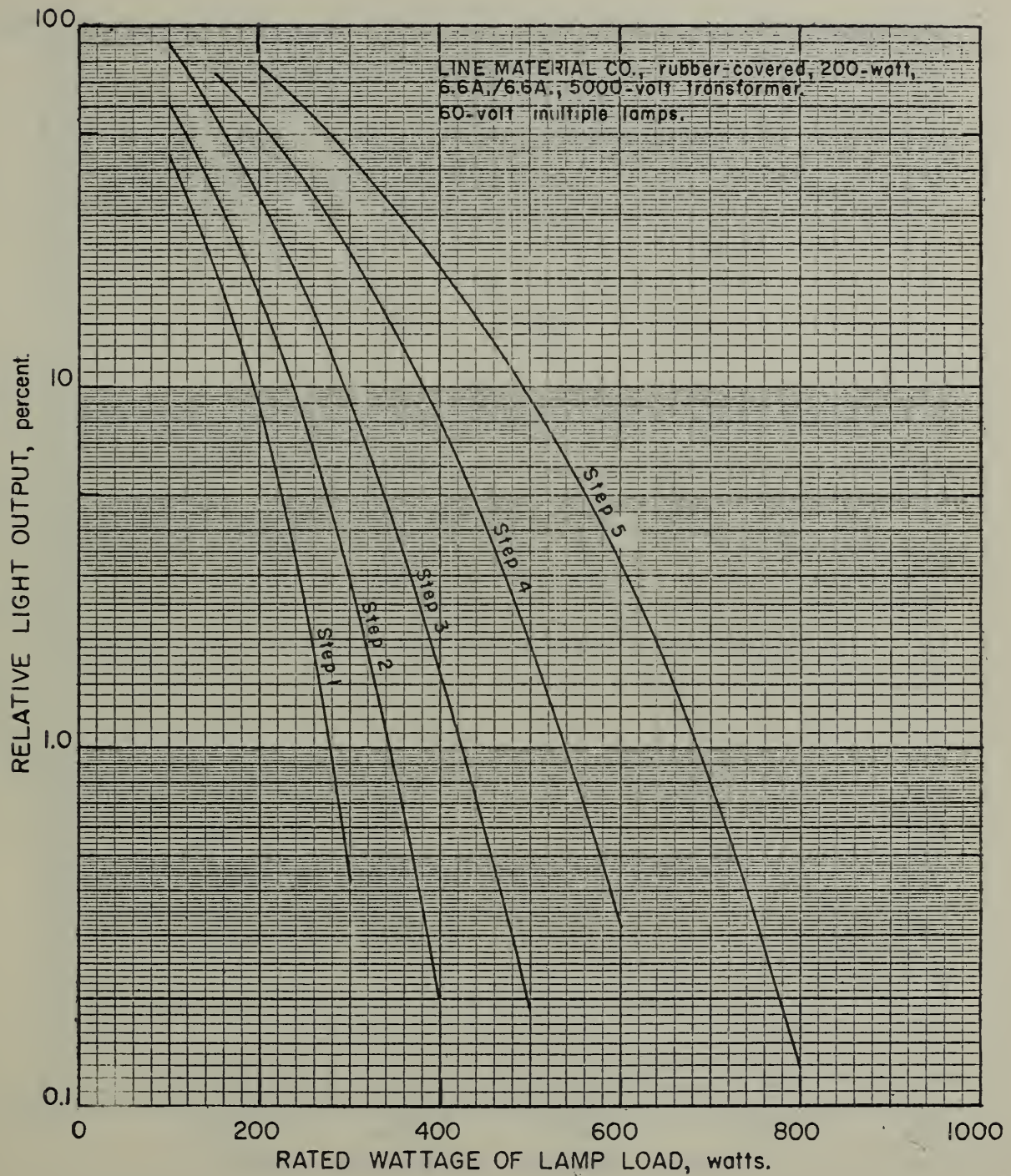


Figure II. Relative light output of one lamp in a multiple lamp load of a series transformer.





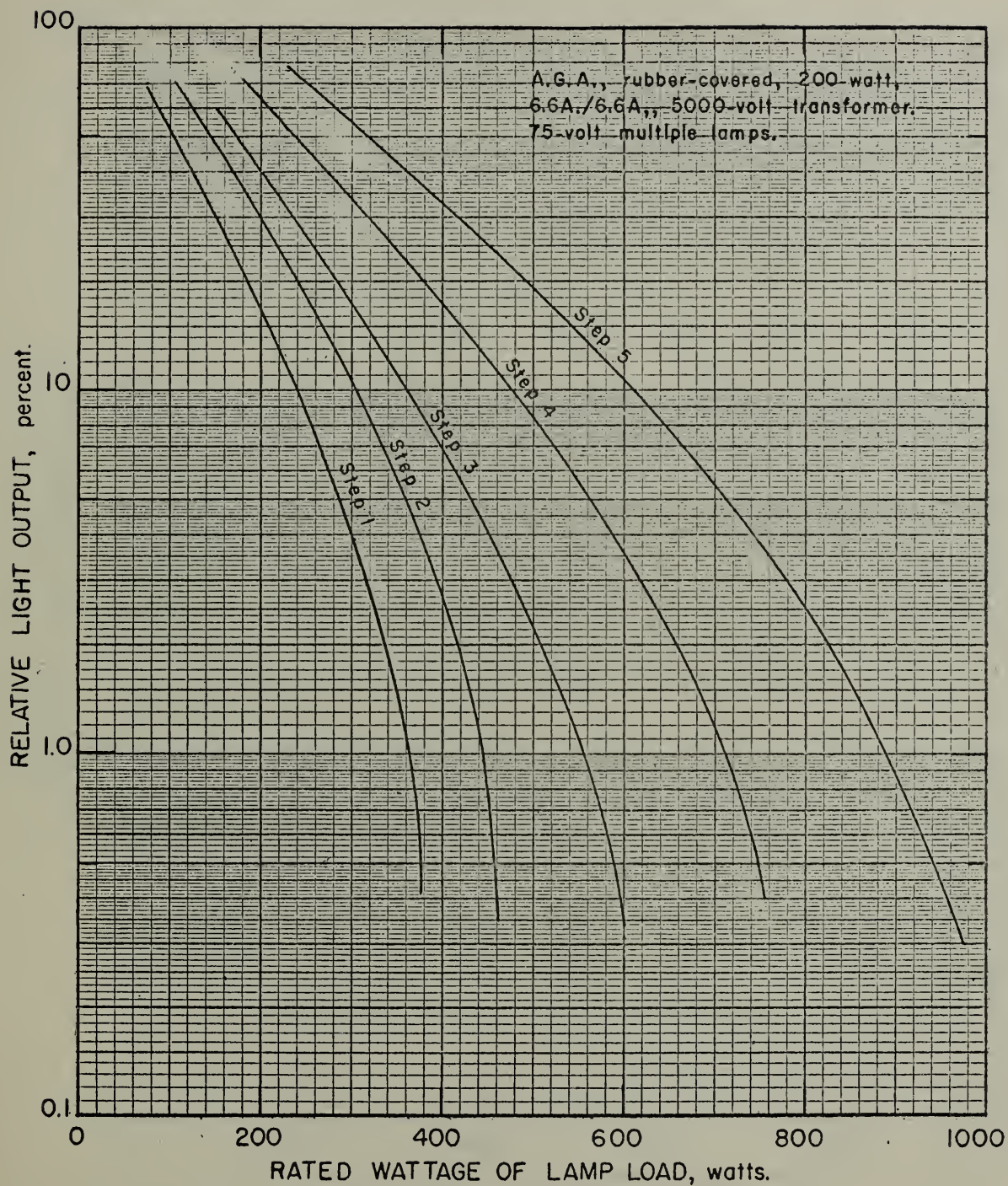


Figure 12. Relative light output of one lamp in a multiple lamp load of a series transformer.





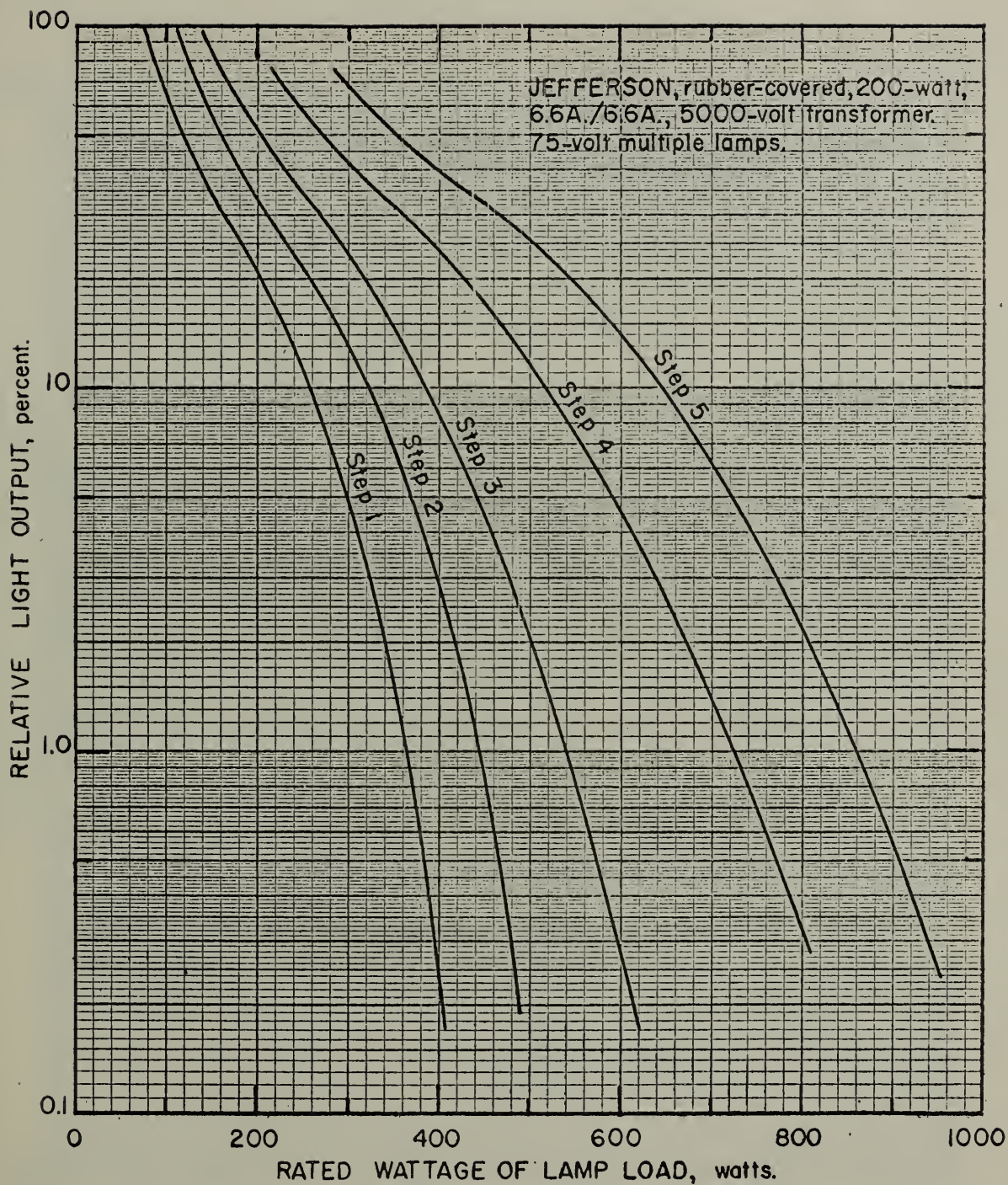


Figure 13. Relative light output of one lamp in a multiple lamp load of a series transformer.





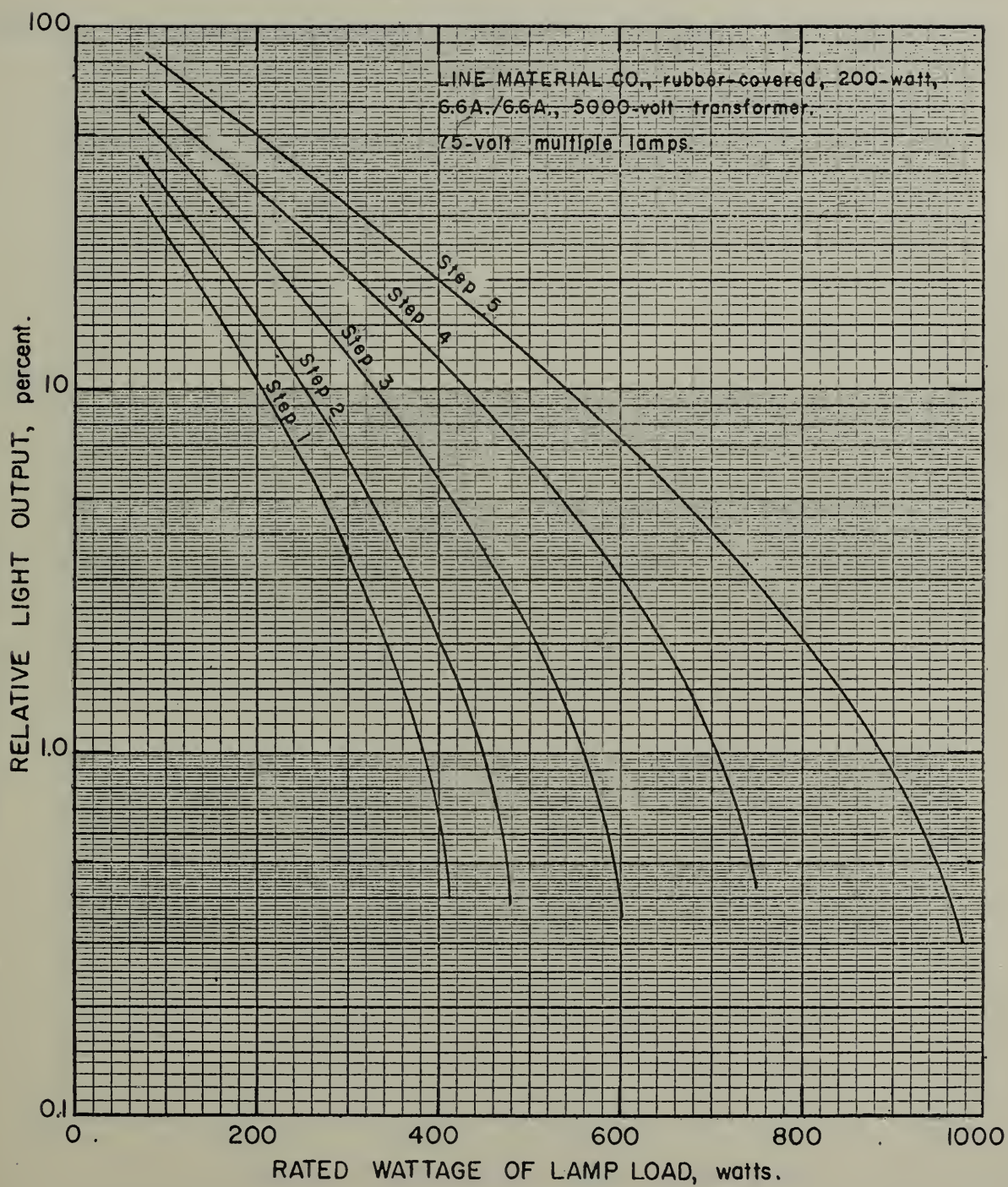


Figure 14. Relative light output of one lamp in a multiple lamp load of a series transformer.





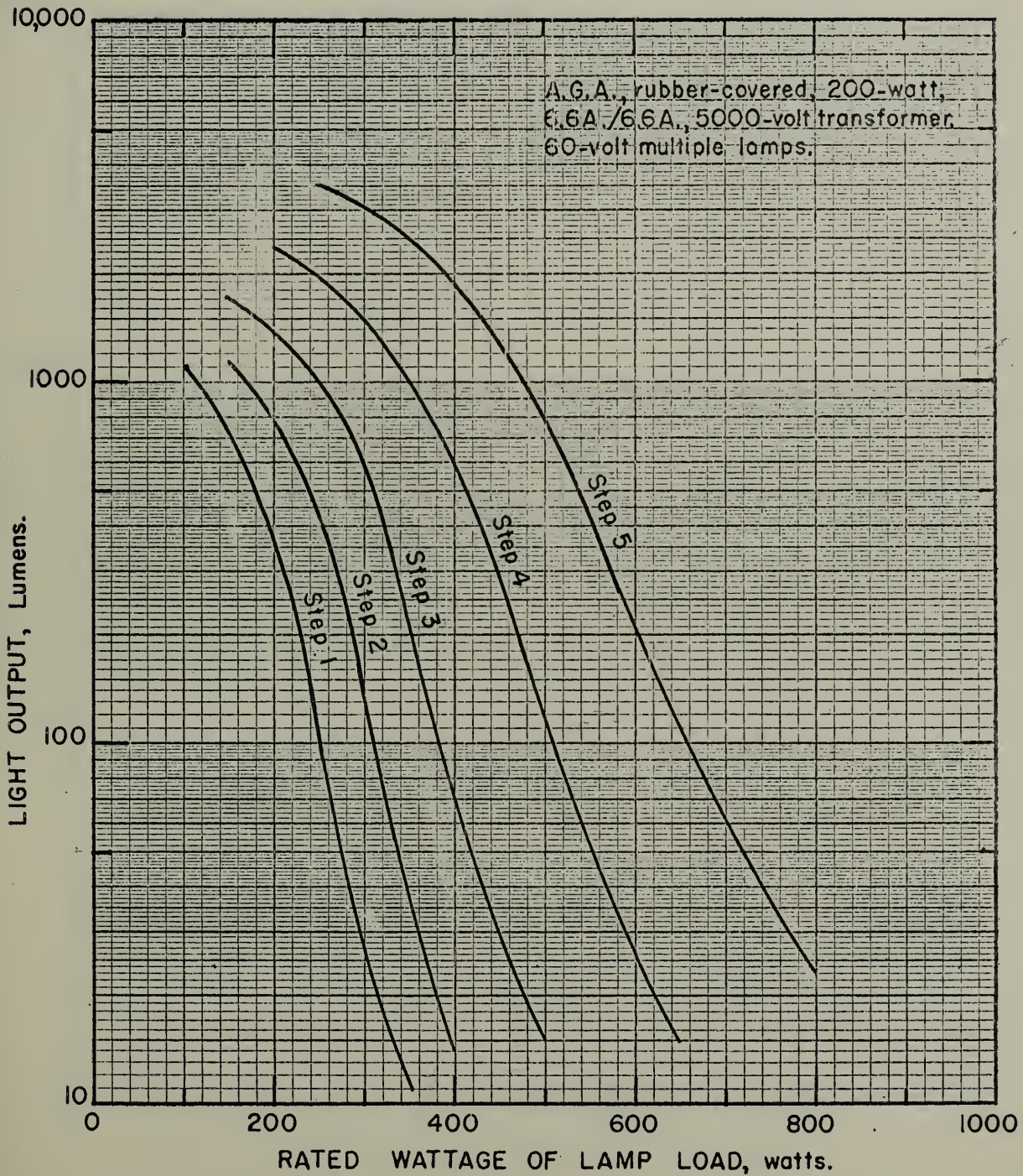


Figure 15. Lumen output of multiple-lamp load for a series transformer.





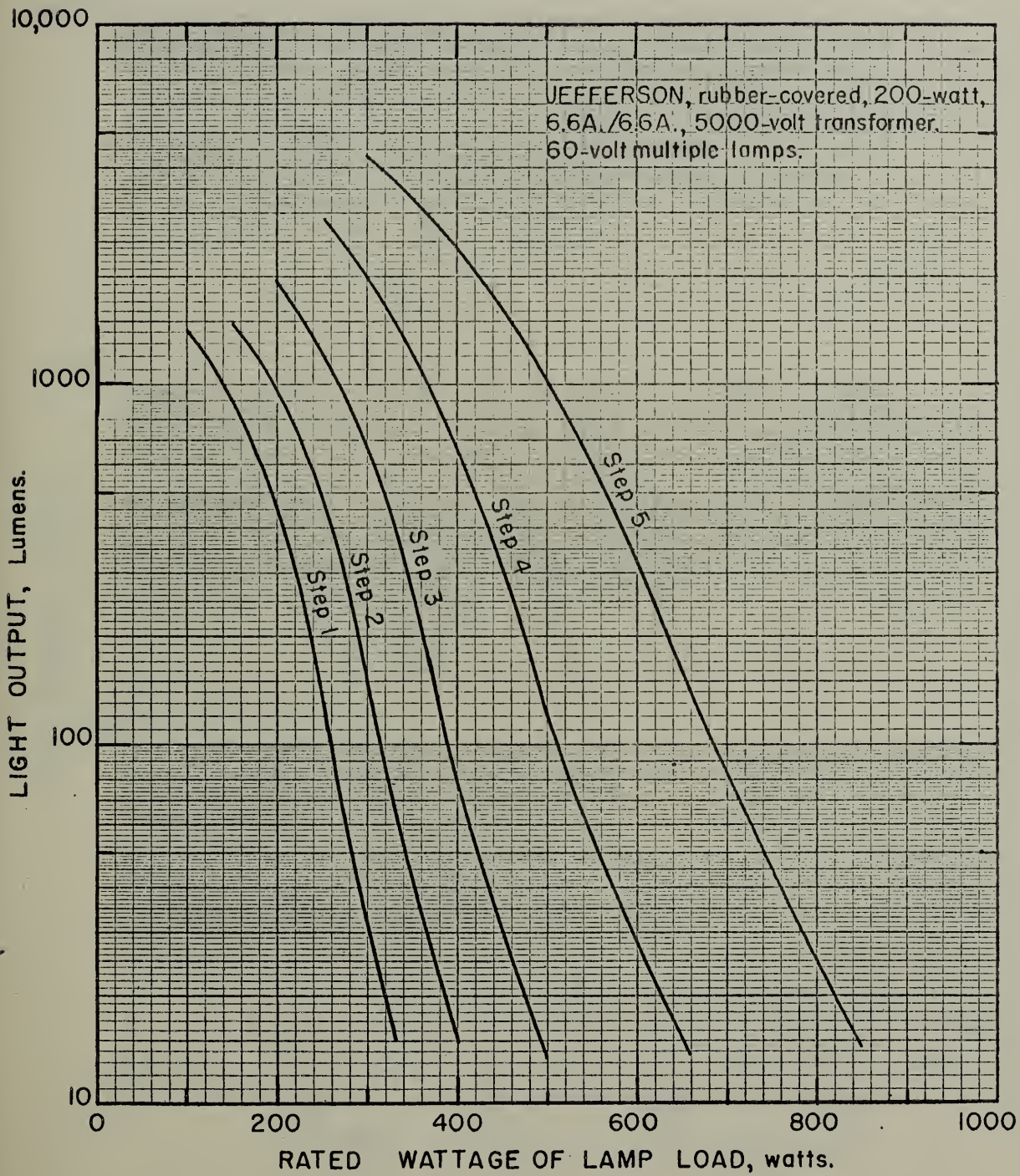


Figure 16. Lumen output of multiple-lamp load for a series transformer.





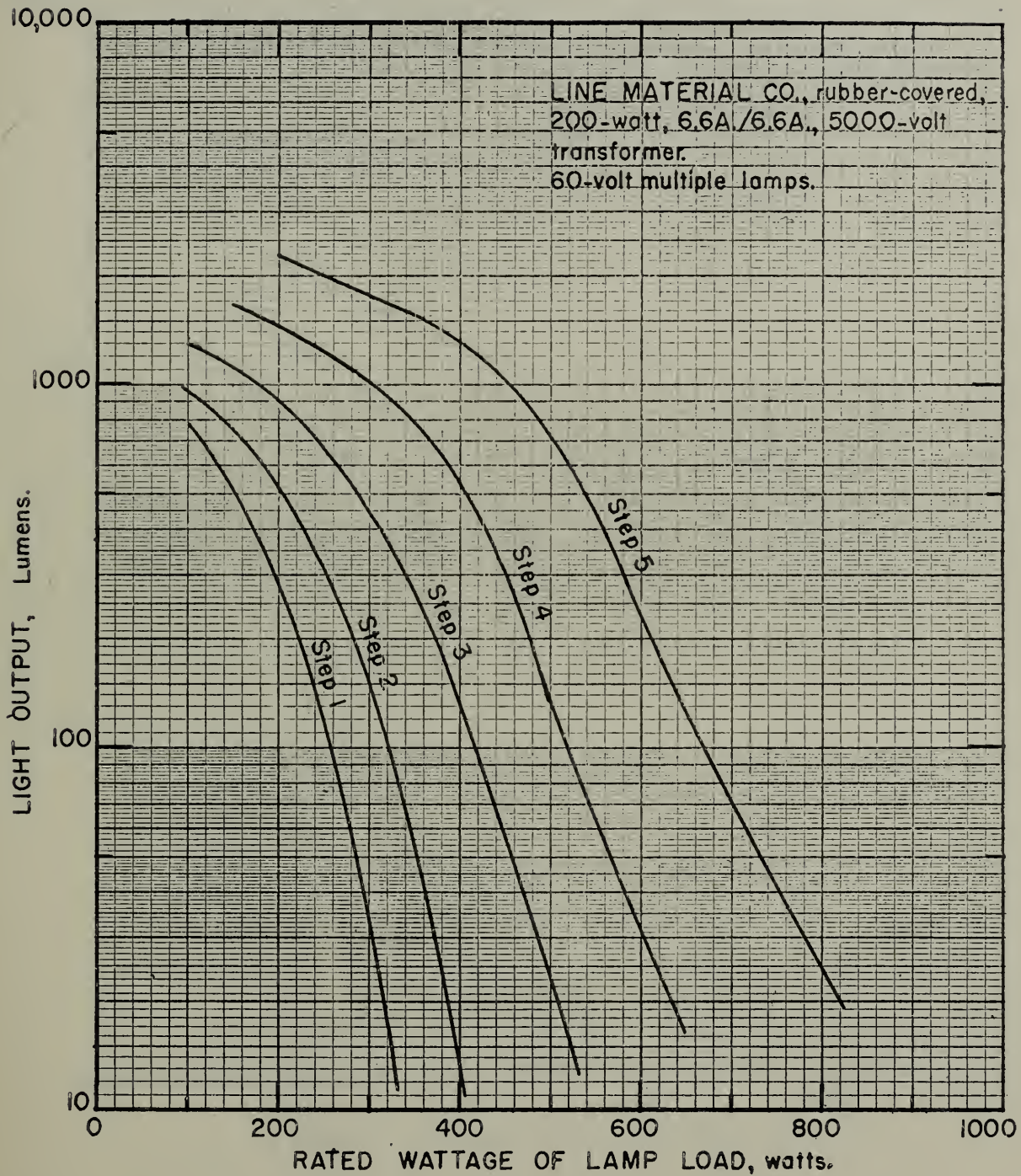


Figure 17. Lumen output of multiple-lamp load for a series transformer.





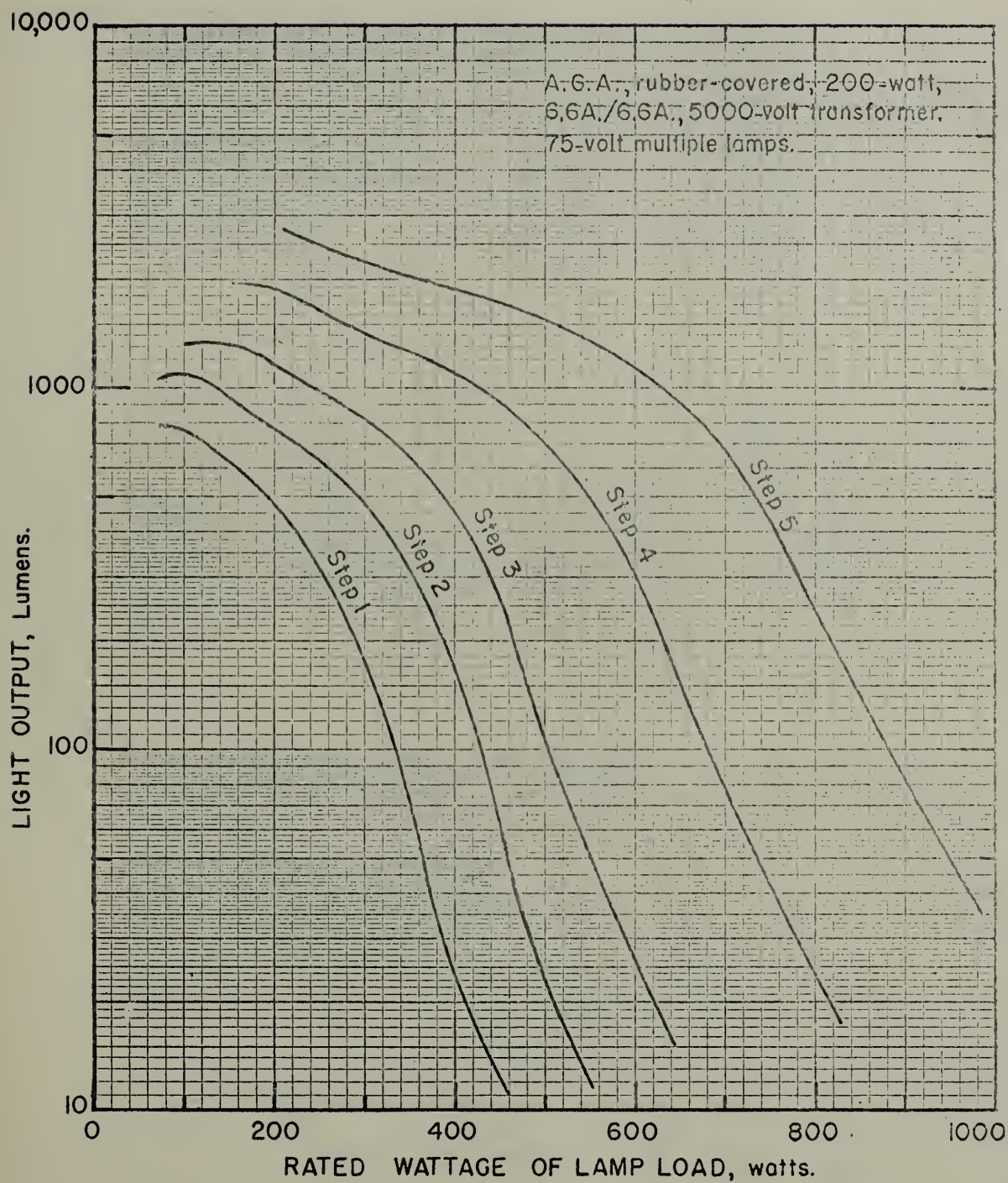


Figure 18. Lumen output of multiple-lamp load for a series transformer.





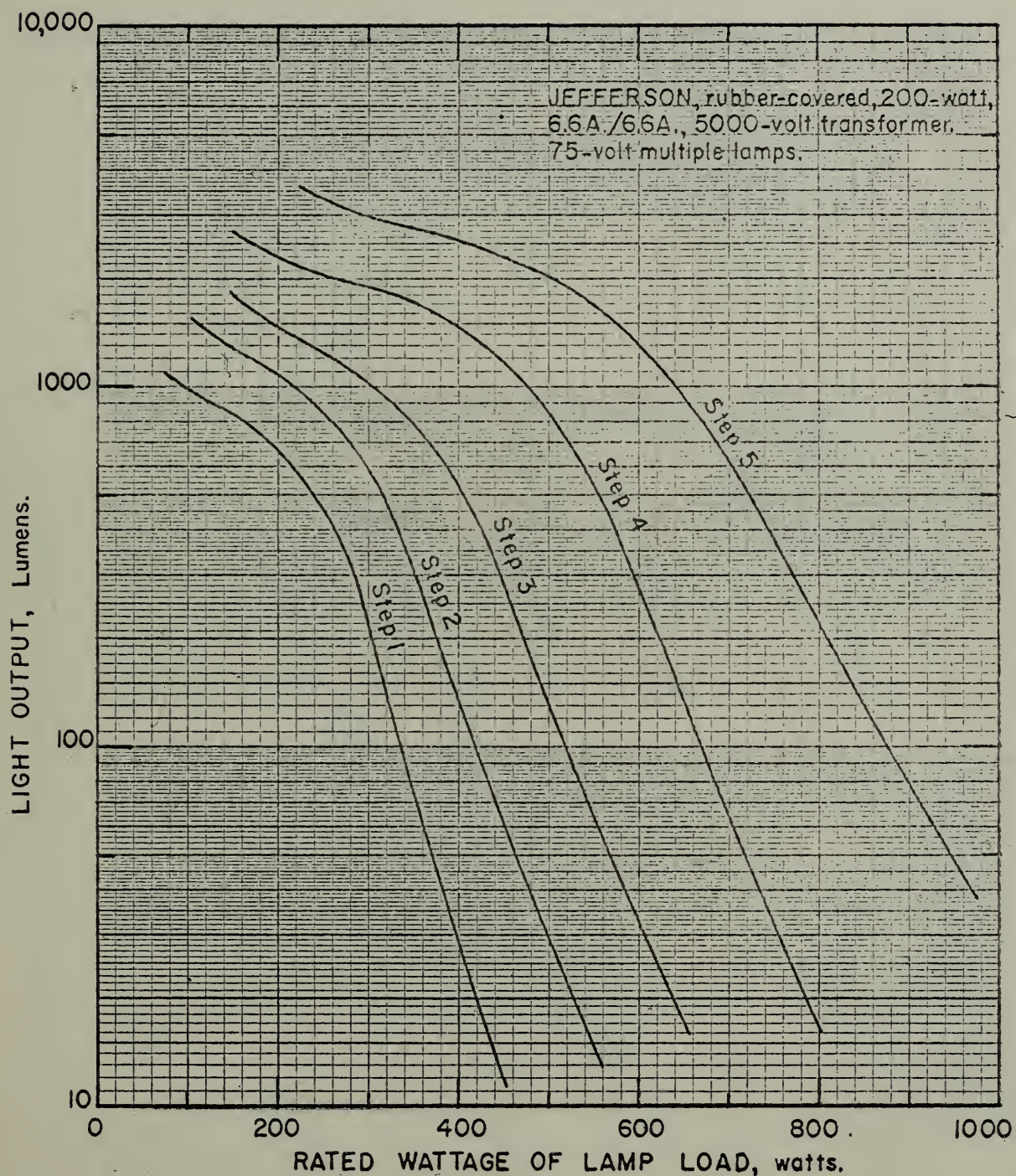


Figure 19. Lumen output of multiple-lamp load for a series transformer.





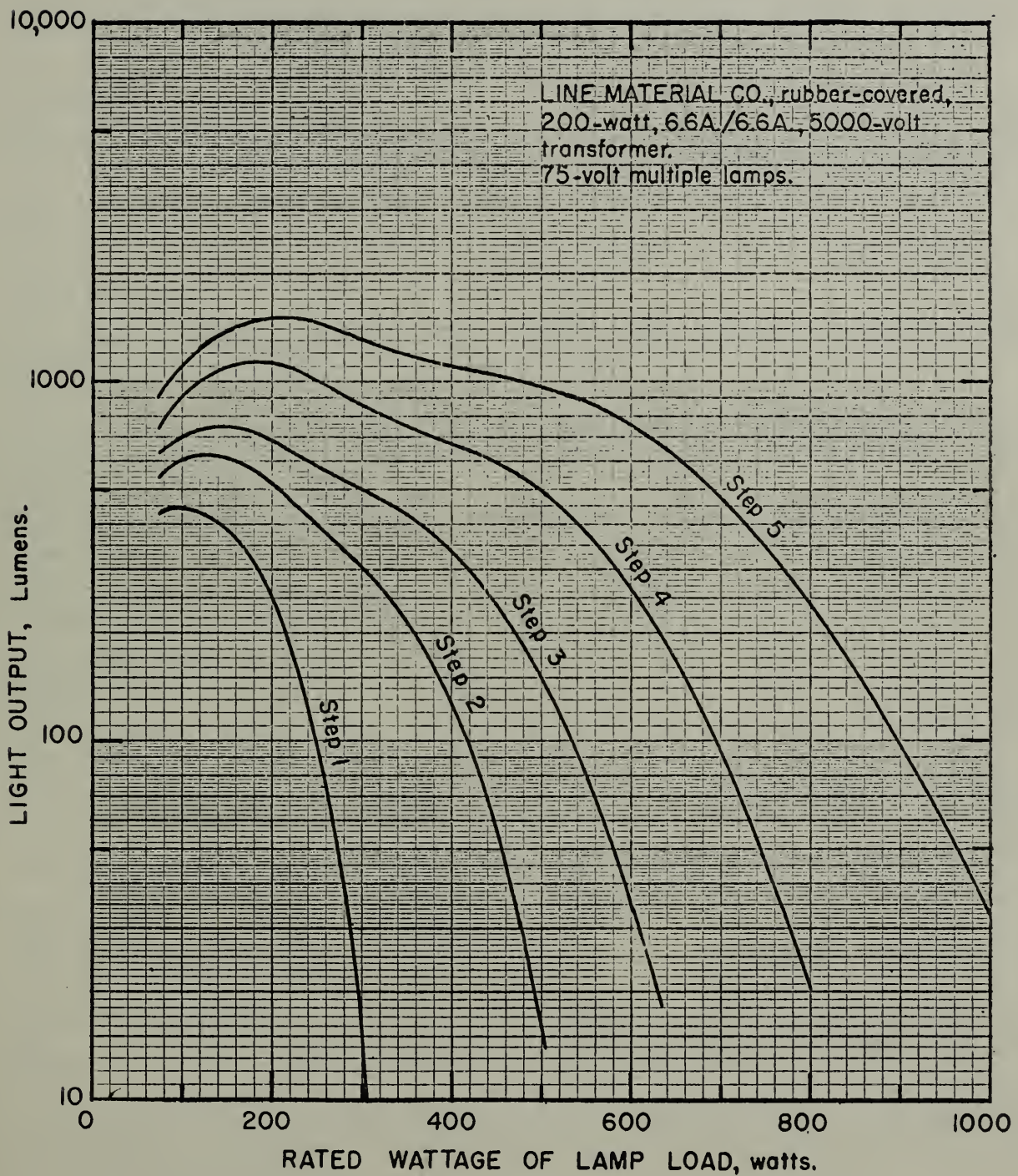


Figure 20. Lumen output of multiple lamp load for a series transformer.



U.S. DEPARTMENT OF COMMERCE

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