NATIONAL BUREAU OF STANDARDS REPORT

6190

Current-Intensity, Voltage-Intensity, and Current-Voltage
of Airfield Lighting Lamps

By
Photometry and Colorimetry Section
Optics and Metrology Division

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NATIONAL BUREAU OF STANDARDS REPORT

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NBS REPORT

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By
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Prepared For
Ship Installations Division
Bureau of Aeronautics
Department of the Navy
and
Aeronautical Accessories Laboratory
Wright Air Development Center
Department of the Air Force

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Current-Intensity, Voltage-Intensity, and Current-Voltage Characteristics of Airfield Lighting Lamps

SUMMARY

This report is an expansion of National Bureau of Standards Report 4463 and contains a compilation of measurements of the intensity-current-voltage characteristics of lamps of the types generally used in approach-, runway-, and taxiway-light systems. The results of a study of the effects of color filters on the relative intensity of the lamps are included. This report includes all data given in NBS Report 4463 in addition to the data obtained subsequent to the preparation of that report.

1. INTRODUCTION

Intensity control is now used on nearly all runway- and approach-light systems and on some taxiway-light systems. The increasing complexity of the problems of intensity control has increased the need for information on the relative intensity characteristics of lamps used in approach, runway, and taxiway lighting as a function of the applied current or voltage. In addition, information on the effect of color filters upon the relative intensity is needed. This report was prepared to meet this need.

Relative intensity is defined as the ratio, in percent, of the intensity of a lighting unit or lamp operated at a given current or voltage to the intensity of the same lighting unit or lamp operated at rated current or voltage. Note that in obtaining the relative intensity of a colored light, measurements of the intensity at both the given current or voltage and the rated current or voltage are made with the color filter in place. Thus, the transmittance of the filter has only a second-order effect on the relative intensity.

2. METHOD OF MEASUREMENT

A color-corrected barrier-layer photocell in a zero-resistance circuit was used in making relative intensity measurements. The response of this photometric system was checked. No significant deviations from

linearity were found. When reflector-type lamps were tested, the peak of the beam was directed at the photocell. The relative intensities of lamps other than the reflector type (325-lumen; 200-watt, T-14; etc.) were obtained by measuring the relative horizontal intensity in a given direction. Previous tests have shown that the relative intensity of the clear units in which these lamps are used does not differ significantly from the relative horizontal intensity of the lamps used. Voltage and current measurements were corrected for losses in the measuring circuits. Whenever possible several lamps of a given type were used, and the results of measurements of individual lamps were averaged.

3. LAMP CHARACTERISTICS

The characteristics of each lamp are given as three curves: a, relative intensity-current; b, relative intensity-voltage; and c, voltage-current. Curves for lamps with similar characteristics have been grouped on the same figures. In addition, relative intensity-voltage characteristics of all 25- and 12.5-volt lamps, the relative intensity-current characteristics of all 20- and 10-ampere lamps and of all 6.6-ampere lamps have been grouped. The lamp types studied and the figures showing their characteristics are listed in table I.

Differences in relative intensity between lamps of the same type may become large when the relative intensity becomes less than 1%. The relative intensities may differ by as much as a factor of 2 when the relative intensity is about 0.2%.

4. EFFECTS OF COLOR FILTERS

Because the transmittance of color filters is a function of the color temperature of the source, the relative intensity characteristics of colored lights will differ from those of similar lights which are "white." The determination and presentation of the relative intensity characteristics of each type of lamp for each aviation color would be unduly expensive. Therefore a study has been made to determine representative correction curves. Relative intensity characteristics were determined for several of the types of lamps listed in Table I in combination with filters representative of the limits of the aviation colors. It was found that the data were adequately represented by the lines plotted on figure 22. These lines show the relative intensity of lights meeting the specification requirements for aviation colors as a function of the relative intensity of the same light used without a filter. The lines are

Table 1

Lamp Type	Designation	Filament Type	Figure
100-watt, 4.17-ampere, sealed reflector, elevated runway light	7656 F/01	C-6	1a, b, c
35-watt, 5.83-ampere, sealed reflector, aerodrome light	6298 X/01	CC-6	2a, b, c
325-lumen, 6.6-ampere, airport marker	325/6.6/A21	C-8	3a, b, c
1020-lumen, 6.6-ampere, airport marker	1020/6.6/A21	C-8	3a, b, c
30-watt, 6.6-ampere, T-10, runway, medium intensity	6.6A/T10/1P	C-2V	3a, b, c
45-watt, 6.6-ampere, T-10, runway, medium intensity	6.6/T10P	C-2V	3a, b, c
45-watt, 6.6-ampere, PAR38, airport flood	45PAR38/6.6	C-6	3a, b, c
200-watt, 6.6-ampere, T-14, runway, high intensity	6.6A/T14P	C-13	4a, b, c
200-watt, 6.6-ampere, PAR46, special	----	CC-6	4a, b, c
200-watt, 6.6-ampere, PAR56, airport approach, high intensity	6.6A/PAR56/2	C-13	4a, b, c
500-watt, 6.6-ampere, T-20, runway, high intensity	6.6A/T20P	C-13D	5a, b, c
250-watt, 10-ampere, T-14, airport marker	----	C-13	6a, b, c
100-watt, 20-ampere, PAR36, flush approach and runway	20A/PAR36	C-6	7a, b, c
120-watt, 20-ampere, PAR64, transmissometer	120PAR	C-6	8a, b, c
300-watt, 20-ampere, PAR56, airport approach, high intensity	20A/PAR56	C-6	9a, b, c
500-watt, 20-ampere, T-20, runway threshold, high intensity	20A/T20/5	C-13	10a, b, c
500-watt, 20-ampere, PAR56, seadrome, pile mounted	20A/PAR56/1	C-6	10a, b, c
500-watt, 20-ampere, T-24, seadrome, buoy mounted	20A/T24/3	C-8	10a, b, c
All 6.6-ampere lamps	----	---	11
All 20-ampere and 10-ampere lamps	----	---	12
50-watt, 6-volt, PAR36, marine light	4588	C-6	13a, b, c
75-watt, 30-volt, PAR38, floodlight	75PAR/FL	C-6	14a, b, c
75-watt, 75-volt, PAR38, floodlight	75PAR/FL	CC-6	14a, b, d
100-watt, 6.5-volt, PAR36, marine light	4586	C-6	15a, b, c
100-watt, 12.5-volt, PAR56, marine searchlight	4545	C-6	16a, b, c
100-watt, 13-volt, PAR36, marine light	4519	C-6	16a, b, c
200-watt, 30-volt, PAR56, locomotive headlight	200PAR	C-13	17a, b, c
200-watt, 30-volt, PAR56, locomotive headlight	200PAR	CC-8	17a, b, c
250-watt, 12.5-volt, T-10, airport approach	20A/T10/P	C-8	18a, b, c
250-watt, 12.5-volt, PAR56, airport approach	250PAR	C-6	18a, b, c
300-watt, 25-volt, PAR56, airport approach	300PAR56	C-13	19a, b, c
350-watt, 25-volt, PAR56, airport approach	350PAR	C-13	19a, b, c
399-watt, 115-volt, PAR56, airport approach	399PAR	CC-13	20a, b, c
500-watt, 120-volt, T-20, airport approach	500T20/25	C-13	20a, b, c
All 25-volt and 12.5-volt lamps	----	---	21

representative of "average" filters. The relative intensity of lights with filters near the specification limits may differ from that indicated by the lines by about ten percent at the lowest relative intensities shown. The difference will, of course, be less at higher relative intensities.

5. DISCUSSION

Differences in the change of relative intensity with change in current or voltage for different lamps are significantly large so that generalized lamp-characteristic exponents cannot be satisfactorily used for all lamp types when the relative intensity is varied over a wide range.

For series lamps with the same rated current and of similar design wattage (within 25%), the relative intensity-current characteristics are similar. See the curves on figures 11 and 12. The data shown on figure 21 indicate that relative intensity-voltage characteristics are similar for multiple lamps of similar design wattage.

The data shown in figures 18a, 18b, and 18c indicate that the characteristics of reflector-type lamps are not significantly different from those of other lamp types of the same rated wattage and voltage or current.

November 1958

US COMM NBS DC

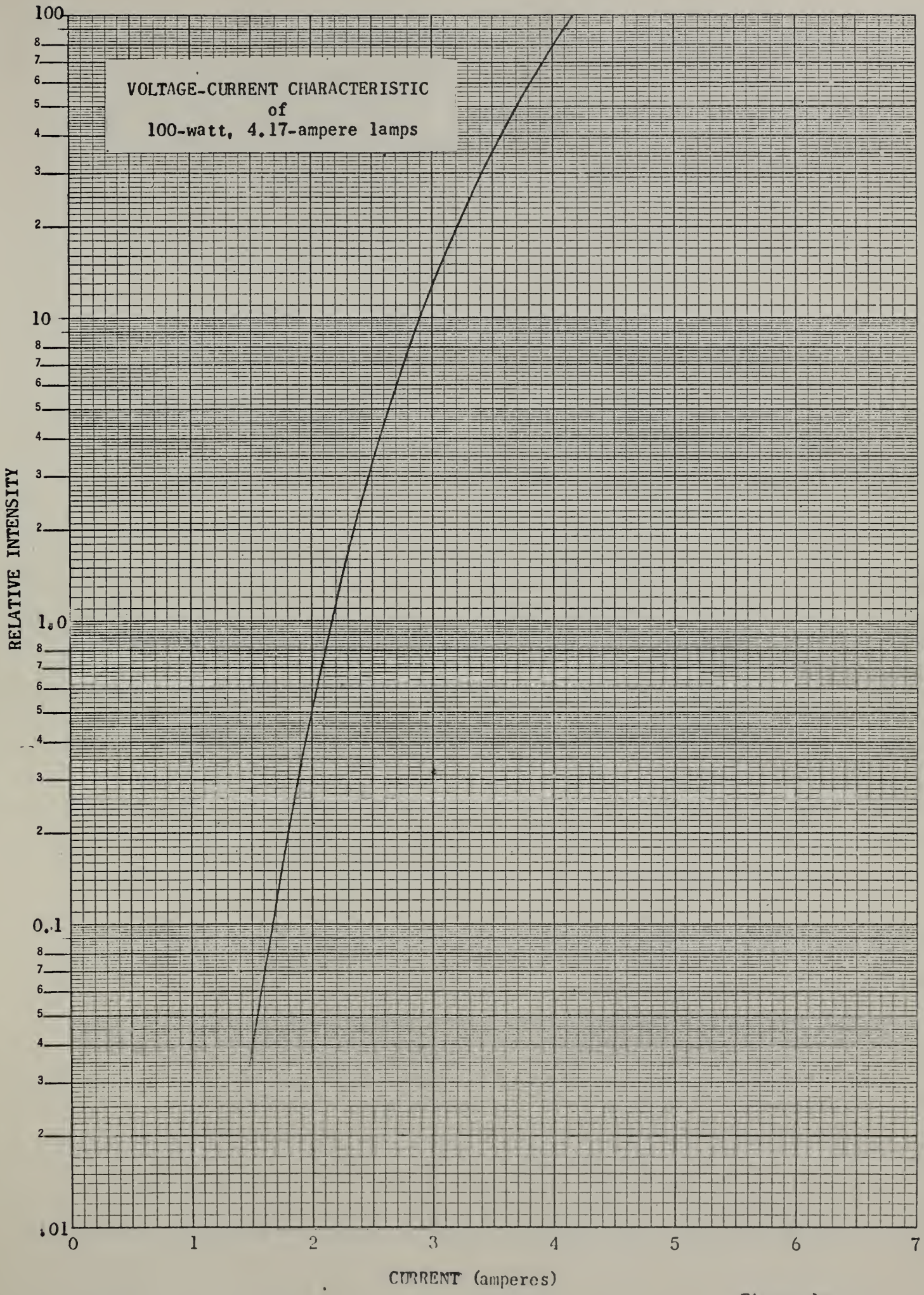
VOLTAGE-CURRENT CHARACTERISTIC
of
100-watt, 4.17-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
CURRENT (amperes)
0
1
2
3
4
5
6
7

Figure 1a

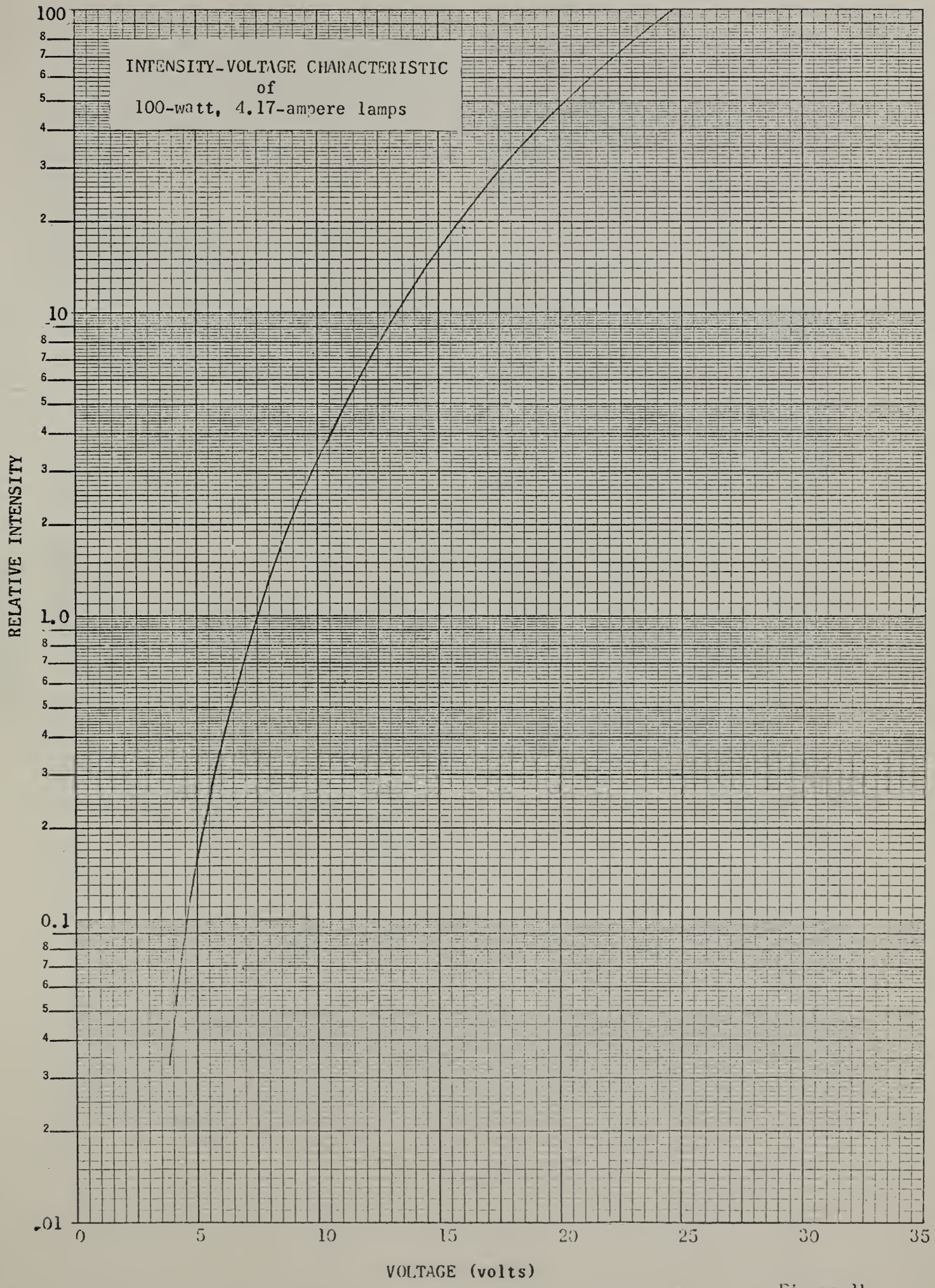
INTENSITY-VOLTAGE CHARACTERISTIC
of
100-watt, 4.17-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
5
10
15
20
25
30
35
VOLTAGE (volts)

Figure 1b

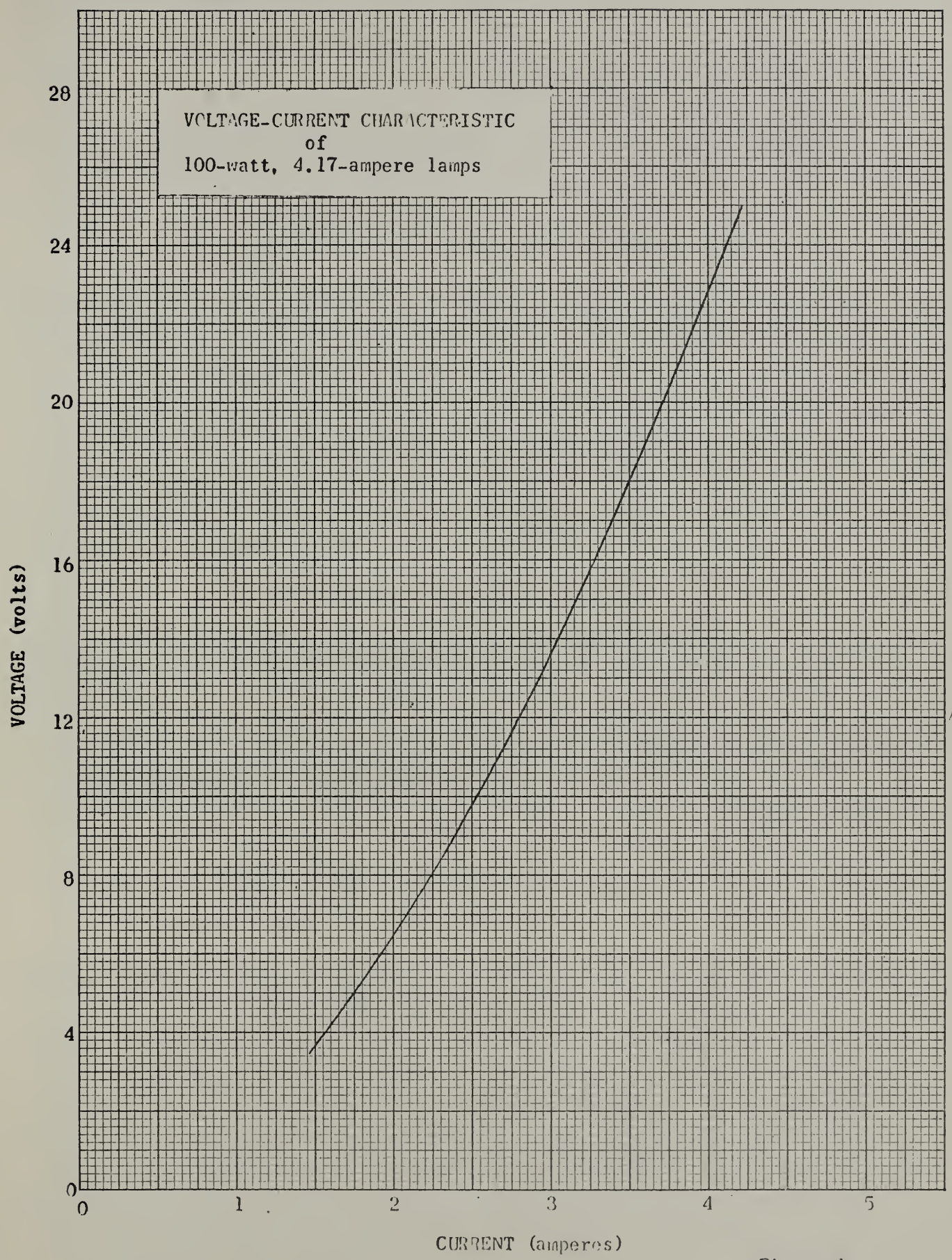
VOLTAGE-CURRENT CHARACTERISTIC
of
100-watt, 4.17-ampere lamps
VOLTAGE (volts)
28
24
20
16
12
8
4
0
0
1
2
3
4
5
CURRENT (amperes)

Figure 1c

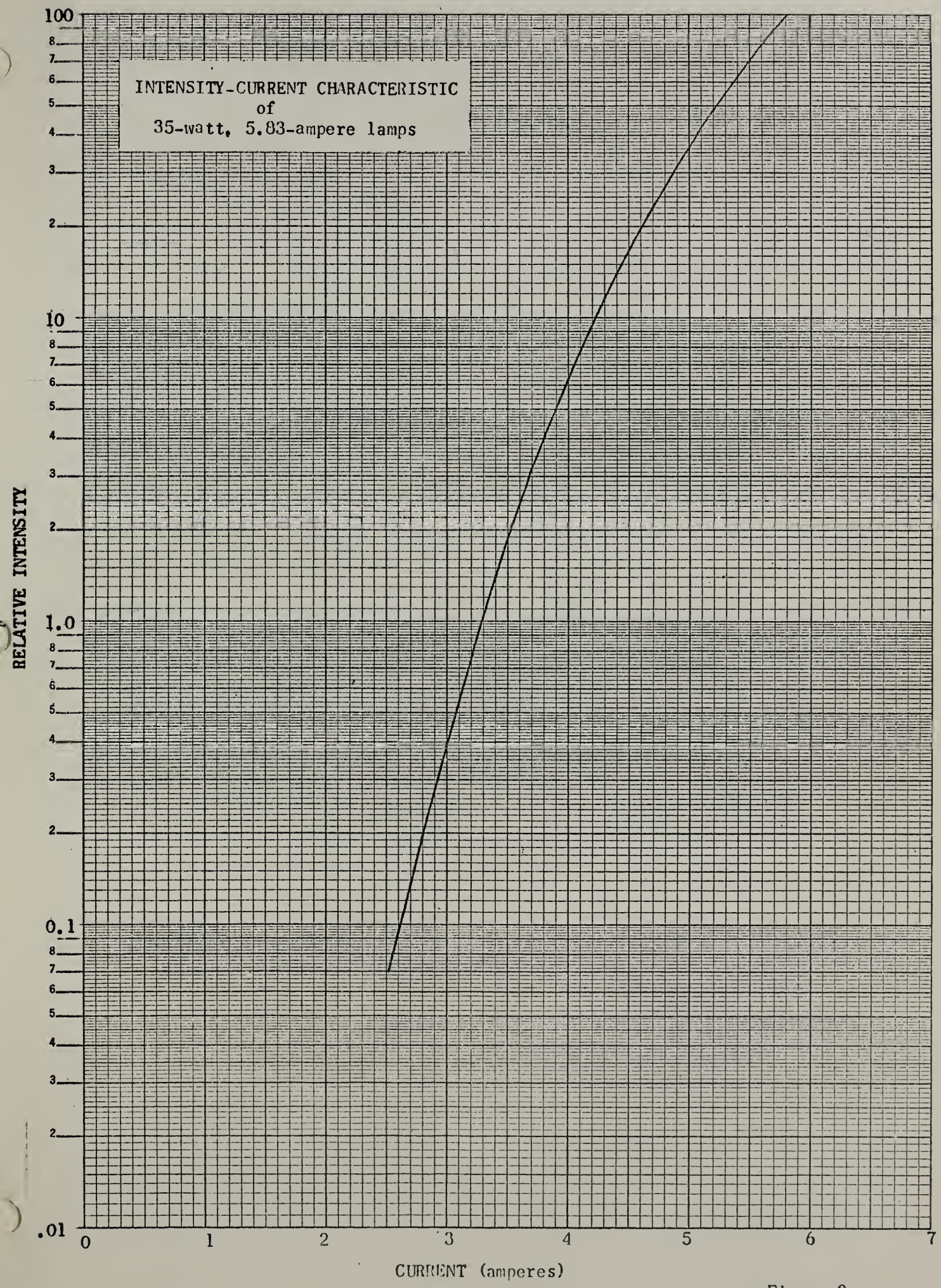
INTENSITY-CURRENT CHARACTERISTIC
of
35-watt, 5.83-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
1
2
3
4
5
6
7
CURRENT (amperes)

Figure 2a

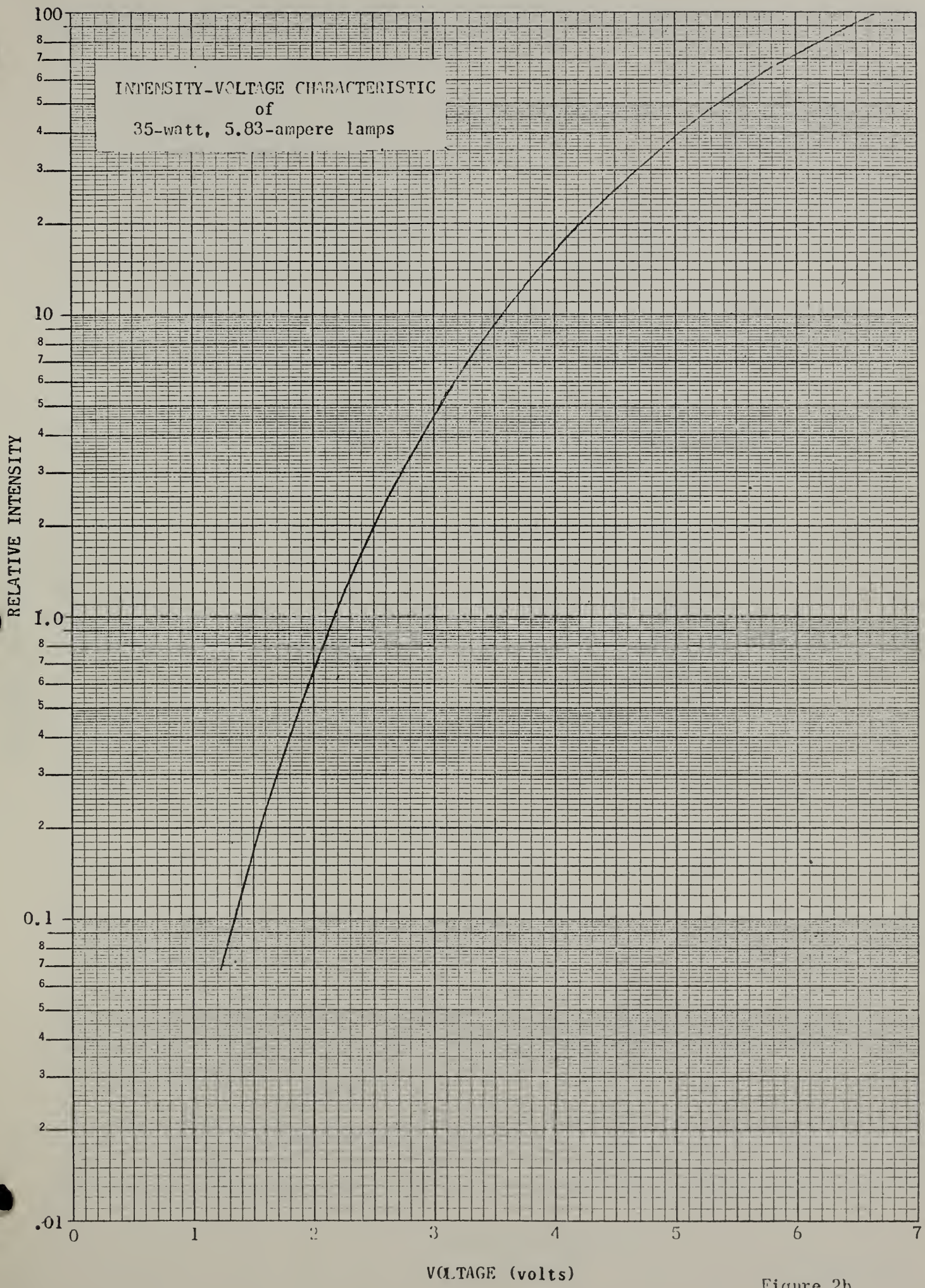
INTENSITY-VOLTAGE CHARACTERISTIC
of
35-watt, 5.83-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
1
2
3
4
5
6
7
VOLTAGE (volts)

Figure 2b

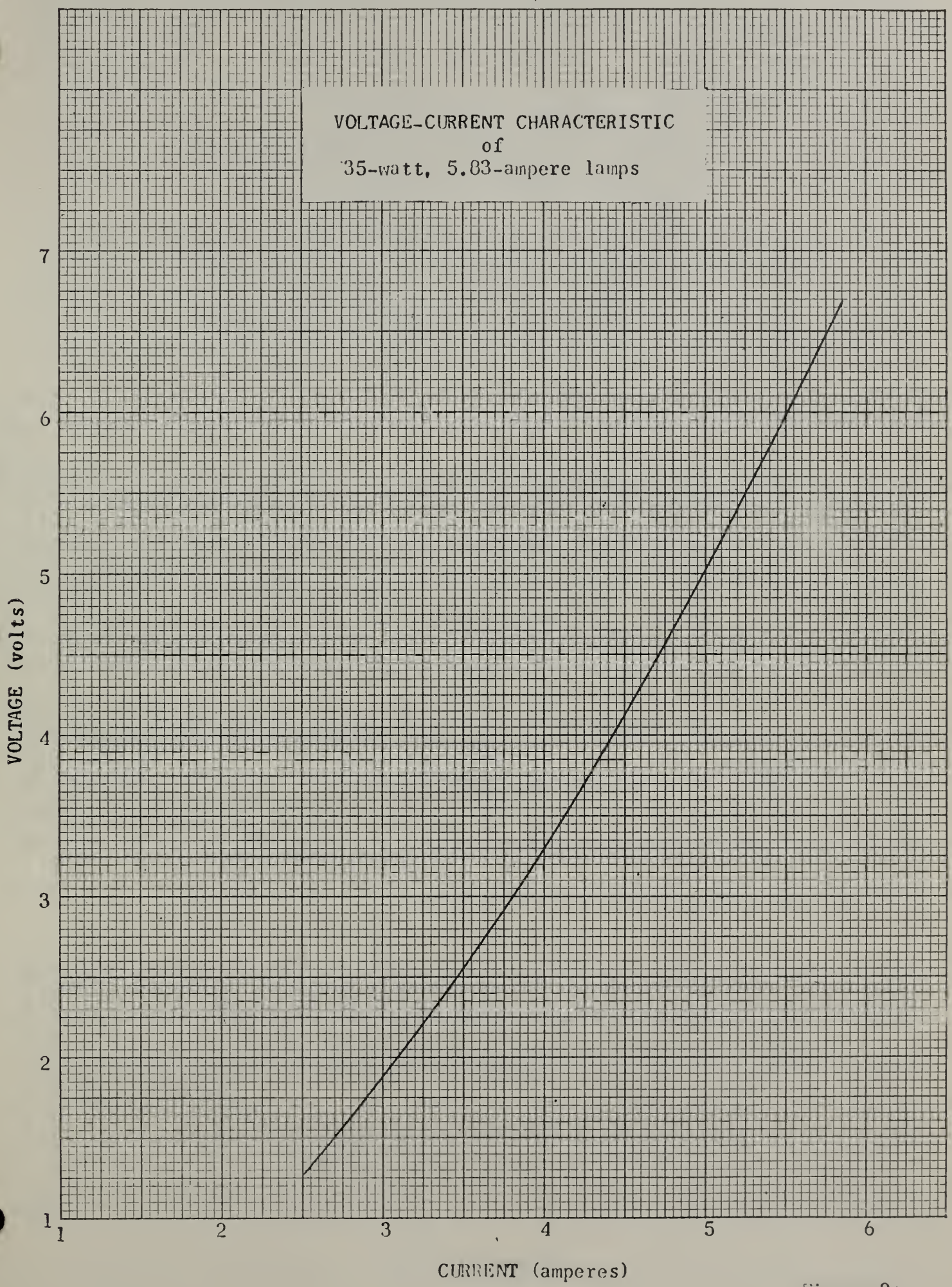
VOLTAGE-CURRENT CHARACTERISTIC
of
35-watt, 5.83-ampere lamps
VOLTAGE (volts)
1
2
3
4
5
6
7
1
2
3
4
5
6
CURRENT (amperes)

Figure 2c

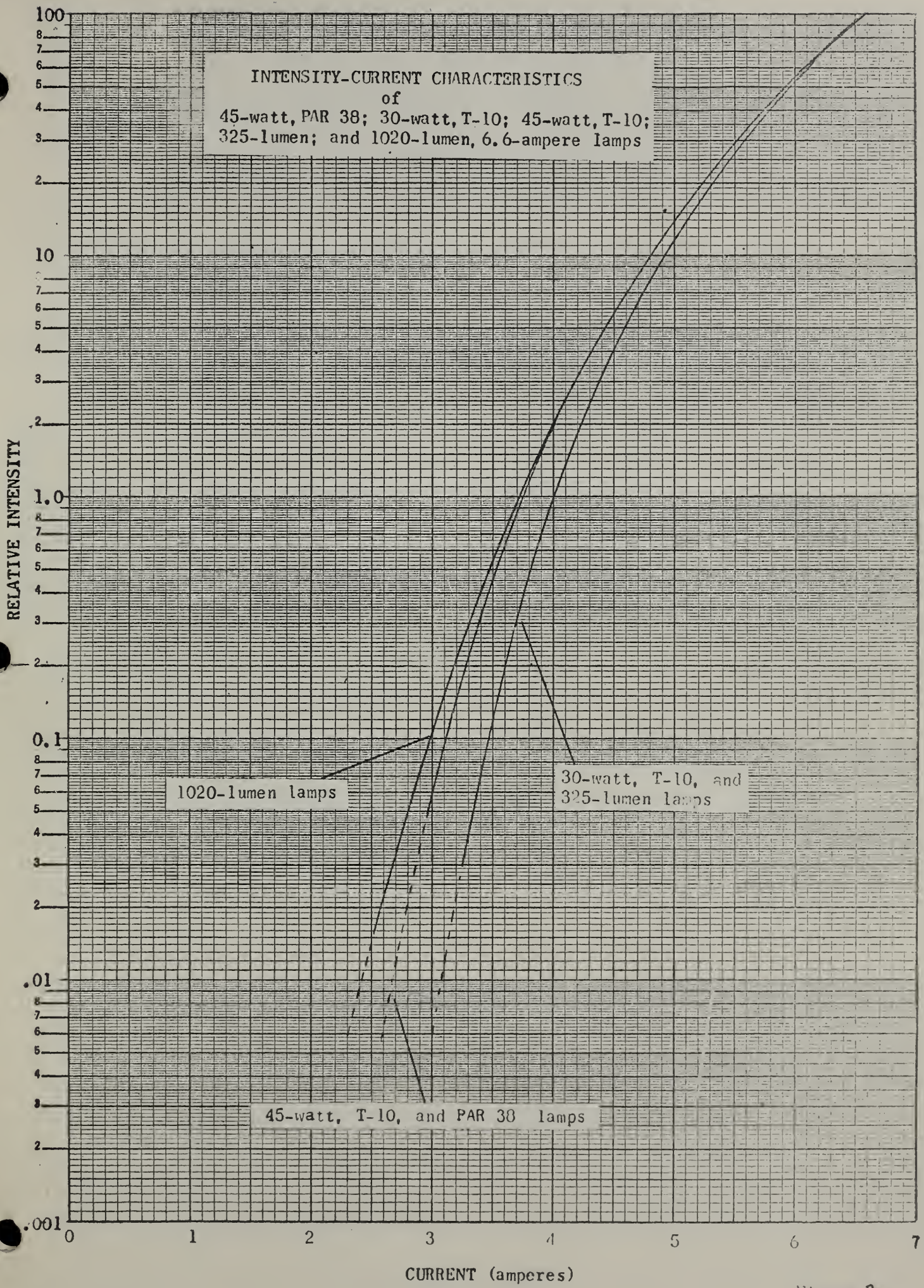
INTENSITY-CURRENT CHARACTERISTICS
of
45-watt, PAR 38; 30-watt, T-10; 45-watt, T-10;
325-lumen; and 1020-lumen, 6.6-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
1020-lumen lamps
30-watt, T-10, and
325-lumen lamps
45-watt, T-10, and PAR 38 lamps
0
1
2
3
4
5
6
7
CURRENT (amperes)

Figure 3a

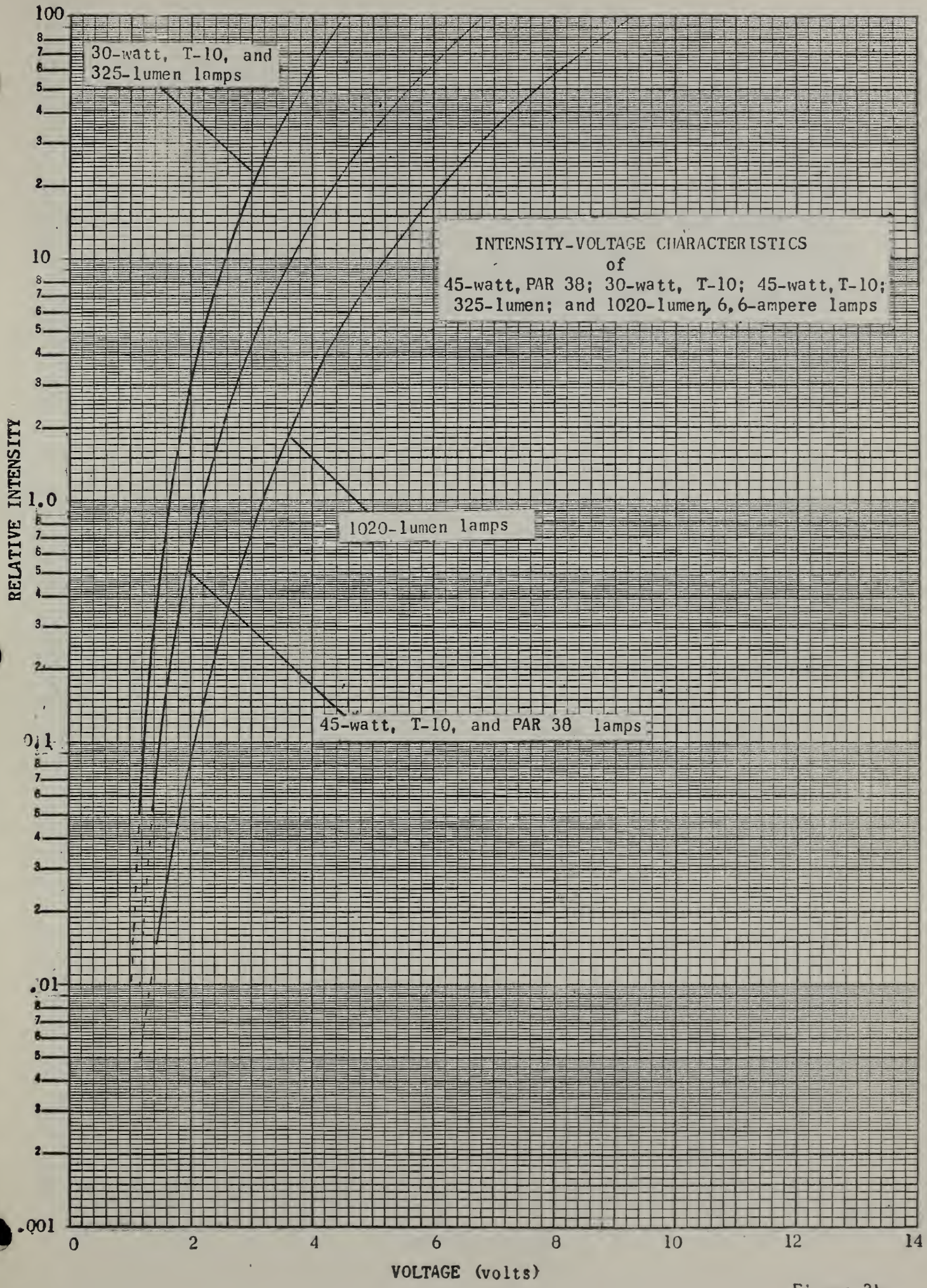
INTENSITY-VOLTAGE CHARACTERISTICS
of
45-watt, PAR 38; 30-watt, T-10; 45-watt, T-10;
325-lumen; and 1020-lumen, 6.6-ampere lamps
30-watt, T-10, and
325-lumen lamps
1020-lumen lamps
45-watt, T-10, and PAR 38 lamps
RELATIVE INTENSITY
100
10
1.0
.01
.001
0
2
4
6
8
10
12
14
VOLTAGE (volts)

Figure 3b

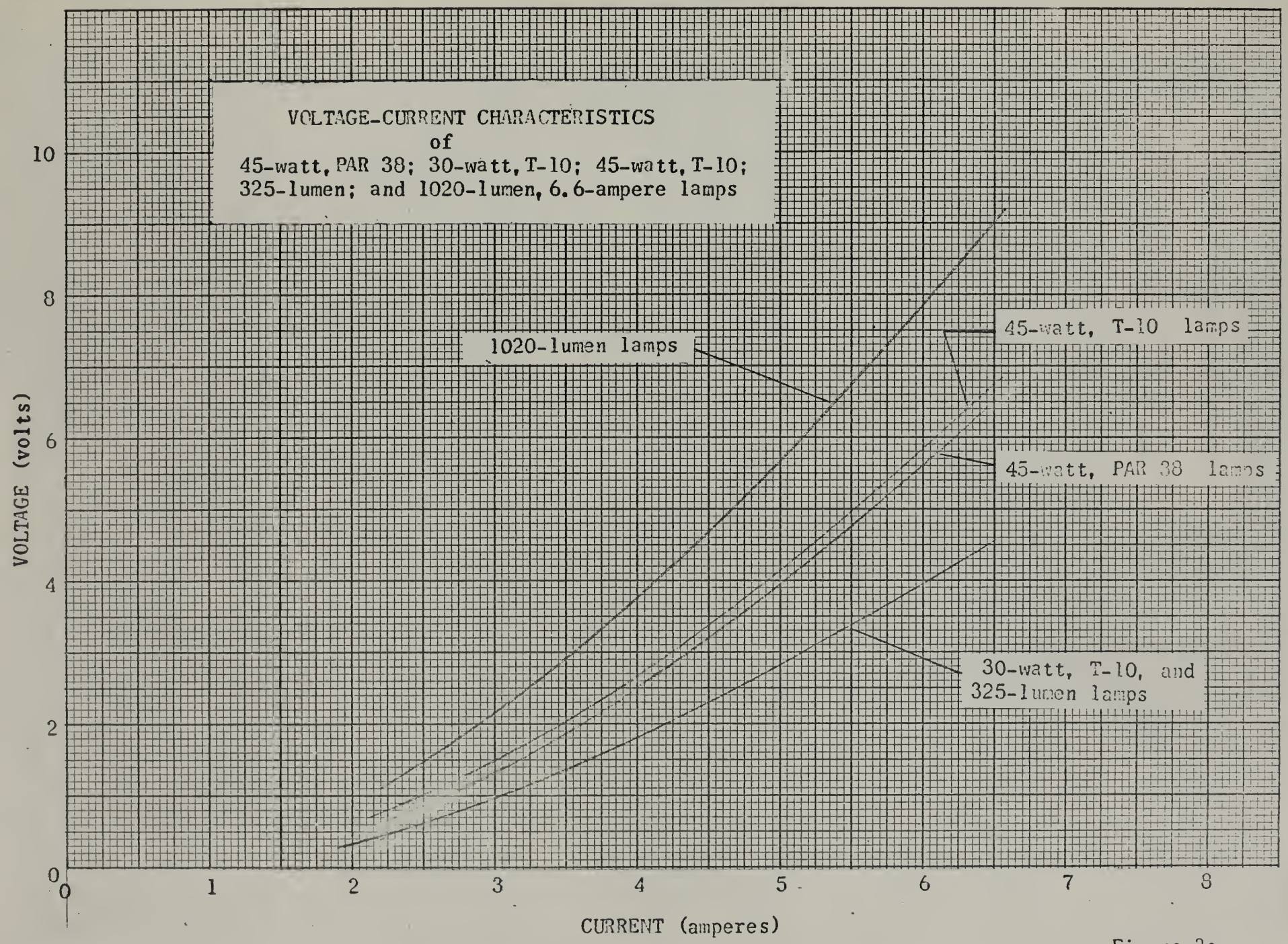
VOLTAGE-CURRENT CHARACTERISTICS
of
45-watt, PAR 38; 30-watt, T-10; 45-watt, T-10;
325-lumen; and 1020-lumen, 6.6-ampere lamps
1020-lumen lamps
45-watt, T-10 lamps
45-watt, PAR 38 lamps
30-watt, T-10, and
325-lumen lamps
VOLTAGE (volts)
CURRENT (amperes)
0
2
4
6
8
10
0
1
2
3
4
5
6
7
8

Figure 3c

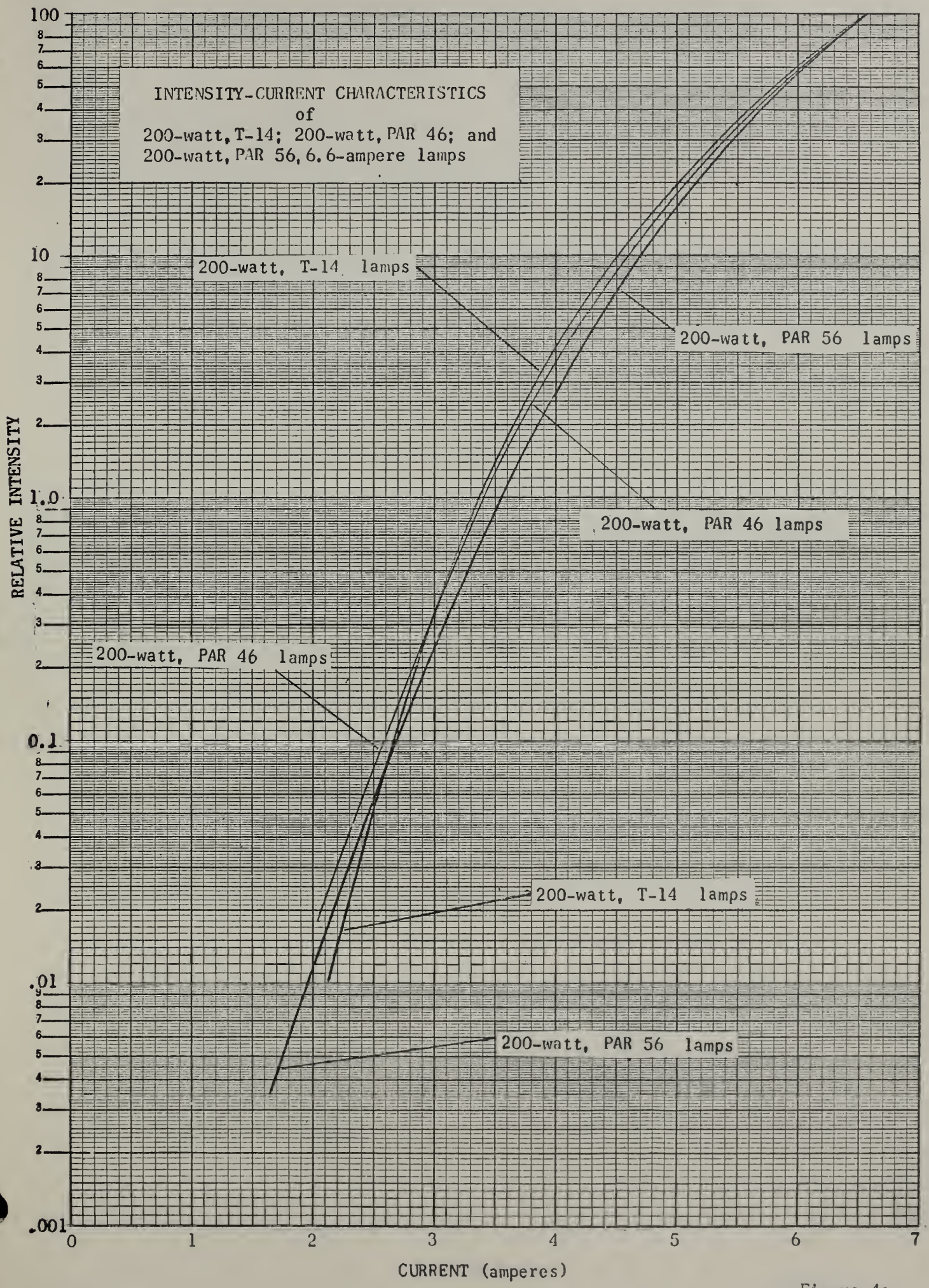
INTENSITY-CURRENT CHARACTERISTICS
of
200-watt, T-14; 200-watt, PAR 46; and
200-watt, PAR 56, 6.6-ampere lamps
200-watt, T-14 lamps
200-watt, PAR 56 lamps
200-watt, PAR 46 lamps
200-watt, PAR 46 lamps
200-watt, T-14 lamps
200-watt, PAR 56 lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
1
2
3
4
5
6
7
CURRENT (amperes)

Figure 4a

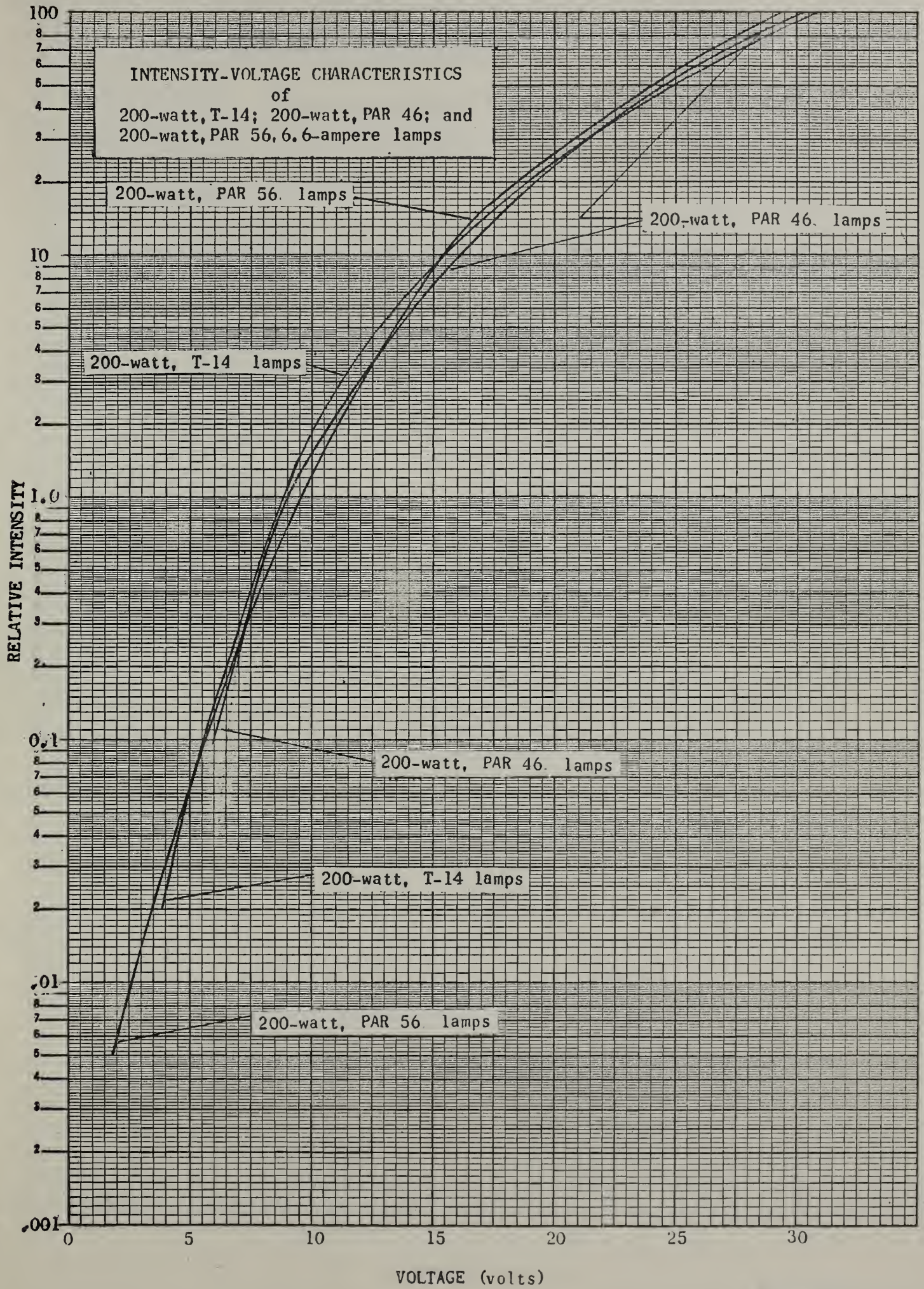
INTENSITY-VOLTAGE CHARACTERISTICS
of
200-watt, T-14; 200-watt, PAR 46; and
200-watt, PAR 56, 6.6-ampere lamps
200-watt, PAR 56 lamps
200-watt, PAR 46 lamps
200-watt, T-14 lamps
200-watt, PAR 46 lamps
200-watt, T-14 lamps
200-watt, PAR 56 lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
5
10
15
20
25
30
VOLTAGE (volts)

Figure 4b

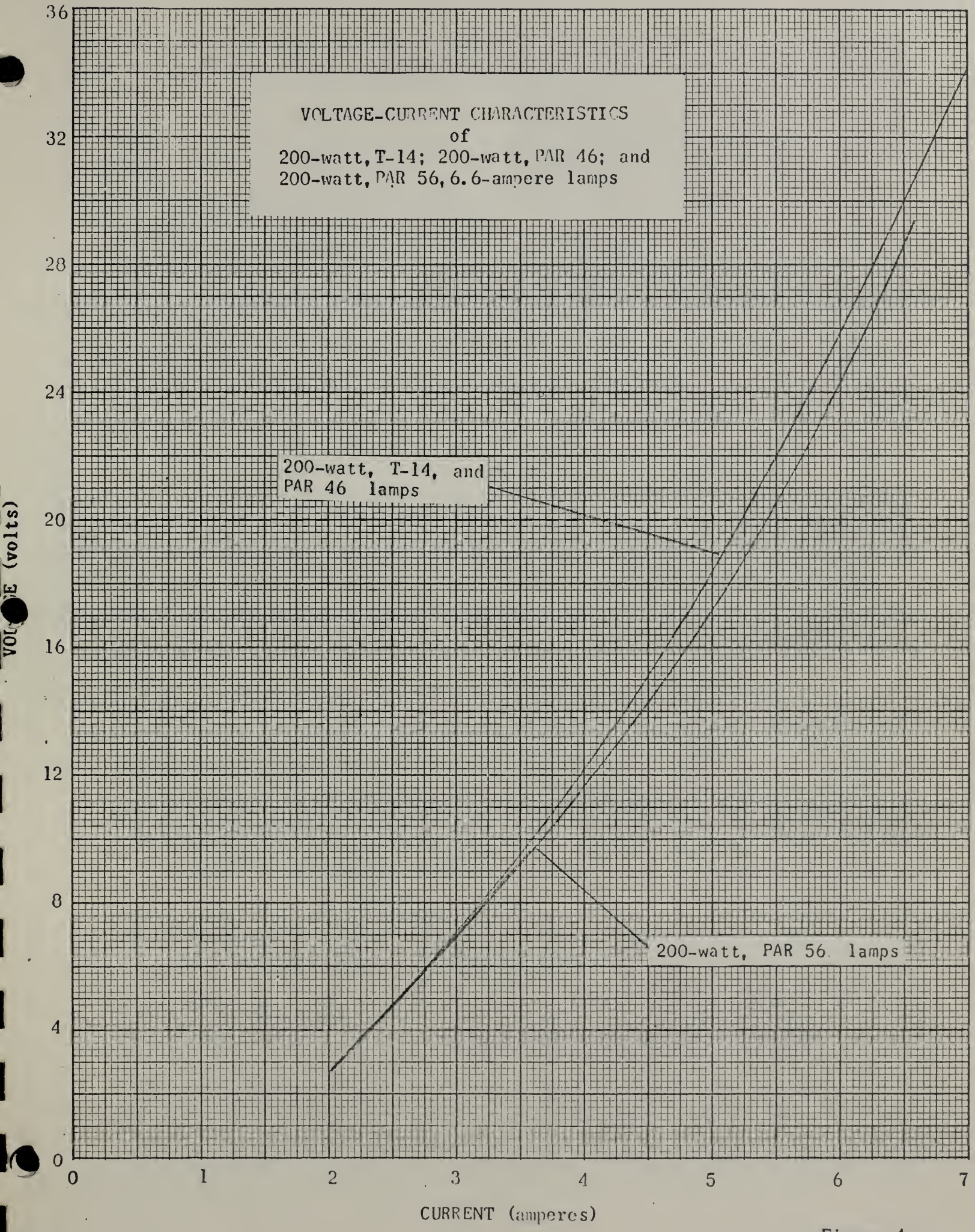
VOLTAGE-CURRENT CHARACTERISTICS
of
200-watt, T-14; 200-watt, PAR 46; and
200-watt, PAR 56, 6.6-ampere lamps
200-watt, T-14, and
PAR 46 lamps
200-watt, PAR 56 lamps
VOLTAGE (volts)
CURRENT (amperes)
0
4
8
12
16
20
24
28
32
36
0
1
2
3
4
5
6
7

Figure 4c

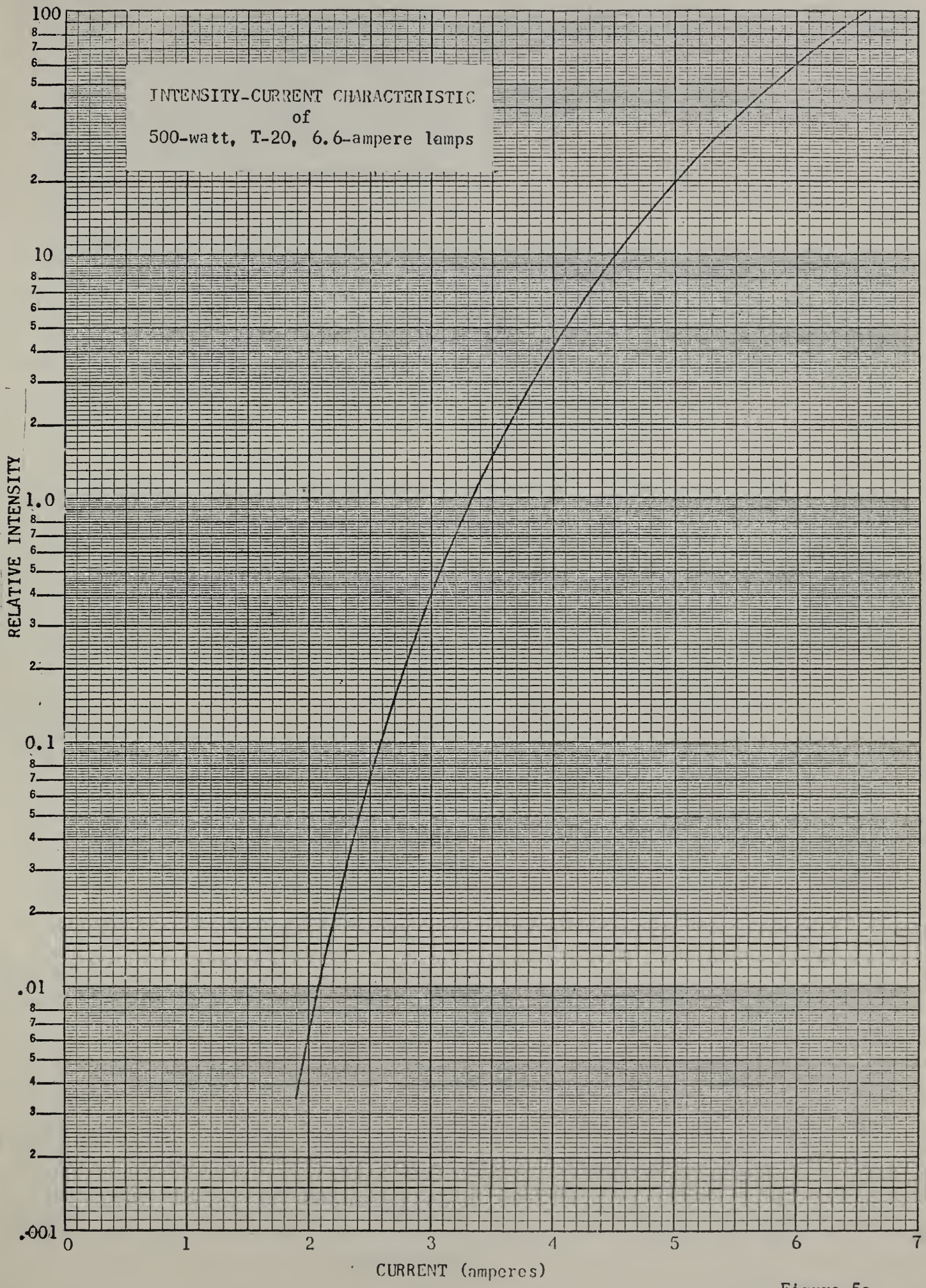
INTENSITY-CURRENT CHARACTERISTIC
of
500-watt, T-20, 6.6-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
1
2
3
4
5
6
7
CURRENT (amperes)

Figure 5a

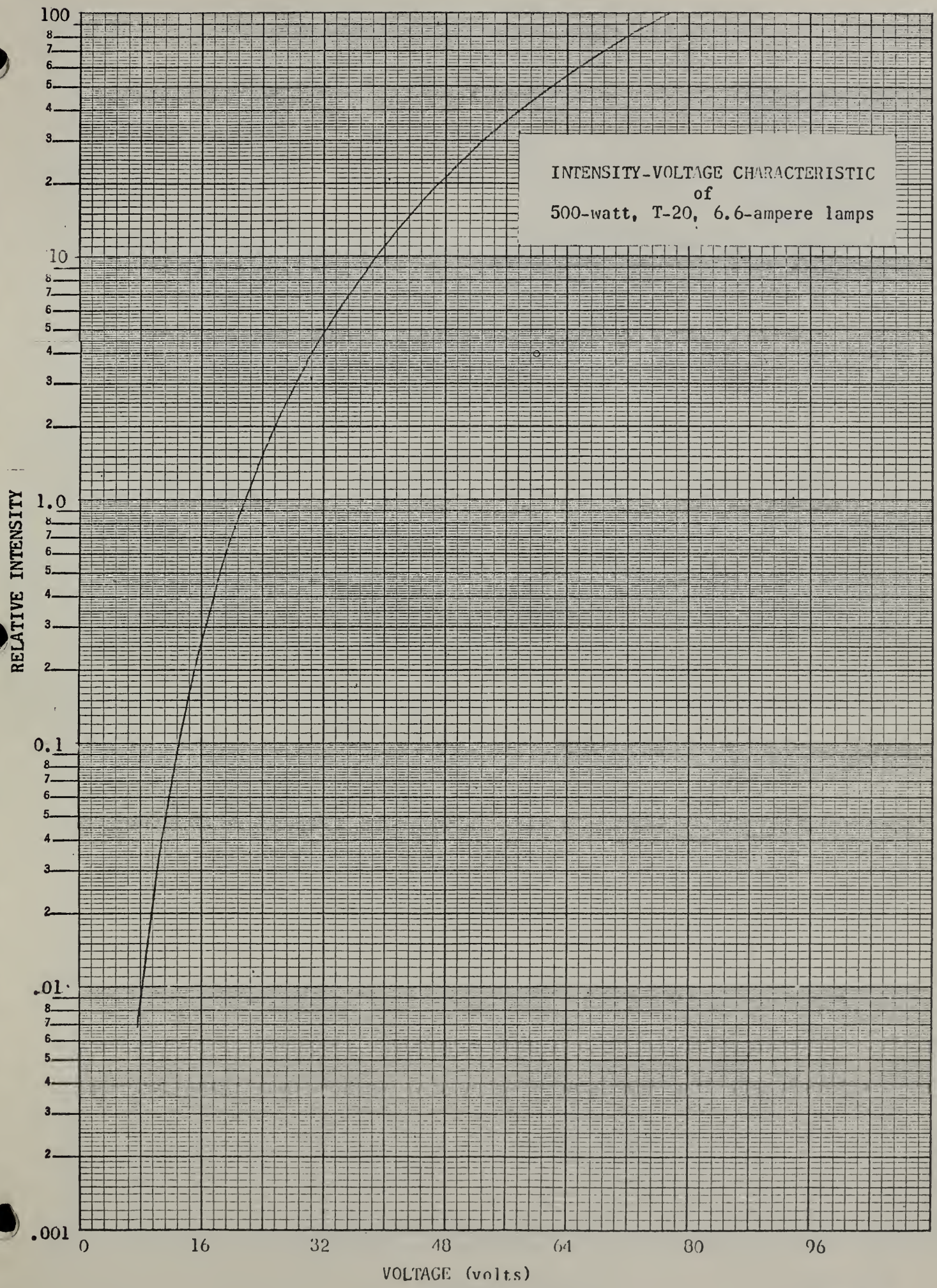
INTENSITY-VOLTAGE CHARACTERISTIC
of
500-watt, T-20, 6.6-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
16
32
48
64
80
96
VOLTAGE (volts)

Figure 5b

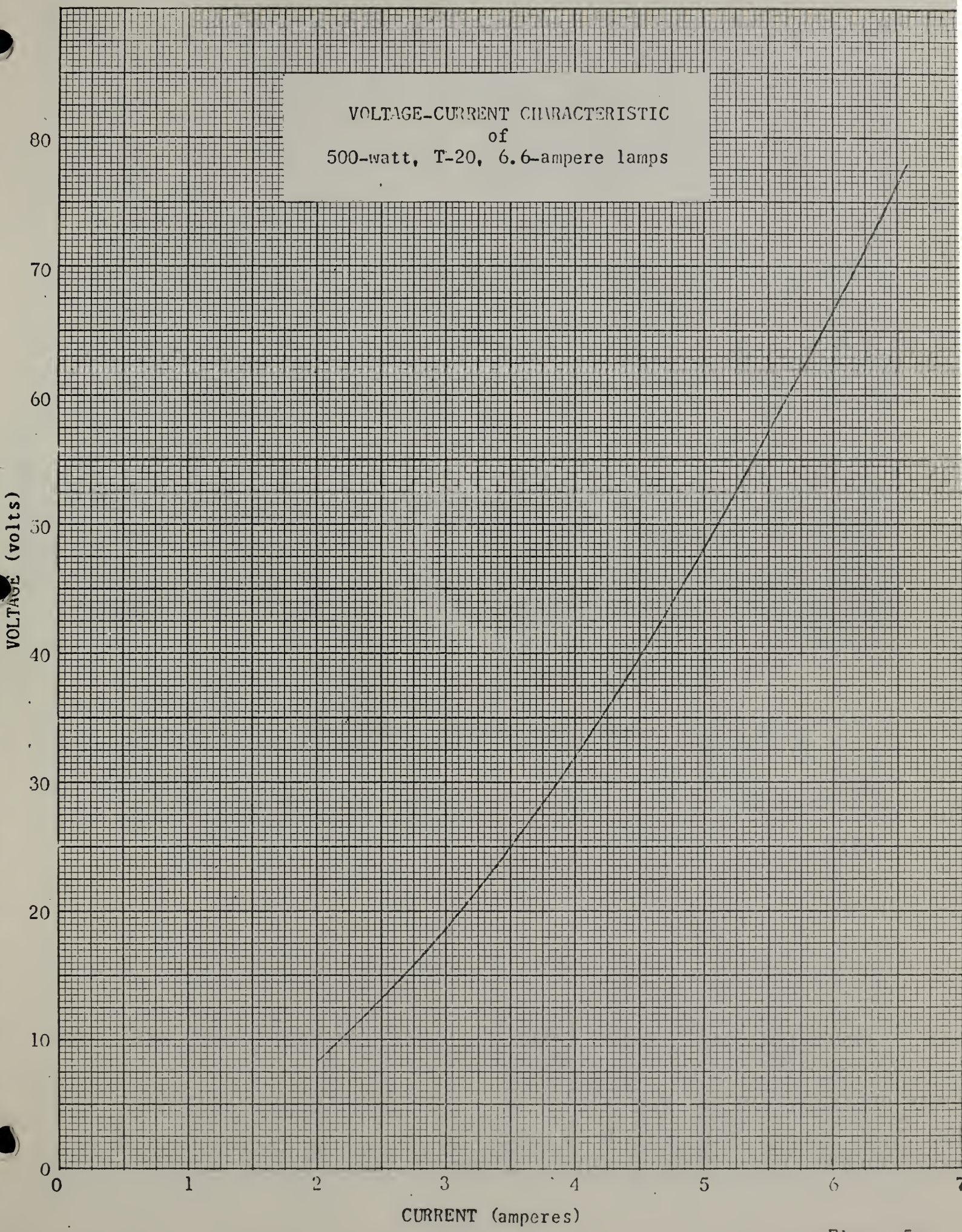
VOLTAGE-CURRENT CHARACTERISTIC
of
500-watt, T-20, 6.6-ampere lamps
VOLTAGE (volts)
0
10
20
30
40
50
60
70
80
CURRENT (amperes)
0
1
2
3
4
5
6
7

Figure 5c

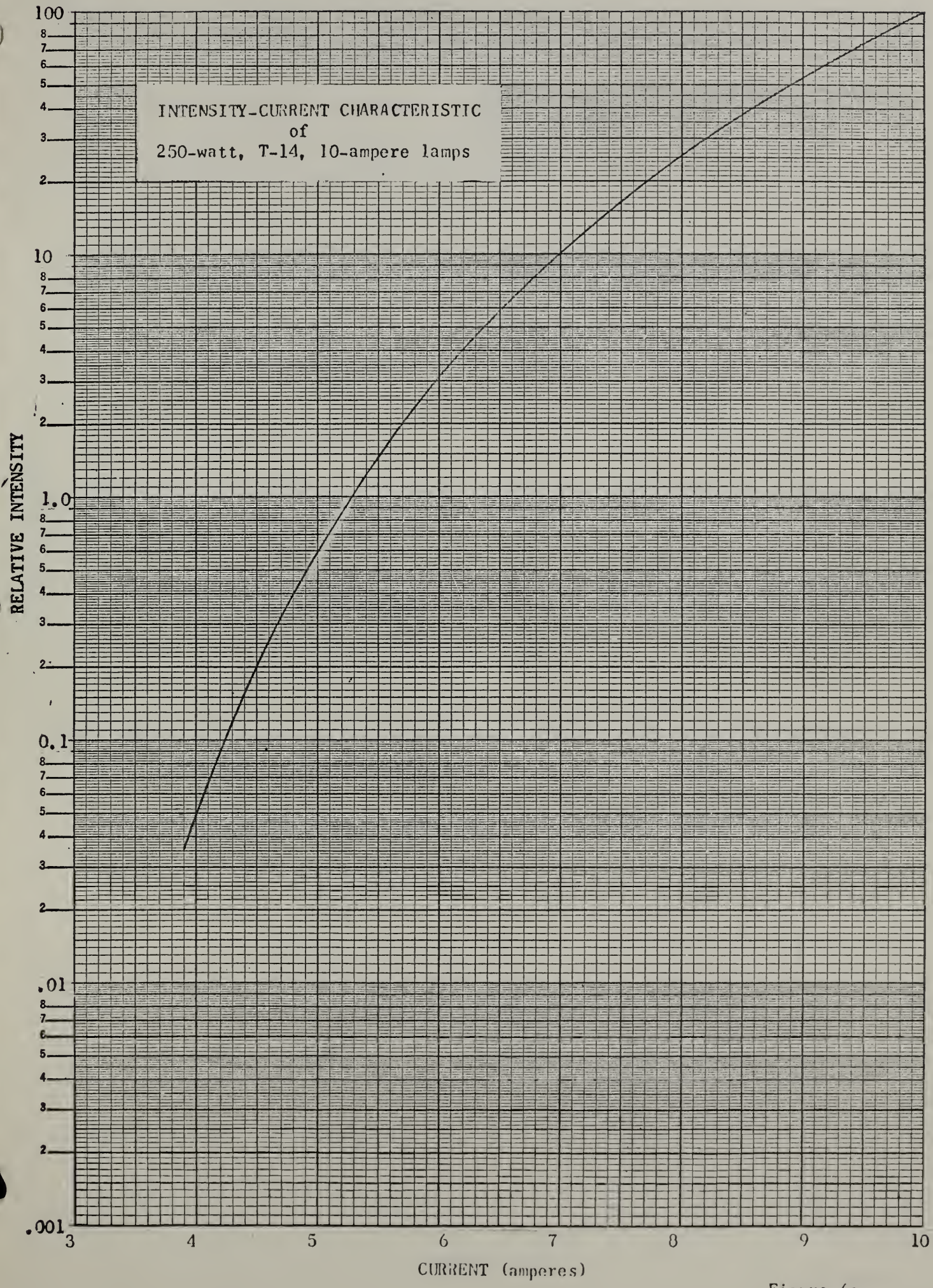
INTENSITY-CURRENT CHARACTERISTIC
of
250-watt, T-14, 10-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
3
4
5
6
7
8
9
10
CURRENT (amperes)

Figure 6a

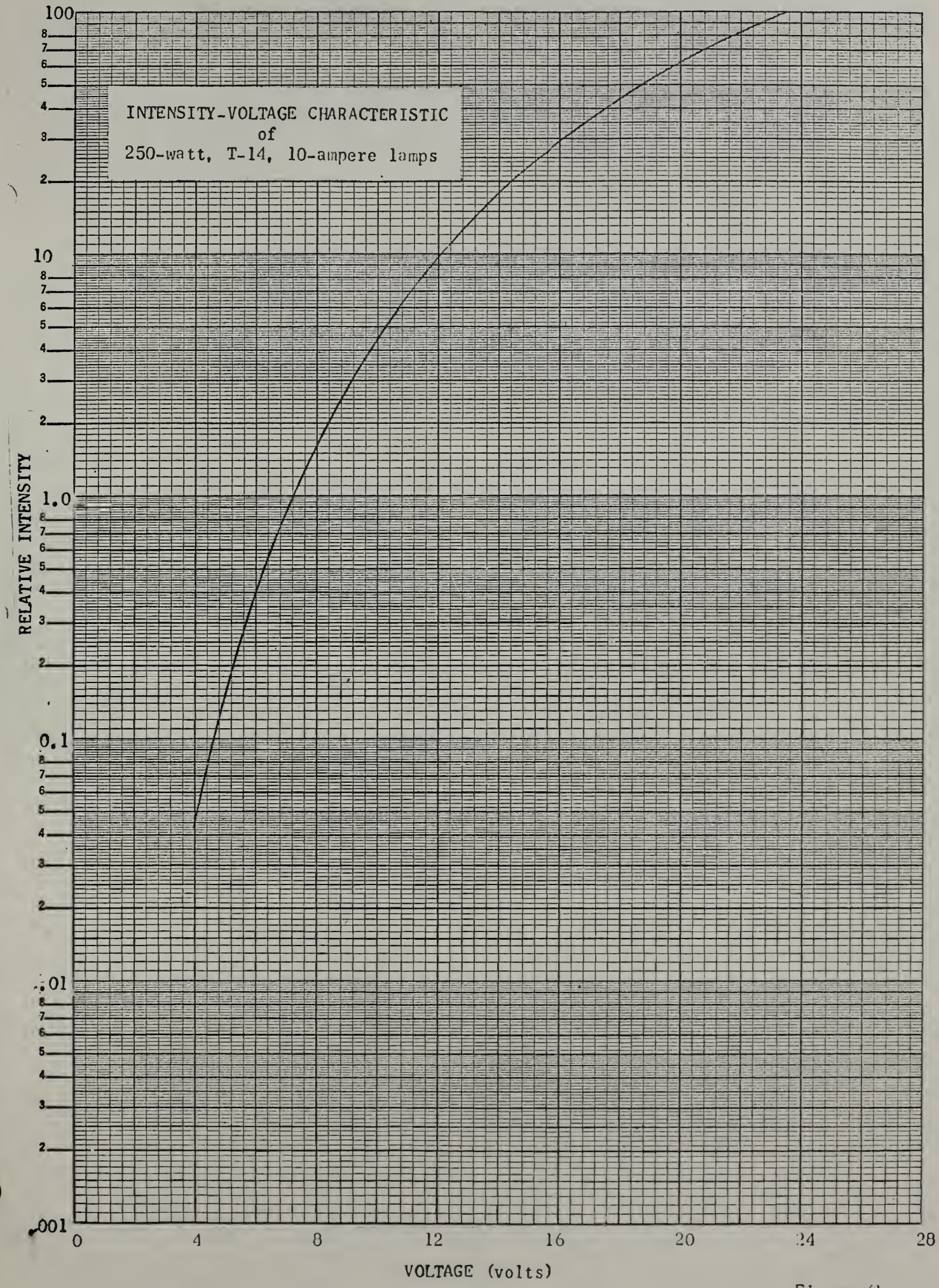
INTENSITY-VOLTAGE CHARACTERISTIC
of
250-watt, T-14, 10-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
4
8
12
16
20
24
28
VOLTAGE (volts)

Figure 6b

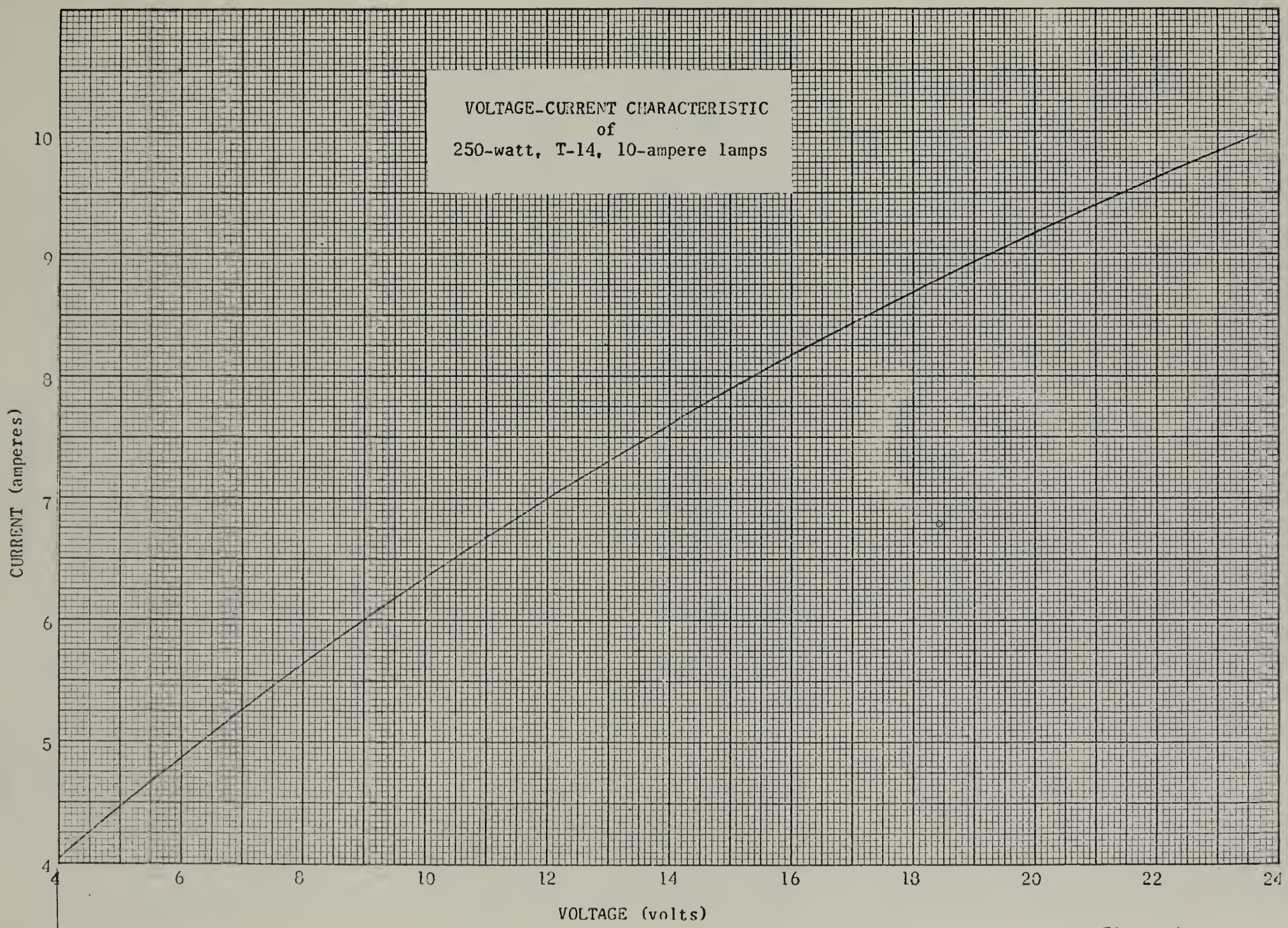
VOLTAGE-CURRENT CHARACTERISTIC
of
250-watt, T-14, 10-ampere lamps
CURRENT (amperes)
10
9
8
7
6
5
4
4
6
8
10
12
14
16
18
20
22
24
VOLTAGE (volts)

Figure 6c

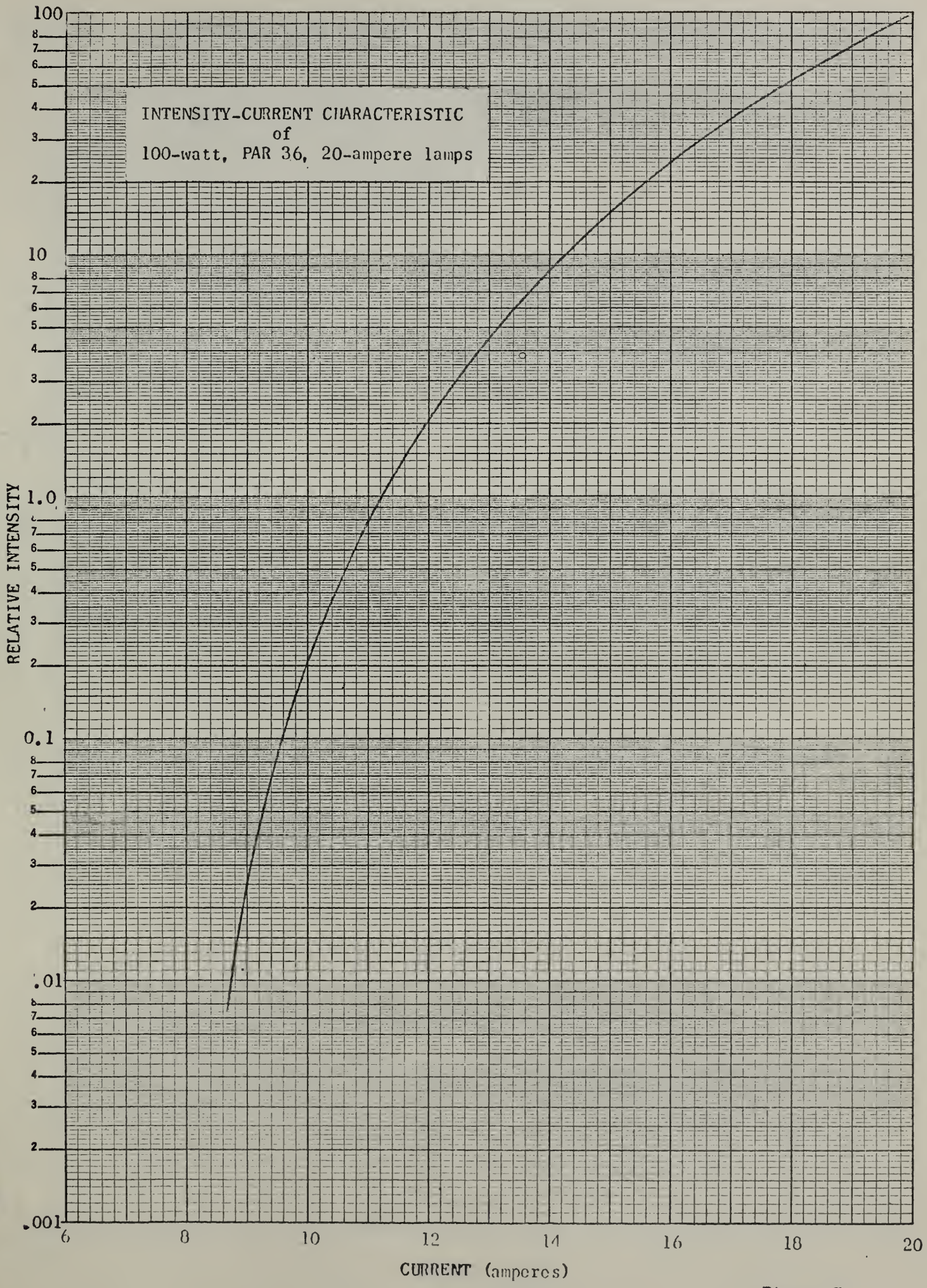
INTENSITY-CURRENT CHARACTERISTIC
of
100-watt, PAR 36, 20-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
6
8
10
12
14
16
18
20
CURRENT (amperes)

Figure 7a

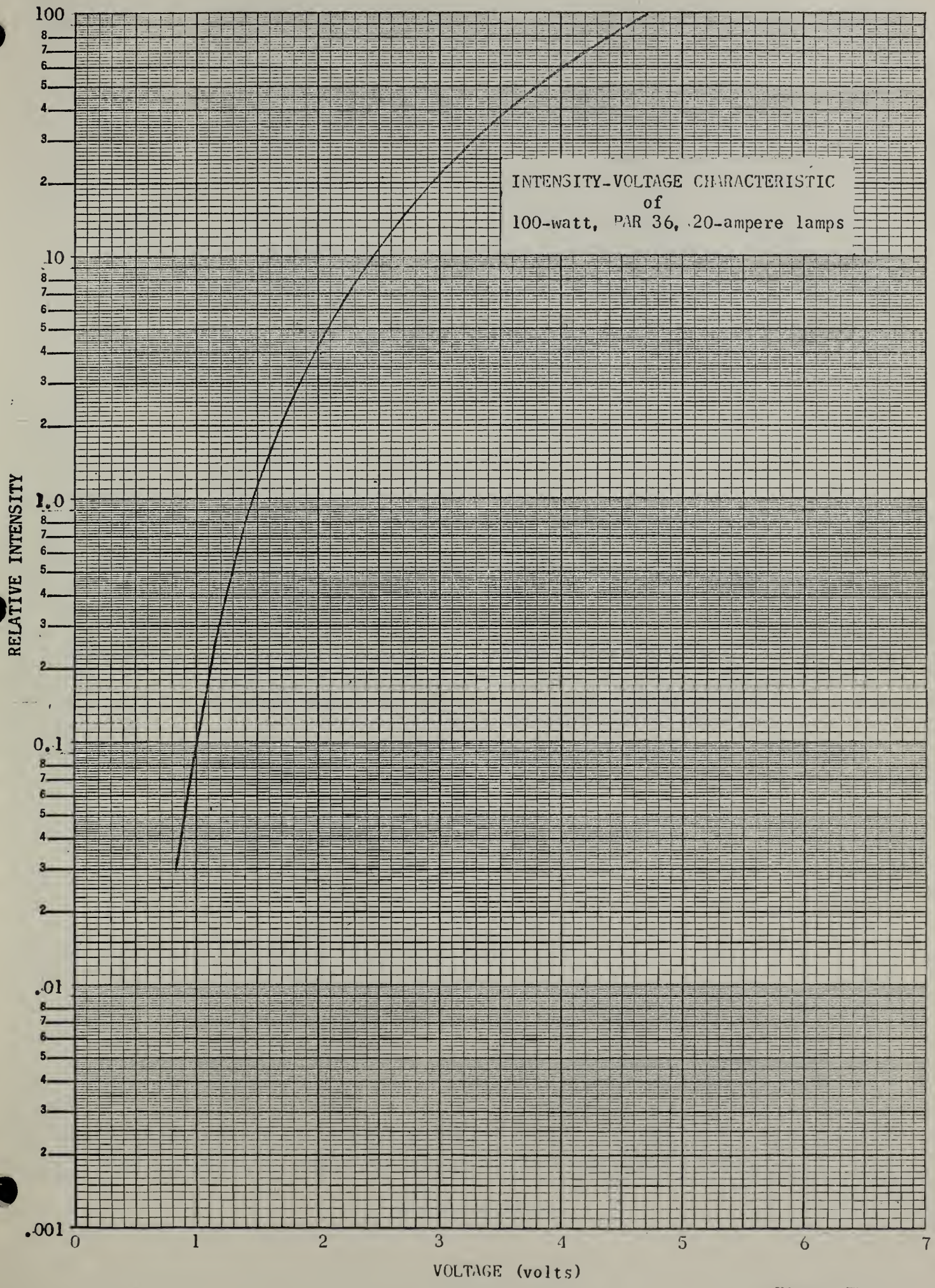
INTENSITY-VOLTAGE CHARACTERISTIC
of
100-watt, PAR 36, 20-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
1
2
3
4
5
6
7
VOLTAGE (volts)

Figure 7b

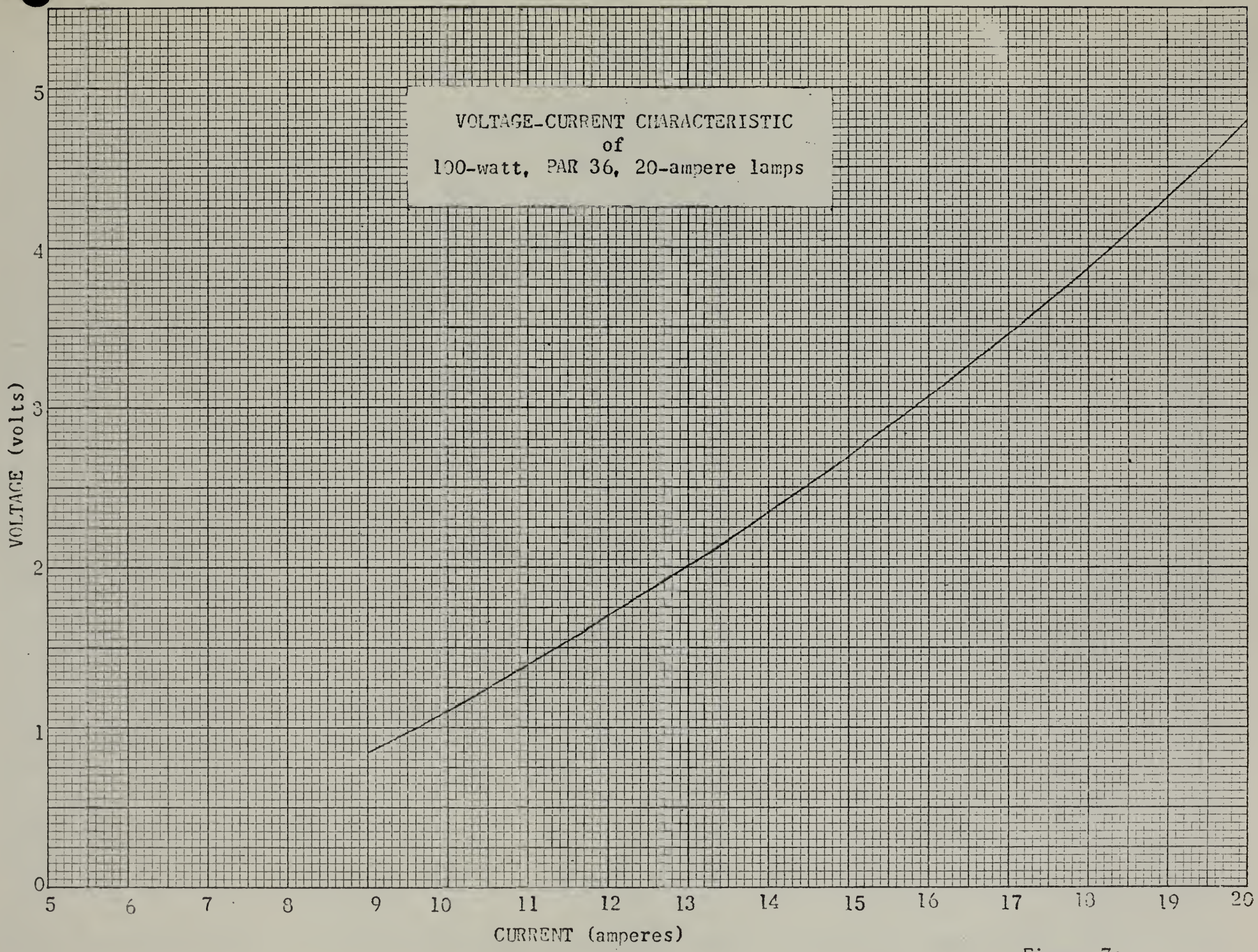
VOLTAGE-CURRENT CHARACTERISTIC
of
100-watt, PAR 36, 20-ampere lamps
VOLTAGE (volts)
0
1
2
3
4
5
CURRENT (amperes)
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Figure 7c

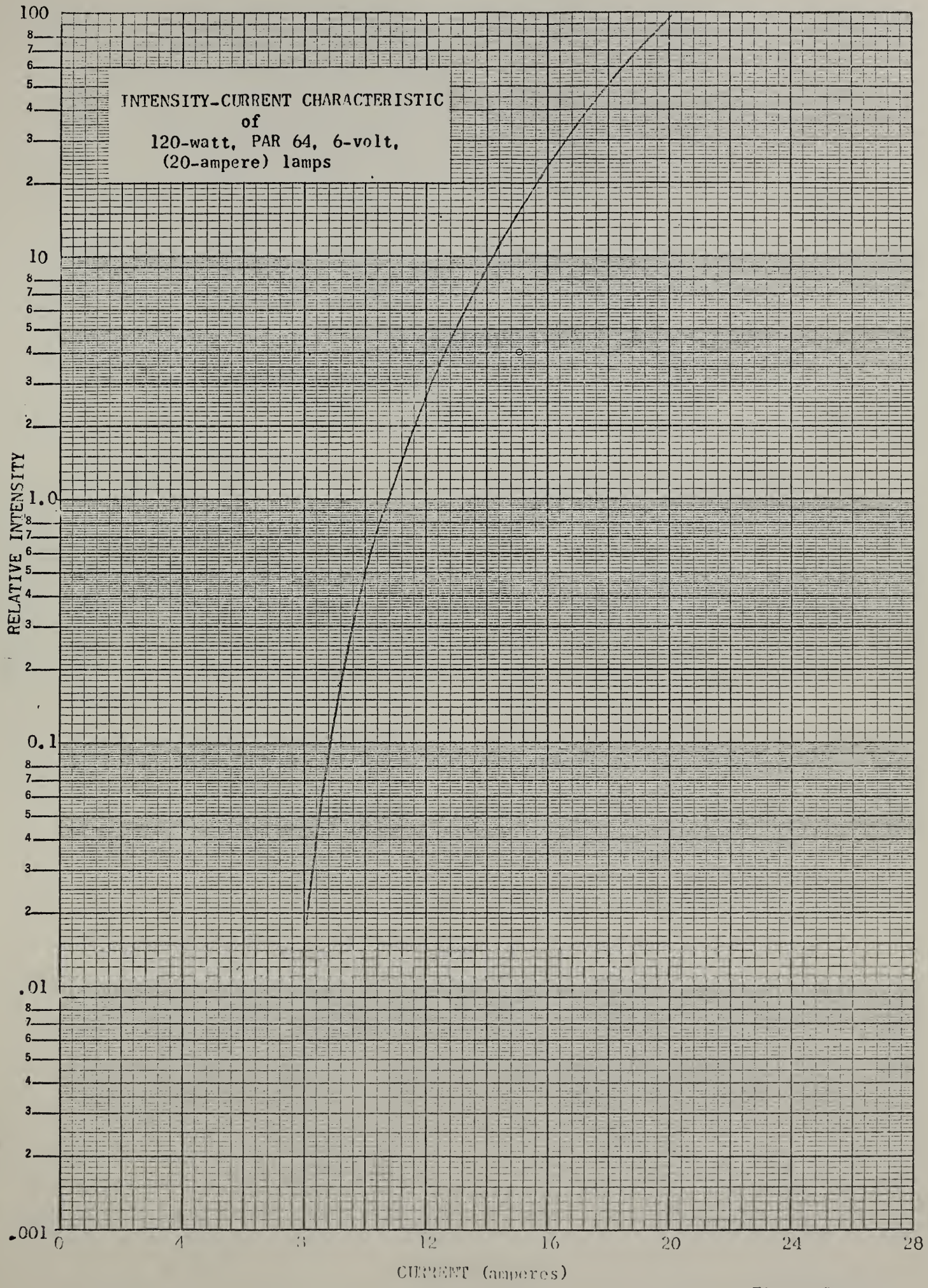
INTENSITY-CURRENT CHARACTERISTIC
of
120-watt, PAR 64, 6-volt,
(20-ampere) lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
4
8
12
16
20
24
28
CURRENT (amperes)

Figure 8a

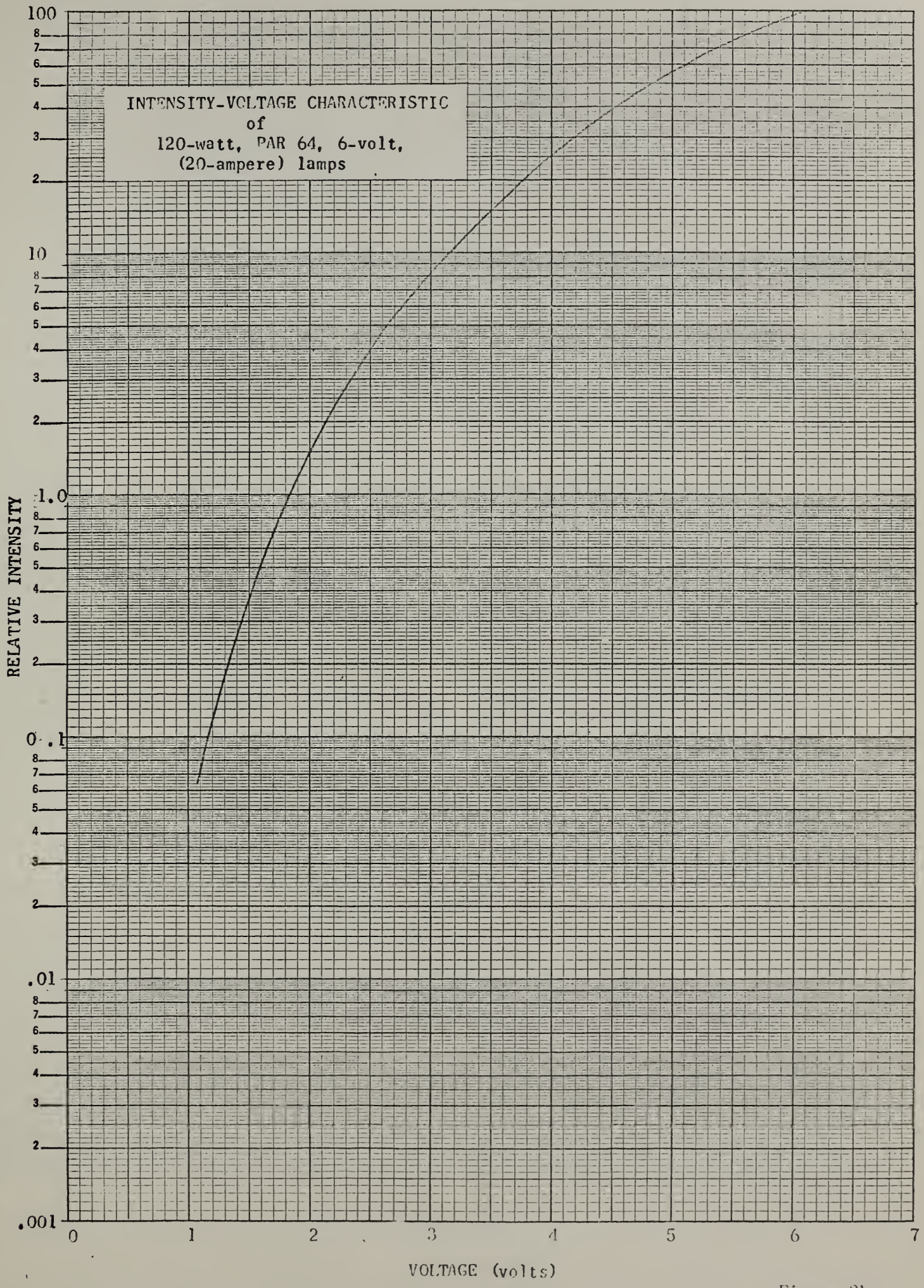
INTENSITY-VOLTAGE CHARACTERISTIC
of
120-watt, PAR 64, 6-volt,
(20-ampere) lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
1
2
3
4
5
6
7
VOLTAGE (volts)

Figure 8b

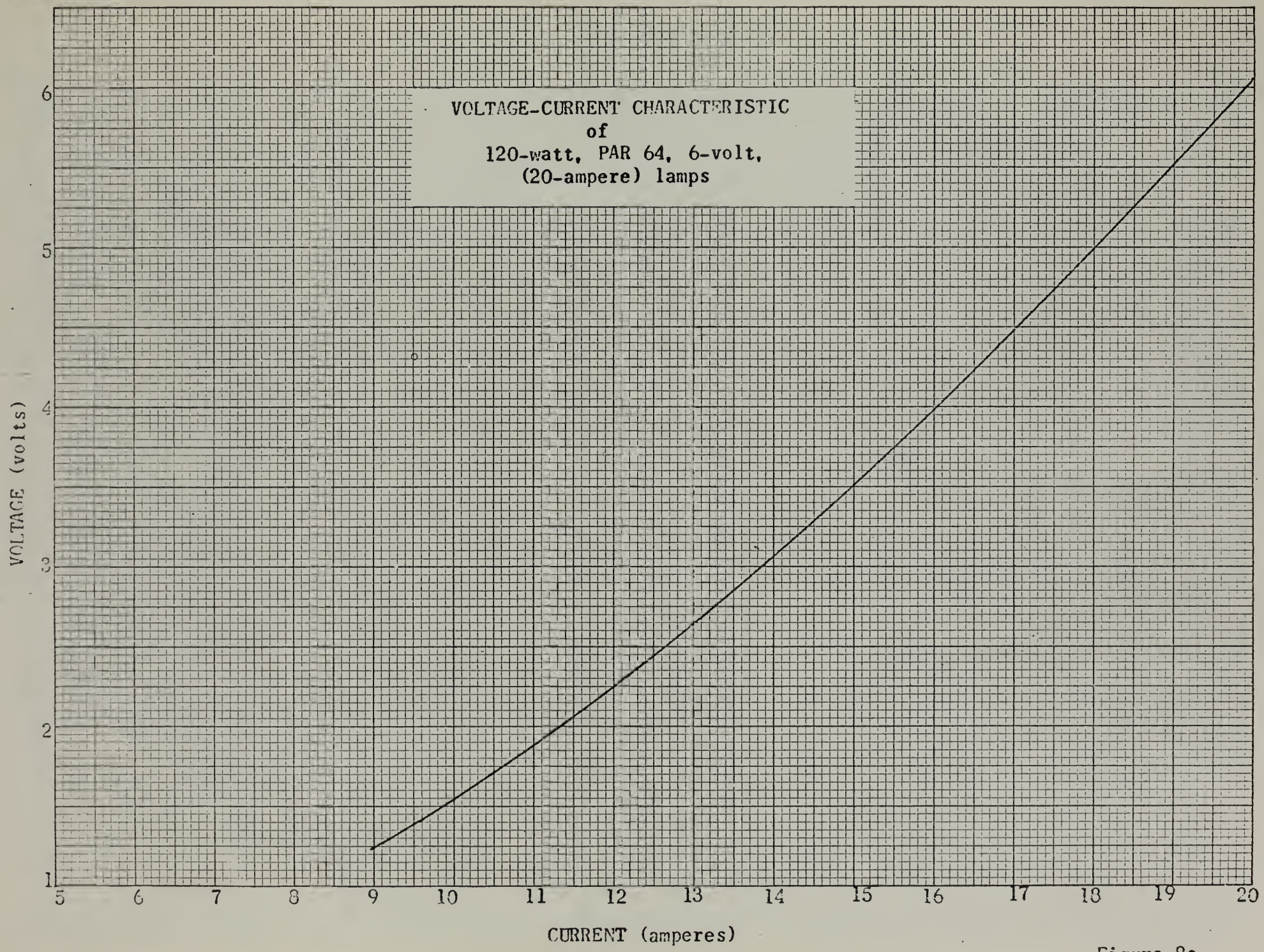
VOLTAGE-CURRENT CHARACTERISTIC
of
120-watt, PAR 64, 6-volt,
(20-ampere) lamps
VOLTAGE (volts)
1
2
3
4
5
6
CURRENT (amperes)
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Figure 8c

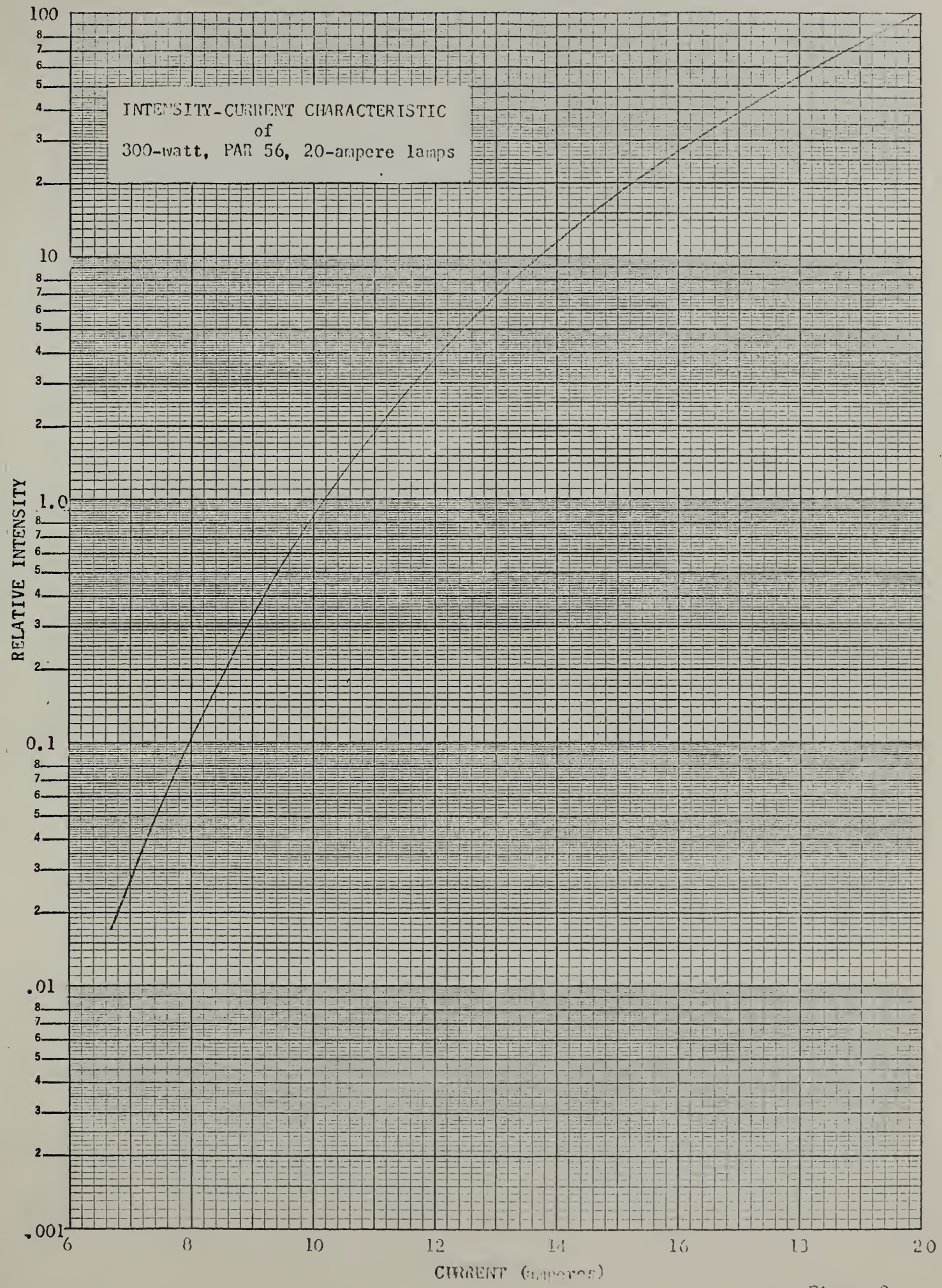
INTENSITY-CURRENT CHARACTERISTIC
of
300-watt, PAR 56, 20-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
6
8
10
12
14
16
18
20
CURRENT (amperes)

Figure 9a

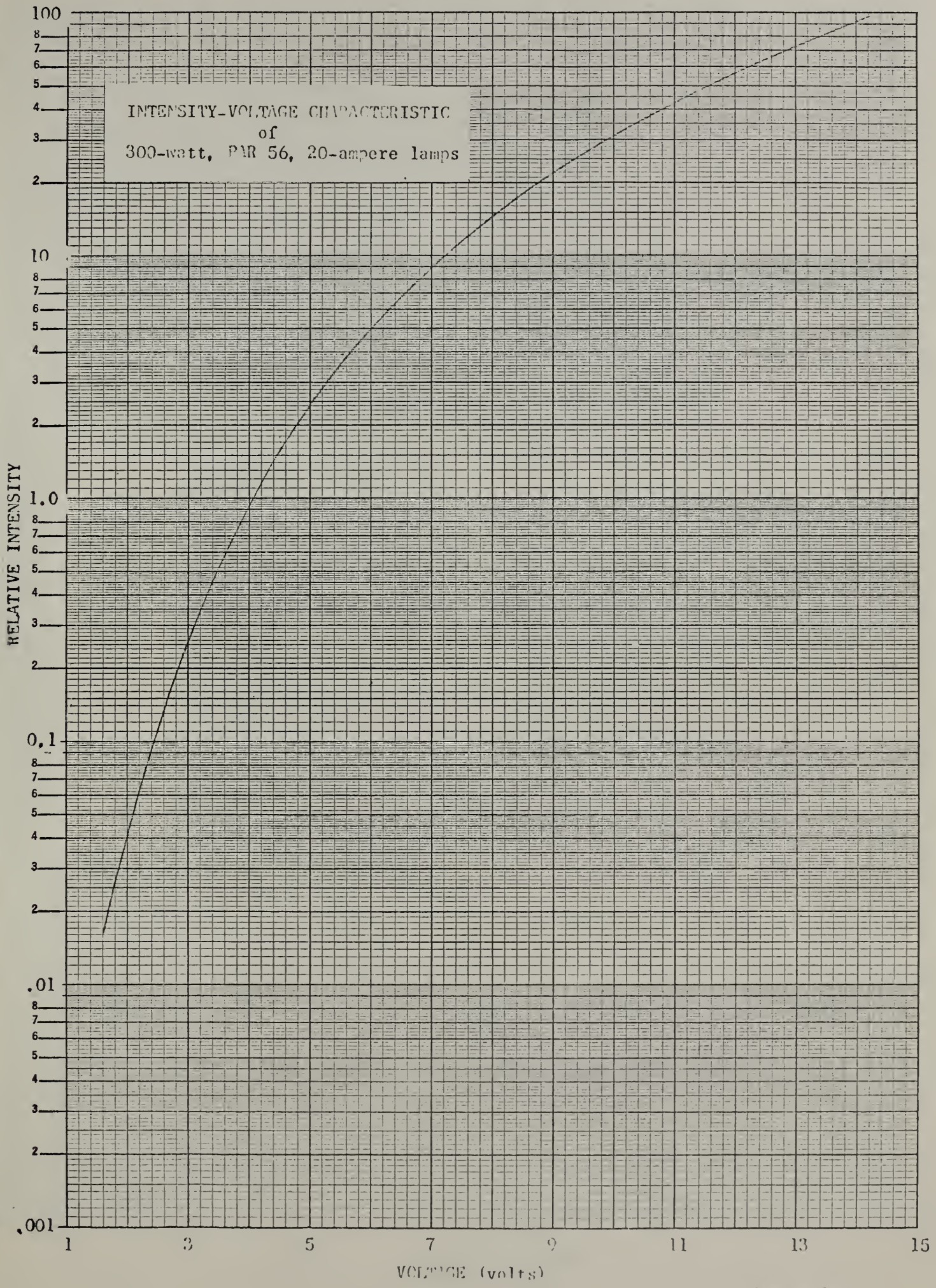
INTENSITY-VOLTAGE CHARACTERISTIC
of
300-watt, PAR 56, 20-ampere lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
1
3
5
7
9
11
13
15
VOLTAGE (volts)

Figure 9b

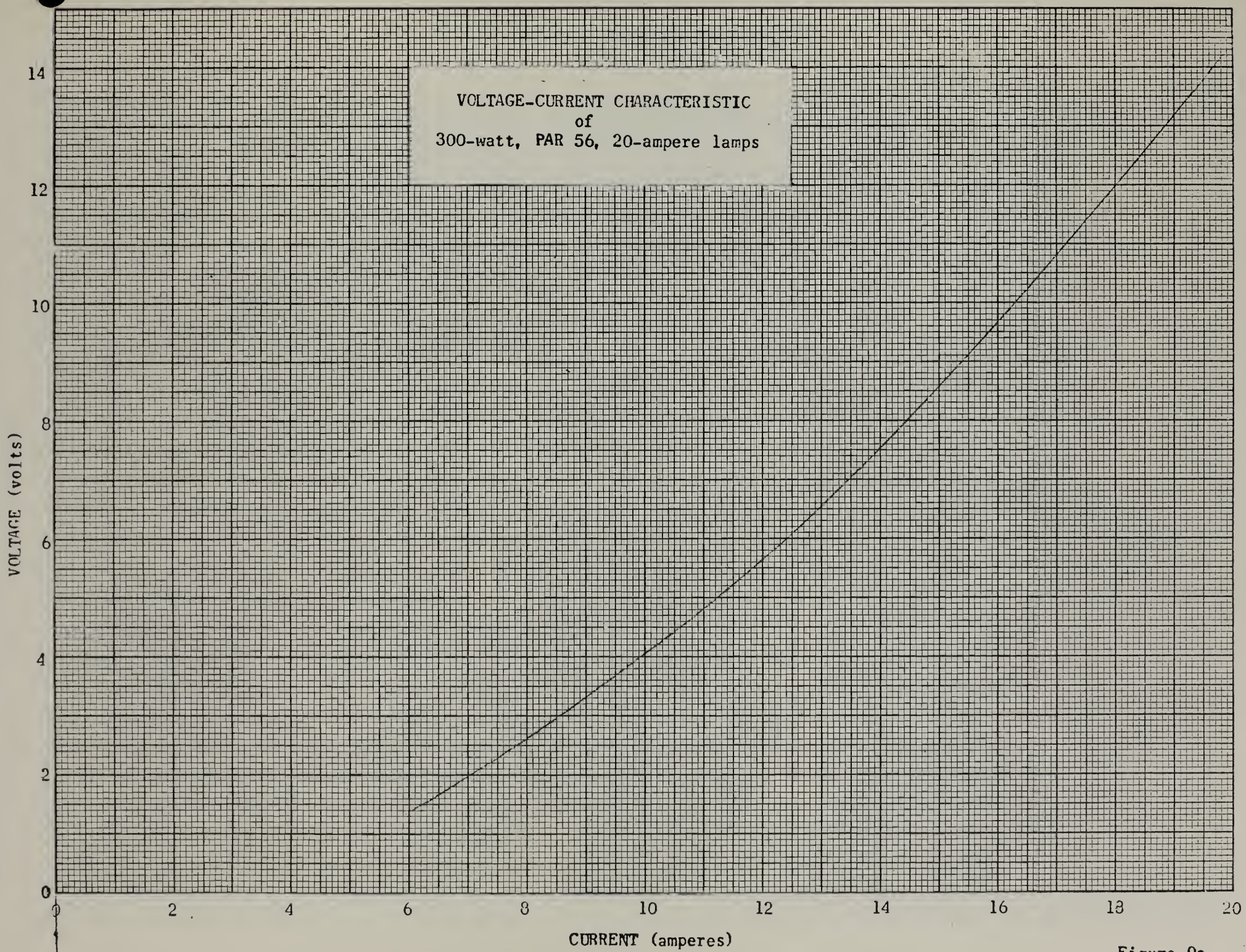
VOLTAGE-CURRENT CHARACTERISTIC
of
300-watt, PAR 56, 20-ampere lamps
VOLTAGE (volts)
0
2
4
6
8
10
12
14
0
2
4
6
8
10
12
14
16
18
20
CURRENT (amperes)

Figure 9c

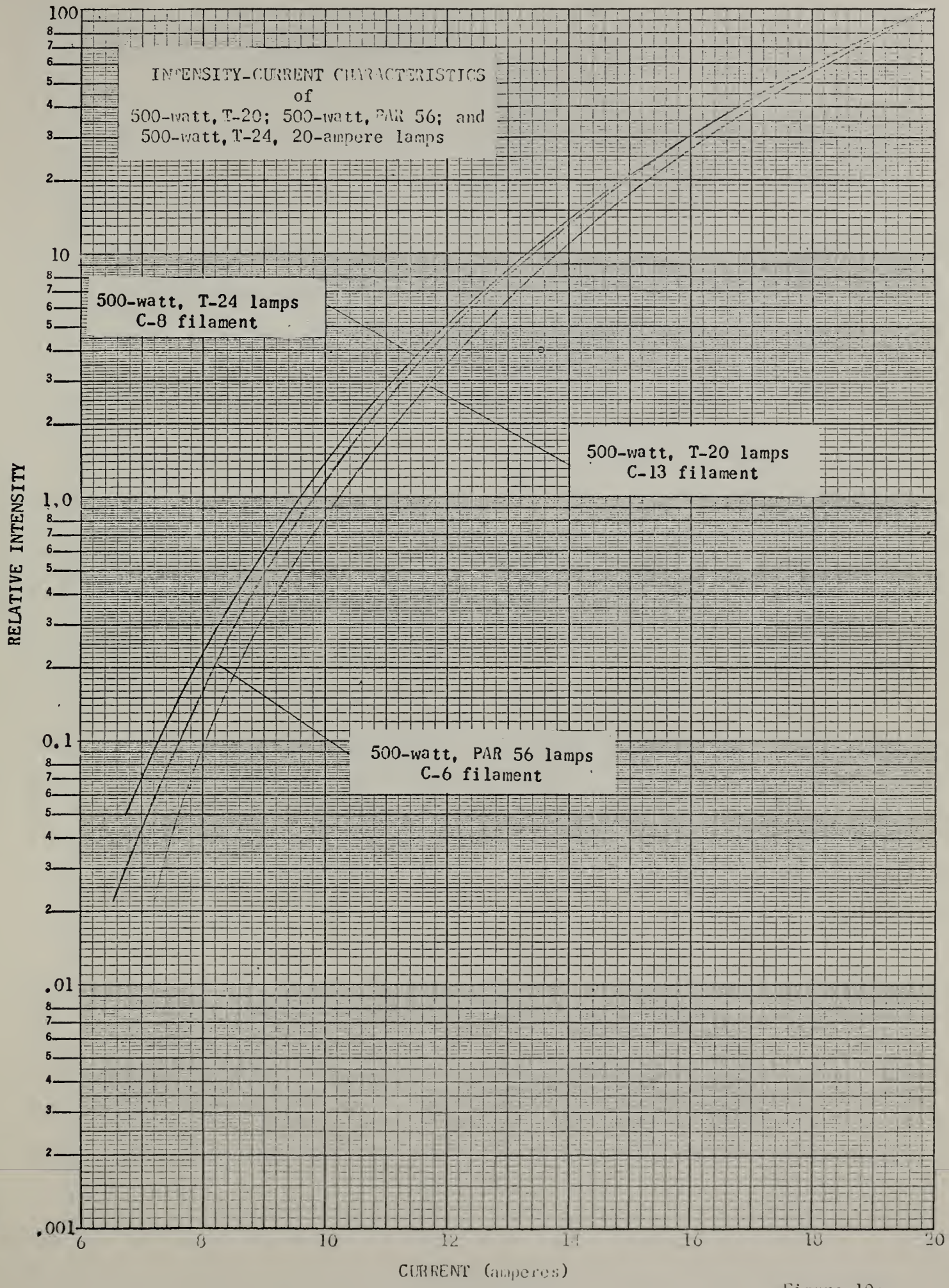
INTENSITY-CURRENT CHARACTERISTICS
of
500-watt, T-20; 500-watt, PAR 56; and
500-watt, T-24, 20-ampere lamps
500-watt, T-24 lamps
C-8 filament
500-watt, T-20 lamps
C-13 filament
500-watt, PAR 56 lamps
C-6 filament
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
6
8
10
12
14
16
18
20
CURRENT (amperes)

Figure 10a

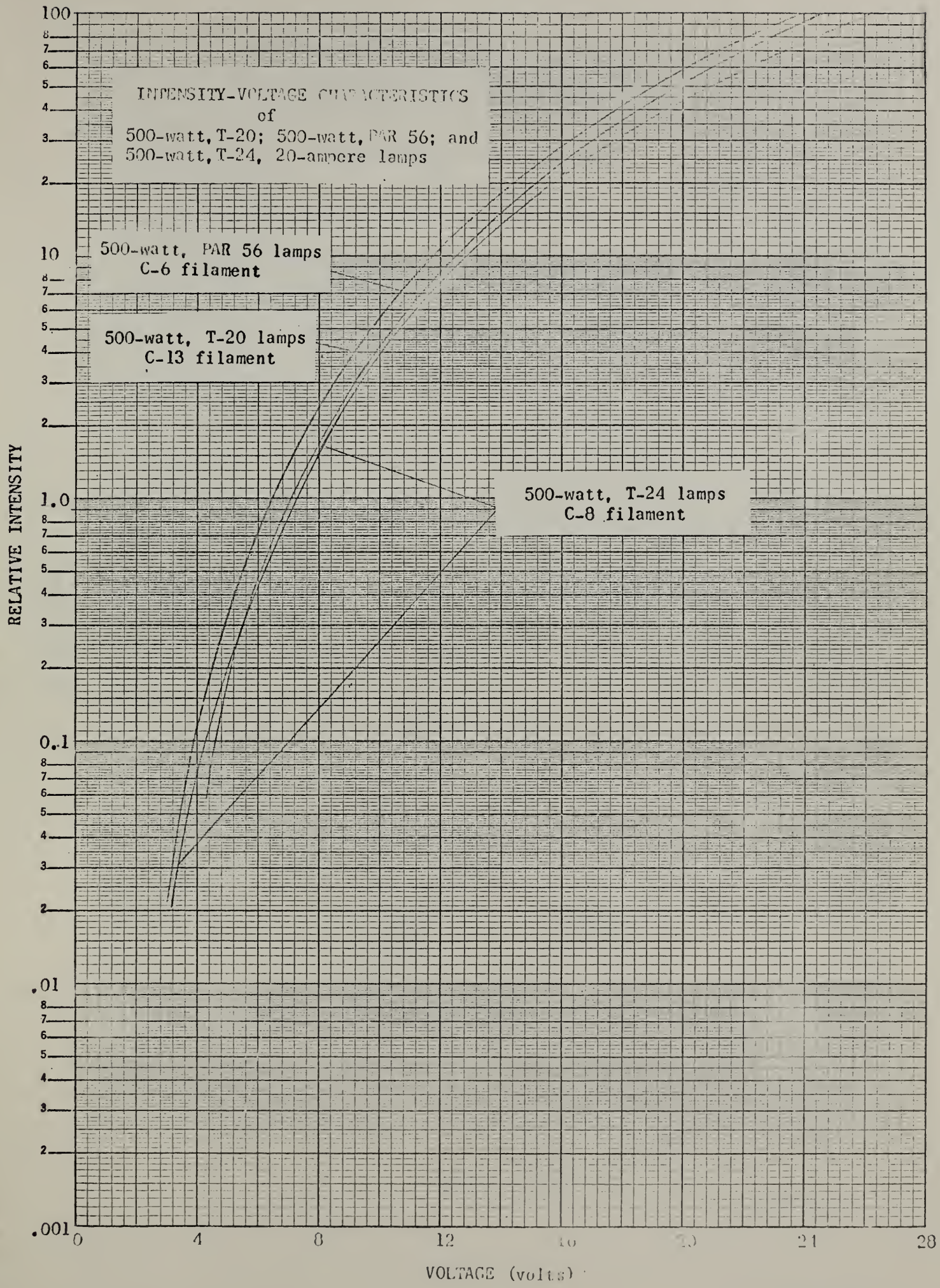
INTENSITY-VOLTAGE CHARACTERISTICS
of
500-watt, T-20; 500-watt, PAR 56; and
500-watt, T-24, 20-ampere lamps
500-watt, PAR 56 lamps
C-6 filament
500-watt, T-20 lamps
C-13 filament
500-watt, T-24 lamps
C-8 filament
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
4
8
12
21
28
VOLTAGE (volts)

Figure 10b

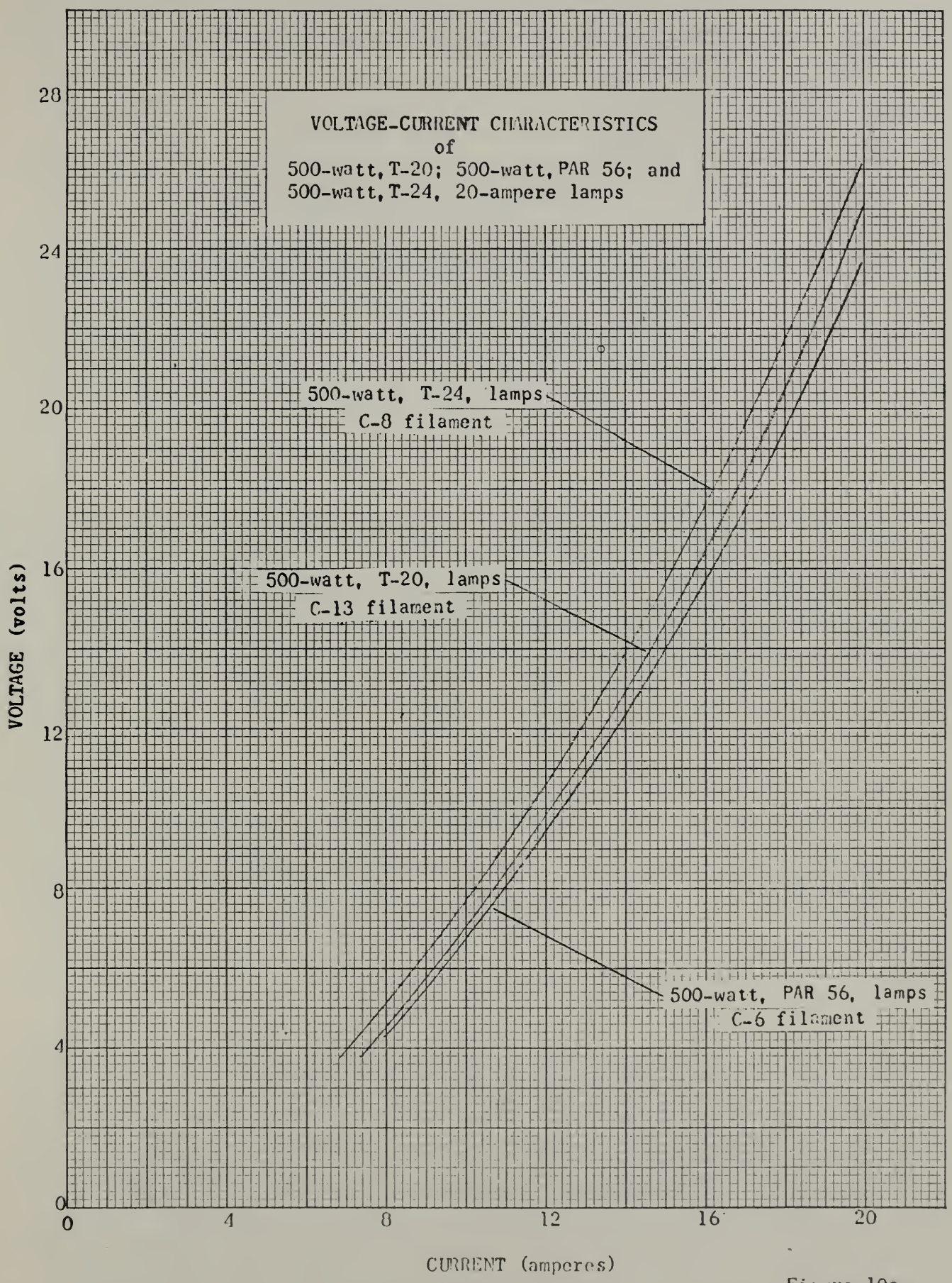
VOLTAGE-CURRENT CHARACTERISTICS
of
500-watt, T-20; 500-watt, PAR 56; and
500-watt, T-24, 20-ampere lamps
500-watt, T-24, lamps
C-8 filament
500-watt, T-20, lamps
C-13 filament
500-watt, PAR 56, lamps
C-6 filament
VOLTAGE (volts)
CURRENT (amperes)
0
4
8
12
16
20
24
28

Figure 10c

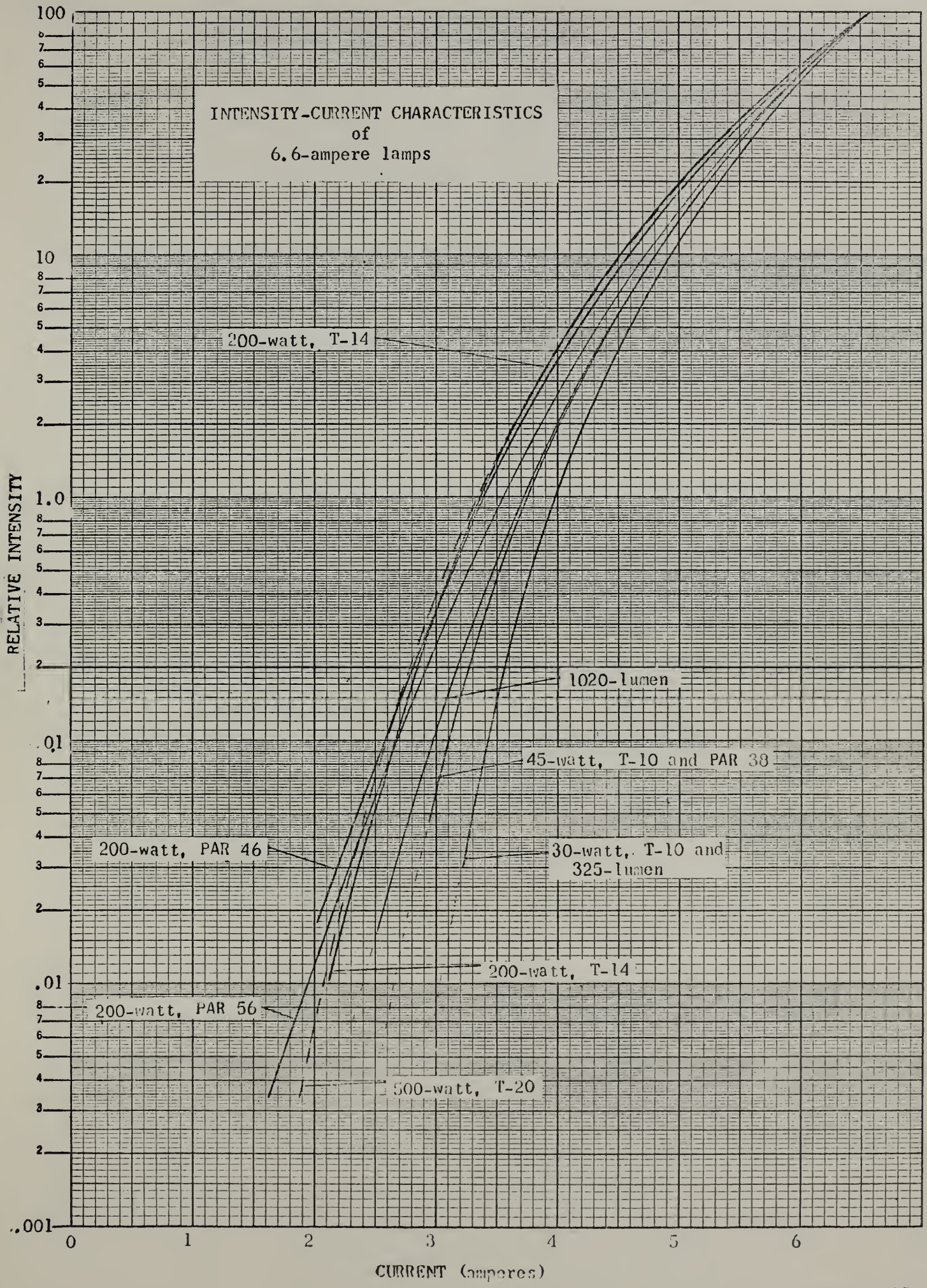
INTENSITY-CURRENT CHARACTERISTICS
of
6.6-ampere lamps
RELATIVE INTENSITY
CURRENT (amperes)
100
10
1.0
.01
.001
0
1
2
3
4
5
6
200-watt, T-14
1020-lumen
45-watt, T-10 and PAR 38
200-watt, PAR 46
30-watt, T-10 and
325-lumen
200-watt, T-14
200-watt, PAR 56
500-watt, T-20

Figure 11

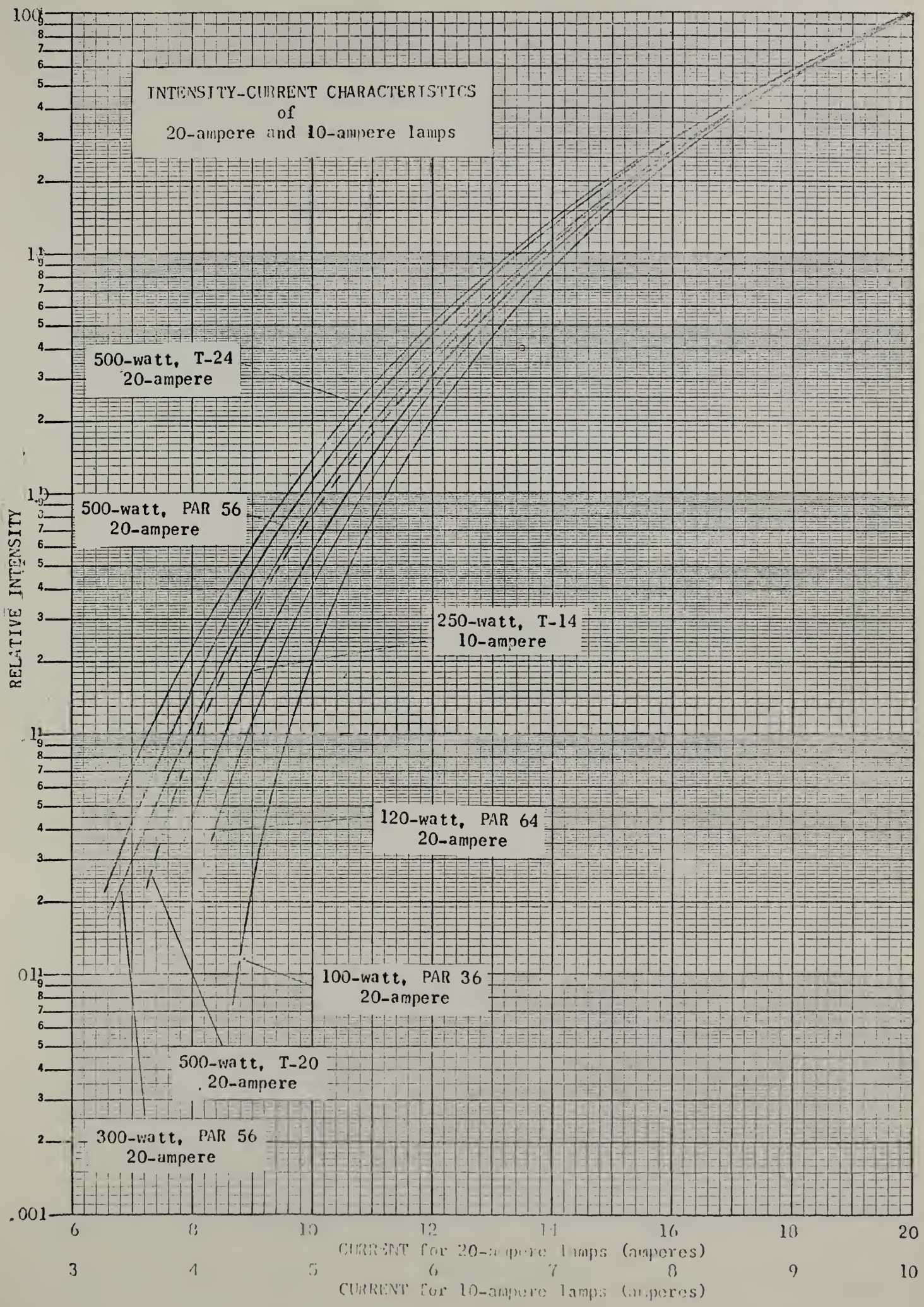
INTENSITY-CURRENT CHARACTERISTICS
of
20-ampere and 10-ampere lamps
500-watt, T-24
20-ampere
500-watt, PAR 56
20-ampere
250-watt, T-14
10-ampere
120-watt, PAR 64
20-ampere
100-watt, PAR 36
20-ampere
500-watt, T-20
20-ampere
300-watt, PAR 56
20-ampere
RELATIVE INTENSITY
100
10
1.0
.1
.01
.001
6
8
10
12
14
16
18
20
CURRENT for 20-ampere lamps (amperes)
3
4
5
6
7
8
9
10
CURRENT for 10-ampere lamps (amperes)

Figure 12

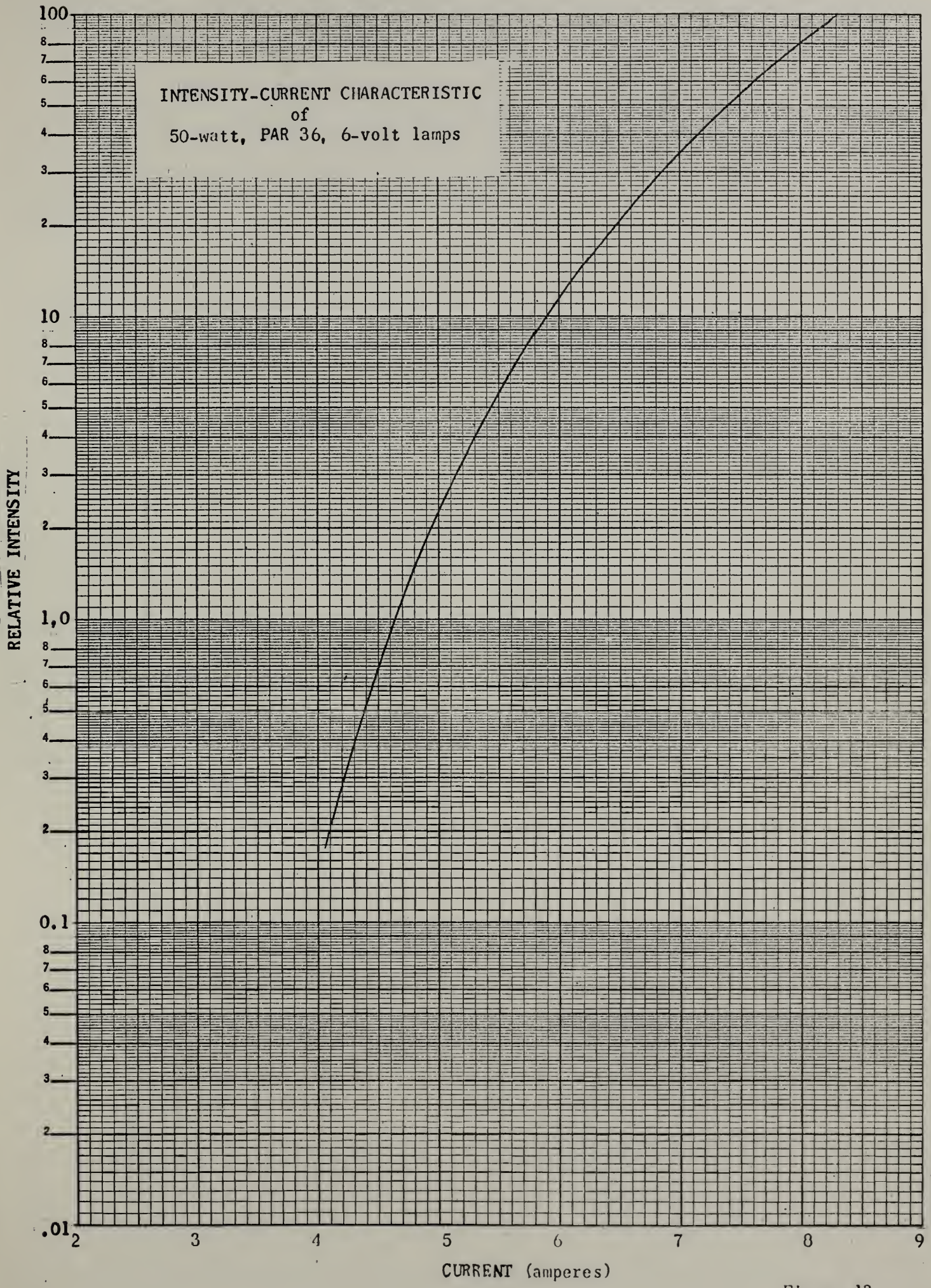
INTENSITY-CURRENT CHARACTERISTIC
of
50-watt, PAR 36, 6-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
2
3
4
5
6
7
8
9
CURRENT (amperes)

Figure 13a

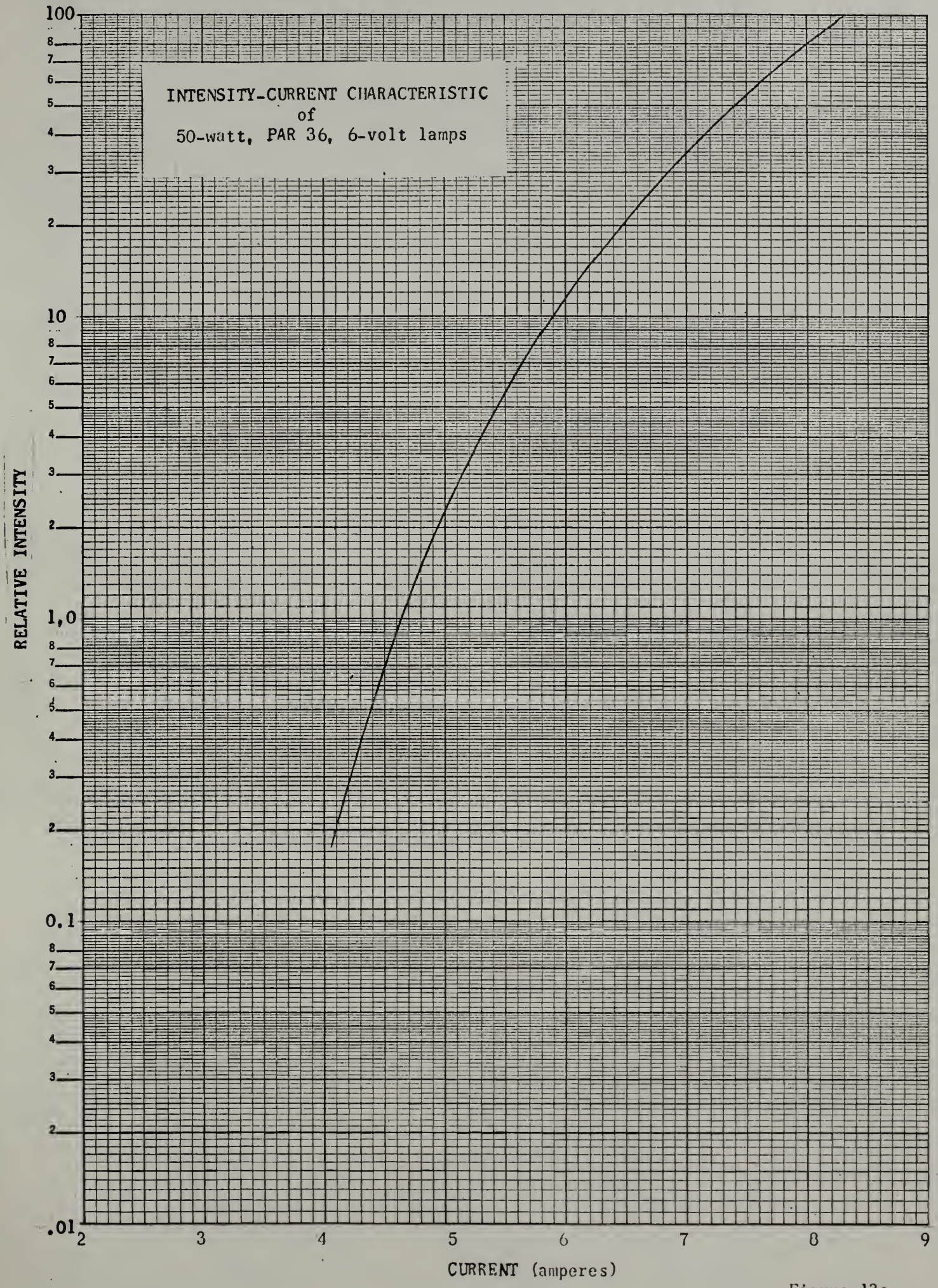
INTENSITY-CURRENT CHARACTERISTIC
of
50-watt, PAR 36, 6-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
2
3
4
5
6
7
8
9
CURRENT (amperes)

Figure 13a

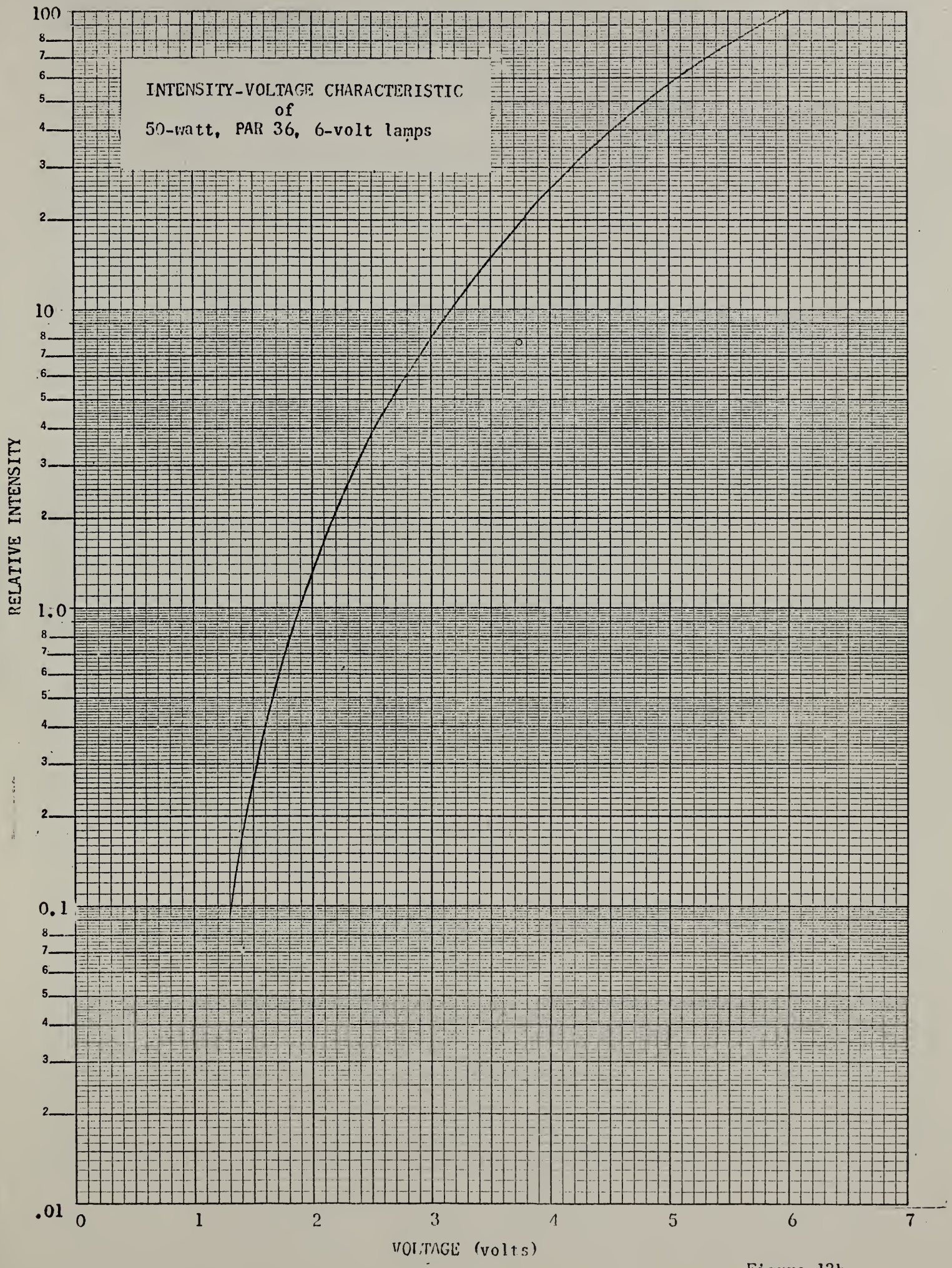
INTENSITY-VOLTAGE CHARACTERISTIC
of
50-watt, PAR 36, 6-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
1
2
3
4
5
6
7
VOLTAGE (volts)

Figure 13b

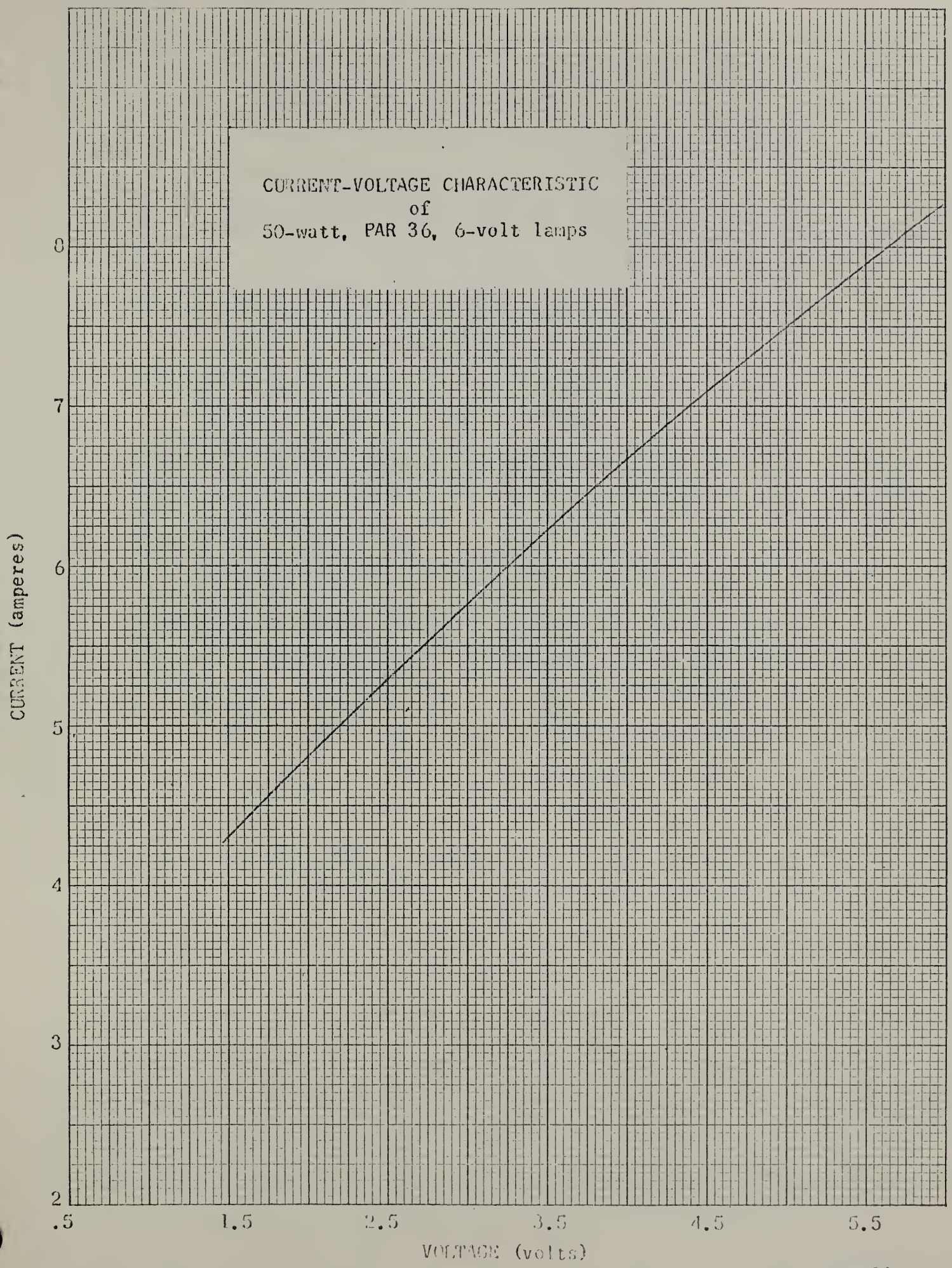
CURRENT-VOLTAGE CHARACTERISTIC
of
50-watt, PAR 36, 6-volt lamps
CURRENT (amperes)
8
7
6
5
4
3
2
.5
1.5
2.5
3.5
4.5
5.5
VOLTAGE (volts)

Figure 13c

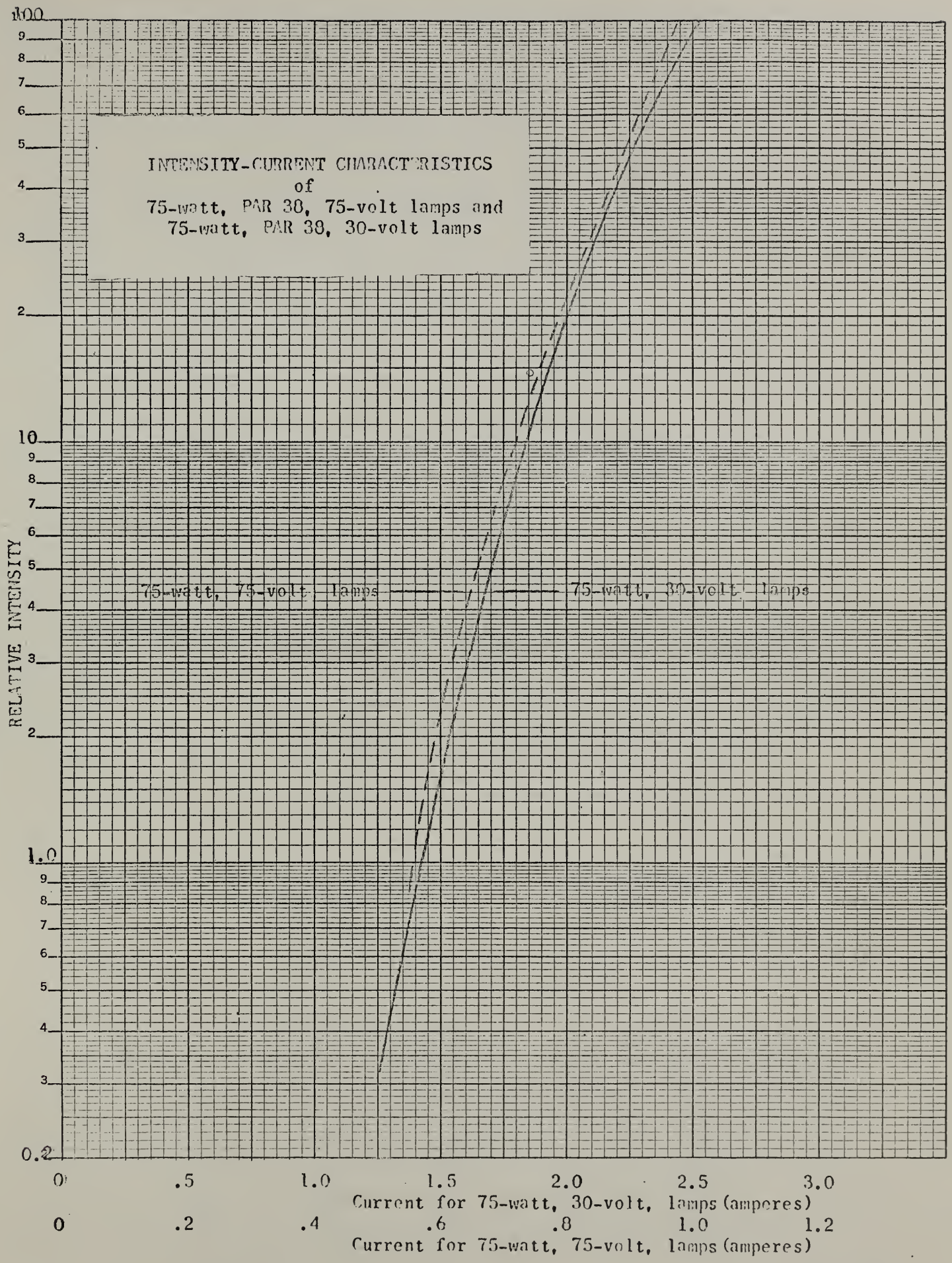
INTENSITY-CURRENT CHARACTERISTICS
of
75-watt, PAR 38, 75-volt lamps and
75-watt, PAR 38, 30-volt lamps
75-watt, 75-volt lamps
75-watt, 30-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.2
0
.5
1.0
1.5
2.0
2.5
3.0
Current for 75-watt, 30-volt, lamps (amperes)
0
.2
.4
.6
.8
1.0
1.2
Current for 75-watt, 75-volt, lamps (amperes)

Figure 14a

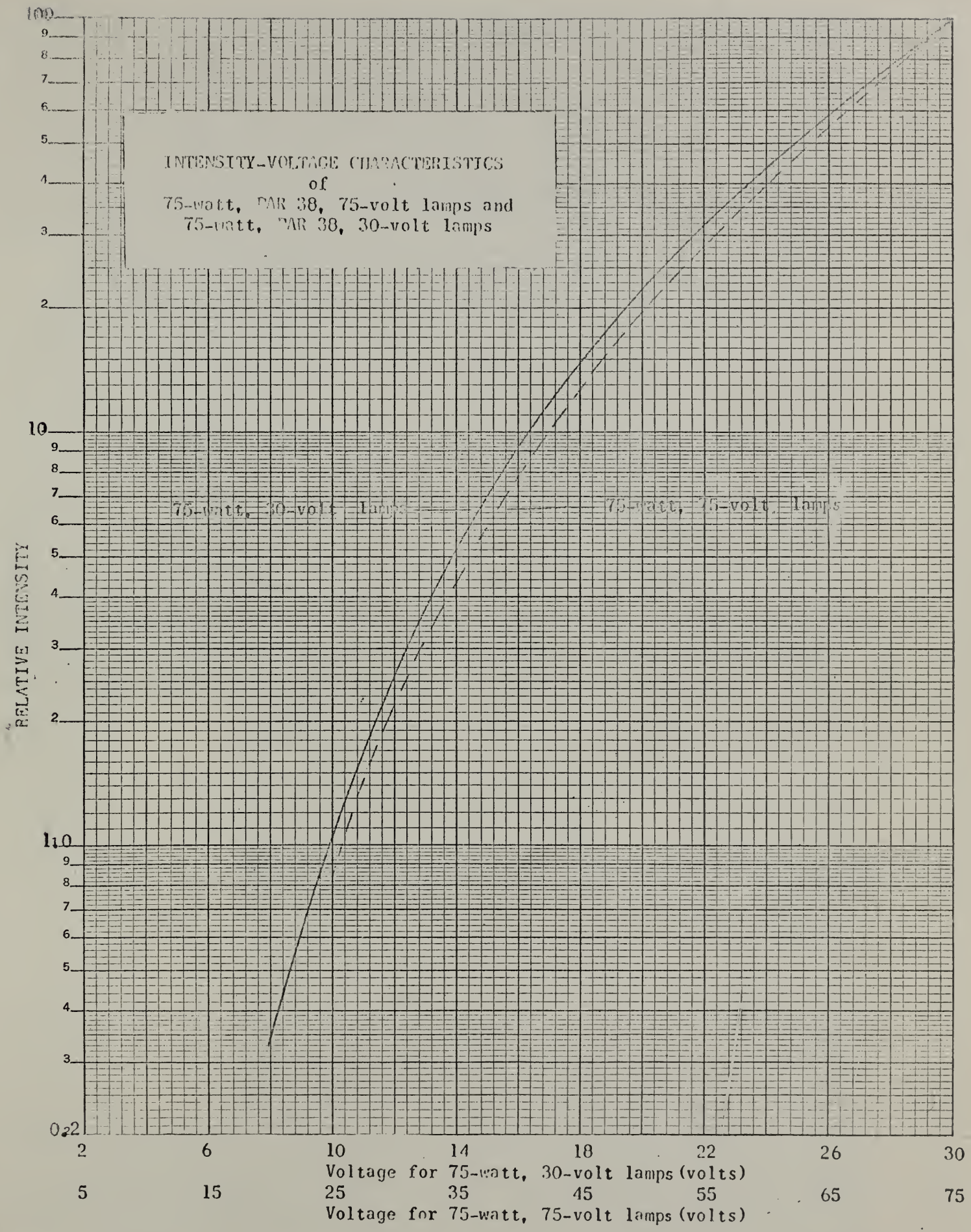
INTENSITY-VOLTAGE CHARACTERISTICS
of
75-watt, PAR 38, 75-volt lamps and
75-watt, PAR 38, 30-volt lamps
75-watt, 30-volt lamps
75-watt, 75-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.2
2
6
10
14
18
22
26
30
Voltage for 75-watt, 30-volt lamps (volts)
5
15
25
35
45
55
65
75
Voltage for 75-watt, 75-volt lamps (volts)

Figure 14b

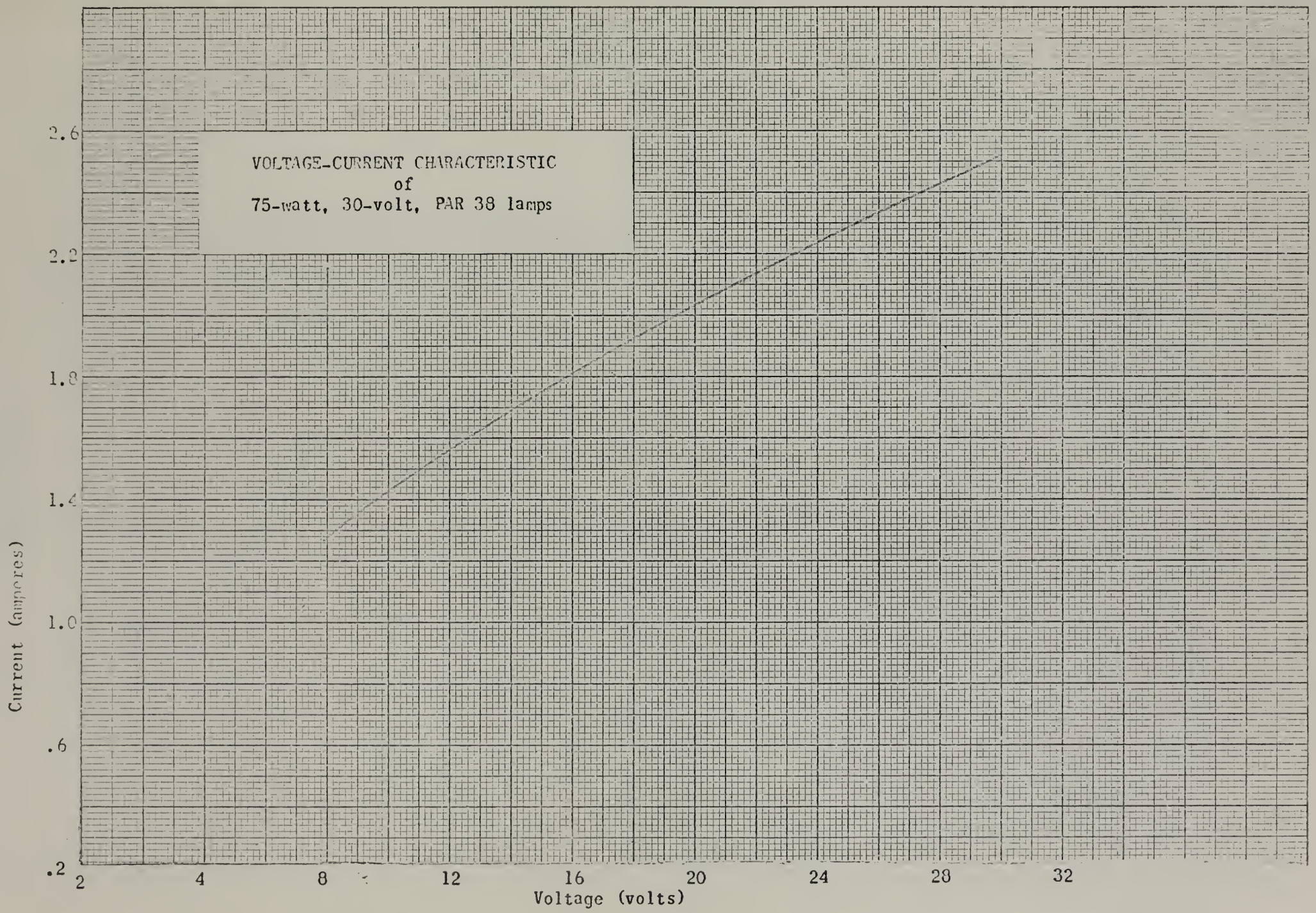
VOLTAGE-CURRENT CHARACTERISTIC
of
75-watt, 30-volt, PAR 38 lamps
2.6
2.2
1.8
1.4
1.0
.6
.2
Current (amperes)
2
4
8
12
16
20
24
28
32
Voltage (volts)

Figure 14c

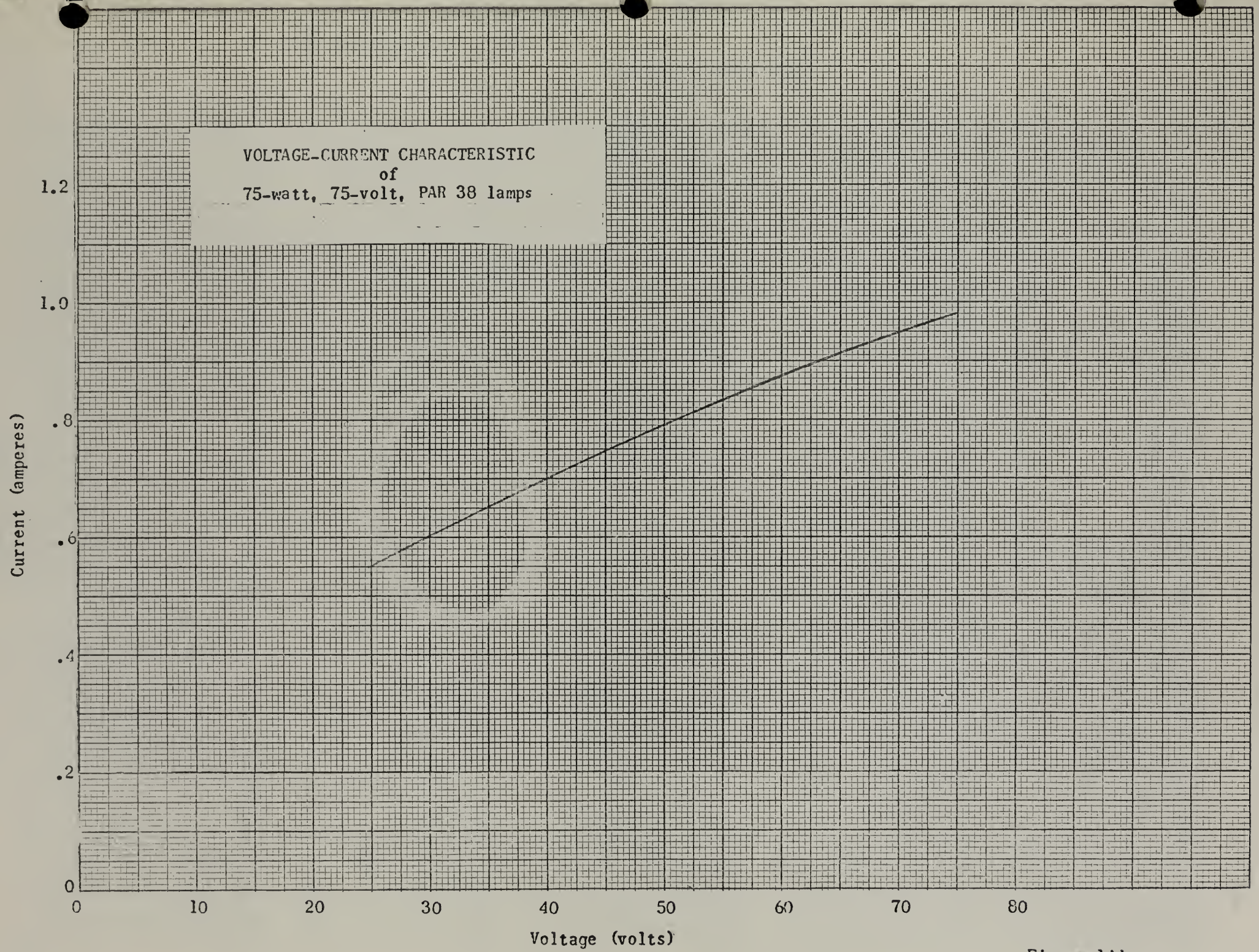
VOLTAGE-CURRENT CHARACTERISTIC
of
75-watt, 75-volt, PAR 38 lamps
Current (amperes)
1.2
1.0
.8
.6
.4
.2
0
0
10
20
30
40
50
60
70
80
Voltage (volts)

Figure 14d

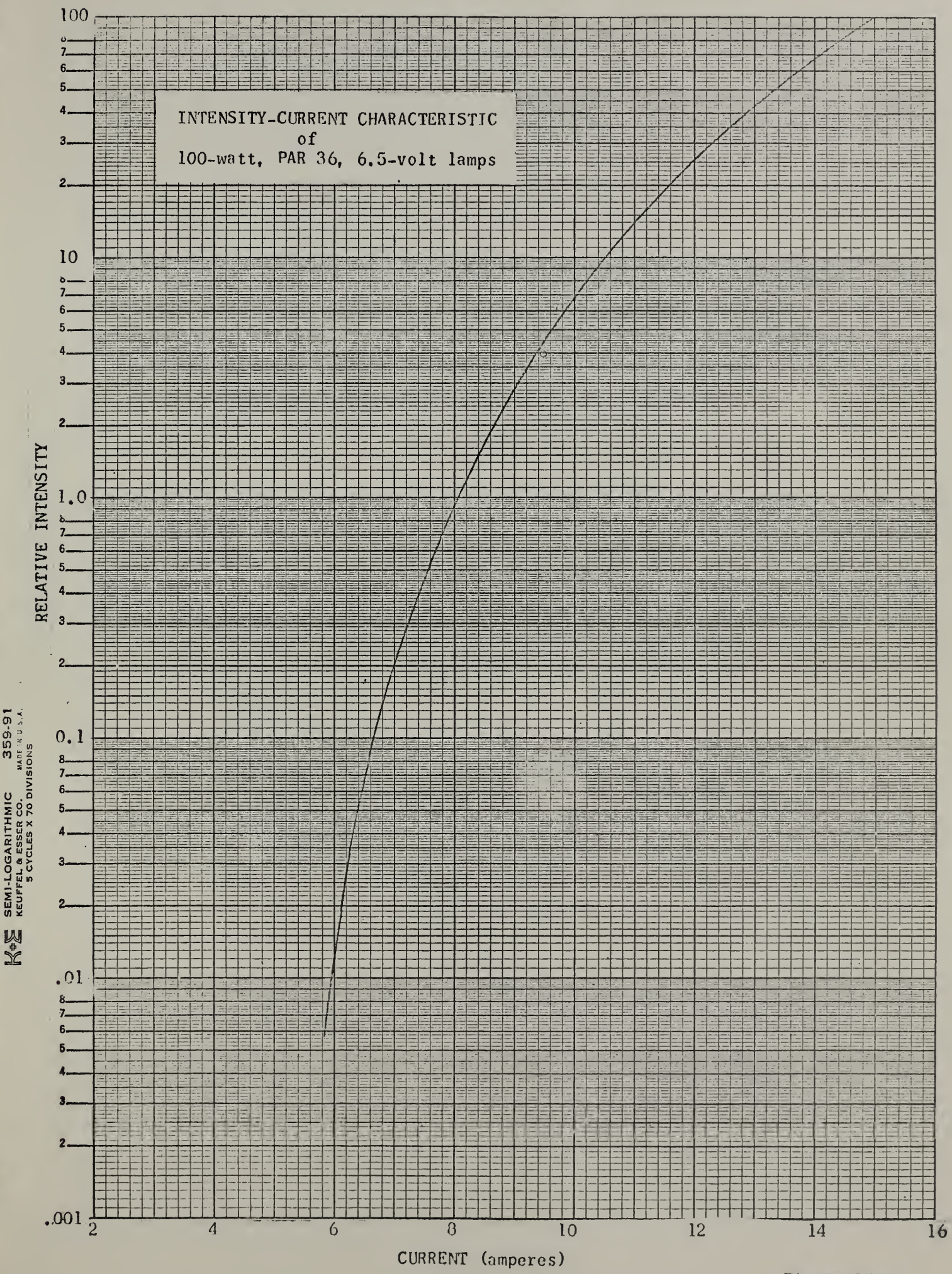
INTENSITY-CURRENT CHARACTERISTIC
of
100-watt, PAR 36, 6.5-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
CURRENT (amperes)
2
4
6
8
10
12
14
16
SEMI-LOGARITHMIC 359-91
KEUFFEL & ESSER CO. MADE IN U.S.A.
5 CYCLES X 70 DIVISIONS

Figure 15a

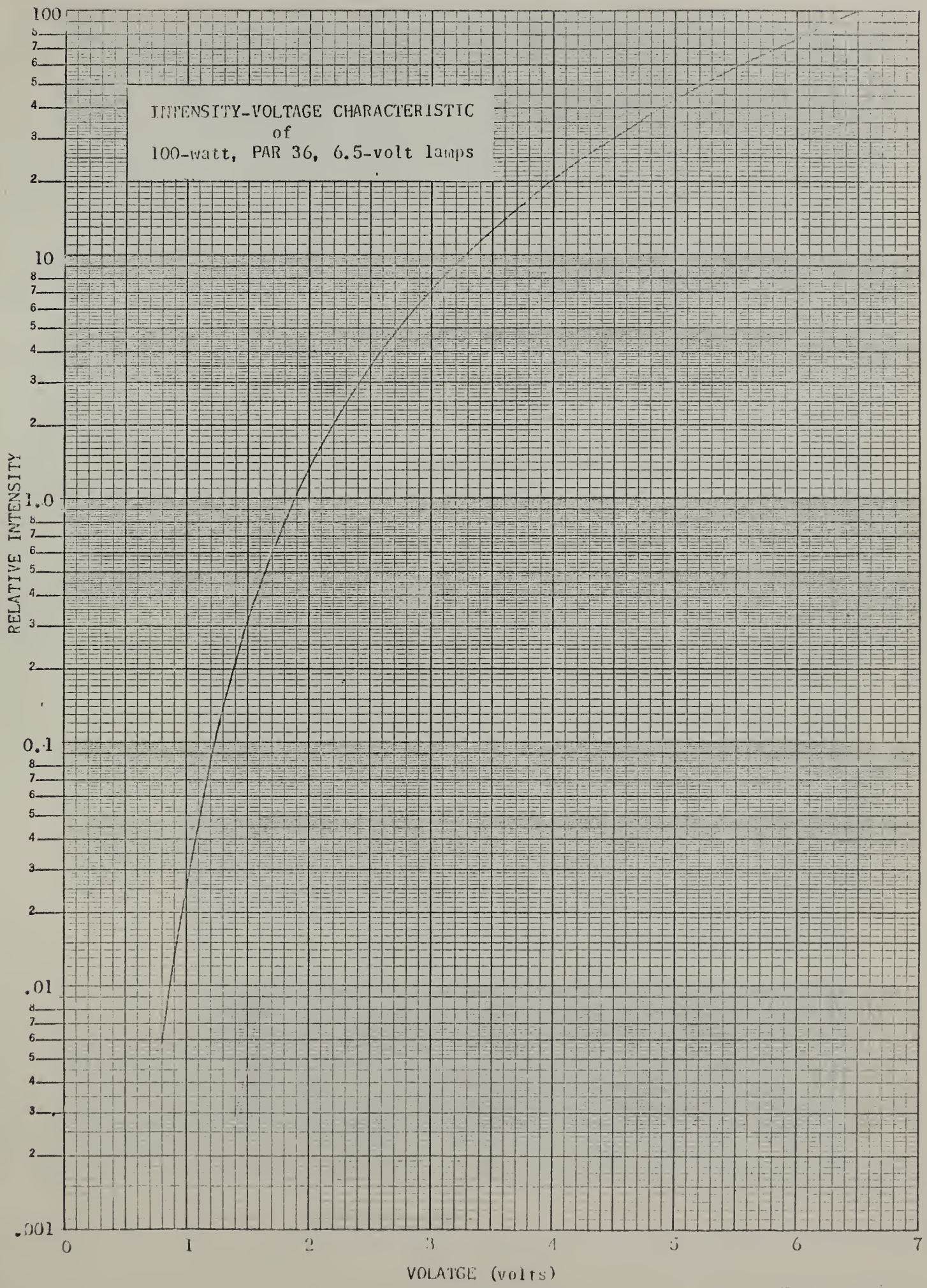
INTENSITY-VOLTAGE CHARACTERISTIC
of
100-watt, PAR 36, 6.5-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
1
2
3
4
5
6
7
VOLATGE (volts)

Figure 15b

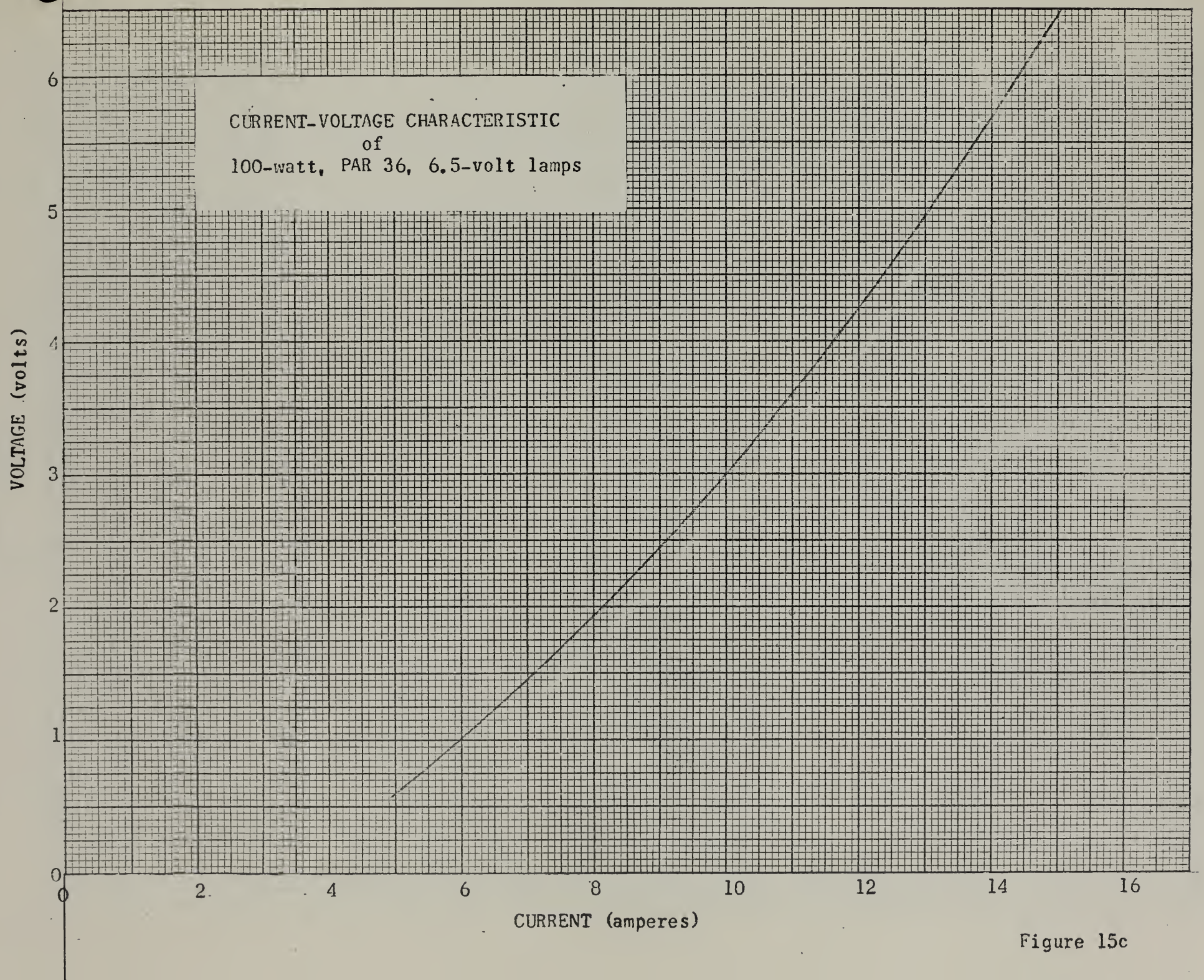
CURRENT-VOLTAGE CHARACTERISTIC
of
100-watt, PAR 36, 6.5-volt lamps
VOLTAGE (volts)
0
1
2
3
4
5
6
0
2
4
6
8
10
12
14
16
CURRENT (amperes)

Figure 15c

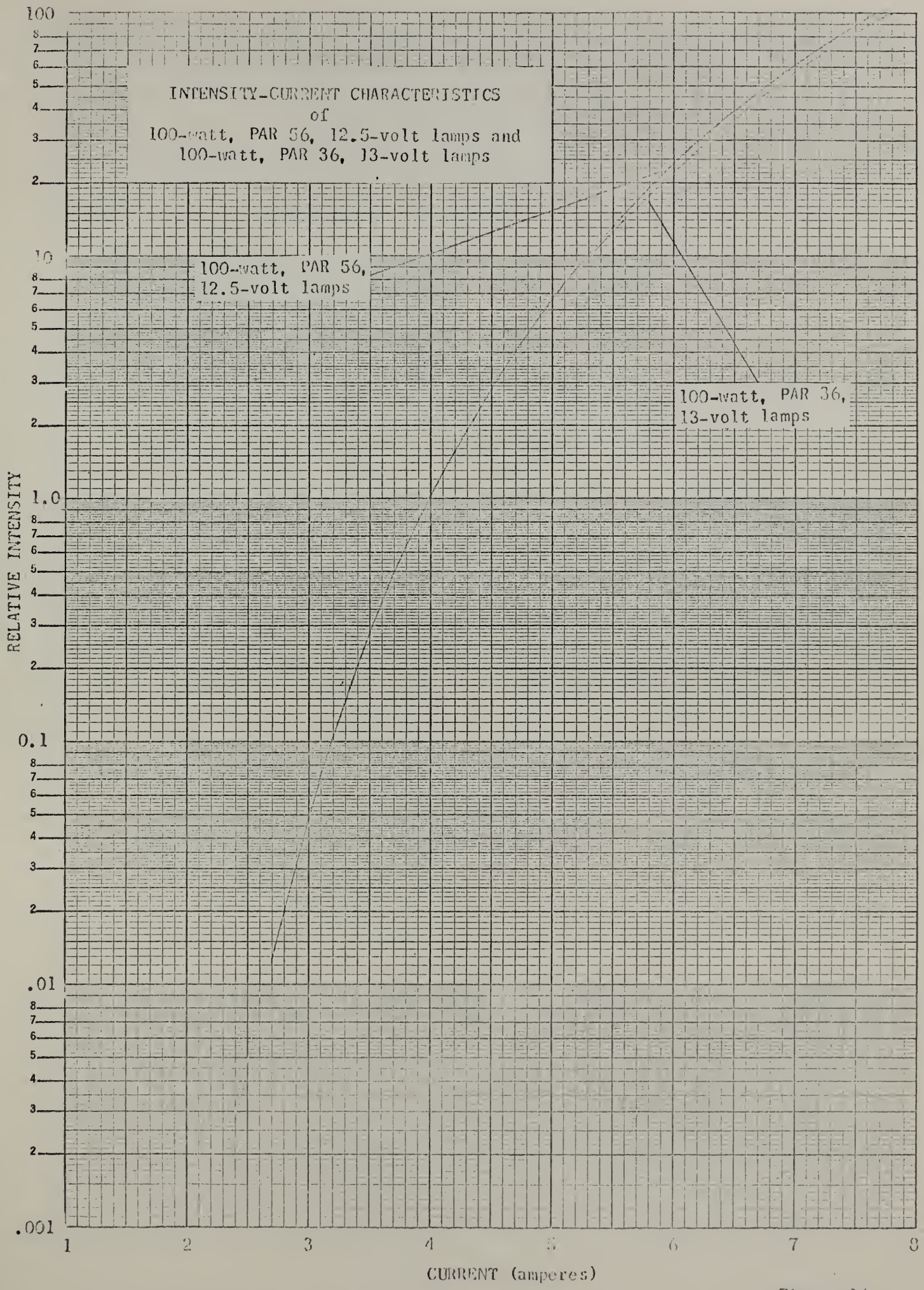
INTENSITY-CURRENT CHARACTERISTICS
of
100-watt, PAR 56, 12.5-volt lamps and
100-watt, PAR 36, 13-volt lamps
100-watt, PAR 56,
12.5-volt lamps
100-watt, PAR 36,
13-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
1
2
3
4
5
6
7
8
CURRENT (amperes)

Figure 16a

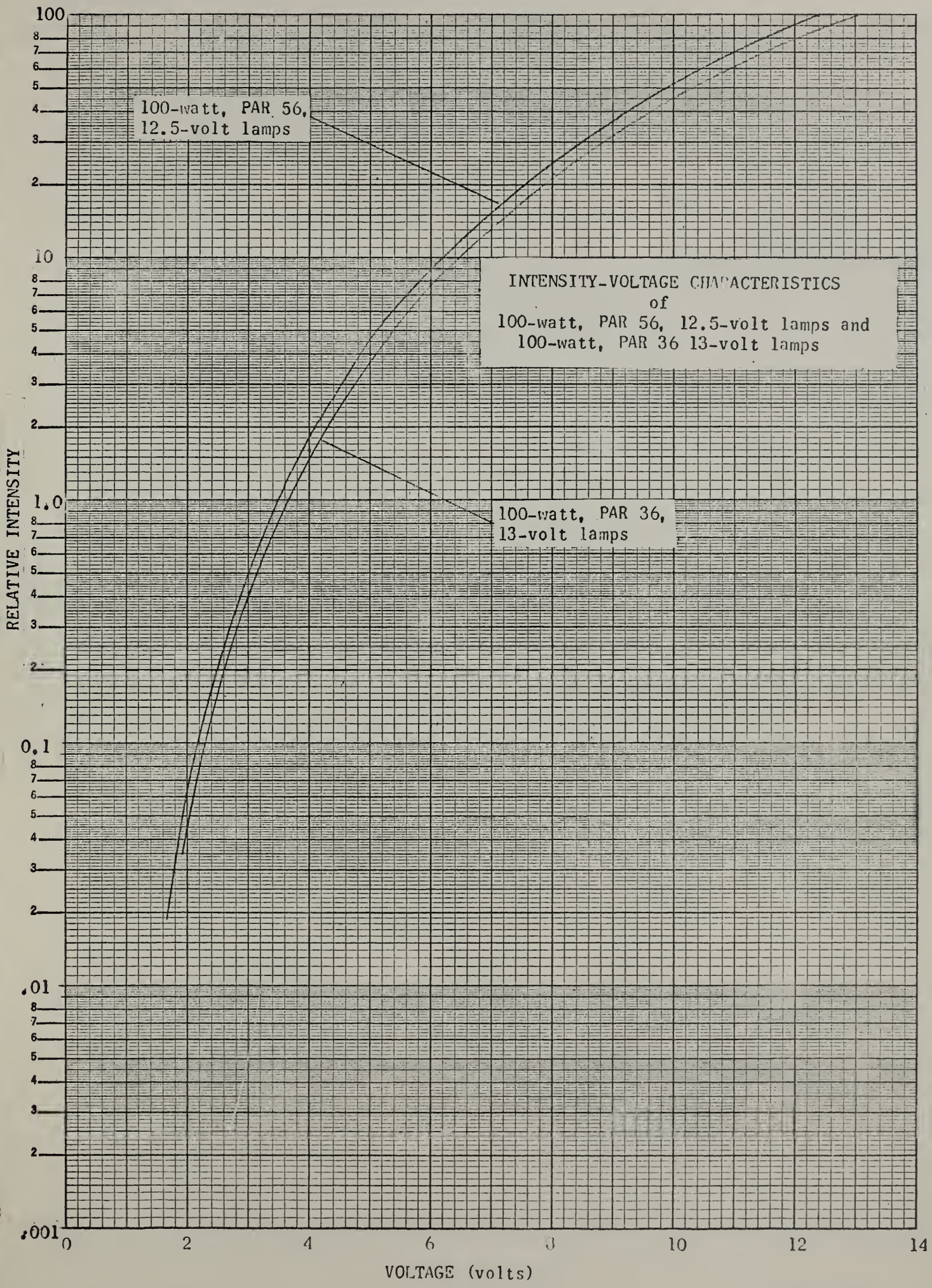
INTENSITY-VOLTAGE CHARACTERISTICS
of
100-watt, PAR 56, 12.5-volt lamps and
100-watt, PAR 36 13-volt lamps
100-watt, PAR 56,
12.5-volt lamps
100-watt, PAR 36,
13-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
2
4
6
8
10
12
14
VOLTAGE (volts)

Figure 16b

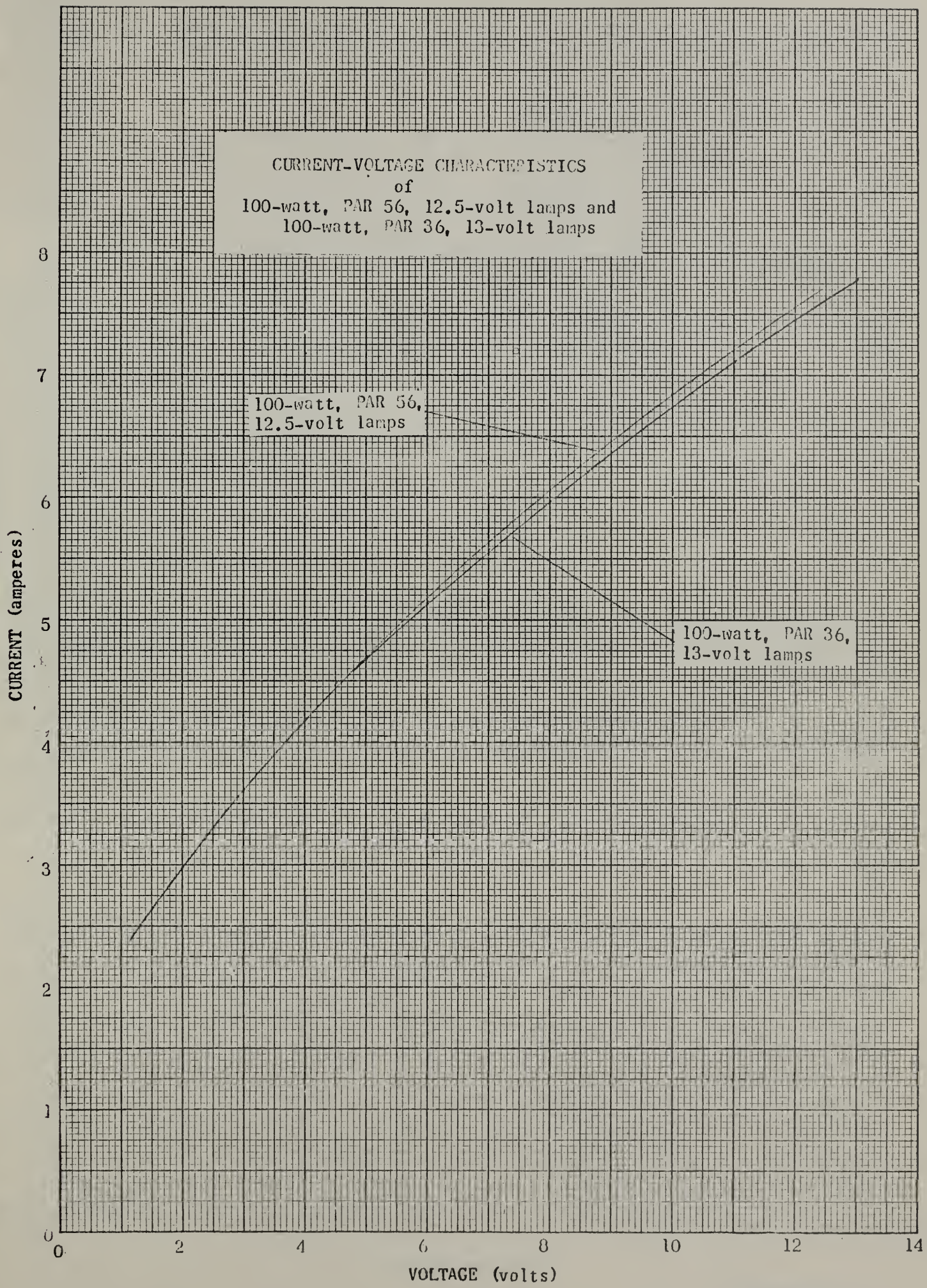
CURRENT-VOLTAGE CHARACTERISTICS
of
100-watt, PAR 56, 12.5-volt lamps and
100-watt, PAR 36, 13-volt lamps
100-watt, PAR 56,
12.5-volt lamps
100-watt, PAR 36,
13-volt lamps
CURRENT (amperes)
VOLTAGE (volts)
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10
12
14

Figure 16c

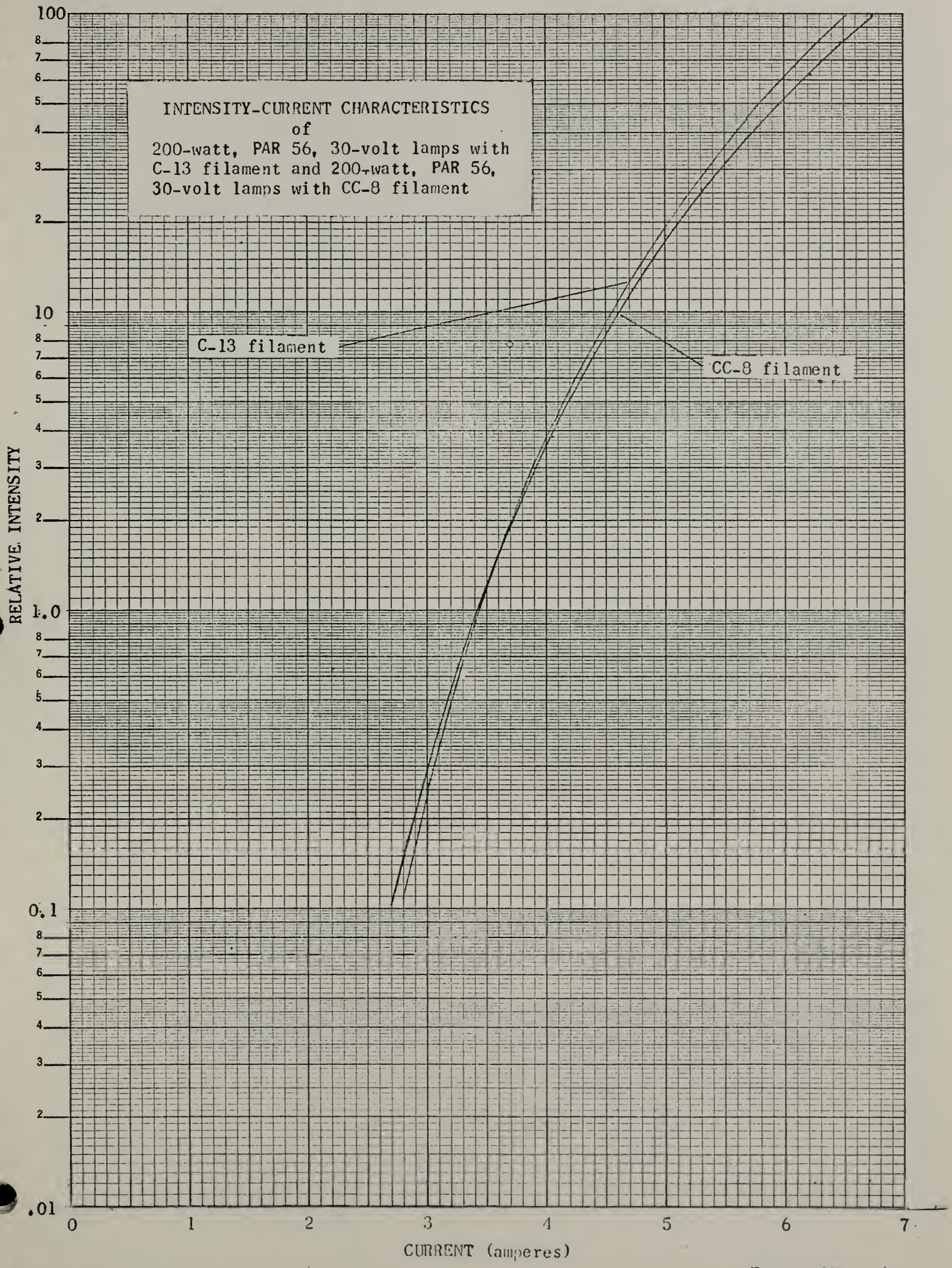
INTENSITY-CURRENT CHARACTERISTICS
of
200-watt, PAR 56, 30-volt lamps with
C-13 filament and 200-watt, PAR 56,
30-volt lamps with CC-8 filament
C-13 filament
CC-8 filament
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
1
2
3
4
5
6
7
CURRENT (amperes)

Figure 17a

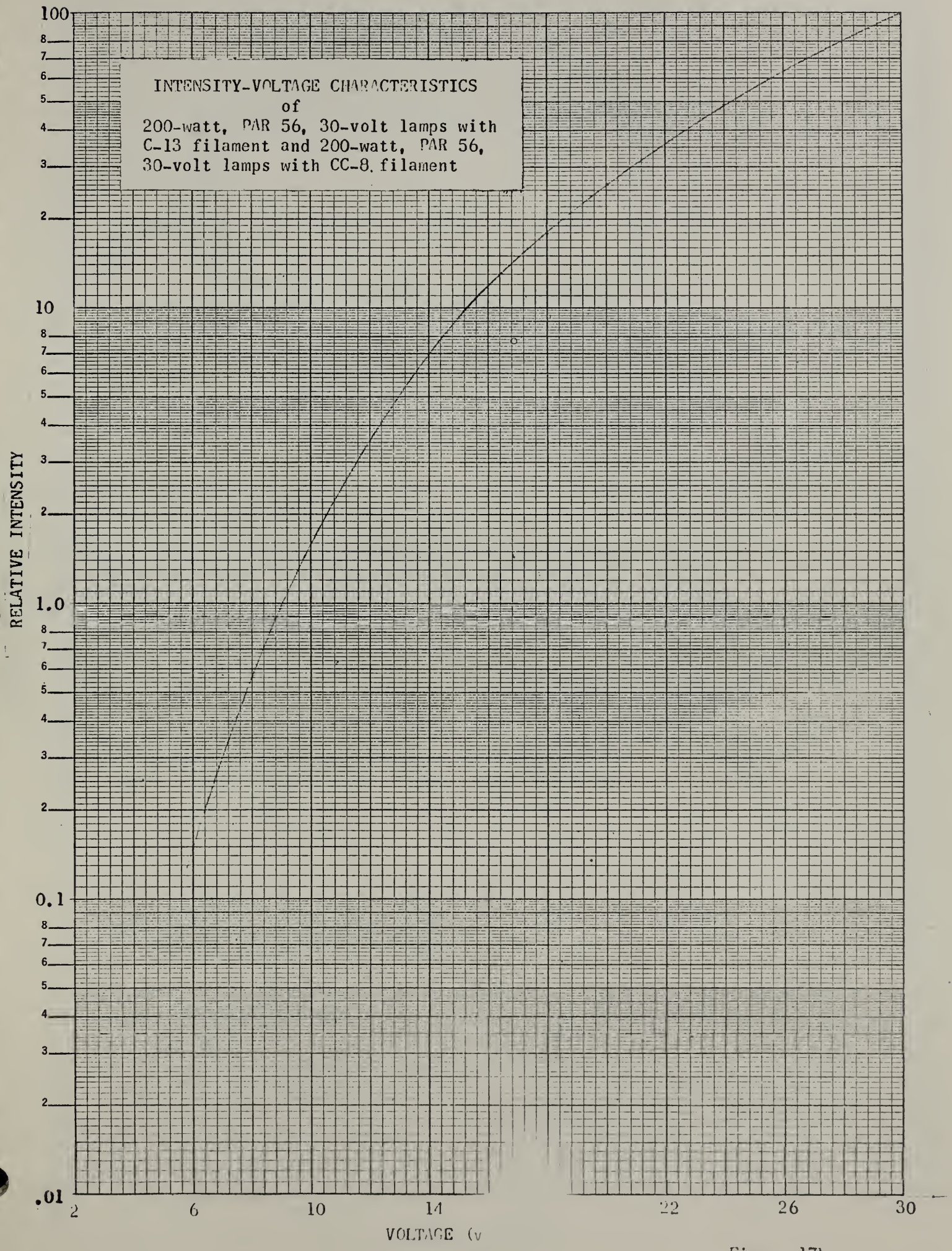
INTENSITY-VOLTAGE CHARACTERISTICS
of
200-watt, PAR 56, 30-volt lamps with
C-13 filament and 200-watt, PAR 56,
30-volt lamps with CC-8 filament
RELATIVE INTENSITY
100
10
1.0
0.1
.01
2
6
10
14
22
26
30
VOLTAGE (v

Figure 17b

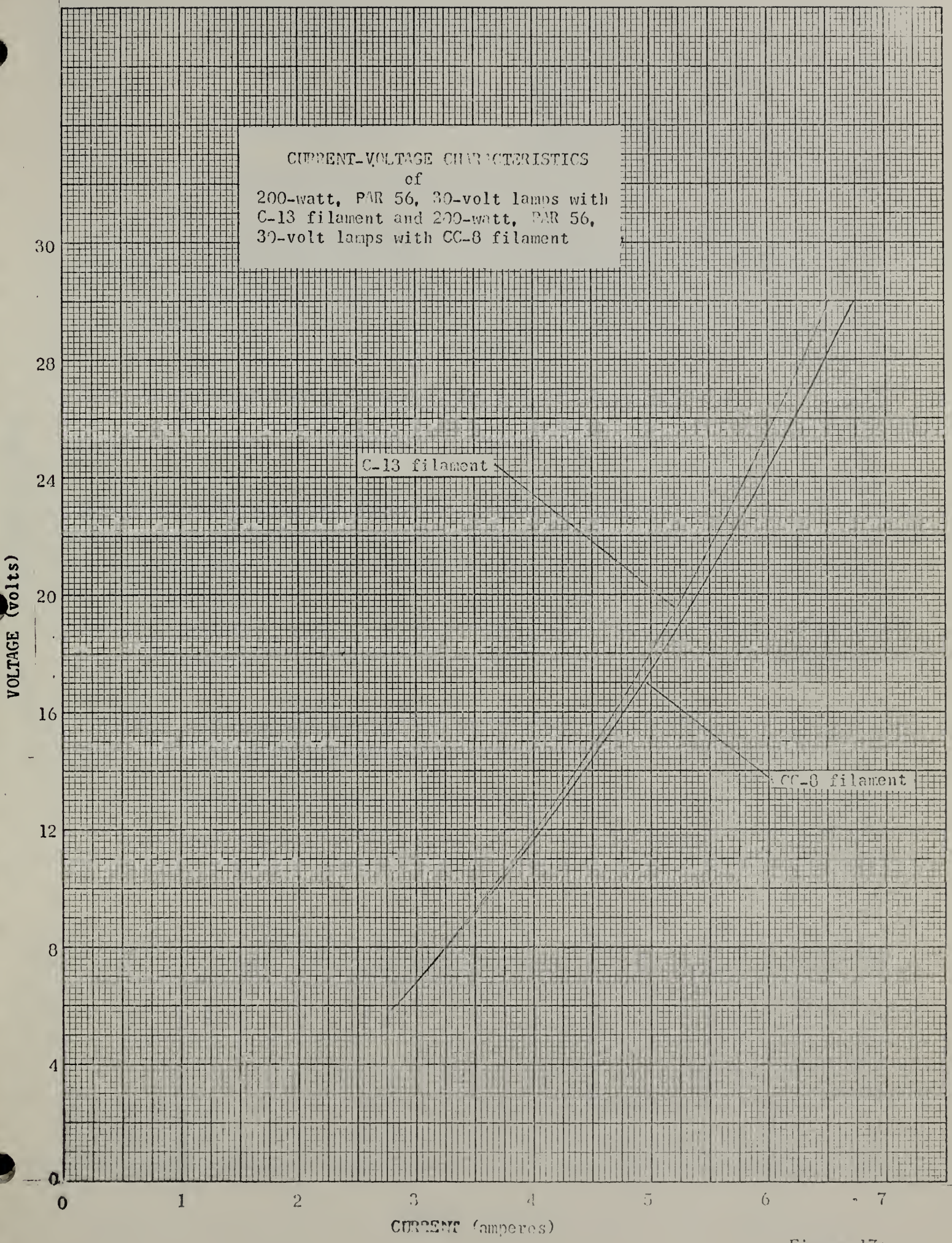
CURRENT-VOLTAGE CHARACTERISTICS
of
200-watt, PAR 56, 30-volt lamps with
C-13 filament and 200-watt, PAR 56,
30-volt lamps with CC-8 filament
C-13 filament
CC-8 filament
VOLTAGE (volts)
CURRENT (amperes)
0
4
8
12
16
20
24
28
30
0
1
2
3
4
5
6
7

Figure 17c

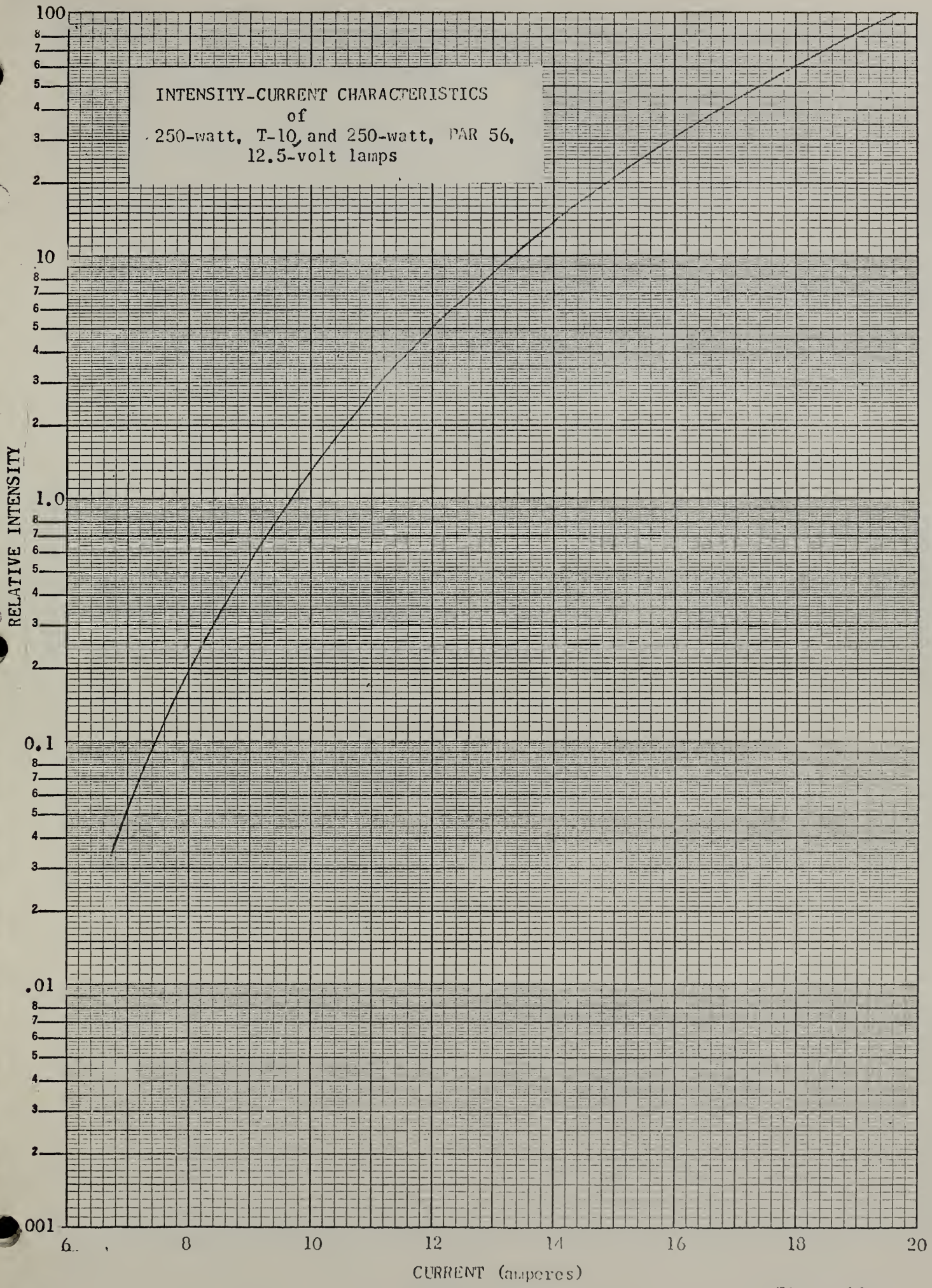
INTENSITY-CURRENT CHARACTERISTICS
of
250-watt, T-10, and 250-watt, PAR 56,
12.5-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
6
8
10
12
14
16
18
20
CURRENT (amperes)

Figure 18a

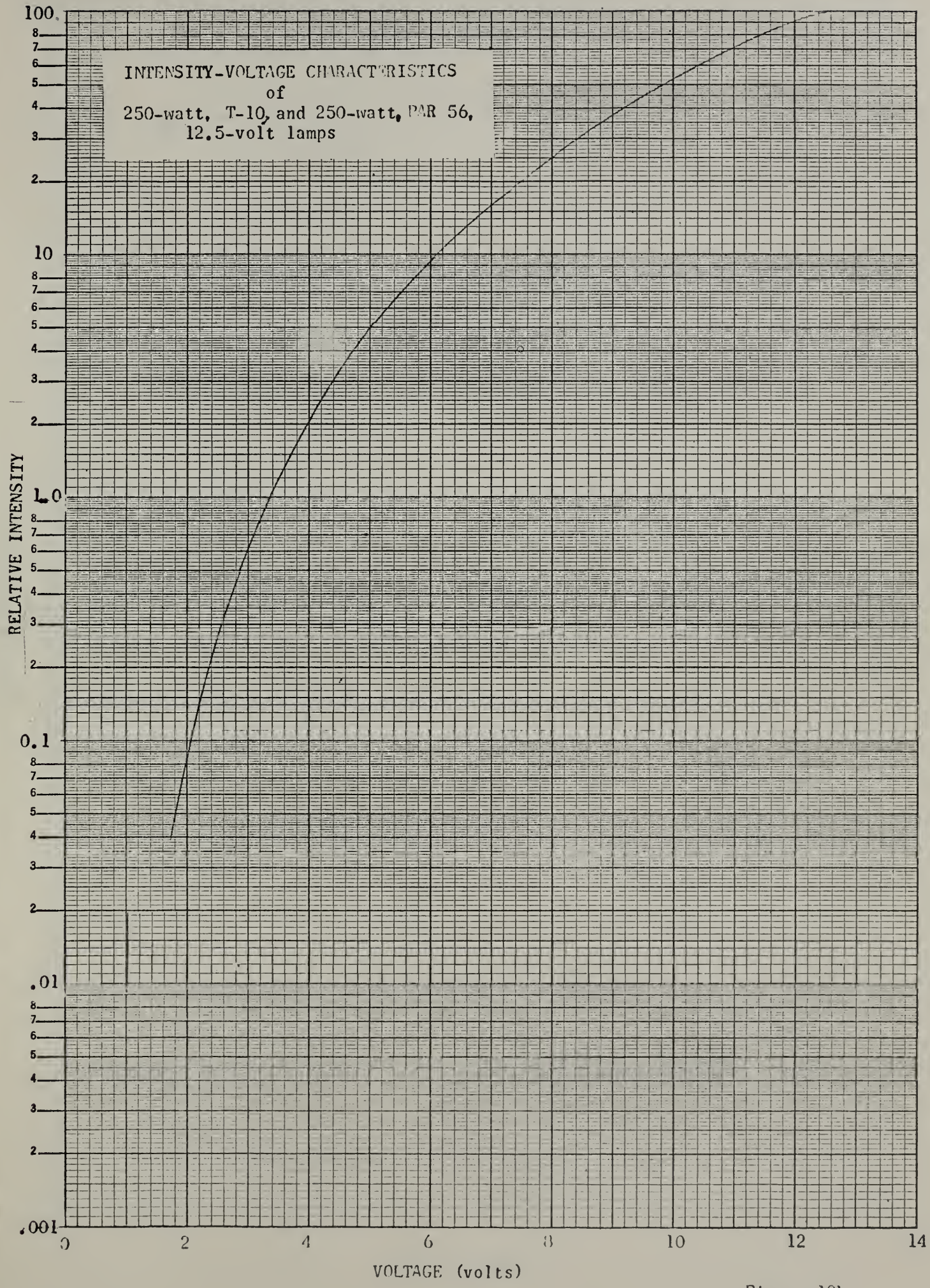
INTENSITY-VOLTAGE CHARACTERISTICS
of
250-watt, T-10, and 250-watt, PAR 56,
12.5-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
2
4
6
8
10
12
14
VOLTAGE (volts)

Figure 18b

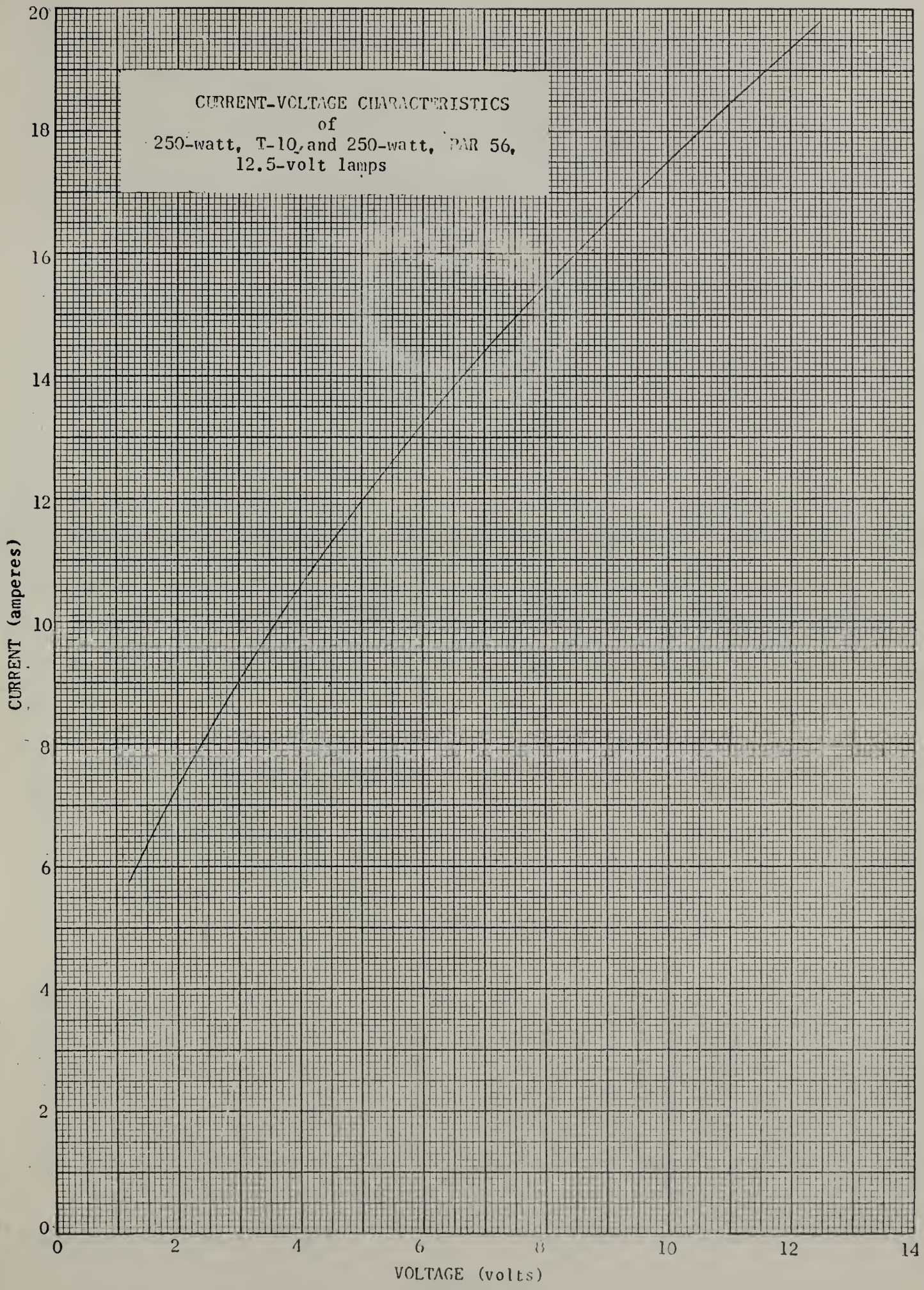
CURRENT-VOLTAGE CHARACTERISTICS
of
250-watt, T-10, and 250-watt, PAR 56,
12.5-volt lamps
CURRENT (amperes)
VOLTAGE (volts)
0
2
4
6
8
10
12
14
16
18
20

Figure 18c

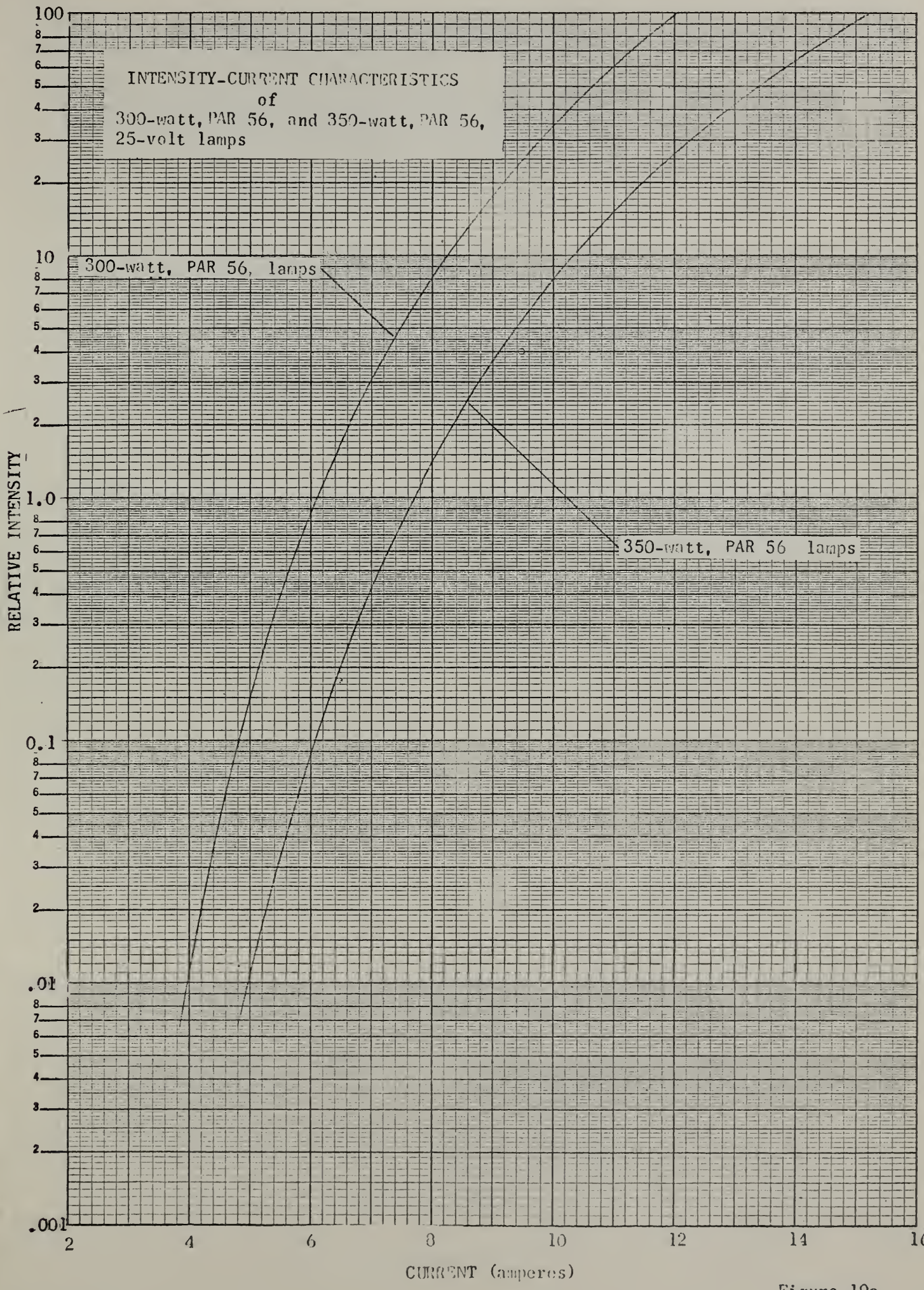
INTENSITY-CURRENT CHARACTERISTICS
of
300-watt, PAR 56, and 350-watt, PAR 56,
25-volt lamps
300-watt, PAR 56, lamps
350-watt, PAR 56 lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
2
4
6
8
10
12
14
16
CURRENT (amperes)

Figure 19a

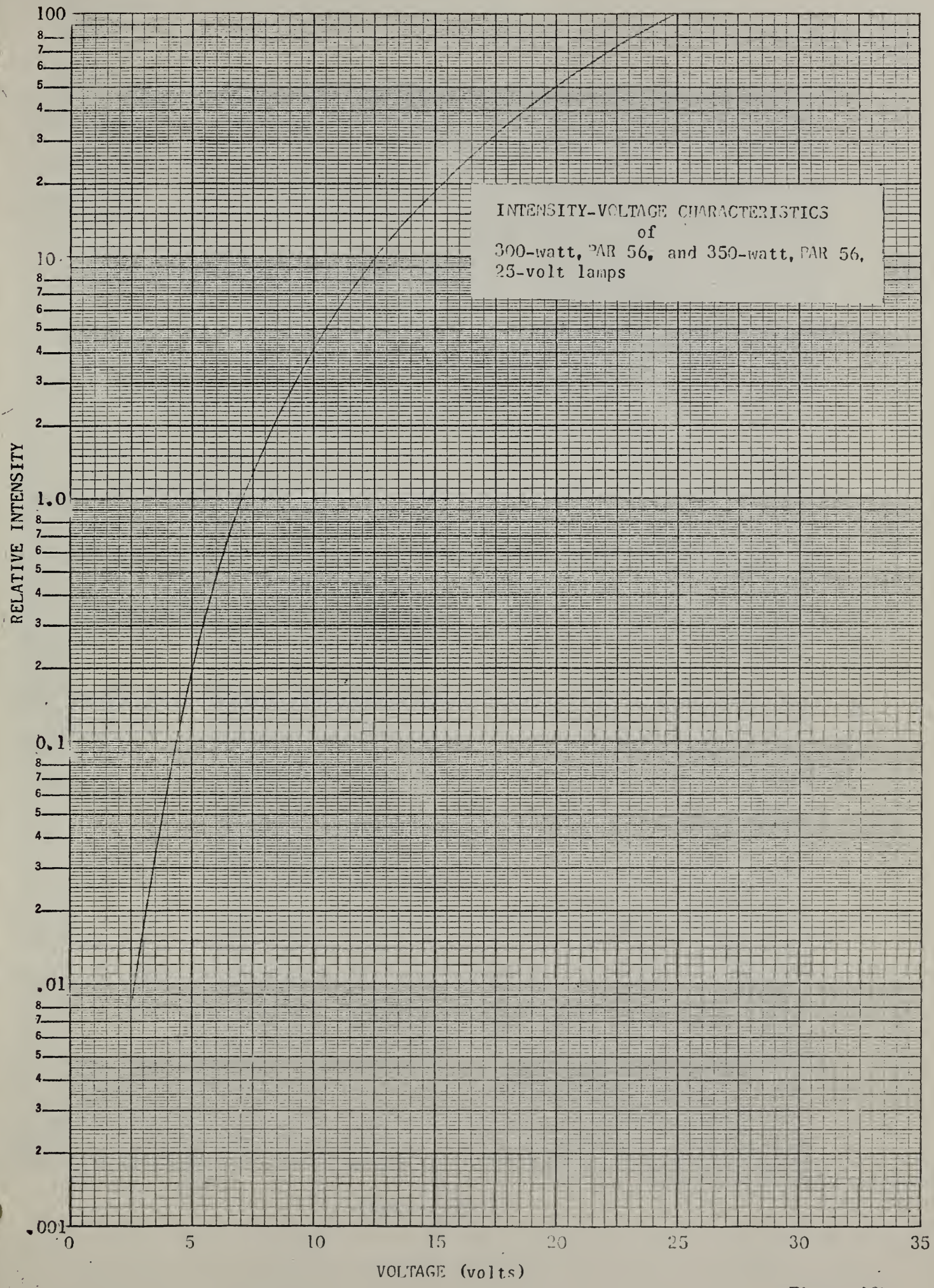
INTENSITY-VOLTAGE CHARACTERISTICS
of
300-watt, PAR 56, and 350-watt, PAR 56,
25-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
5
10
15
20
25
30
35
VOLTAGE (volts)

Figure 19b

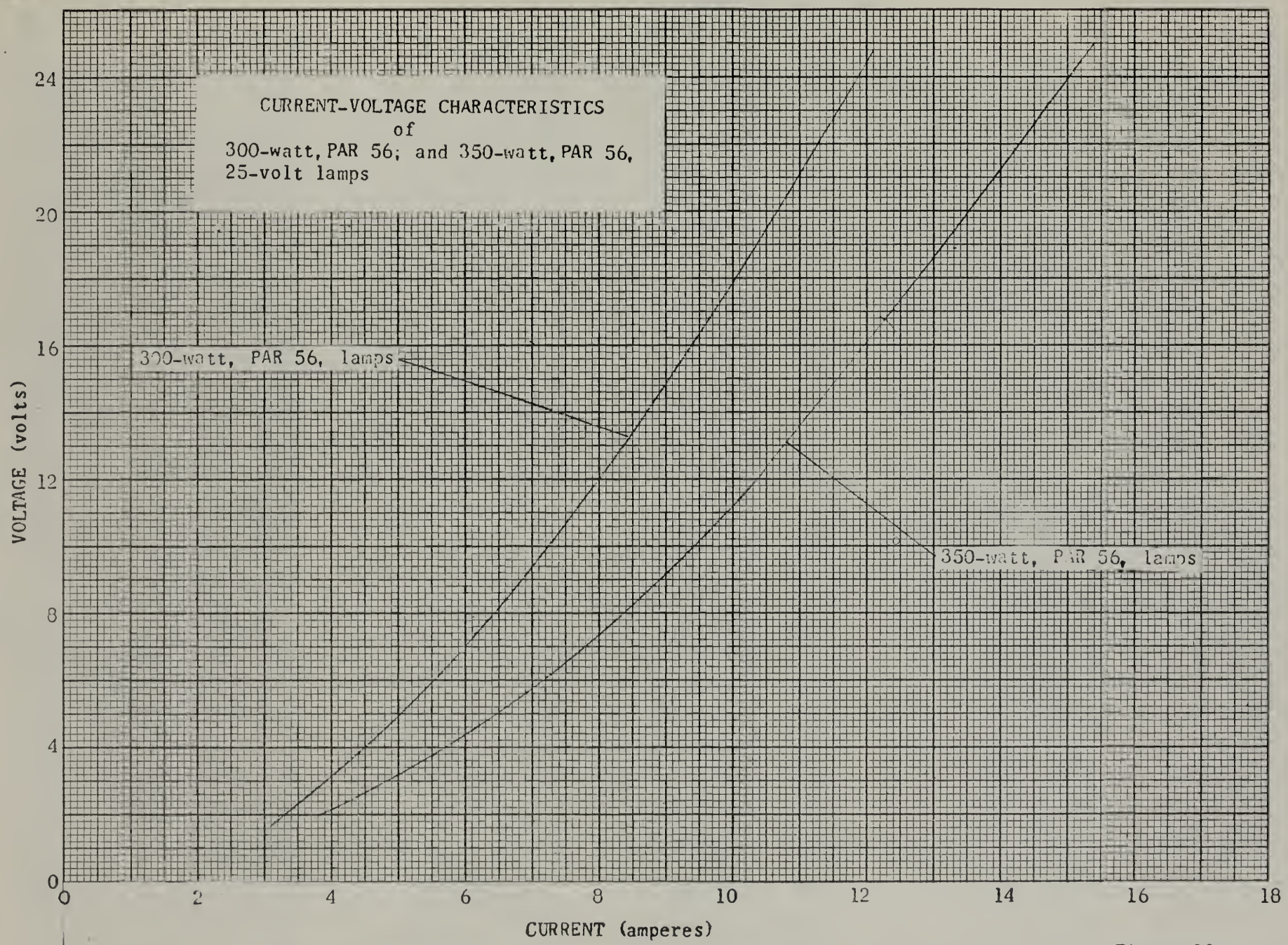
CURRENT-VOLTAGE CHARACTERISTICS
of
300-watt, PAR 56; and 350-watt, PAR 56,
25-volt lamps
300-watt, PAR 56, lamps
350-watt, PAR 56, lamps
VOLTAGE (volts)
CURRENT (amperes)
0
4
8
12
16
20
24
0
2
4
6
8
10
12
14
16
18

Figure 19c

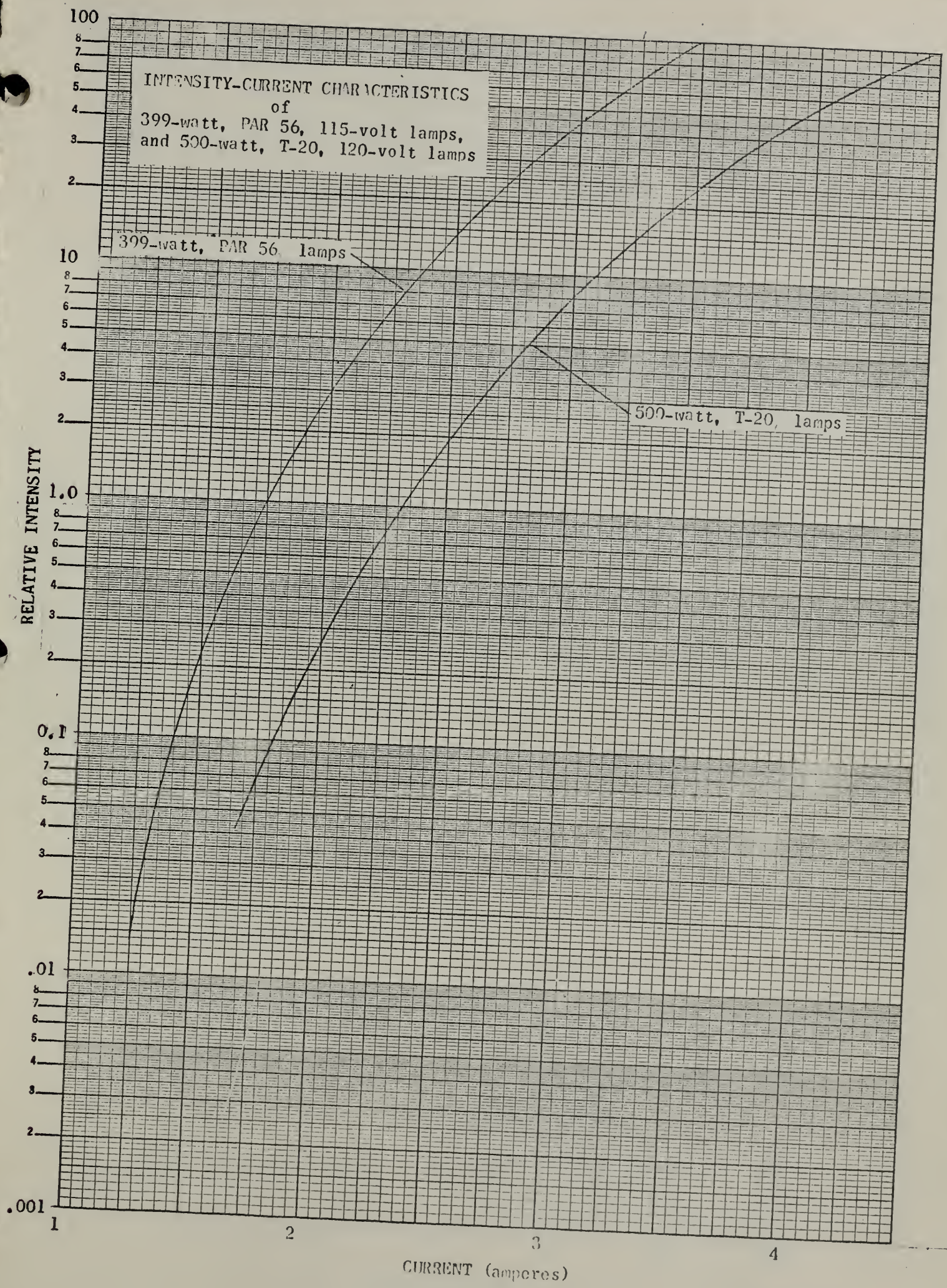
INTENSITY-CURRENT CHARACTERISTICS
of
399-watt, PAR 56, 115-volt lamps,
and 500-watt, T-20, 120-volt lamps
399-watt, PAR 56 lamps
500-watt, T-20 lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
1
2
3
4
CURRENT (amperes)

Figure 20a

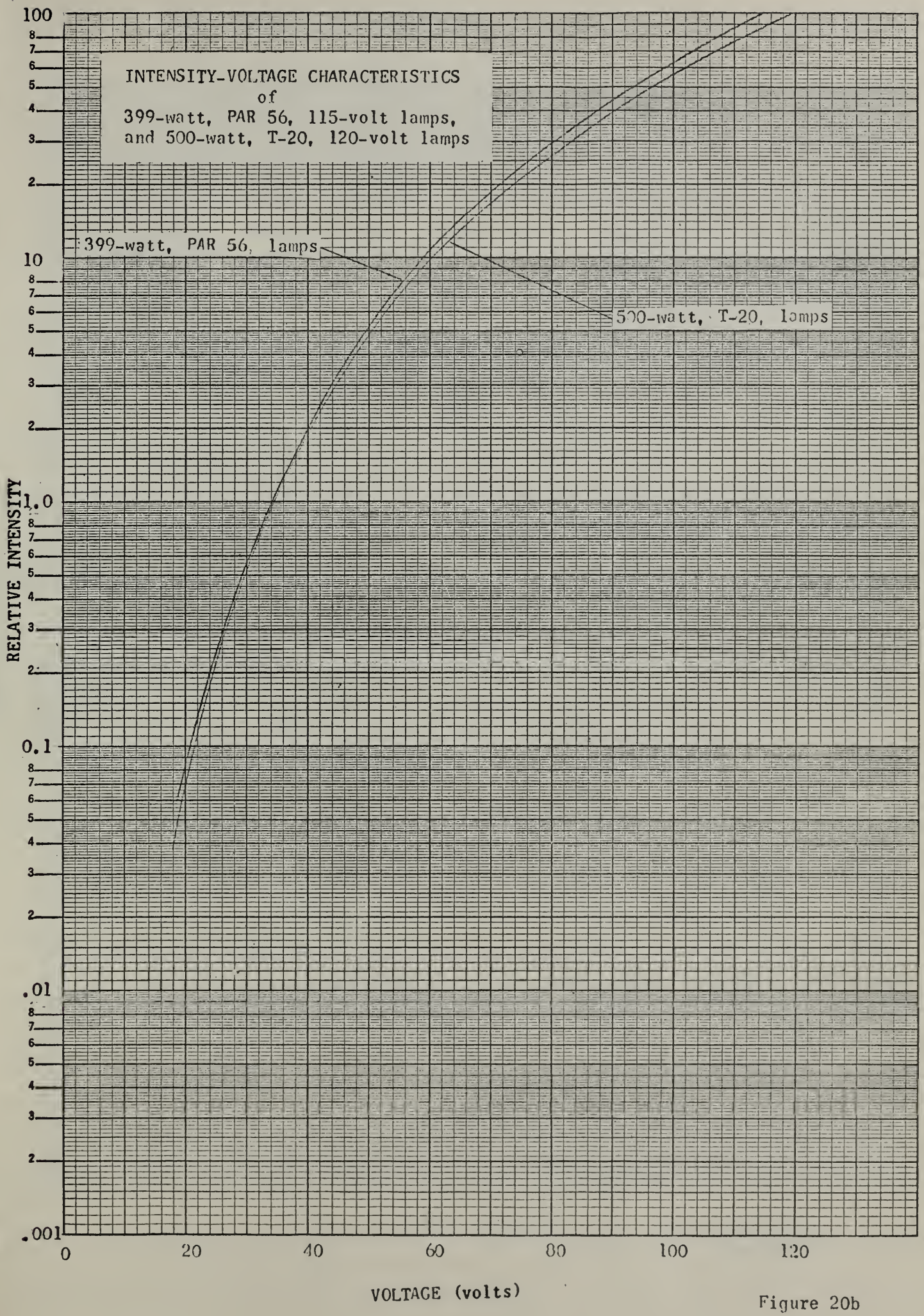
INTENSITY-VOLTAGE CHARACTERISTICS
of
399-watt, PAR 56, 115-volt lamps,
and 500-watt, T-20, 120-volt lamps
399-watt, PAR 56, lamps
500-watt, T-20, lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
20
40
60
80
100
120
VOLTAGE (volts)

Figure 20b

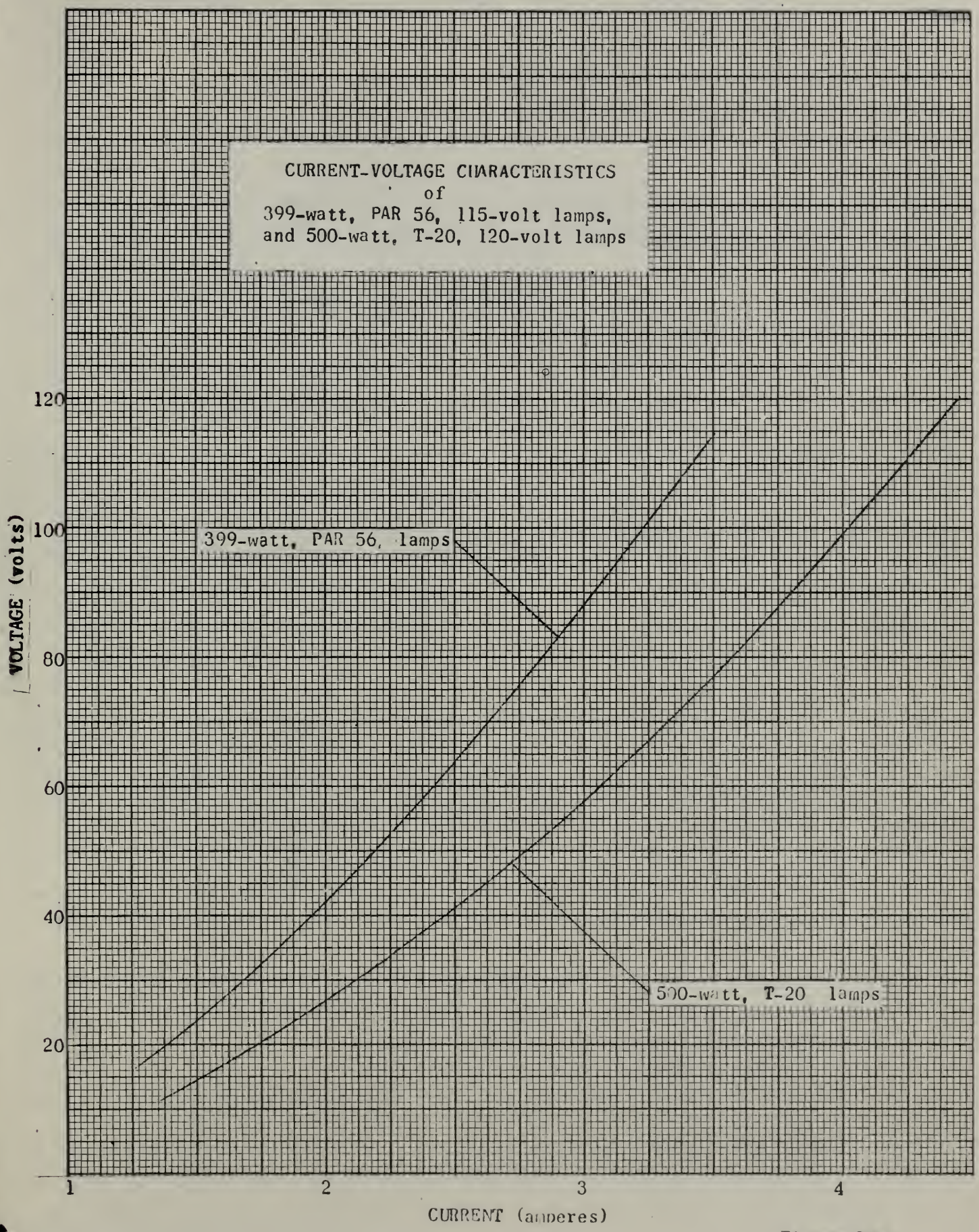
CURRENT-VOLTAGE CHARACTERISTICS
of
399-watt, PAR 56, 115-volt lamps,
and 500-watt, T-20, 120-volt lamps
399-watt, PAR 56, lamps
500-watt, T-20 lamps
VOLTAGE (volts)
120
100
80
60
40
20
1
2
3
4
CURRENT (amperes)

Figure 20c

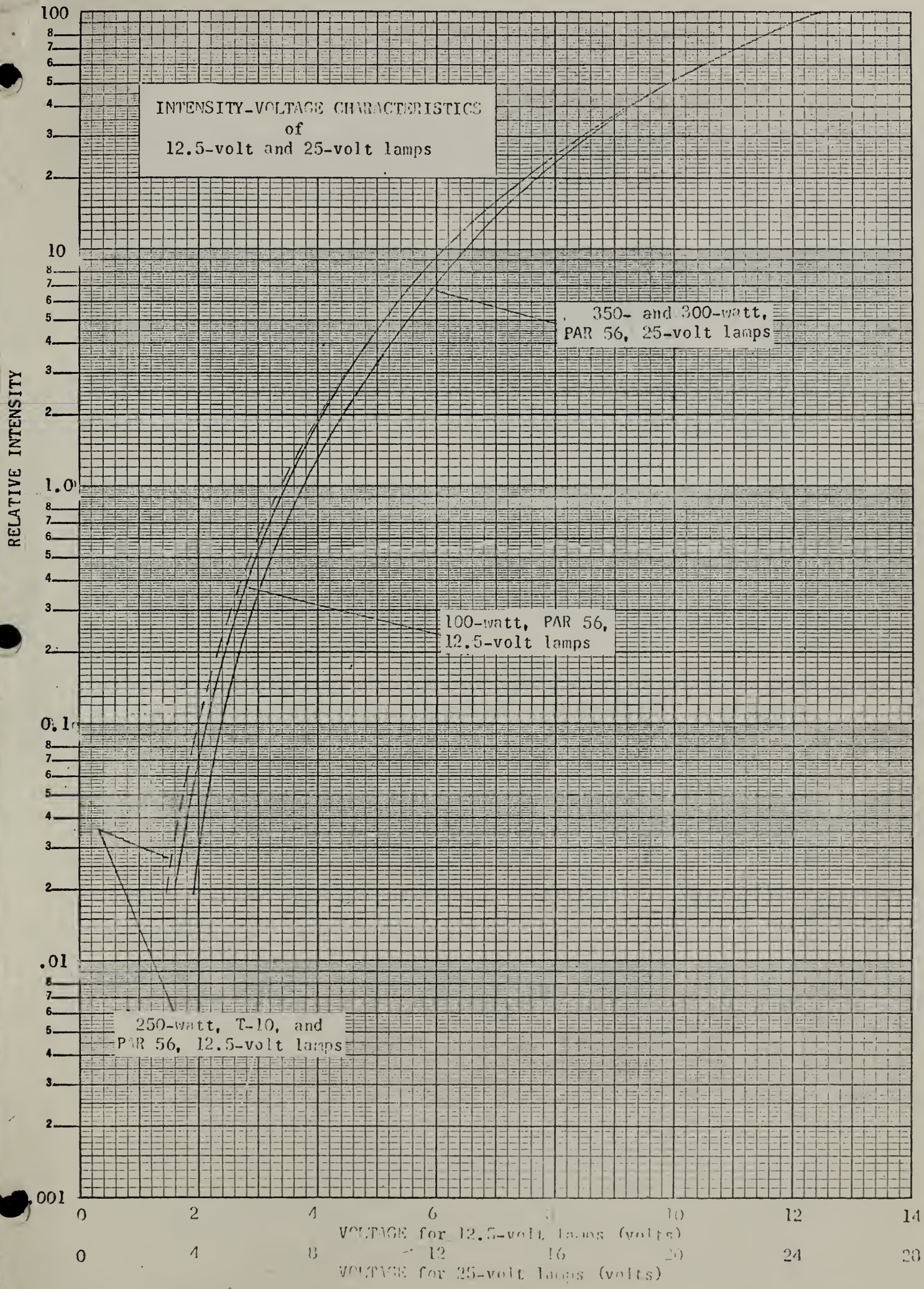
INTENSITY-VOLTAGE CHARACTERISTICS
of
12.5-volt and 25-volt lamps
350- and 300-watt, PAR 56, 25-volt lamps
100-watt, PAR 56, 12.5-volt lamps
250-watt, T-10, and PAR 56, 12.5-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
.001
0
2
4
6
8
10
12
14
VOLTAGE for 12.5-volt lamps (volts)
0
4
8
12
16
20
24
28
VOLTAGE for 25-volt lamps (volts)

Figure 21

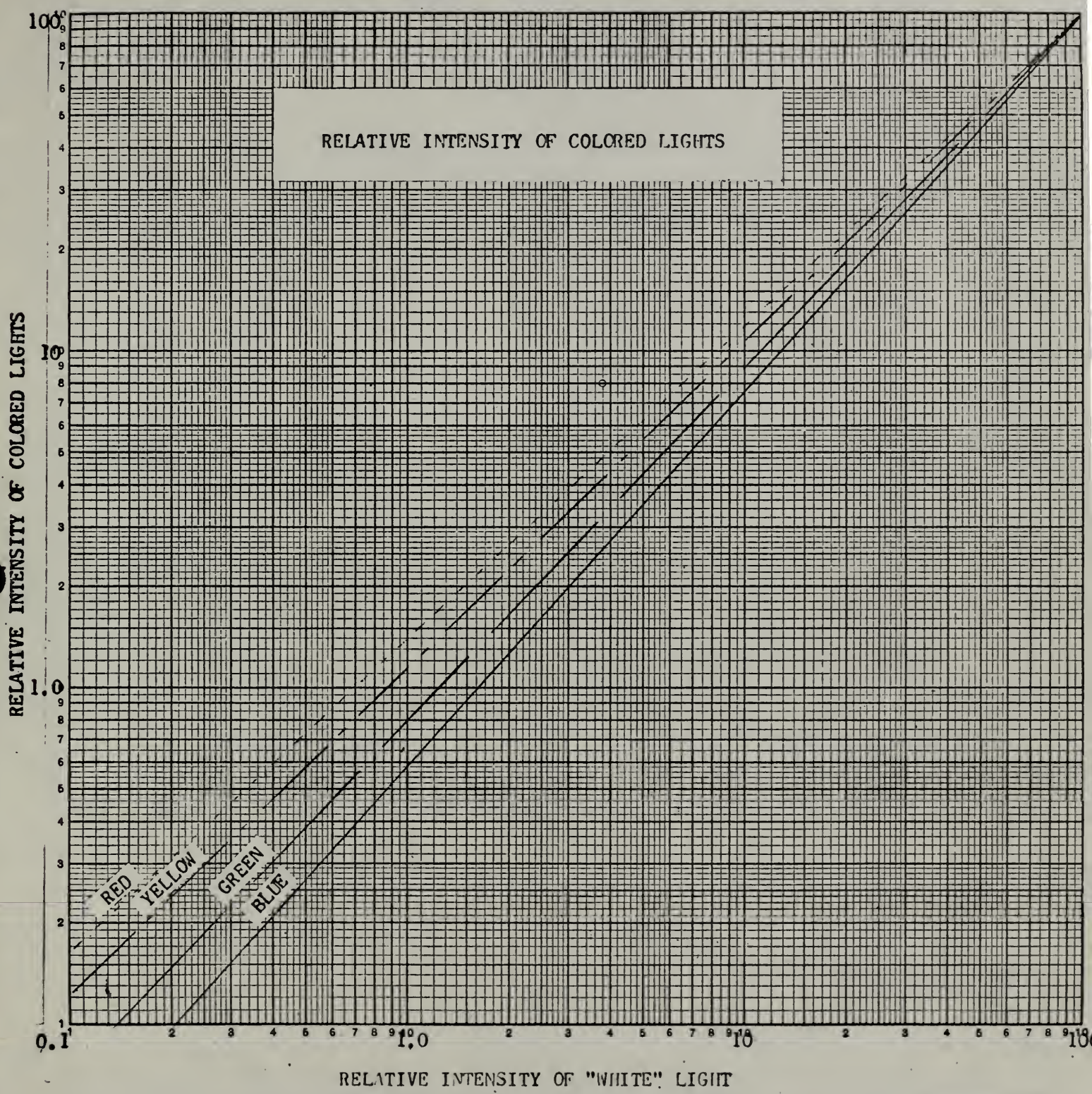
RELATIVE INTENSITY OF COLORED LIGHTS
RELATIVE INTENSITY OF "WHITE" LIGHT
RED
YELLOW
GREEN
BLUE
100
10
1.0
0.1
1.0
10
100

Figure 22