NATIONAL BUREAU OF STANDARDS REPORT

6190
Supplementary

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

By

Photometry and Colorimetry Section
Metrology Division

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NBS PROJECT		NBS REPORT
0201-20-02411	September 1962	6190 Supplementary

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By
Photometry and Colorimetry Section
Metrology Division

Prepared for
Ship Aeronautics Division
Bureau of Naval Weapons
Department of the Navy
Washington 25, D. C.

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

6190 Supplementary

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

SUMMARY

This report is a supplement to National Bureau of Standards Report 6190 which contained a compilation of measurements of the intensity-current-voltage characteristics of lamps of the types generally used in approach-, runway-, and taxiway-light systems. This supplement reports the characteristics of those lamps which have been developed since Report 6190 was issued in October 1958. The characteristics for lamps 4588 and 4586 as shown in figures 29a,b,c and 30a,b,c in this report should be considered as replacements for the curves shown in NBS Report 6190, figures 13a,b,c and 15a,b,c. These new curves are representative of current lamp production.

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. NBS Reports 6190 and 6190 Supplementary were 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.

2. METHOD OF MEASUREMENT

A color-corrected barrier-layer photocell in a zero-resistance circuit was used in making the 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 (Quartzline, T-12, and T-20) 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 the measurements of individual lamps were averaged.

3. LAMP CHARACTERISTICS

The characteristics of each type of lamp are given as three curves: a, relative intensity-current; b, relative intensity-voltage; and c, voltage-current. In addition, relative intensity-current curves of all the 6.6-ampere lamps and relative intensity-voltage curves for all of the 115-volt and 120-volt lamps have been grouped on two figures. The lamp types studied and the figures showing their characteristics are listed in table Ia, which is a continuation of Table I, Report 6190. Figure numbers are consecutive with those of that report.

Table Ia

Lamp Type	Designation	Filament Type	Figure
45-w, 6.6-a, Quartzline light	6.6A/T2½Q/CL[1]	C-8	23a,b,c
100-w, 6.6-a, Quartzline light	6.6A/T3Q/ICL	C-8	24a,b,c
200-w, 6.6-a, Quartzline light	6.6A/T4Q/CL[2]	CC-8	25a,b,c
200-w, 6.6-a, PAR64, VGSI light	----	-	26a,b,c
300-w, 6.6-a, PAR64, VGSI light	6.6PAR64/3	CC-6	26a,b,c
6.6-a lamps			27
200-w, 20-a, PAR64, VGSI light	----	-	28a,b,c
50-w, 6.5-v, PAR36, marine light	4588	C-6[3]	29a,b,c
100-w, 6.5-v, PAR36, marine light	4586	C-6[3]	30a,b,c
150-w, 21-v, "Tru-Flector" projection light	150T12TFR/LV	CC-6	31a,b,c
300-w, 120-v, PAR56, medium floodlight	300PAR56MFL[4]	CC-13	32a,b,c
500-w, 120-v, PAR64, narrow spotlight	500PAR64NSP[5]	CC-13	33a,b,c
1000-w, 120-v, T-12, projection light	1M/T12/46	C-13d[6]	34a,b,c
1200-w, 115-v, T-20[7], beacon light	1200T20	CC-8[6]	35a,b,c
115-v and 120-v lamps	----	-	36
All 6.6-a lamps, NBS Reports 6190 and 6190Supp.	----	-	37
All 10-a and 20-a lamps, NBS 6190 and 6190Supp.	----	-	38
All 115-v and 120-v lamps, NBS Reports 6190 and 6190Supp.		-	39

[1] Same as 6.6A/T2½Q/ICL except for base
[2] Same as 6.6A/T4Q/ICL except for base
[3] Hemispherical shield in front of filament
[4] Same as 300 PAR56WFL and 300PAR56NSP except for cover
[5] Same as 500 PAR64MFL and 500PAR64WFL except for cover
[6] Equipped with a collector grid
[7] Heat resistant glass bulb

Differences in relative intensities among lamps of the same type may become large when the relative intensities become less than 1%. The relative intensities may differ by as much as a factor of 2 when the relative intensities are 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". For information on the effects of color filters, refer to NBS Report 6190.

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.

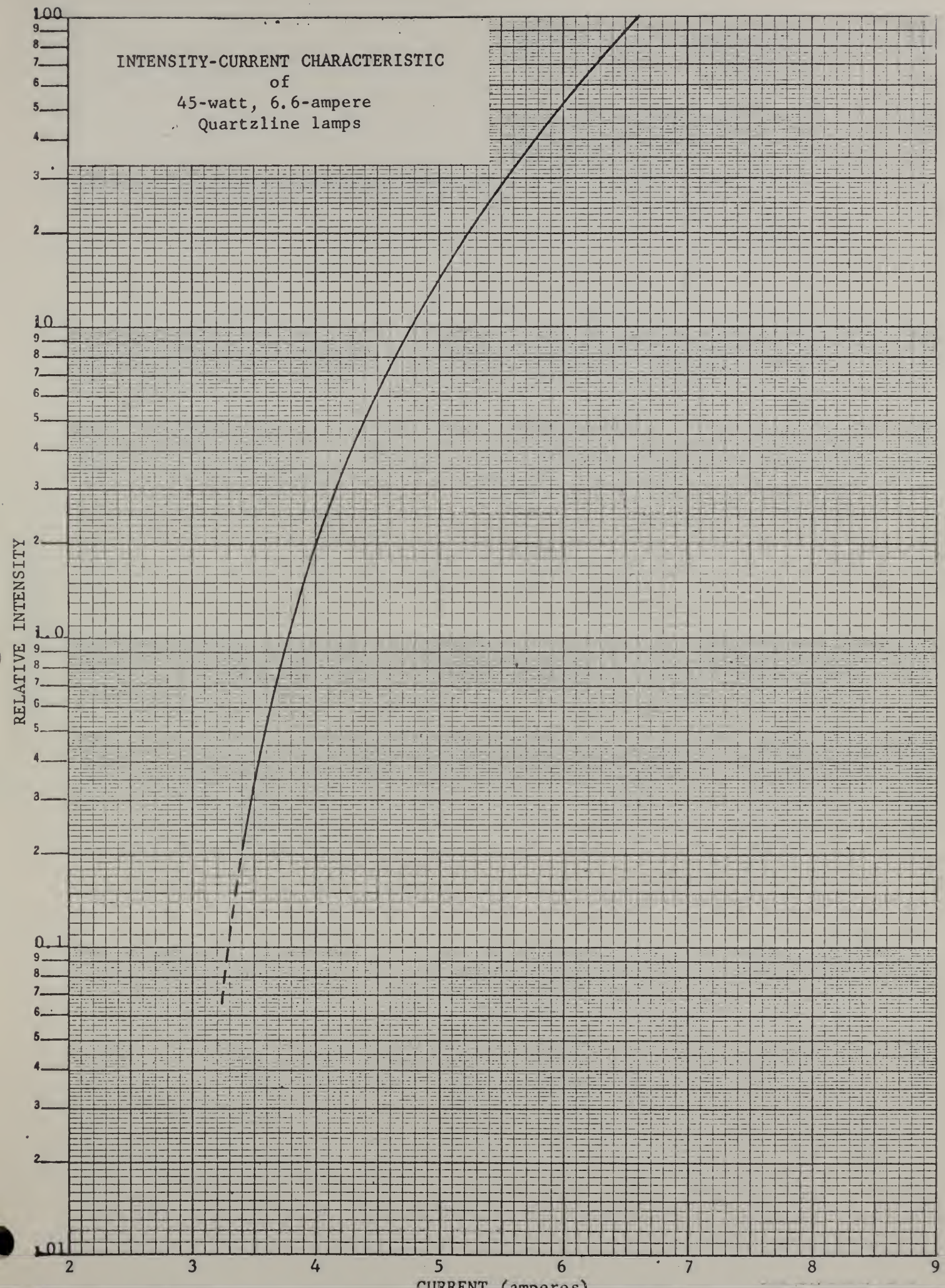
INTENSITY-CURRENT CHARACTERISTIC
of
45-watt, 6.6-ampere
Quartzline lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
2
3
4
5
6
7
8
9
CURRENT (amperes)

Figure 23a

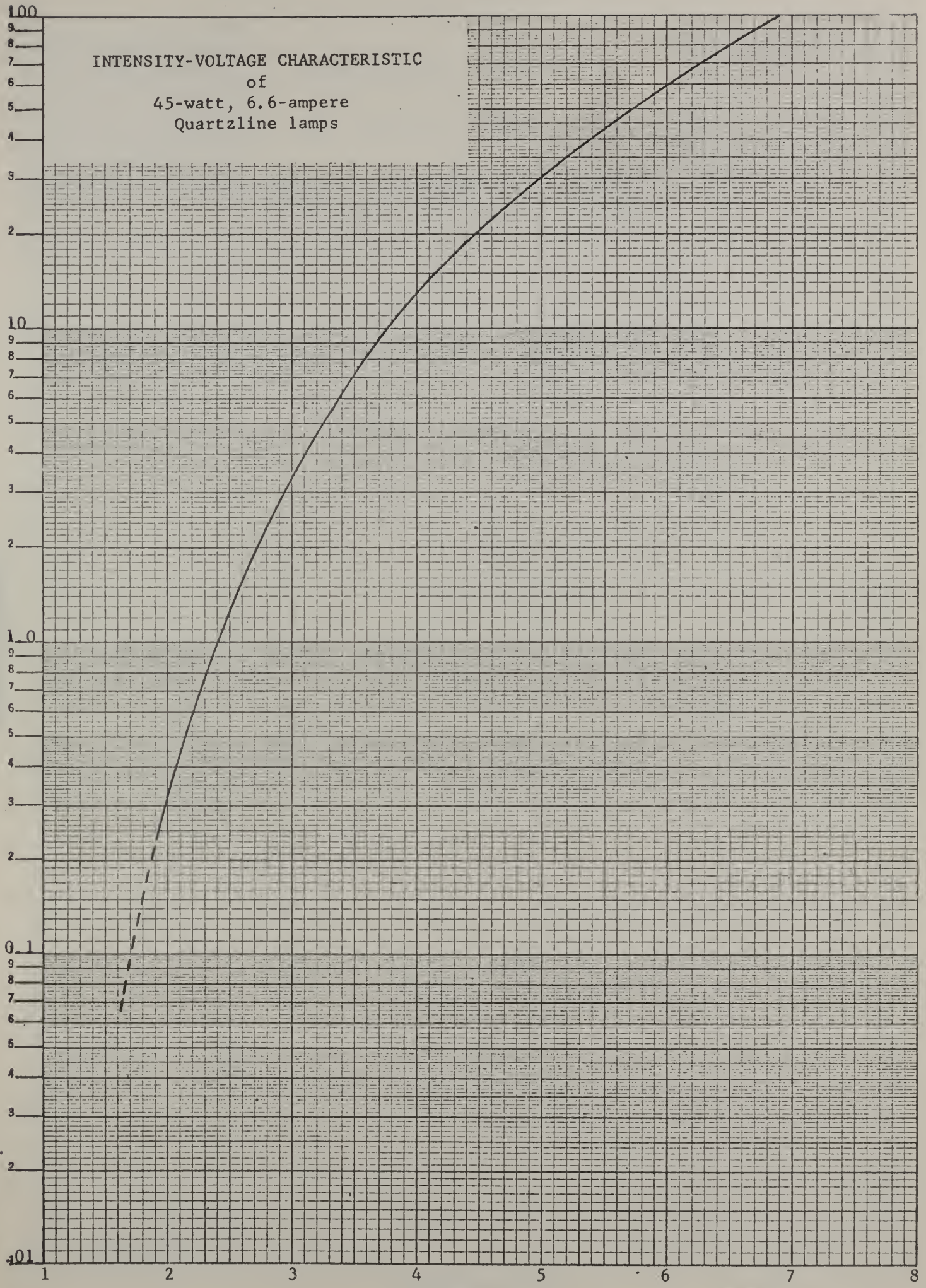
INTENSITY-VOLTAGE CHARACTERISTIC
of
45-watt, 6.6-ampere
Quartzline lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
1
2
3
4
5
6
7
8
VOLTAGE (volts)

Figure 23b

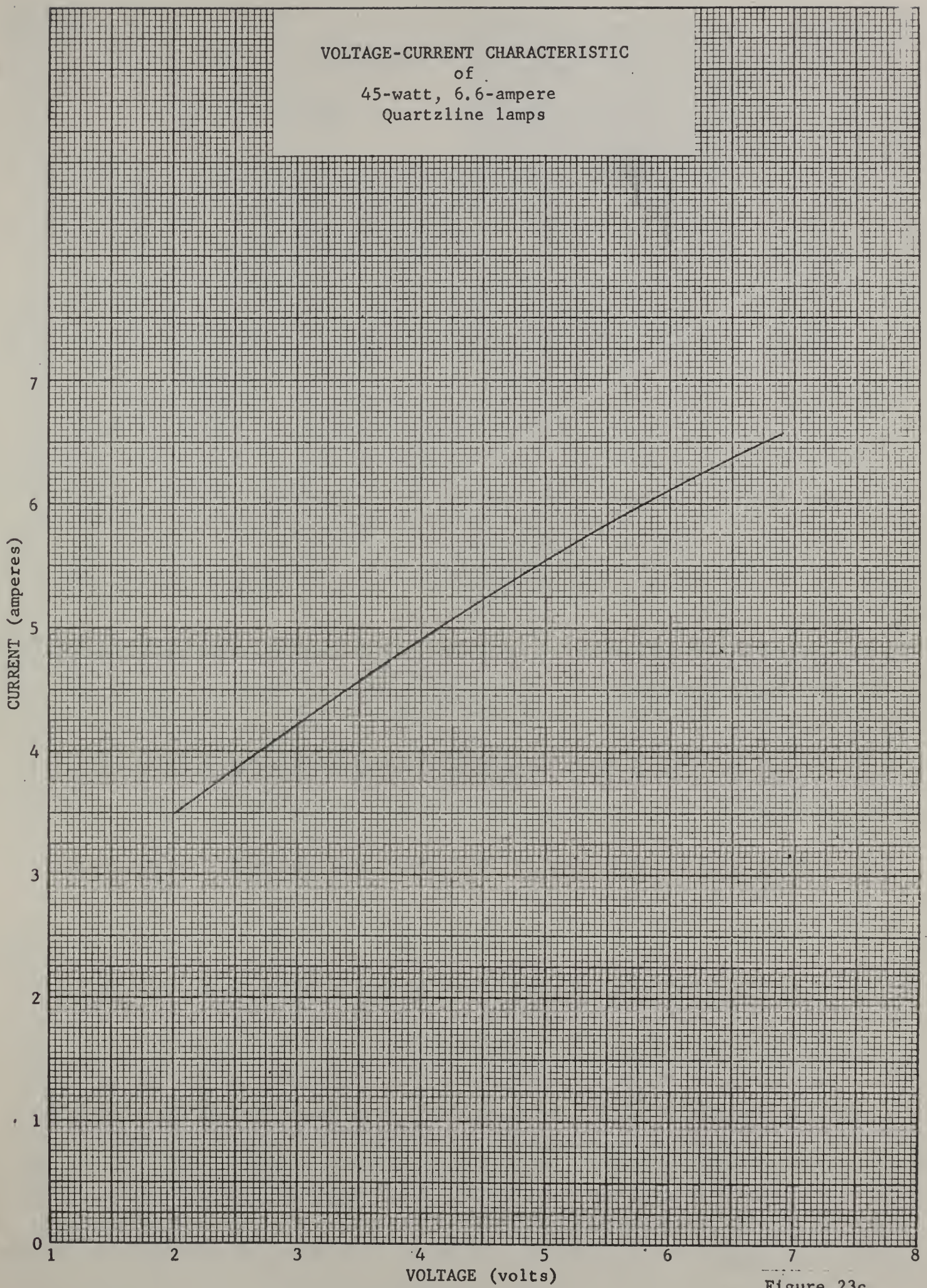
VOLTAGE-CURRENT CHARACTERISTIC
of
45-watt, 6.6-ampere
Quartzline lamps
CURRENT (amperes)
0
1
2
3
4
5
6
7
1
2
3
4
5
6
7
8
VOLTAGE (volts)

Figure 23c

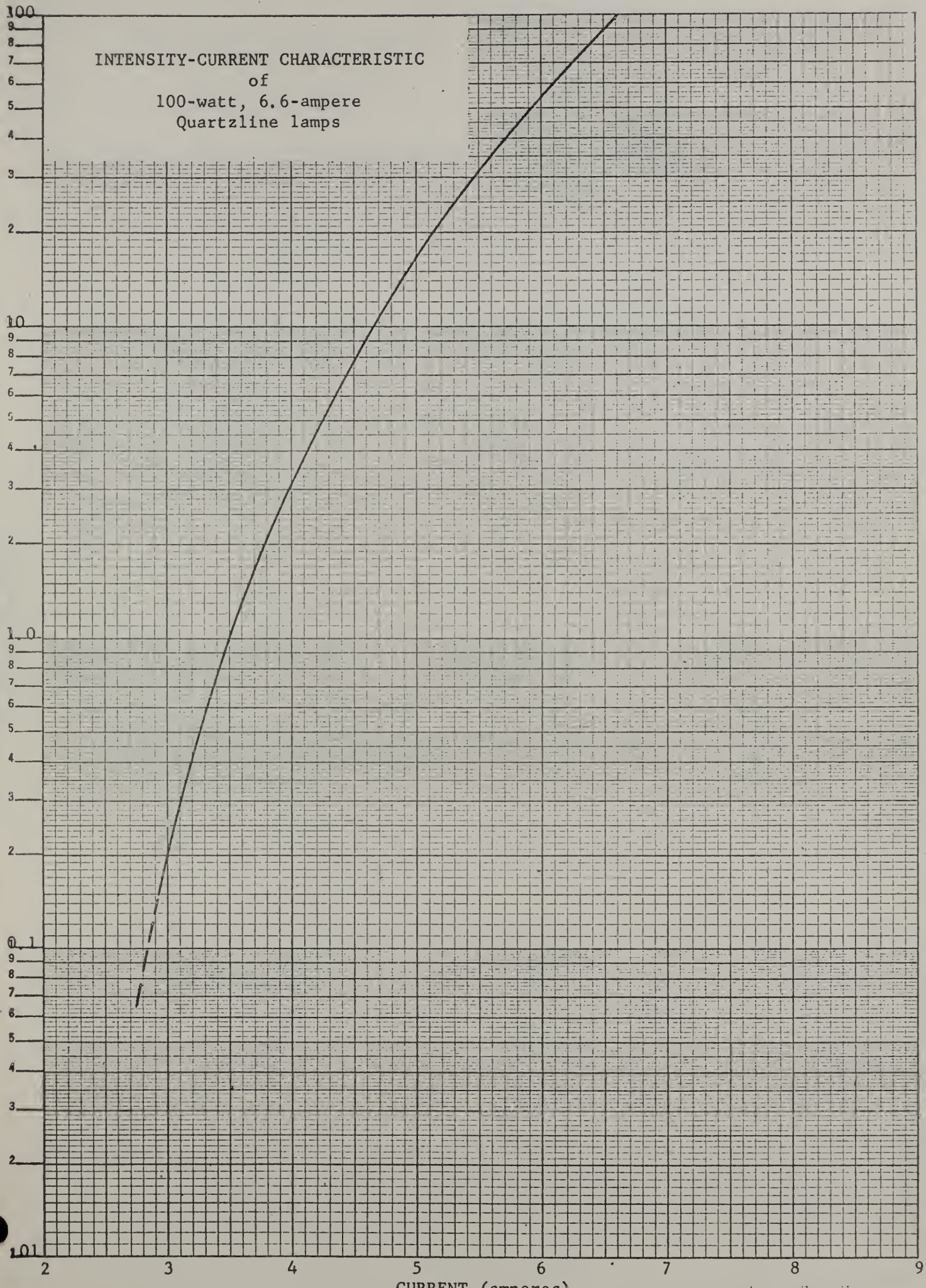
INTENSITY-CURRENT CHARACTERISTIC
of
100-watt, 6.6-ampere
Quartzline lamps
RELATIVE INTENSITY
100
10
1.0
0.1
0.01
2
3
4
5
6
7
8
9
CURRENT (amperes)

Figure 24a

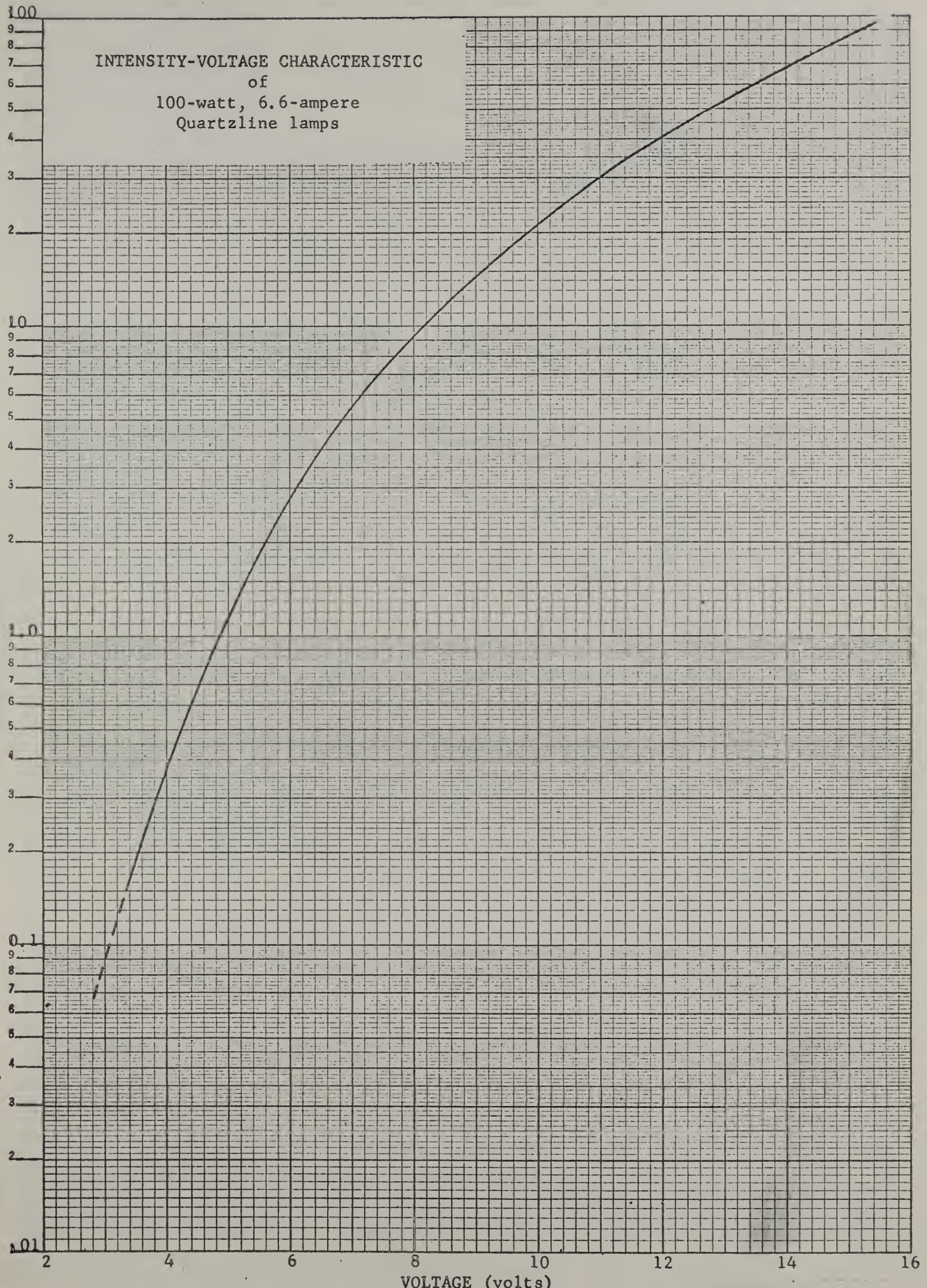
INTENSITY-VOLTAGE CHARACTERISTIC
of
100-watt, 6.6-ampere
Quartzline lamps
RELATIVE INTENSITY
100
10
1.0
0.1
0.01
2
4
6
8
10
12
14
16
VOLTAGE (volts)

Figure 24b

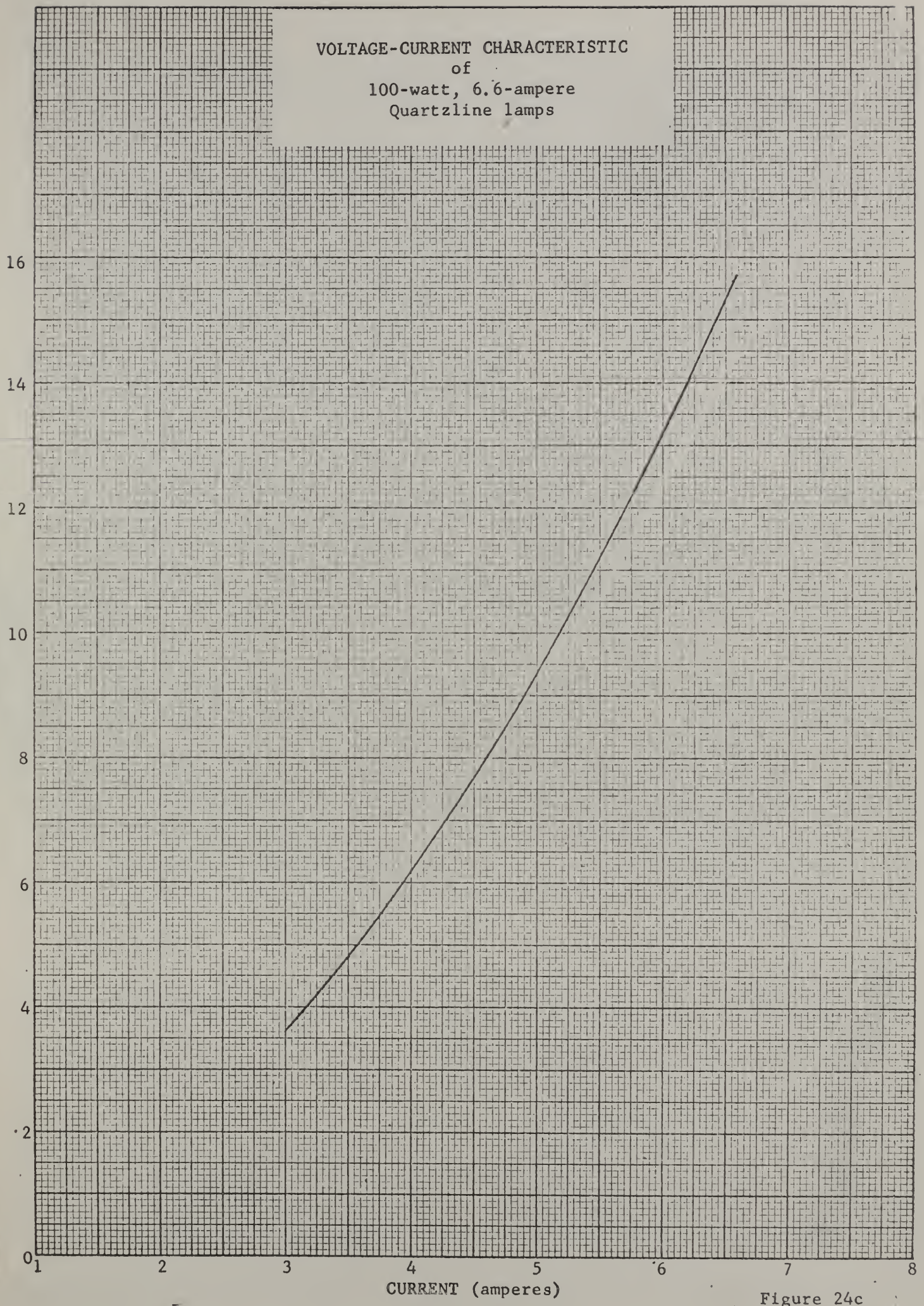
VOLTAGE-CURRENT CHARACTERISTIC
of
100-watt, 6.6-ampere
Quartzline lamps
VOLTAGE (volts)
0
2
4
6
8
10
12
14
16
1
2
3
4
5
6
7
8
CURRENT (amperes)

Figure 24c

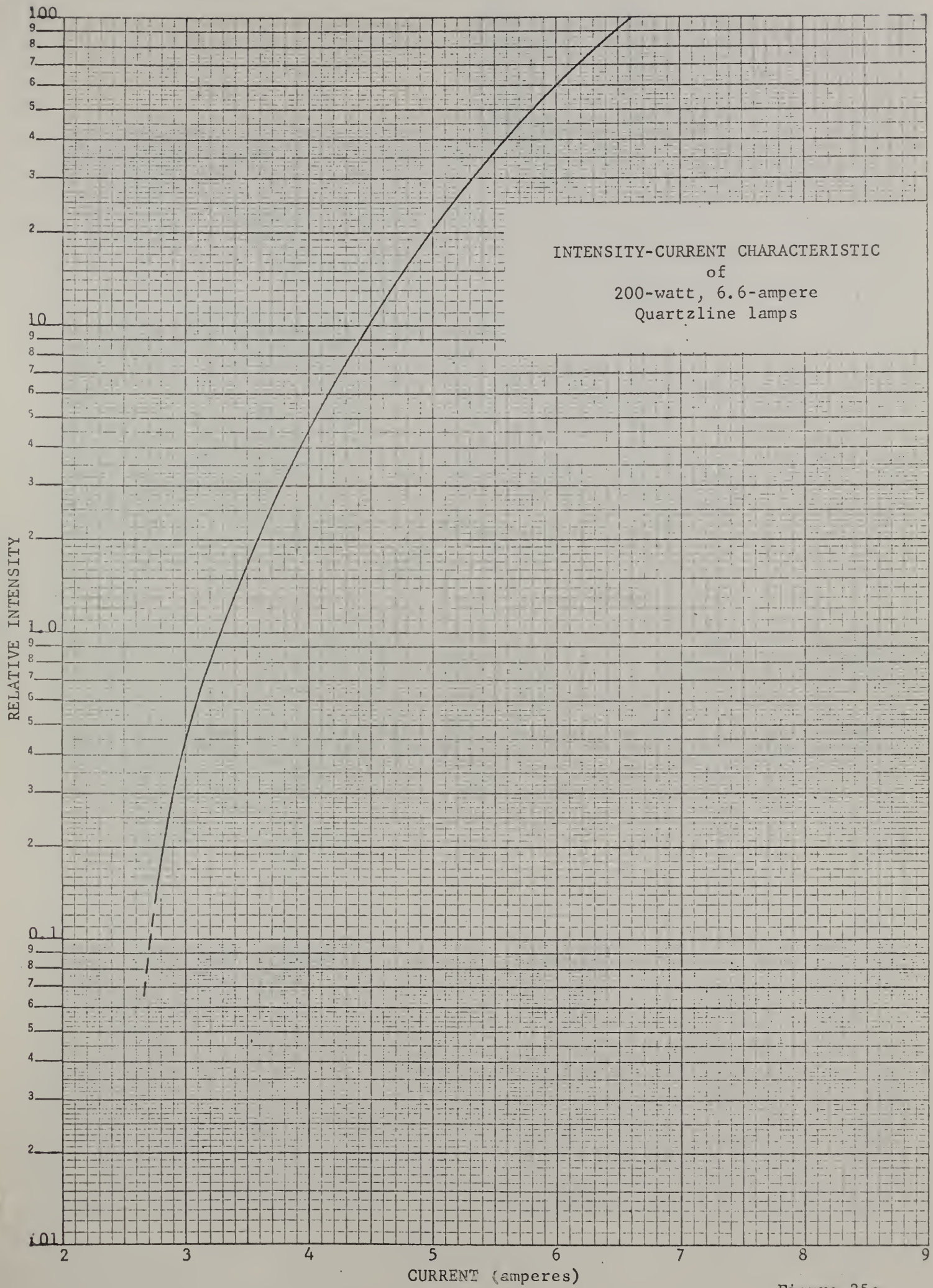
INTENSITY-CURRENT CHARACTERISTIC
of
200-watt, 6.6-ampere
Quartzline lamps
RELATIVE INTENSITY
100
10
1.0
0.1
0.01
2
3
4
5
6
7
8
9
CURRENT (amperes)

Figure 25a

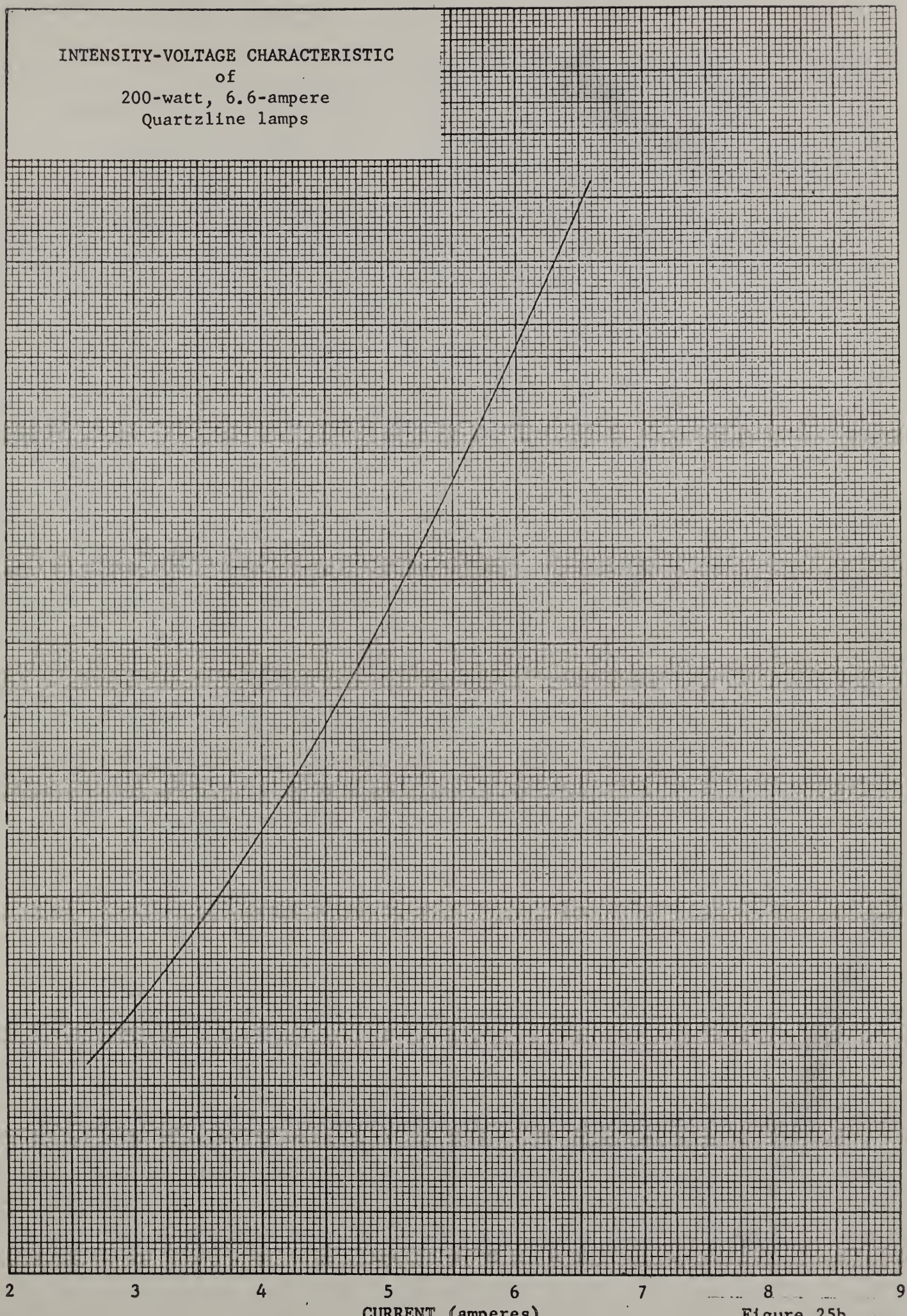
INTENSITY-VOLTAGE CHARACTERISTIC
of
200-watt, 6.6-ampere
Quartzline lamps
VOLTAGE (volts)
0
4
8
12
16
20
24
28
32
36
2
3
4
5
6
7
8
9
CURRENT (amperes)

Figure 25b

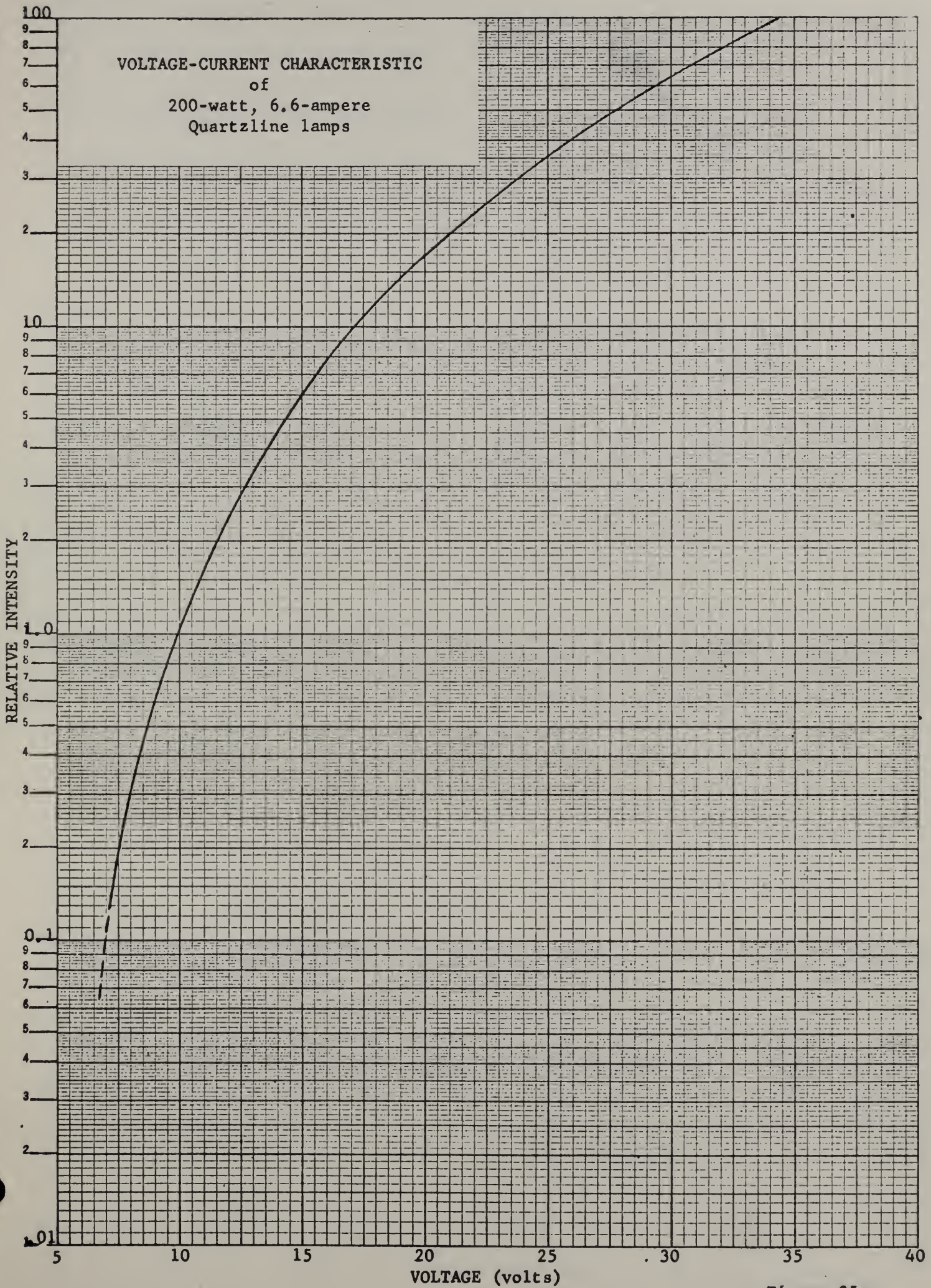
VOLTAGE-CURRENT CHARACTERISTIC
of
200-watt, 6.6-ampere
Quartzline lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
5
10
15
20
25
30
35
40
VOLTAGE (volts)

Figure 25c

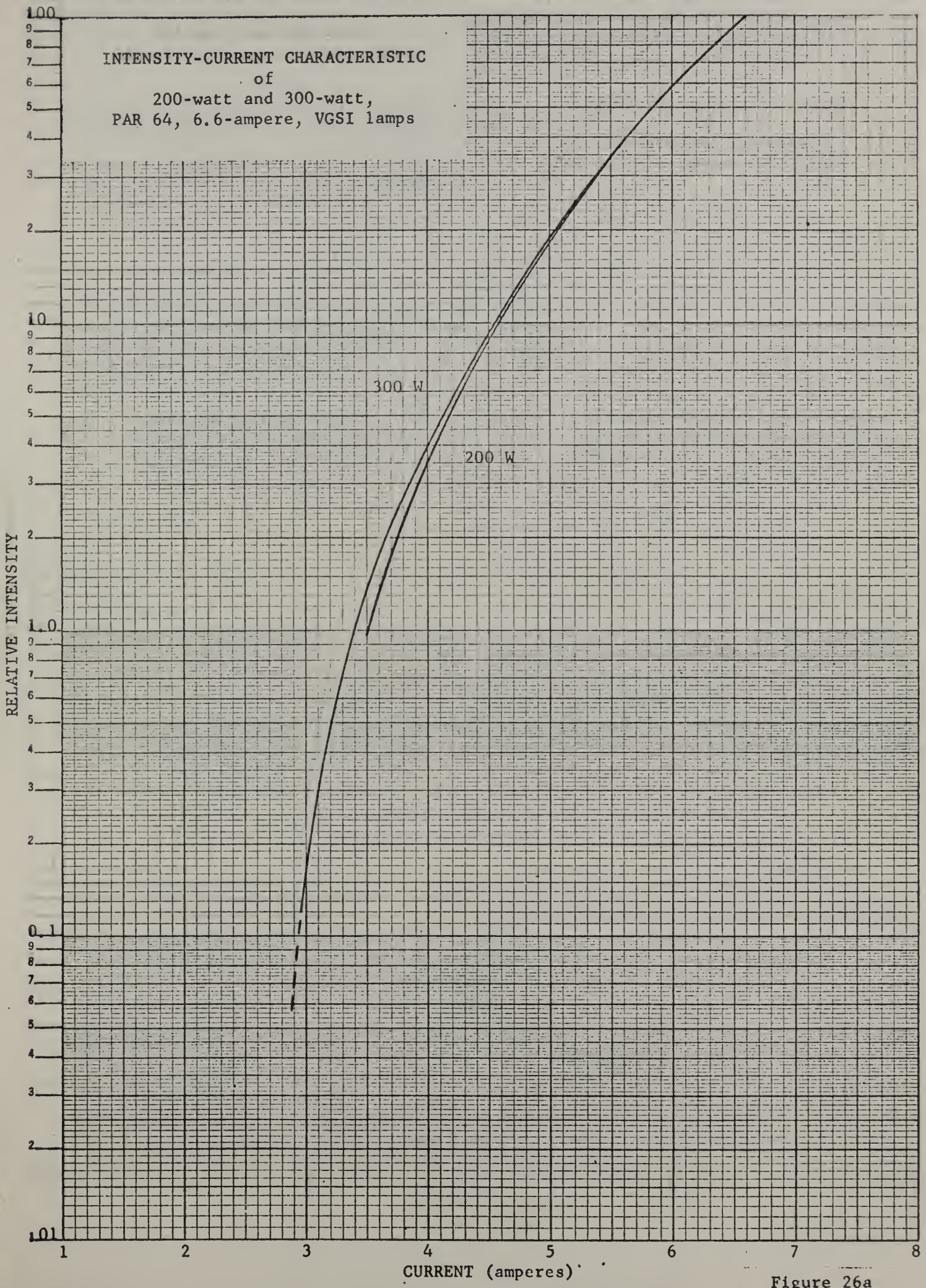
INTENSITY-CURRENT CHARACTERISTIC
of
200-watt and 300-watt,
PAR 64, 6.6-ampere, VGSI lamps
300 W
200 W
RELATIVE INTENSITY
100
10
1.0
0.1
.01
1
2
3
4
5
6
7
8
CURRENT (amperes)

Figure 26a

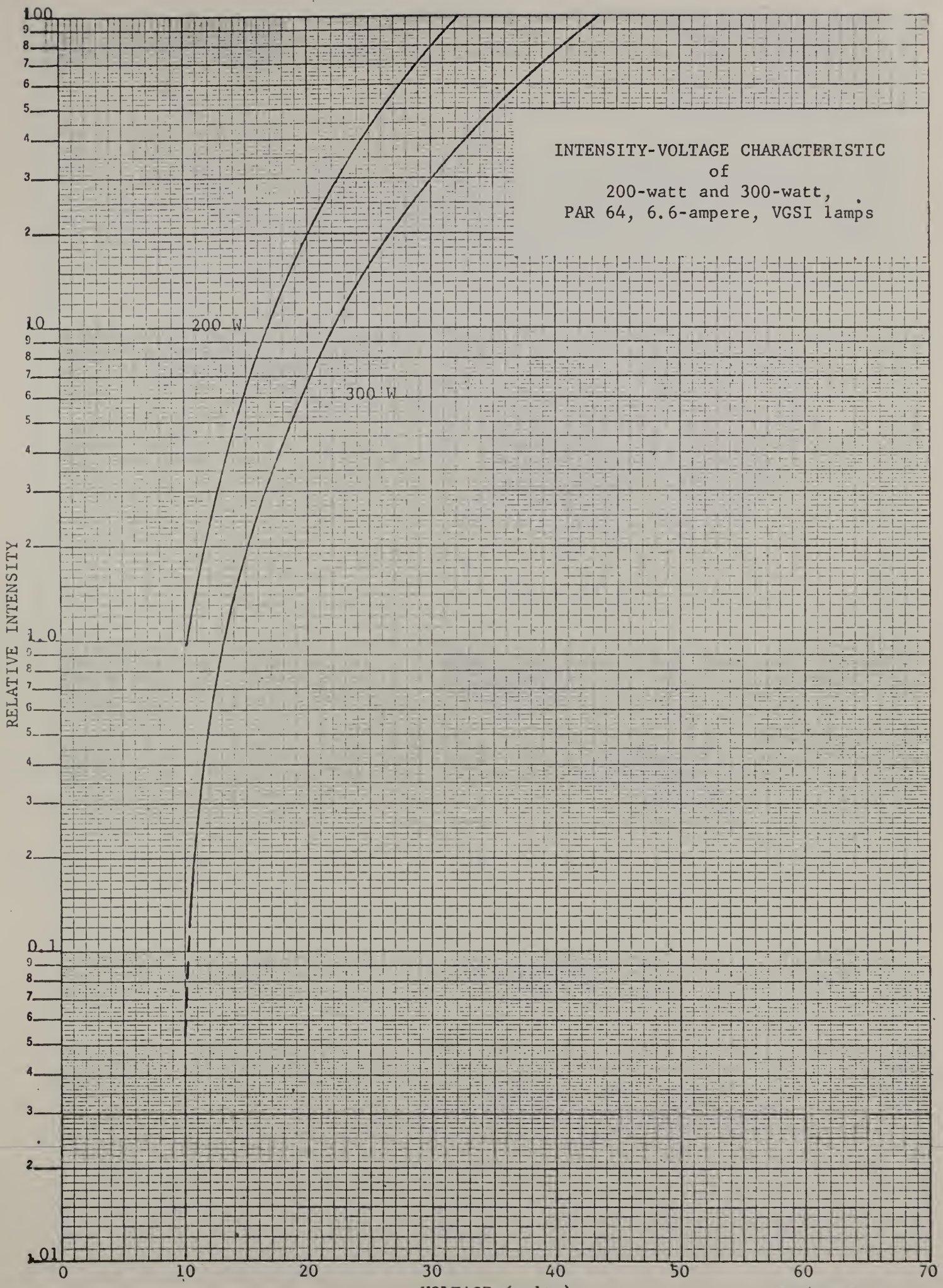
INTENSITY-VOLTAGE CHARACTERISTIC
of
200-watt and 300-watt,
PAR 64, 6.6-ampere, VGSI lamps
200 W
300 W
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
10
20
30
40
50
60
70
VOLTAGE (volts)

Figure 26b

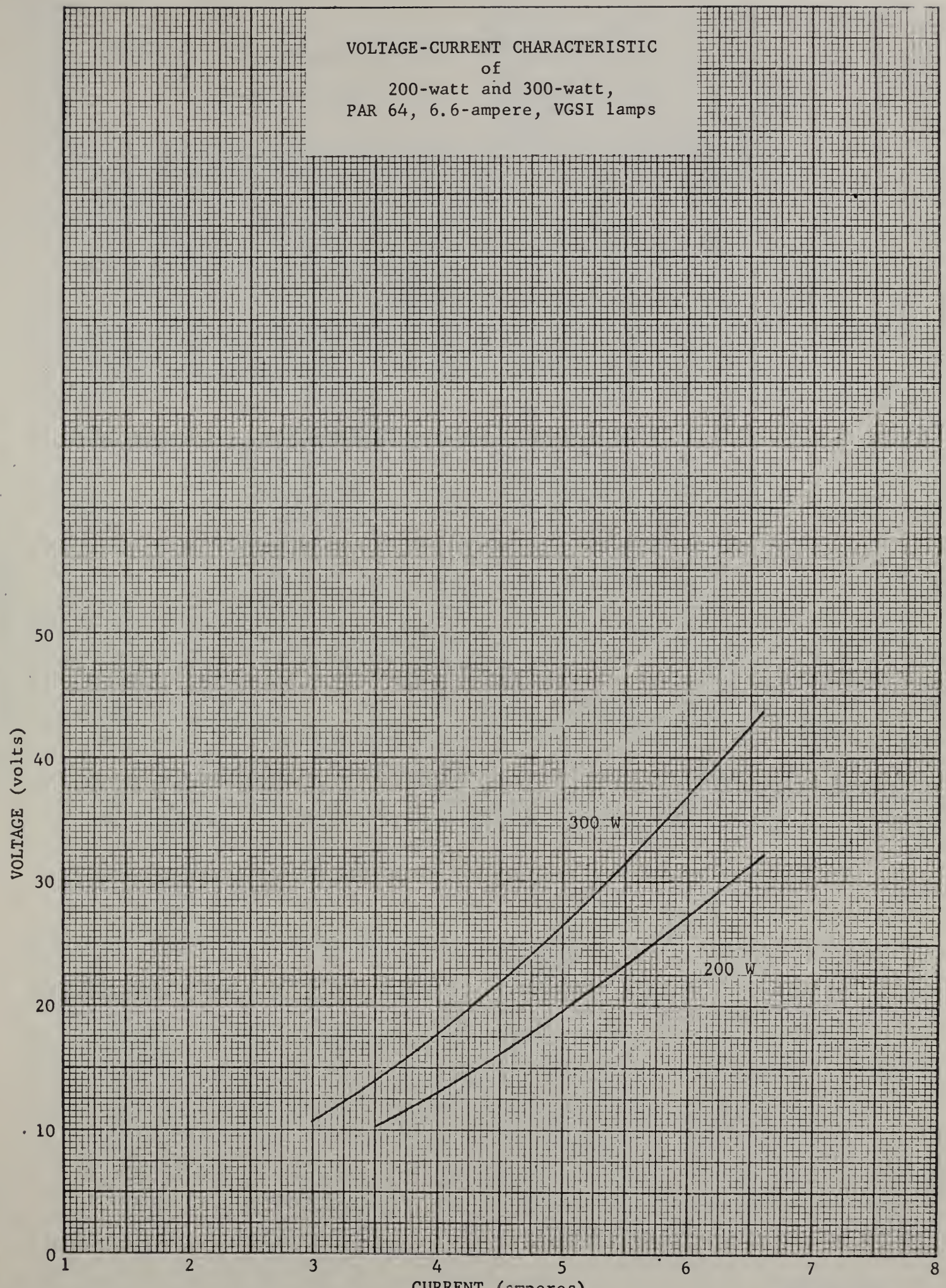
VOLTAGE-CURRENT CHARACTERISTIC
of
200-watt and 300-watt,
PAR 64, 6.6-ampere, VGSI lamps
VOLTAGE (volts)
0
10
20
30
40
50
300 W
200 W
1
2
3
4
5
6
7
8
CURRENT (amperes)

Figure 26c

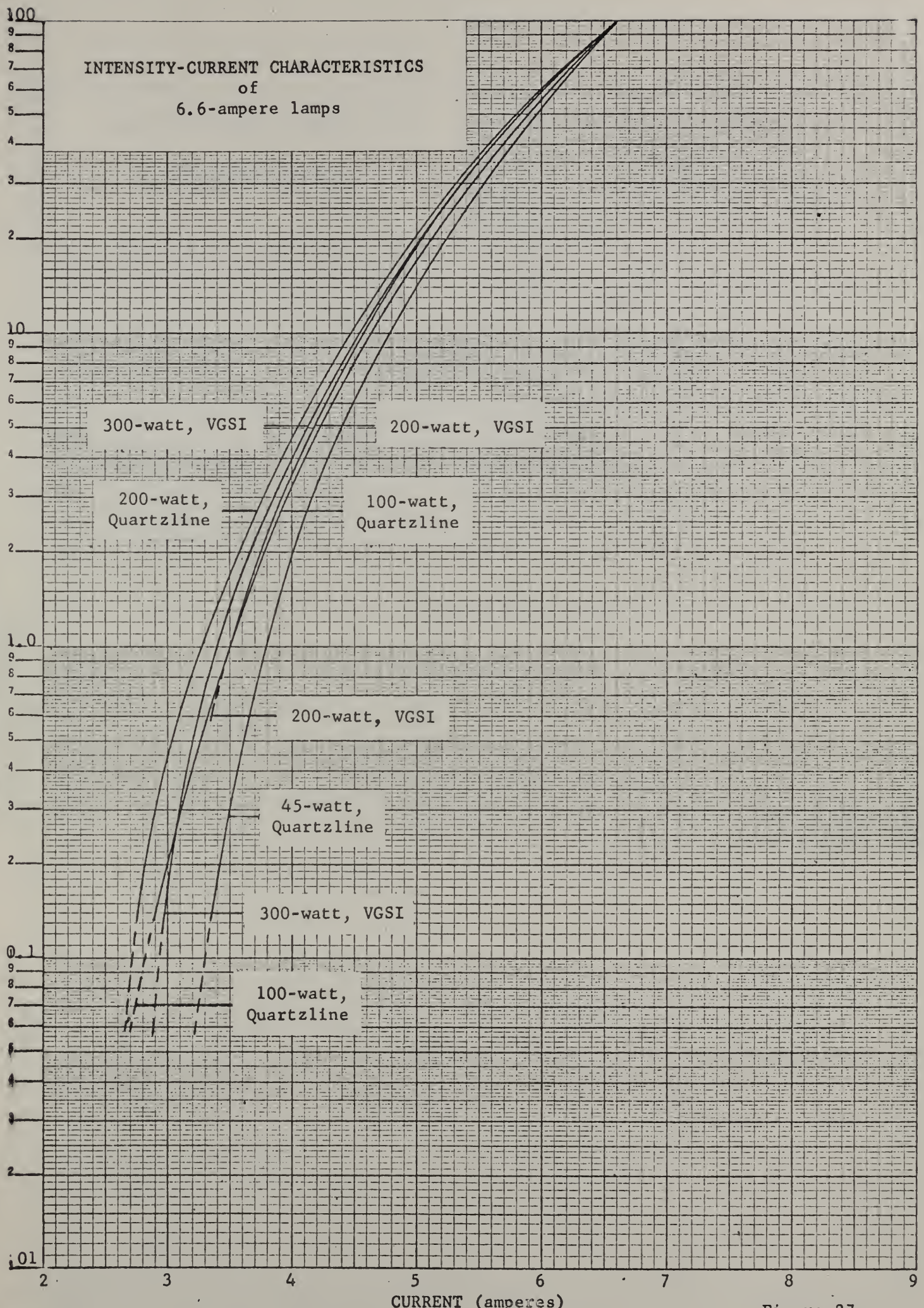
INTENSITY-CURRENT CHARACTERISTICS
of
6.6-ampere lamps
300-watt, VGSI
200-watt, VGSI
200-watt, Quartzline
100-watt, Quartzline
200-watt, VGSI
45-watt, Quartzline
300-watt, VGSI
100-watt, Quartzline
RELATIVE INTENSITY
100
10
1.0
0.1
.01
2
3
4
5
6
7
8
9
CURRENT (amperes)

Figure 27

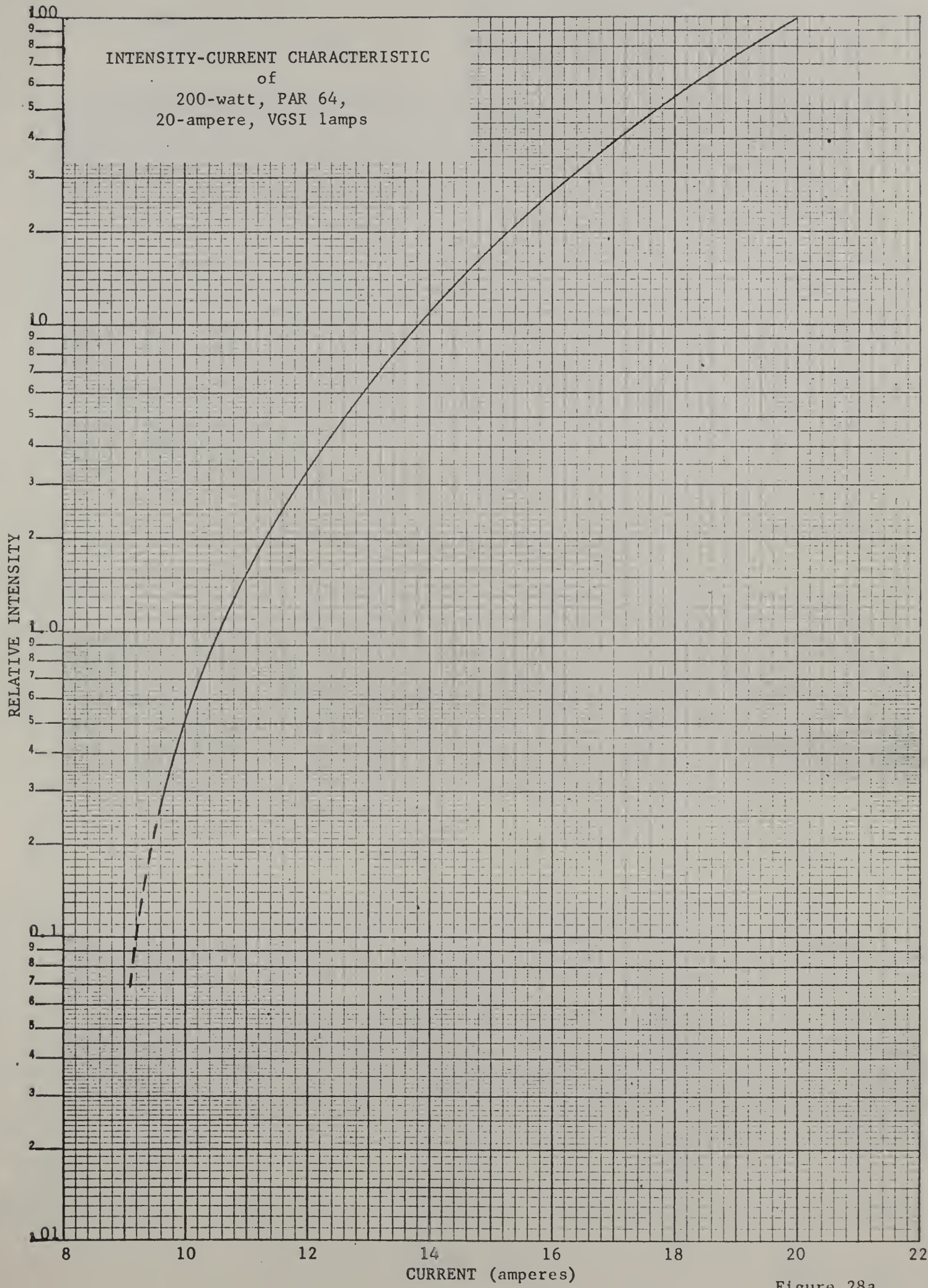
INTENSITY-CURRENT CHARACTERISTIC
of
200-watt, PAR 64,
20-ampere, VGSI lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
8
10
12
14
16
18
20
22
CURRENT (amperes)

Figure 28a

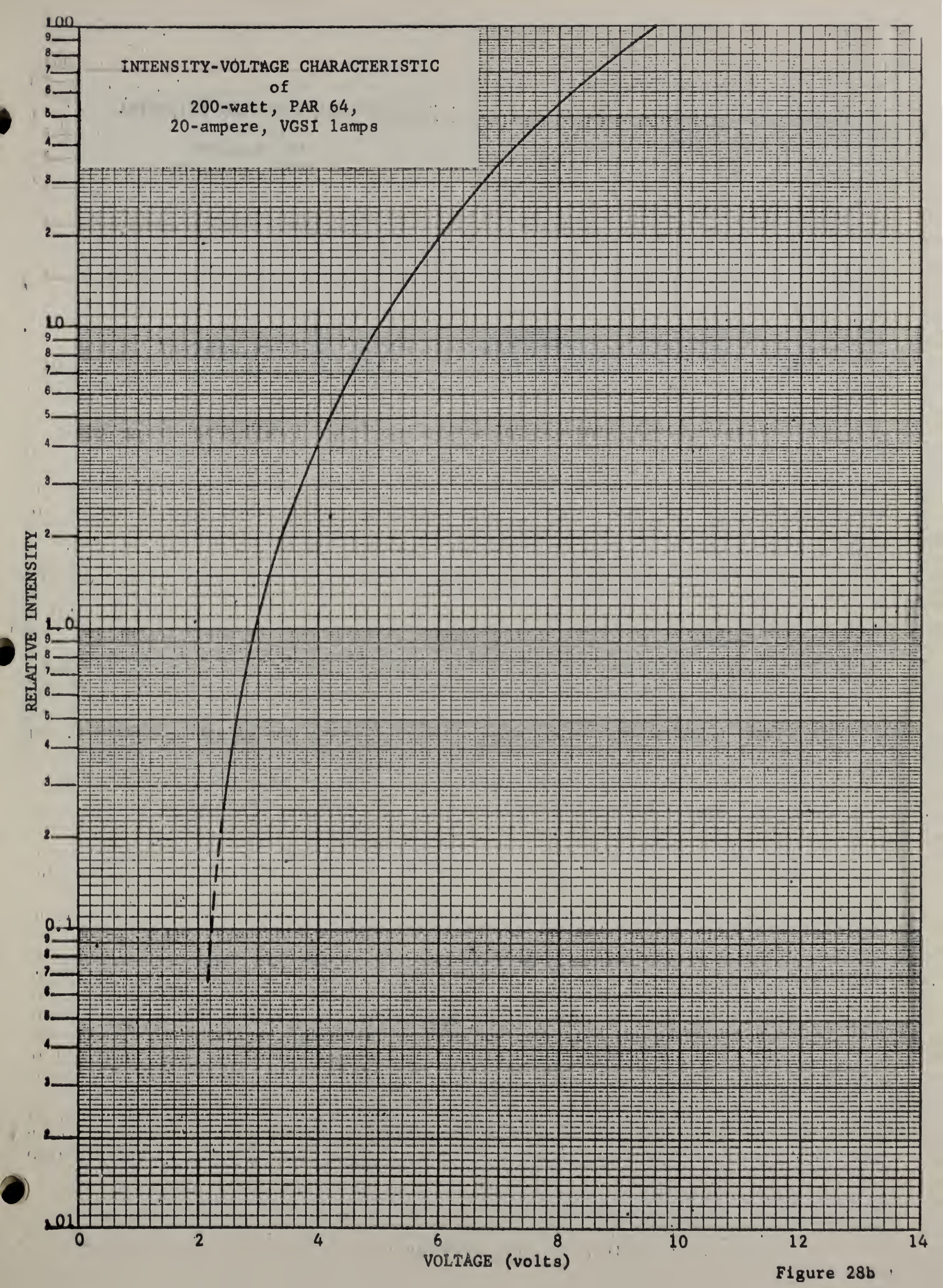
INTENSITY-VOLTAGE CHARACTERISTIC
of
200-watt, PAR 64,
20-ampere, VGSI lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
2
4
6
8
10
12
14
VOLTAGE (volts)

Figure 28b

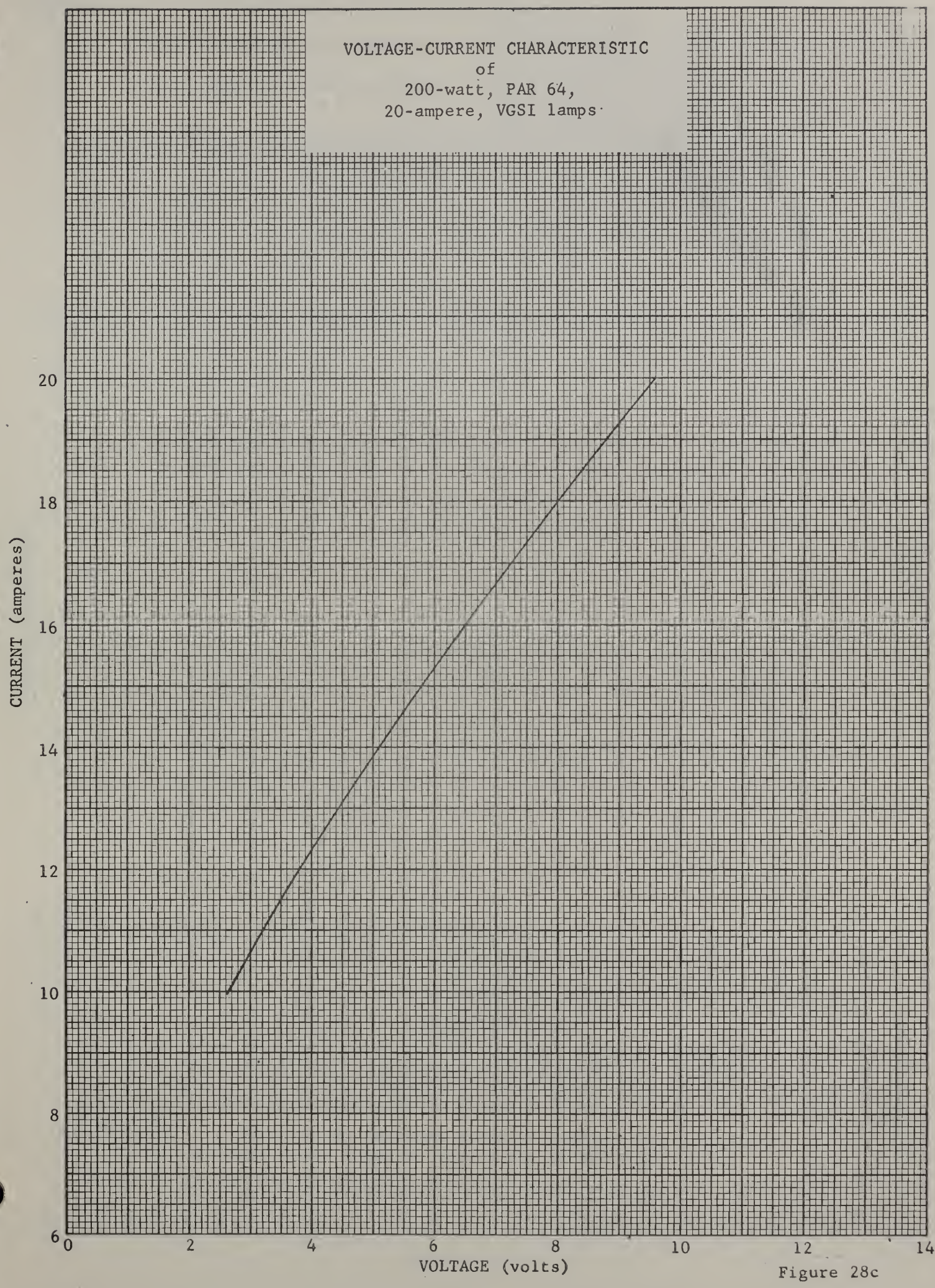
VOLTAGE-CURRENT CHARACTERISTIC
of
200-watt, PAR 64,
20-ampere, VGSI lamps
CURRENT (amperes)
20
18
16
14
12
10
8
6
0
2
4
6
8
10
12
14
VOLTAGE (volts)

Figure 28c

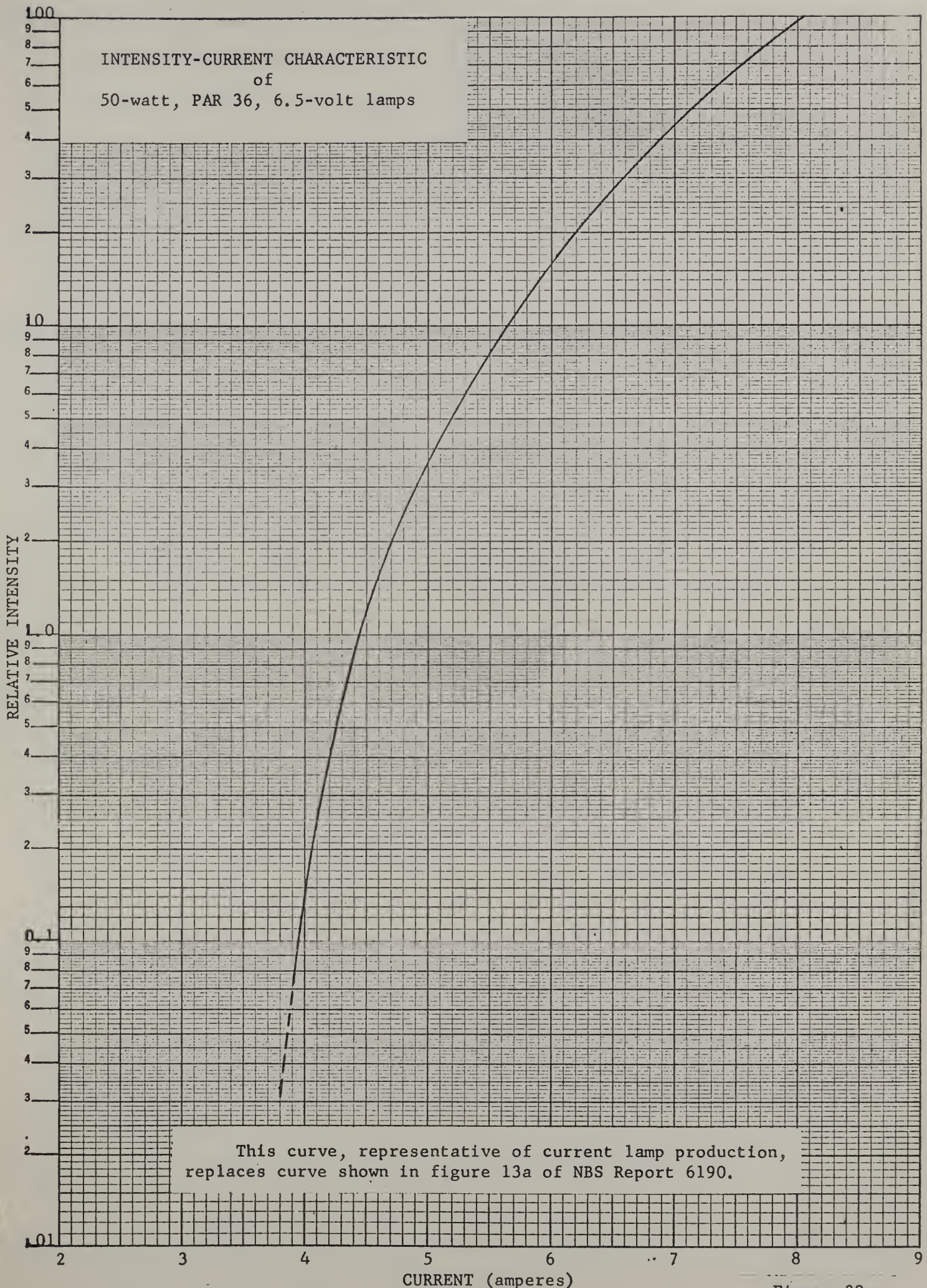
INTENSITY-CURRENT CHARACTERISTIC
of
50-watt, PAR 36, 6.5-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
2
3
4
5
6
7
8
9
CURRENT (amperes)
This curve, representative of current lamp production, replaces curve shown in figure 13a of NBS Report 6190.

Figure 29a

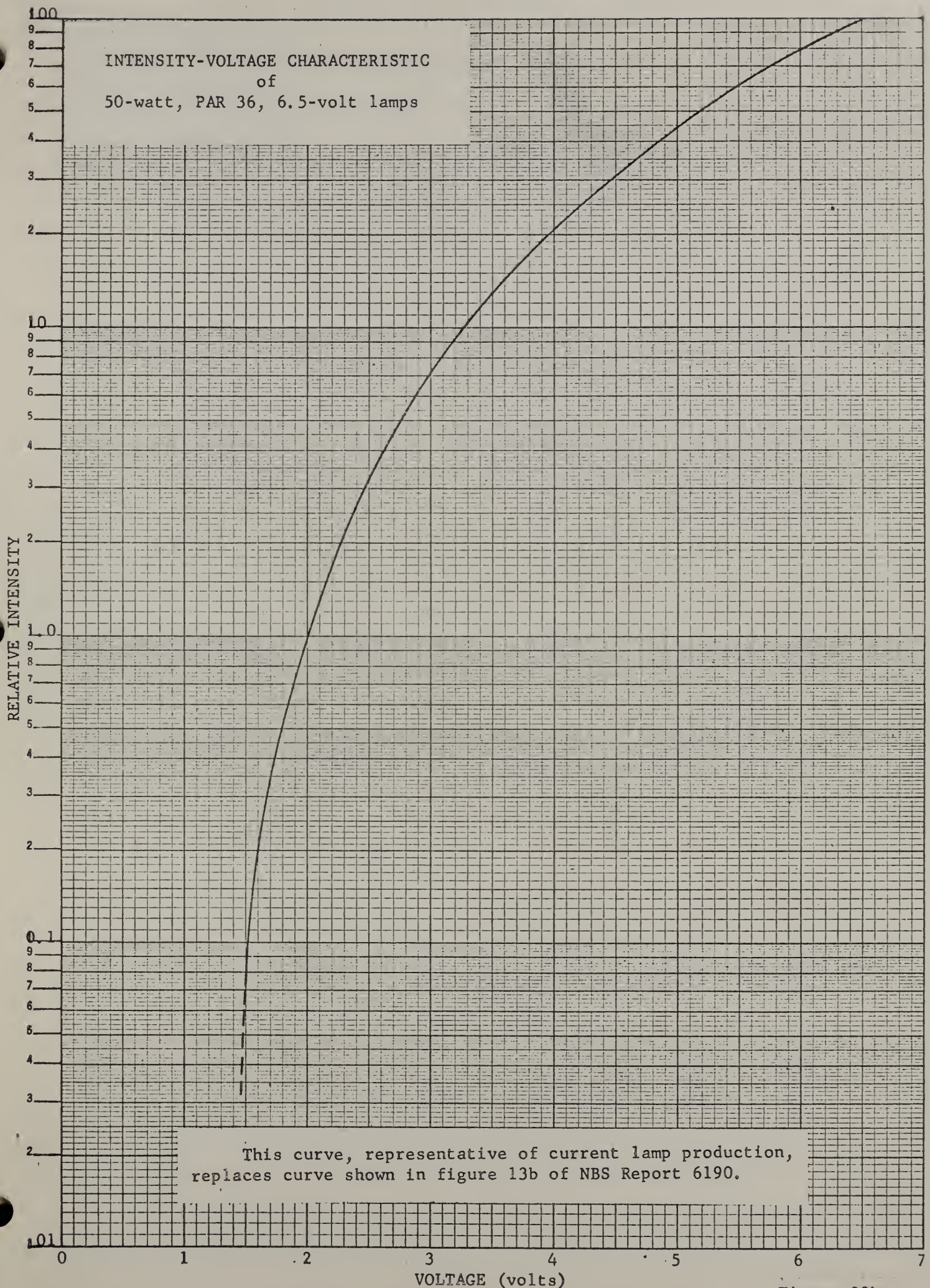
INTENSITY-VOLTAGE CHARACTERISTIC
of
50-watt, PAR 36, 6.5-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
1
2
3
4
5
6
7
VOLTAGE (volts)
This curve, representative of current lamp production, replaces curve shown in figure 13b of NBS Report 6190.

Figure 29b

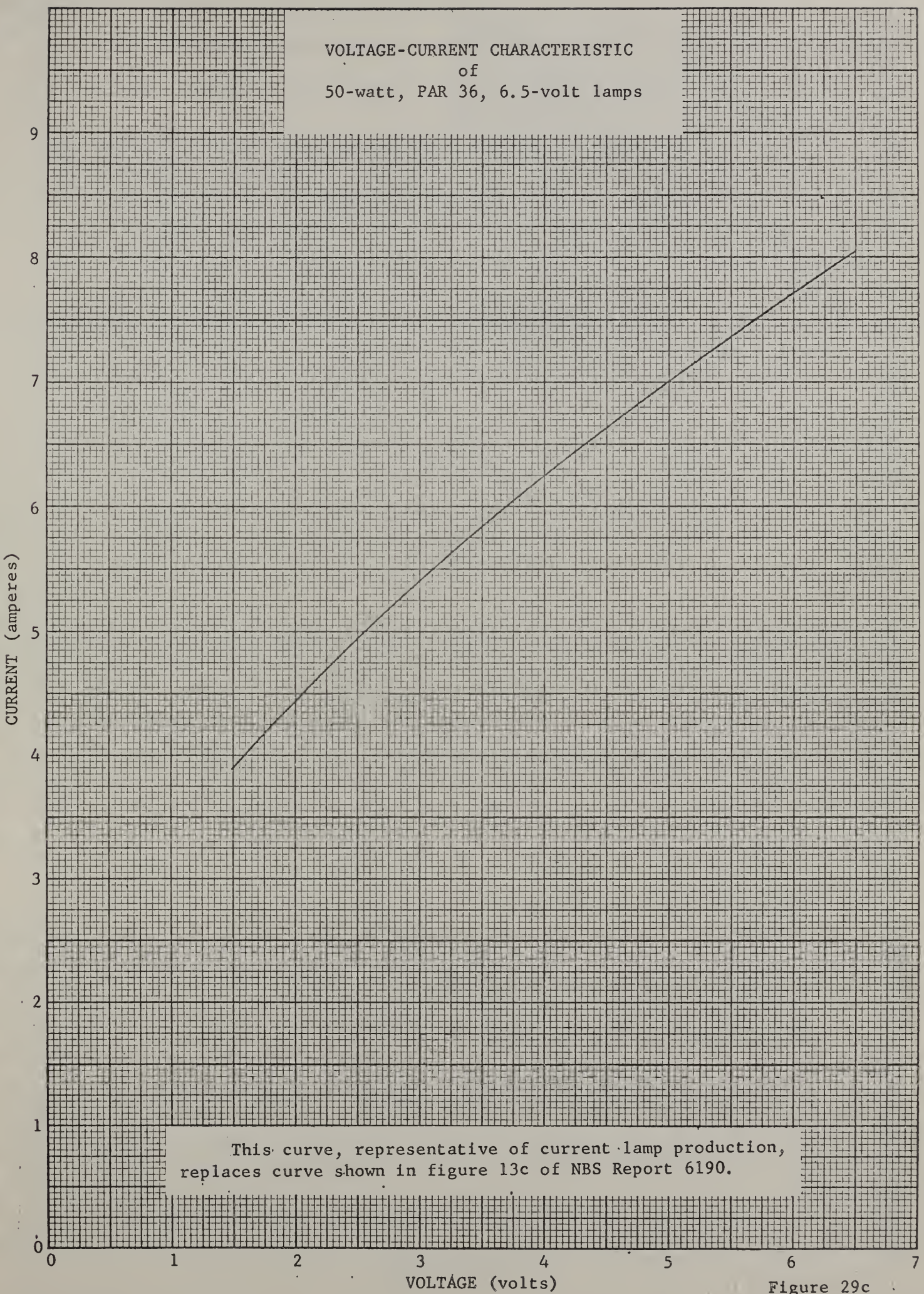
VOLTAGE-CURRENT CHARACTERISTIC
of
50-watt, PAR 36, 6.5-volt lamps
CURRENT (amperes)
0
1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
6
7
VOLTAGE (volts)
This curve, representative of current lamp production, replaces curve shown in figure 13c of NBS Report 6190.

Figure 29c

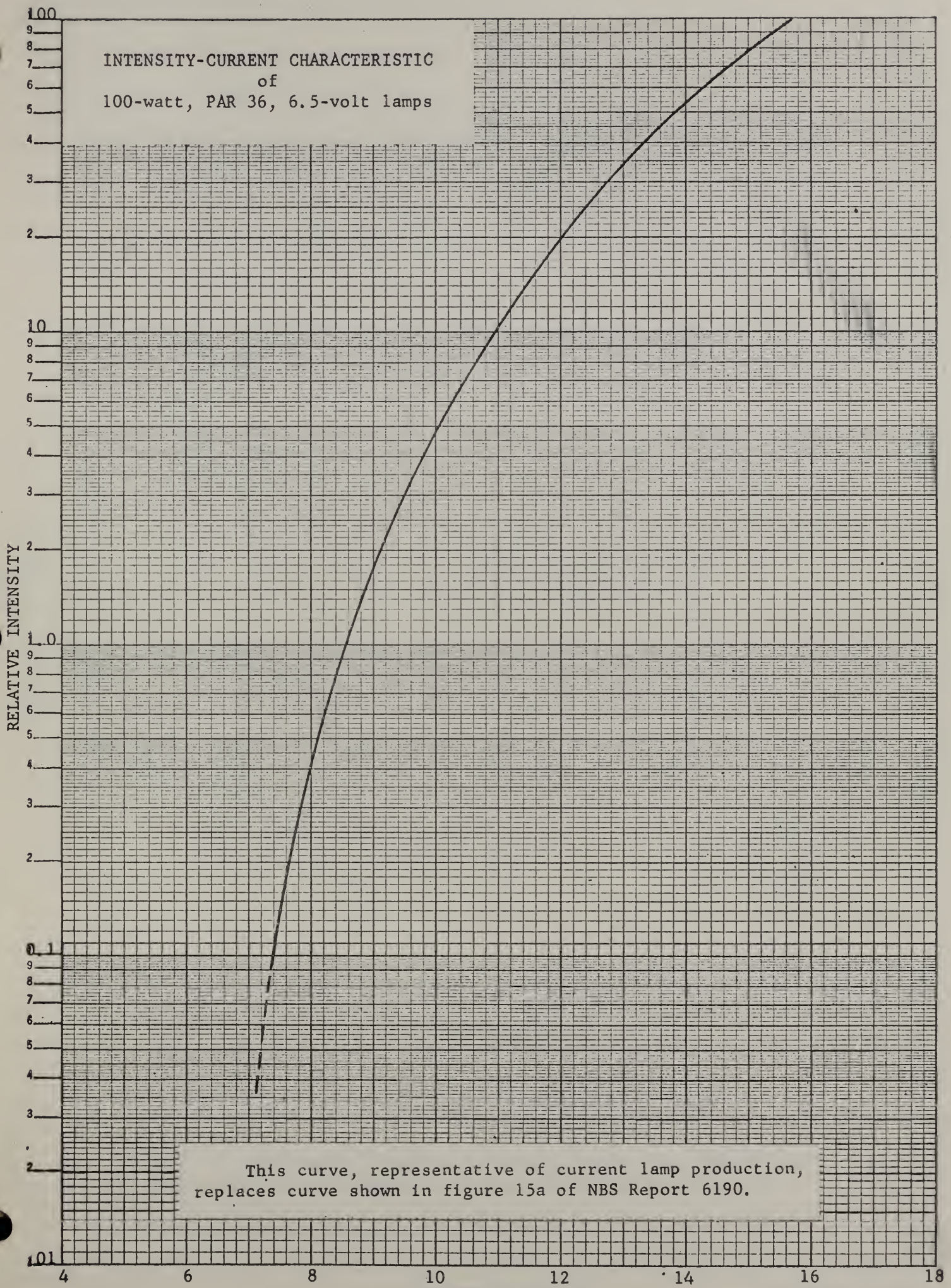
INTENSITY-CURRENT CHARACTERISTIC
of
100-watt, PAR 36, 6.5-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
4
6
8
10
12
14
16
18
CURRENT (amperes)
This curve, representative of current lamp production, replaces curve shown in figure 15a of NBS Report 6190.

Figure 30a

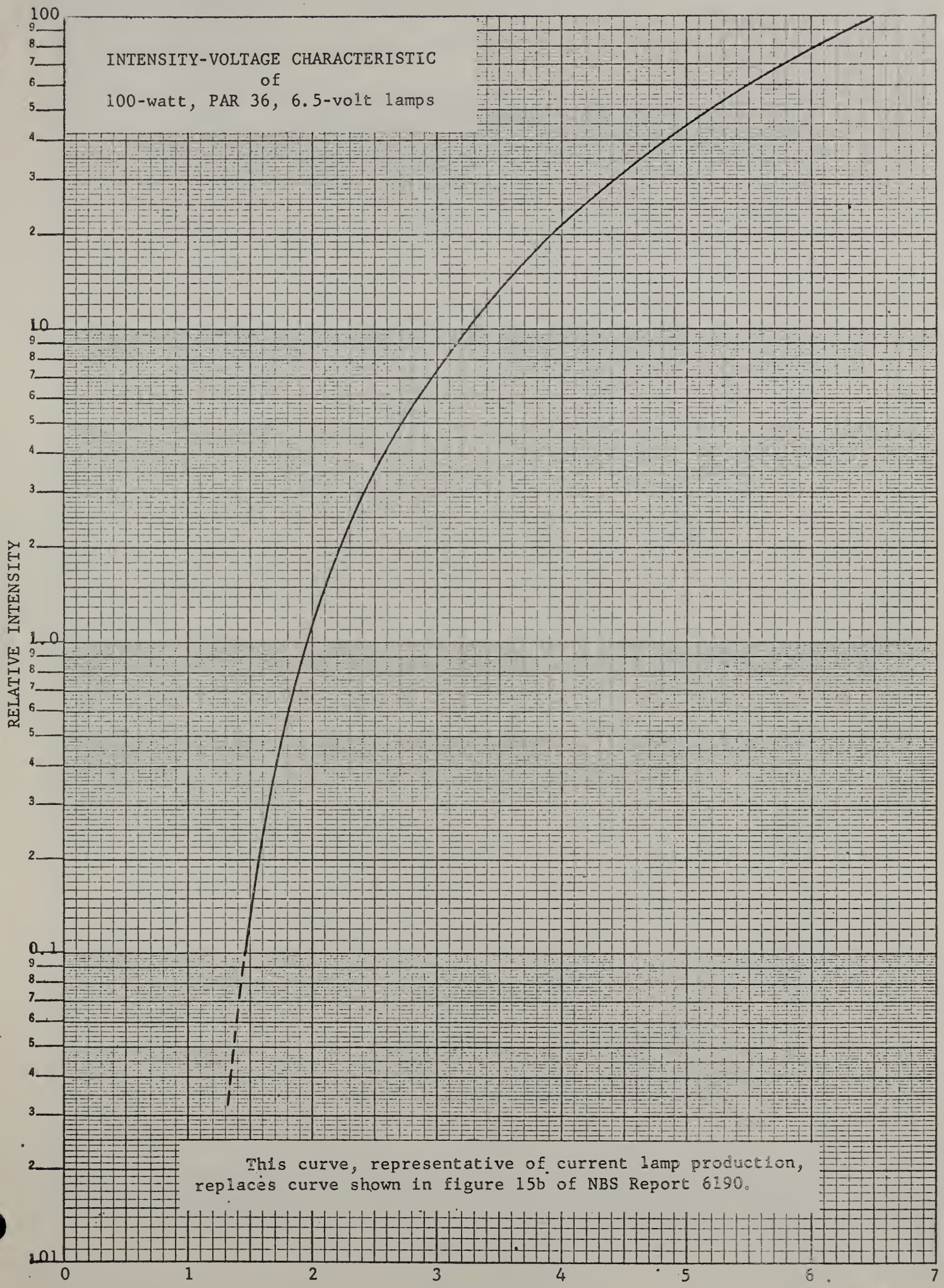
INTENSITY-VOLTAGE CHARACTERISTIC
of
100-watt, PAR 36, 6.5-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
0.01
0
1
2
3
4
5
6
7
VOLTAGE (volts)
This curve, representative of current lamp production, replaces curve shown in figure 15b of NBS Report 6190.

Figure 30b

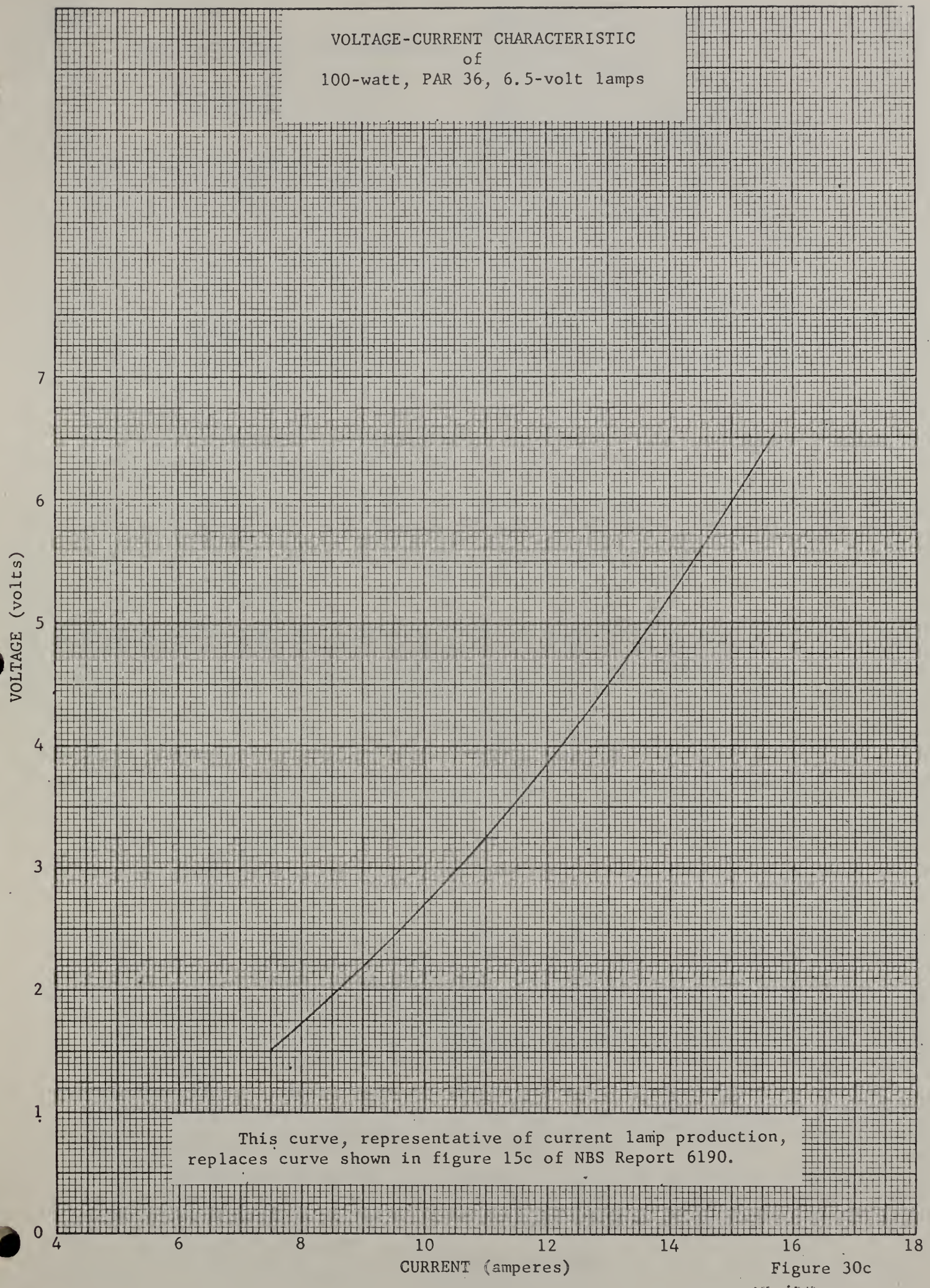
VOLTAGE-CURRENT CHARACTERISTIC
of
100-watt, PAR 36, 6.5-volt lamps
VOLTAGE (volts)
0
1
2
3
4
5
6
7
4
6
8
10
12
14
16
18
CURRENT (amperes)
This curve, representative of current lamp production, replaces curve shown in figure 15c of NBS Report 6190.

Figure 30c

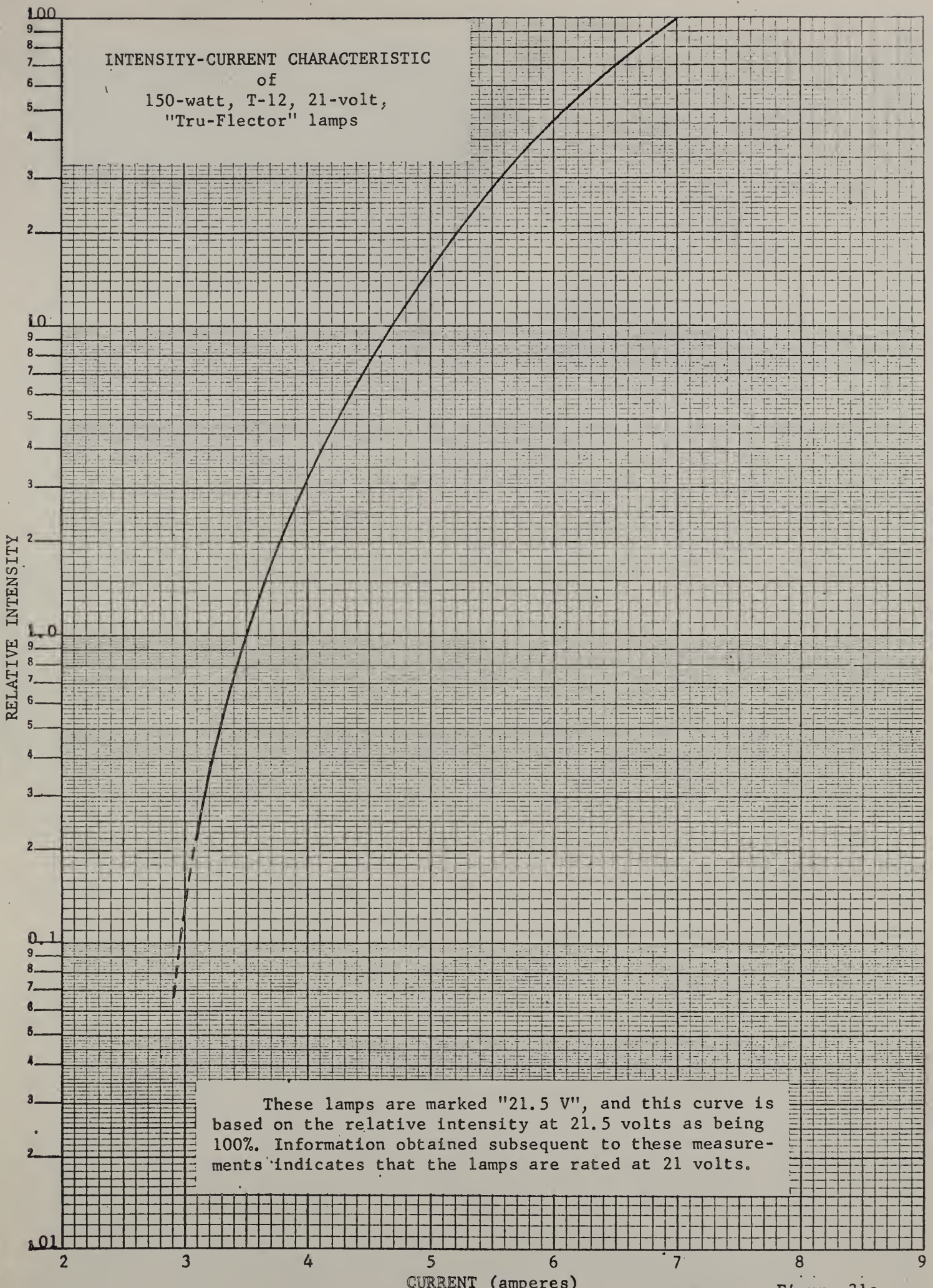
INTENSITY-CURRENT CHARACTERISTIC
of
150-watt, T-12, 21-volt,
"Tru-Flector" lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
2
3
4
5
6
7
8
9
CURRENT (amperes)
These lamps are marked "21.5 V", and this curve is based on the relative intensity at 21.5 volts as being 100%. Information obtained subsequent to these measurements indicates that the lamps are rated at 21 volts.

Figure 31a

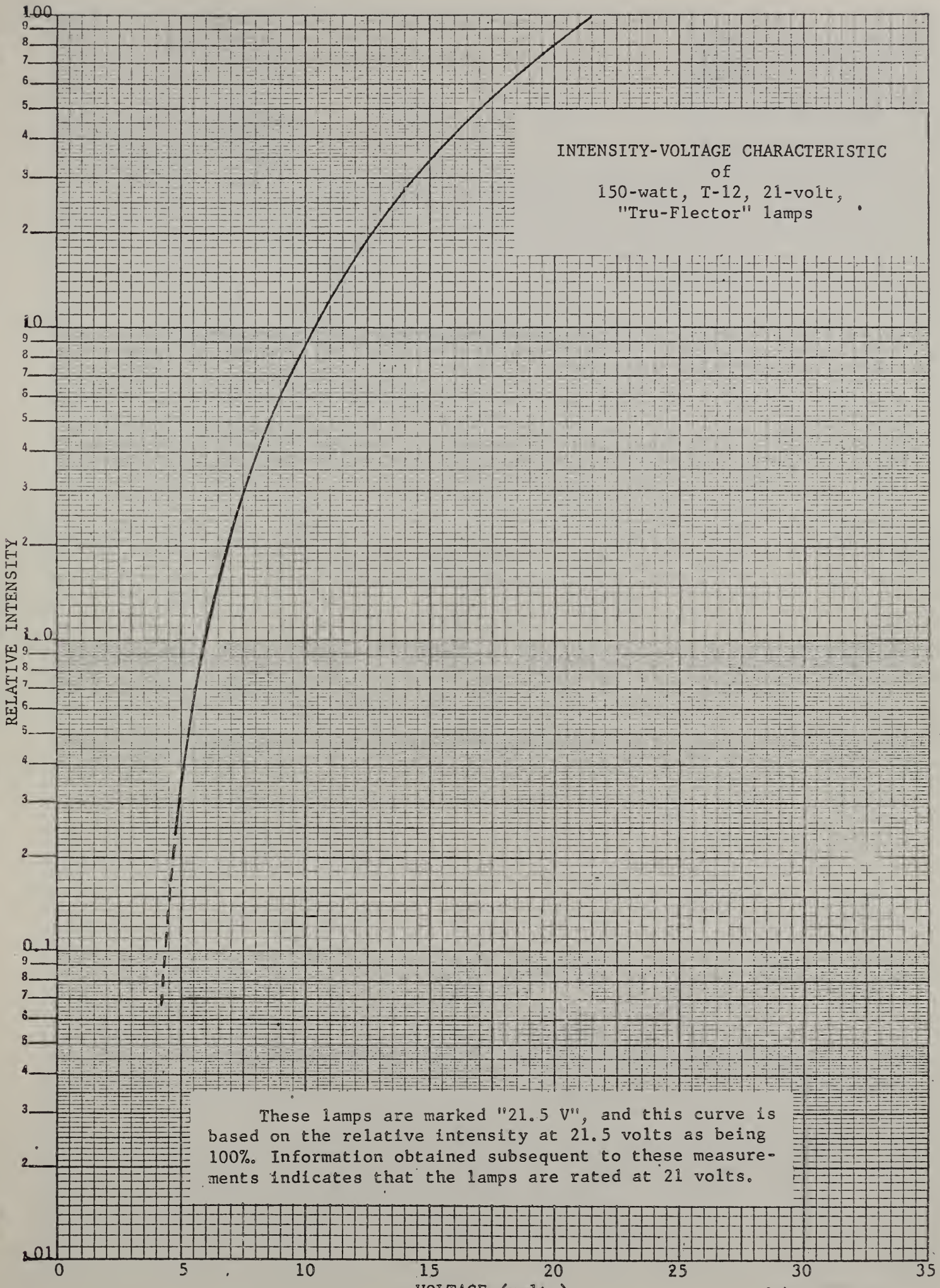
INTENSITY-VOLTAGE CHARACTERISTIC
of
150-watt, T-12, 21-volt,
"Tru-Flector" lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
5
10
15
20
25
30
35
VOLTAGE (volts)
These lamps are marked "21.5 V", and this curve is based on the relative intensity at 21.5 volts as being 100%. Information obtained subsequent to these measurements indicates that the lamps are rated at 21 volts.

Figure 31b

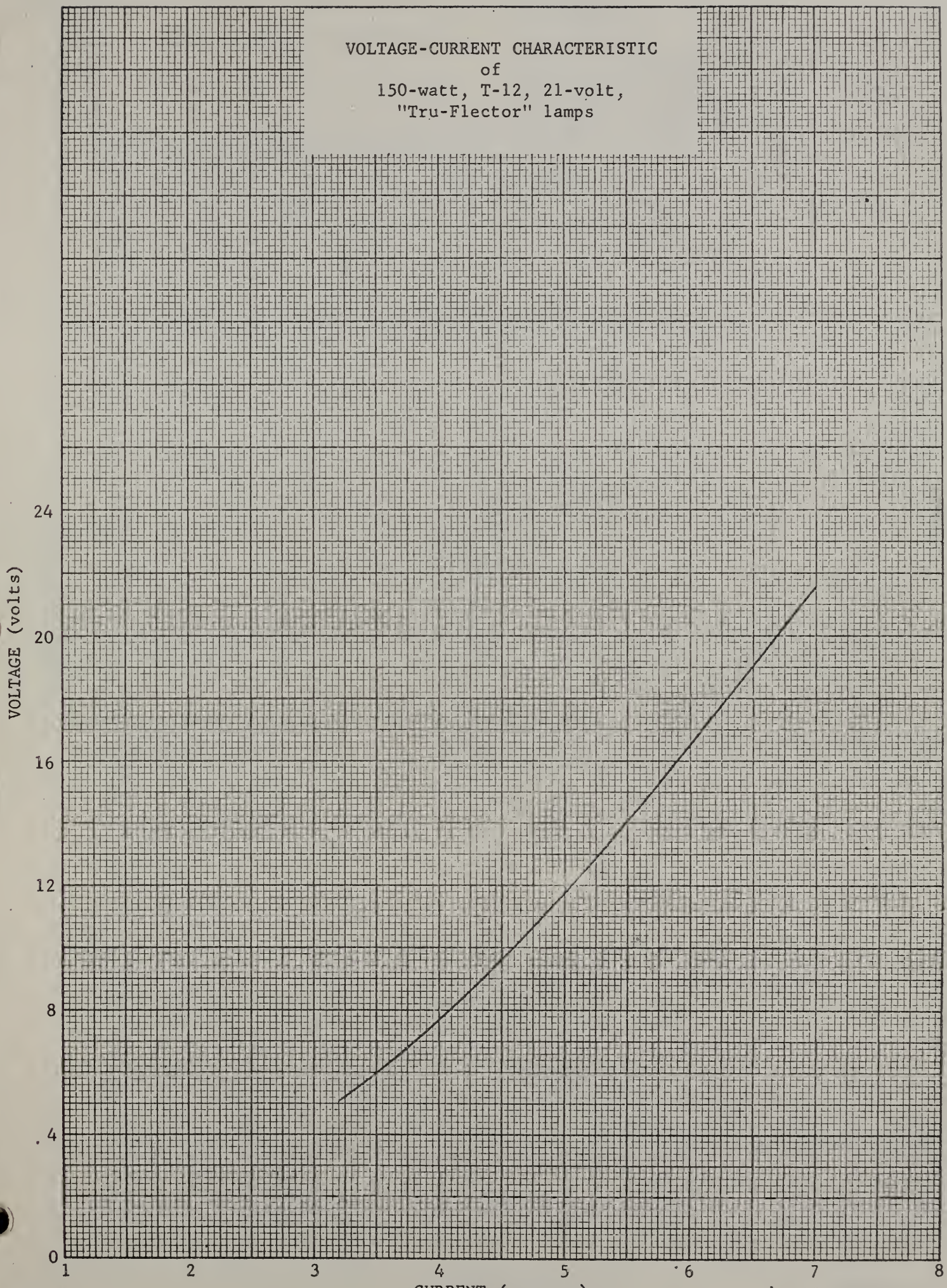
VOLTAGE-CURRENT CHARACTERISTIC
of
150-watt, T-12, 21-volt,
"Tru-Flector" lamps
VOLTAGE (volts)
0
4
8
12
16
20
24
1
2
3
4
5
6
7
8
CURRENT (amperes)

Figure 31c

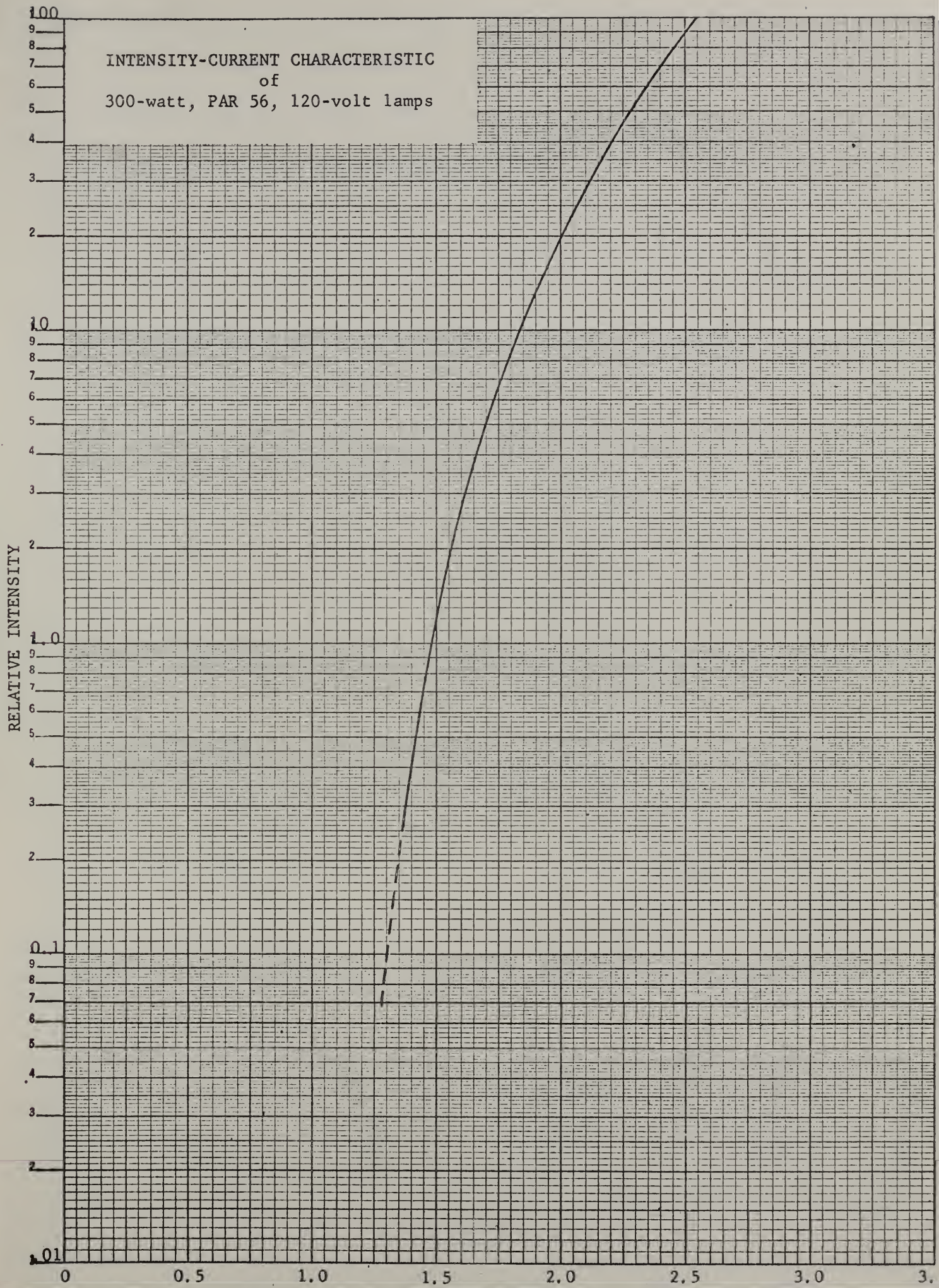
INTENSITY-CURRENT CHARACTERISTIC
of
300-watt, PAR 56, 120-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
0.5
1.0
1.5
2.0
2.5
3.0
CURRENT (amperes)

Figure 32a

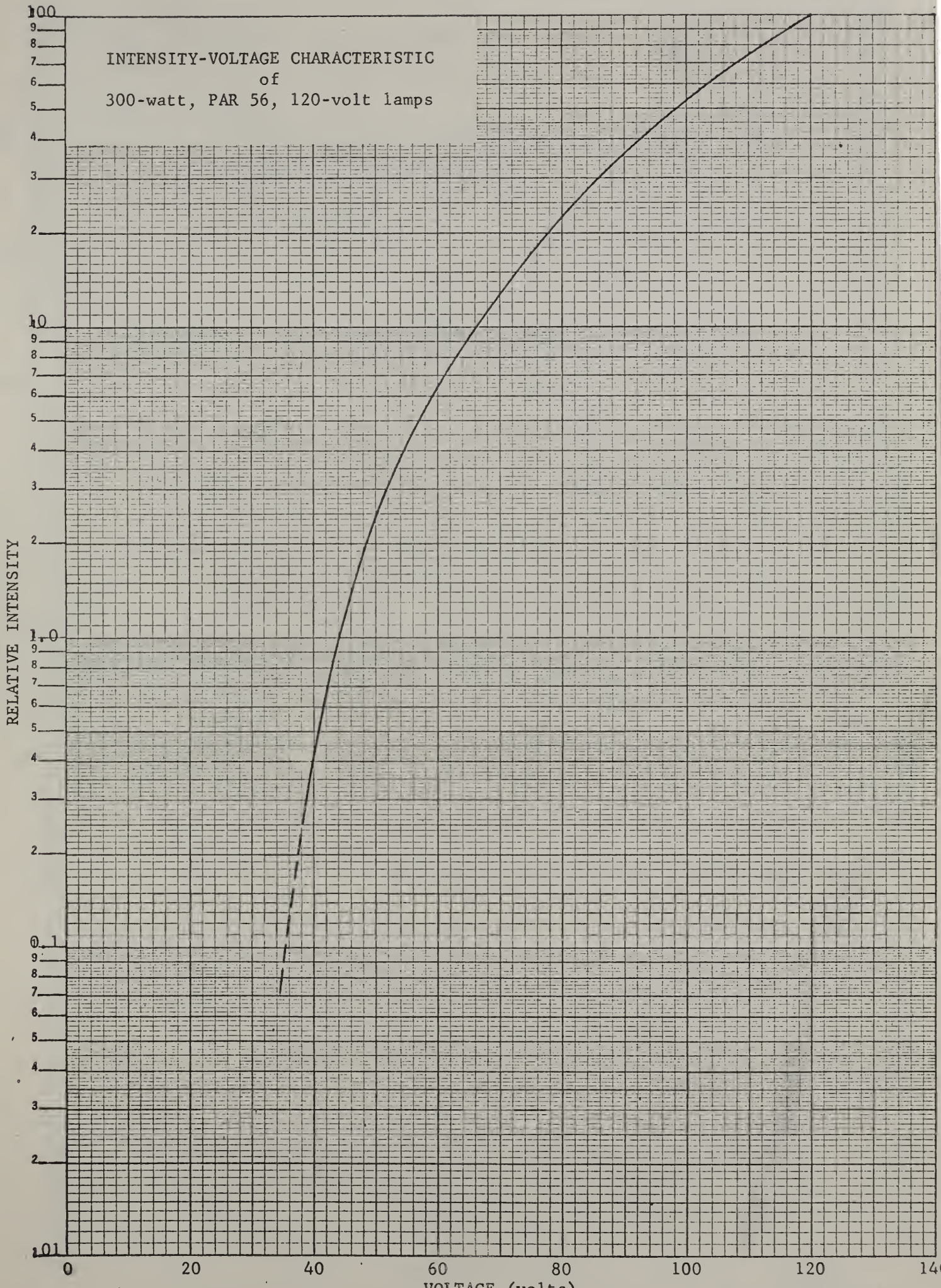
INTENSITY-VOLTAGE CHARACTERISTIC
of
300-watt, PAR 56, 120-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
20
40
60
80
100
120
140
VOLTAGE (volts)

Figure 3.

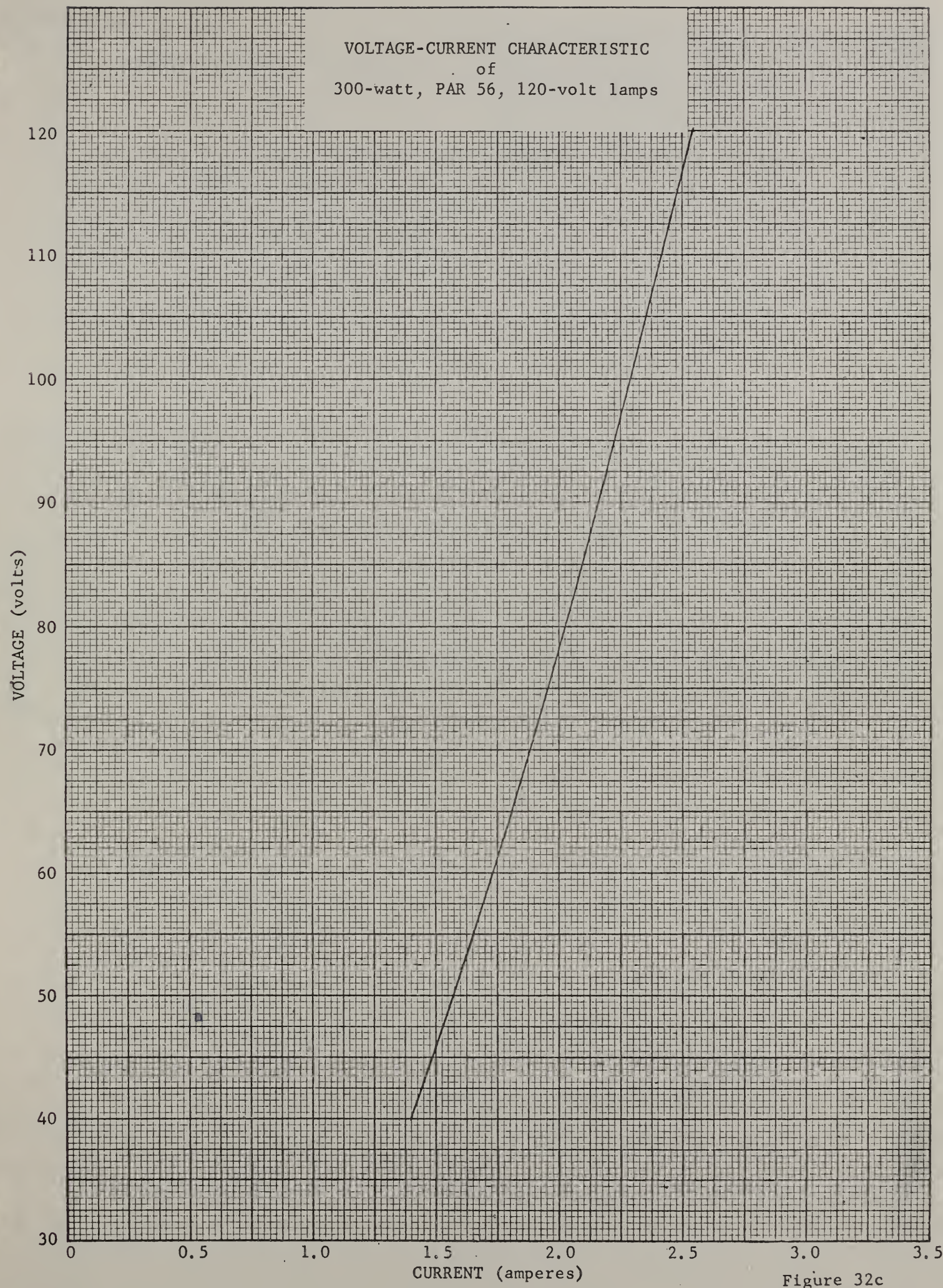
VOLTAGE-CURRENT CHARACTERISTIC
of
300-watt, PAR 56, 120-volt lamps
VOLTAGE (volts)
120
110
100
90
80
70
60
50
40
30
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
CURRENT (amperes)

Figure 32c

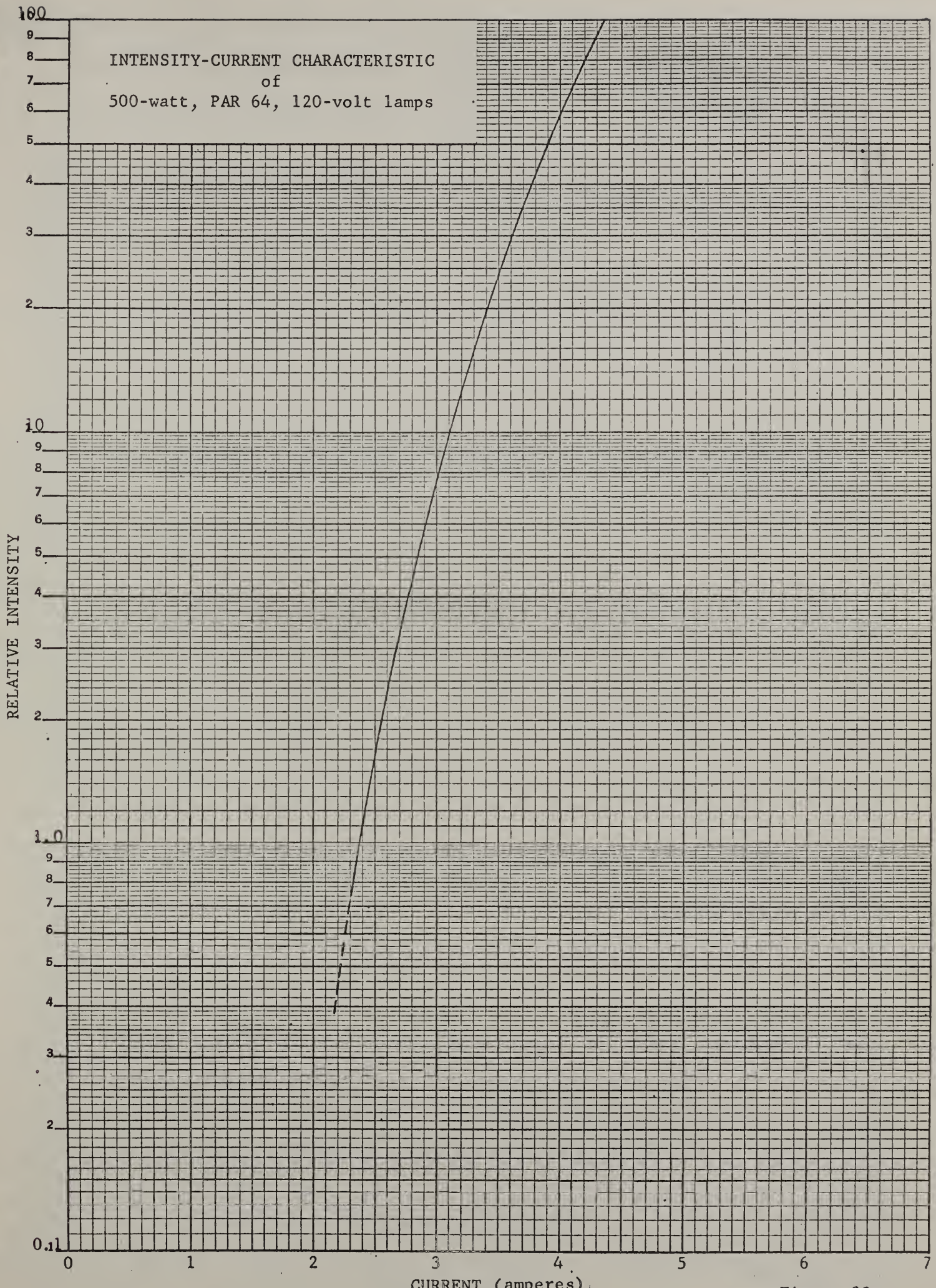
INTENSITY-CURRENT CHARACTERISTIC
of
500-watt, PAR 64, 120-volt lamps
RELATIVE INTENSITY
100
9
8
7
6
5
4
3
2
10
9
8
7
6
5
4
3
2
1.0
9
8
7
6
5
4
3
2
0.1
0
1
2
3
4
5
6
7
CURRENT (amperes)

Figure 33a

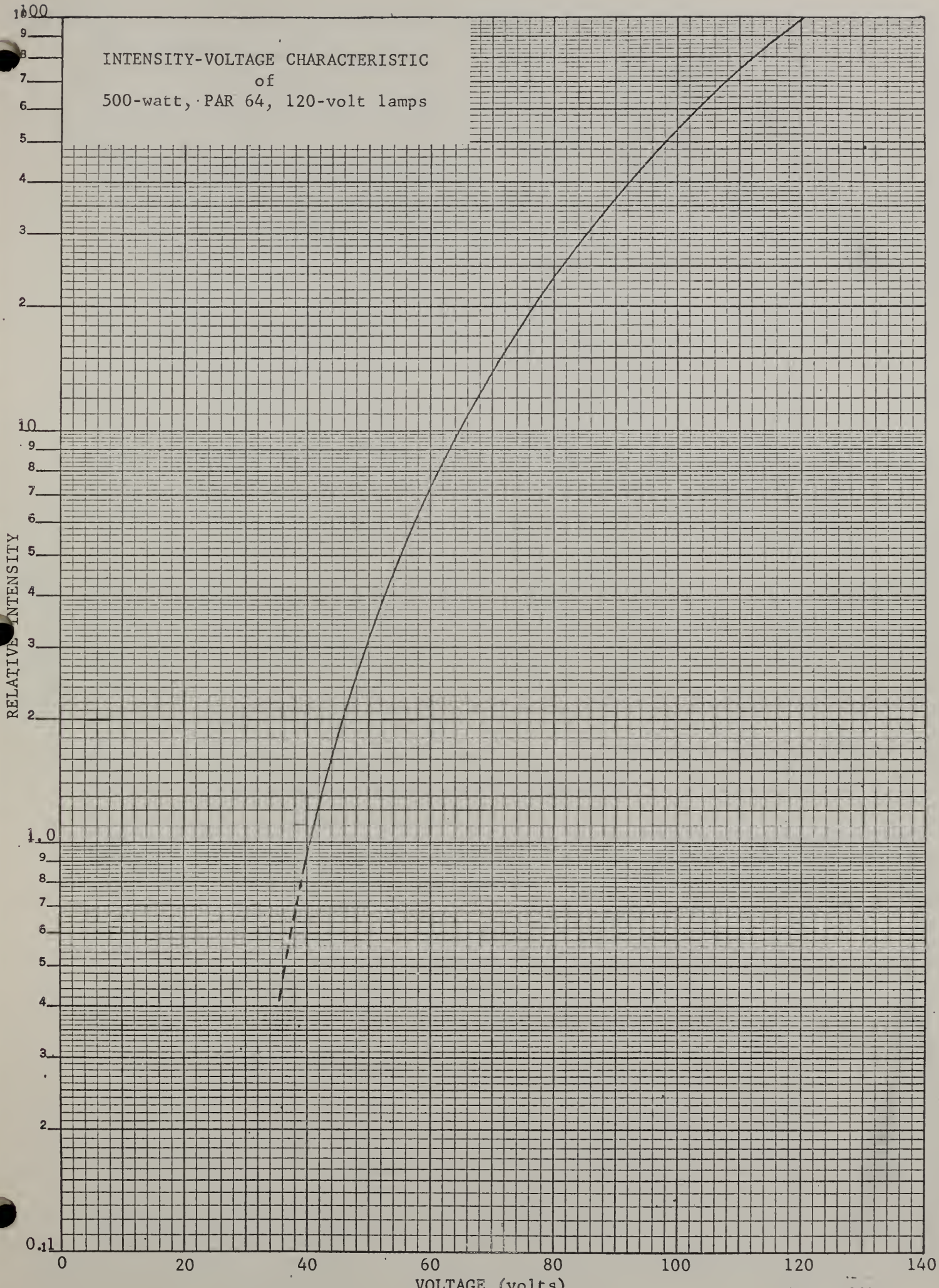
INTENSITY-VOLTAGE CHARACTERISTIC
of
500-watt, PAR 64, 120-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
0
20
40
60
80
100
120
140
VOLTAGE (volts)

Figure 33b

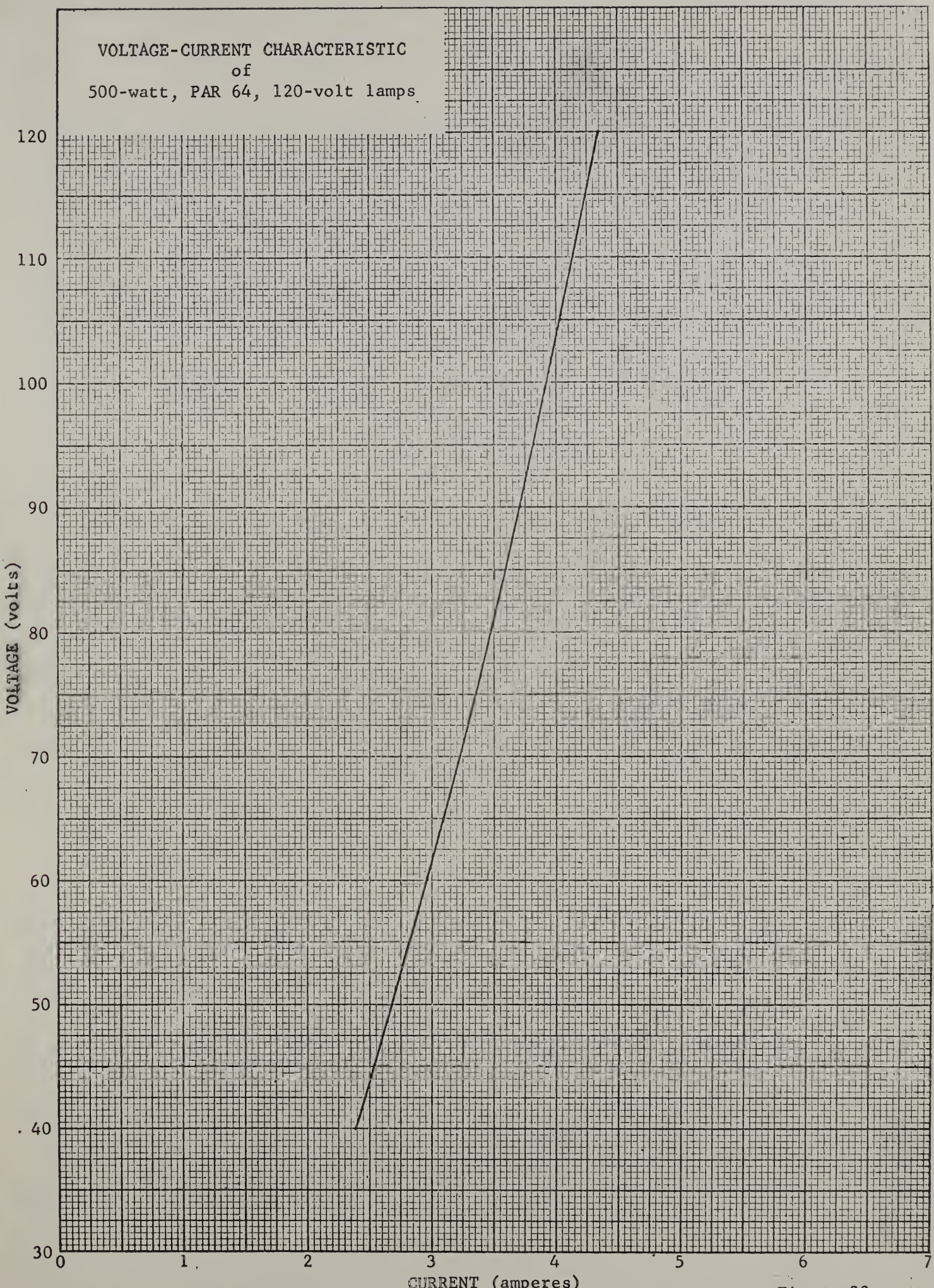
VOLTAGE-CURRENT CHARACTERISTIC
of
500-watt, PAR 64, 120-volt lamps
120
110
100
90
80
70
60
50
40
30
VOLTAGE (volts)
0
1
2
3
4
5
6
7
CURRENT (amperes)

Figure 33c

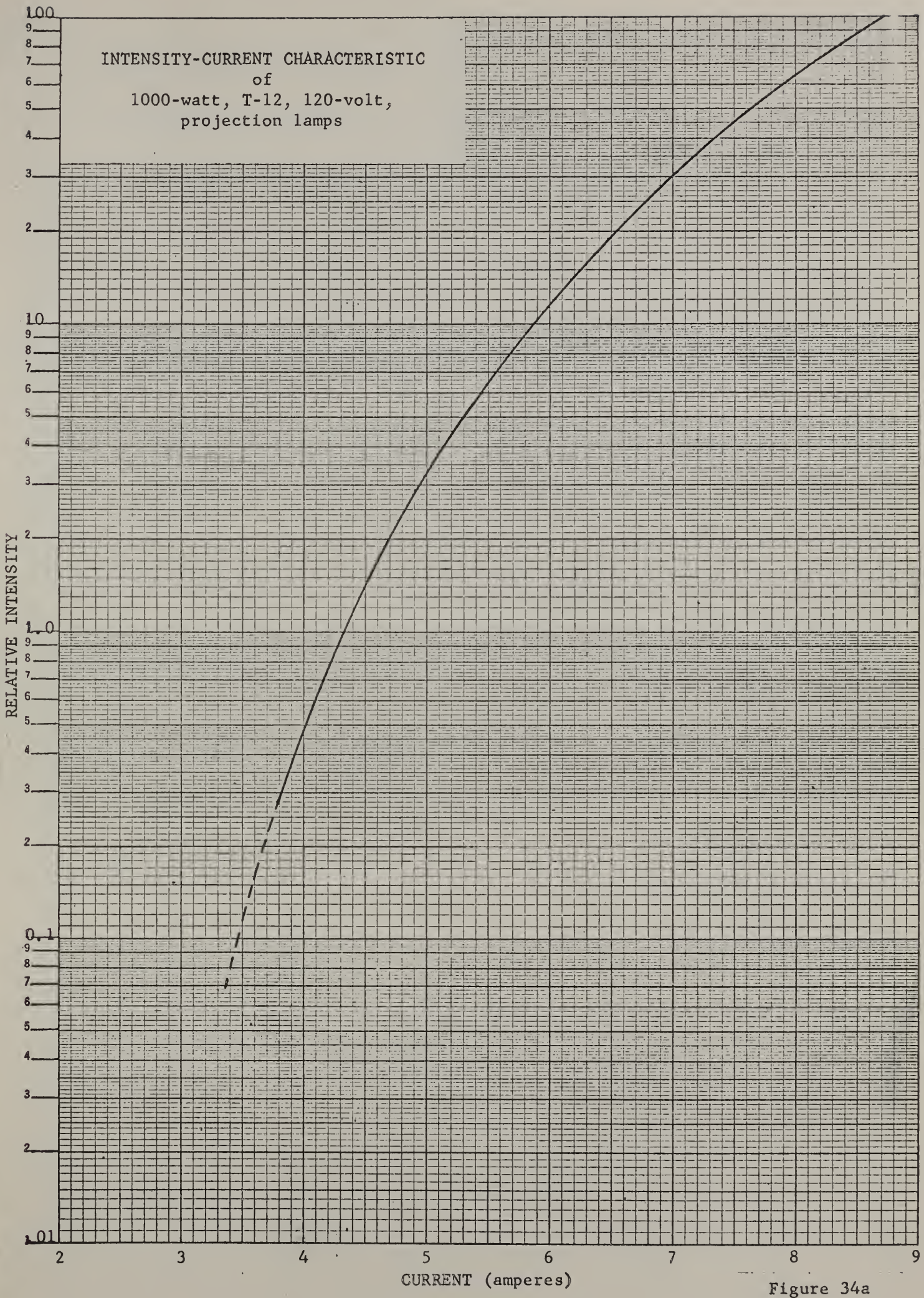
INTENSITY-CURRENT CHARACTERISTIC
of
1000-watt, T-12, 120-volt,
projection lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
2
3
4
5
6
7
8
9
CURRENT (amperes)

Figure 34a

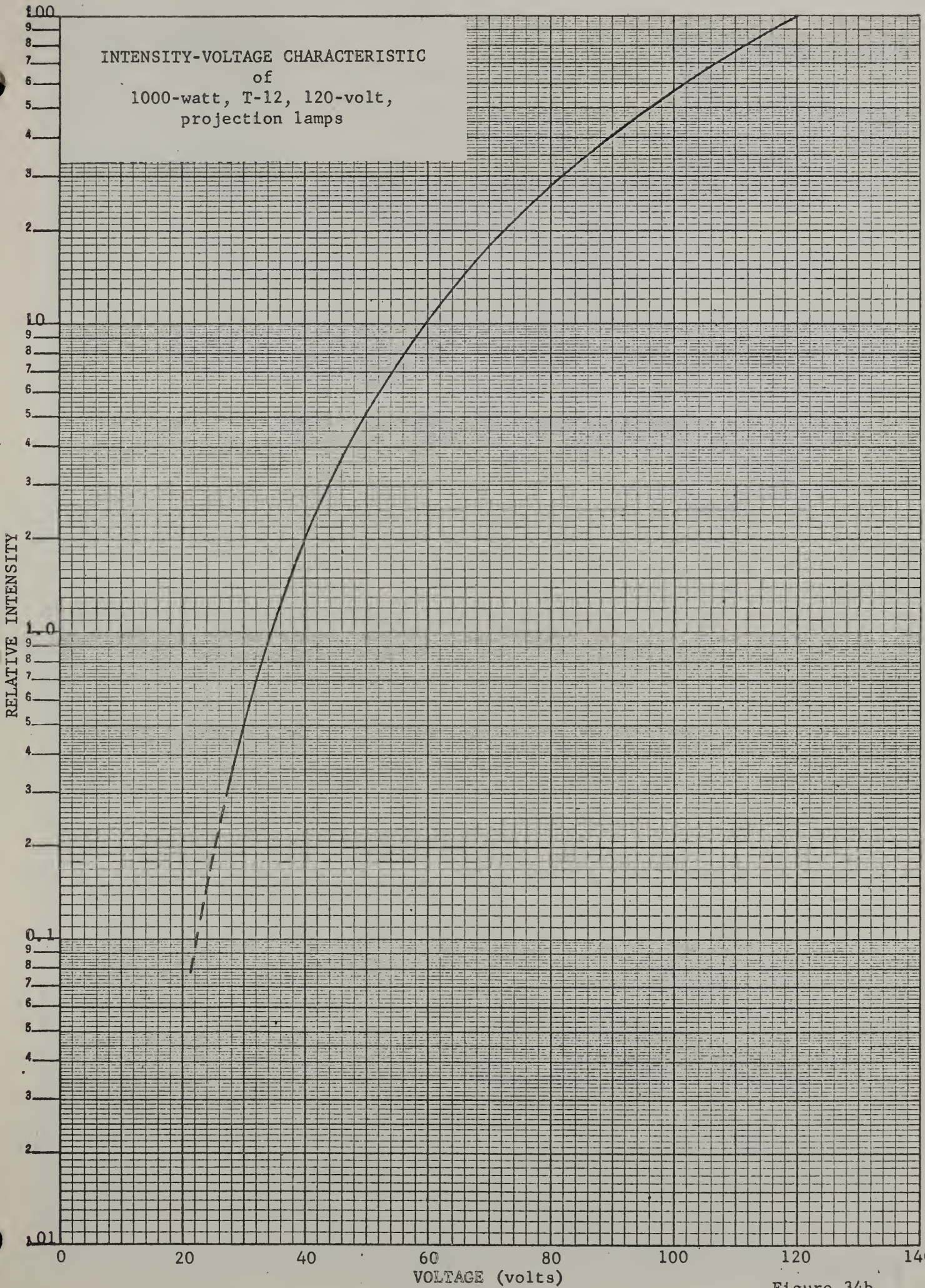
INTENSITY-VOLTAGE CHARACTERISTIC
of
1000-watt, T-12, 120-volt,
projection lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
20
40
60
80
100
120
140
VOLTAGE (volts)

Figure 34b

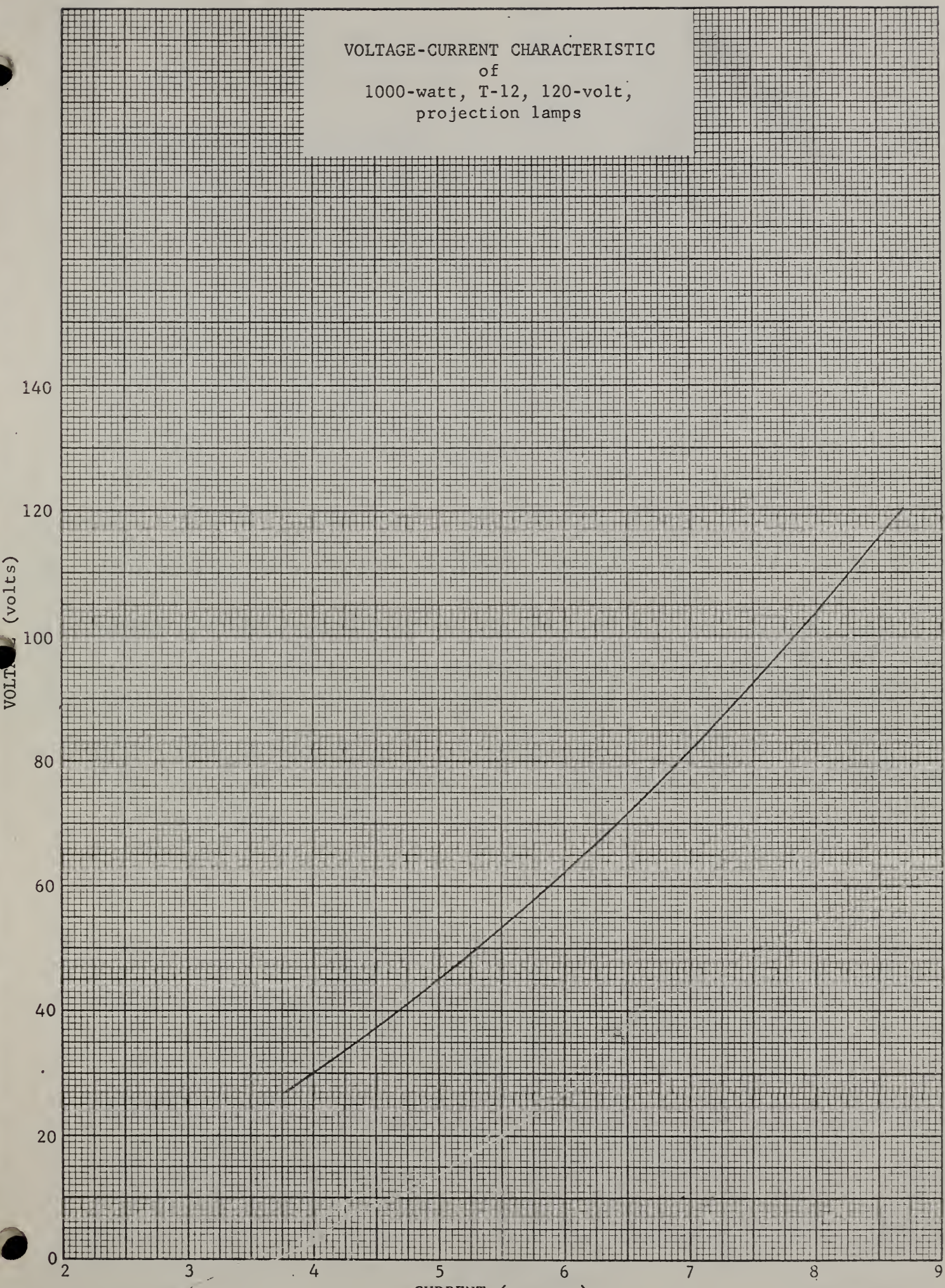
VOLTAGE-CURRENT CHARACTERISTIC
of
1000-watt, T-12, 120-volt,
projection lamps
VOLTAGE (volts)
0
20
40
60
80
100
120
140
2
3
4
5
6
7
8
9
CURRENT (amperes)

Figure 34c

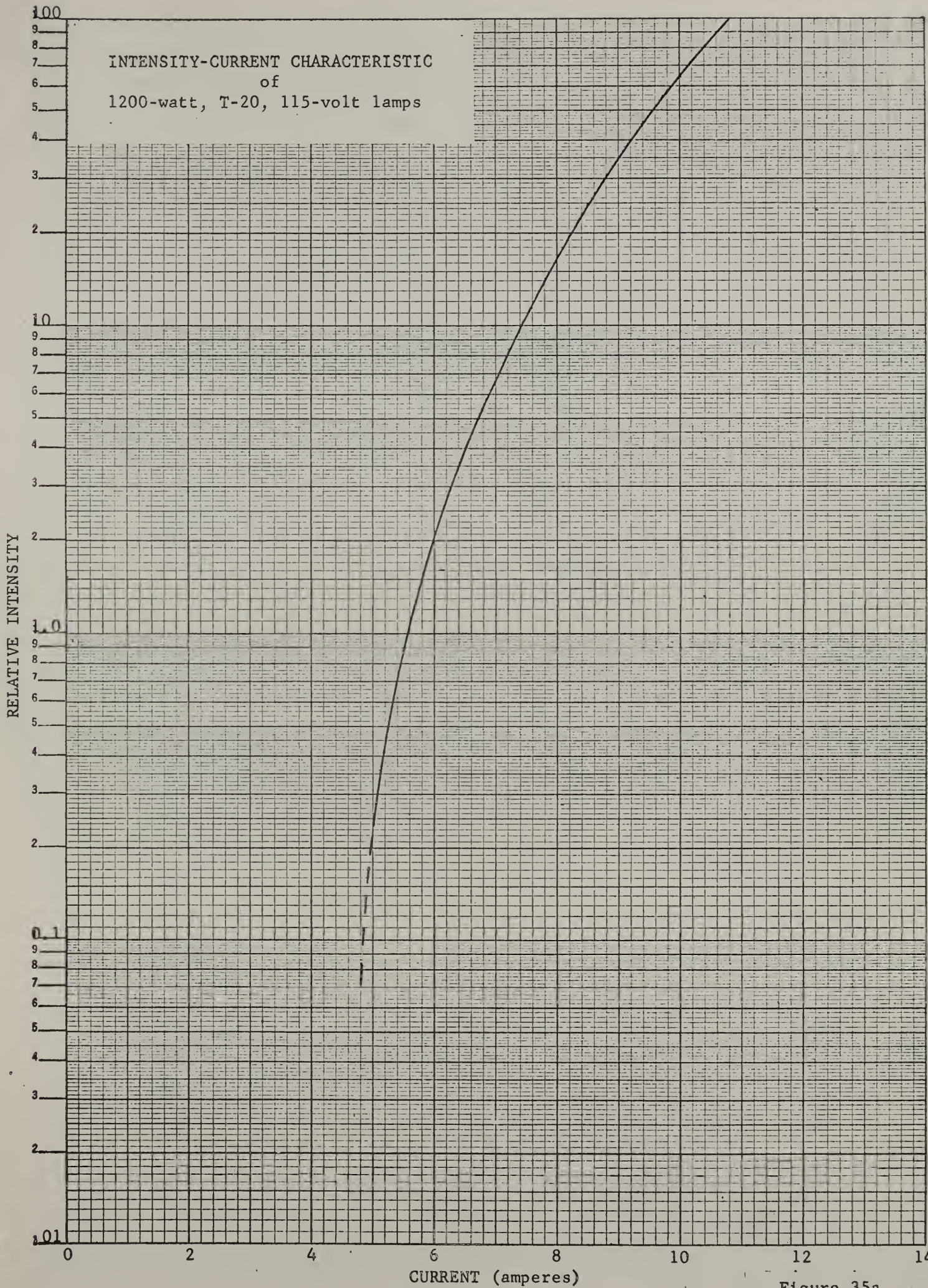
INTENSITY-CURRENT CHARACTERISTIC
of
1200-watt, T-20, 115-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
2
4
6
8
10
12
CURRENT (amperes)

Figure 35a

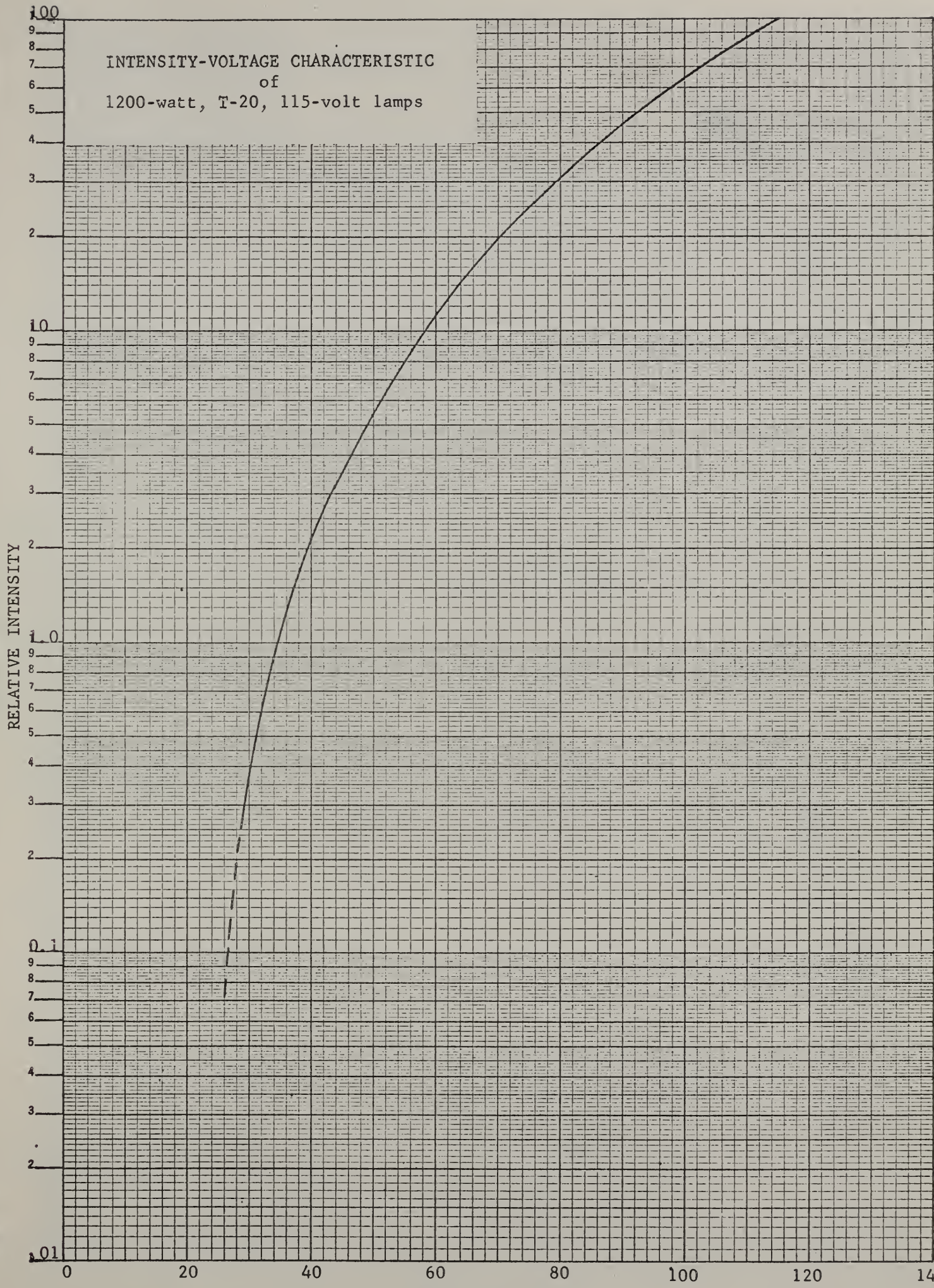
INTENSITY-VOLTAGE CHARACTERISTIC
of
1200-watt, T-20, 115-volt lamps
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
20
40
60
80
100
120
VOLTAGE (volts)

Figure 35b

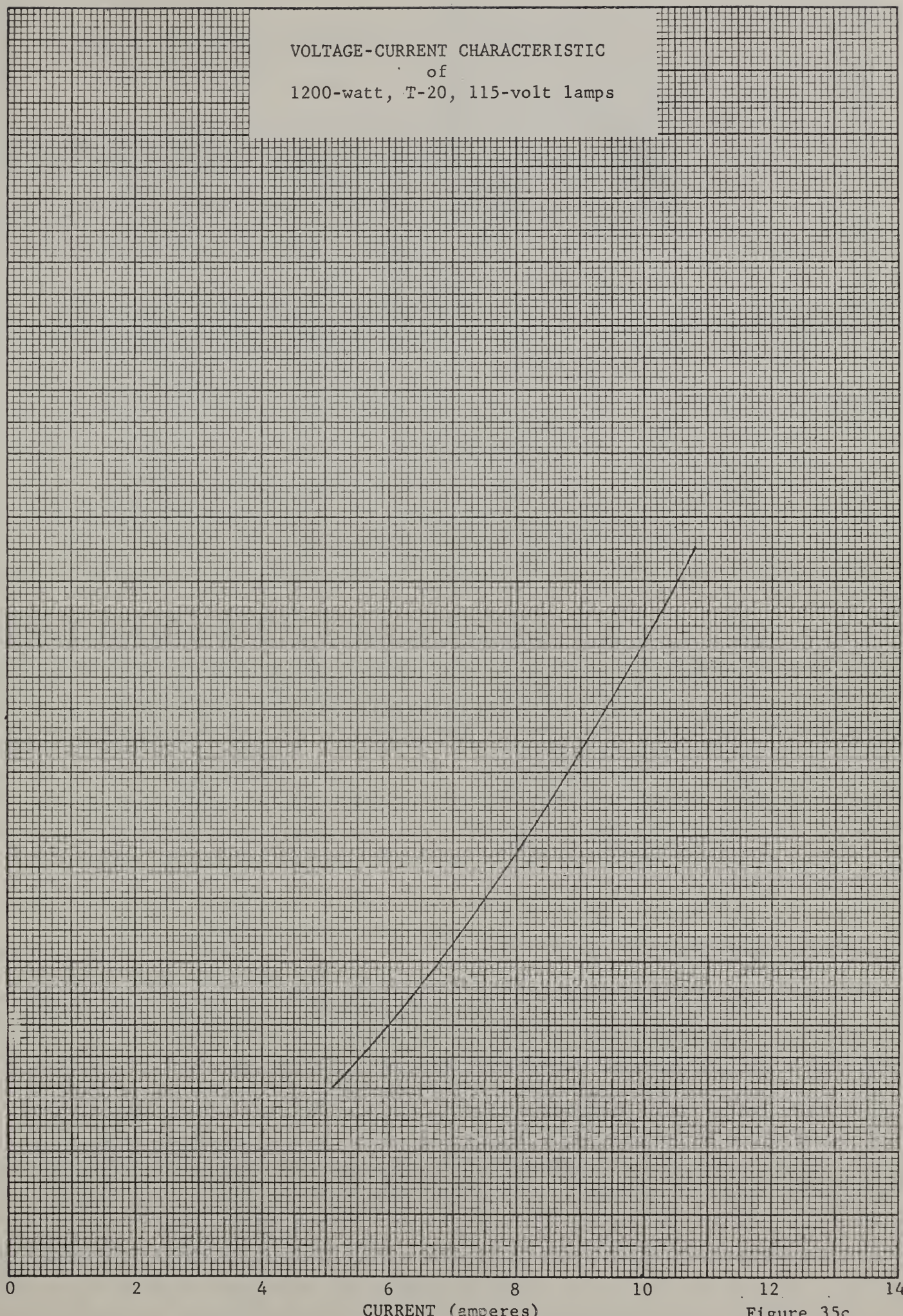
VOLTAGE-CURRENT CHARACTERISTIC
of
1200-watt, T-20, 115-volt lamps
VOLTAGE (volts)
0
20
40
60
80
100
120
0
2
4
6
8
10
12
14
CURRENT (amperes)

Figure 35c

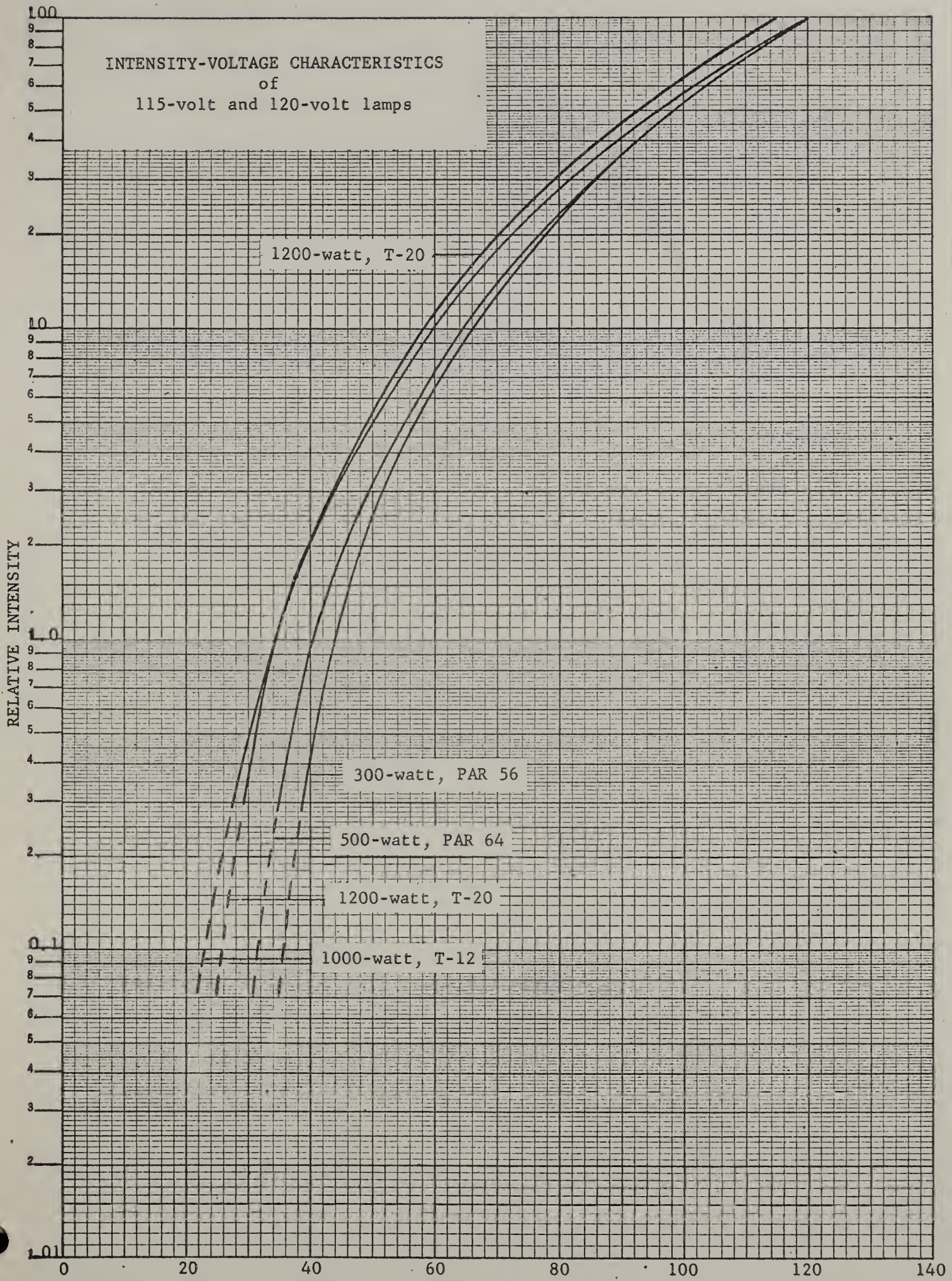
INTENSITY-VOLTAGE CHARACTERISTICS
of
115-volt and 120-volt lamps
1200-watt, T-20
300-watt, PAR 56
500-watt, PAR 64
1200-watt, T-20
1000-watt, T-12
RELATIVE INTENSITY
100
10
1.0
0.1
0.01
0
20
40
60
80
100
120
140
VOLTAGE (volts)

Figure 36

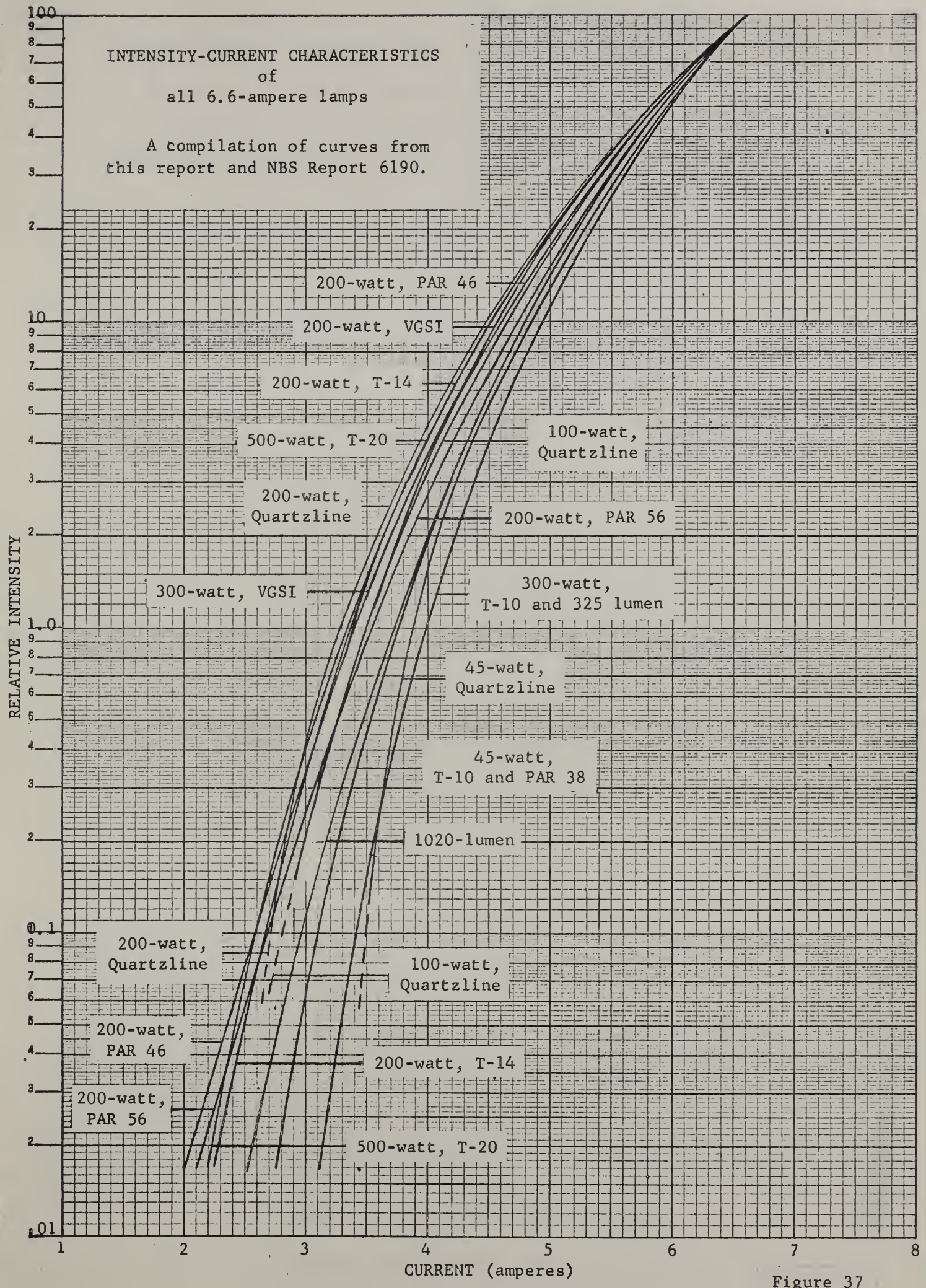
INTENSITY-CURRENT CHARACTERISTICS
of
all 6.6-ampere lamps
A compilation of curves from
this report and NBS Report 6190.
200-watt, PAR 46
200-watt, VGSI
200-watt, T-14
500-watt, T-20
100-watt, Quartzline
200-watt, Quartzline
200-watt, PAR 56
300-watt, VGSI
300-watt, T-10 and 325 lumen
45-watt, Quartzline
45-watt, T-10 and PAR 38
1020-lumen
200-watt, Quartzline
100-watt, Quartzline
200-watt, PAR 46
200-watt, T-14
200-watt, PAR 56
500-watt, T-20
RELATIVE INTENSITY
CURRENT (amperes)

Figure 37

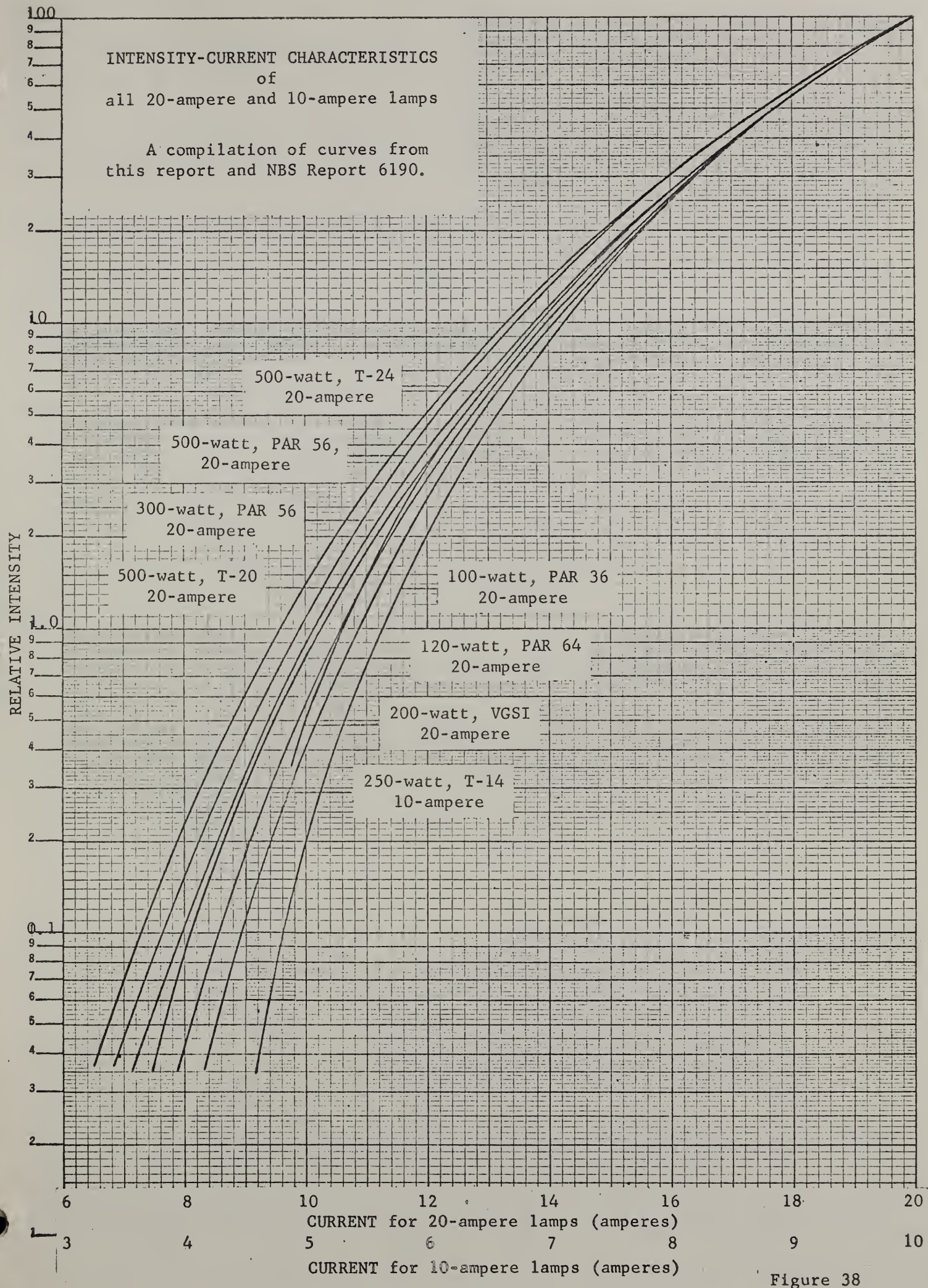
INTENSITY-CURRENT CHARACTERISTICS
of
all 20-ampere and 10-ampere lamps
A compilation of curves from
this report and NBS Report 6190.
500-watt, T-24
20-ampere
500-watt, PAR 56,
20-ampere
300-watt, PAR 56
20-ampere
500-watt, T-20
20-ampere
100-watt, PAR 36
20-ampere
120-watt, PAR 64
20-ampere
200-watt, VGSI
20-ampere
250-watt, T-14
10-ampere
RELATIVE INTENSITY
100
10
1.0
0.1
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 38

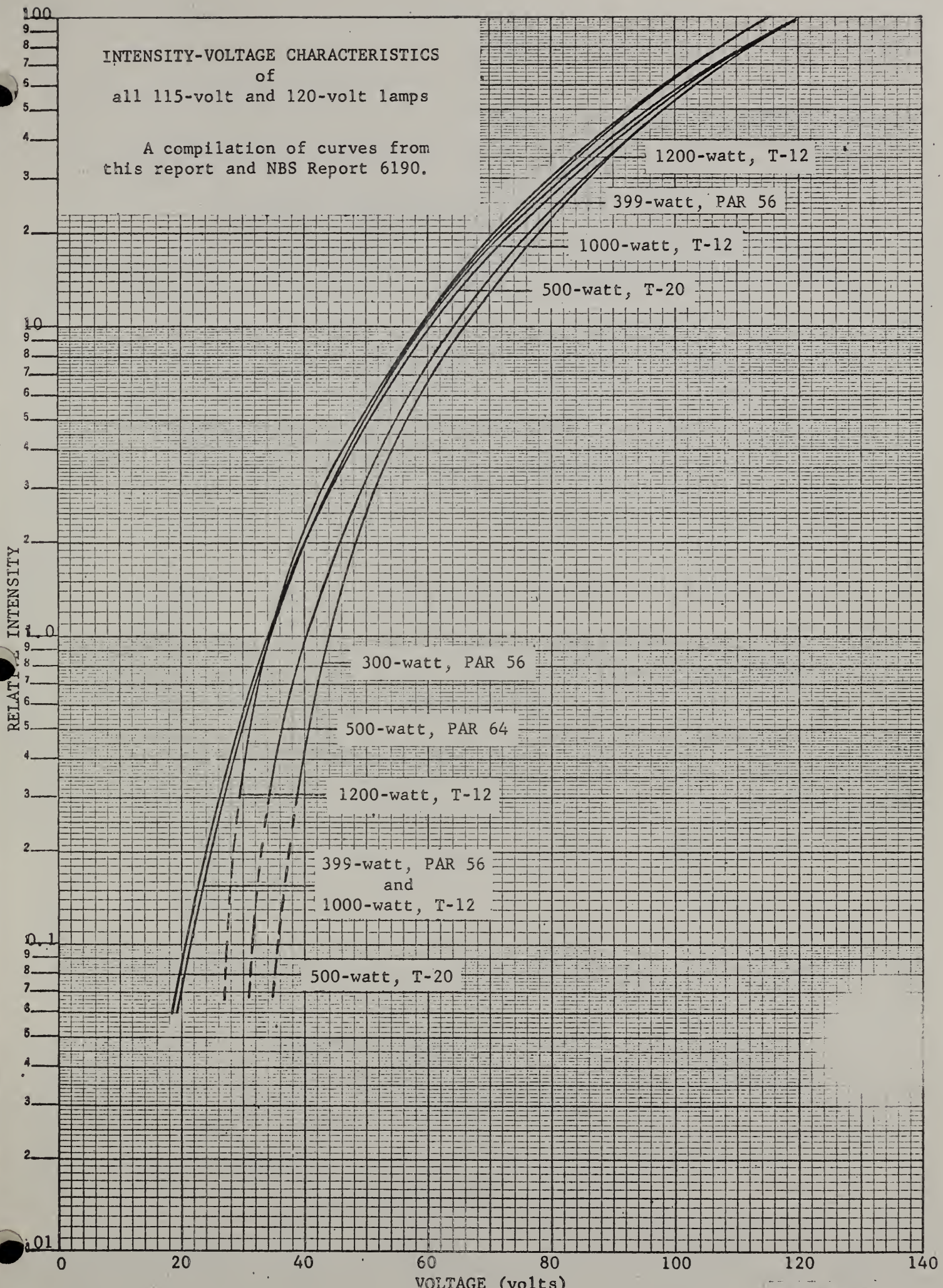
INTENSITY-VOLTAGE CHARACTERISTICS
of
all 115-volt and 120-volt lamps
A compilation of curves from this report and NBS Report 6190.
1200-watt, T-12
399-watt, PAR 56
1000-watt, T-12
500-watt, T-20
300-watt, PAR 56
500-watt, PAR 64
1200-watt, T-12
399-watt, PAR 56
and
1000-watt, T-12
500-watt, T-20
RELATIVE INTENSITY
100
10
1.0
0.1
.01
0
20
40
60
80
100
120
140
VOLTAGE (volts)

Figure 39

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D. C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

Polymers. Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Microscopy and Diffraction. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials. Metallic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Far Ultraviolet Physics. Solid State Physics. Electron Physics. Atomic Physics. Plasma Spectroscopy.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Elementary Processes. Mass Spectrometry. Photochemistry and Radiation Chemistry.

Office of Weights and Measures.

BOULDER, COLO.

Cryogenic Engineering Laboratory. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Cryogenic Technical Services.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Radio Propagation Engineering. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Frequency Utilization. Modulation Research. Antenna Research. Radiodetermination.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. High Latitude Ionosphere Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Physics. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Radio Plasma. Millimeter-Wave Research.

Circuit Standards. High Frequency Electrical Standards. High Frequency Calibration Services. High Frequency Impedance Standards. Microwave Calibration Services. Microwave Circuit Standards. Low Frequency Calibration Services.


NBS