Rectifier Tube Report File

REC'D JUL 16 1945 J. J. FITZPATRICK RECT. TUBE DIV.

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GENERAL ELECTRIC COMPANY

SCHENECTADY, N. Y., U. S. A.

DATA FOLDER No. 45746

Title ANODE TEMPERATURE RISE, JAN 4B26 RECTIFIER TUBE

By

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Date JUNE 30, 1945

No remarks on rough surface causing highly localized high temperature hot spots on anode surface
J.F. 7/16/45

ANODE TEMPERATURE RISE, JAN4B26 RECTIFIER TUBE

Purpose:

The object of this investigation was to determine the time required for the anode to reach a stable operating temperature, in order to establish the minimum time for a thorough peak inverse voltage test.

Apparatus Tested:

Three Catalog #189049 Tungar Bulbs (JAN4B26) containing thermocouples and exhausted in the laboratory according to the standard bench exhaust schedule were used for these tests.

Summary:

The curve of temperature rise is substantially flat at the end of five minutes, at which time the top side of the anode has reached 98% to 100% of the final value.

It was recommended to the personnel of the JETEC Subcommittee on Tungar-Rectigon types that the minimum time limit for JAN-1A operation test F-6N be changed from the thirty seconds of the present issue or the two minutes proposed by Continental Electric Company to five minutes. (Reference: The author's letter of June 16 to Mr. Lewin.)

Procedure:

Temperature readings were taken by means of a thermocouple resting against the top side of the graphite anode and with leads brought out to a thermocouple potentiometer.

Rated filament voltage was applied to the tube under test, followed in one to three seconds by the application of rated maximum peak inverse voltage with a resistance load adjusted to rated load current.

The data for curve #1 of C-4108339 was taken with .030" diameter iron-constantan Foxboro thermocouple wires sealed in a pinch at the edge of the anode flare. The seal was protected with clear glyptal, but leaked enough on exhaust (due to the mismatch of the thermal coefficients of expansion) to prevent the obtaining of good performance characteristics. Intermediate leads of tungsten were tried but caused spurious temperature readings due to the rising temperature of the effective cold junction; i.e., the welds between the T.C. wires and the tungsten. An attempt was made to swage the wires flat to reduce strains in the seal but the wires were burned in two at the thinned section during the sealing operation. The use of graded seals in conjunction with a platinum-iridium thermocouple was not thought practical because of the high baking temperature required on exhaust--500 C. Tubes having characteristics within the published limits were obtained by the use of .010" diameter iron-constantin Revere thermocouple wire. A "pantleg" approximately two inches long of Nonex glass was slipped over the wires, heated, and pinched in the middle. The pantleg protected the wires from the direct action of the flames as the assembly was sealed into a tubulation at the edge of the anode flare. Here again the seal was imperfect, as the glass did not form a bond to the constantin wire, but the leakage was slow enough to permit a normal exhaust treatment. Clear glyptal was used on the exterior of the seal. The tubes of curves 2 and 3 (C-4108339) were prepared in this way. Curve 4 was taken on the tube of curve 2 after re-aging. A special curve on Revere thermocouple wire plotted by R. D. Green (11/7/44) was used up to 380 C. Above that point Bureau of Standards data was used to extrapolate from the Revere Curve. The d-c characteristics given are "hot" readings, arc drop at 6 amperes.

Results:

1. Accuracy of Data

The actual values of temperature listed are open to question because of the relatively poor thermal contact between the anode and the thermocouple. The tube of curves 2 and 4 was overloaded (I_o = 12.4 Adc) until the anode reached a temperature of 844C as measured by a Leeds and Northrup optical pyrometer. No correction was made for absorption by the glass envelope of the Tungar bulb. The thermocouple indicated a temperature of 733C, 13% lower than the optical pyrometer. The existence of physical contact between the thermocouple and the anode was verified by a check for electrical continuity from the thermocouple leads to the anode lead. The thermocouple was then broken out of the tube and checked at one point against a standard in the laboratory, corroborating the millivolt-temperature scale used.

It has been suggested that a truer indication of anode temperature might be obtained by packing the thermocouple into a small hole drilled in the anode. The determination of anode temperature was, however, secondary to the purpose of this report. This was, as stated above, to determine the time taken by the top of the anode to reach a constant temperature. The top surface of the anode was chosen as the coolest region likely to reach a high enough temperature to form a cathode spot and initiate a reverse arc. The location of the thermocouple hot junction is sketched on curve C-4108339.

2. Discussion of Data

The curve (C-4108339) illustrates a tendency for tubes operating at lower losses not only to stabilize at a lower temperature but to stabilize more slowly. The recommended minimum time of five minutes is judged to be long enough to allow for this trend in both the 4B26 and 4B28 (Cat. 189048).

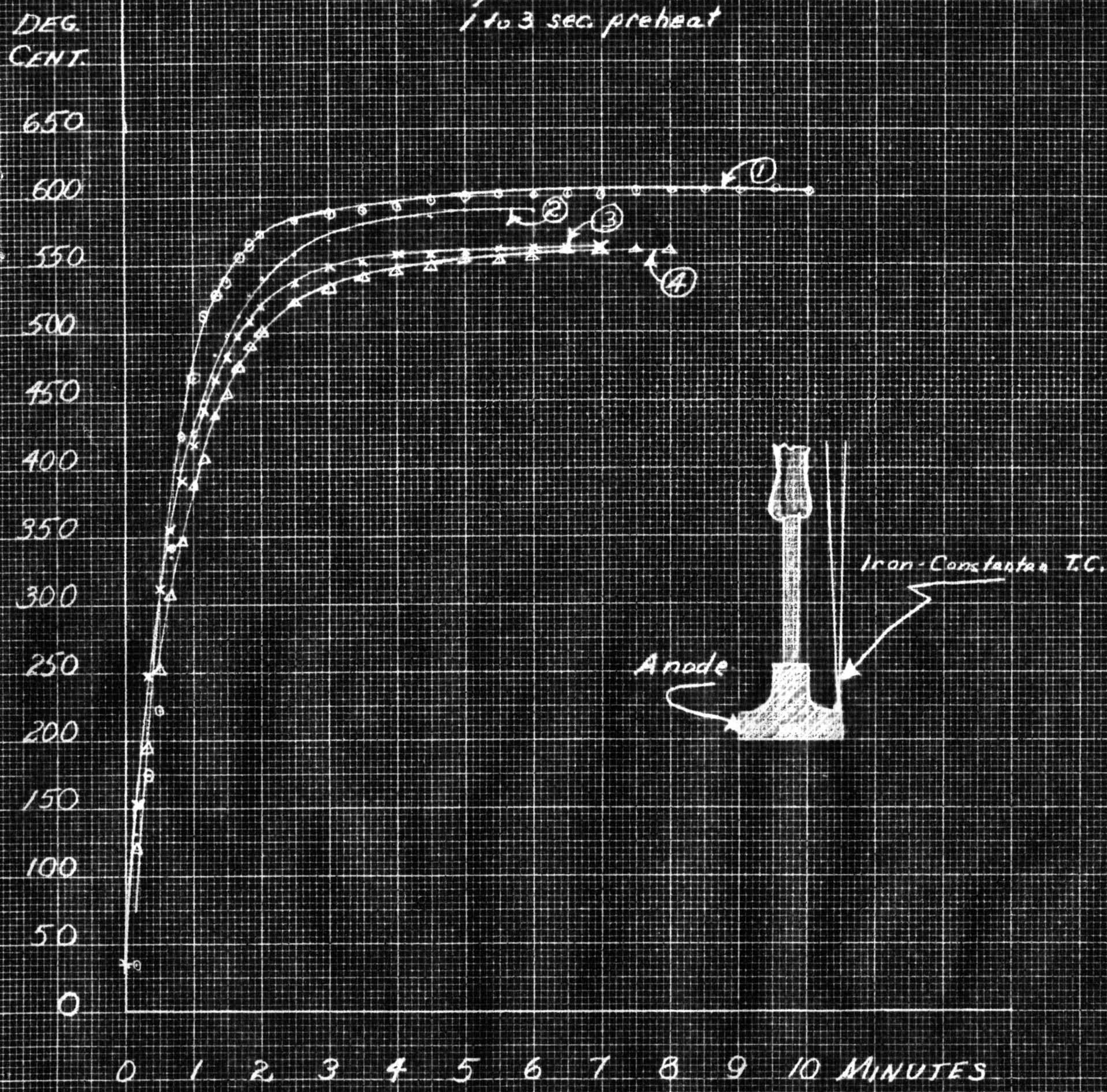
The question may well be asked--"What is the dependence of maximum peak inverse voltage upon anode temperature?" If the anode be perfectly pure and free of foreign material such as magnesium from the getter, there probably is no connection between maximum voltage and anode temperature within the operating range. Certain marginal tubes, however, have been observed to arc back after a minute or more on voltage. It is theorized that such an arc back is precipitated by thermionic emission from some impurity on the surface of the anode. To be safe, then, a tube should be operated until the anode has reached its maximum temperature, a process requiring five minutes in the case of the 4B26.

A curve of anode cooling time (C-4108341) taken in the same manner as the heating curves discussed above illustrates that twenty to thirty minutes is required to cool the anode to room temperature with free access to circulating air but no forced cooling. In fifteen minutes, the "off" time on intermittent life tests, 98% of the temperature drop has taken place.

Curve C-4108340 was taken with a thermocouple taped to the upper edge of the base and is included for reference.

ANODE TEMPERATURE RISE, TYPE 4B26

Resistance load; epy = 375 v I_b = 6.0 Adc E_{pp} = 265 Vac
E_f = 2.25 Vac
1 to 3 sec. preheat



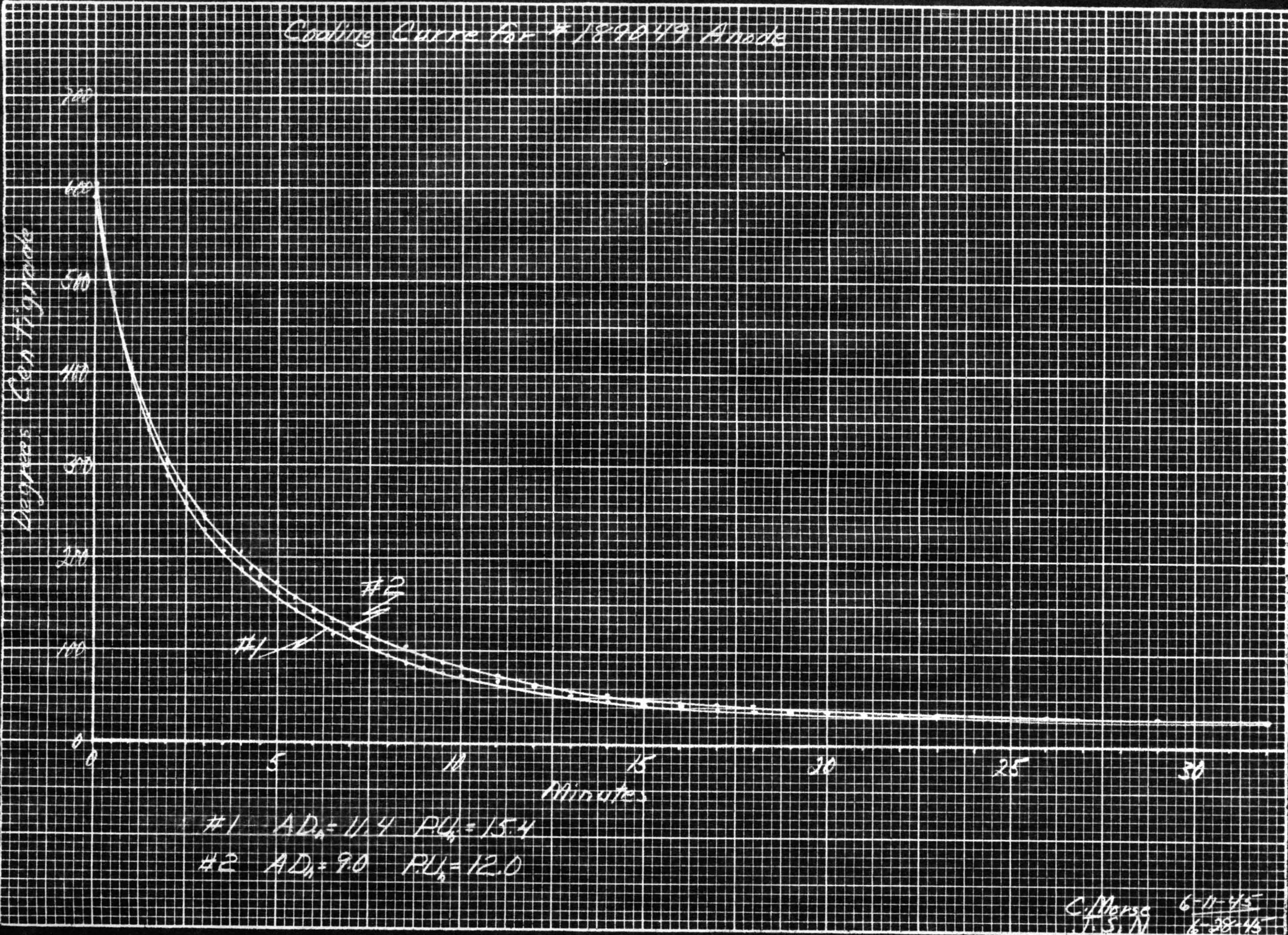
CURVE	DC CHARACTERISTICS Pick-up	Arc drop
1	15.4	11.4
2	12.0	9.0
3	15.0	8.0
4	13.1	8.4

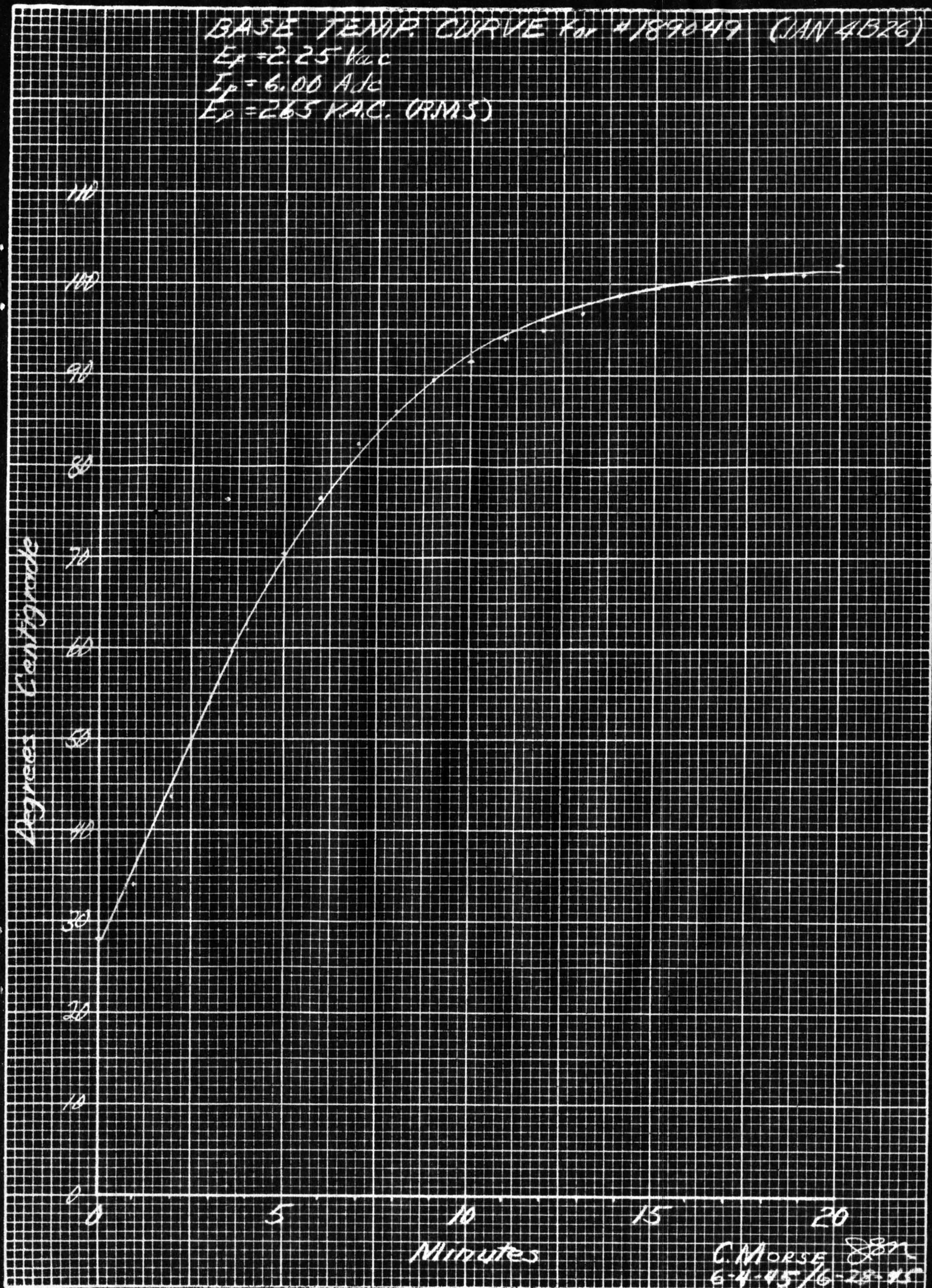
J. E. Nelson
6-15-45

C-4108339

C-4108339

C-4108341


Cooling Curve for #189049 Anode
Degrees Centigrade
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
Minutes
#1
#2
#1 AD_h = 11.4 PU_h = 15.4
#2 AD_h = 9.0 PU_h = 12.0
C. Morse 6-11-45
J.S.N. 6-28-45


BASE TEMP. CURVE for #189049 (JAN 4B26)
E_f = 2.25 V.a.c
I_p = 6.00 A.d.c
E_p = 265 V.A.C. (RMS)
Degrees Centigrade
0
10
20
30
40
50
60
70
80
90
100
110
0
5
10
15
20
Minutes
C. Morse
6-4-45/6-28-45

C-4108340