September 11, 1956

Title: Some temperature and emission characteristics of the 9QP4 compared to the 21ATP4A.

I. Object of report

To present some emission and cathode temperature data of the 9QP4 for comparison with our standard product.

II. Discussion

It has been noted that some 9QP4 tubes show an extreme emission sensitivity to underheating at zero bias operation, and it becomes immediately desirable to determine whether this characteristic may be a cause for undesirable performance characteristics of the tube under chassis operating voltages, and, if so, whether this characteristic may be due to the design of the gun structure, the materials or component parts of the gun, or to less than optimum processing schedules. Emission and cathode temperature data have been taken on the 9QP4 and the 21ATP4A. Also, some operating characteristics of the 6AF4 receiving tube--which uses a cathode identical with the one used in the 9QP4--have been determined.

III. Data

Since the graphs are completely self-explanatory it seems unnecessary to present the data in any additional form. The 12% spread of heater current (6% on either side of rated value) represents the change in current which occurs with a + 10% to -10% swing in heater voltage from rated value. This is the tolerance within which the tube should operate satisfactorily.

Tubes K, M, O and Q, taken at random from the factory, were first discovered to be emission sensitive with heater current by William Liggett. In order to verify these rather disturbing findings and to obtain additional independent data, these same tubes were read again and plotted by myself and William Kires. Both sets of data indicated the same characteristic--when the cathode temperature (determined by heater current) was decreased, there was a large change in zero bias emission. The emission values at each point were higher in my readings because the grid 1 and cathode were tied together to give true zero bias, while in the readings taken for Liggett the grid 1 supply was turned to zero but still connected which allowed a very small bias to build up.

Next, a larger random sample was taken from the factory on a different day to see if this characteristic is really typical. It is.

It was next decided to check our standard product, as represented by the 21ATP4A. The operating current is comfortably beyond the knee of the curve.

Since the operating characteristics of the tube in a chassis in the field is a prime design criterion, tubes K, M, O and Q were biased such that the cathode current was 80 microamperes (a practical average d.c. level) at a heater current of 300 milliamperes. With this bias maintained throughout each run, the heater current was varied and emission change recorded.

Since we are using the same cathode which is used in the 6AF4 tube, some data for curves was taken from three of these tubes to check their emission sensitivity to heater current changes.

Since emission characteristics so basically depend on temperature, values of temperature versus heater current were taken for the 9QP4 and the 21ATP4A. A thermocouple spot welded to the cathode was used.

IV. Conclusions

The 9QP4 is emission sensitive, at the zero bias condition, to underheating while the 21ATP4A is not. In Fig. 1 there is an indication that this sensitivity may be related to emission build-up, which, in turn, is related to processing, but the data is not sufficient to state this conclusively. When biased to its operating condition (see Fig. 5) in a chassis the sensitivity diminishes until it becomes almost indiscernible as far as raster brightness is concerned. Of course, a tube must operate properly (space-charge-limited) while a signal is being applied, and this signal can pulse the instantaneous potential between grid 1-cathode to zero. However, I believe there should be further studies conducted comparing pulse emission with zero bias steady state emission in regards to this sensitivity to underheating. Possibly this sensitivity will be negligible under pulse conditions which, after all, are the conditions of a tube receiving a T.V. signal.

The 6AF4 receiving tube displays the same type of sensitivity to underheating as the 9QP4. Since the emissive state of the cathode (temperature-limited or space-charge-limited) depends on the plate voltage applied, this data was taken with rated plate voltage, then with one half of rated voltage, and even one curve with one fourth of rated voltage. The same characteristic persisted throughout.

The comparison of cathode temperatures and temperature changes with varying heater currents between the 9QP4 and the 21ATP4A indicate no problem in the design of the gun structure. Although the average temperature of the 9QP4 is 807°C and the average for the 21ATP4A is 866°C, both are within the range of good oxide-coated cathode operation. The average temperature change of the 9QP4 for a 6% current change is 66°C compared to a change of 54°C for the 21ATP4A. The difference is negligible. The emission was read for one 21ATP4A at a temperature of 825°C and the temperature was increased and decreased by 12°C; the change in emission was 10 microamps.

It has been noted that the 9QP4 cathode is furnished to us with a double carbonate emission coating, while our standard product uses a triple carbonate coating. It is a well established fact that the triple carbonate produces a lower work function than the double and, consequently, gives better emission at lower temperatures. In Anniston, where the 9QP4 cathode is sprayed, the experience has been that the combination of cathode base alloy 220 and triple carbonate coating is conducive to flaking of the coating, so the double carbonate was chosen for the 6AF4. However, at the Syracuse Tube Plant the triple carbonate has been used successfully with alloy 220 for years; therefore, 200 cathodes sprayed with RCA triple carbonate have been ordered and will be built into tubes promptly and tested.

A substantial amount of experimentation has been accomplished by R. Charles in the variation of activation schedules to determine whether the optimum schedule is being used with this double carbonate.

H. L. McLeland
Mono. Picture Tube Prod. Engg.
CATHODE RAY TUBE DEPARTMENT

HLM:jfe
attach.

Distribution

RH Berg
VC Campbell
R Charles
WJ Harber
WL Jones, Jr.
LC Kunz
JM Lang
WE Liggett
LC Maier
RA Norman
RE Ostrowski
AN Reagan
PE Sullivan
LE Swedlund
PN Taggett

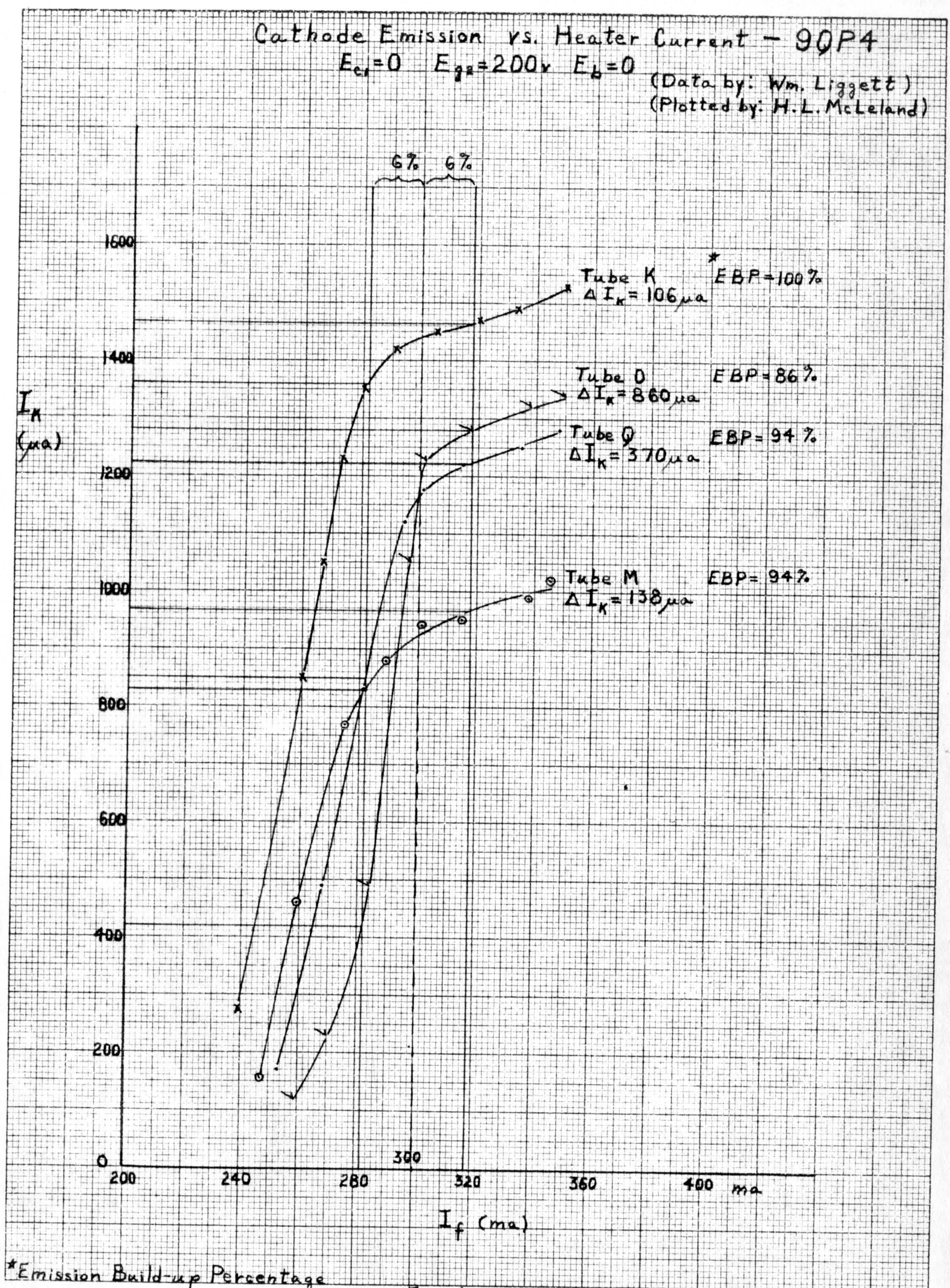
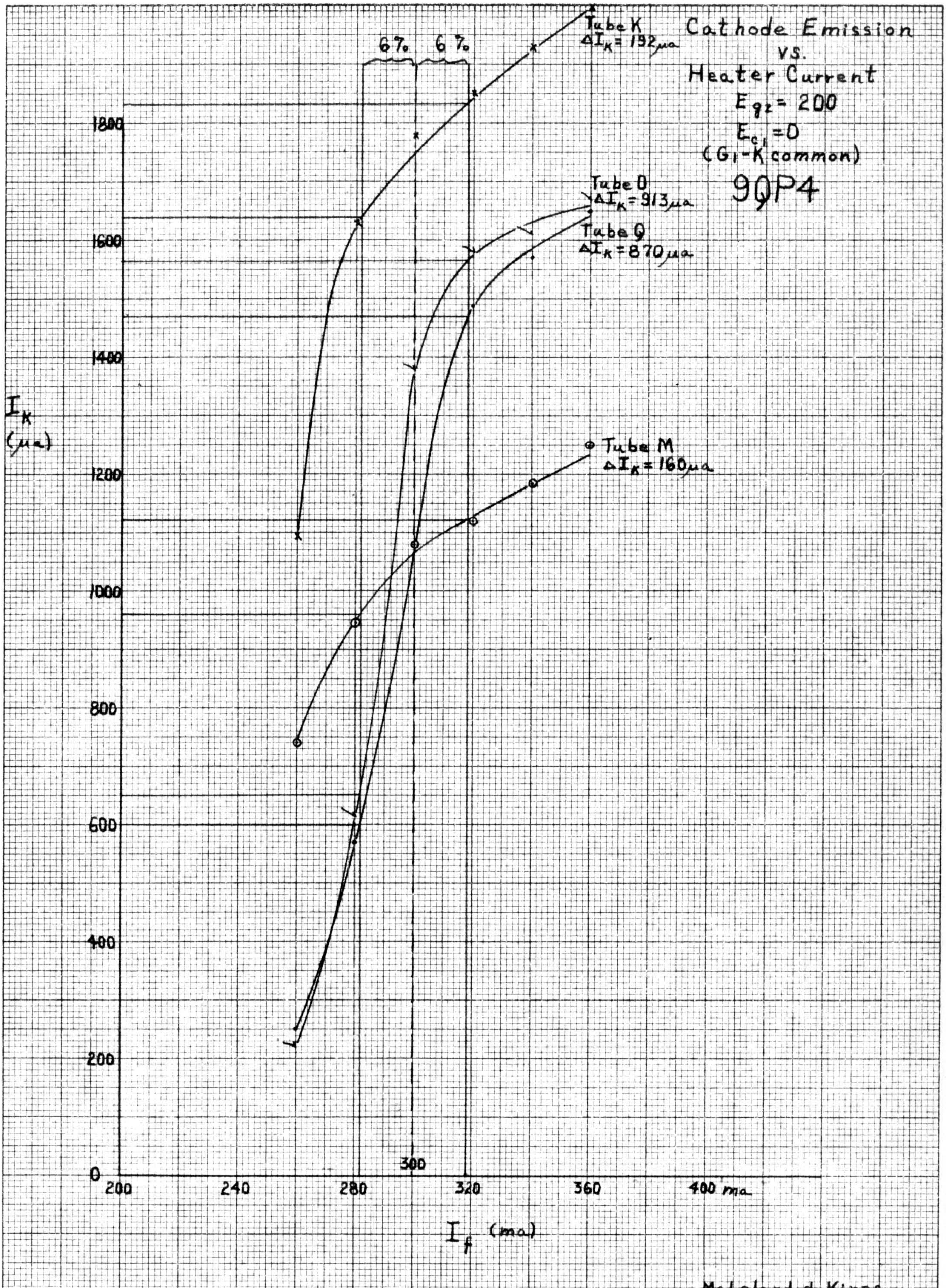

Cathode Emission vs. Heater Current - 90P4
E c1 = 0   E g2 = 200v   E b = 0
(Data by: Wm. Liggett)
(Plotted by: H.L. McLeland)
6%   6%
Tube K
Δ I K = 106 μa
*EBP = 100%
Tube O
Δ I K = 860 μa
EBP = 86%
Tube Q
Δ I K = 370 μa
EBP = 94 %
Tube M
Δ I K = 138 μa
EBP = 94%
I K (μa)
1600
1400
1200
1000
800
600
400
200
0
200
240
280
300
320
360
400 ma
I f (ma)
*Emission Build-up Percentage

Fig. 1



Cathode Emission
vs.
Heater Current
E_{g2} = 200
E_{c1} = 0
(G_1-K common)
9QP4
Tube K
ΔI_K = 192 μa
Tube O
ΔI_K = 913 μa
Tube Q
ΔI_K = 870 μa
Tube M
ΔI_K = 160 μa
6%
6%
I_K (μa)
I_f (ma)
1800
1600
1400
1200
1000
800
600
400
200
0
200
240
280
300
320
360
400 ma
McLeland + Kires

Fig. 2

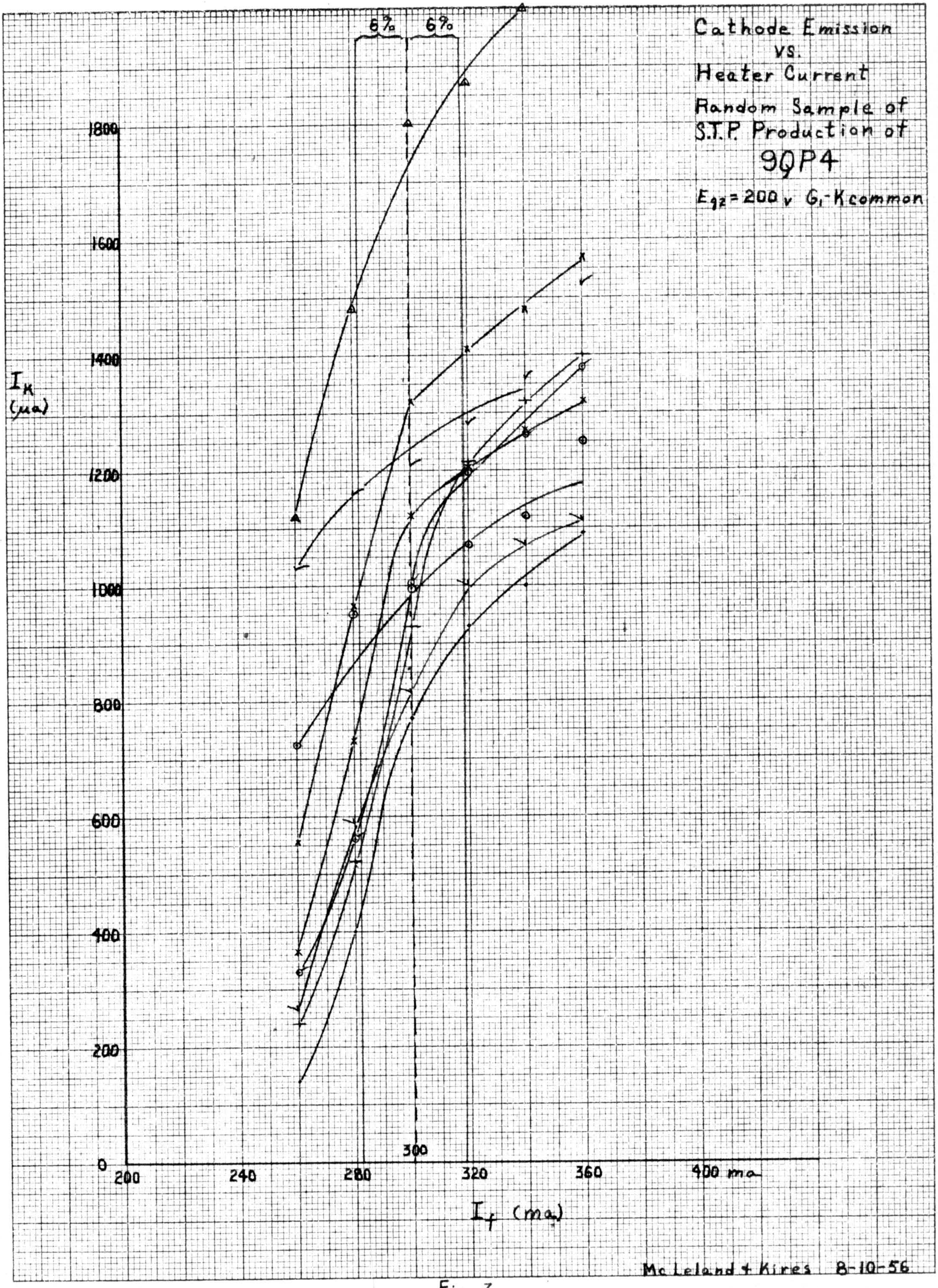
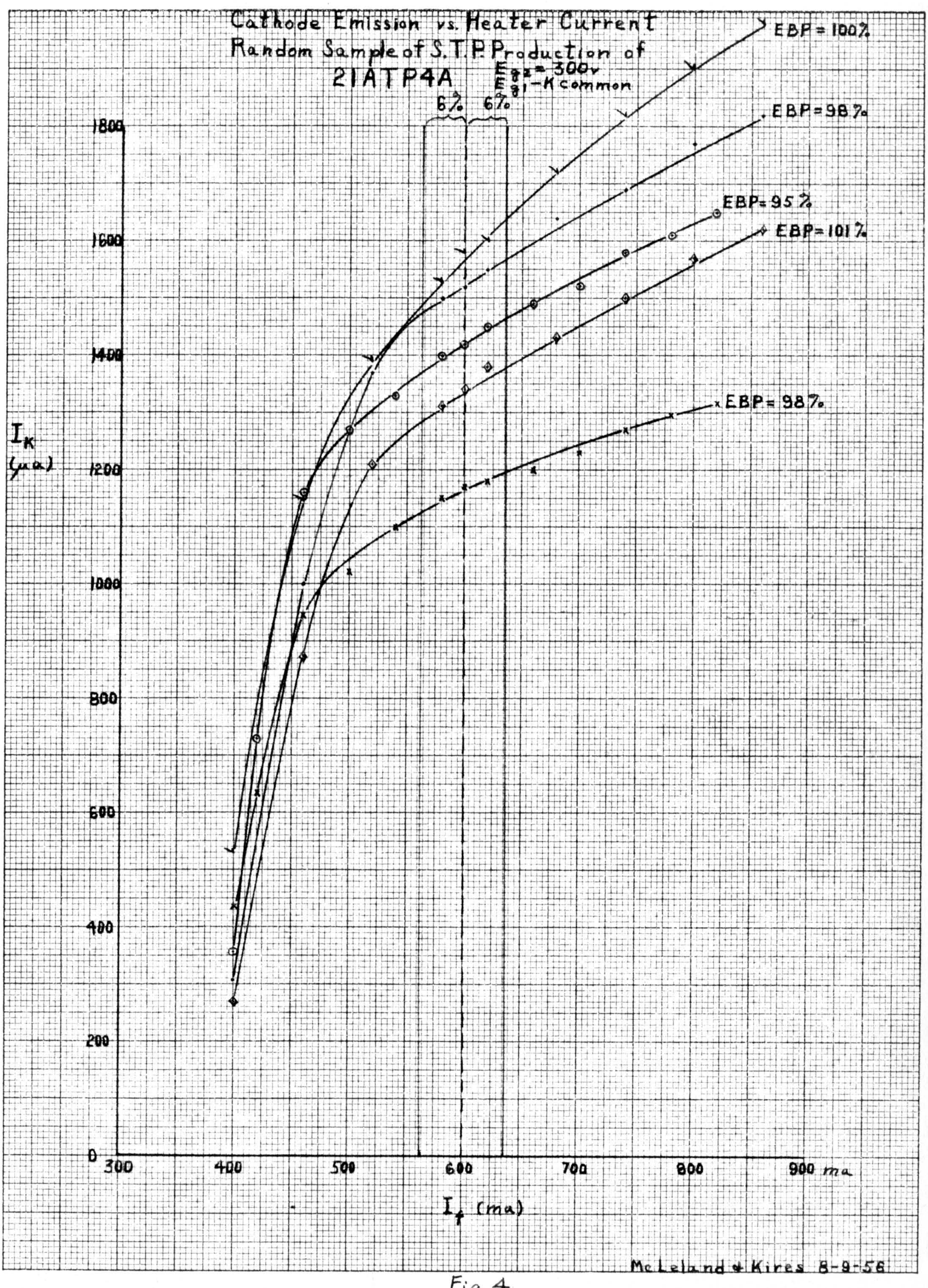

Cathode Emission
vs.
Heater Current
Random Sample of
S.T.P. Production of
9QP4
Eg2 = 200 v G1-K common
6%
6%
IK
(ma)
1800
1600
1400
1200
1000
800
600
400
200
0
200
240
280
300
320
360
400 ma
If (ma)
McLeland + Kires 8-10-56

Fig. 3



Cathode Emission vs. Heater Current
Random Sample of S.T.P. Production of
21ATP4A
$E_{g2} = 300v$
E_{g1}-K common
6%
6%
EBP = 100%
EBP = 98%
EBP = 95%
EBP = 101%
EBP = 98%
I_K (μa)
1800
1600
1400
1200
1000
800
600
400
200
0
300
400
500
600
700
800
900 ma
I_f (ma)
McLeland & Kires 8-9-56

Fig. 4

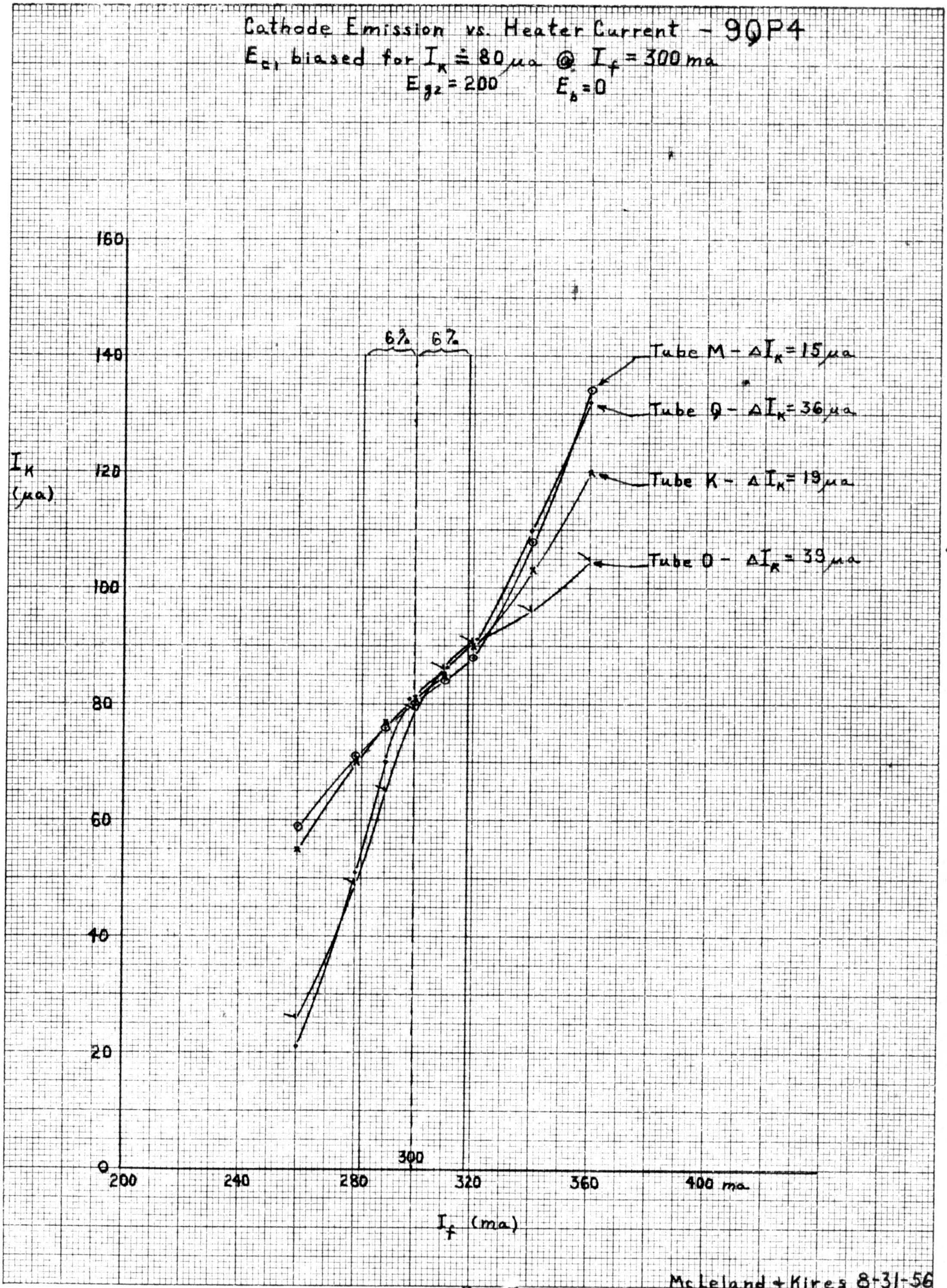

Cathode Emission vs. Heater Current - 90P4
E_{c1} biased for $I_K \doteq 80$ μa @ $I_f = 300$ ma
$E_{g2} = 200$ $E_b = 0$
6% 6%
Tube M - $\Delta I_K = 15$ μa
Tube Q - $\Delta I_K = 36$ μa
Tube K - $\Delta I_K = 19$ μa
Tube O - $\Delta I_K = 39$ μa
I_K (μa)
160
140
120
100
80
60
40
20
0
200
240
280
300
320
360
400 ma
I_f (ma)
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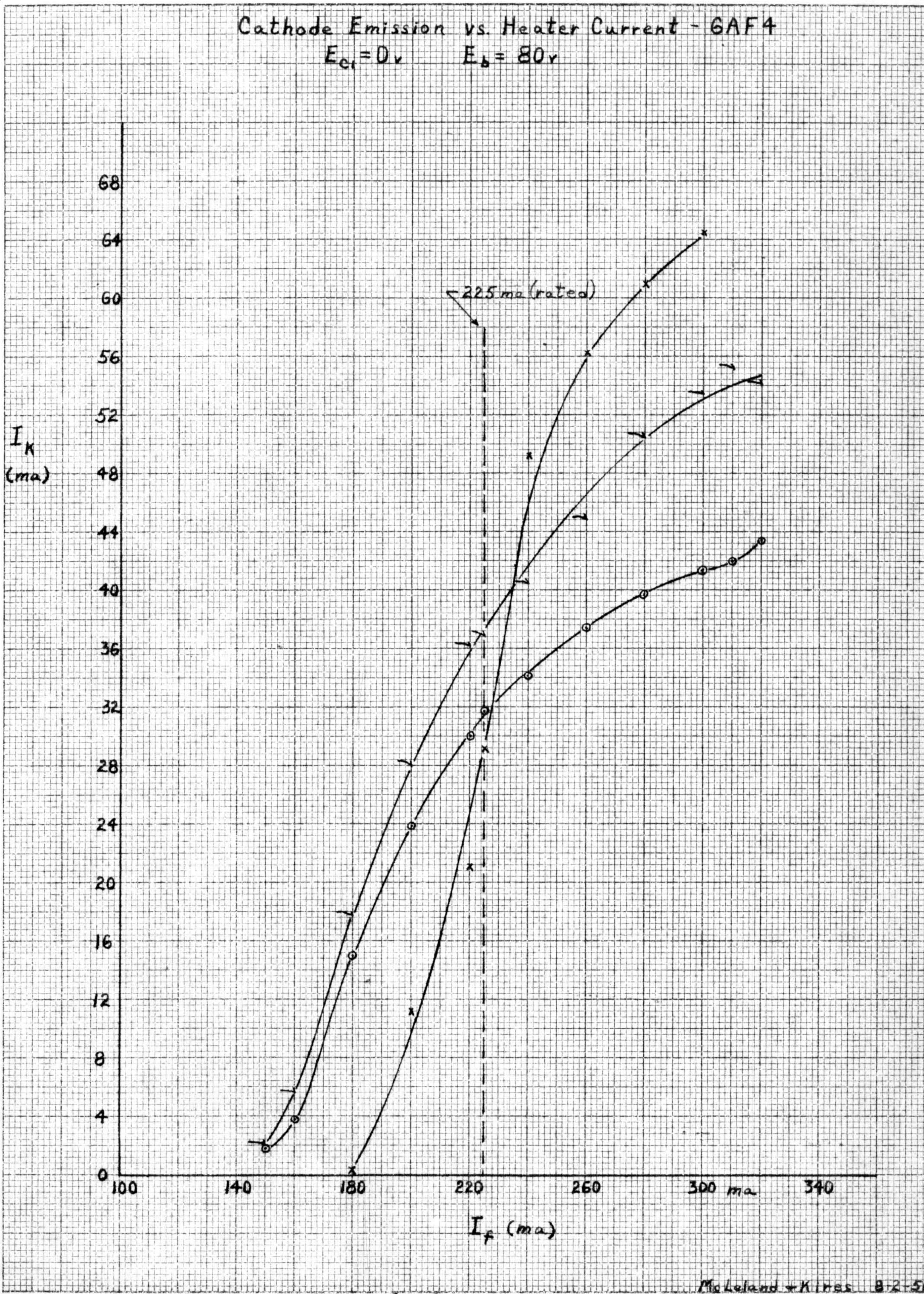
Fig. 5



Cathode Emission vs. Heater Current - 6AF4
E_{c_1} = 0v E_b = 80v
225 ma (rated)
I_K (ma)
68
64
60
56
52
48
44
40
36
32
28
24
20
16
12
8
4
0
100
140
180
220
260
300 ma
340
I_f (ma)
McLeland + Kires 8-2-56

Fig. 6

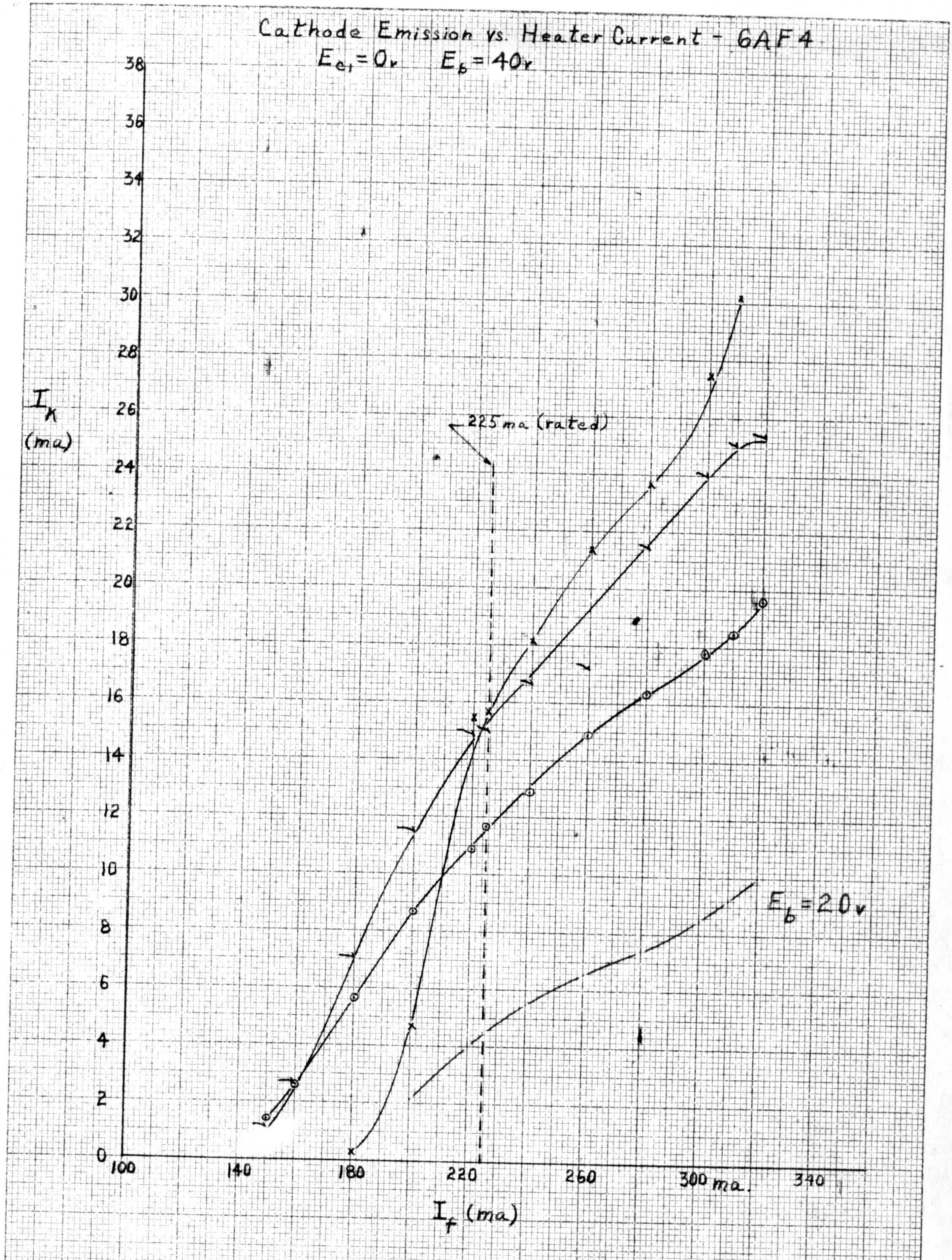

Cathode Emission vs. Heater Current - 6AF4
$E_{c_1} = 0_v$ $E_b = 40_v$
I_k (ma)
I_f (ma)
225 ma (rated)
$E_b = 20_v$
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
100
140
180
220
260
300 ma.
340
McLeland + Kires 8-2-56

Fig. 7

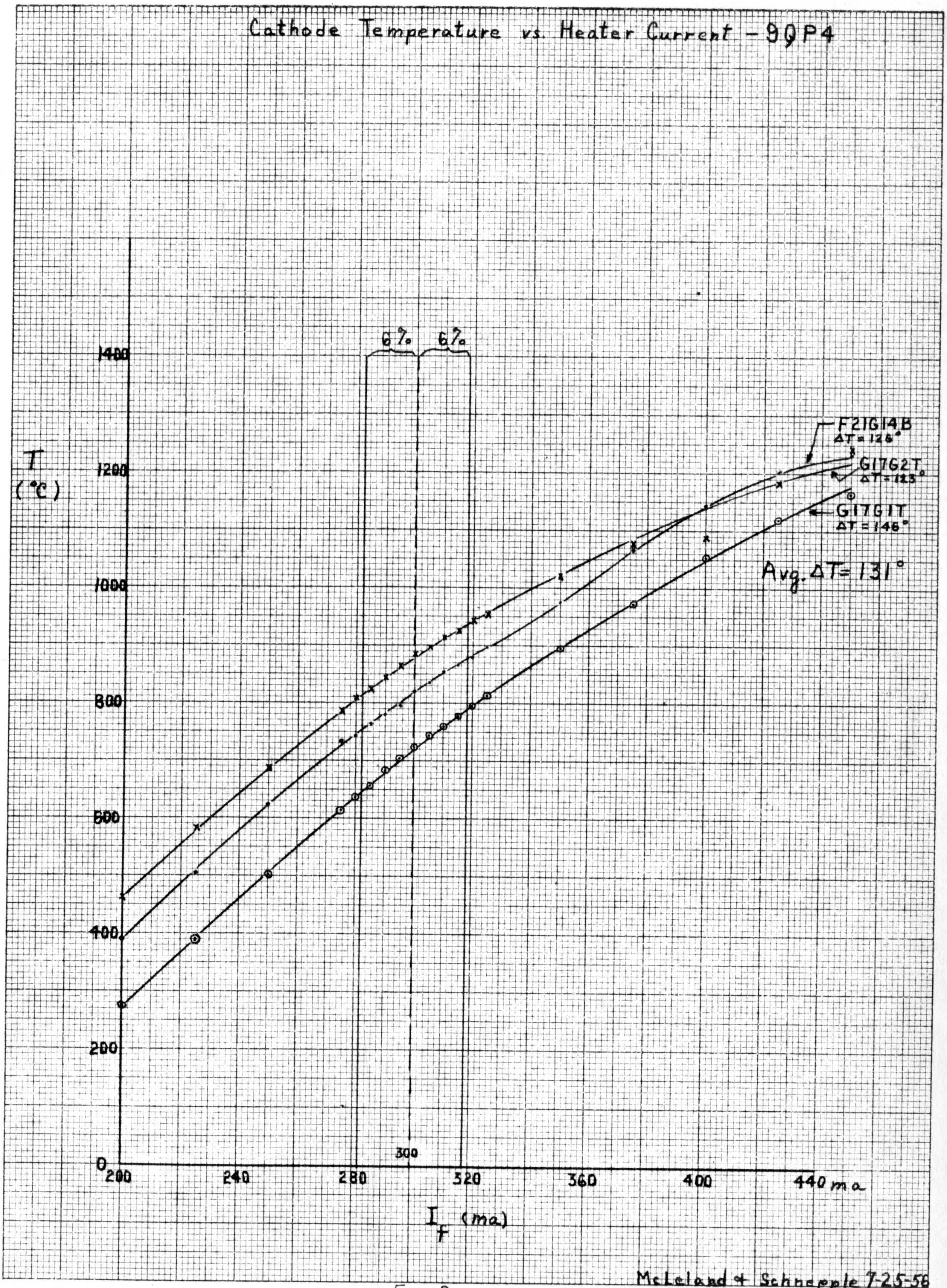

Cathode Temperature vs. Heater Current - 9QP4
T (°C)
0
200
400
600
800
1000
1200
1400
200
240
280
300
320
360
400
440 ma
I_f (ma)
6%
6%
F21G14B ΔT = 126°
G17G2T ΔT = 123°
G17G1T ΔT = 146°
Avg. ΔT = 131°
McLeland + Schnepple 7-25-56

Fig 8

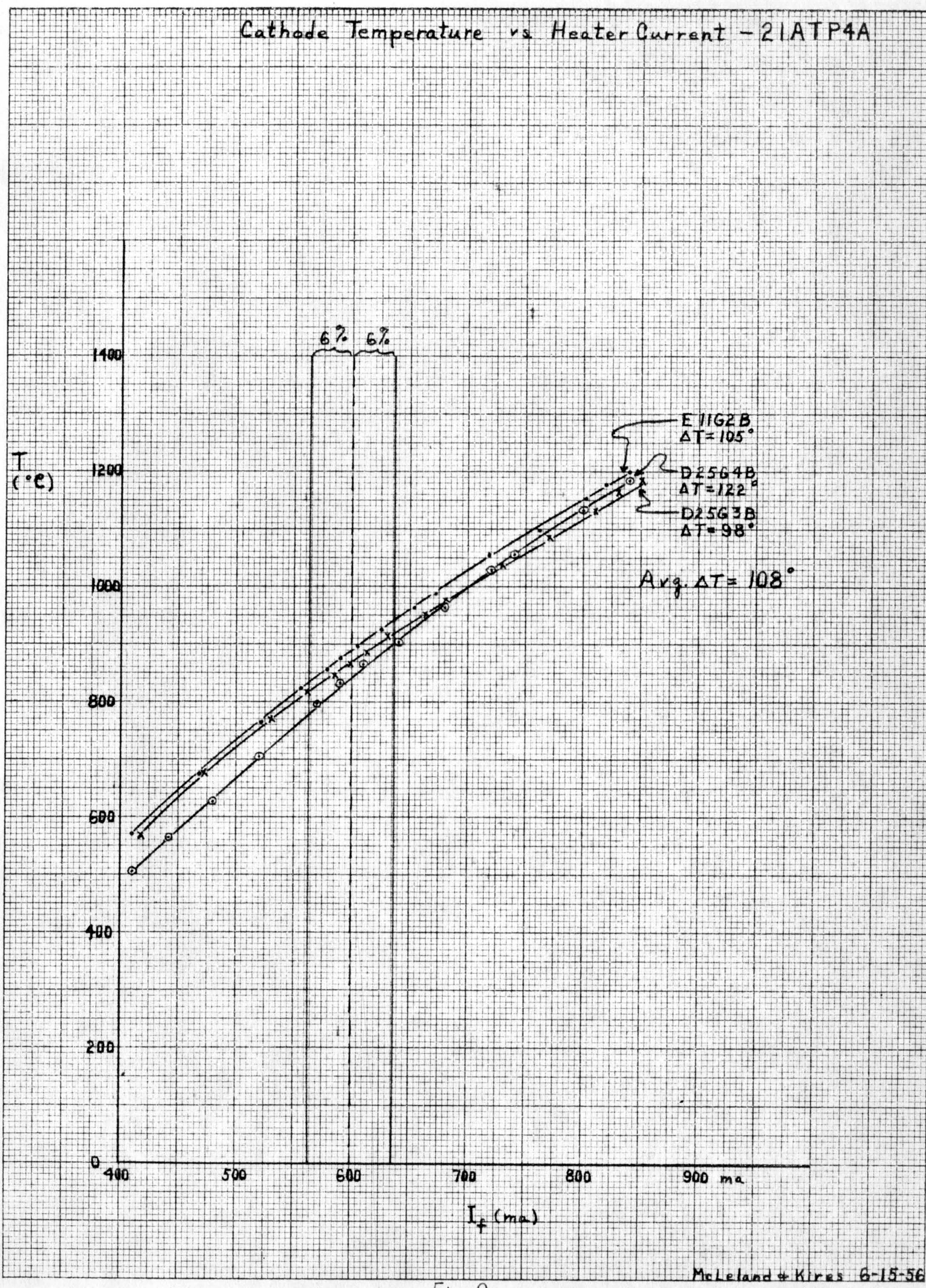

Cathode Temperature vs Heater Current - 21ATP4A
T (°C)
1400
1200
1000
800
600
400
200
0
400
500
600
700
800
900 ma
If (ma)
6%
6%
E11G2B ΔT=105°
D25G4B ΔT=122°
D25G3B ΔT=98°
Avg. ΔT= 108°
McLeland & Kires 6-15-56

Fig. 9