RAYTHEON
MANUFACTURING COMPANY

RADIO RECEIVING TUBE DIVISION
CHAPEL STREET · NEWTON · 58 · MASS.

Tube Design Circular No. 5

PENTODE NO. 3 GRID MUTUAL CONDUCTANCE CHARACTERISTICS

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This brief report represents a survey of the available information on Gm 3-P transconductance from suppressor-grid to plate. Some of the data presented here came from the files of the Tube Design Department and more was gathered experimentally. The procedure was to place fixed voltage (usually 250,100,-3 or 100,100,-3) on plate, screen and control-grids respectively on the Miller Bridge, and then to read Gm 3-P as a function of Eg_3. At the same time a record was kept of plate current, screen current and plate resistance.

Throughout the report, it must be kept in mind that particular numerical values mentioned apply only to tubes with the same plate diameter and number two grid.

Types 78,6S7G,7B7 and 6SD7GT furnished excellent data, since test lots had been made in which only the #3 grid was varied. These are all variable-mu r.f. pentodes. In addition: types 57, 58, 77, 6D6, 6K7G, and 6W7G were examined, and were found to agree with the behavior of the four main types.

Type 78

With type 78 tubes, raising the pitch of the suppressor-grid raises the peak value of Gm 3-P, and causes the peak to occur at smaller negative voltages on G3 (Figure 1). Larger bias voltages on the control grid result in lower peak values of Gm 3-P, as would be expected, but do not change the suppressor voltage at which these peaks occur (Figure 2). The use of 100, 100, -3 for the test voltages, instead of 250, 100, -3, results in a higher value of Gm 3-P peak occurring at a lower voltage than before. These effects are illustrated in the graphs and in Table 1 below. Substantially the same behavior is shown by type 77. (Figure 3).

Table 1

Type	G3 TPI	Peak Gm 3-P	Peak at Eg3	Test Conditions
78	23	380*	-30 v.	180, 100, -3
	21½	380	-32	" " "
	19	280	-40	" " "

*Probably somewhat low, due to use of only 1 tube.
Value should be average of ten tubes.

For range of lots, see fig. 4.

Above tests were with .680" i.d. plates where it was found that 21 tpi grids gave curves equivalent to those with 19 tpi grids of same size for other makes using .750" i.d. plates. (It was necessary to adjust the curve shape and location of the peak because of usage in composite oscillators with No. 3 grid injection.)

Type 7B7

Nine or ten test-lots of type 7B7 (skeleton plate) having a variety of suppressor-grids, were in the storeroom, and those were tested thoroughly. The experiments showed conclusively that, for this type of tube, an increase of G3 tpi raises Rp and Gm 3-P, and lowers the negative voltage at which Gm 3-P peaks. Table 4, and graphs 4-7 illustrate this:

Table 2

Type	Lot	G3	Test Conditions	Peak at Eg3	Peak Gm 3-P
7B7	37	19.5/5/.373" i.d.	250,100, -3	-37 v	500
	40	25/5/.373	"	-23	650
	43	30/5/.373	"	-16	850
	37	19.5/5.373	100,100, -3	-18	600
	40	25/5/.373	"	-12.5	800
	43	30/5/.373	"	-10	800

Note also that Gm 3-P reaches a higher peak at 100,100.-3 than at 250,100.-3.

Several checks were made to determine the reliability of the experimental data taken during July and August on the Miller Bridge. Four 7B7 tubes of lot 37 were re-read on the Bridge for Gm 3-P, one tube of lot 40, and one 6SD7GT. The lot 40 tube was very unreliable, due to serious microphonics, but the others gave good, consistent data. The results for two tubes, typical of the group, are shown graphically in figure 8. This makes it clear that for all practical purposes the readings on this work are reliable and reproducible.

In this connection, it is interesting to note that the highest tube in a group of five tested at 250,100, -3 was often lowest or next-to-lowest when that lot was re-tested at 100,100 -3, and vice versa. (Data for this are not included here.)

The effect of the diameter of G3 on Gm 3-P was not investigated. However, a quantitative measurement of this would be easy to make, for the storeroom contains test lots of 7A7's and 7B7's with suppressors of 19.5, 25 and 30 tpi in diameters of .300", .343", and .373".

Type 6SD7GT

Type 6SD7GT, a semi-remote cut off tube, was studied, even though different lots could not be as closely compared as with 7B7. Here again, the #3 grid voltage where the peak Gm 3-P occurs grows smaller as Ep and Eag are reduced. This peak is smallest at 250, 100, -2, and is higher at both 250,150, -2 and 100,100 -2.

Table 3

Type	Lot	G3	Peak at Eg3	Peak Gm 3-P	Test Conditions
6SD7GT	66	21/5/.350	-23	700	250,150, -2
	62	19/5/.380	-36	600	"
	66	21/5/.350	-21	650	250,100, -2
	62	19/5/.380	-34	550	"
	66	21/5/.350	-11	775	100,100, -2
	62	19/5/.380	-16	600	"

The above data show also that a small change in G_3 i.d. affects the peak of Gm 3-P a good deal less than does a similar small change in G_3 tpi.

Type 6S7G

Figures 9-12 show the effect on type 7S7G of raising the pitch of the #3 grid. Passing from 15 to 21 tpi, Gm 3-P is increased from approximately 250 micromhos to about 500. In this, the tube resembles a 78. However, unlike the 78 it shows a lower peak value at Gm 3-P when the test voltages are lowered (from 250, 100 to 100, 100). With type 78, a higher peak results at 100,100, due to the geometry of the tube. The curves of figure 9 were taken at RCA. Unfortunately, the plate-diameter was not recorded, but it was probably 0.720 inch, i.d.

Table 4

Type	Lot	G3	Peak at Eg3	Peak Gm 3-P	Test Conditions
6S7G	33	15/5/.375x.410	-45	275	250,100, -3
	42	19/5/.380x.410	-37	475	"
	34	21/5/.375x.410	-23	525	"
	32	23/5/.375	-27.5*	860	"
	33	15	-27	225	135,67.5, -3
	42	19	-	-	"
	34	21	-12	475	"
	32	23	-15*	725	"

* Unexpected value

Figure 13 shows Gm 3-P, Rp and Ip of a typical tube (QT-91 in this case) plotted against Eg3. Note that Ip varies steadily although not uniformly, and that Rp has its minimum when Gm 3-P is at the maximum.

Supporting data for curves in this report and additional graphs and other information may be found in a folder entitled "Gm 3-P Investigation" in the files of the Tube Design Department.

George Blackwell

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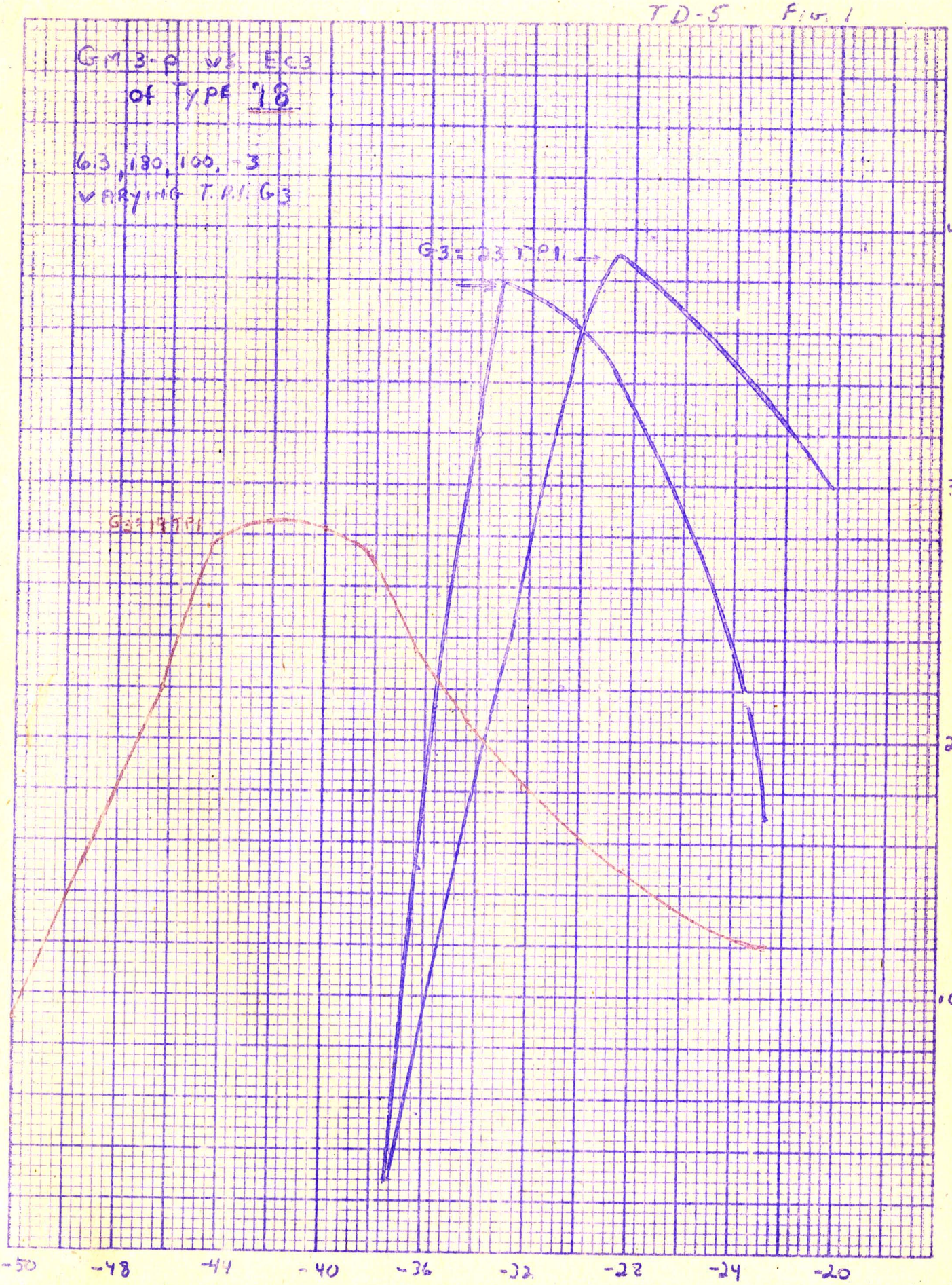
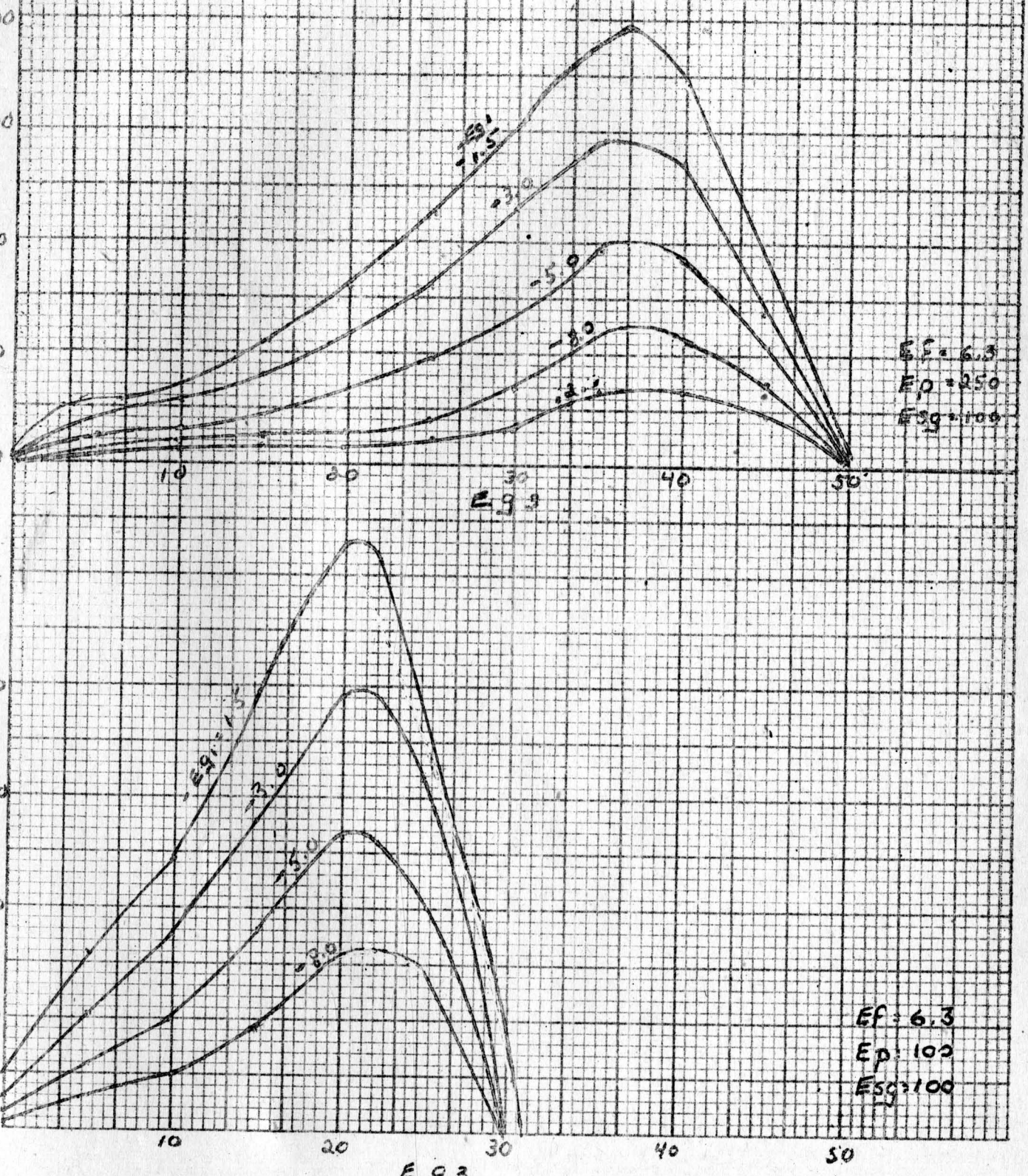
TD-5 Fig 1


Gm 3-p vs Ec3
of Type 78
6.3, 180, 100, -3
varying T.P.I. G3
G3 = 23 T.P.I.
G3 = 18 T.P.I.
400
300
200
100
-50
-48
-44
-40
-36
-32
-28
-24
-20

TD-5 FIG. 2

AVERAGE RAYTHEON

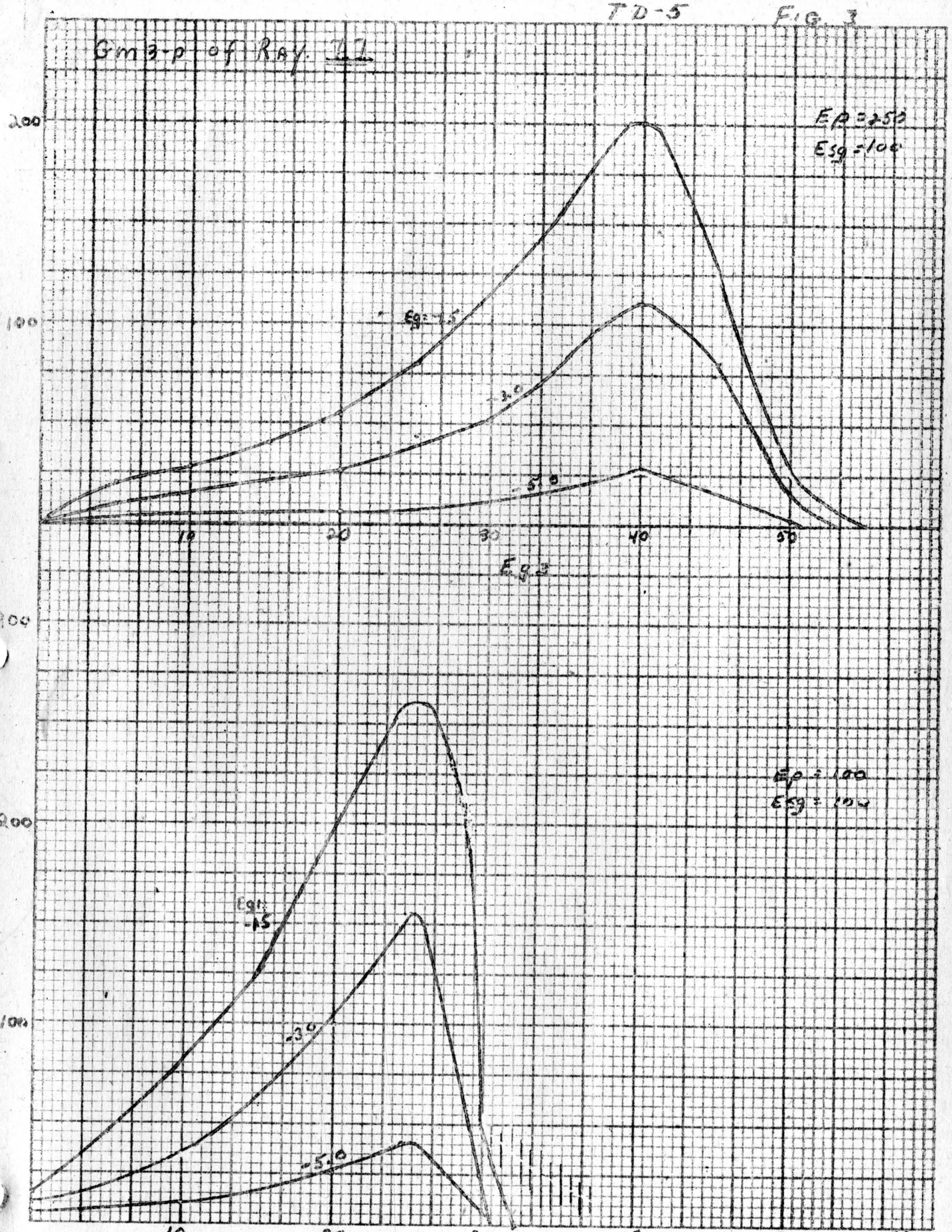
78



ORIGINAL CURVES
DRAWN 7-1-33

TD-5 Fig 3

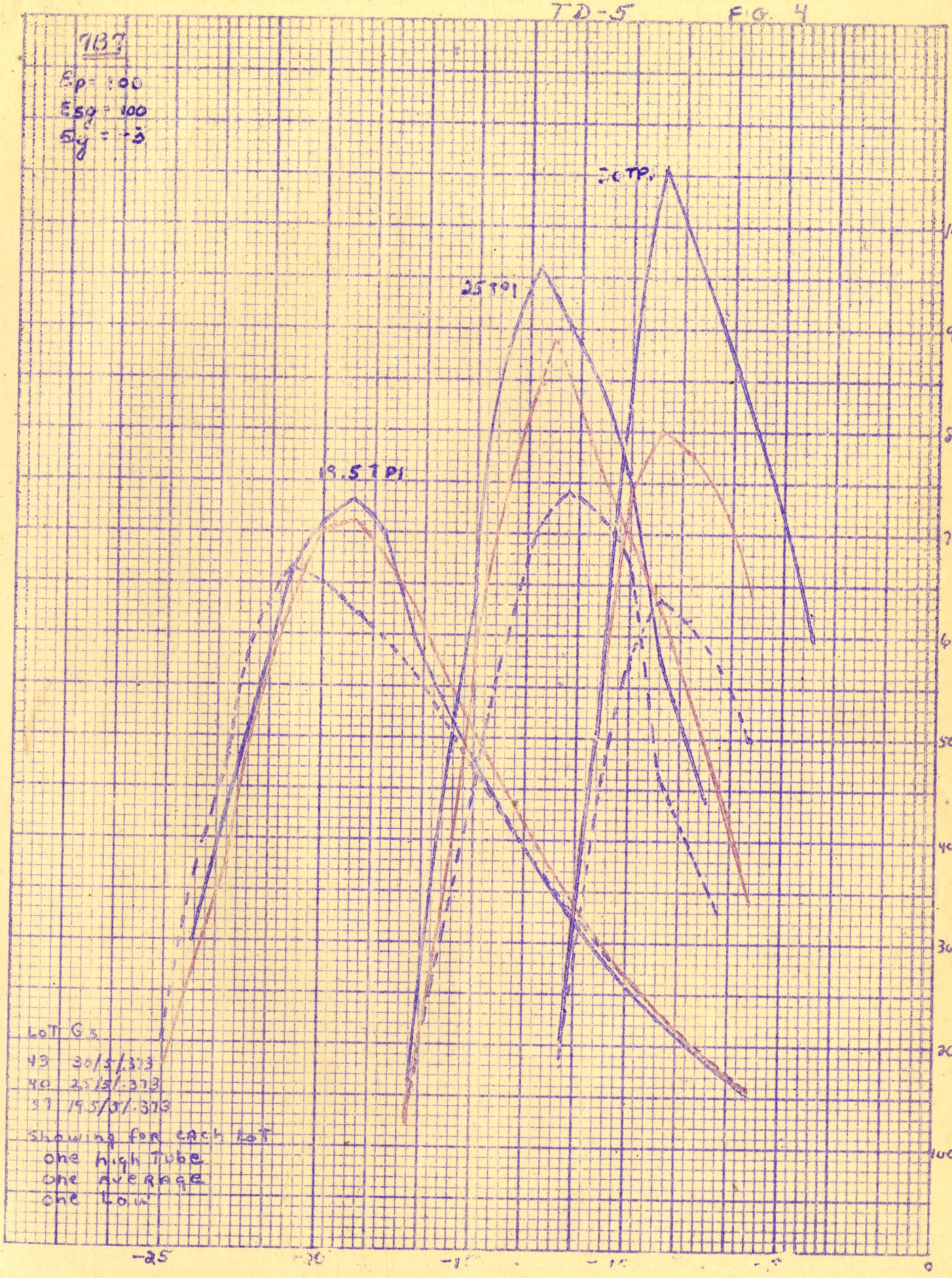
Gm 3-p of Ray 11



Eg3

HFR
71.133
REDRAWN GHB.
8/12/04

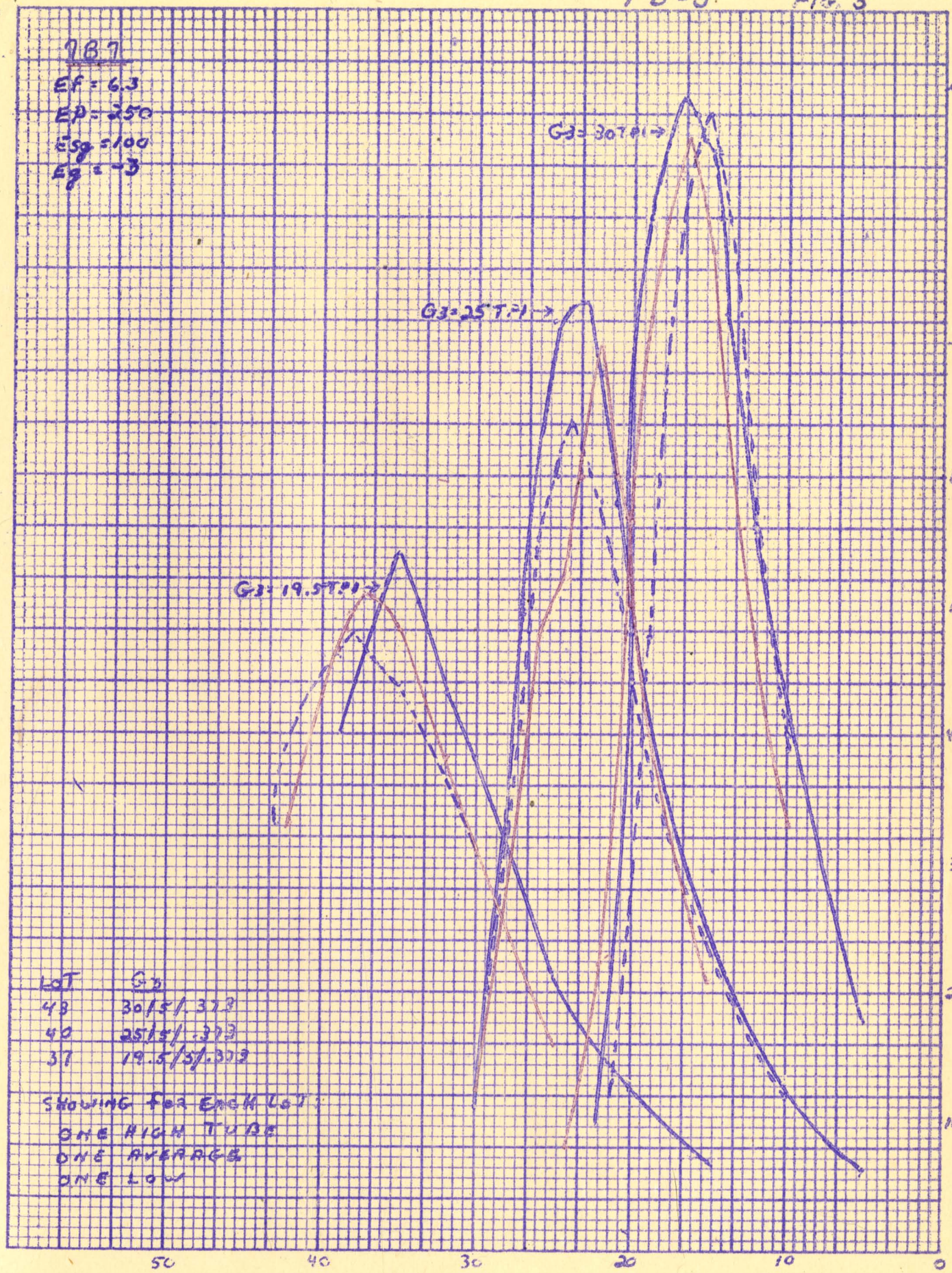
TD-5 FIG. 4


787
Ep = 100
Esg = 100
Eg = -3
30 TPi
25 TPi
19.5 TPi
1000
900
800
700
600
500
400
300
200
100
Gm 3-5 μmhos
-25
-20
-15
-10
-5
0
EG3, VOLTS
LOT G3
43 30/5/.373
40 25/5/.373
37 19.5/5/.373
Showing for each lot
one high Tube
one average
one low

TD-5 Fig. 5

1B7

Ef = 6.3
Ep = 250
Esg = 100
Eg = -3

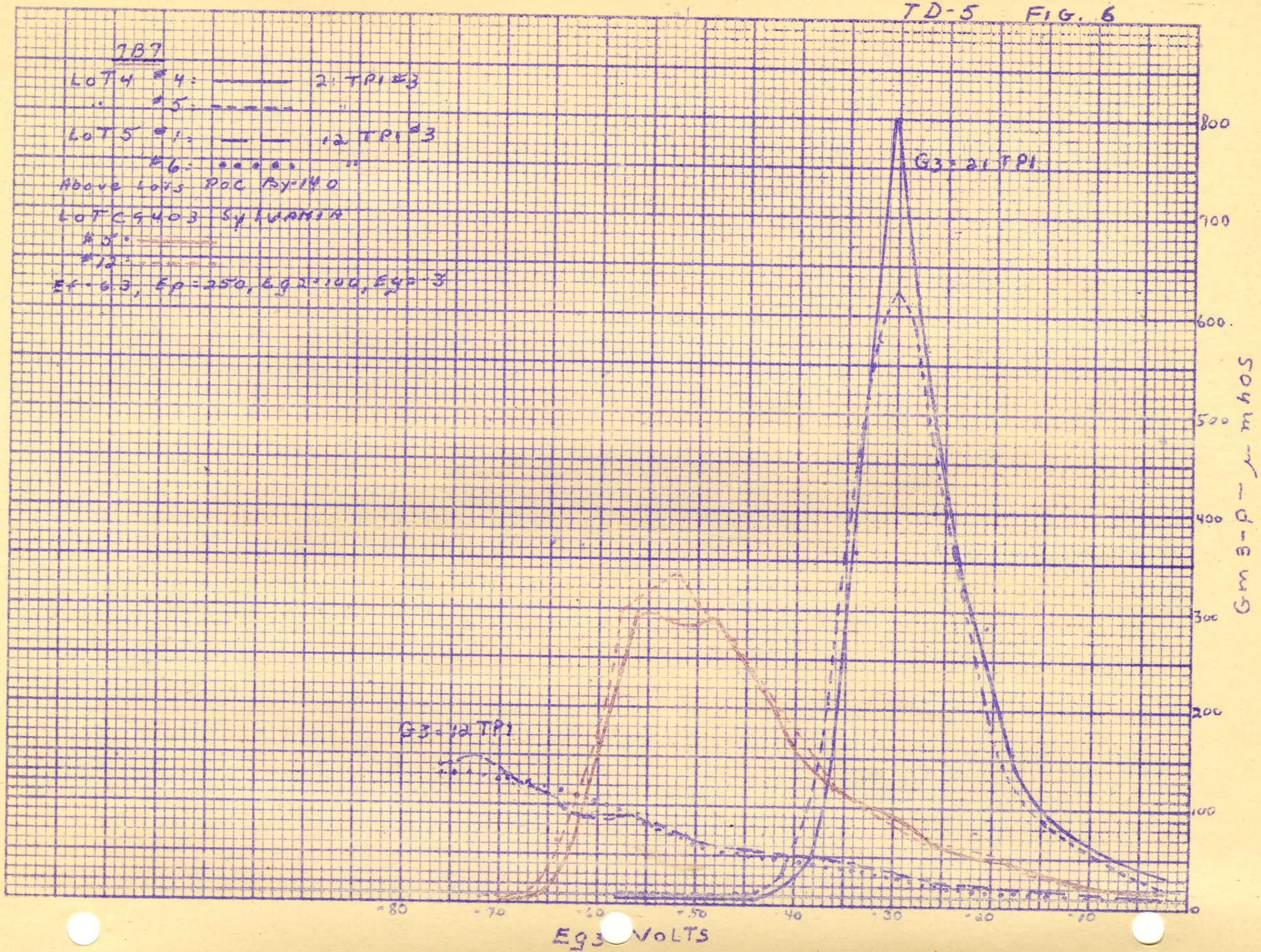


Gm 3-g - μmhos

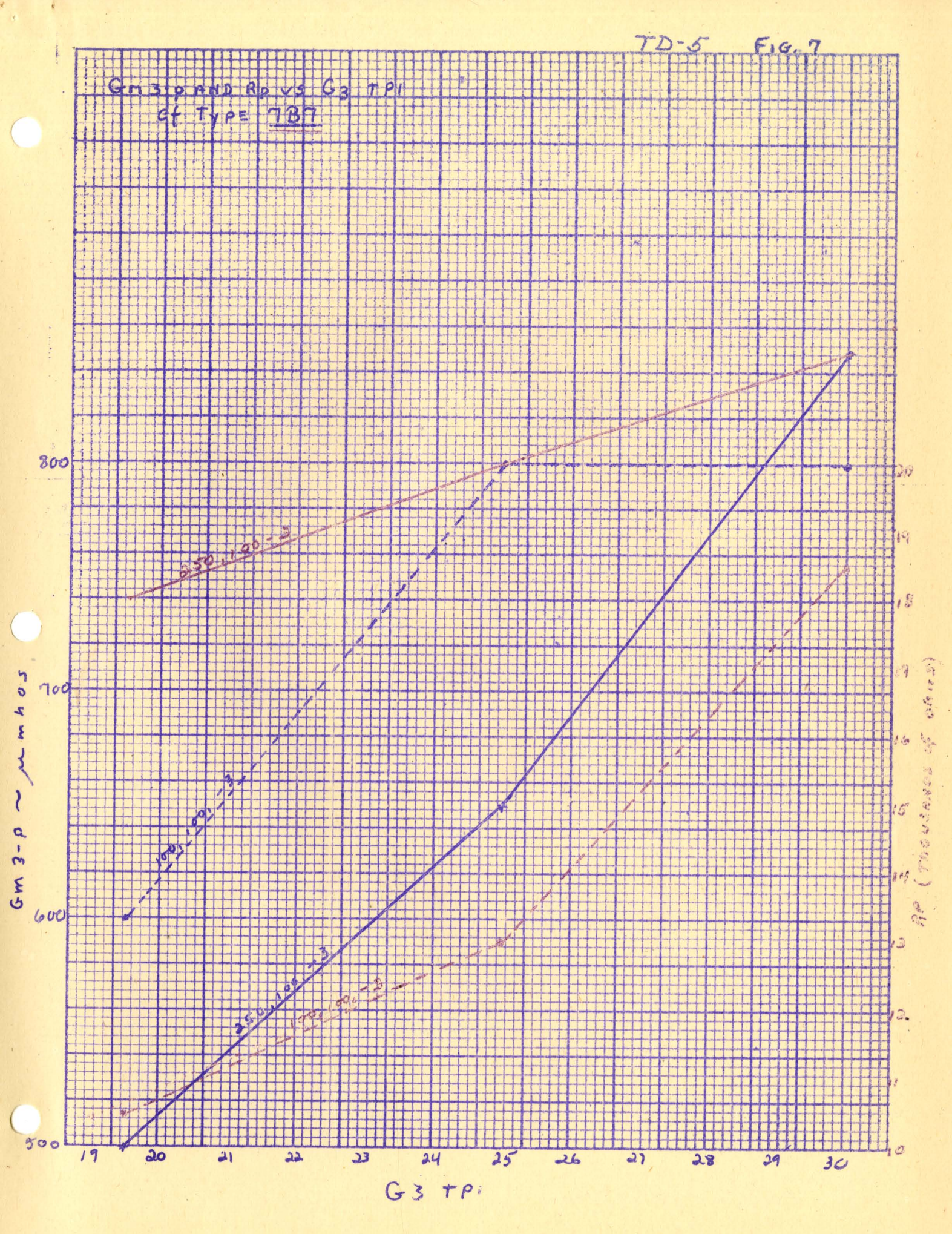
LOT	G3
43	30/5/.373
40	25/5/.373
37	19.5/5/.373

SHOWING FOR EACH LOT:
ONE HIGH TUBE
ONE AVERAGE
ONE LOW

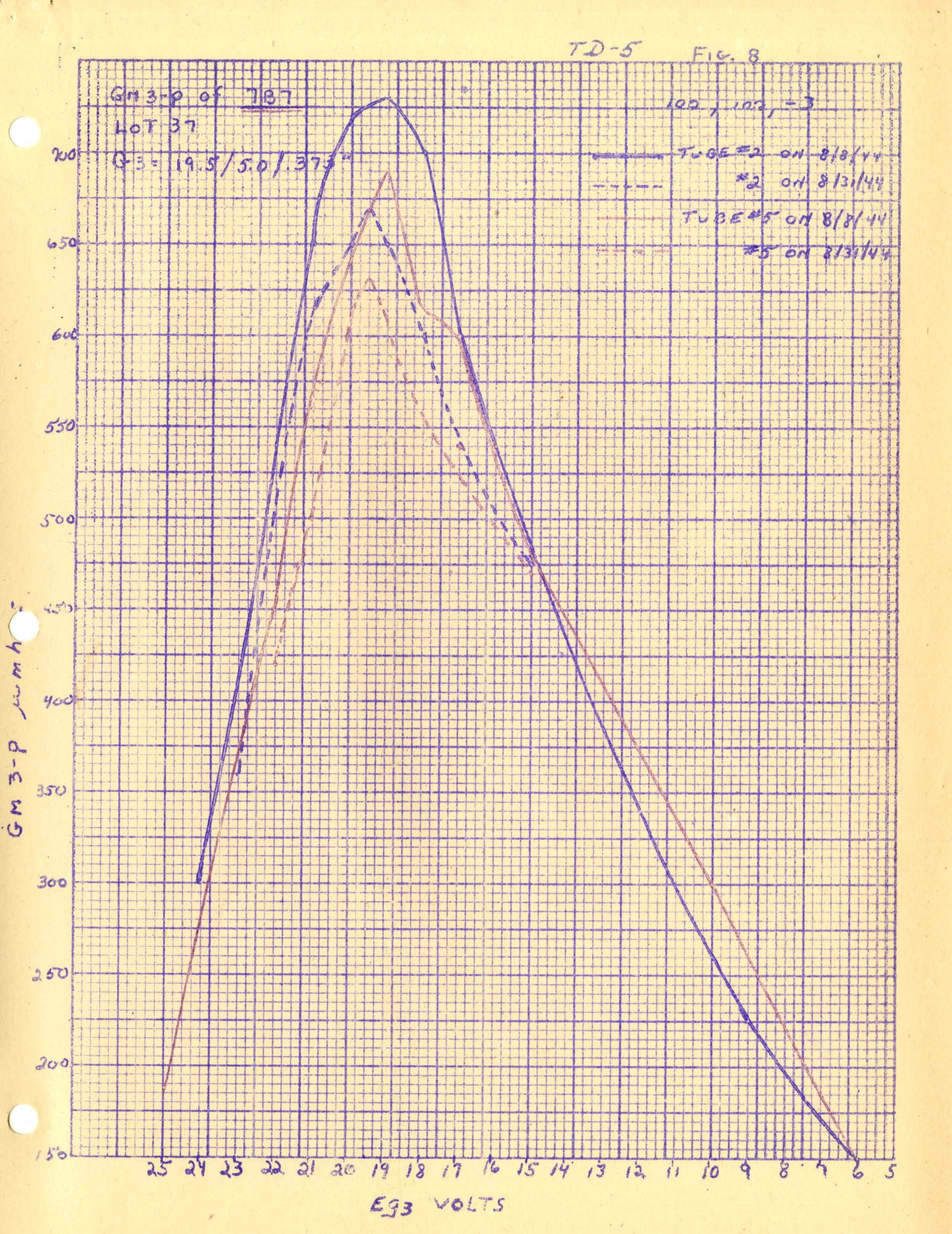
TD-5 FIG. 6


6BJ7
LOT 4 #4: ——— 2 TP1 #3
" #5: - - - - -
LOT 5 #1: — — — 2 TP1 #3
" #6: • • • • •
Above Lots POC By-140
LOT C9403 Sylvania
#5:
#12:
Ef=6.3, Ep=250, Eg2=100, Eg1=-3
G3=2 TP1
G3=1 TP1
800
700
600
500
400
300
200
100
0
-80
-70
-60
-50
-40
-30
-20
-10
Eg3 VOLTS
Gm3-0 — μmhos

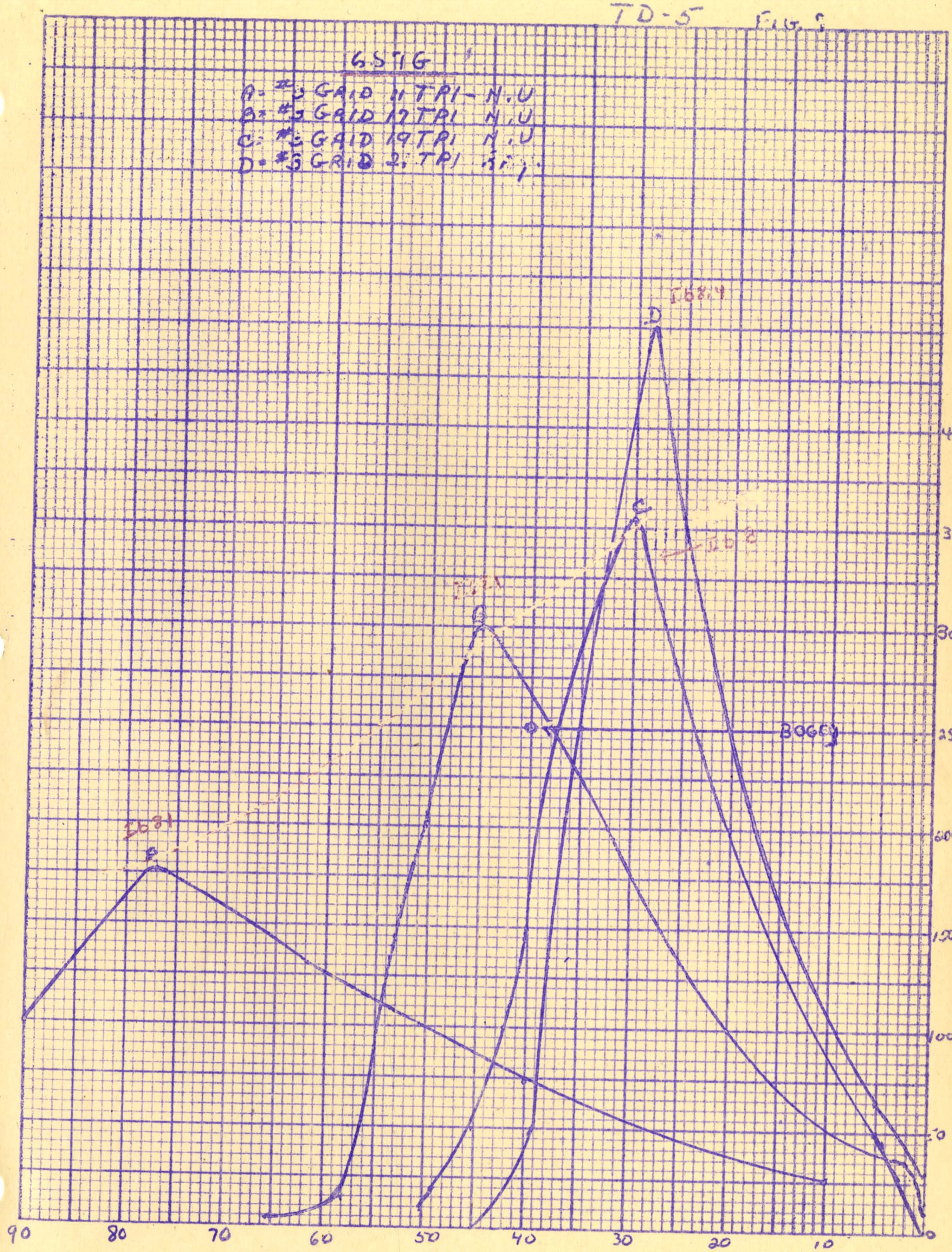
TD-5 FIG. 7


Gm 3-p AND Rp vs G3 TPI
Gf TYPE 7B7
800
700
600
500
Gm 3-p ~ μmhos
19
20
21
22
23
24
25
26
27
28
29
30
G3 TPI
250 100 3
100 100 3
100 100 3
100 100 3
20
19
18
17
16
15
14
13
12
11
10

TD-5 Fig. 8


GM 3-P of 7B7
LOT 37
G3 = 19.5/5.0/.375"
100, 100, -3
TUBE #2 ON 8/8/44
#2 ON 8/31/44
TUBE #5 ON 8/8/44
#5 ON 8/31/44
GM 3-P μmhos
700
650
600
550
500
450
400
350
300
250
200
150
25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5
EG3 VOLTS

TD-5 FIG. 9


6S7G
A- #3 GRID #1 TRI- N.U
B- #3 GRID #2 TRI N.U
C- #3 GRID #9 TRI N.U
D- #3 GRID #2 TRI #1
D
C
B
A
BOGEY
400
350
300
250
200
150
100
50
0
90
80
70
60
50
40
30
20
10
GM G-3 - μ MICROMHOS

E-3

TD-5 FIG 10

6 5 7 G

LOT 34 #5 = ——— , - - -

LOT 34 #6 =

6.3, 250, 100, -3 = ———

6.3, 135, 67.5, -3 = - - -

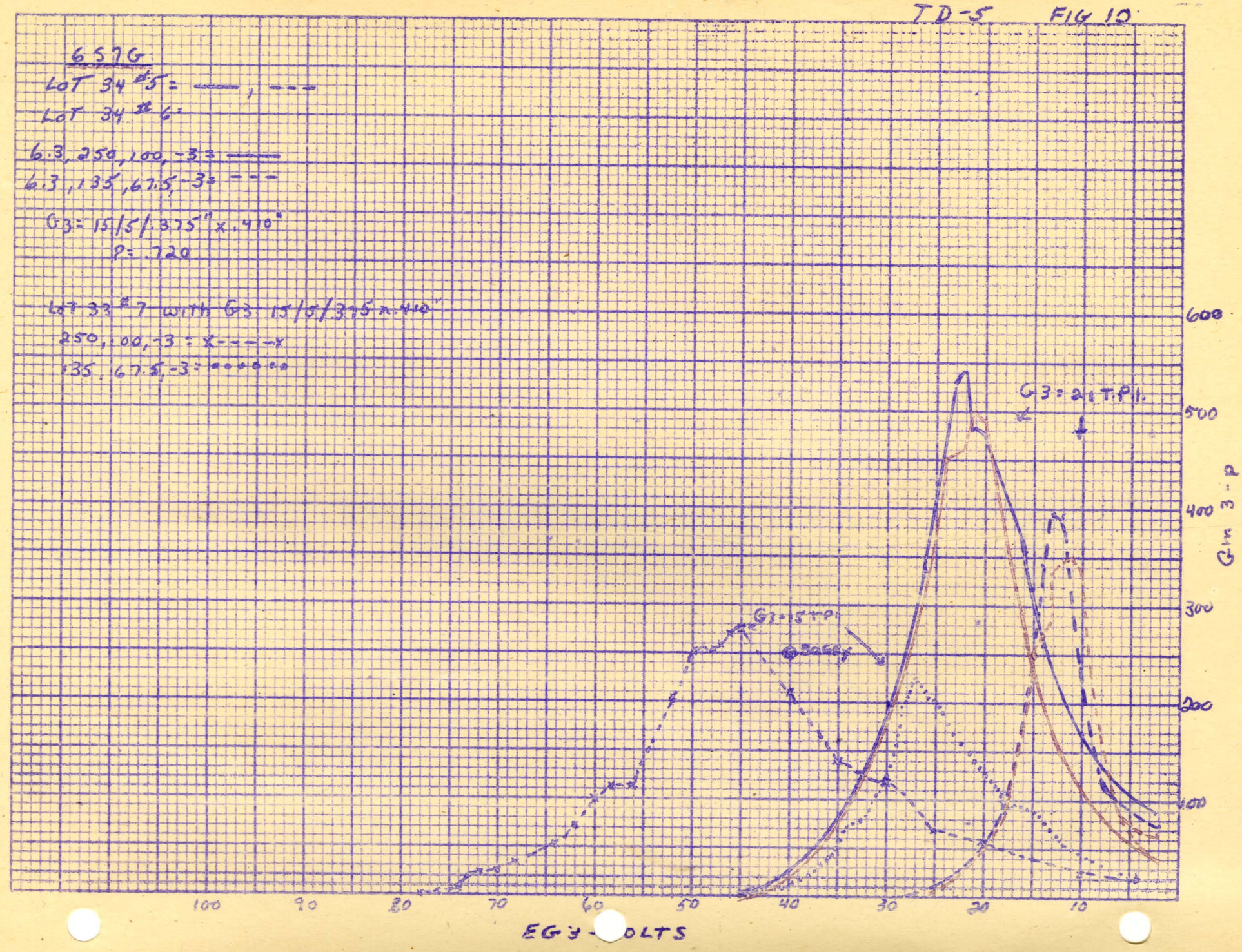
G3 = 15/5/.375" x .410"

P = .720

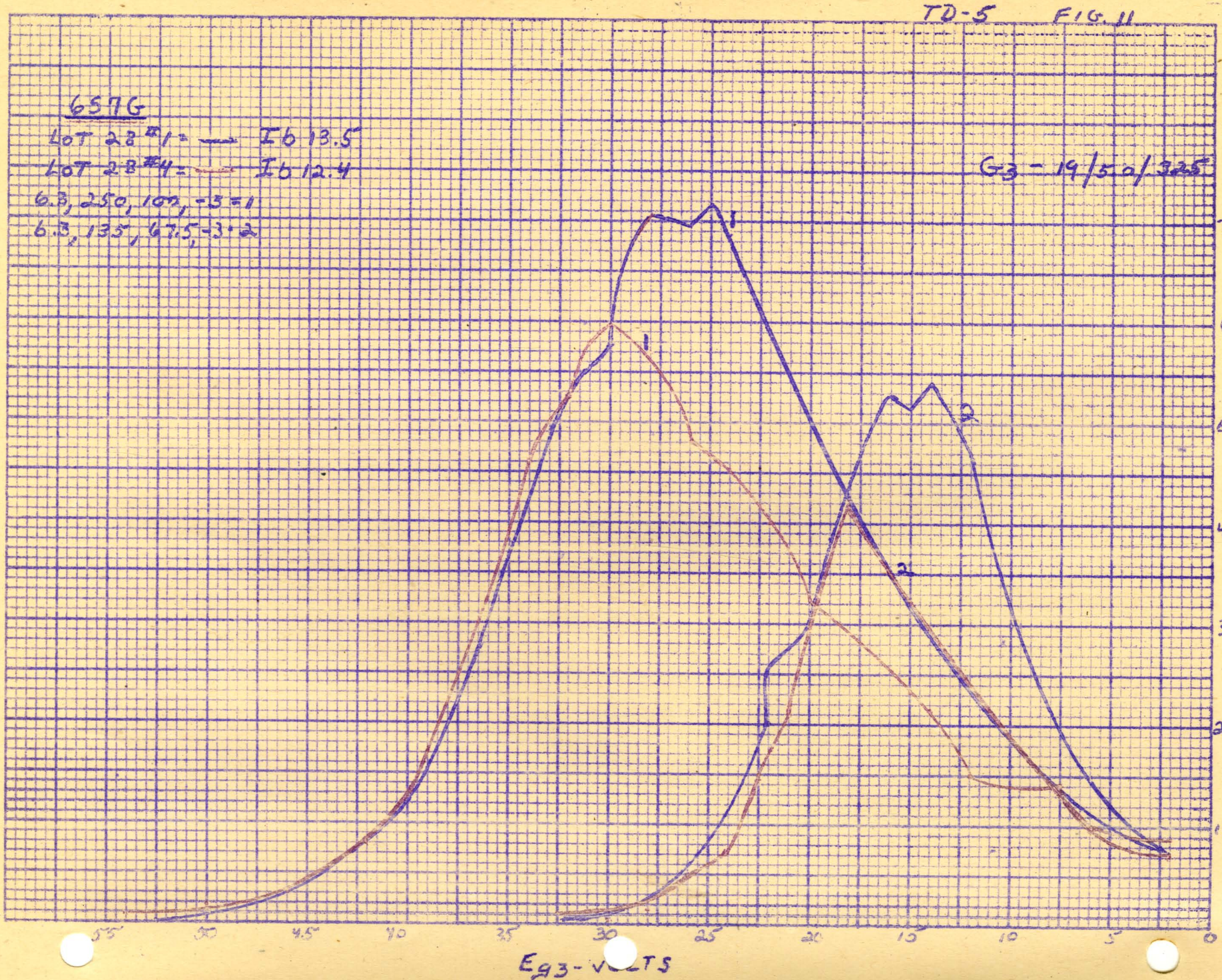
LOT 33 #7 with G3 = 15/5/.375 x .410"

250, 100, -3 = x - - - x

135, 67.5, -3 = • • • • • •



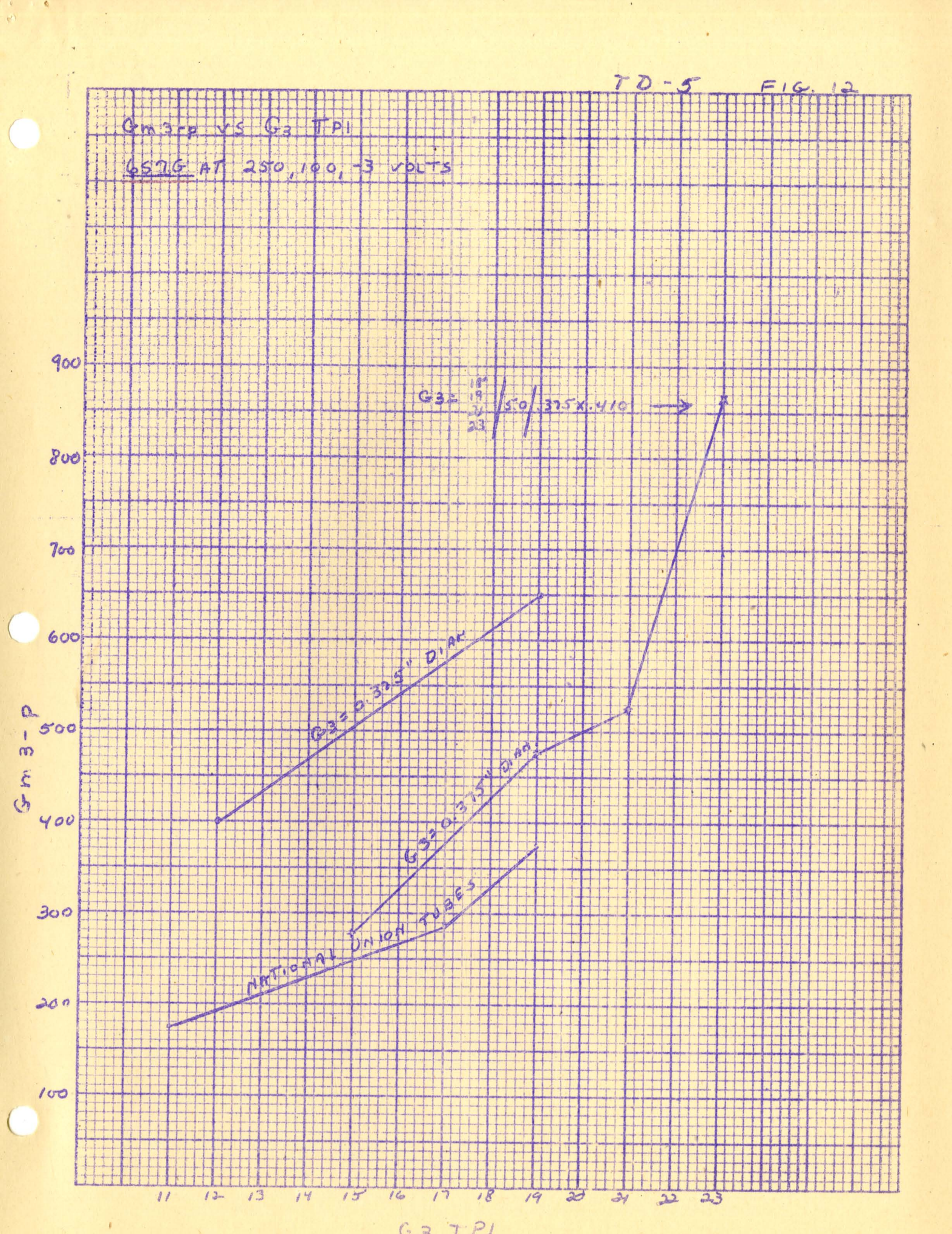
TD-5 FIG. 11


6SN7G
LoT 28 #1 = — Ib 13.5
LoT 28 #4 = — Ib 12.4
6.3, 250, 100, -3 = 1
6.3, 135, 67.5, -3 = 2
G3 - 19/5 a/ 325
700
600
500
400
300
200
100
GM-3-P
55
50
45
40
35
30
25
20
15
10
5
0
Eg3-VOLTS
1
2

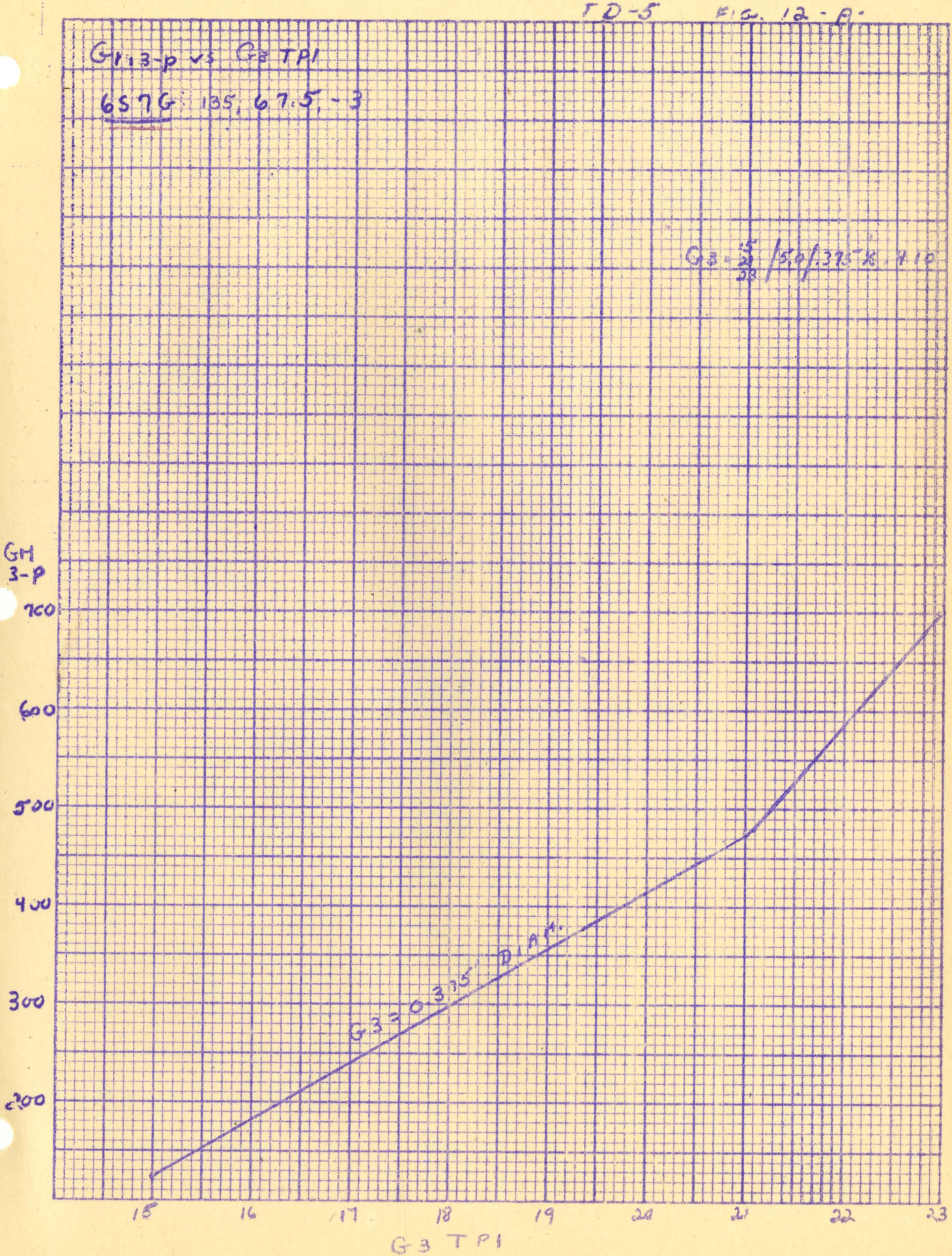
TD-5 FIG. 12

Gm 3-p VS G_3 TPI

6S7G AT 250, 100, -3 VOLTS



TD-5 Fig. 12-A.


GM 3-P vs G3 TPI
6S7G 135, 67.5, -3
G3 = 5/29 / 5.0 / .375" Ø .410
GM 3-P
700
600
500
400
300
200
G3 = 0.375" DIAM.
15
16
17
18
19
20
21
22
23
G3 TPI

TD-5 FIG 13

OT-91 LOT 66 TUBE # 2

100, 100, -2