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RADIO RECEIVING TUBE DIVISION
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Tube Design Circular No. 8

R. F. PENTODE PLATE RESISTANCE AND MUTUAL CONDUCTANCE AS AFFECTED BY NUMBER 3 GRID PITCH

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R. F. PENTODE PLATE RESISTANCE AND MUTUAL CONDUCTANCE AS AFFECTED BY NO. 3 GRID PITCH

In July, 1944, a study was undertaken of the effects of suppressor-grid pitch upon plate resistance in pentode tubes. Tube test data in the files of the Tube Design Department were examined, previous incomplete approaches to the problem were reviewed, and selected tubes removed from stock and retested in an effort to fill certain gaps in the data and to check existing information.

Only those pentodes were considered which exhibited structural changes in G3 alone - chiefly types 78, 6SD7GT, 7A7 and 7B7. Where only five or six tubes were available or had been tested, the test data were carefully examined to see if they were consistent. Spot diagrams, showing Rp against Ip for individual tubes, furnished indication of the trustworthiness of such data. In at least one case, further analysis was made of certain lots which it were of especial interest.

All mutual conductances in this report are Gm 1-P and not to be confused with Gm 3-P of a related report.

A. SKELETON PLATE TYPES

Type 6SD7GT was found to offer very acceptable experimental information. In general, it appears that as G3 is increased upward from 12 tpi at both 250 Eb with 100 Esg and 100 Eb with 100 Esg, the plate resistance declines and reaches a minimum at 19 or 19.5 T.P.I. However, figures for grids more closely wound than this are either missing or unreliable, so that the picture for grids of higher T.P.I. is incomplete.

An exception to this general trend will be noted in the face that lots 3 and 4 show no great variation of Rp at 250 Eb, 100 Esg, -2 Egl, even though they differ a good deal in G3. However, Rp does decline slightly with increased T.P.I. and at 100 Ep, 100 Esg, -1 Egl this decline becomes marked. The Gm of type 6SD7GT goes steadily down as the T.P.I. of G3 goes up. (See Figure 1) The upward slope of the line for lots 59 and 66 at 250, 100, -3 is probably due to a space-charge condition and is left in to show that the data are not always perfectly uniform.

Type 7A7, contained sixteen very consistent lots with a good range of suppressors. Data on lots 17 - 30 were examined as to Ib, Isg and contact potential. The consistent nature of these figures makes it reasonable to assume that the change in G3 was responsible for the changes observed in Gm and Rp. In general, the data for these show Rp reaching a maximum at 19.5 T.P.I. both for 250, 100, -3 and for 100, 100, -1. The value of Rp declines on either side of 19.5 T.P.I. (Figures 2 and 3). The graphs show that larger negative values of grid voltage exaggerate the slope of the Rp vs. T.P.I. curve so that the 19.5 T.P.I. peak is sharper. At grid-voltages of -1 or -3 (Figures 3 and 3A) almost no peak shows up and Rp is much lower, as would be expected. The value of 19.5 T.P.I. and 0.343" minor i.d. seems to offer the maximum of shielding with a minimum reduction of Rp, especially at the low-voltage conditions (100, 100, -1), and hence has been the normal grid for these tubes in regular production.

The 7A7's show peak Gm at about 1900 umhos at 250, 100, and -3, though the three common grid diameters have peaks at a different T.P.I. (Figure 4). At 100, 100, -1, the Gm peak occurs at about 2450 (Figure 5). Lots 17-30 show an Rp peak at 19 T.P.I. at 250, 100, -3, but the peak shifts to 15 T.P.I. at 100, 100, -3 (Figure 6).

Type 7B7. Here data on several desirable lots was missing from the files. Three lots were found, however, for each of three diameters and suppressor grid pitches lots 35-43. Data taken at 250, 100, and -3 indicate that Rp is measurably affected by number three grid T.P.I. and that plate resistance reaches a peak at 19.5 T.P.I. (Figure 7). The figures for 100, 100 and -1 volt conditions are less clear. This is partly because no data exists below 19.5 T.P.I. and partly because only five tubes per lot had been read. The indications are, however, that maximum Rp again occurs at 19.5 T.P.I. The curves for Gm vs. G3 T.P.I. at 100, 100 and -1 show that for suppressors with a 0.300" or 0.343" I.D. minor transconductance reaches its maximum at about 2150. For a minor diameter of 0.373" the peak is reached a little below 2000 micromhos (Figure 8). At 250, 100 and -3, the peak is shifted somewhat. Since suppressors coarser than 15 T.P.I. were not used, the actual peak for 0.300" and 0.343" grids cannot be exactly located. It is likely, however, that the 0.300" I.D. peak would be at a lower value of G3 T.P.I. than for 0.343". The latter would probably reach its maximum in its neighborhood of 15 T.P.I. The 0.373" suppressors peaked at over 25 T.P.I. at a level of 1825 micromhos, which is a good deal lower than at 1900 and 1925 micromhos for 0.300" and 0.373" grids respectively.

Type 7H7 showed test lots with interesting variations in suppressor-winding but due to unusual procedure with these lots and to poor emission and other factors, the data was finally discarded as untrustworthy.

B. ROUND PLATE - TYPE 78

A good deal of data were found in the files for type 78. Lots 24A, 25, 26 and 27 showed good uniformity of characteristics both from lot to lot and within lots. In view of this fact, it is interesting to note the wide range of conditions under which data on these tubes were obtained. The data from the file showed that four tubes had been read for lot 25, three for lot 26, five for lot 27, and ten for lot 24A.

In general, Rp appears to be a maximum at 22 or 25 T.P.I. and to drop off somewhat at 30 T.P.I. (for 0.680" i.d. plates). It will be noted, however, that at 250, 150, and -15 volts Rp is identical for 22 and 25 T.P.I. and the value of Rp for 30 T.P.I. is higher than for either 22 or 25 T.P.I. In contrast to this, the Rp slope is found to decline to 30 T.P.I. at 250, 150 and -9 or 250, 150 and -5.5 and at the 90 volt test conditions also. (Figure 9)

At 250, 90, -6.5 the change in Rp from 2.4 megohms at 25 T.P.I. to 2.15 meg at 22 T.P.I. seems greater than elsewhere and may indicate a lead which should be followed up in any future study of the problem. (Data for this are in G3-Rp folder.)

The best data for lots 24A, 25, 26 and 27 were taken at 110, 60 and -1.5 volts. Their results can be taken as indicative of the trend of behavior of these tubes. They show that increasing the T.P.I. of G3 steadily reduces Rp and Gm. (Figure 10)

C. EFFECT OF DIAMETER ON Rp and Gm

Types 7A7 and 7B7 offer the only experimental suppressor lots in which the diameter of G3 was varied independently of everything else.

Some excellent test lots were still on file in the Tube Design Department, along with data for their performance. These data were supplemented by testing certain lots of both types on the Miller Bridge. The information gathered is shown graphically herewith. On type 7A7 at 250, 100 and -3 as the diameter of G3 increases Rp is found to increase to 19 T.P.I. and then fall off again. (Figures 7, 11, and 12). At 100, 100, -1, the maximum Rp occurs at 15 T.P.I. instead. At the high voltage conditions, the Gm reaches its peak at 1900 micromhos for each of the three minor diameters studied - 0.300", 0.343" and 0.373" i.d. (Figure 4). At 100, 100, - 1 the peak is raised to about 2450 Gm. (Figure 5)

Type 7B7 showed a somewhat similar effect of diameter on both Rp and Gm at 250, 100 and -3. Rp increased with increasing diameter of the #3 grid from 0.300" i.d. to 0.343" i.d. and then decreased for 0.373" and Gm peaked at 19.5 T.P.I. However, at 100, 100, -1, plate resistance declined steadily as suppressor-diameter was increased and peak value of Gm was reached somewhere between 15 and 19.5 T.P.I.

An approximate numerical relation between Rp and suppressor-grid diameter is difficult to arrive at without more experimental information. Some indication of the trend of this relation may, nevertheless, be gained from the foregoing types. Here, using 19.5 T.P.I. as a starting point, an increase of one-half turn per inch in the pitch of G3 is approximately equivalent to a 0.030" decrease in diameter. In the other direction, a decrease of one-half T.P.I. is nearly equivalent to increasing the diameter 0.020".

The data on which this report is based, together with additional graphs and grid-specifications for the various tubes, may be found in a folder labeled "G3-Rp Investigation" in the files of the Tube Design Department. Considerable data on actual gain measurements - chiefly with 100 volt screen conditions - are given in memoranda by J. R. Nelson of January 26, 1940, and March 23, 1939 to H. F. Argento and Dr. Weeks. These measurements were made in connection with the design of the original 7H7 tube for maximum gain at 100 volts on the screen grid. A copy of these memoranda and the original test data is in a "R-F Gain" folder.

George Blackwell

OK
AGR

6SD7GT

TD-8

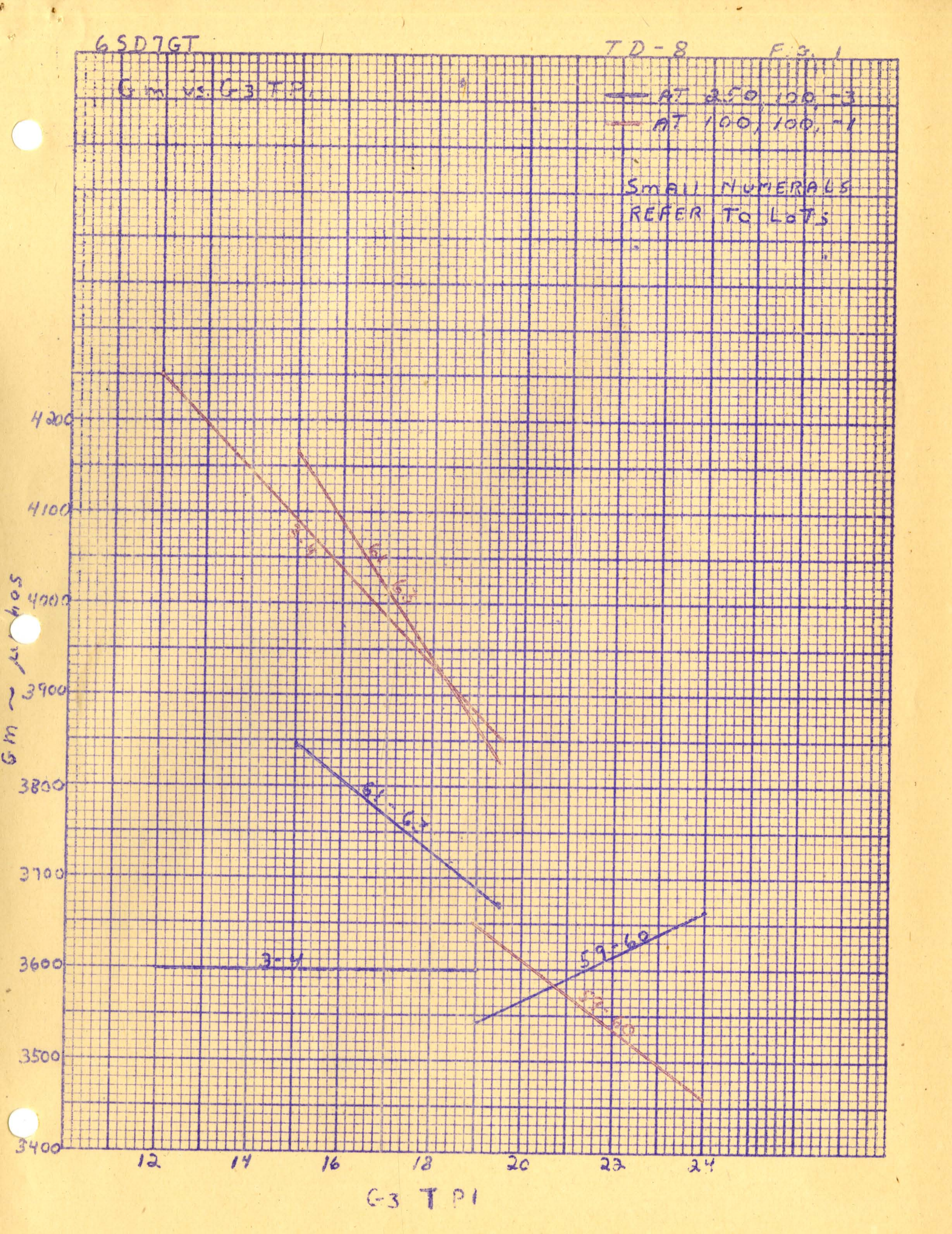
F. 3. 1

Gm vs. G3 TP1

— AT 250, 100, -3

— AT 100, 100, -1

Small numerals refer to lots



7A7

TD-8 FIG 2

Rp VS #3 GRID TPI

	E_f	E_{g2}	E_{g1}
A-	250	100	-10
B-	250	100	-6
C-	250	100	-3
D-	250	100	-1

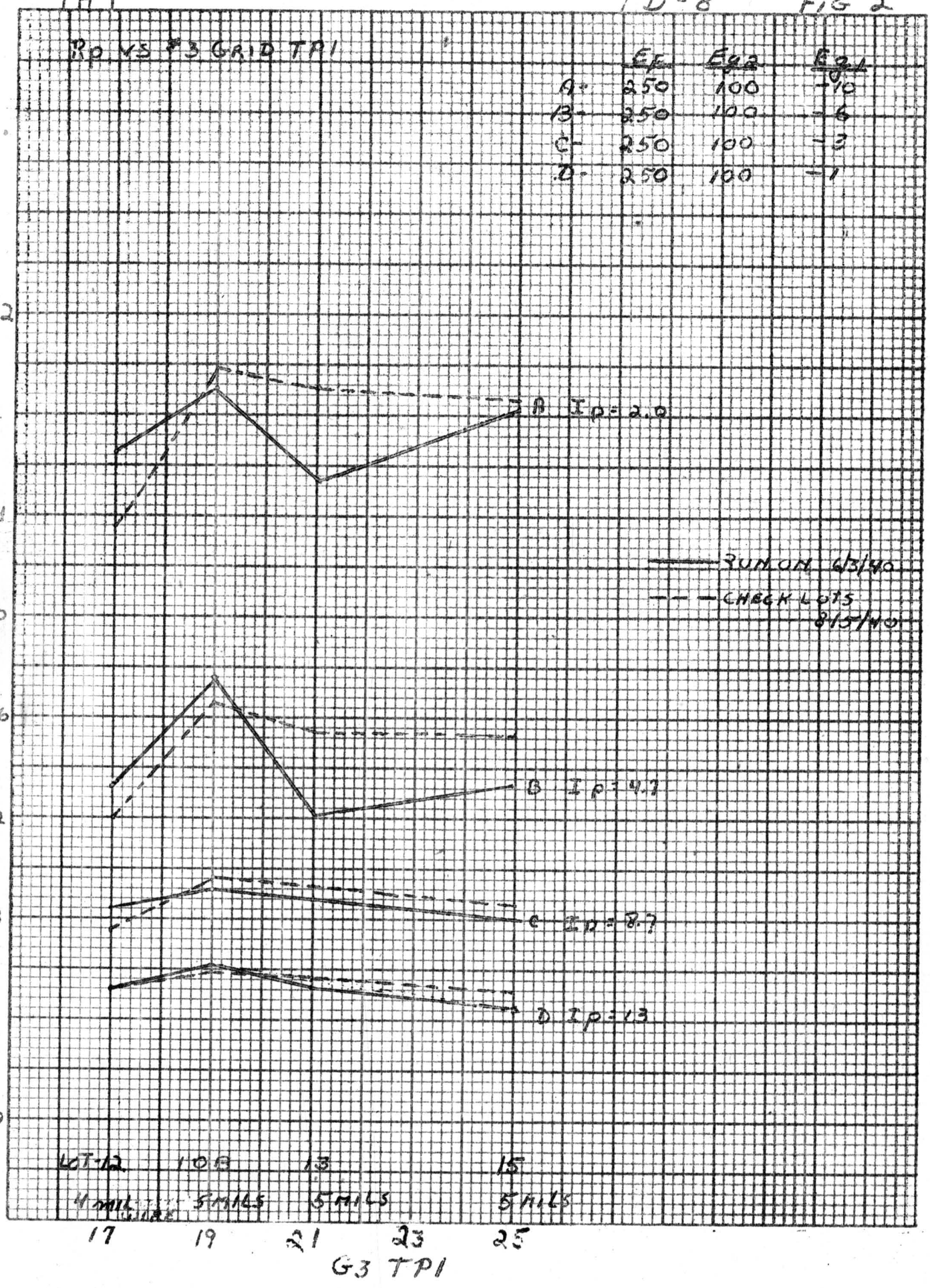


FIG. 3

7A7- R_p VS #3 GRID TPI

TD-8

7/22/40

	E_p	E_{g_2}	E_{g_1}
A:	100	100	-15
B:	100	100	-10
C:	100	100	-8
D:	100	100	-3
E:	100	100	-1

CHECK LOTS 8/6/40

A I_p = 1.0

B I_p = 2.0

C I_p = 3.0

D I_p = 8.5

E I_p = 12.6

2.8
2.4
2.0
1.6
1.2
.8
.4

LOT 12 100 13 15

17 19 21 23 25

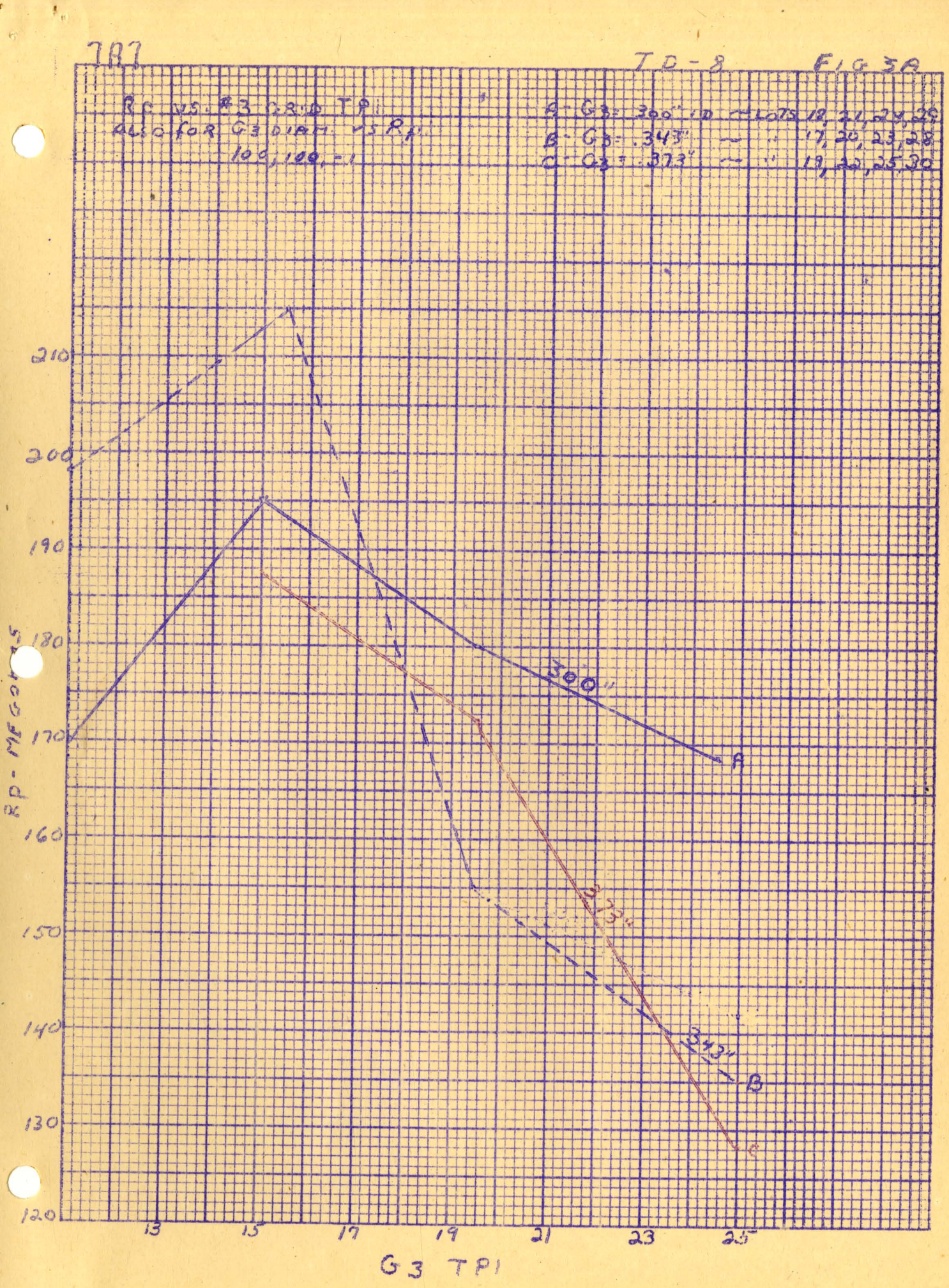
#3 GRID TPI

LOT 12 - 4 MIL WIRE

TR7 TD-8 FIG 3A

Rc vs #3 GRID TPI
ALSO for G3 DIAM. vs Rp
100,000 = 1

A - G3 = .300" ID — LOTS 18, 21, 24, 29
B - G3 = .343" — " 17, 20, 23, 28
C - G3 = .373" — " 19, 22, 25, 30



TAT - Gm vs G3 TPI

TD-8

FIG. 4

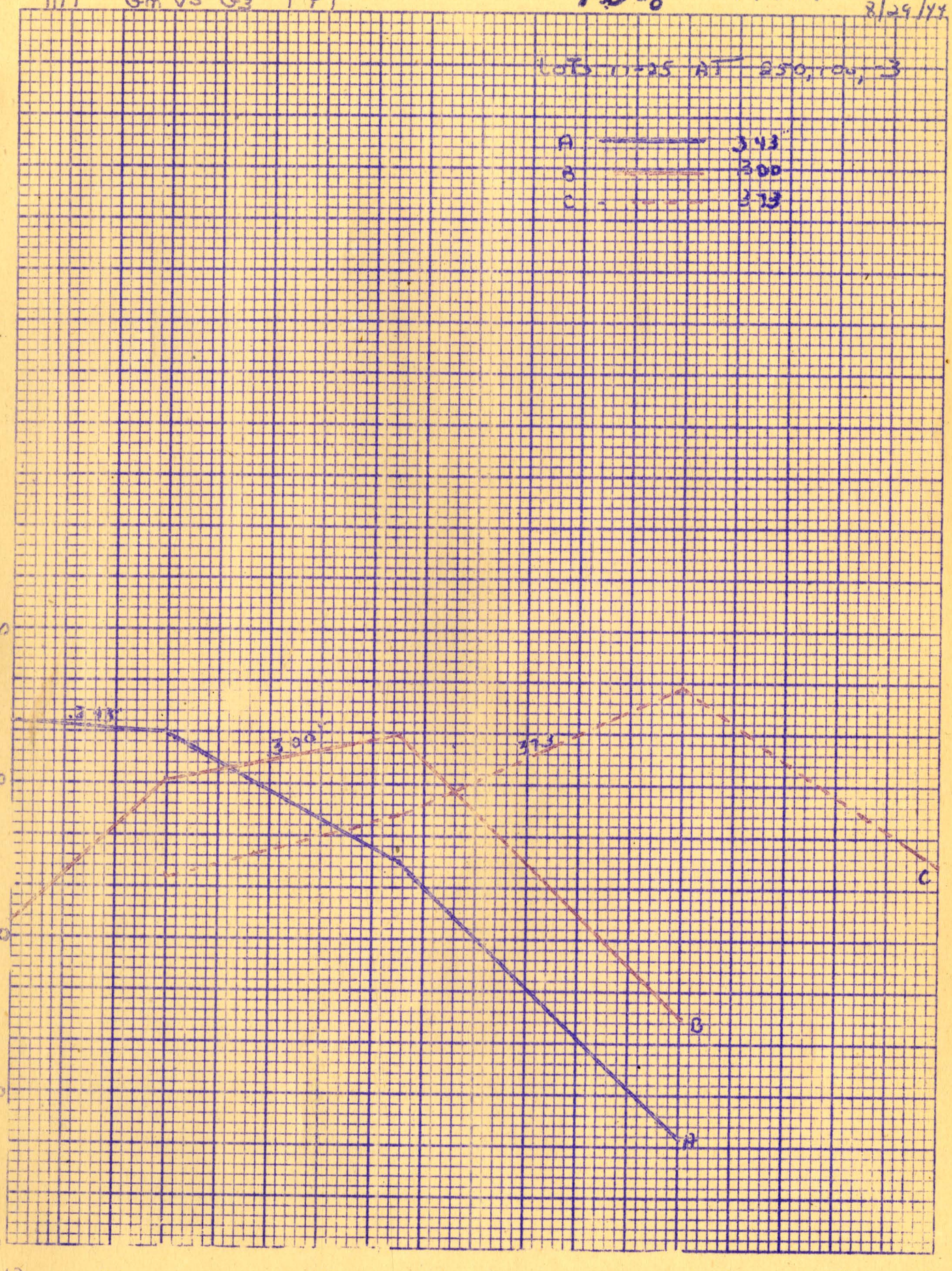
8/29/47

Lot 10-25 AT 250,000, -3

A 343

B 300

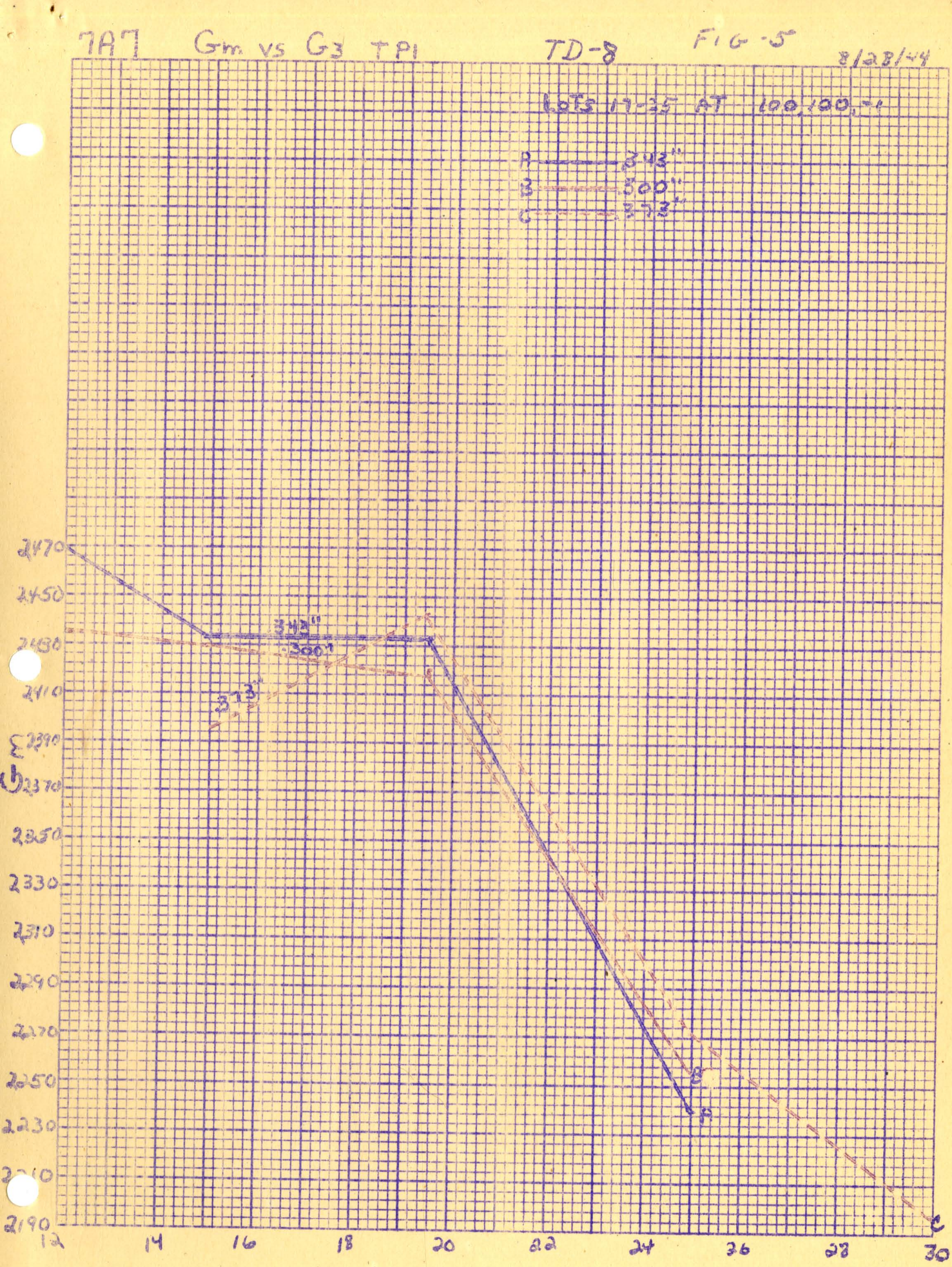
C 313



7A7 Gm vs G3 TPI TD-8 FIG-5 8/28/64

LOTS 19-35 AT 100,100,-4

A ——— .343"
B ——— .300"
C ——— .313"



G3 TPI

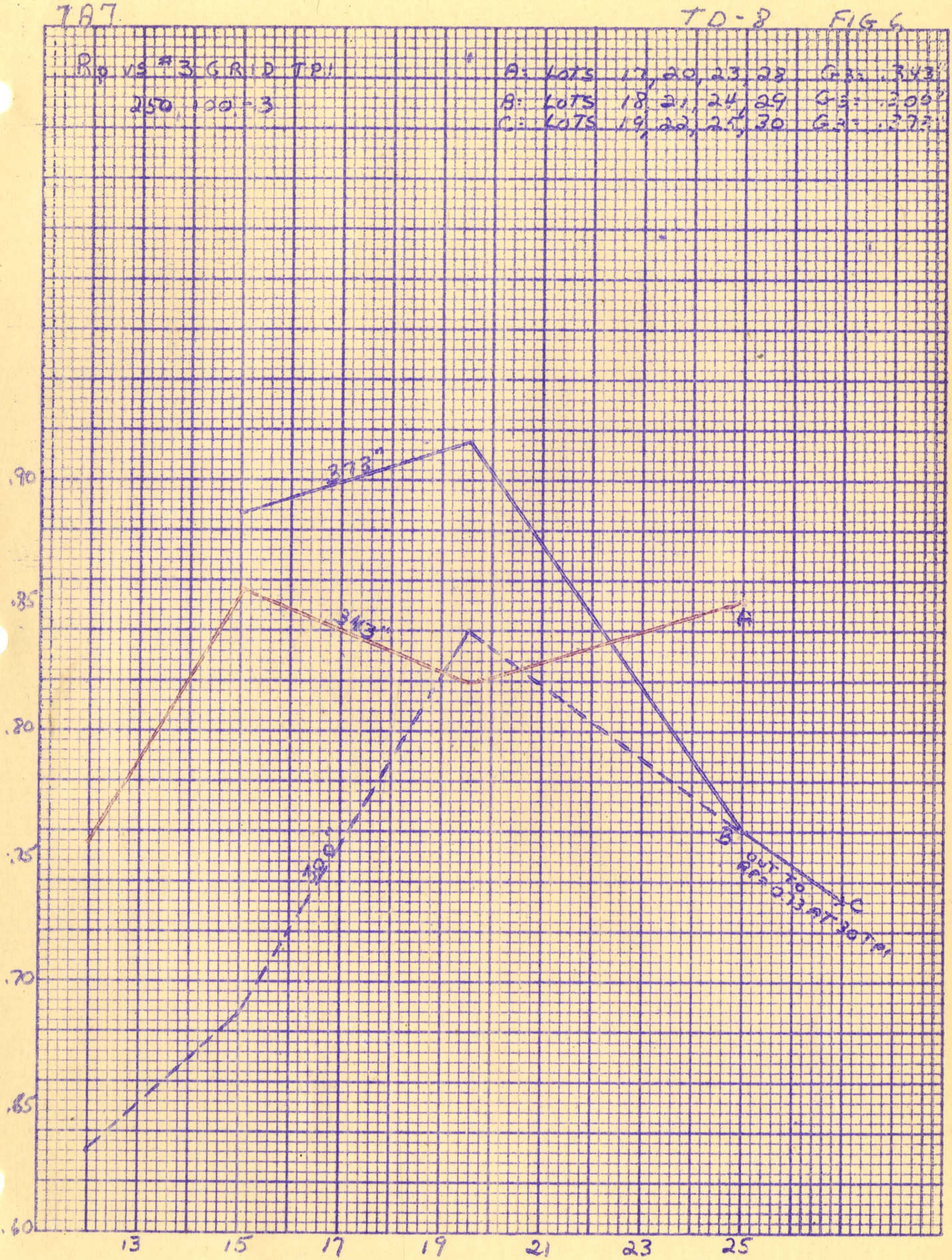
R_ϕ VS #3 GRID TPI

250 100-3

A: LOTS 17, 20, 23, 28 G_3: .343

B: LOTS 18, 21, 24, 29 G_3: .300

C: LOTS 19, 22, 25, 30 G_3: .273



7B7 R_D vs G3 TPI TD-8

250, 100, -3

A ——— .343" 5 mil - Lots 35, 38, 41

B - - - - .300" 5 mil - Lots 36, 39, 42

C - · - · - .313" 5 mil - Lots 37, 40, 43

1 - Tubes Tested per Lot

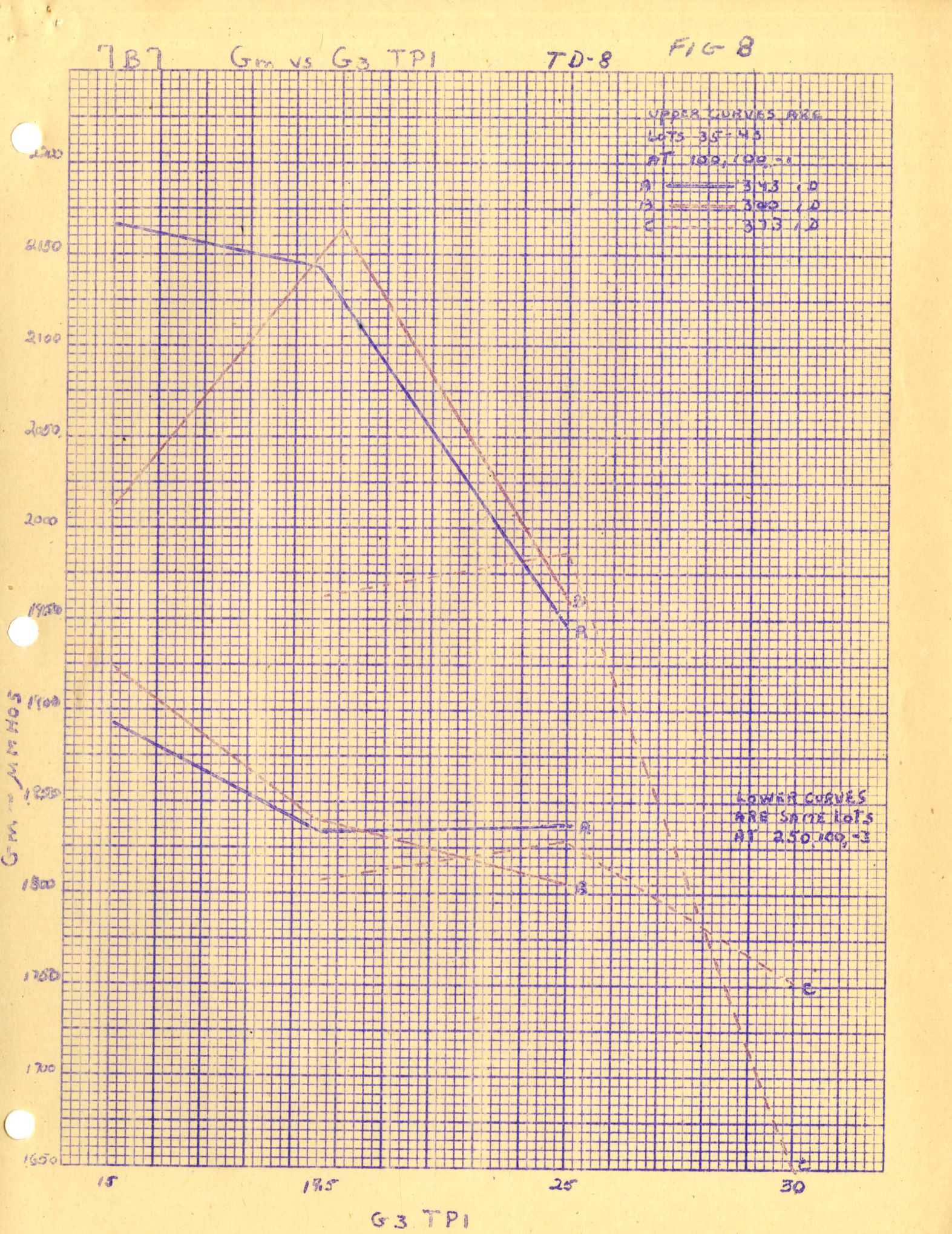
.96
.92
.88
.84
.80
.76
.72
.68
.64
.60
.56

α_{CE}

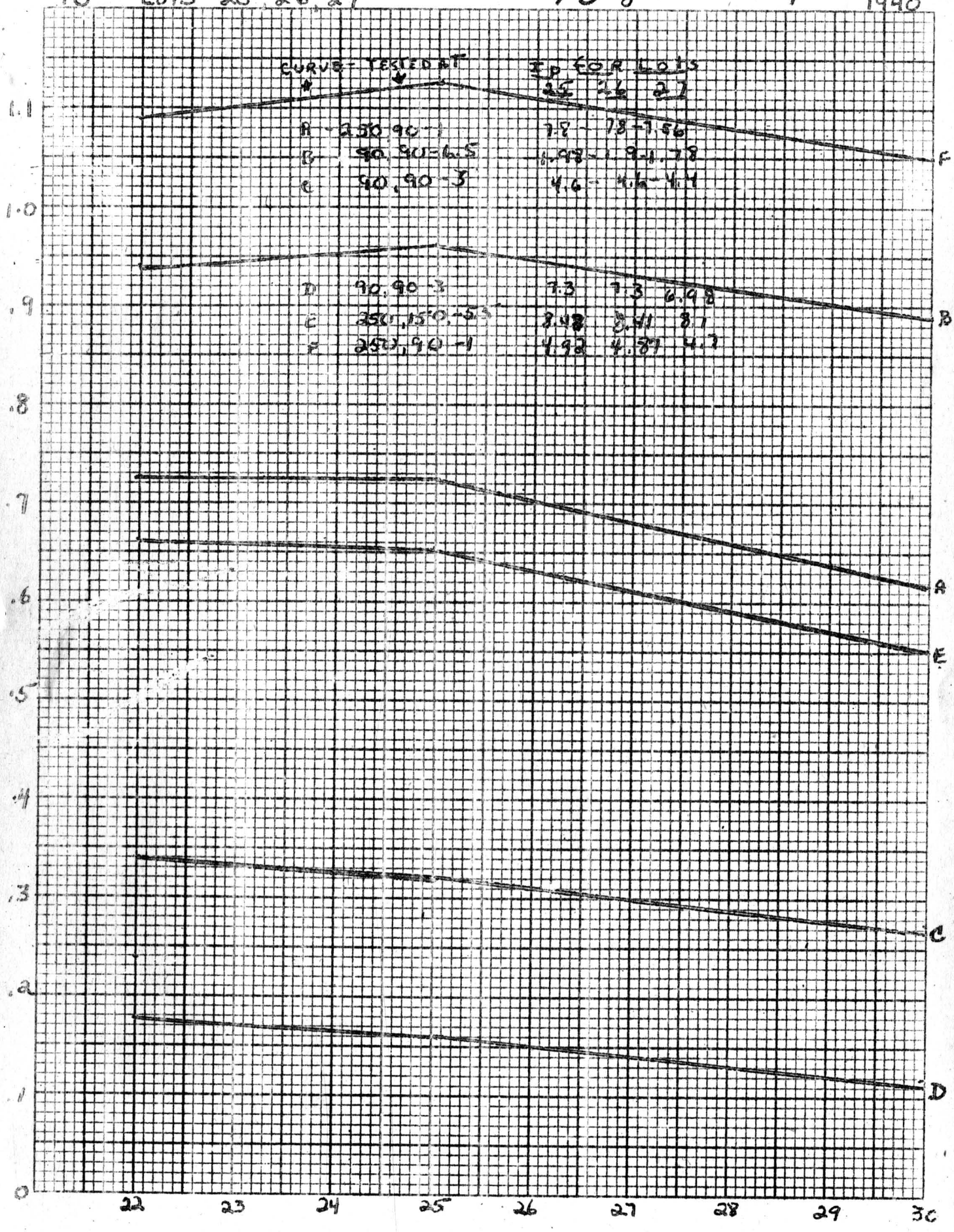
15 18 21 24 27 30

G3 TPI

7B7 Gm vs G3 TPI TD-8 FIG 8



78 LOTS 25, 26, 27 TD-8 FIG 9 1940



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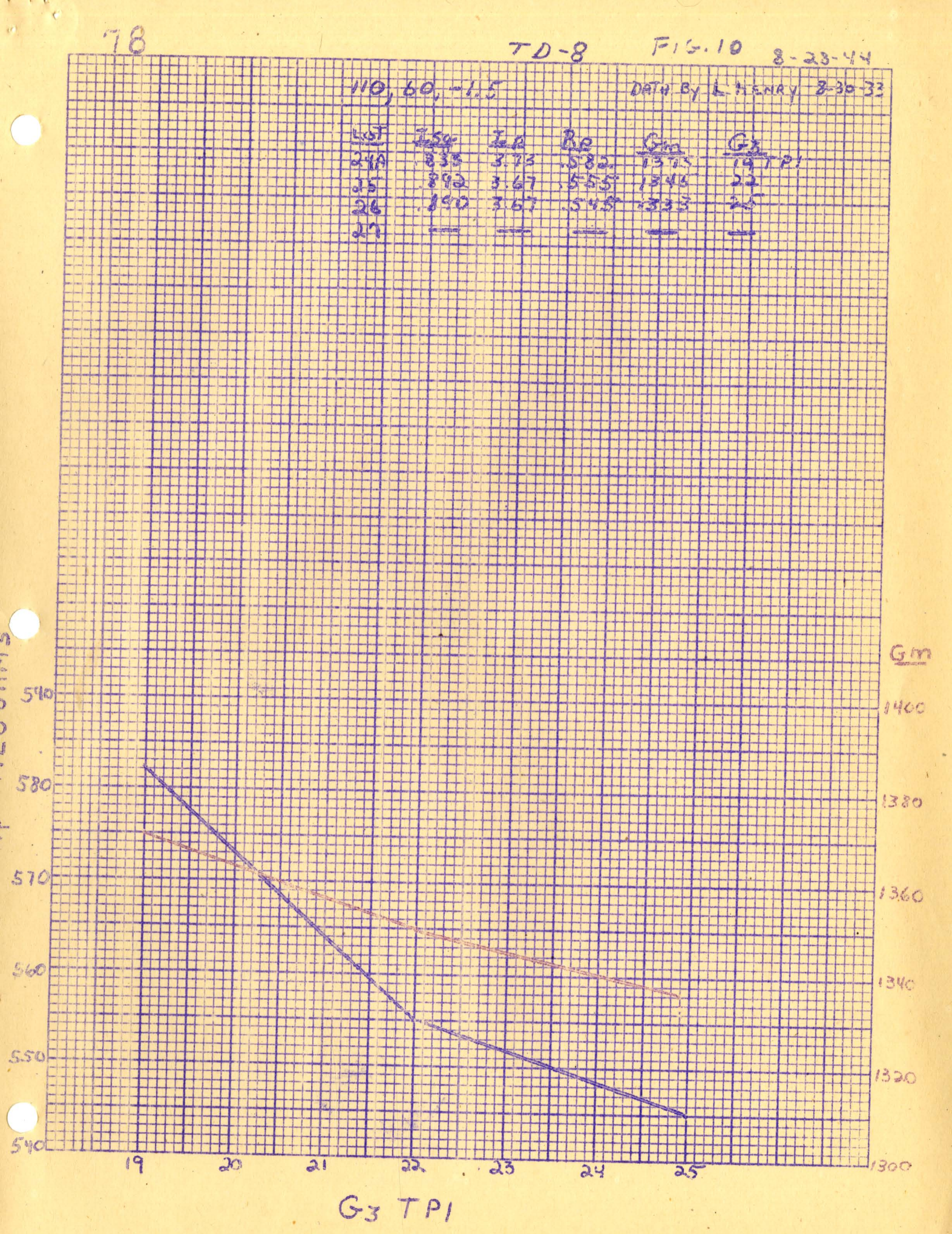
TD-8 FIG. 10 8-23-44

110, 60, -1.5 DATA BY L. HENRY 8-30-32

LOT	I_{SQ}	I_A	B_R	G_M	G_3
24A	.835	3.73	.582	1515	19 TPI
25	.892	3.67	.555	1346	22
26	.940	3.67	.545	1333	25
27	—	—	—	—	—



78 G3 TPI vs Rp TD-8 FIG. 11 8/7/40

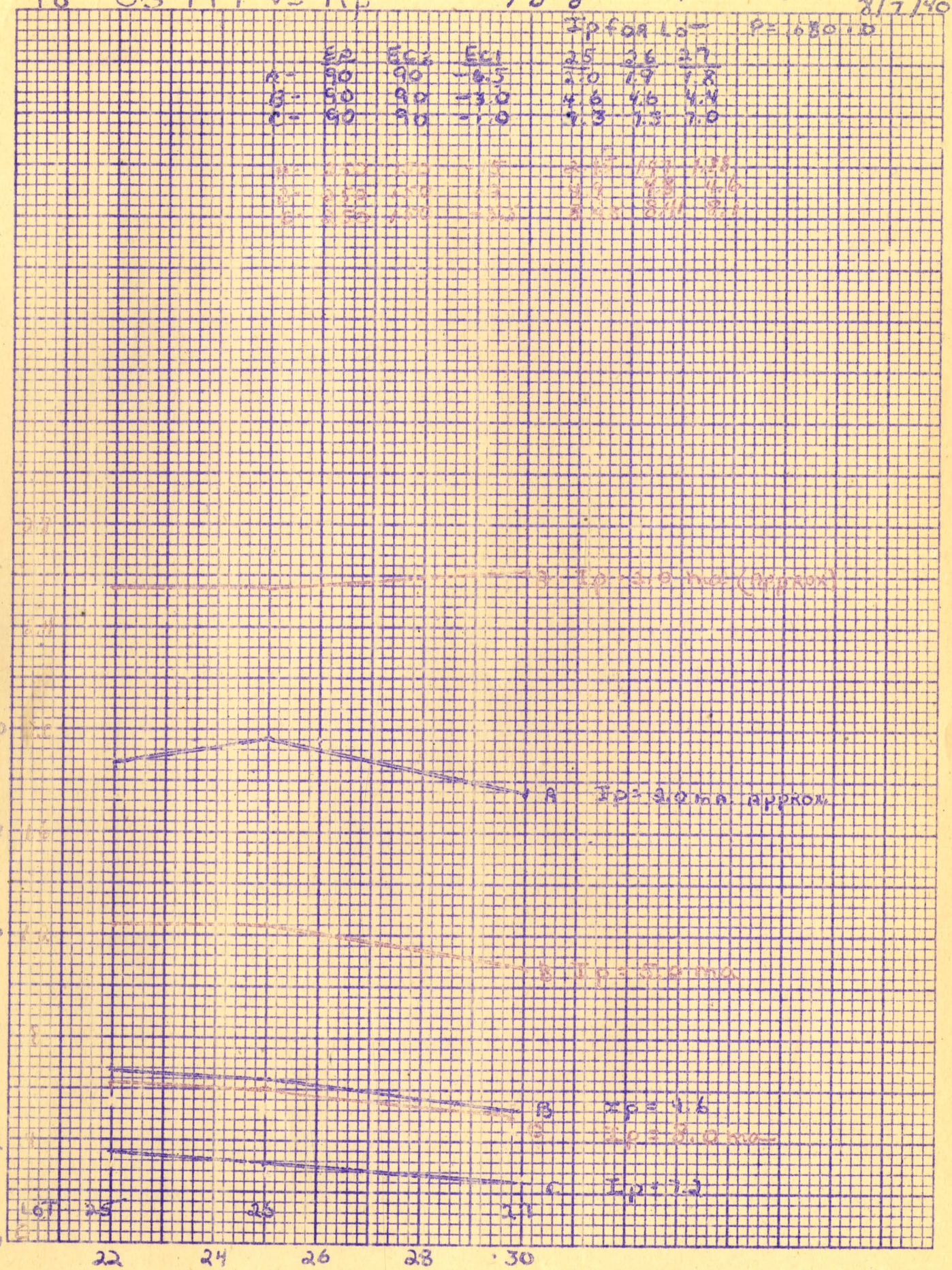


FIG. 12.

TB7 - R_p vs G3 DIAMETER TD-8 8-24-44

250, 100, -3

A ——— LOTS 32, 33
B - - - - LOTS 34, 35, 66
C ——— LOTS 37, 38, 39
D - - - - LOTS 40, 41, 42