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UNIVERSITY OF CALIFORNIA RADIATION LABORATORY

BEVATRON
D. C. MODEL MAGNET TESTS

April - September 1948

by

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CONTENTS

I. INTRODUCTION

This report is a summary of the results that were obtained from D. C. model magnet tests of the bevatron. These tests were made from April through September 1948. The main purpose of this work was to determine the magnet design that would meet the general specifications laid down by the initial calculations for the machine.

Four general types of measurements were made:

(1) Magnetization - the flux density at the gap center compared to the ampere turns applied to the magnet,

(2) Return path flux - the flux density at various positions in the iron return path compared to the number of ampere turns applied to the magnet,

(3) Uniformity - the variation of the flux density with position in the magnet gap,

(4) Coil flux linkage - the total flux linkages of the exciting coil compared to the number of ampere turns applied to the magnet.

The data for each model have been arranged in this general order.

While these tests were in progress it was decided to build the machine in two stages. The magnet for the initial stage would have a large aperture which would allow larger vertical and horizontal oscillations of the ions, and larger tolerances for the R. F. tracking system. This larger aperture design also would give smaller losses from gas scattering.

It has been assumed that the larger aperture design must be capable of being converted, by rewinding the existing coils and by adding poles to the existing steel yoke, to a magnet which will meet the specifications outlined in Section II of this report.

D. C. model magnets were used for these initial tests because they can be fabricated more cheaply and quickly than A. C. models. Also at the time these tests were made, D. C. magnetic measurements could be made with greater speed than the A. C. measurements.

Models DC6A.3 and DC6.6 were chosen as the large aperture (4' high by 14' wide) and the small aperture (1' high by 4' wide) design as a result of these tests. It was decided at this point that further tests should be made dynamically on A. C. models. The results of these A. C. tests will be covered in another report.

The results of the magnetic measurements on the quarter scale operating model which is now being constructed will be given in another report.

II. GENERAL SPECIFICATIONS

The following are the general specifications for the bevatron magnet:

A. The maximum stored energy of the magnet is not to exceed eighty megajoules.

B. The rise time to peak current should not exceed 2 seconds with 100,000 KVA. (A shorter time is preferred.)

C. The total weight of steel is not to exceed 10,000 tons.

D. The peak ampere turns is not to exceed 735,000 ampere turns.

E. The peak magnetic field at the center of the gap is to be at least 16 kilogauss.

F. The value of n is dependent on theoretical factors. This value was first taken as 0.75 and later changed to 0.73.

G. The radial width of the usable magnetic field at the injection field is not to be less than 48 inches. At the maximum magnetic field the useful radial width is not to be less than 18 inches.

H. The inside dimensions of the vacuum chamber are to be at least 12 inches in height and 48 inches in radial width.

III. QUANTITIES USED TO COMPARE MODELS

Models were made to scale in linear dimensions and coil placement. The results were computed for the full scale magnet from all quantities which were measured on model magnets. These results were compared directly with the full scale specifications.

A. The weight of the full scale magnet steel was computed from the weight of the model magnet steel scaled up.

$$T_{FS} = T_M (360^\circ/\theta) (S)^3$$

where

T_{FS} is the weight of the full scale magnet steel

T_M is the weight of model steel computed from model dimensions

θ is the "angular length" of the model in degrees

S is the scaling factor.

B. The gap height scales directly as the scaling factor, S.

C. The radial pole width scales directly as the scaling factor, S.

D. The flux density in the model and the full scale magnet are equal.

E. The number of ampere turns on the full scale magnet is computed from the model magnet.

$$(NI)_{FS} = (NI)_M(S)$$

where

$(NI)_{FS}$ is the number of ampere turns on the full scale magnet

$(NI)_M$ is the number of ampere turns on the model magnet.

F. The average volts per coil turn is computed from the total coil loop flux linkage measurements on the model magnet.

$$\phi_M = (\phi_t)_M / N_M$$

where

ϕ_M is the average flux in maxwells linking a coil turn on the model magnet

$(\phi_t)_M$ is the total measured flux linkage on the model magnet in maxwell turns

N_M is the number of turns in the coils of the model

$$\phi_{FS} = \phi_M (S)^2 (360^o/\theta)$$

where

ϕ_{FS} is the average flux in maxwells linking a coil turn on the full scale magnet

θ is the angle in degrees over which the flux linkage measurement was made

$$(V/N)_{FS} = \frac{\phi_{FS}}{t} (10^{-8})$$

where

$(V/N)_{FS}$ is the volts per turn on the exciting coils on the full scale magnet

t is the rise time in seconds.

G. The peak KVA is computed in the following manner:

$$KVA = (V/N)_{FS} (NI)_{FS} \times 10^{-3}$$

H. The useful gap width, the radial distance from $n = 1.0$ to $n = 0.5$, was determined from the radial uniformity curves. The value, n, is computed from the change in magnetic field in relation to the change in radius.

$$H = H_o (r_o/r)^n$$

$$n \ln. r_o/r = \ln. H/H_o$$

$$-n/r = (1/H) (dH/dr)$$

$$n = -(r/H) (dH/dr)$$

where

H is the magnetic field at a point

H_o is the magnetic field at gap center

r_o is the radius at gap center

r is the radius where field is H

I. The efficiency of the magnet is computed from the ratio of the mmf that appears across the center of the air gap to the total mmf produced by the current in the exciting coils.

$$(NI)g = 2.02\ (H)g(L)g$$

where

$(NI)g$ is the number of ampere turns across the air gap

$(H)g$ is the magnetic field in gauss at the center of the air gap

$(L)g$ is the length of the air gap in inches

then

$$\% \text{ Efficiency} = \frac{(NI)g \quad 100}{NI}$$

where

NI is the number of ampere turns of the exciting coils.

J. The stored energy of the full scale magnet is calculated from the total coil loop flux linkage measurements.

$$W_M = 10^{-8} \int_0^I I\ (d\phi_t)_M$$

where

W_M is the stored energy on the model magnet in joules

I is the current in amperes

$(\phi_t)_M$ is the total flux linkages in maxwell turns

$$W_{FS} = W_M\ (360^\circ/\theta)\ (S)^3$$

where

W_{FS} is the stored energy of the full scale magnet

θ is the angle of the model magnet through which the flux was measured

K. Average coil leakage coefficient is calculated from the total coil loop flux linkage measurements and the magnetization measurements.

$$L = \phi_t / NHA$$

where

L is the average coil leakage coefficient at a given current

ϕ_t is the total flux linkages in maxwell turns

N is the number of turns on the exciting coils

H is the flux density at the gap center

A is the pole area calculated from the minimum specified useful width at the injection field.

NOTE: It has been assumed for the calculation of these quantities that the flux density at the gap center is constant inside the magnet quadrant, but that it falls to zero immediately outside the end of the quadrant.

IV. TYPES OF MEASUREMENTS MADE ON DIRECT CURRENT MODEL MAGNETS

A. The flux density in the gap center was measured at various currents with a General Electric fluxmeter (Cat. No. 32C247G6) and a calibrated search coil. The search coils were approximately one centimeter high and 1 centimeter in diameter. They were wound with a large number of turns of small wire (A. W. G. #46) which gave them an effective area of approximately 1500 turns cm^2. Two procedures were used to make these measurements:

1. The search coil was held stationary while the exciting current was turned on and off. (The residual field must be added to these measurements.)
2. The exciting current was held constant while the search coil was flipped through 180°.

B. Flux in various positions in the magnetic path was measured at various exciting currents. A loop of wire was placed around the magnet part in which the flux was to be measured. This loop was connected to a fluxmeter. The observations were made when the exciting current was turned on and off.

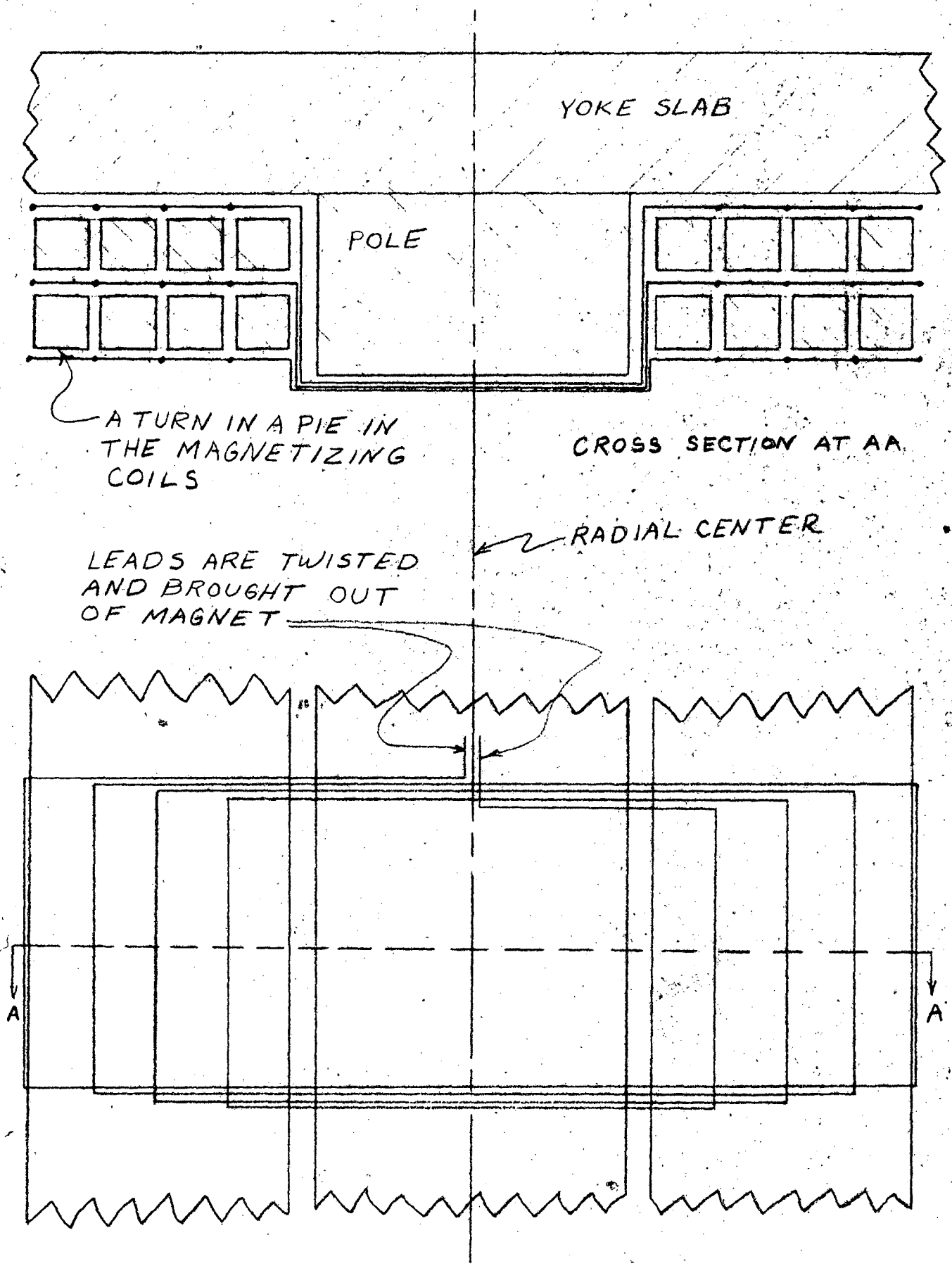
C. Coil flux linkages were measured by placing wire loops across the magnet pole end between the coil pies in such a manner that each exciting coil turn corresponded to a coil flux loop. (See sketch on following page.) The exciting current was turned on and off and deflections were observed on a fluxmeter.

D. Uniformity measurements (variations in flux density) at constant current were made within the model magnet gap along a radius and along an arc. A roving search coil, a stationary bucking coil, and a flux meter were used for these measurements. Differences in the magnetic field at a constant exciting current were measured by moving the search coil from point to point and observing the deflections on the fluxmeter.

E. Residual field measurements were made on the model magnets by flipping a search coil through 180° and observing deflections on a flux meter.

F. Stray field (flux density outside the magnet gap) was measured by the same procedure described in "D" of this section.

SCHEMATIC DRAWING OF LOOPS USED TO MEASURE COIL FLUX LINKAGES ON BEVATRON MODEL MAGNETS



Loops used to measure coil flux linkages on bevatron model magnets

BEVA 1/4 240

V. RESULTS

A. Table I

B. Models

Two types of DC model magnets were designed and tested concurrently to predict magnet performance on the full scale bevatron. One type had the exciting coils across the air gap (referred to as Type A), and the other type had the exciting coils above and below the air gap (referred to as Type B). Type B was designed with "wings" to increase the useful gap width at the injection field. These "wings" will saturate at the higher fields and give a smaller useful gap width, hence, a greater magnet efficiency.

Revised APRIL 26, 1949 A.D.

Job 94-9
4-13
D.C.S.

BEVATRON MODEL MAGNET TESTS (PAGE 1)

Model	Iron (Tons) Full Scale	Gap (Inches) Full Scale	Pole Width Inches Full Scale	Field (Gauss) Center of Gap	Amp Turns X 10^3 Full Scale	Peak KVA Full Scale (1 Sec. Rise)	Useful Gap Width (Inches) m=1/2 to m=1	Ave. Coil Leakage Coeff.	Volts Per Coil Turn	Efficiency o/o	Energy Megajoules Full Scale
DC1	9600	14	48 (+ wings) (72)	16000 245	9.0	236,000	5 46	1.40	261	50	67.9
DC3	7950	14	54	16000 230	5.0	127,000	22 26	1.35	253	91	63.2
DC3A	8650	26	108	8600	5.0	126,000	~73 ~73	1.26	251	91	~63.2
DC4	9800	14	48 (+ wings) (66)	16000 379	7.0	206,000	18 ~40	1.58	293	65	80.3
DC4B	9800	14	48 BENT (+ wings) (66)	16000 208	7.1		20 ~ .52			64	
DC4C	9800	14	66	16000	8.0	256,000		1.76	320	56	~96.5
DC5A	8900	26	108	8000 197	4.4	100,000	94 95	1.20	226	94	62.2
DC5	8050	14	54	14100 205	4.3	107,000	44 44	1.40	250	94	
Ideal		14	48	16000	4.52	84,500	48	1.00	187	100	42.3
		26	96	8000	4.20	78,500	96	1.00	187	100	39.3
		54	168	4000	4.36	71,100	168	1.00	163	100	35.5
DC6A	8700	54	179.25	5000	6.63	147,700		1.18	223	82.5	67.0
DC6	9930	14	48 (+ wings) (66)	16000	7.27	217,800		1.61	299	62.2	81.3
DC6.1	9930	14	48(+ WINGS 66)	16000	7.09	204,800		1.55	289	63.9	79.2
DC6A.1	8700	54	179.25	5300	7.06	157,000	135	1.12	222	82.9	69.1

BEVATRON MODEL MAGNET TESTS (PAGE 2)

MODEL	IRON (TONS) (F.S.)	GAP (INCHES) (F.S.)	POLE WIDTH (INCHES) (F.S.)	FIELD (GAUSS) GAP CENTER	AMPERE TURNS X10⁵ (F.S.)	PEAK KVA (1 SECOND RISE) (F.S.)	USEFUL GAP WIDTH (INCHES) n=0.5 TO n=1	AVE. COIL LEAKAGE COEFF.	VOLTS PER COIL TURN	EFF. (IN %)	ENERGY (MEGA JOULES) (F.S.)
DC6A	8700	54	179.25	5000	6.63	147,700		1:18	223	82.5	67.0
DC6	19930	14	48 + WINGS 66	16000	7.27	217,800		1.61	299	62.2	81.3
DC6.1	9930	14	48 + WINGS 66	16000	7.09	204,800		1.55	289	63.9	79.2
DC6A.1	8700	54	179.25	5300	7.06	157,000	135	1.12	222	82.9	69.1
DC6A.2	8790	54	179.25	5300	7.21		135			80.7	
DC6.2	10190	14	48 + WINGS 66	16000	6.65					68.0	
DC6.3	10450	14	48 + Wings 66	16000	6.47					69.7	
DC6.4	10090	14	48 + WINGS 66	16000	6.81					66.4	
DC6.5	10,020	14	48 + WINGS 66	16000	6.85	188,000		1.47	275	66.0	73.0
DC6.6	10,180	14	48 + WINGS 66	16000	6.56					69.0	
DC6.7	10,340	14	48 + WINGS 66	16000	6.45					70.2	
DC6.8	10,440	14	48 + WINGS 66	16000	6.49					69.9	
DC6.9	10,290	14	48 + WINGS 66	16000	6.58					68.9	
DC6A.3	8950	54	179.25	5350 5300	7.06 6.96	158,000	141	1.12	224	82.7 83.0	69.7
DC6A.4	8950	54	179.25	5300	6.72					86.1	
DC6A.5	8950	54	179.25	5300	6.61					87.5	
DC6A.6	8950	54	179.25	5300	6.68					86.5	

1 Model Magnet DC1 Index

a. Discussion

b. Sketch

c. Photographs

BEVA 15

BEVA 13

d. Graphs

L-DC1-1 (cor)	Efficiency and leakage coefficients
H-DC1-1	Flux density around the magnetic path
U-DC1-1	Radial uniformity
U-DC1-1a	Radial uniformity - Expanded
F-DC1-1 (cor)	Coil flux linkage
F-DC1-1a (cor)	Total coil flux linkage
E-DC1-1 (cor)	Stored energy
S-DC1-1	Stray field

1 Model Magnet DC1

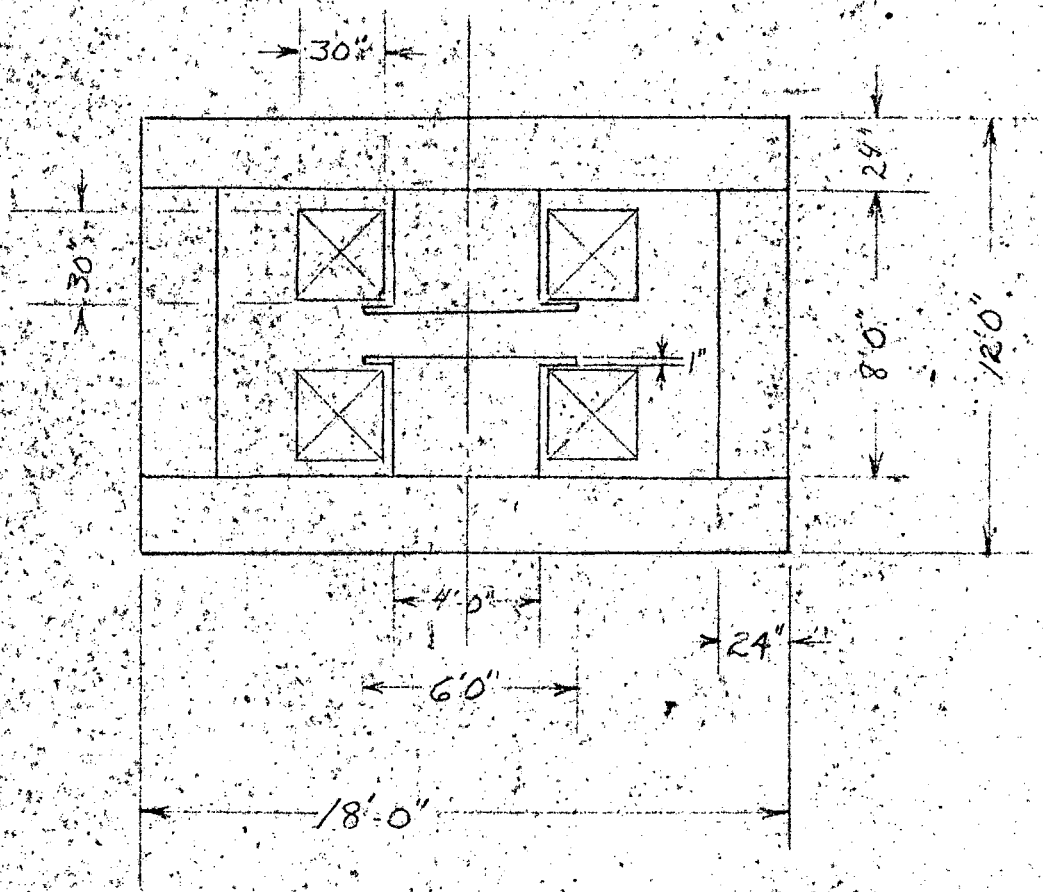
a. Discussion

Bevatron model magnet DC1 was the first attempt to make a DC model (type B) to predict performance of the magnet for a full scale bevatron.

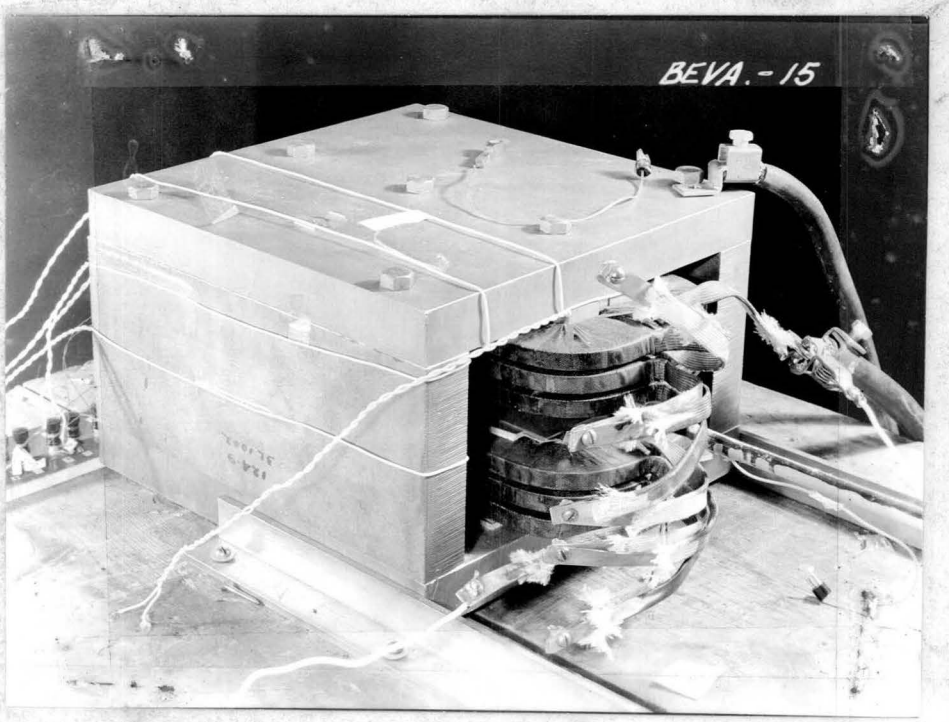
This magnet failed to meet some of the general specifications. (See Section II and Table I) The ampere turns required were 9.0×10^5 instead of the specified 7.35×10^5. The peak KVA required was 236×10^3 for a rise time of one second. The specified 100×10^3 KVA is for a rise time of not greater than 2.0 seconds. The useful gap was 5 inches when the magnetic field strength was 16 kilogauss at the gap center instead of the specified 18 inches.

The efficiency of this magnet was only 50 percent. The flux loop measurements showed that a portion of the iron in the magnetic path reached saturation when the field in the gap was approximately 15,000 gauss. It was decided that drastic design changes should be made. These changes will be shown in the following model. (See model DC4)

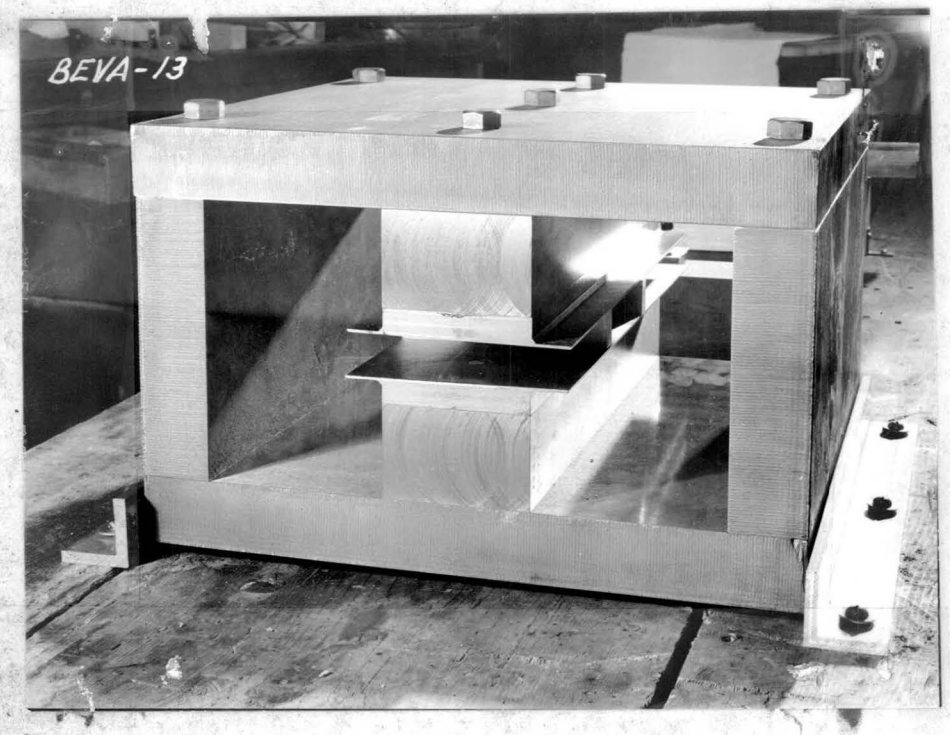
BEVATRON MODEL MAGNET DC 1



GAP 14"
RADIUS 50'
$n = 0.75$
MODEL COILS: 6 COILS 25 TURNS EACH = 150 TURNS
DIMENSIONS ARE FULL SCALE
MODEL IS 1/16 SCALE
ASSEMBLY DWG. 3L 1062



BEVA 15



BEVA 13

Bevatron Model Magnet DC1

4-28-48.
CORRECTED

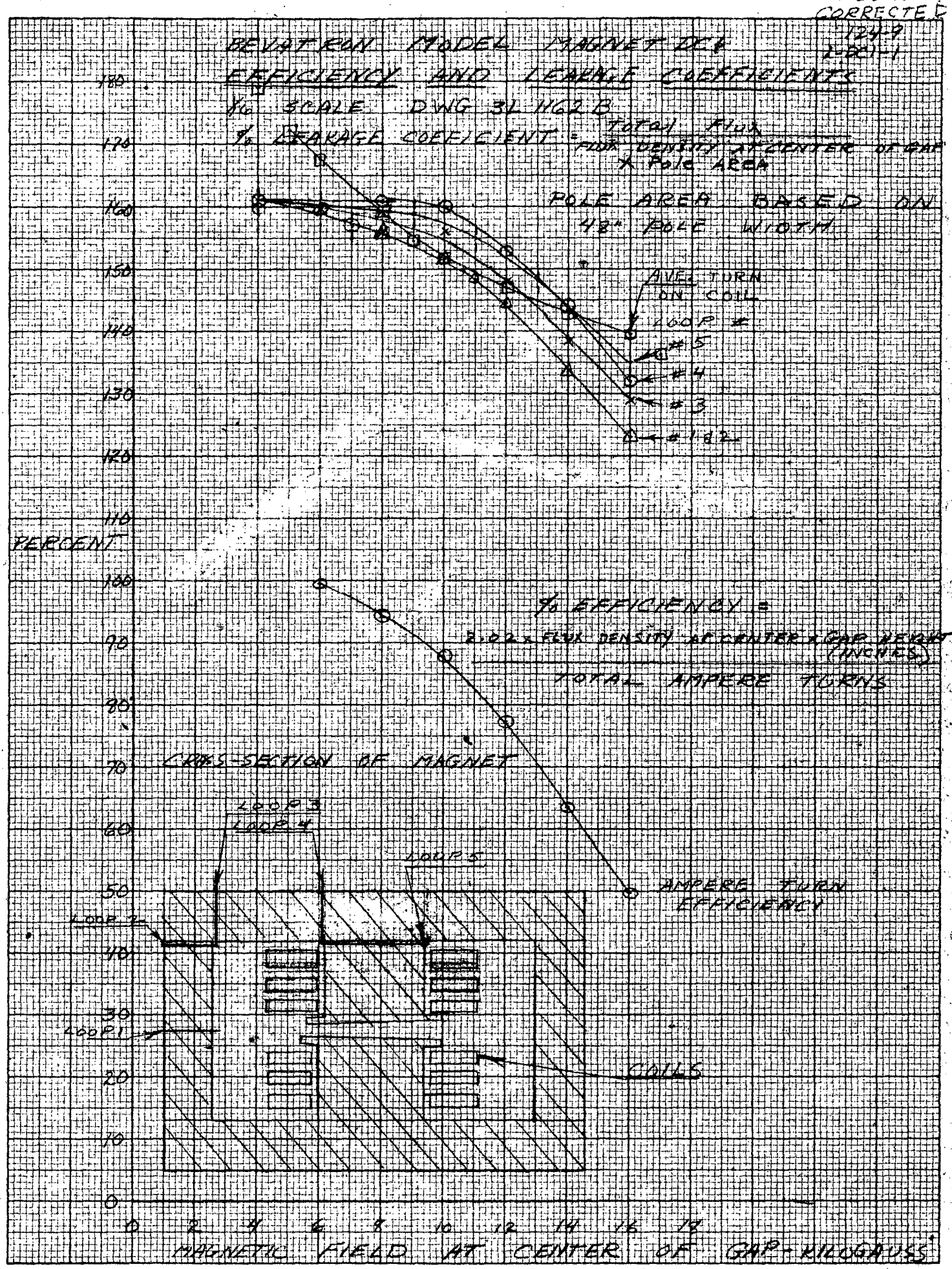
124-9
L-821-1

REVATRON MODEL MAGNET DEF
EFFICIENCY AND LEAKAGE COEFFICIENTS

% SCALE DWG 3L 1462 B

% LEAKAGE COEFFICIENT = $\frac{\text{Total Flux}}{\text{Flux Density at Center of Gap} \times \text{Pole Area}}$

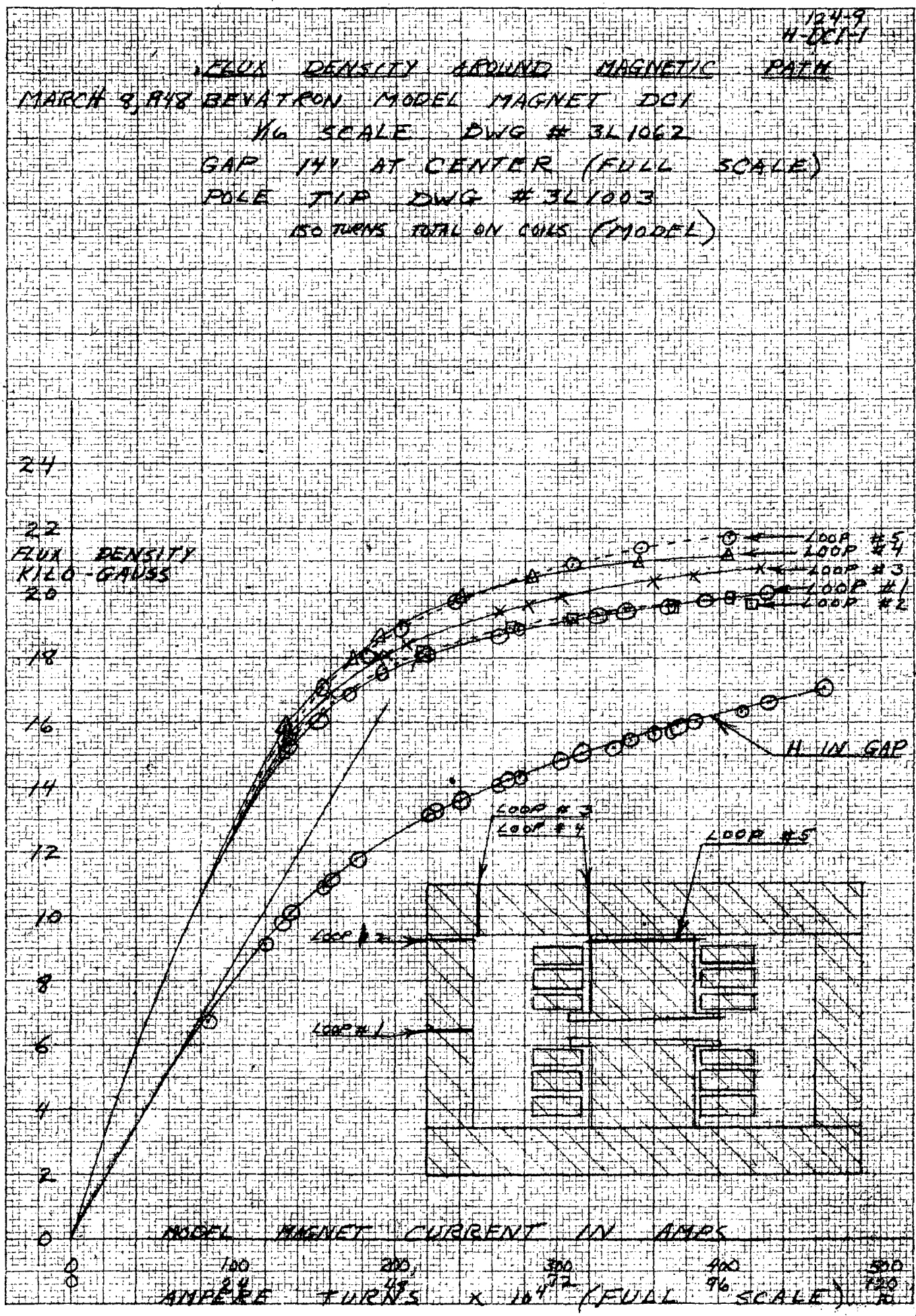
POLE AREA BASED ON 48" POLE WIDTH

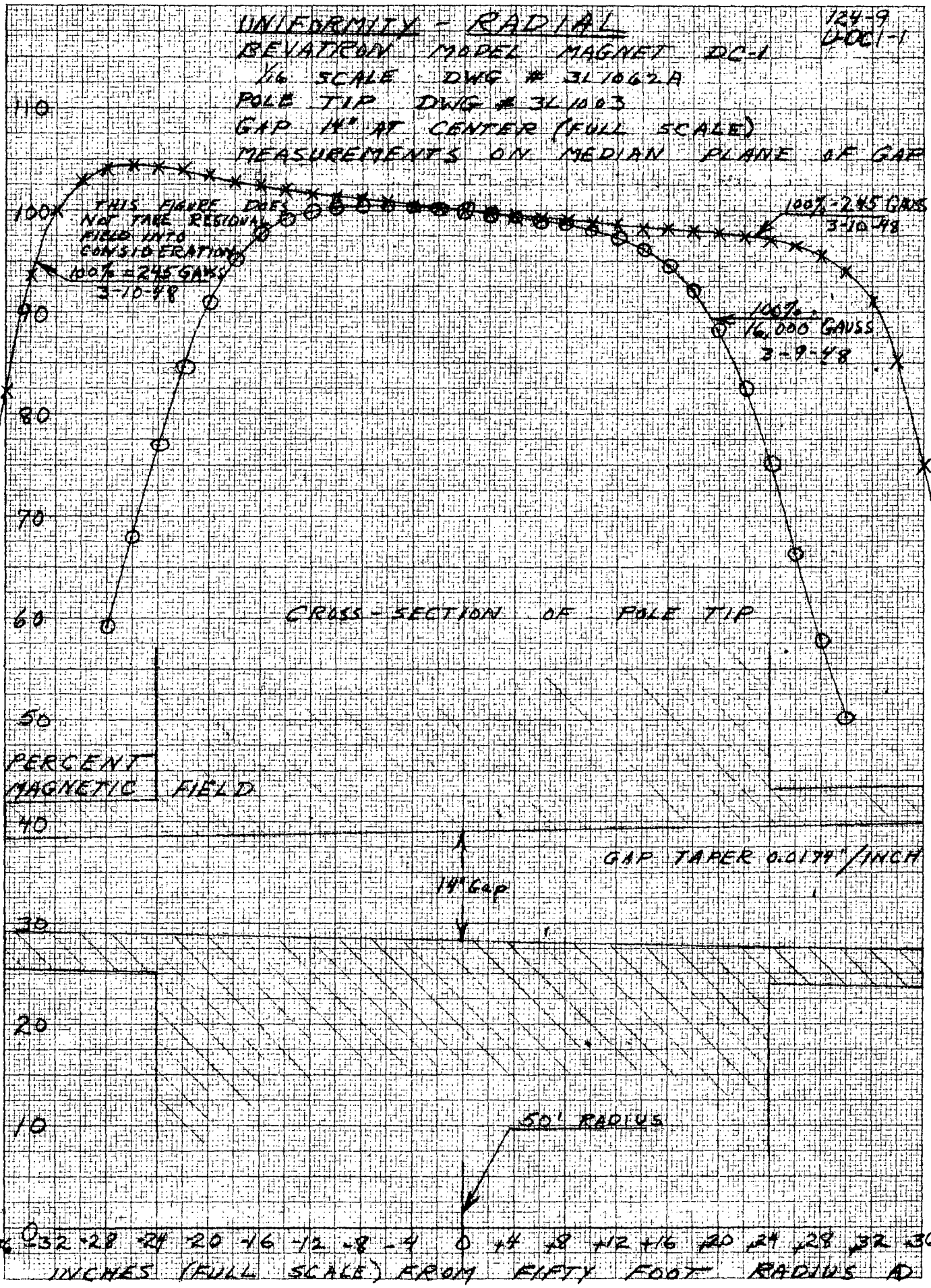


AD

124-9
H-DC1-1

FLUX DENSITY AROUND MAGNETIC PATH
MARCH 9, 1948 BEVATRON MODEL MAGNET DC1
1/6 SCALE DWG # 3L1062
GAP 14" AT CENTER (FULL SCALE)
POLE TIP DWG # 3L1003
150 TURNS TOTAL ON COILS (MODEL)

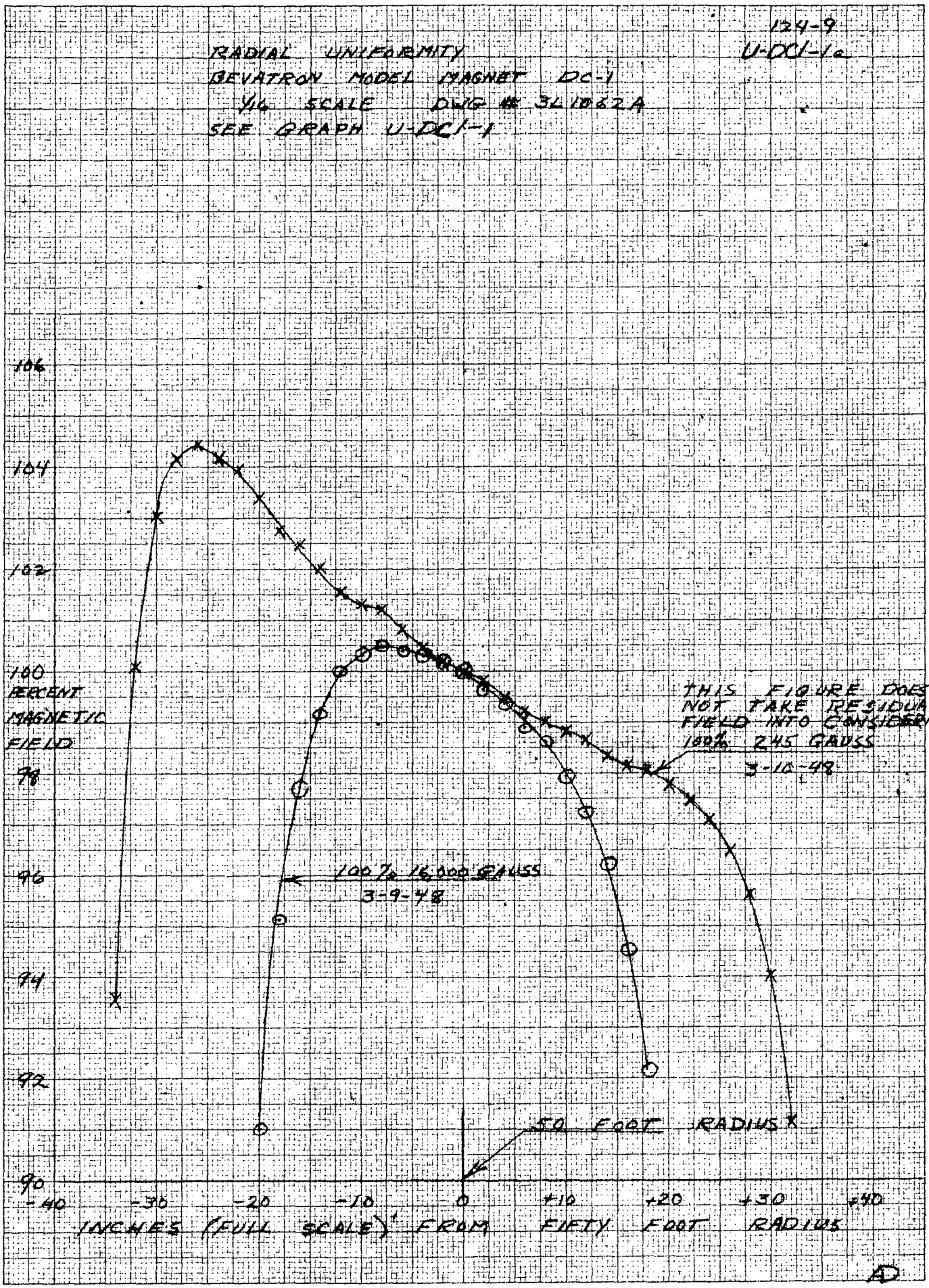




124-9

U-DC1-1a

RADIAL UNIFORMITY
BEVATRON MODEL MAGNET DC-1
1/6 SCALE DWG # 34 1062 A
SEE GRAPH U-DC1-1



KEUFFEL & ESSER CO., N. Y. NO. 359-14
Millimeters, 20th lines to inch.
MADE IN U.S.A.

121-8

F-DC1-1

CORRECTED 4-19-48

APRIL 19, 1948

ELEVATION MODEL MAGNET DC4

COIL FLUX LINKAGE

½ SCALE DWG 3L 1062

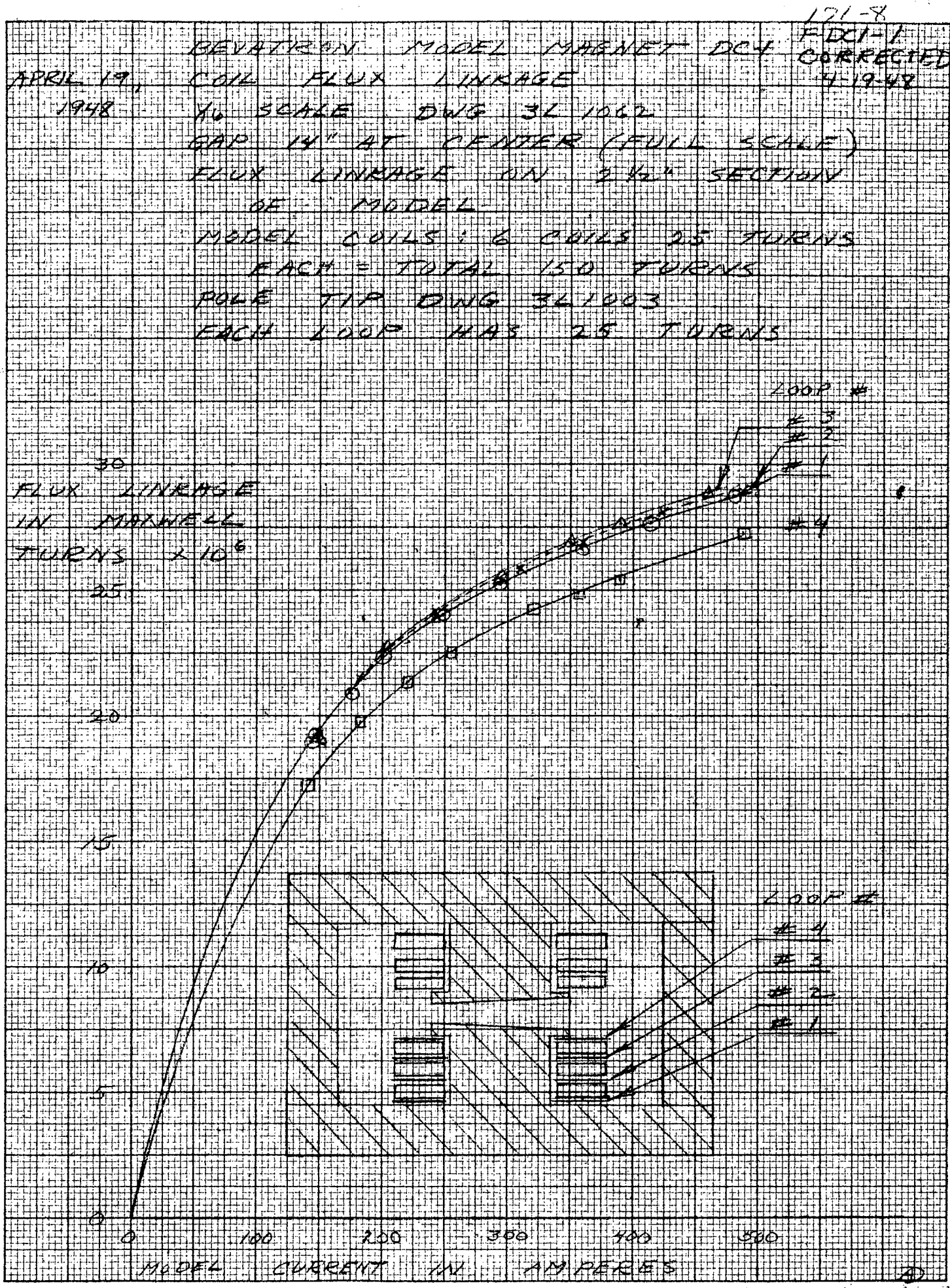
GAP 1¼" AT CENTER (FULL SCALE)

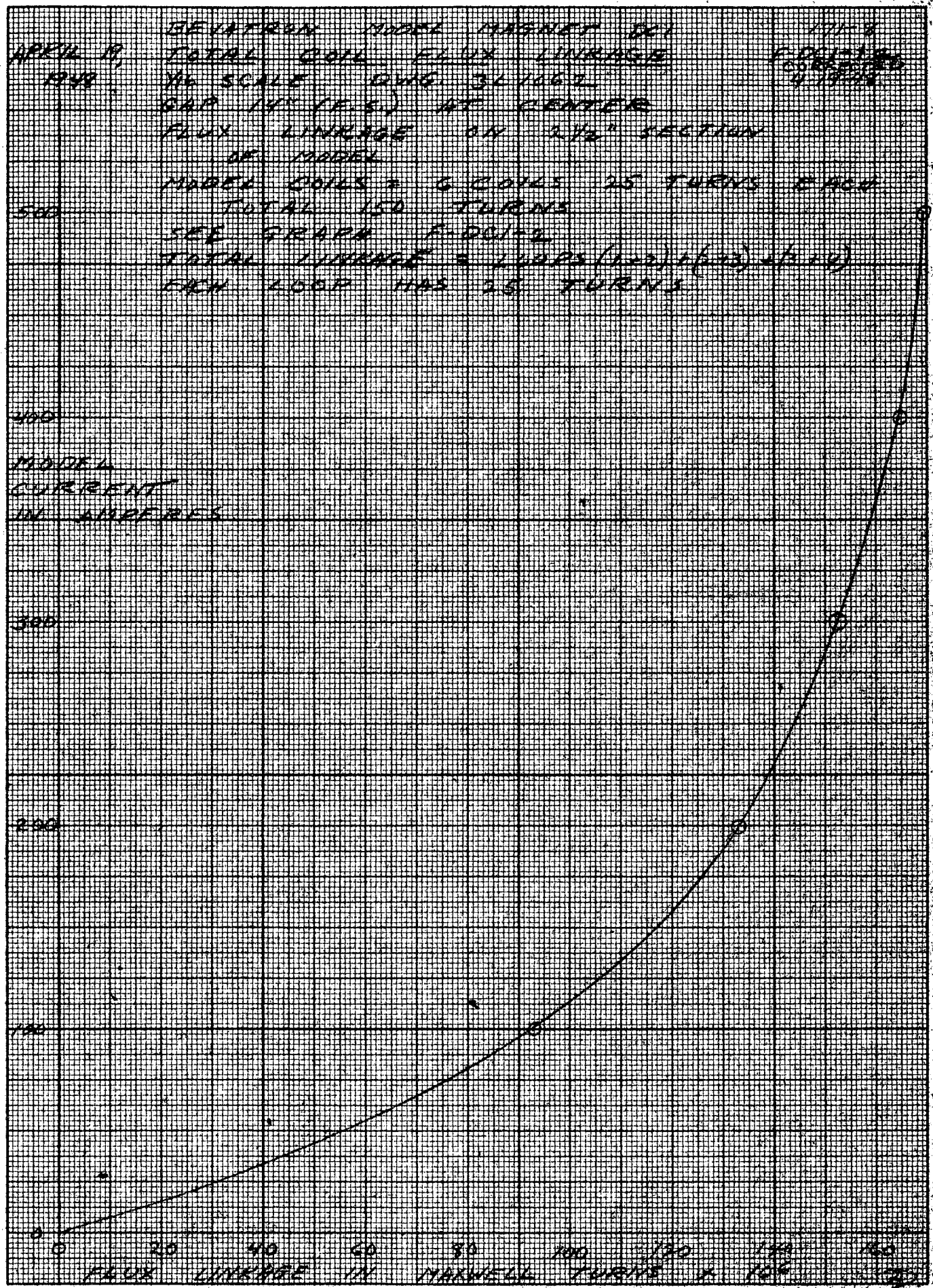
FLUX LINKAGE ON 2½" SECTION OF MODEL

MODEL COILS: 6 COILS 25 TURNS EACH = TOTAL 150 TURNS

POLE TIP DWG 3L 1003

EACH LOOP HAS 25 TURNS



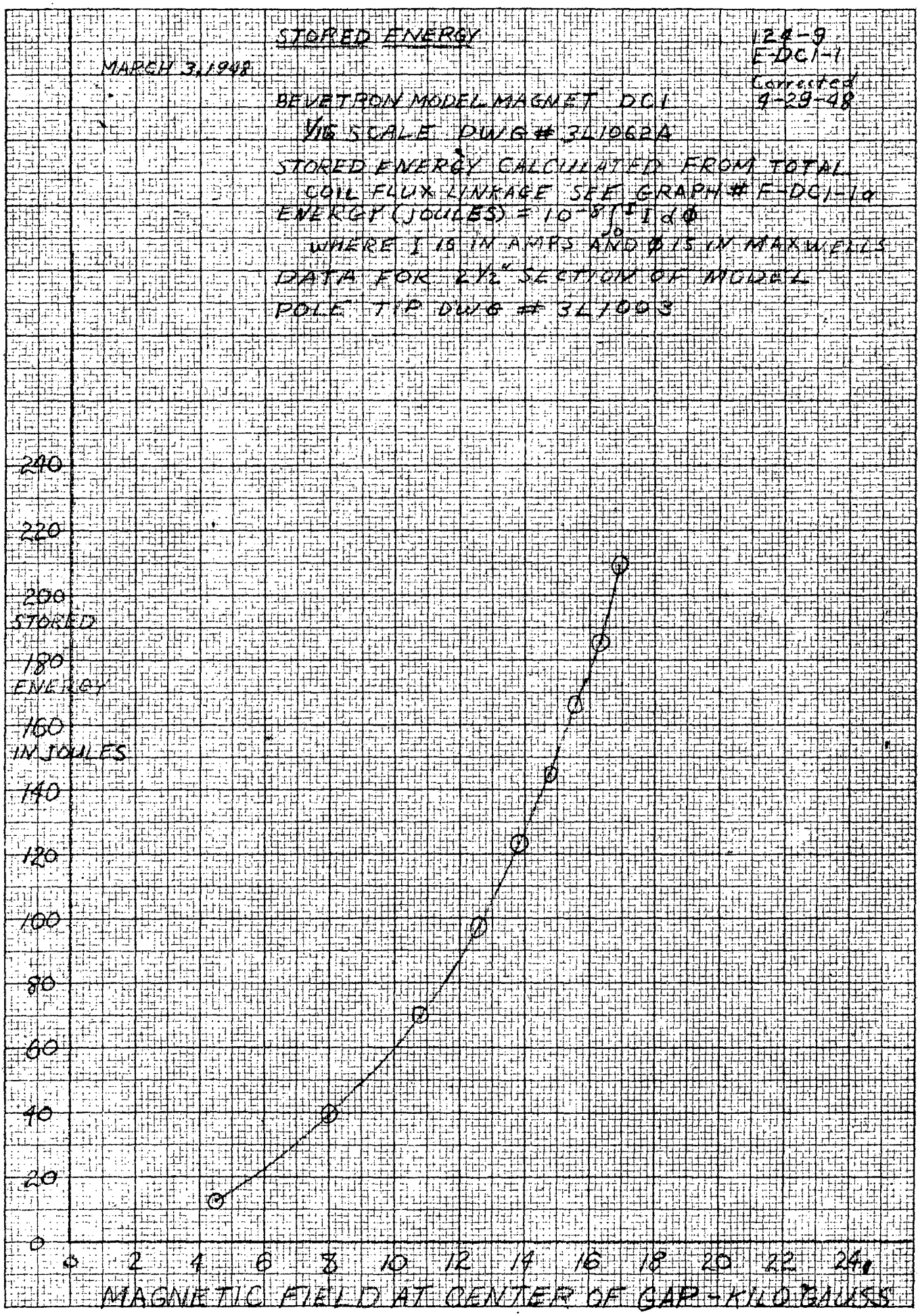


STORED ENERGY

124-9
E-DC1-1
Corrected
9-29-48

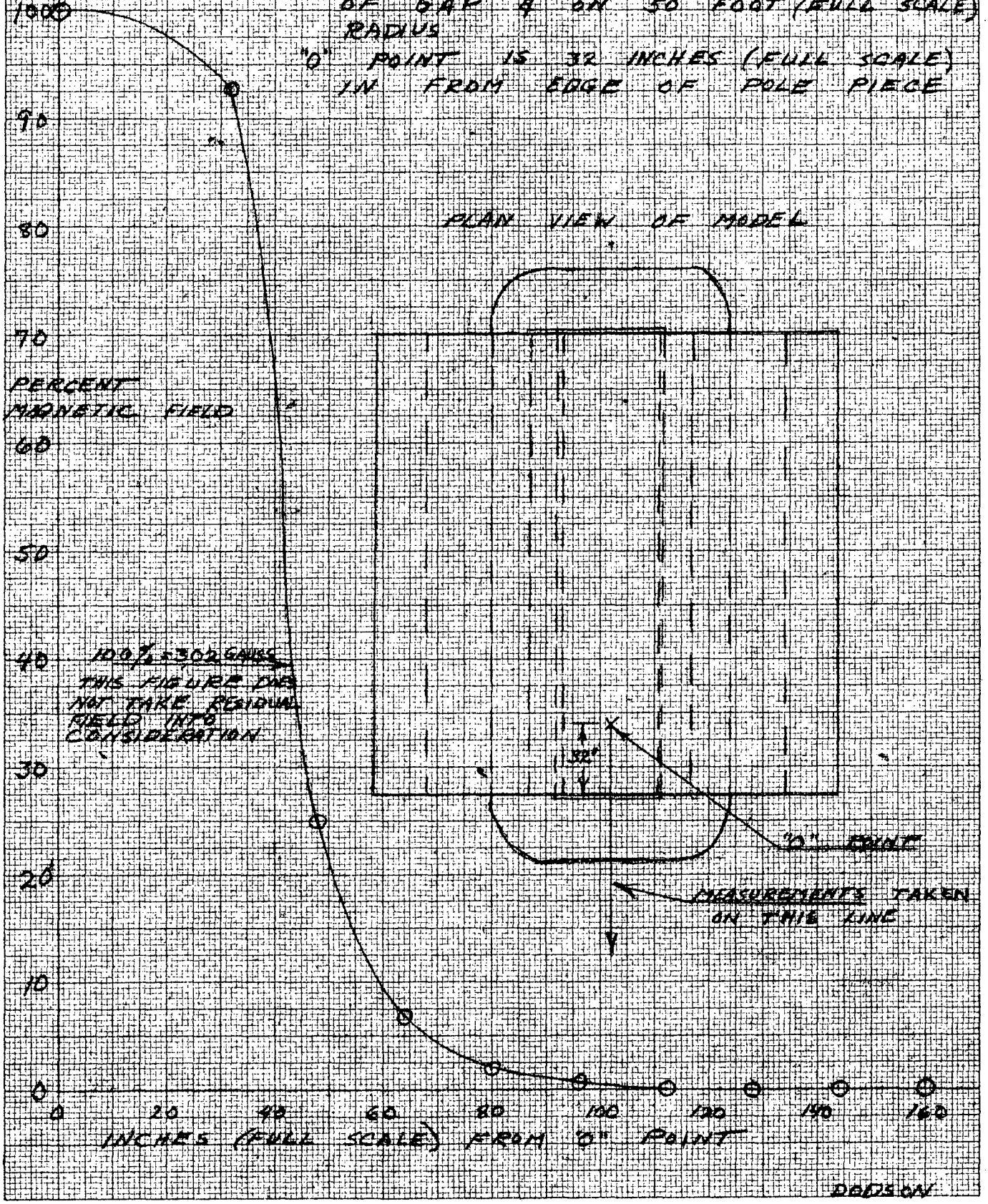
MARCH 3, 1948

BEVATRON MODEL MAGNET DC1
1/16 SCALE DWG # 3L1062A
STORED ENERGY CALCULATED FROM TOTAL COIL FLUX LINKAGE SEE GRAPH # F-DC1-1a
ENERGY (JOULES) = $10^{-8} \int_0^{\Phi} I \, d\Phi$
WHERE I IS IN AMPS AND Φ IS IN MAXWELLS
DATA FOR 2½" SECTION OF MODEL
POLE TIP DWG # 3L1003



STRAY FIELD

MARCH 17, 1948 ELEVATION MODEL MAGNET DC1
1/4 SCALE DWG # 3L 1062A
MEASUREMENTS ON MEDIAN PLANE
OF GAP 4 ON 50 FOOT (FULL SCALE)
RADIUS
"0" POINT IS 32 INCHES (FULL SCALE)
IN FROM EDGE OF POLE PIECE



DEDSON

2 Model Magnet DC4 Index

a. Discussion

b. Sketch

c. Photographs

BEVA 17

d. Graphs

L-DC4-1	Efficiency and leakage coefficients
H-DC4-1	Flux density around the magnetic path
H-DC4-2	H in the gap center
U-DC4-1	Radial uniformity
U-DC4-1a	Radial uniformity - Expanded
F-DC4-1	Coil flux linkage
F-DC4-1a	Total coil flux linkage
F-DC4-2	Coil flux linkage (Low field)
F-DC4-2a	Total coil flux linkage - low field
E-DC4-1	Stored energy

2 Model Magnet DC4

a. Discussion

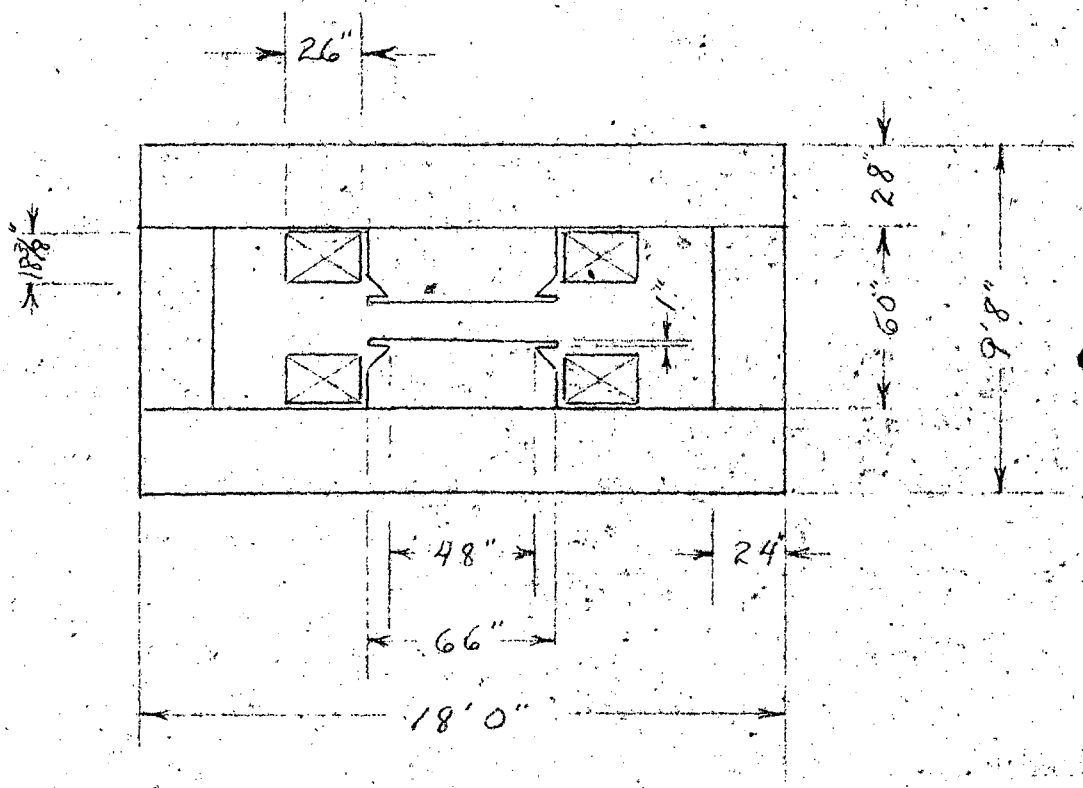
Bevatron model magnet DC4 was designed to correct faults observed in the tests made on model DC1. The thickness of the yoke slabs was increased. The distance between the yoke slabs was decreased. The height of the poles and the total radial width of the poles were decreased. Notches were cut in the pole pieces to form "wings", but the same radial width at the base of the pole was retained. The cross-sectional area of the exciting coils was decreased.

Model DC4 failed to meet some of the general specifications. (See Section II and Table I.) The peak KVA required was 206×10^3 for a rise time of one second. The specified 100×10^3 KVA is for a rise time of not greater than 2.0 seconds. The radial width of the usable field at injection field was 40 inches instead of the specified 48 inches.

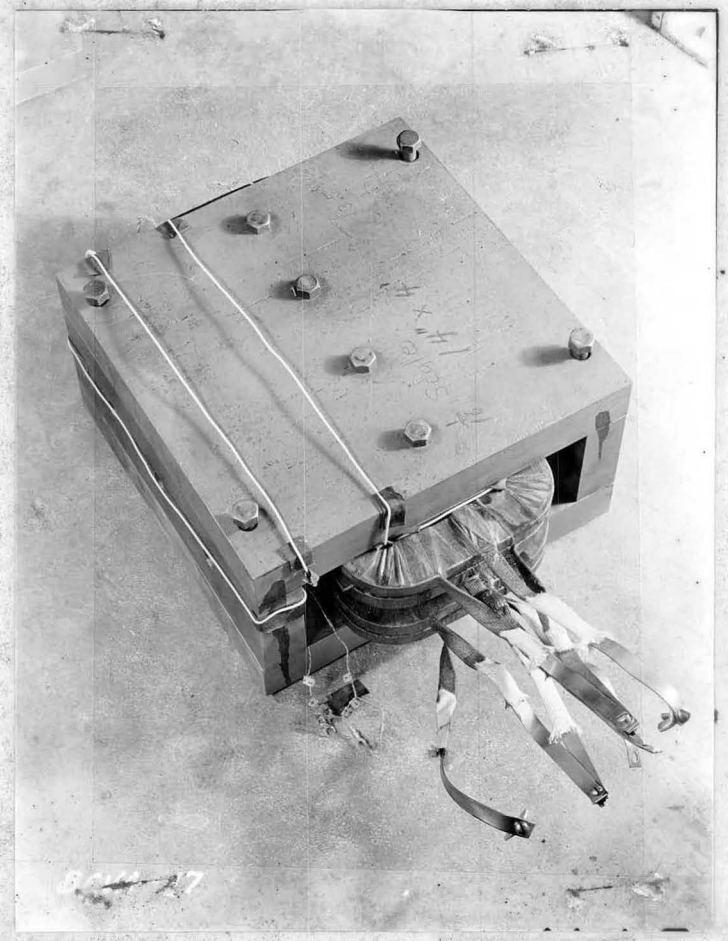
A comparison of magnet performance on DC4 and DC1 shows some improvements. The number of ampere turns required was decreased from 9.0×10^5 to 7.0×10^5. The peak KVA required was decreased from 236×10^3 to 206×10^3 for a rise time of one second. The useful gap width at 16 kilogauss field was increased from 5 inches to 18 inches. The efficiency of the magnet was increased from 50 percent to 65 percent.

It was decided to change the profile of the pole pieces to increase the useful width of the magnetic field at the injection field. (See DC4B and DC4C.)

BEVATRON MODEL MAGNET DC 4

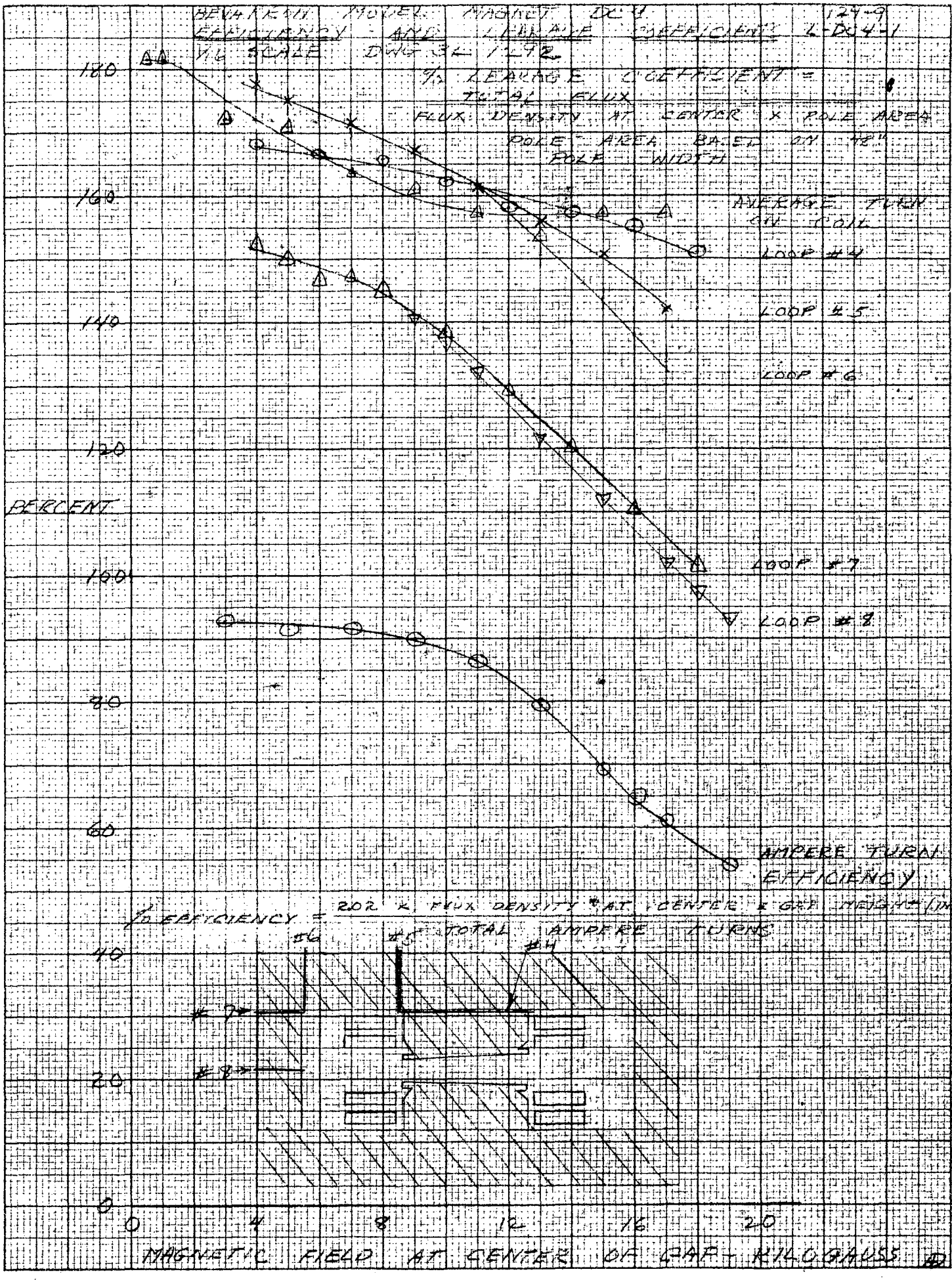


GAP 14"
RADIUS 50'
$n = 0.75$
MODEL COILS: 4 COILS 23 TURNS EACH = 92 TURNS
DIMENSIONS ARE FULL SCALE
MODEL IS 1/16 SCALE
ASSEMBLY DWG. 3L1292
POLE TIP DWG. 3L 1262-1



BEVA 17

Bevatron model magnet DC4



DEVIATRON MODEL MAGNET DC 4 124-9

FLUX DENSITY AROUND MAGNETIC PATH M-DC4-1

4-1-48

APRIL 1, '48

1/16 SCALE DWG 3L 1291A

GAP 14" AT CENTER (FULL SCALE)

92 TURNS TOTAL ON MODEL COILS

LOOP #5

LOOP #6

LOOP #4

¼ IN GAP

LOOP #7

LOOP #8

FLUX DENSITY KILO-GAUSS

22

20

18

16

14

12

10

8

6

4

2

0

LOOP POSITIONS

#6 #5 #4

#7

#8

AMPERE TURNS x 10³ (FULL SCALE)

30 60 90 120

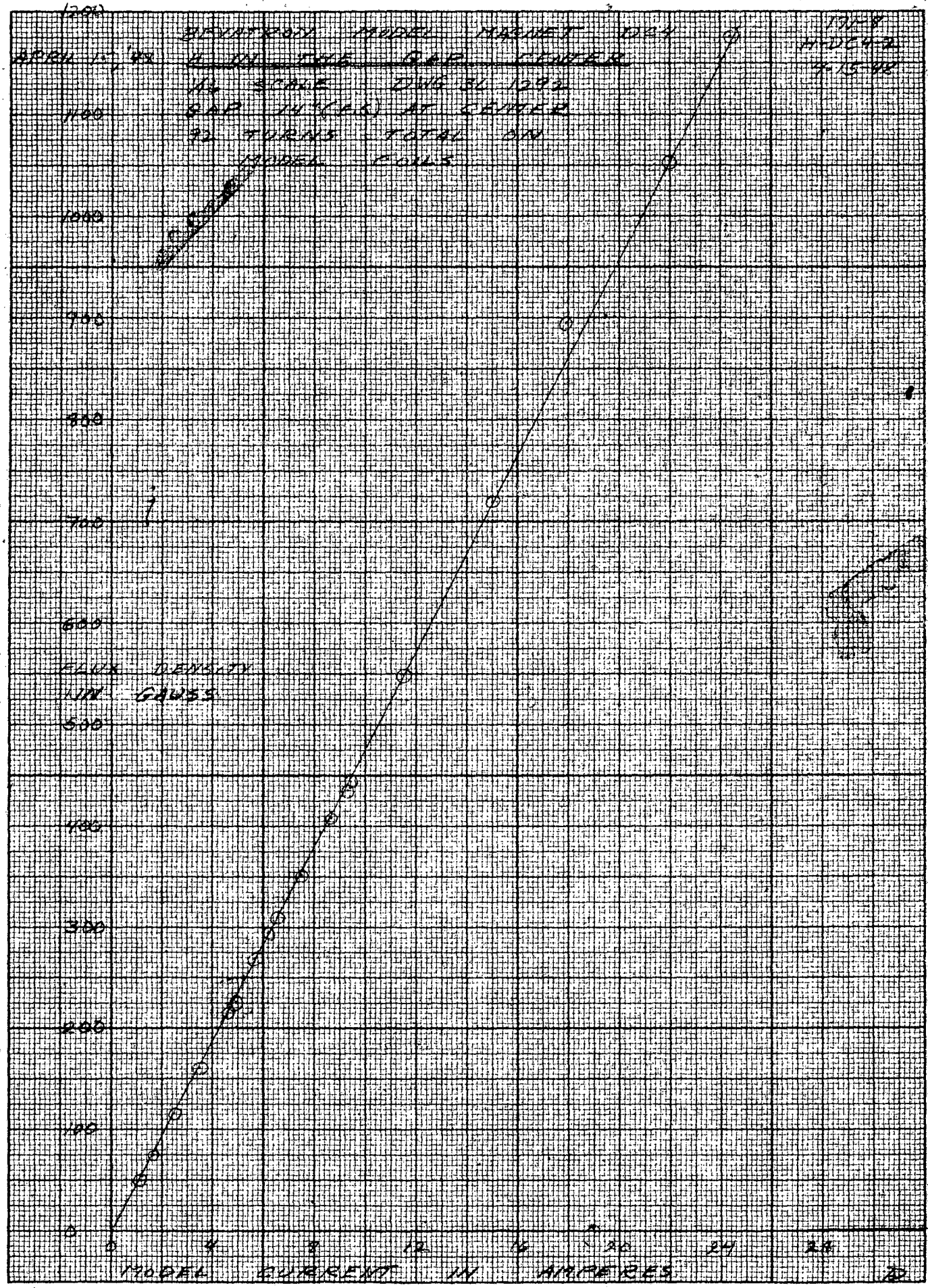
100 200 300 400 500 600 700 800

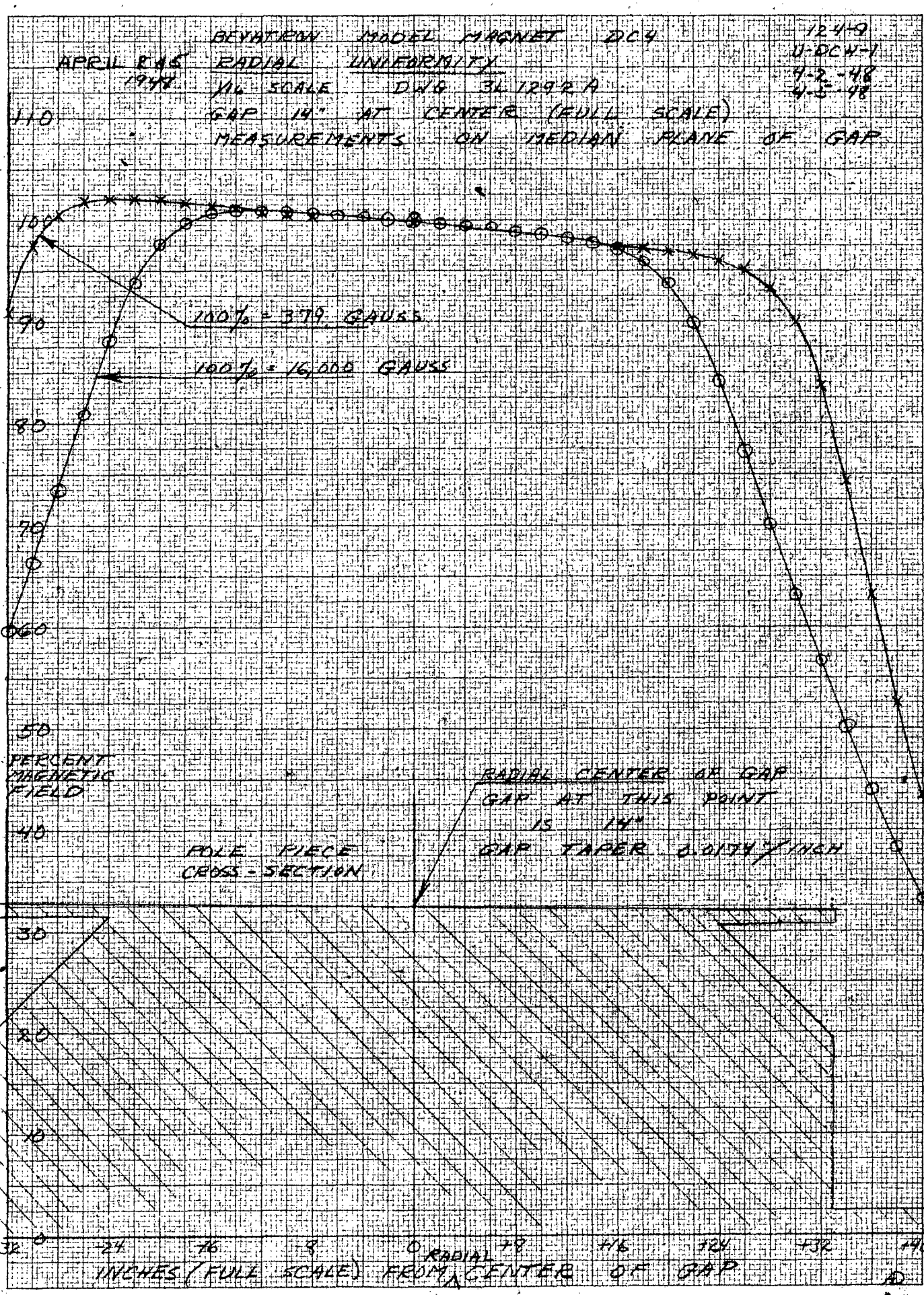
MODEL CURRENT IN AMPERES

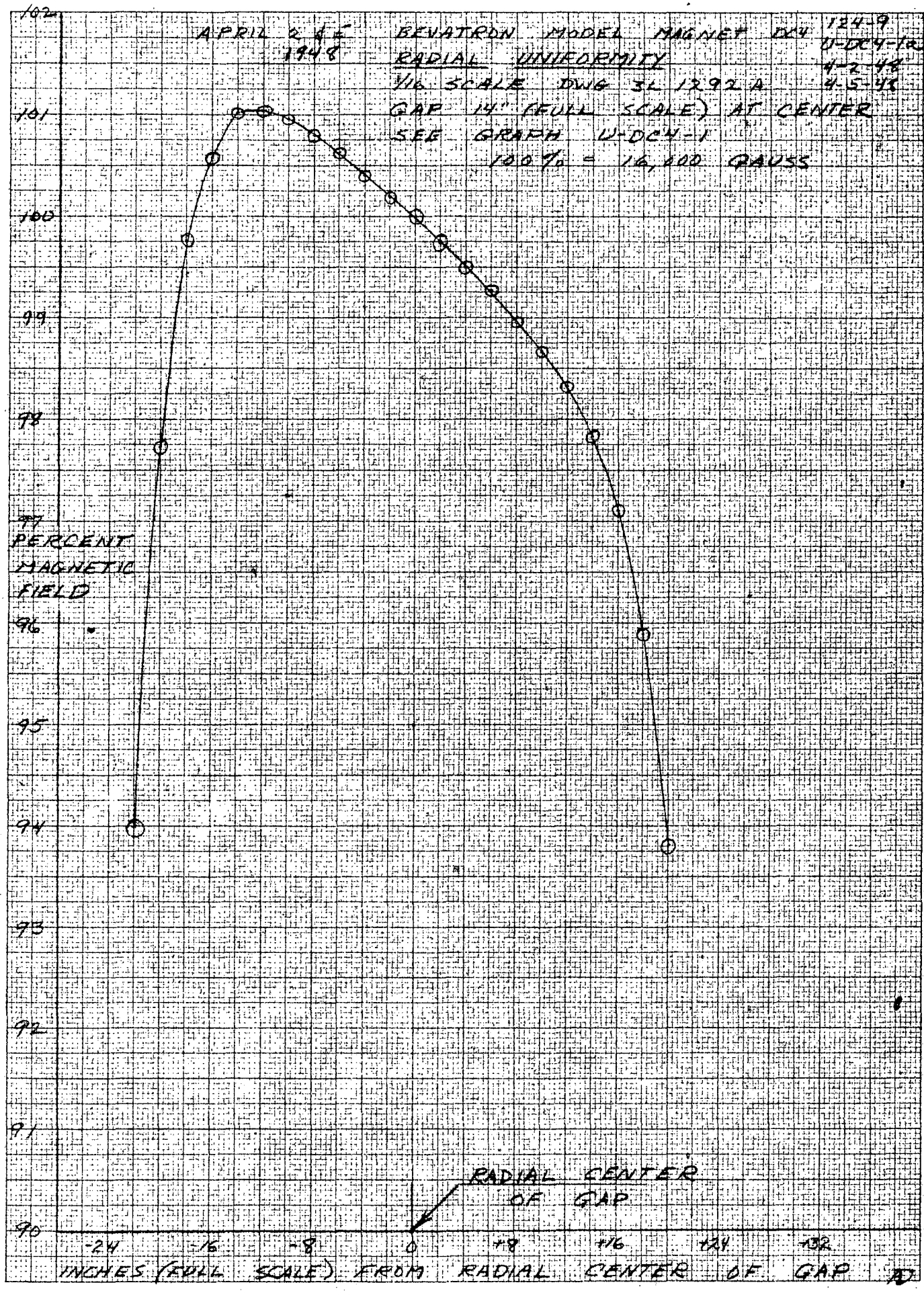
KEUFFEL & ESSER CO., N. Y. NO. 368-14

Millimeters, 10th line heavy.

MADE IN U.S.A.







124-9
F-DC4-1
4-1-48

BEVATRON MODEL MAGNET DC4

COIL FLUX LINKAGE

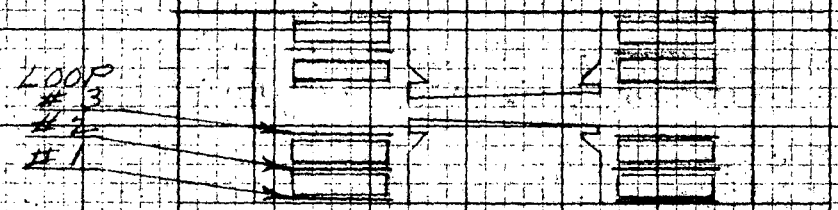
APRIL 1, 1948 Y/C SCALE DWG. # 3L 12824

GAP 14" AT CENTER (FULL SCALE)

FLUX LINKAGE ON 2½" SECTION OF MODEL

MODEL COILS : 4 COILS 23 TURNS EACH
92 TURNS TOTAL

EACH LOOP HAS 23 TURNS



LOOP II

FLUX LINKAGE IN MAXWELLS TURNS x 10^6

40
30
20
10
0

0 100 200 300 400 500 600

MODEL CURRENT IN AMPERES

AD

APRIL 1, '48

DEVATRON MODEL MAGNET DC4

TOTAL COIL FLUX LINKAGE

½ SCALE DWG 3L 1292A

GAP 1¼" AT CENTER (FULL SCALE)

FLUX LINKAGE ON 2½" SECTION OF MODEL

MODEL COILS: 4 COILS 23 TURNS EACH. 92 TURNS TOTAL

SEE GRAPH F-DC4-1

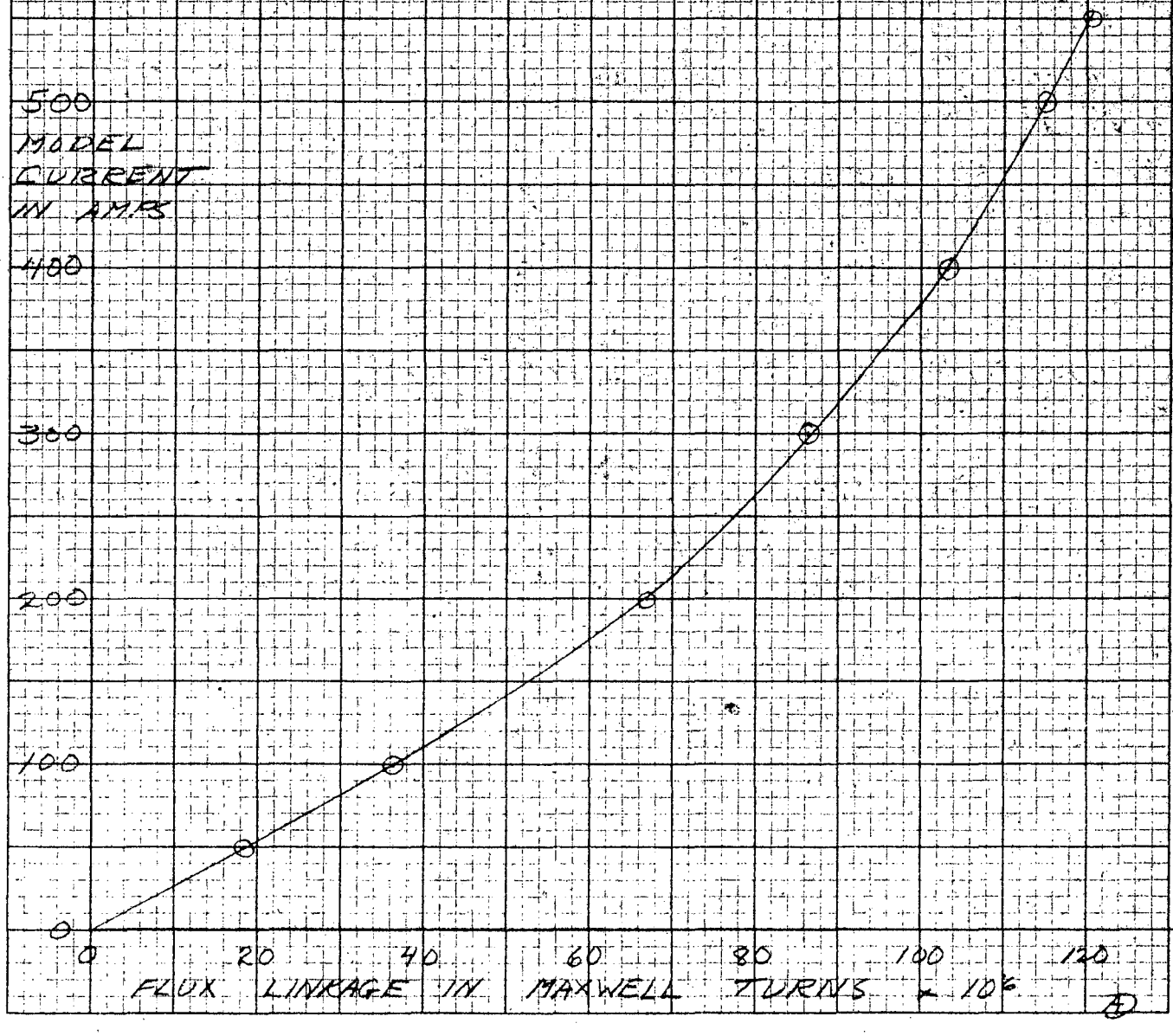
TOTAL LINKAGE = (LOOP 1+2) + (LOOP 2+3)

EACH LOOP HAS 23 TURNS

124-9

F-DC4-1a

4-1-48



KEUFFEL & ESSER CO., N. Y. NO. 359-6
7 × 5 to the ½ inch.
MADE IN U.S.A.

BEVATRON MODEL MAGNET DCY F-DCY-2

APRIL 16, 48 COIL FLUX LINKAGE 4-16-48

ALL SCALE DWG 32 12924

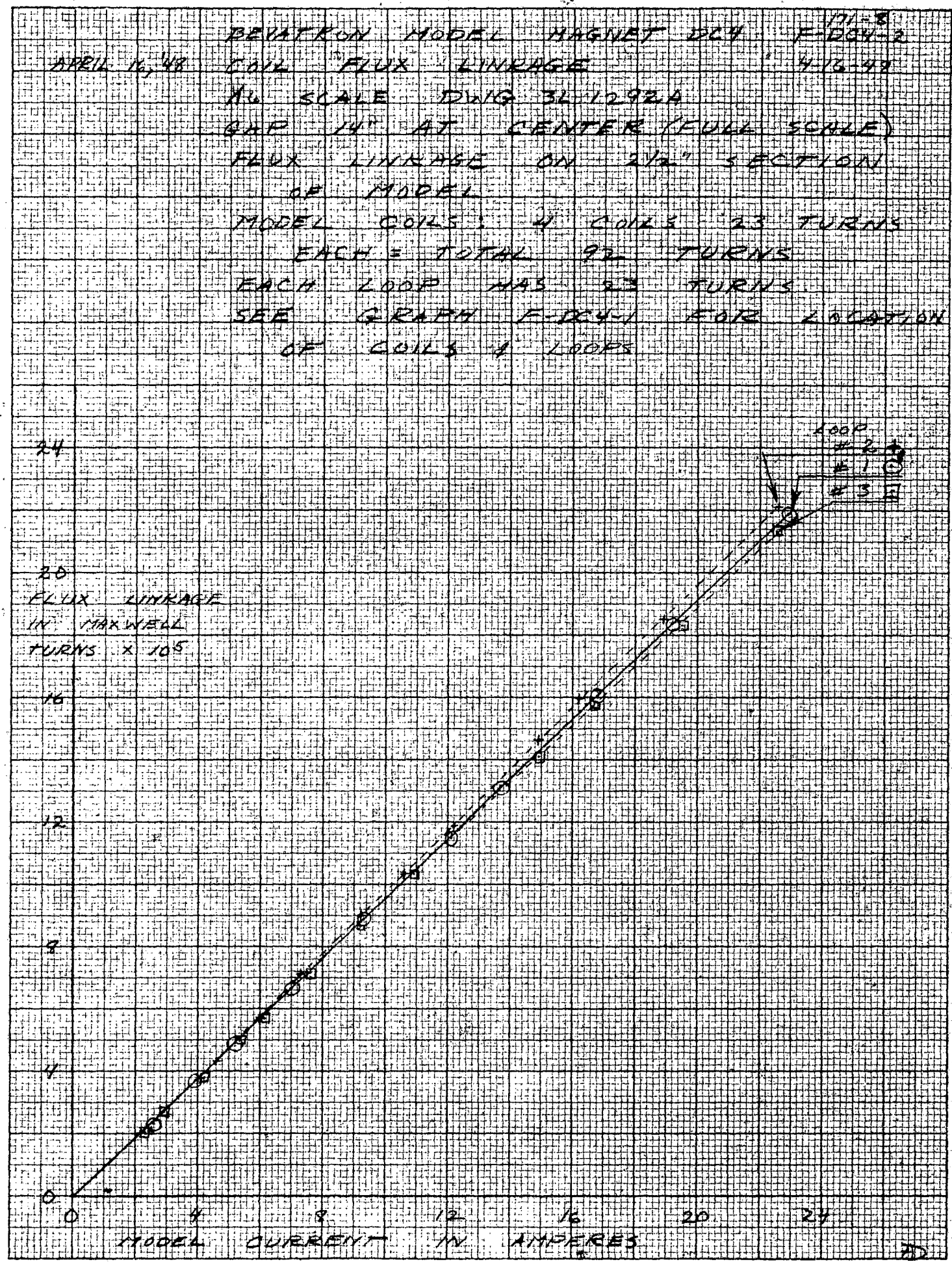
GAP 14" AT CENTER (FULL SCALE)

FLUX LINKAGE ON 2½" SECTION OF MODEL

MODEL COILS: 4 COILS 23 TURNS EACH = TOTAL 92 TURNS

EACH LOOP HAS 23 TURNS

SEE GRAPH F-DCY-1 FOR LOCATION OF COILS & LOOPS



BETATRON MODEL MAGNET DC4

APRIL 16, '48 TOTAL COIL FLUX LINKAGE

F-DC4-2a

4-16-48

1/6 SCALE DWG 31 1252A

GAP 1½" AT CENTER (FULL SCALE)

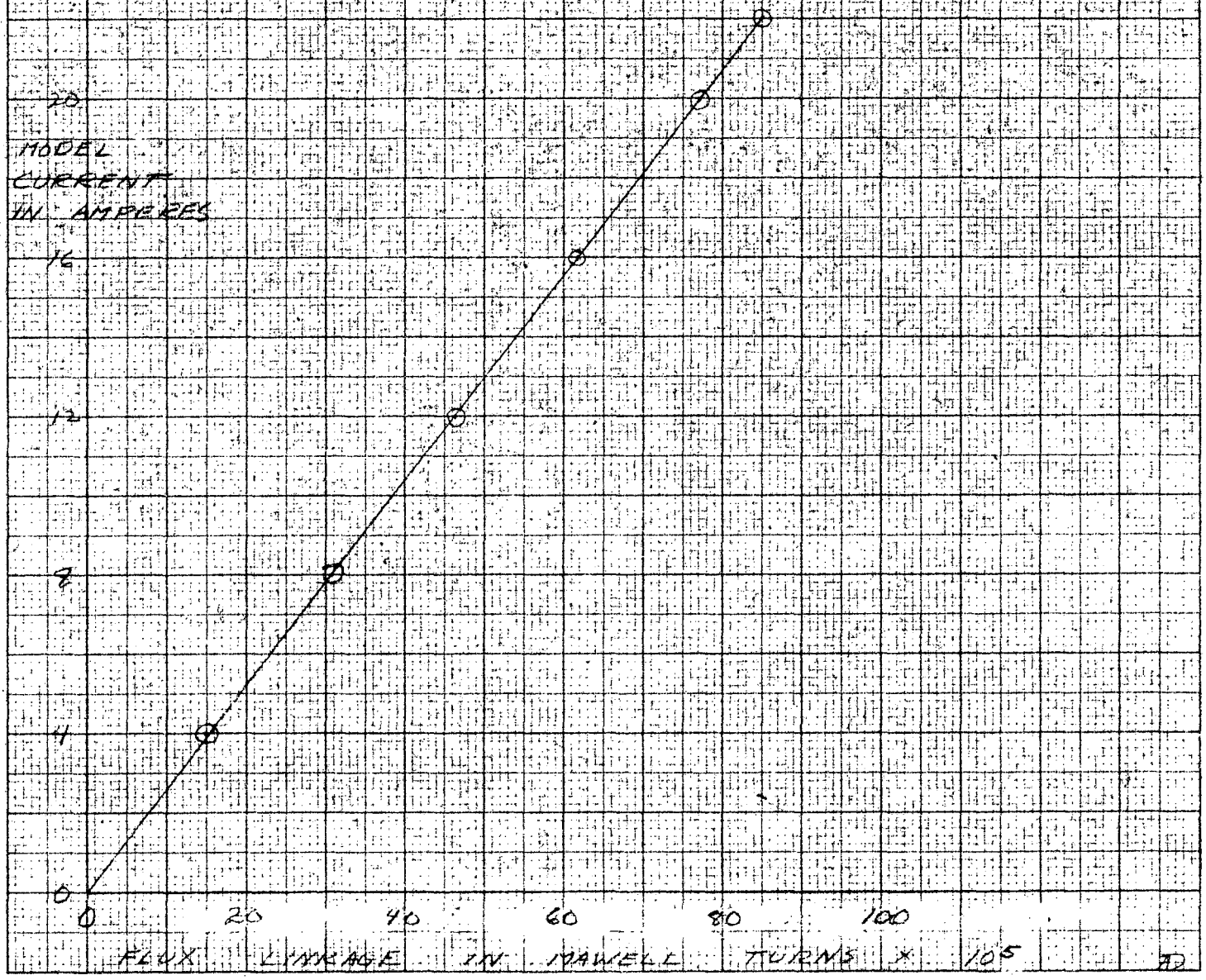
FLUX LINKAGE IN 2½° SECTION OF MODEL

MODEL COILS 4 COILS 23 TURNS EACH = TOTAL 92 TURNS

EACH LOOP HAS 23 TURNS

SEE GRAPH F-DC4-2.

TOTAL LINKAGE = LOOP (1+2) + (2+3)



KEUFFEL & ESSER CO., N. Y. NO. 359-140
10 × 10 to the ½ inch, 5th lines accented
MADE IN U.S.A.

BEVATRON MODEL MAGNET DC4 124-9

STORED ENERGY E-DC4-1

APRIL 1, 1948 1/16 SCALE DWG SL 12924 4-1-48

STORED ENERGY CALCULATED FROM TOTAL COIL FLUX LINKAGE

SEE GRAPH F-DC4-10

ENERGY (JOULES) = $10^{-7} \int I \, d\phi$

WHERE I IS IN AMPERES $d\phi$ IS IN MAXWELL TURNS

DATA IS FOR 2½ SECTION ON MODEL

MODEL STORED ENERGY IN JOULES

240
220
200
180
160
140
120
100
80
60
40
20
0

0 2 4 6 8 10 12 14 16

MAGNETIC FIELD AT CENTER OF GAP - KILOGAUSS

AD.

3 Model Magnet DC4B Index

a. Discussion

b. Sketch

c. Graphs

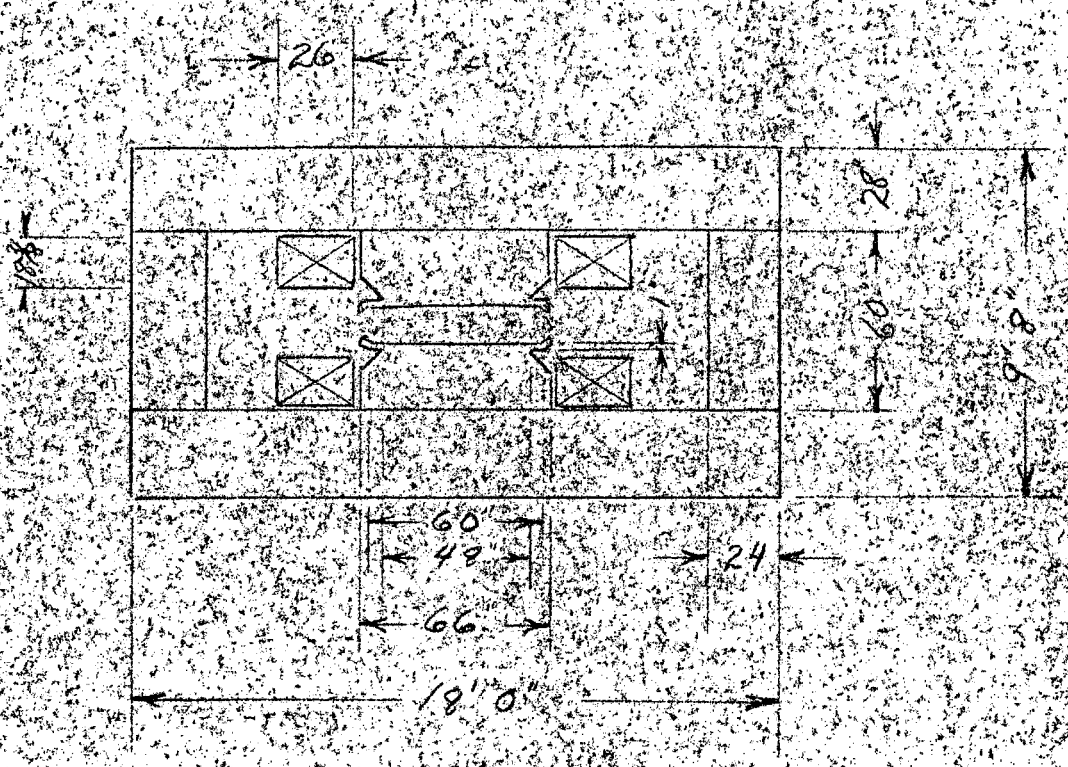
H-DC4B-1	H in gap center
U-DC4B-1	Radial uniformity
U-DC4B-1a	Radial uniformity - Expanded

3 Model DC4B

a. Discussion

Bevatron model magnet DC4B was designed to try to increase the useful radial width of the magnetic field at the injection field by changing the profile of the pole pieces of model DC4. The outer 3" on each "wing" of the pole was bent slightly toward the gap center. This was the only change from model DC4. Although this change did not give the proper shaped magnetic field it was concluded from these measurements that the useful gap width at the injection field could be increased to approximately 50 inches by making small changes in the shape of the wings. The pole pieces were not further modified to obtain the desired field at this time. Otherwise, the performance of model DC4B was similar to that of DC4 on the basis of the measurements which were made.

BEVATRON MODEL MAGNET DC 4B

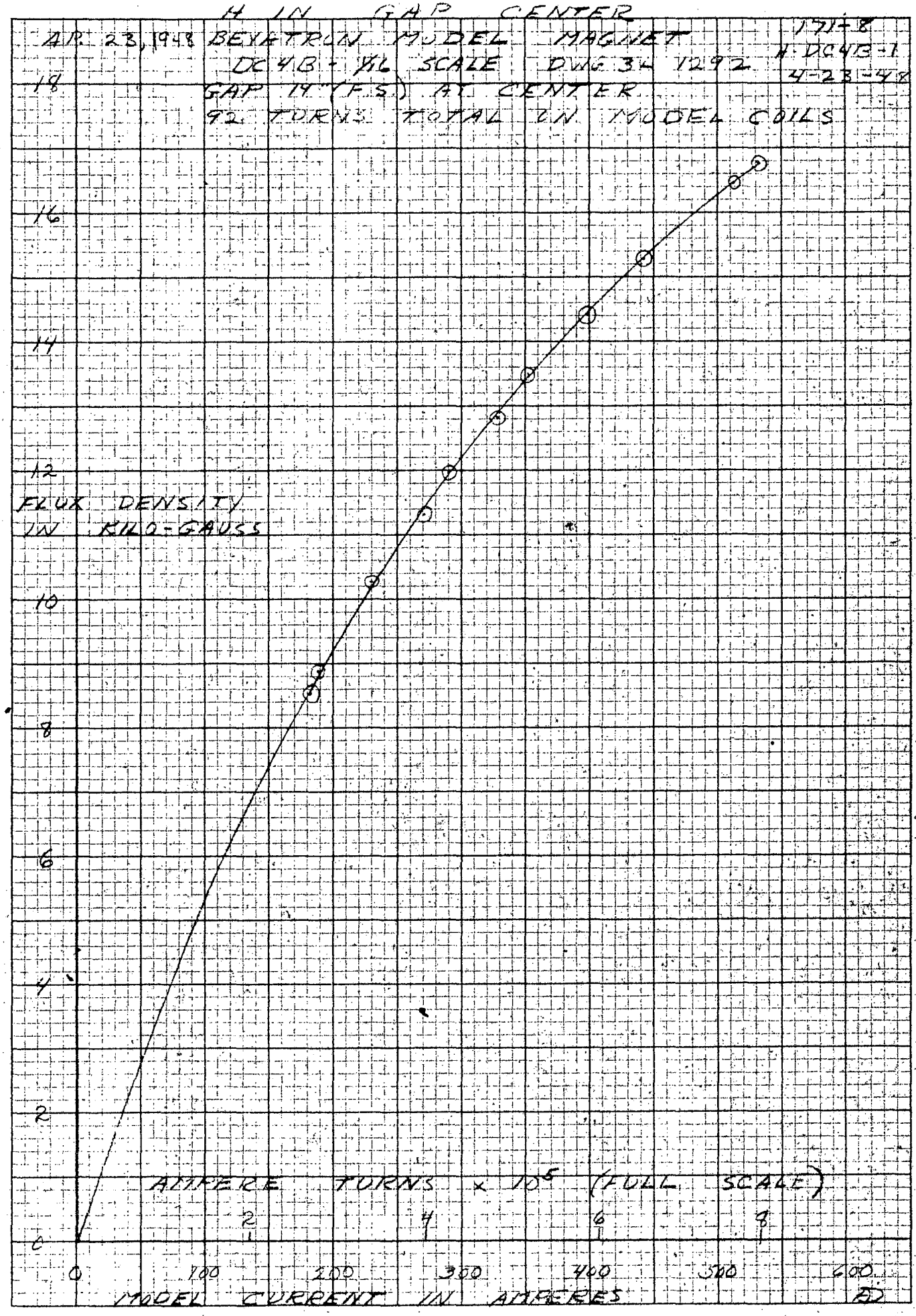


GAP 14"
RADIUS 50'
$n = 0.75$
MODEL COILS 4 COILS 23 TURNS EACH = 92 TURNS
DIMENSIONS ARE FULL SCALE
MODEL IS 1/16 SCALE
ASSEMBLY DWG #3L 1292
POLE TIP DWG 3L 1262-2

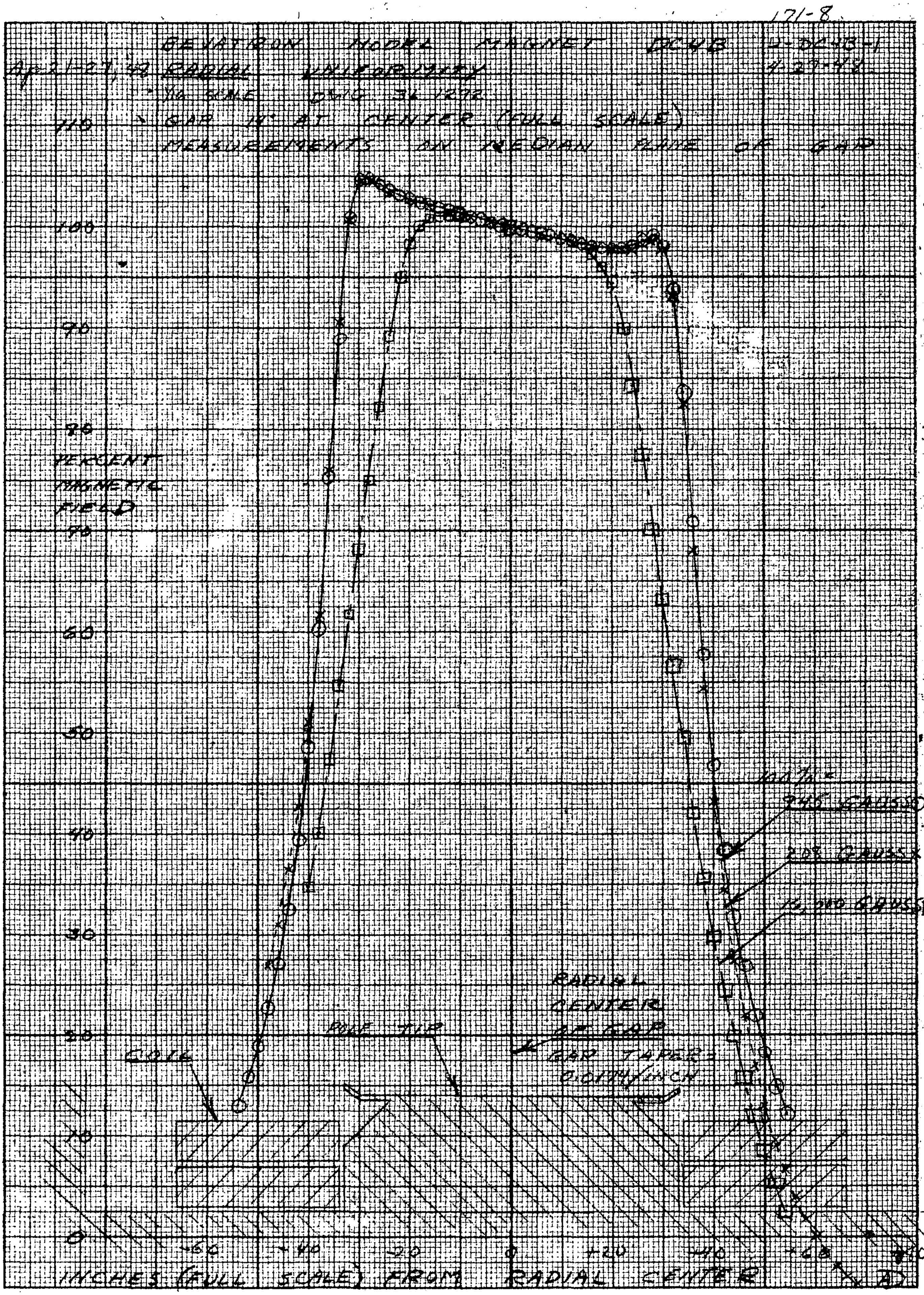
4 IN GAP CENTER

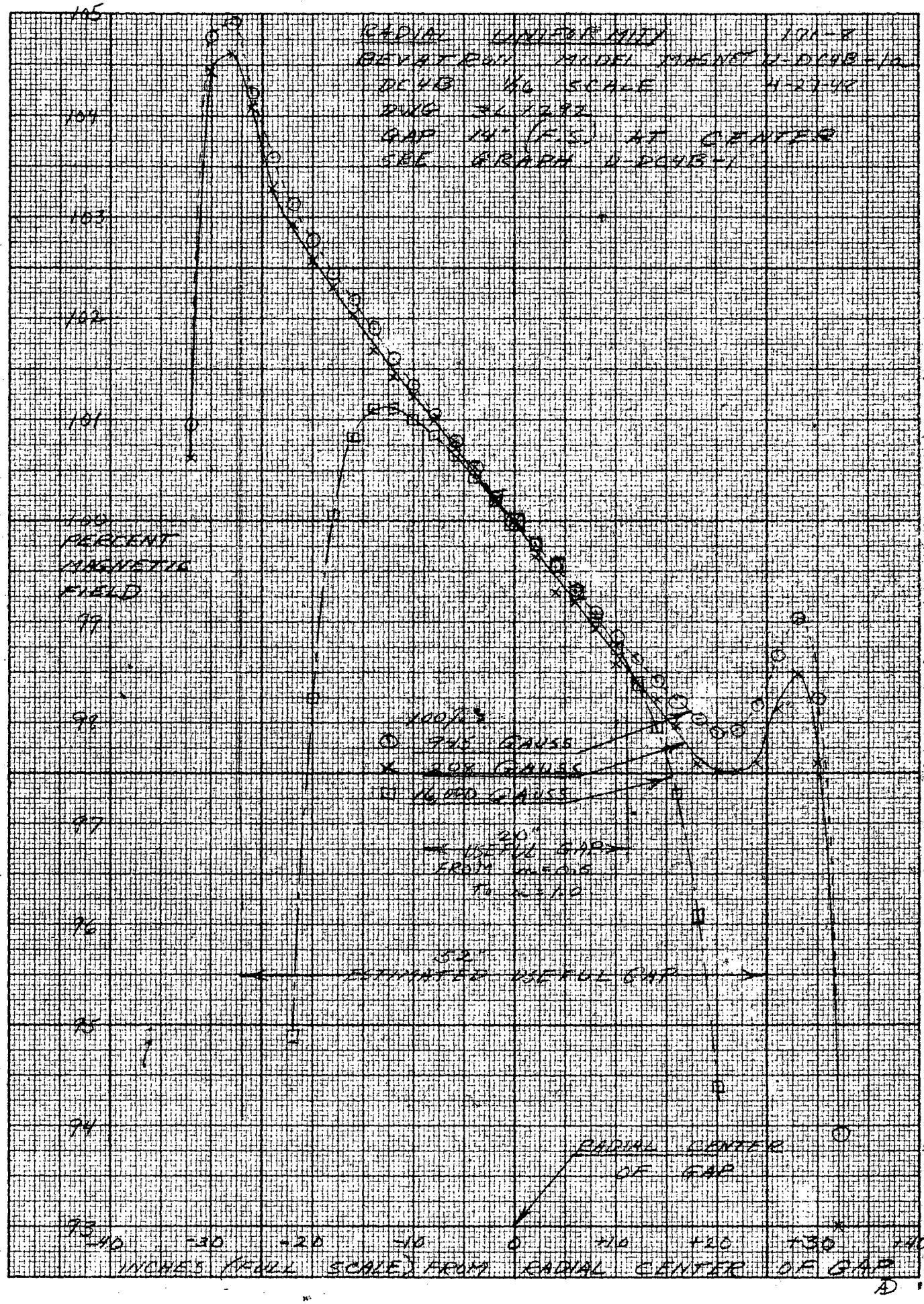
APR 23, 1948 BEVATRON MODEL MAGNET 171-8
DC 48 + 1/16 SCALE DWG 34 1292 # DC 413-1
4-23-48

GAP 14" (F.S.) AT CENTER
92 TURNS TOTAL IN MODEL COILS



171-8





EUGENE DIETZGEN CO.
PRINTED IN U.S.A.

NO. 340 - M DIETZGEN GRAPH PAPER.
MILLIMETER

4 Model Magnet DC4C Index

a. Discussion

b. Sketch

c. Graphs

L-DC4C-1	Efficiency and leakage coefficients
H-DC4C-1	Flux density around the magnetic path
U-DC4C-1	Radial uniformity
U-DC4C-1a	Radial uniformity - Expanded
F-DC4C-1	Coil flux linkage
F-DC4C-1a	Total coil flux linkage
E-DC4C-1	Stored energy

4 Model Magnet DC4C

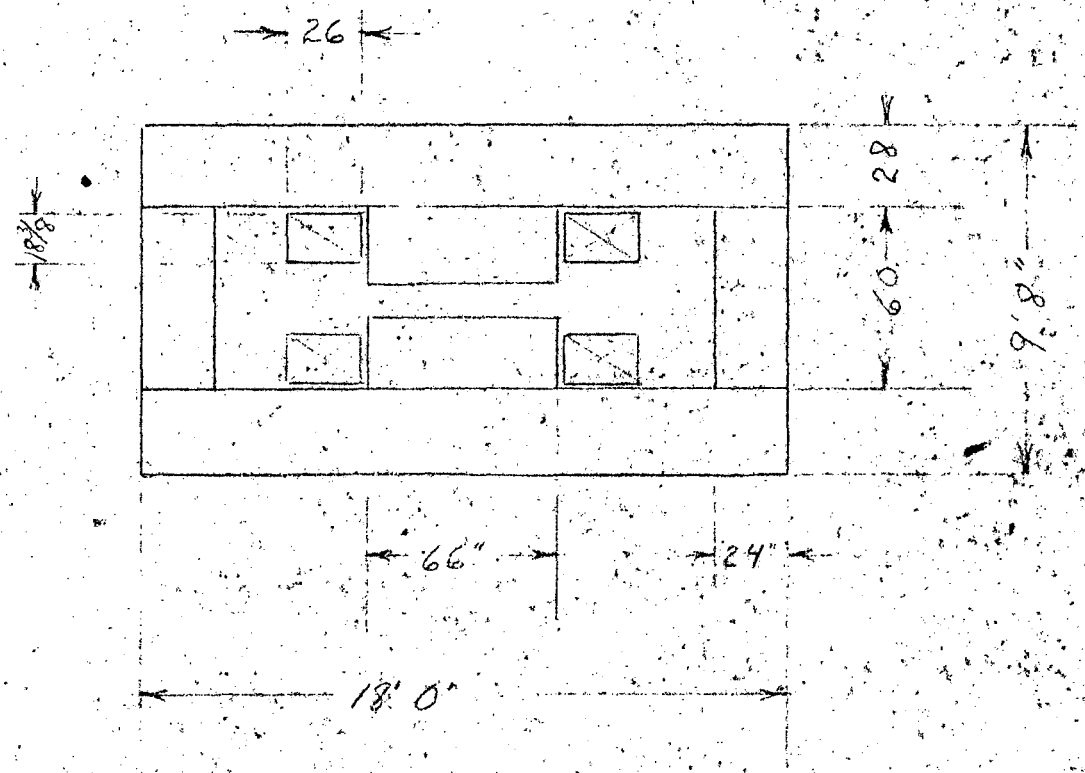
a. Discussion

Bevatron model magnet DC4C was designed to observe the difference in magnet performance caused by a solid pole piece. The pole pieces were designed with straight sides, without notches or "wings". This was the only change from model DC4.

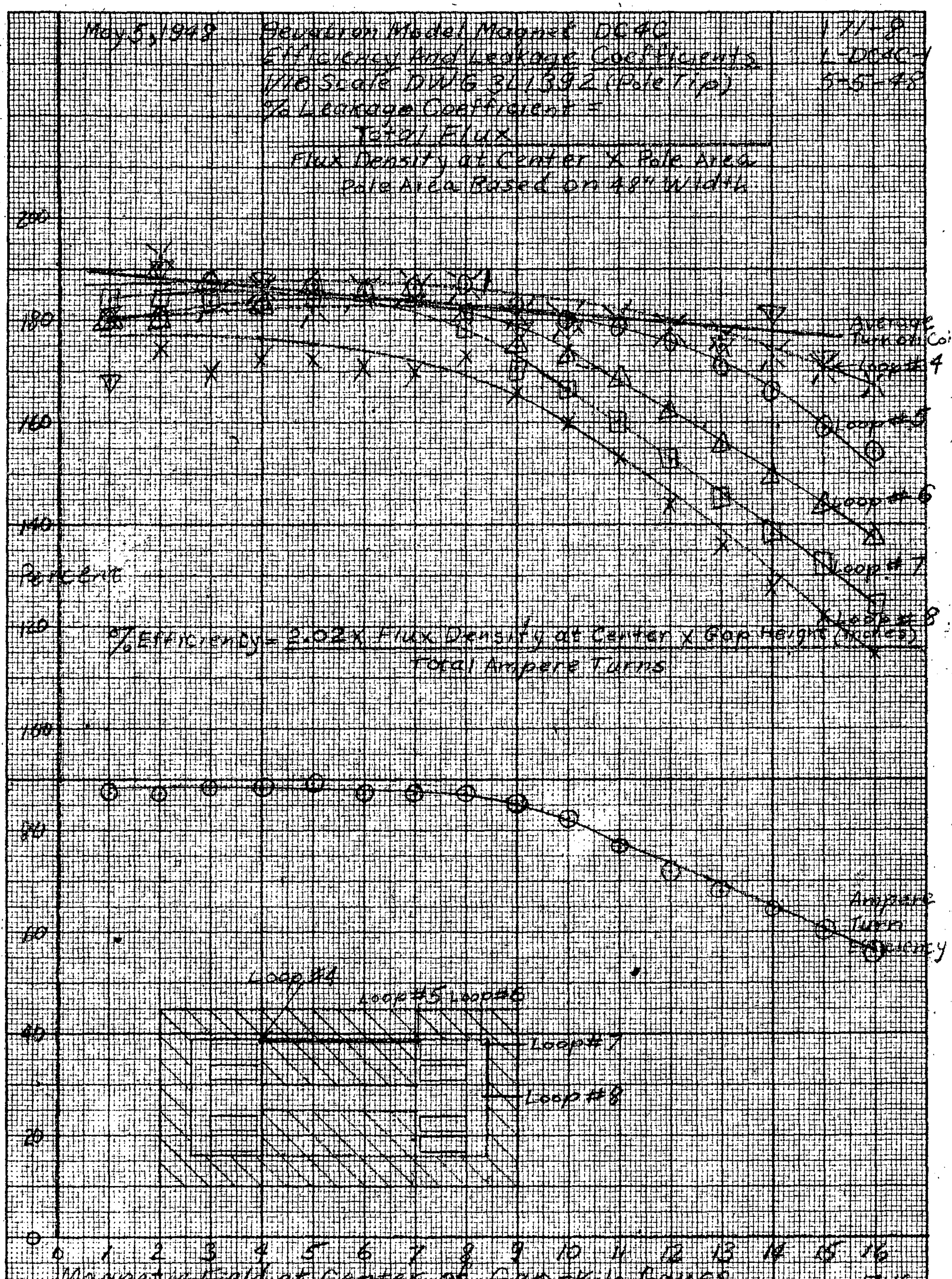
Model Magnet DC4C failed to meet some of the general specifications. (See Section II and Table I.) The number of ampere turns required was 8.0×10^5 instead of 7.35×10^5 as specified. The peak KVA required was 256×10^3 for a rise time of one second. The specified 100×10^3 KVA is for a rise time of not greater than 2.0 seconds. The maximum stored energy was 97 megajoules instead of 80 megajoules as specified.

A comparison of magnet performance on DC4 and DC4C shows some differences. The number of ampere turns required was increased from 7×10^5 to 8×10^5. The peak KVA required was increased from 206×10^3 to 256×10^3 KVA for a rise time of one second. The useful radial width of the magnetic field at the injection field was increased from 40 inches to 46 inches. The efficiency of the magnet decreased from 65% to 56percent. The maximum stored energy increased from 80 megajoules to 97 megajoules. It was concluded from the preceding comparison of models DC4 and DC4B that the "winged" poles are more efficient for this type magnet. The next type B model was DC6.

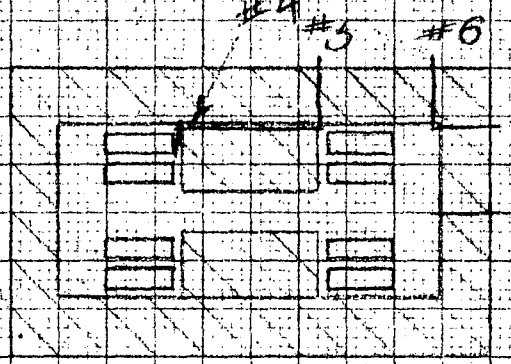
BEVATRON MODEL MAGNET DC 4C



GAP 14"
RADIUS 50'
$n = 0.75$
MODEL COILS : 4 COILS 23 TURNS EACH = 92 TURNS
DIMENSIONS ARE FULL SCALE
MODEL IS 1/16 SCALE
ASSEMBLY DWG. 3L 1292
POLE TIP DWG. 3L 1392



April 29, 1948 Bevatron Model Magnet DC 4C +171-8
Flux Density Around Magnetic Path H-DC4C-1
1/16 Scale Dwg 3L1392 (Pole Tip) 4-29-48
Gap 14" (Full Scale) at Center
92 Turns Total on Model Coils



Flux Density in Kilo-Gauss

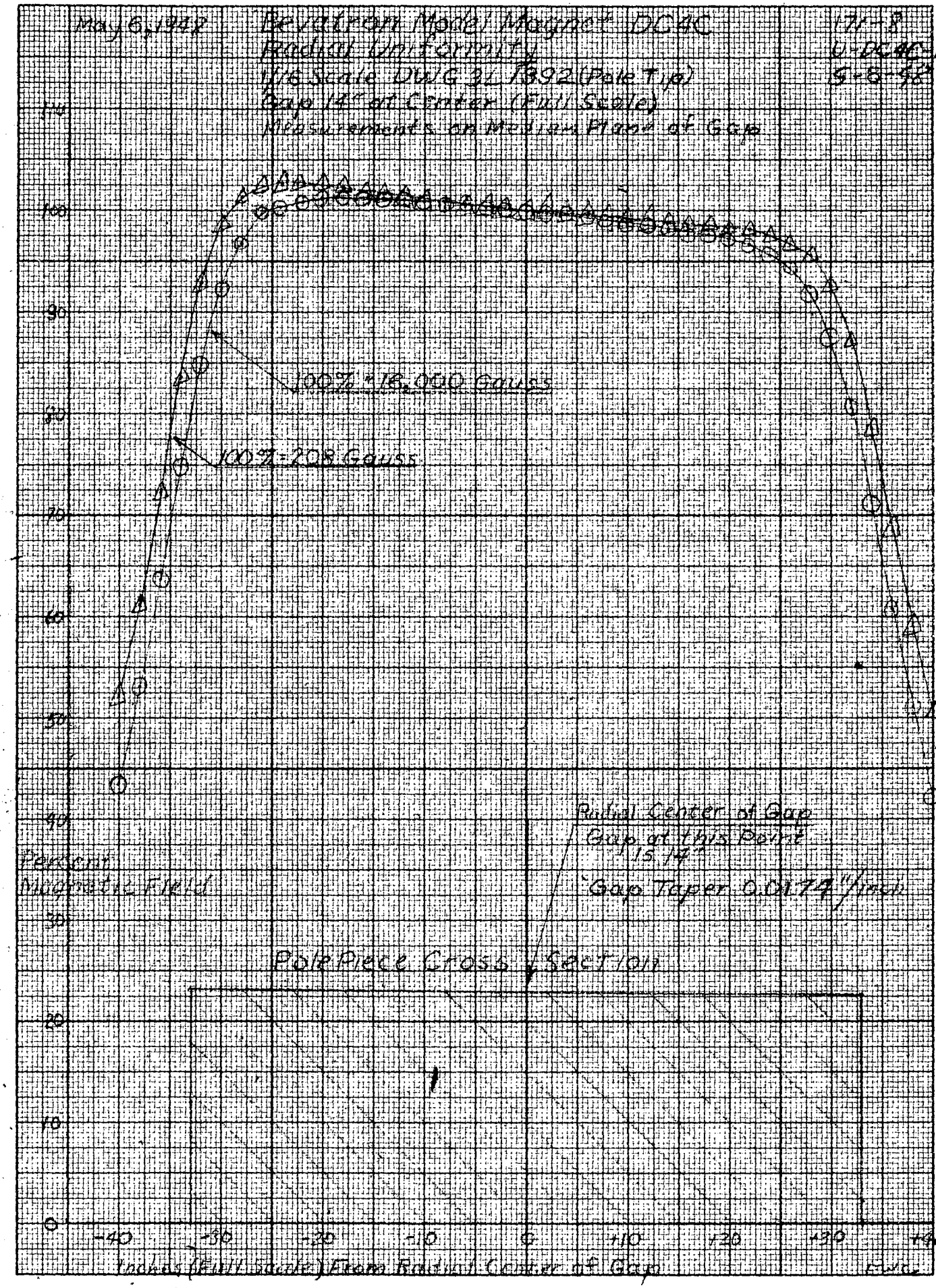
24
22
20
18
16
14
12
10
8
6
4
2
0

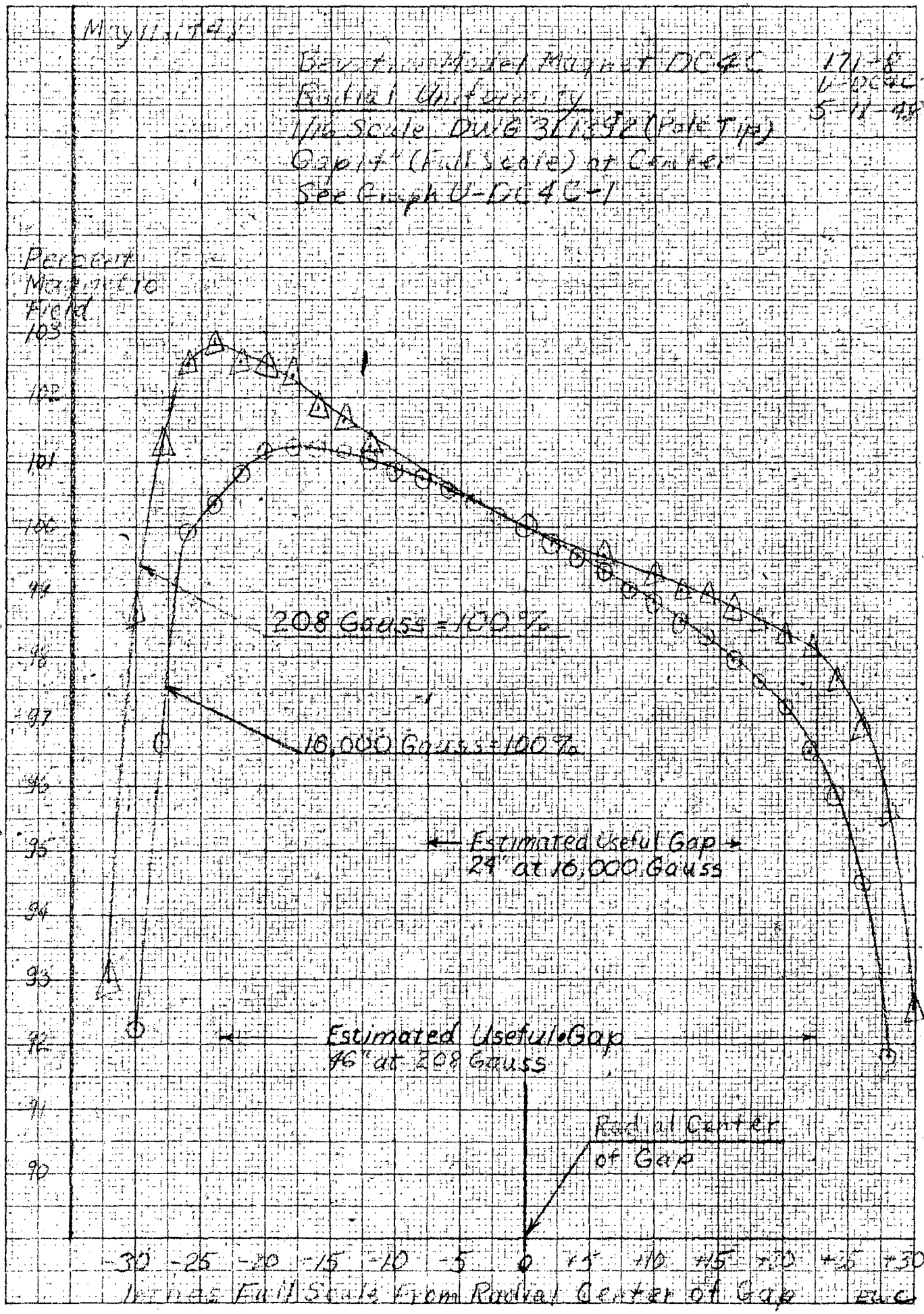
H in Gap
Loop #
4
5
6
7
8

Ampere Turns X 10⁴ (Full Scale)
25
50
75

0
100
200
300
400
500
600
Model Current in Amperes

May 6, 1942 Betatron Model Magnet DC 6C
Radial Uniformity
1/6 Scale DWG 31 1392 (Pole T, P)
Gap 14" at Center (Full Scale)
Measurements on Median Plane of Gap





April 27, 1948 Electron Model Magnet DC 4C 171-8

Coil Flux Linkage F-DC4C-1

1/16 Scale DWG 3L13992 (Pole Tip) 4-27-48

Gap 14" (Full Scale) at Center

Flux Linkage on 2½" Section of Model

Model Coils: 4 Coils 23 Turns Each.

92 Turns Total

Each Loop has 23 Turns

Flux Linkage in Maxwell Turns x 10^6

Loop #
1
2
3

Loop #1 #2 #3

Model Current in Amperes

0 100 200 300 400 500 600

0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32

KEUFFEL & ESSER CO., N. Y. NO. 359-11G
10 × 10 to the ½ Inch, 5th lines accented.
Engraving 7 × 10 in.
MADE IN U.S.A.

May 4, 1948 Betatron Modal Magnet DC4C 11-8

Total Coil Flux Linkage F-DC4C-1α

1/16 Scale DWG 32/1392 (Pole Type) 5-4-48

Gap 1⅜" (Full Scale) at Center

Flux Linkage on 2½" Section of Model

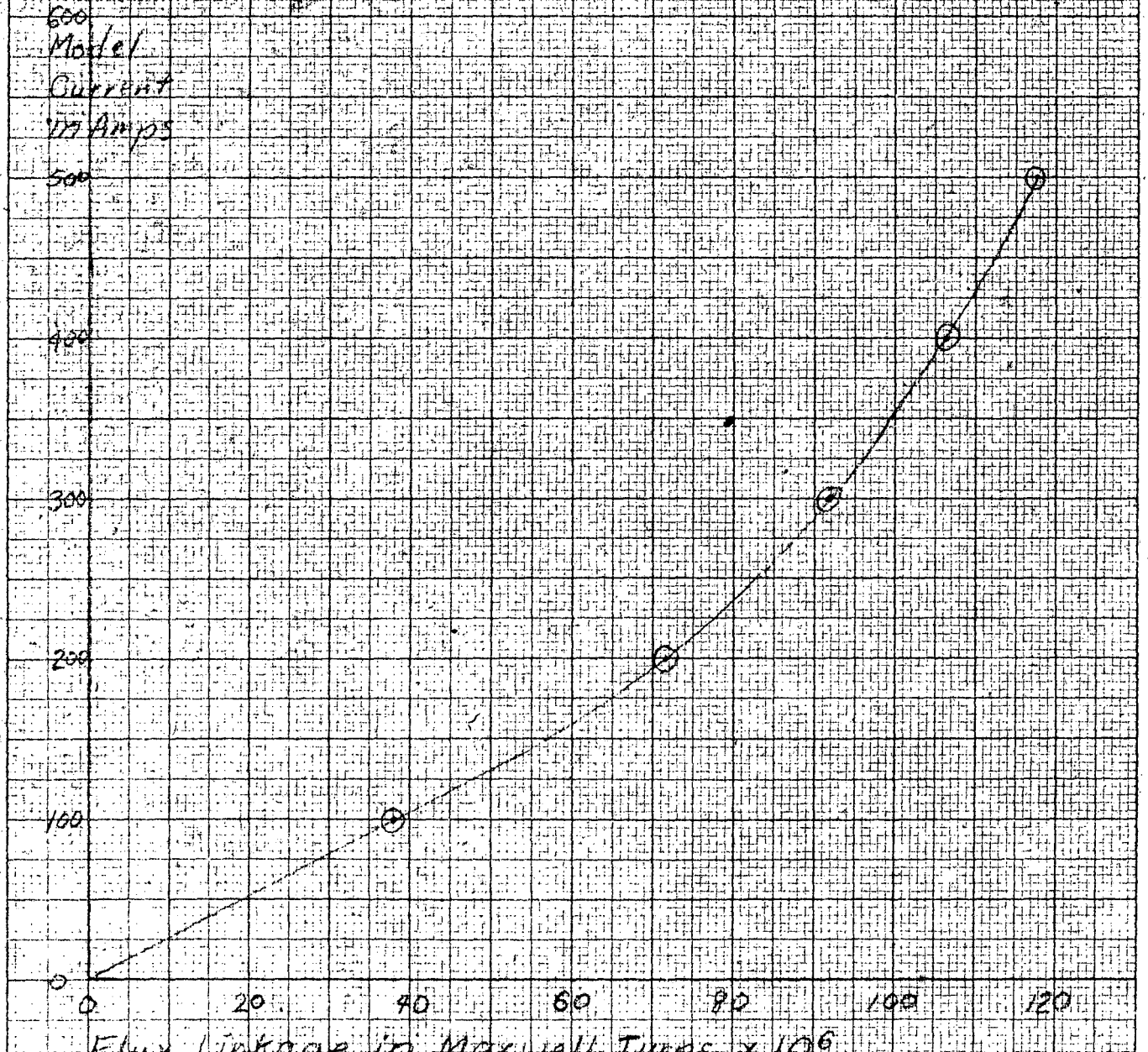
Model Coils - 4 Coils 23 Turns Each

92 Turns Total

See Graph F-DC4C-1

Total Linkage = Loops (1+2) + (2+3)

Each Loop Has 23 Turns



KEUFFEL & ESSER CO., N. Y. NO. 359-11C
10 × 10 to the ½ Inch, 5th lines accented.
Engraving 7 × 10 in.
MADE IN U.S.A.

Bevatron Model Magnet DC4C — 171-9

May 11, 1948 — 1/16 Scale Dwg 3L1392 (Pole Tip) — E-DC4C-1

Stored Energy Calculated From — 5-11-48

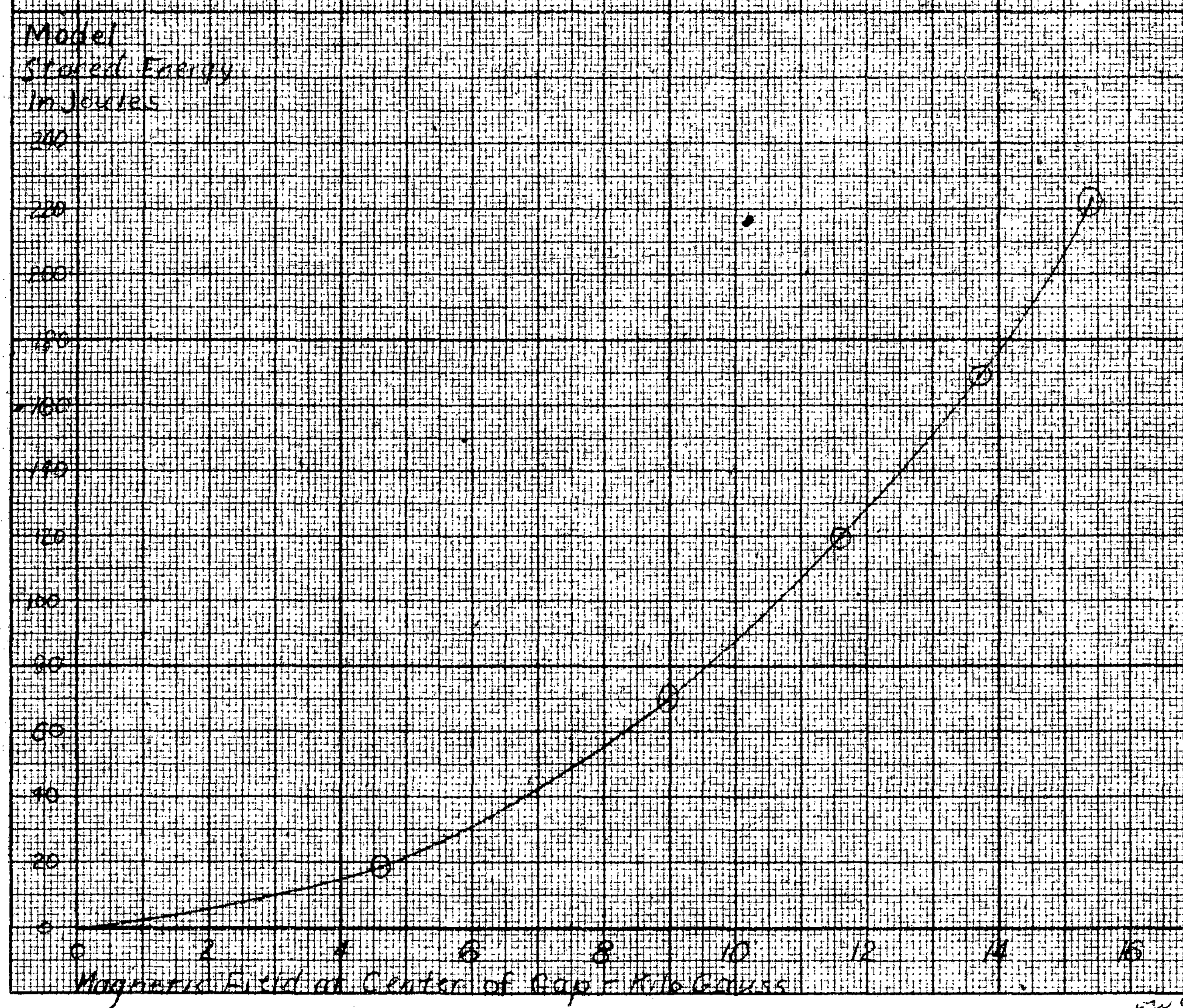
Total Coil Flux Linkage

$$\text{Energy (Joules)} = 10^{-8}\int^{I} I\,d\phi$$

Where I is in Amperes

ϕ is in Maxwell Turns

Data is For 2½" Section on Model



5 Model Magnet DC3 Index

a. Discussion

b. Sketch

c. Photographs

BEVA 16

d. Graphs

L-DC3-1	Efficiency and leakage coefficients
H-DC3-1	Flux density around the magnetic path
U-DC3-1	Radial uniformity (26")
U-DC3-1a	Radial uniformity (26") - Expanded
U-DC3-2	Radial uniformity (62")
F-DC3-1	Coil flux linkage
F-DC3-1a	Total coil flux linkage
E-DC3-1	Stored energy

5 Model Magnet DC3

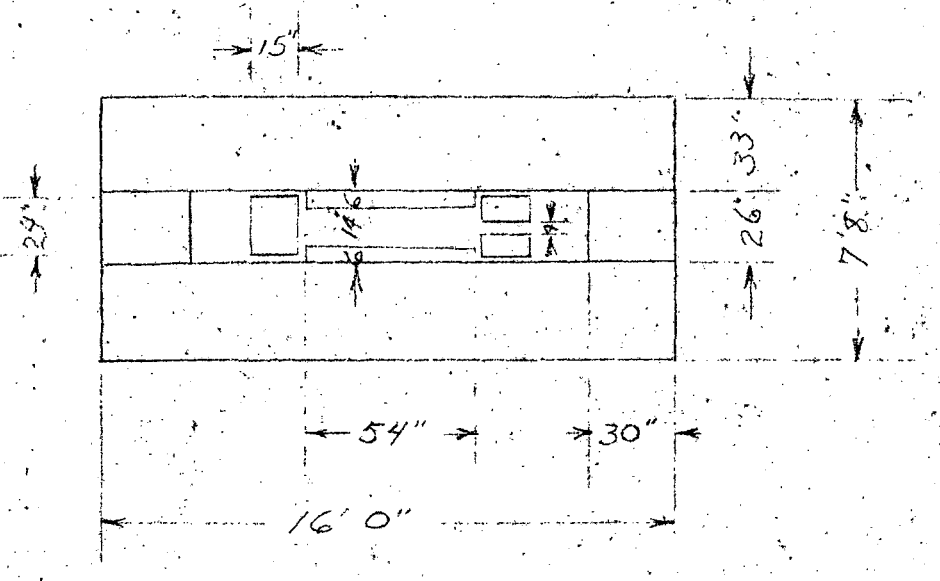
a. Discussion

Bevatron model magnet DC3 was the first attempt to design a DC model magnet of type A to predict performance of the magnet for a full-scale bevatron.

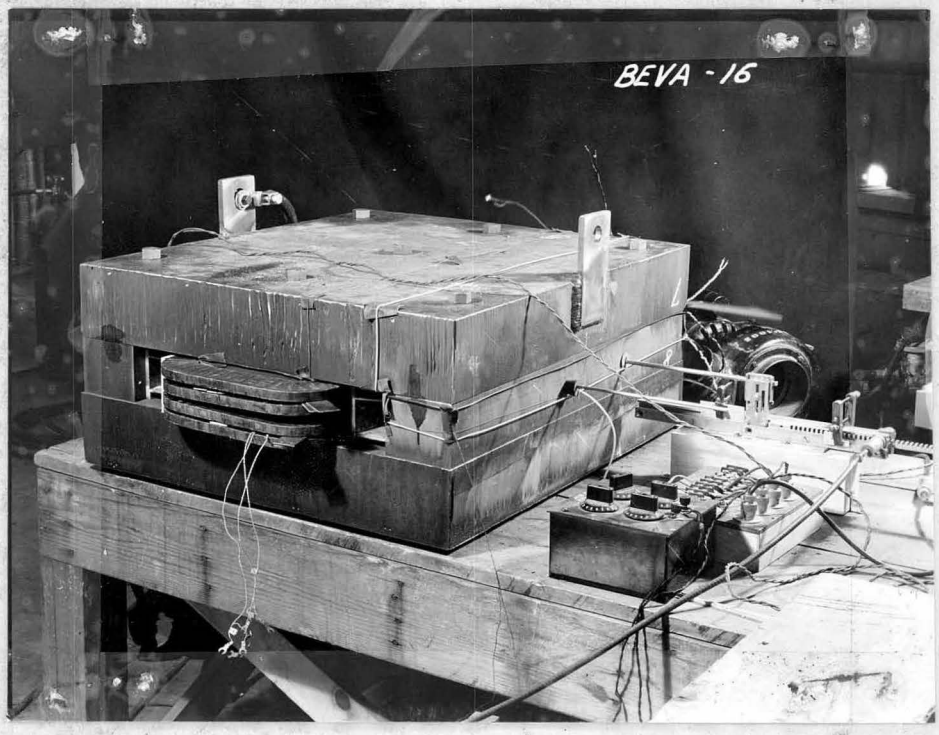
This model met the general specifications except that the useful width of the magnetic field at the injection field was 26 inches instead of the specified 48 inches.

A decision was made at this time to design a model magnet with a larger aperture, 2 feet by 8 feet, as an initial stage in the development of the bevatron. This magnet was to be designed so that it could be converted to the 1' x 4' aperture at a later time. Changes were made to adapt model DC3 for the larger aperture. (See model DC3A.)

BEVATRON MODEL MAGNET DC3



GAP 14"
RADIUS 50'
$n = 0.75$
MODEL COILS : 4 COILS 27 TURNS EACH = 108 TURNS
DIMENSIONS ARE FULL SCALE
MODEL IS 1/8" SCALE
ASSEMBLY DWG. 3L 1192



BEVA 16

Bevatron Model Magnet DC3

BEVATRON MODEL MAGNET DC3 L-DC3-1

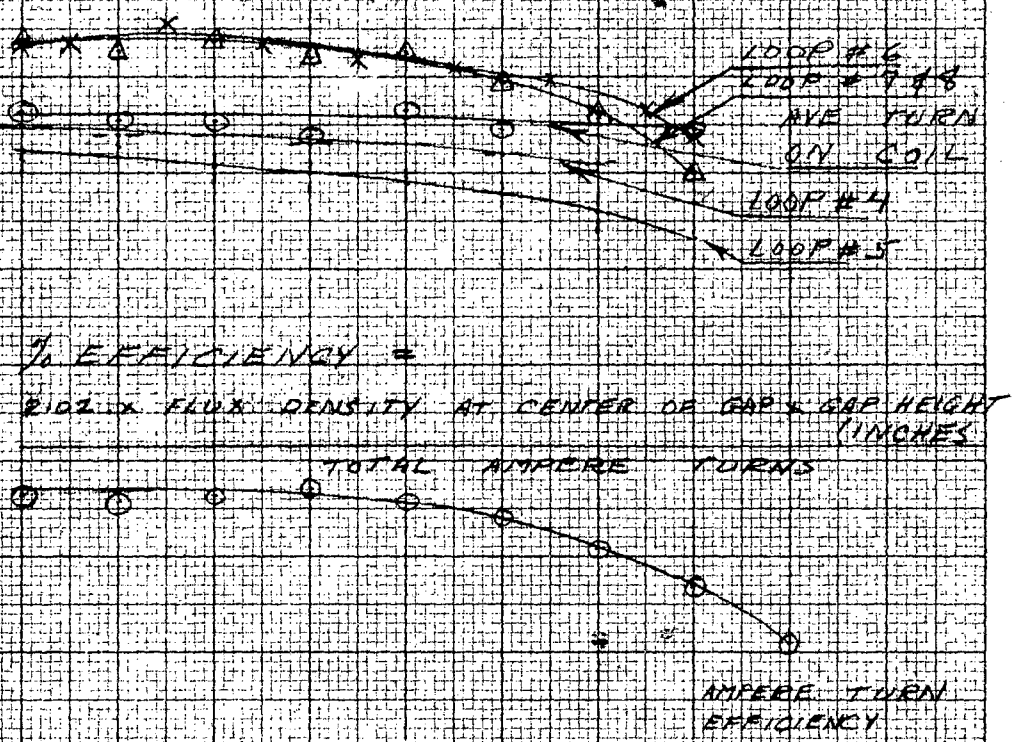
EFFICIENCY AND LEAKAGE COEFFICIENTS

1/8 SCALE DWG 5L/192

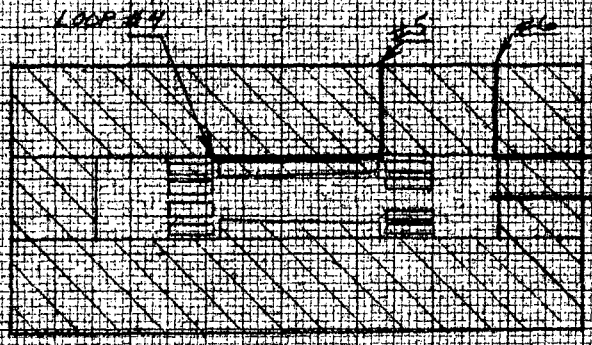
% LEAKAGE COEFFICIENTS =

$$\frac{\text{TOTAL FLUX}}{\text{FLUX DENSITY AT CENTER OF GAP} \times \text{POLE AREA}}$$

POLE AREA BASED ON 4⅛" GAP WIDTH



BEVATRON MODEL MAGNET DC 3
MARCH 28 '48 FLUX DENSITY AROUND MAGNETIC PATH
½ SCALE DWG # 3L 1192
GAP ¾" AT CENTER (FULL SCALE)
10 K TURNS TOTAL ON MODEL COILS



H IN GAP

Loop #4
Loop #5
Loop #6
Loop #8

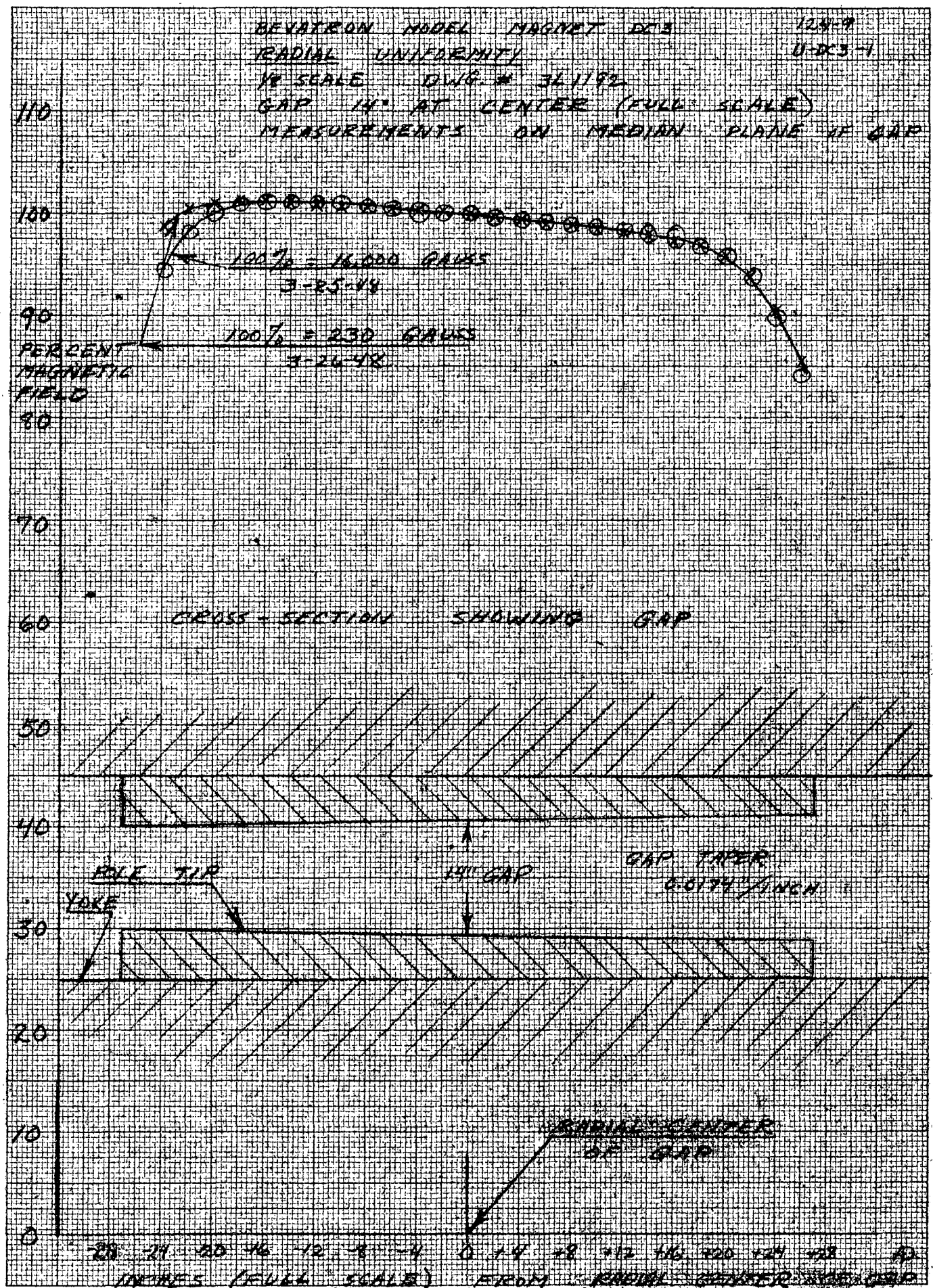
FLUX DENSITY
KILO-GAUSS

2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0

AMPERE TURNS × 10⁴ (FULL SCALE)
10 20 30 40 50 60 70
0 100 200 300 400 500 600 700 800

MODEL CURRENT IN AMPERES

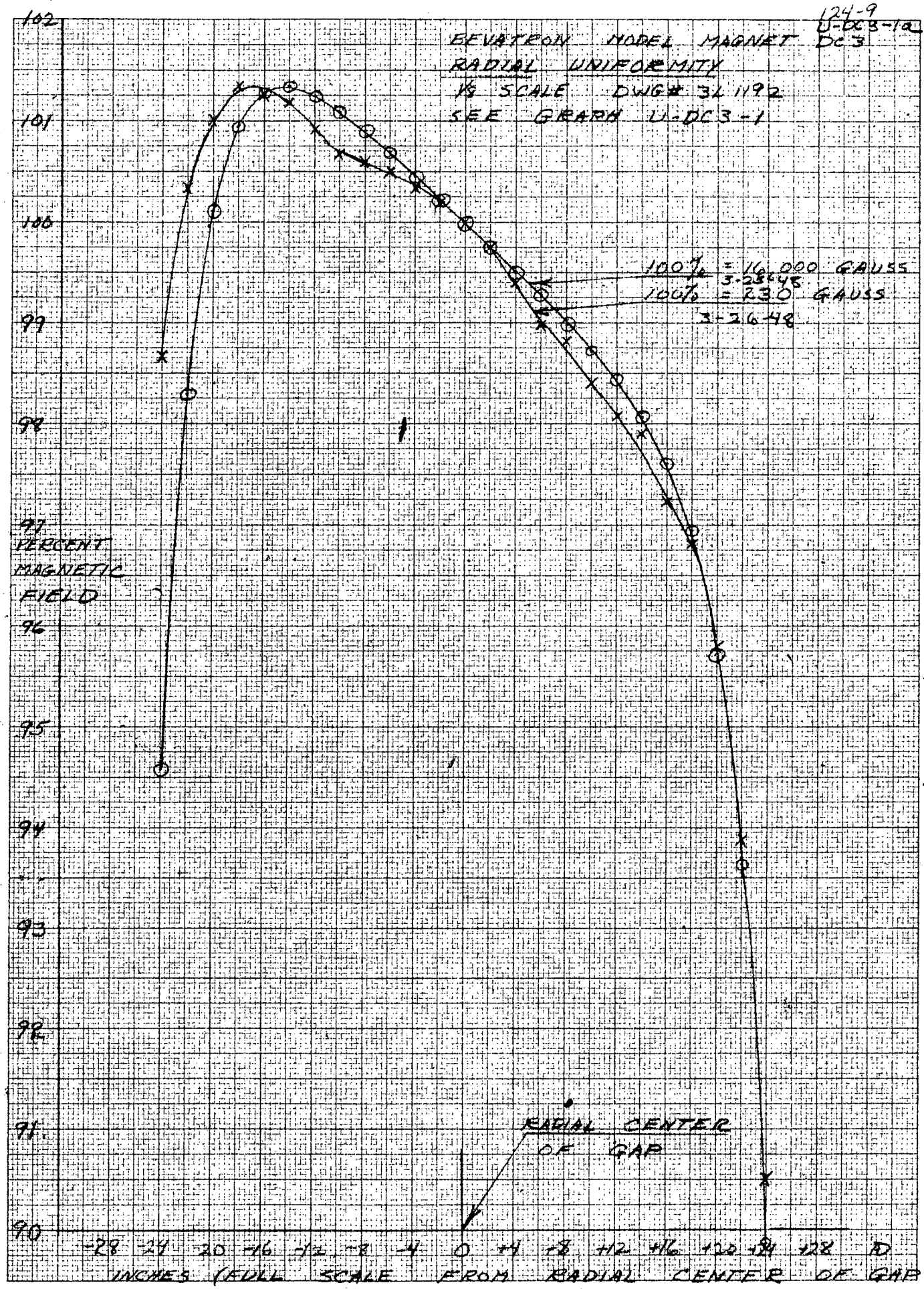
D

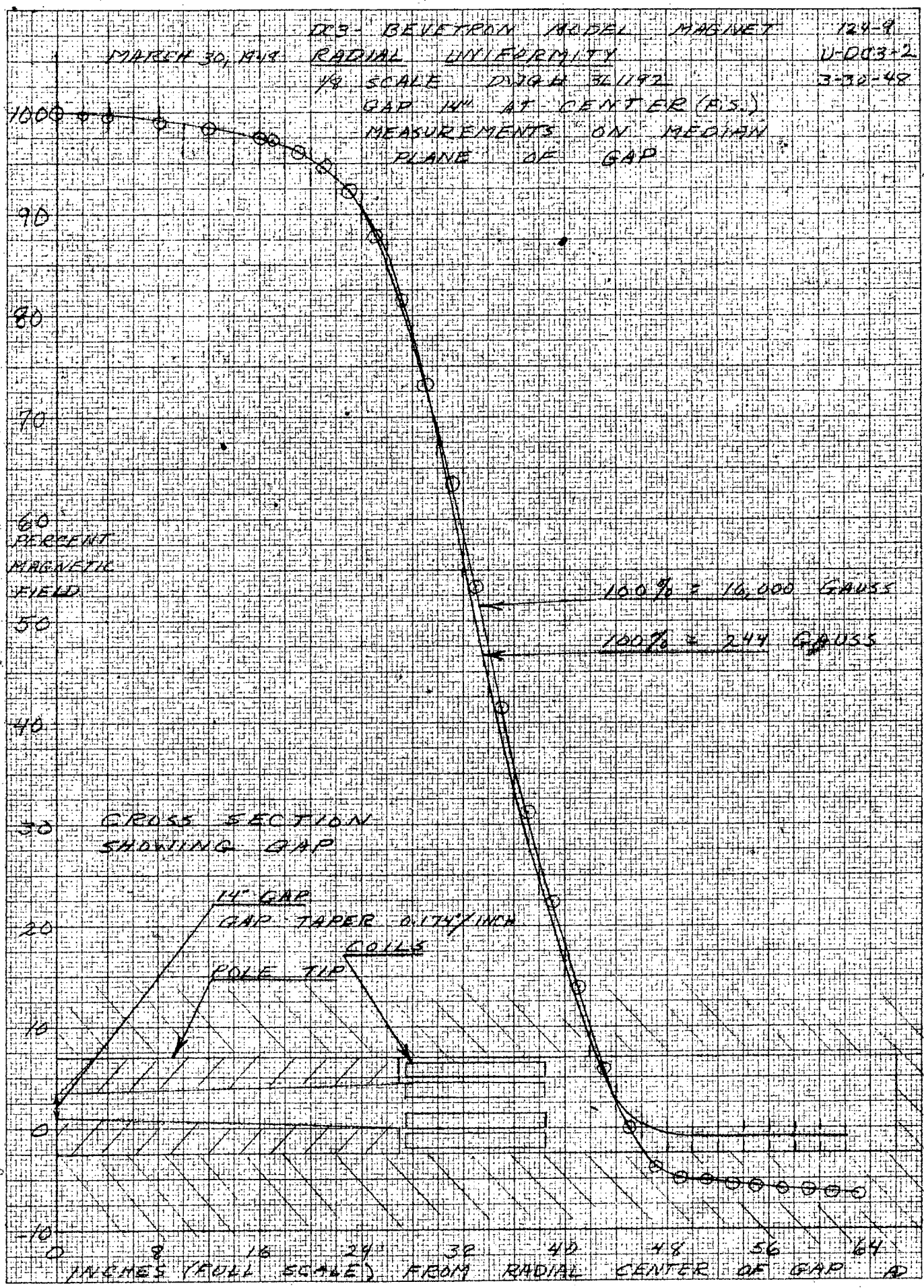


124-9
U-DC3-12

ELEVATION MODEL MAGNET DC3
RADIAL UNIFORMITY
½ SCALE DWG# 3L 1192
SEE GRAPH U-DC3-1

100% = 16,000 GAUSS
3-25-48
100% = 230 GAUSS
3-26-48





COIL FLUX LINKAGE 124-9

MARCH 23, 48 BEVATRON MODEL MAGNET DC3 F-DC3-1

½ SCALE DWG # 3L 1172

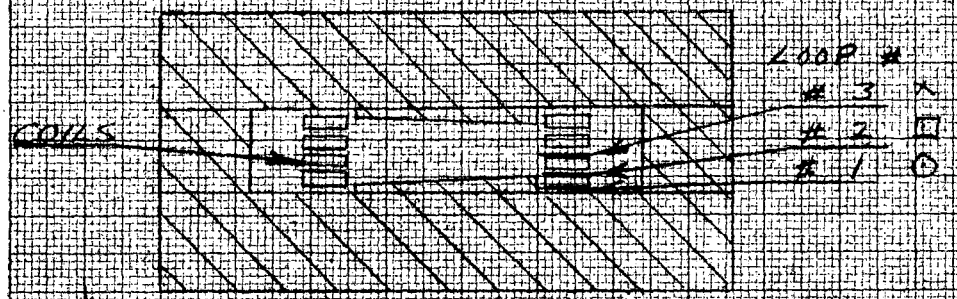
GAP 14" AT CENTER (FULL SCALE)

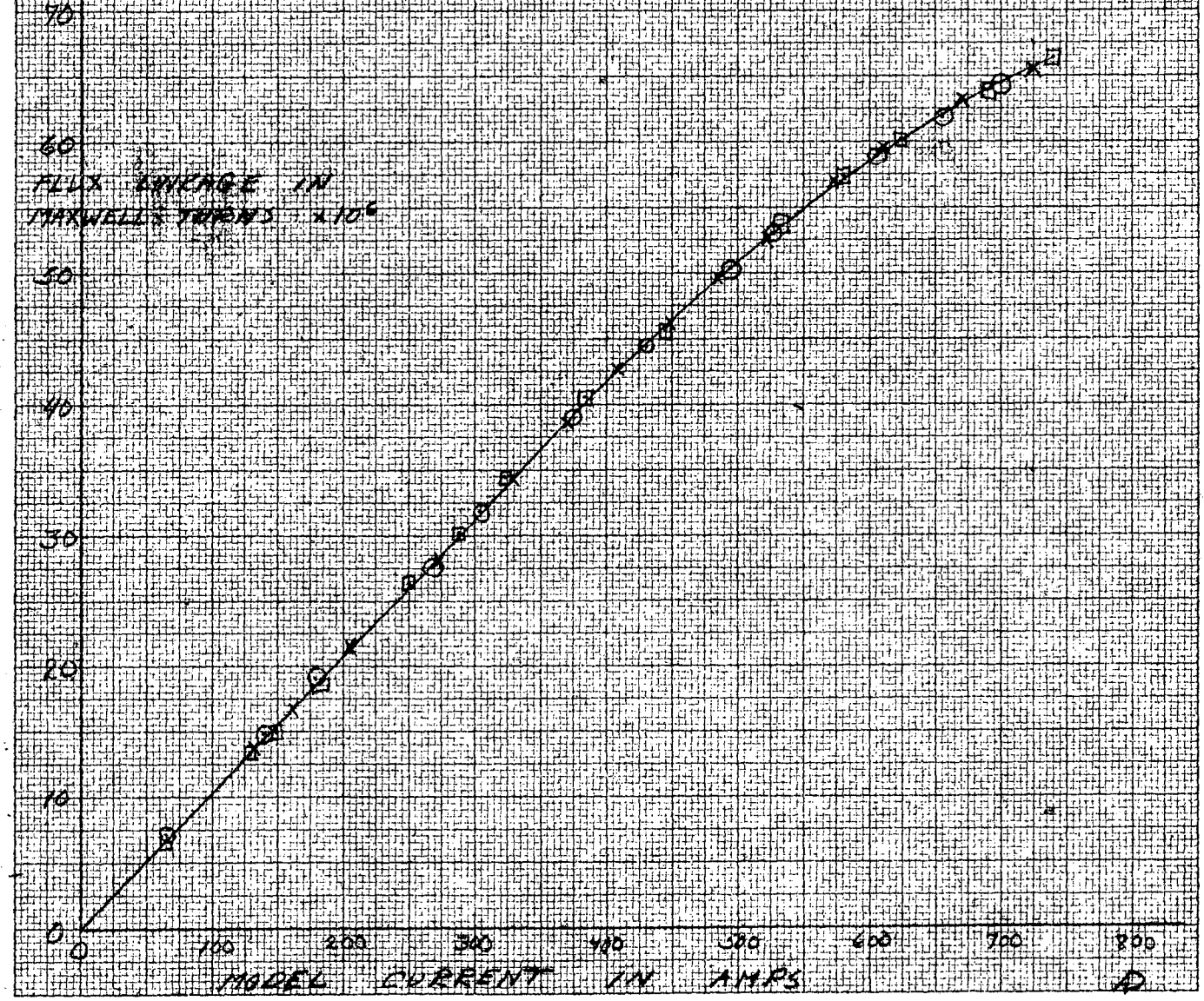
FLUX LINKAGE ON 2½" SECTION ON MODEL

MODEL COILS: 4 COILS 27 TURNS EACH

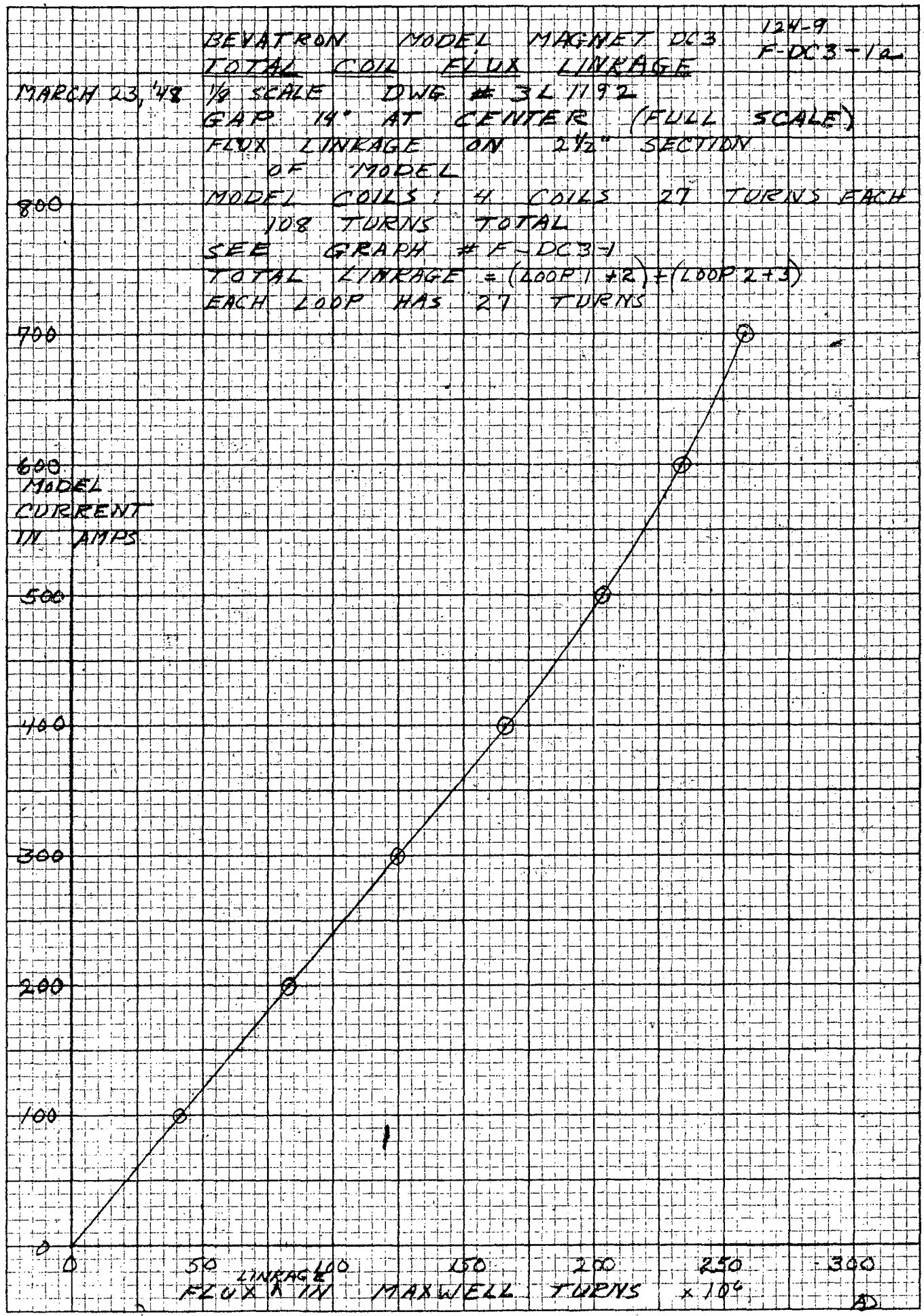
108 TURNS TOTAL

EACH LOOP HAS 27 TURNS





KEUFFEL & ESSER CO., N. Y. NO. 359-14
Millimeters, 10th lines heavy.
MADE IN U.S.A.



E-DC3-1

BEVATRON MODEL MAGNET DC3

MAR 23 '48 STORED ENERGY

1/8 SCALE DWG # 3L 1192

STORED ENERGY CALCULATED FROM TOTAL COIL FLUX LINKAGE

SEE GRAPH E-DC3-1a

$\text{ENERGY (JOULES)} = 10^{-8} \int_0^{\Phi} I \, d\Phi$

WHERE I IS IN AMPS & Φ IS IN MAXWELL TURNS

DATA FOR 2½" SECTION OF MODEL

MODEL STORED ENERGY JOULES

900
800
700
600
500
400
300
200
100
0

0 2 4 6 8 10 12 14 16 18 20

MAGNETIC FIELD AT CENTER OF GAP - KILOGAUSS

6 Model Magnet DC3A Index

a. Discussion

b. Sketch

c. Photographs

BEVA 18

d. Graphs

L-DC3A-1	Efficiency and leakage coefficients
H-DC3A-1	Flux density around the magnetic path
U-DC3A-1	Radial uniformity
F-DC3A-1	Coil flux linkage
F-DC3A-1a	Total coil flux linkage
E-DC3A-1	Stored energy

6 Model Magnet DC3A

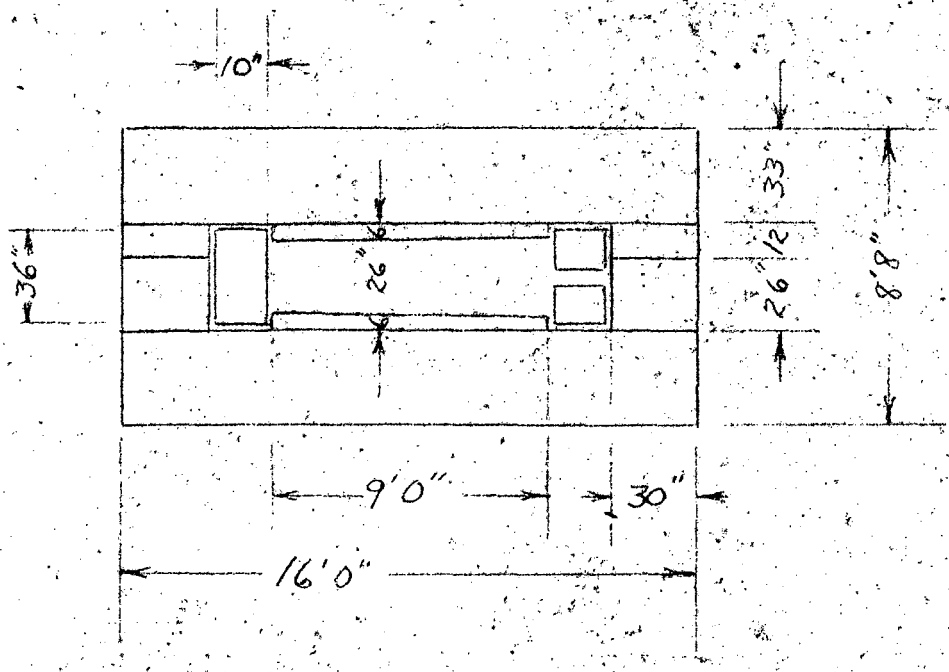
a. Discussion

Bevatron model magnet DC3A was a larger gap design of model DC3. The general specifications (see Section II) for the smaller aperture (1' x 4') apply to this larger aperture (2' x 8') except for the maximum flux density at the gap center and the width of the useful magnetic field. It was decided to accept whatever was available for the maximum flux density and useful gap width when the other specifications were met, with the additional provision that when this model is converted to give the 1' x 4' aperture, all of the original specifications must be met.

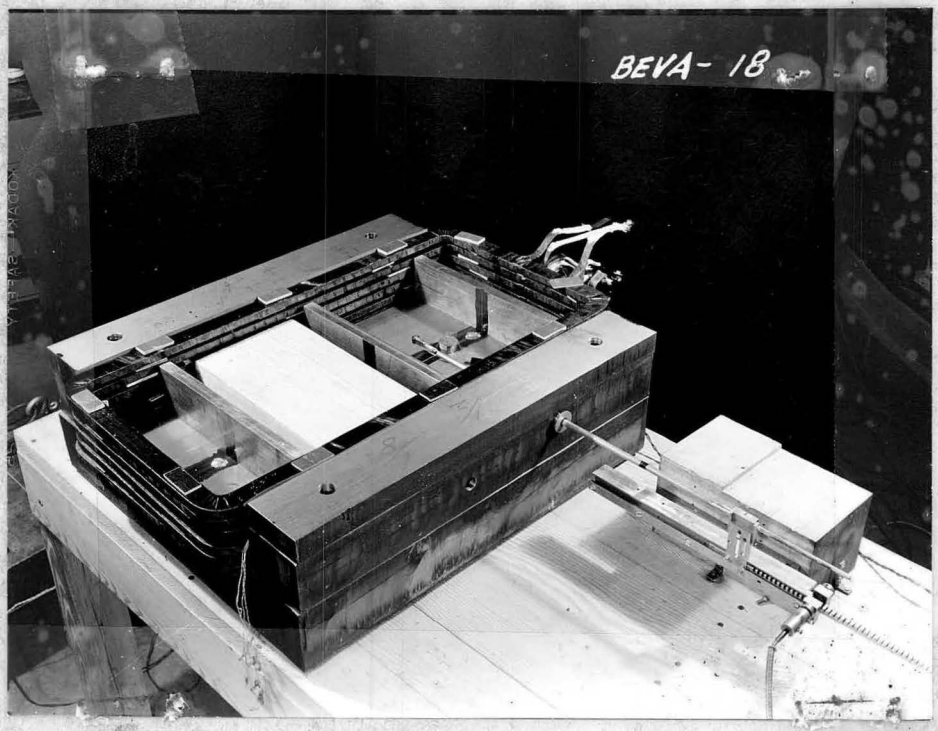
The following design changes were made in model DC3 to give this model DC3A. The pole pieces were increased in radial width from 54 inches to 108 inches. The gap was increased from 14 inches to 26 inches. Extensions were added to the legs to increase the distance between the yoke slabs. The cross-sectional area of the exciting coils was increased. An error in the design resulted in an n of 0.40 instead of 0.75 as specified.

It was decided after testing this model to change the design to increase the useful gap width at the injection field. (See model DC5 and DC5A.)

BEVATRON MODEL MAGNET DC 3A.



GAP 26"
RADIUS 50'
n = 0.40
MODEL COILS: 6 COILS 17 TURNS EACH = 102 TURNS.
DIMENSIONS ARE FULL SCALE.
MODEL IS 1/8 SCALE
ASSEMBLY DWG. 3L 1192



BEVA 18

Bevatron Model Magnet DC3A

BENTSON MODEL MAGNET - DC3A 124-9

EFFICIENCY & LEAKAGE COEFFICIENT L-DC3A-1

#8 SCALE DWG 3L 1192

% LEAKAGE COEFFICIENT = $\frac{\text{TOTAL FLUX}}{\text{FLUX DENSITY AT CENTER} \times \text{POLE AREA}}$

POLE AREA BASED ON 9½" POLE WIDTH

LOOP #

#5 ×

#6 □

#7 △

#8 ▽

#9 ○

AVE. TURN ON COIL

% EFFICIENCY = 2.02 × FLUX DENSITY AT CENTER × GAP HEIGHT (INCHES) / TOTAL AMPERE TURNS

AMPERE TURN EFFICIENCY

CROSS-SECTION OF MAGNET

LOOP #5

#7 #6

#5

#8

#9

180

160

140

120

PERCENT

100

80

60

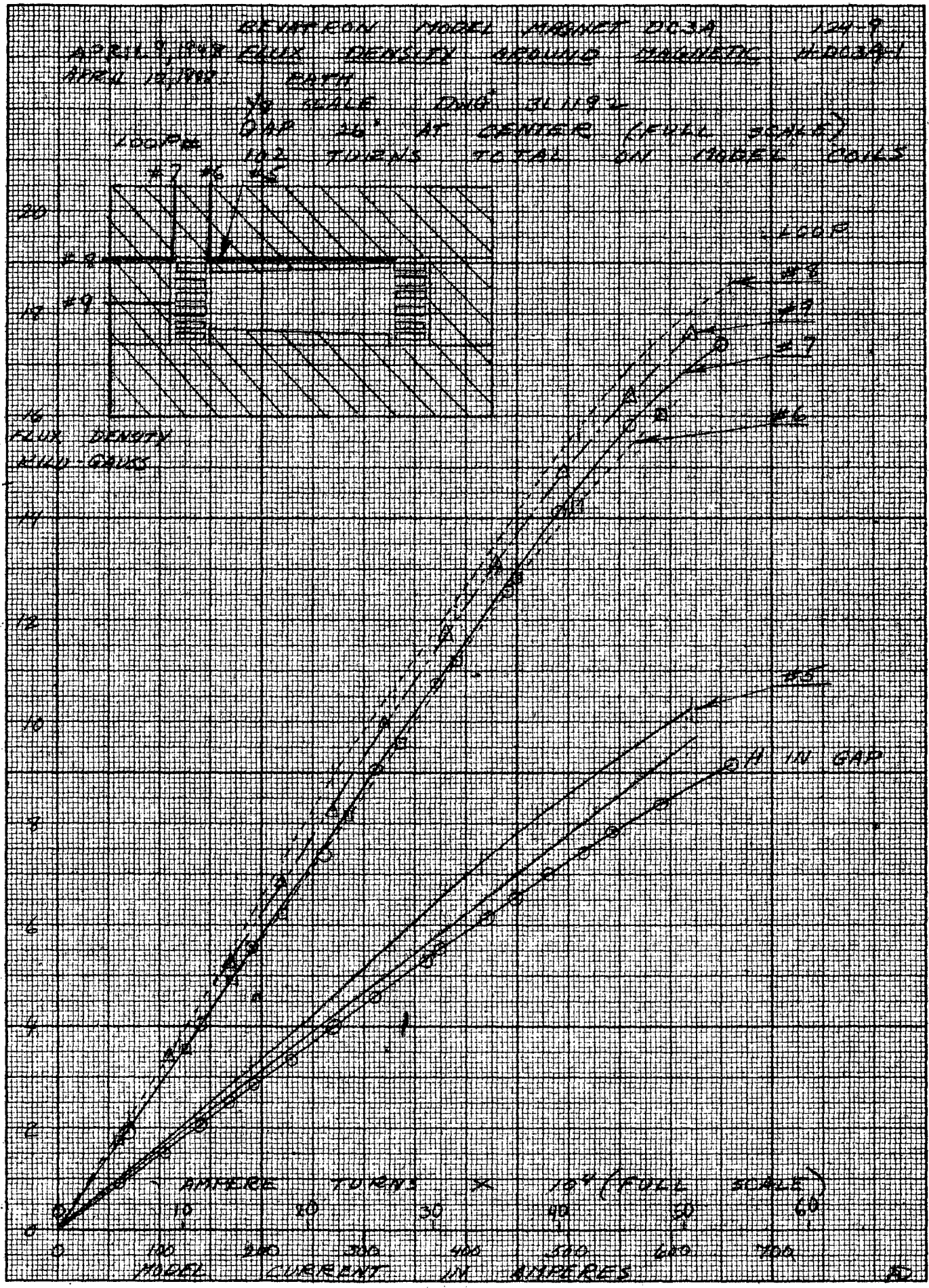
40

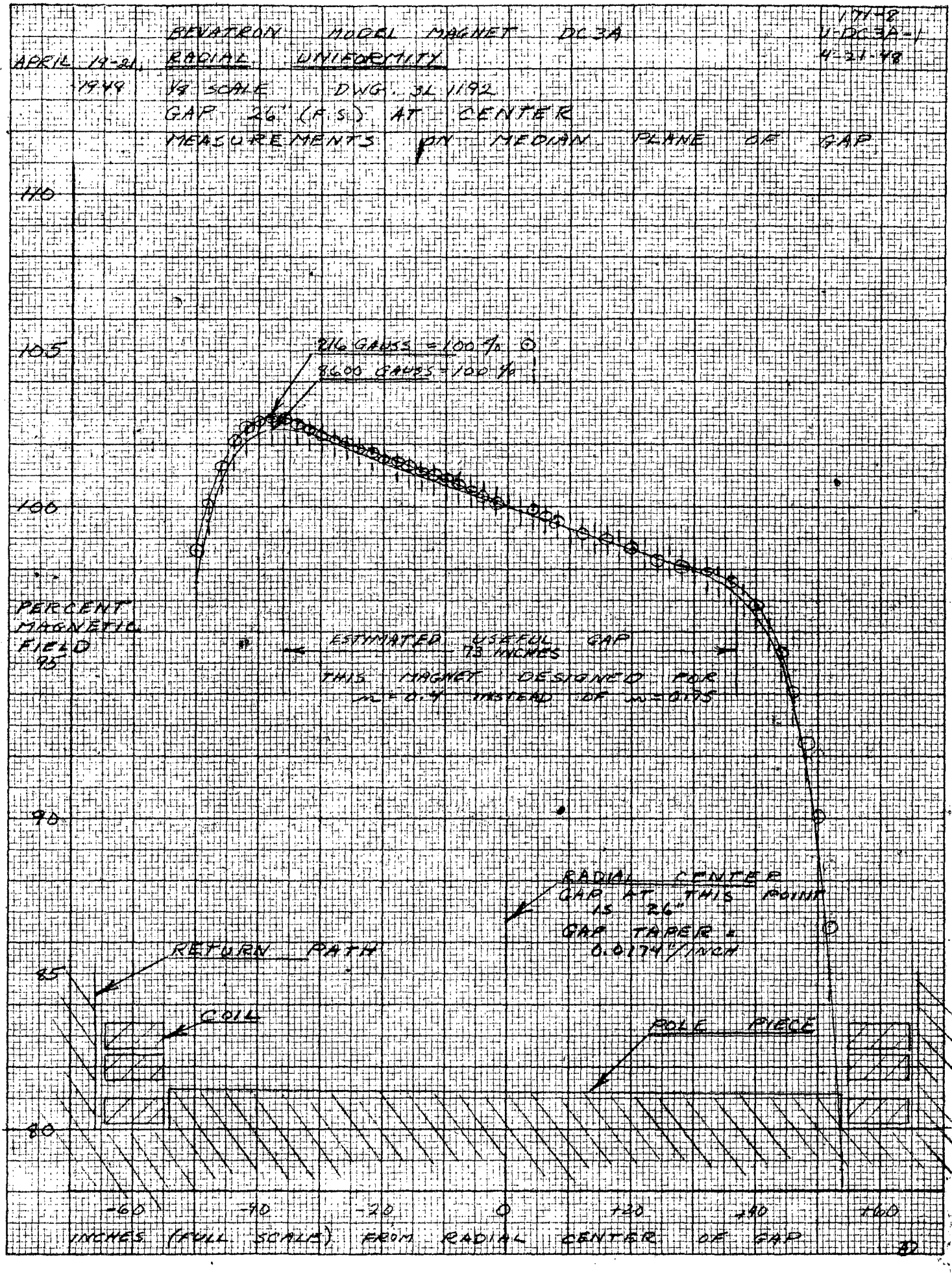
20

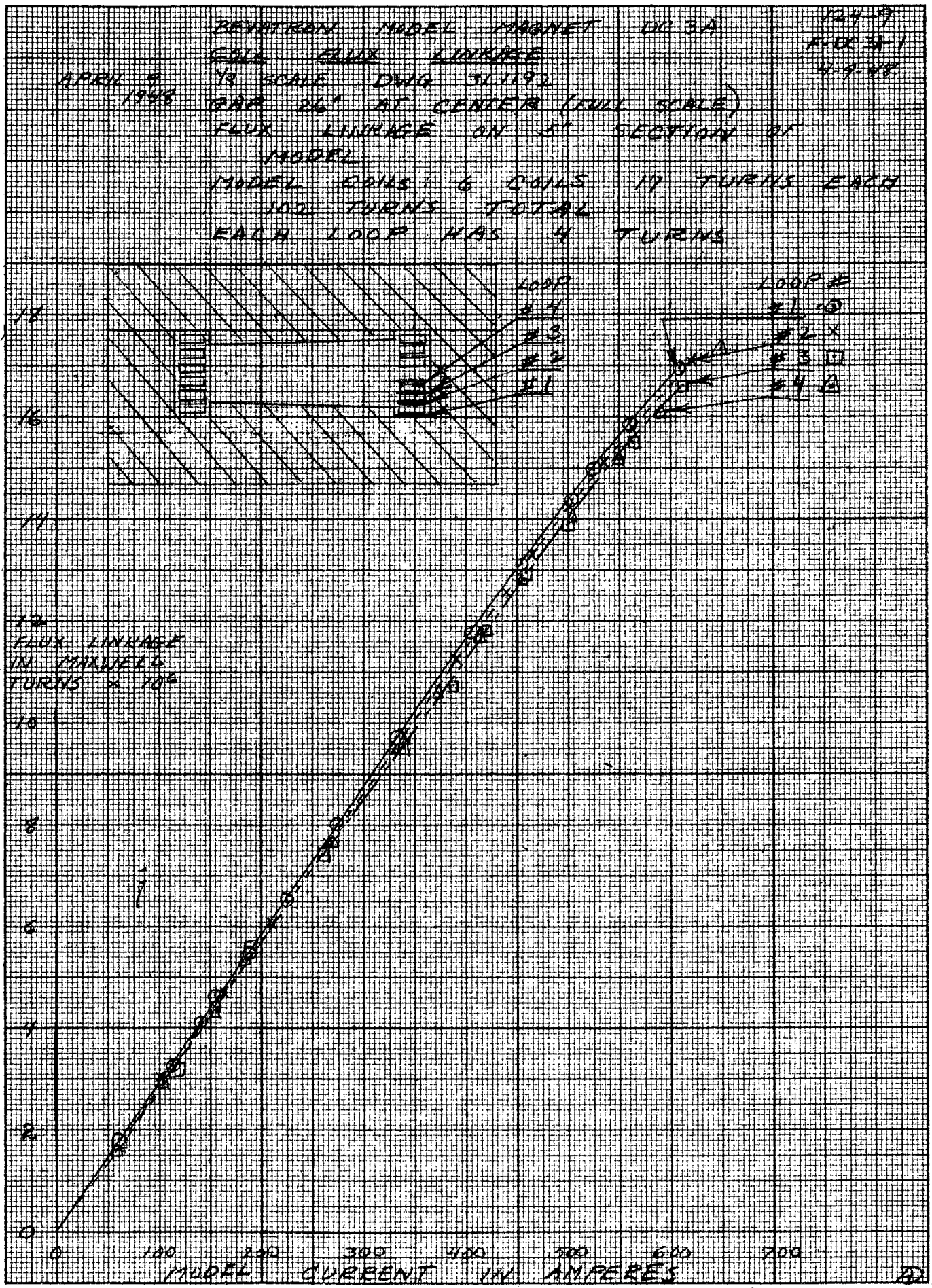
0

0 2 4 6 8 10 12

KILO-GAUSS - MAGNETIC FIELD AT CENTER OF GAP



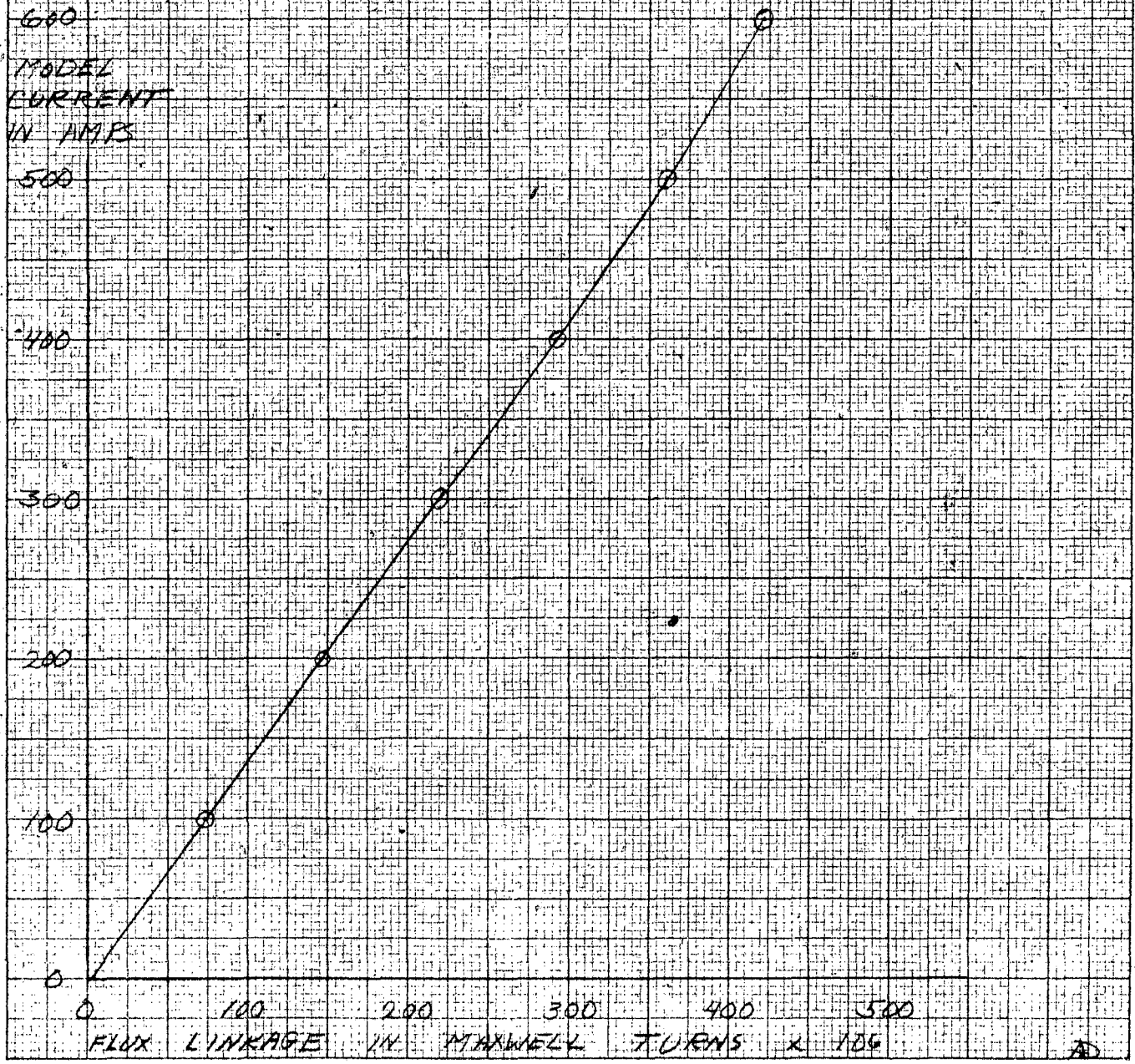




APRIL 9, '48

BEVATRON MODEL MAGNET DC3A
TOTAL COIL FLUX LINKAGE
1/8 SCALE DWG 3L 1192
GAP 26" AT CENTER (FULL SCALE)
FLUX LINKAGE ON 5" SECTION OF MODEL
MODEL COILS - 6 COILS 17 TURNS EACH - 102 TURNS TOTAL
SEE GRAPH F-DC3A-1
TOTAL LINKAGE = LOOPS (1+2)+(2+3)+(3+4)
EACH LOOP HAS 4 TURNS

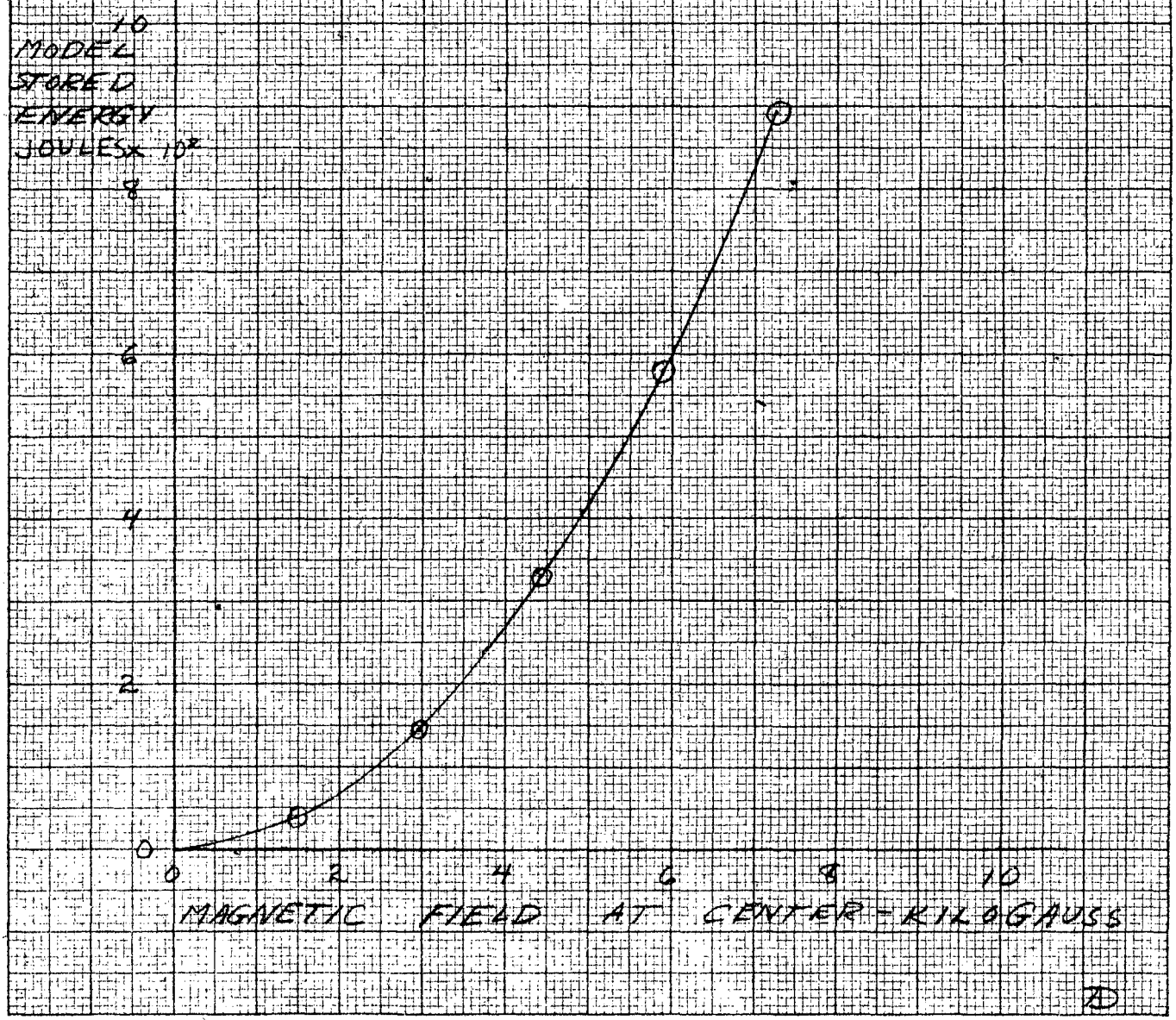
F-DC3A-1a
4-9-48



BEVATRON MODEL MAGNET-DC3A 171-8
APRIL 9, '58 1/8 SCALE DWG 3L 1192 E-DC3A-1
5-10-48
STORED ENERGY CALCULATED FROM
TOTAL COIL FLUX LINKAGE E-DC3A-1a

$$\text{ENERGY(JOULES)} = 10^{-8} \int_0^I I \, d\phi$$

WHERE I IS IN AMPERES ϕ
ϕ IS IN MAXWELL TURNS
DATA FOR 5" SECTION ON MODEL



7 Model Magnet DC5 Index

a. Discussion

b. Sketch

c. Photographs

BEVA 23

d. Graphs

L-DC5-1	Efficiency and leakage coefficients
H-DC5-1	Flux density around the magnetic path
U-DC5-1	Radial uniformity
U-DC5-1a	Radial uniformity - Expanded
F-DC5-1	Coil flux linkage
F-DC5-1a	Total coil flux linkage
E-DC5-1	Stored energy

7 Model Magnet DC5

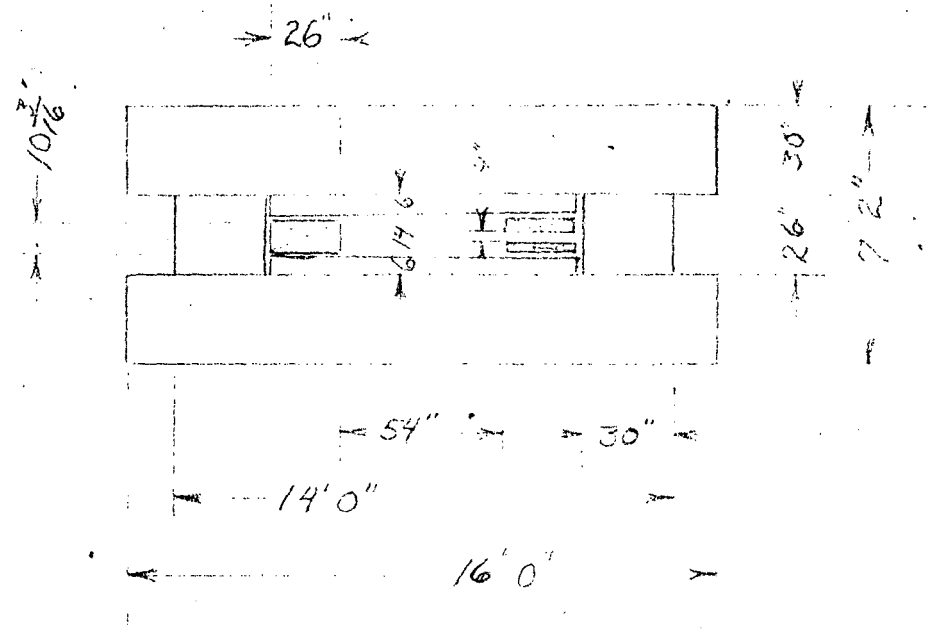
a. Discussion

Bevatron model magnet DC5 was similar in design to model DC3. Changes were made in the exciting coils in an effort to increase the useful gap width. The distance between the leg slabs was decreased but the radial width of the yoke slabs and the thickness of the leg slabs were not decreased.

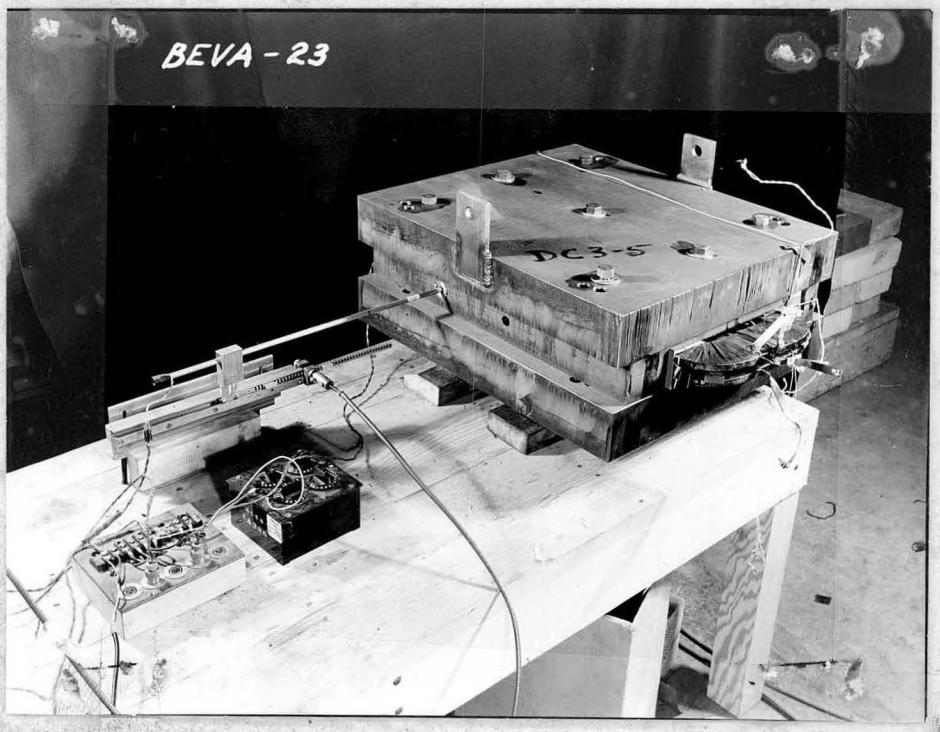
A comparison of magnet performance of model DC5 with the performance of model DC3 shows some changes. The peak KVA required was increased from 127 x 10^3 to 142 x 10^3 KVA for a rise time of one second. The useful radial gap width was increased at the injection field from 26 inches to 44 inches and at 16 kilogauss from 22 inches to 44 inches.

Model magnet DC5 was then modified for the larger aperture (2' x 8') model of DC5. (See DC5A)

BEVATRON MODEL MAGNET DC 5



$n = 0.75$
GAP 14"
RADIUS 50'
MODEL COILS: 2 COILS 46 TURNS EACH = 92 TURNS
DIMENSIONS ARE FULL SCALE
MODEL IS 1/8 SCALE
ASSEMBLY DWG. 3L 1402



BEVA 23

Bevatron Model Magnet DC5

GENERATOR MODEL MAGNET DC3
EFFICIENCY AND LEAKAGE COEFFICIENTS
½ SCALE DWG 3L 1402

17-8
L-DC3-1
5-10-48

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

PERCENT

LOOP # 3

LOOP # 4

AVERAGE TURN ON COIL

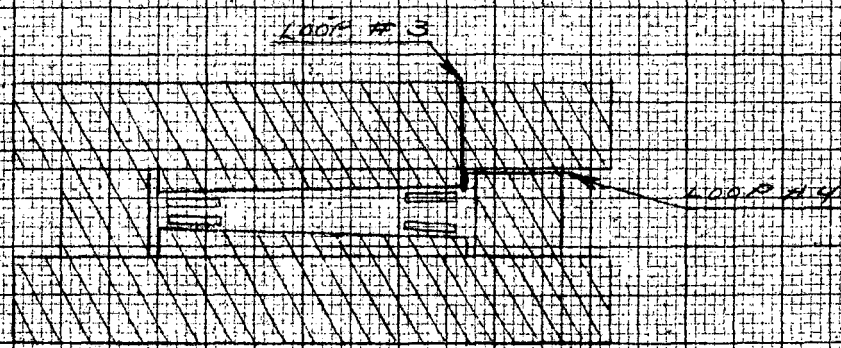
% LEAKAGE COEFFICIENT = TOTAL FLUX / FLUX DENSITY AT CENTER × POLE AREA

POLE AREA BASED ON 48" WIDTH

% EFFICIENCY = 2.02 × FLUX DENSITY AT CENTER × GAP HEIGHT (INCHES) / TOTAL AMPERE TURNS

AMPERE TURN EFFICIENCY

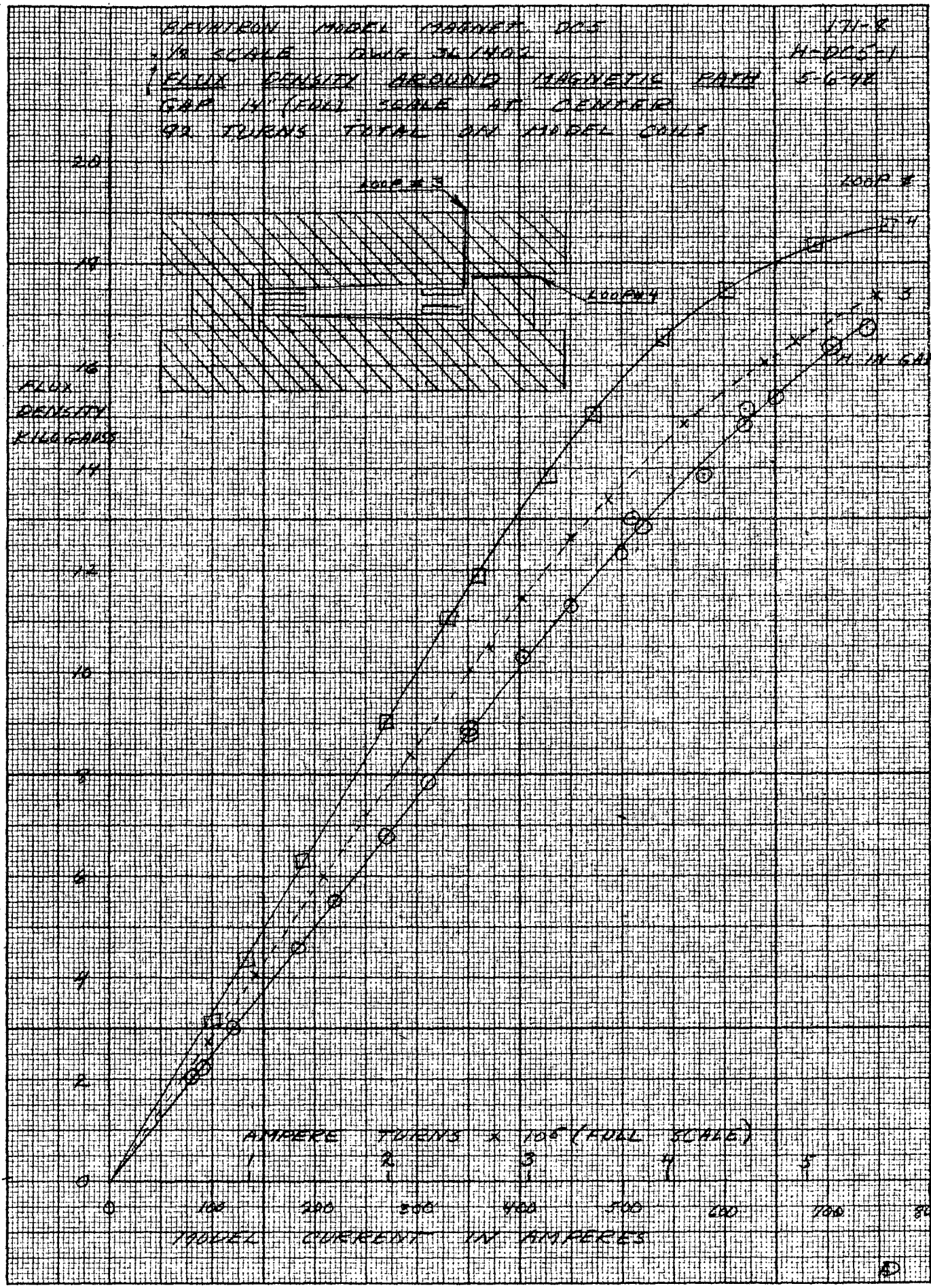
CROSS-SECTION OF MODEL

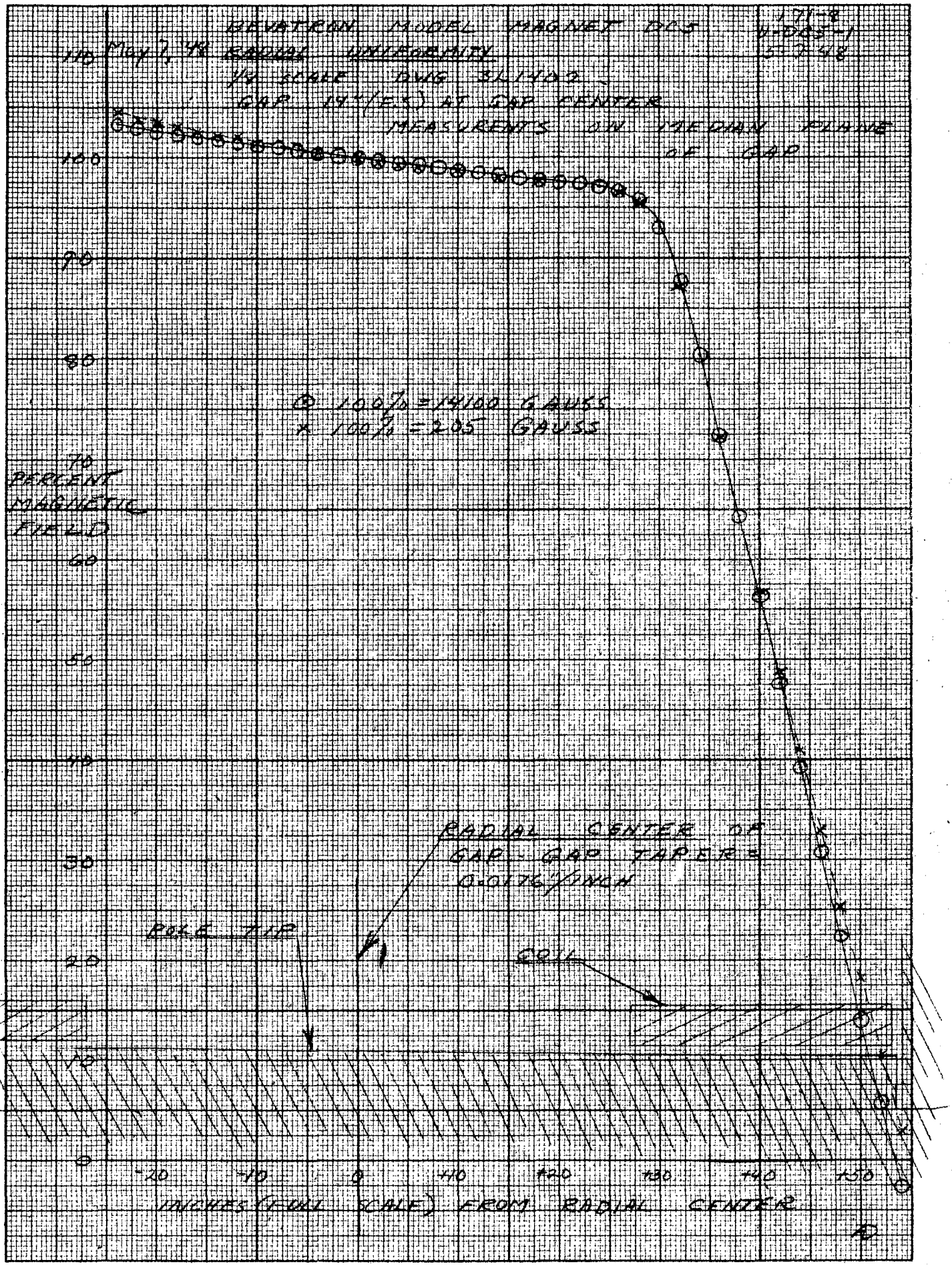


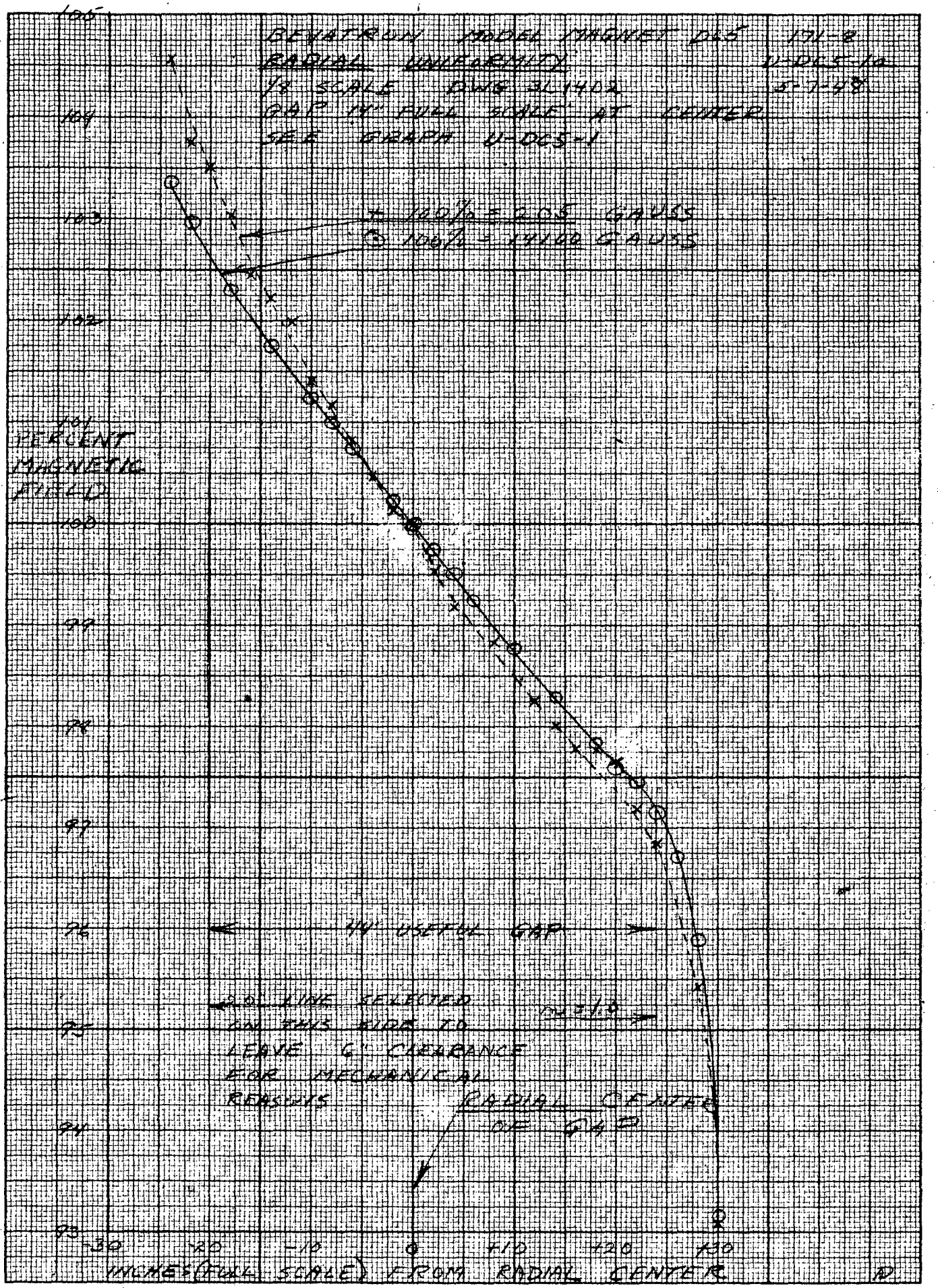
4 8 12 16 20

MAGNETIC FIELD AT CENTER OF GAP - KILOGAUSS

KEUFFEL & ESSER CO., N. Y. NO. 359-11G
10 × 10 to the ½ inch. 5th lines accented.
Engraving 7 × 10 in.
MADE IN U.S.A.






ELECTRON MODEL MAGNET DES 191-2
RADIAL UNIFORMITY
1/8 SCALE DWG 3L1402
SEE 5 GRAPH U-DCS-1
U-DCS-1a
5-7-48
100% = 12000 GAUSS
120% = 14400 GAUSS
PERCENT MAGNETIC FIELD
104
103
102
101
100
99
98
97
96
95
94
93
14" USEFUL GAP
POLE LINE SELECTED
FOR THIS RUN TO
LEAVE 6" CLEARANCE
FOR MECHANICAL
RESULTS
RADIAL CENTER
OF GAP
-30 -20 -10 0 +10 +20 +30
INCHES (FULL SCALE) FROM RADIAL CENTER

May 6, 1948

Bevatron Model Magnet DC5

Coil Flux Linkage

1/8 Scale DWG 3L1402

Gap 14" at Center (Full Scale)

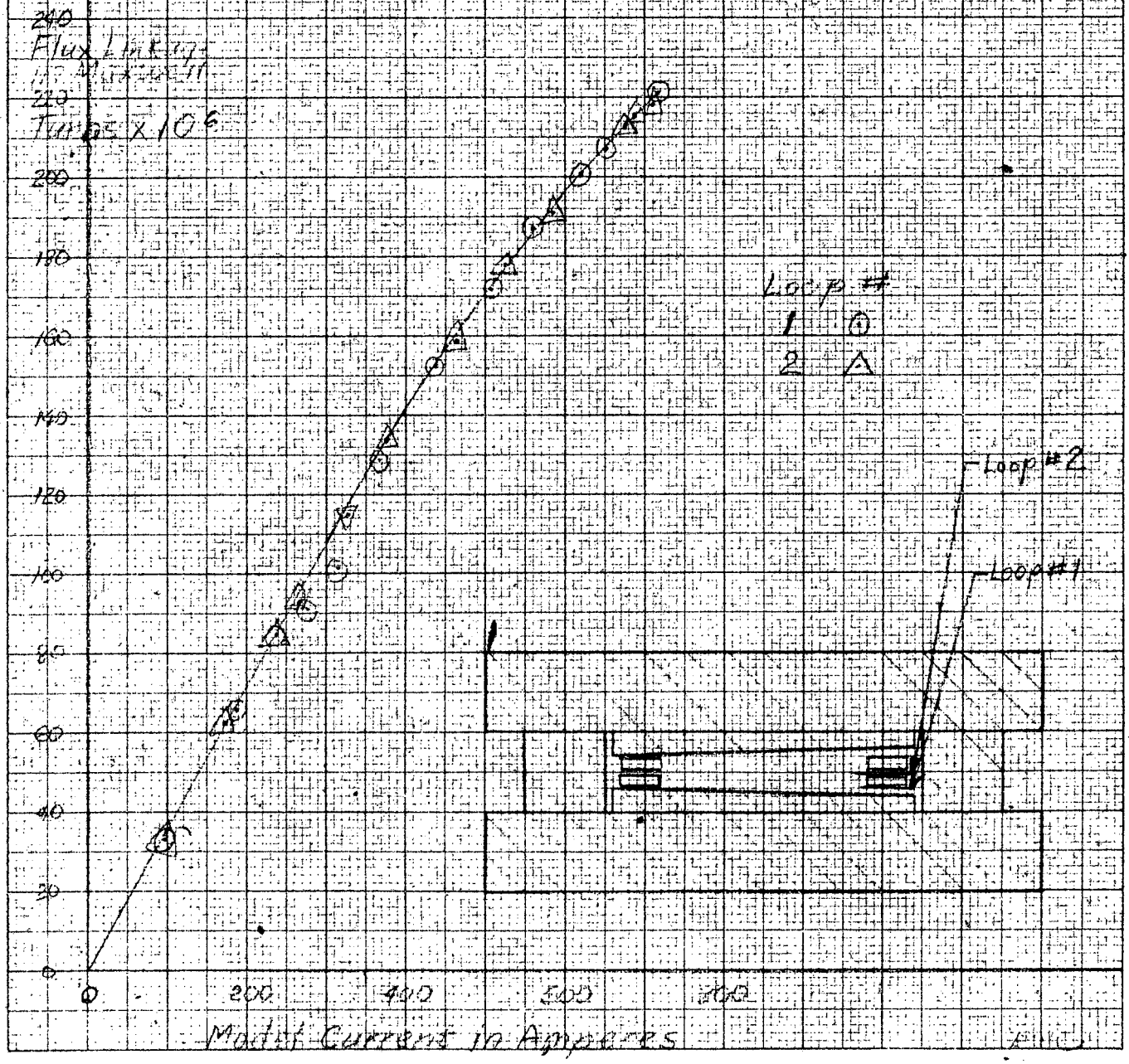
Flux Linkage on 5" Section of Model

Model Coils: 2 Coils 46 Turns Each

92 Turns Total

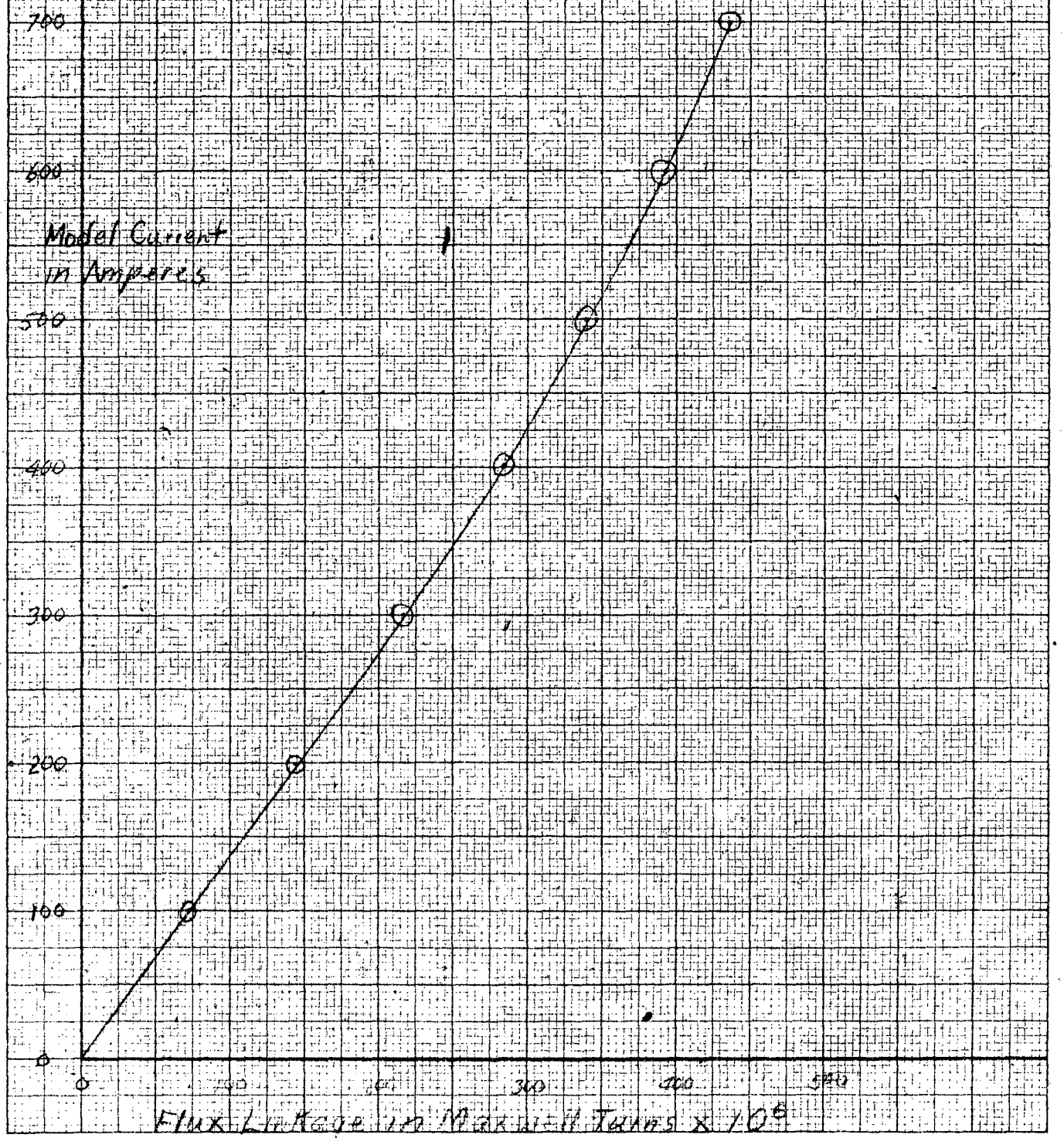
Each Loop has 46 Turns

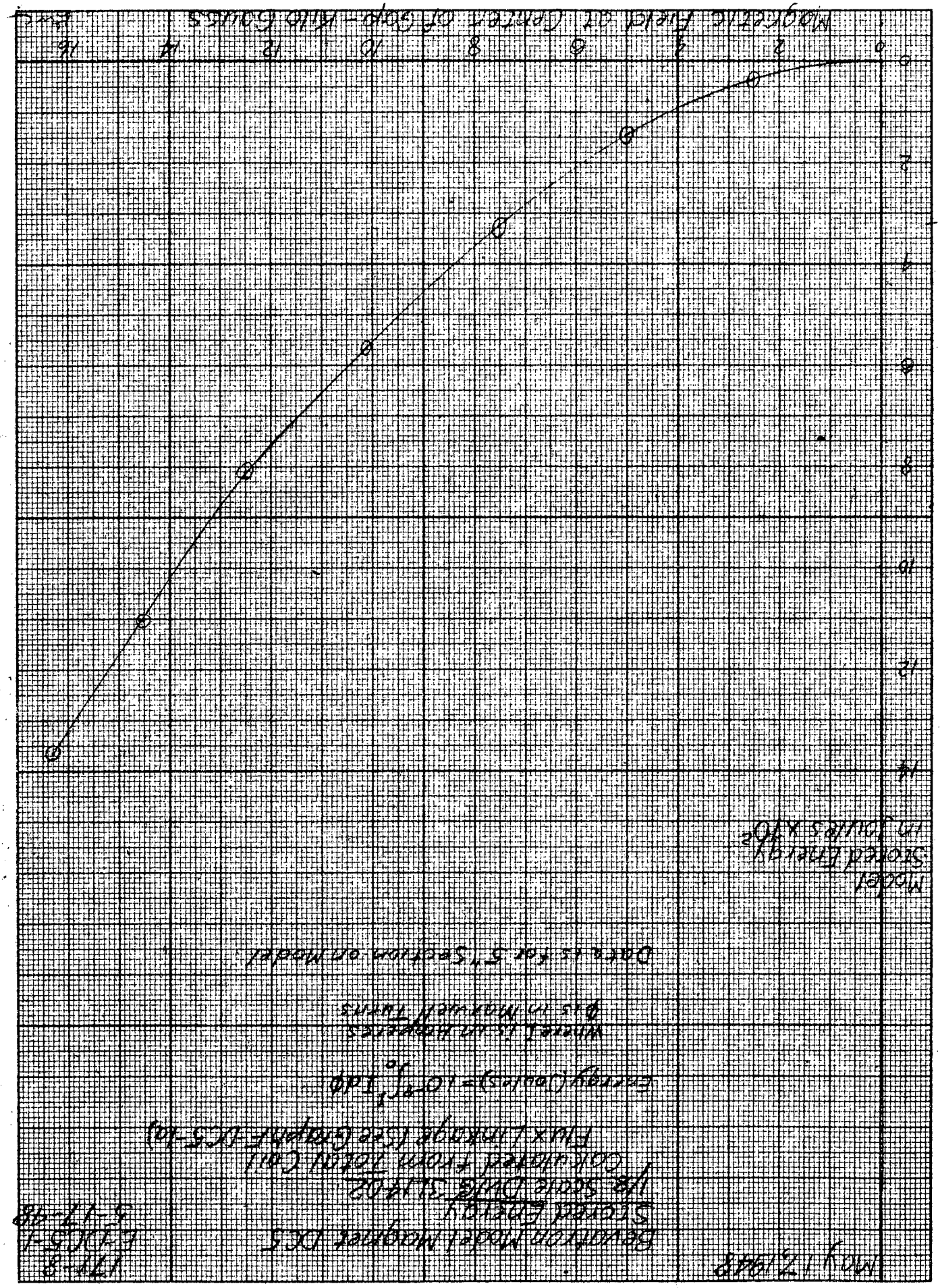
171-8
F-1205-1
5-6-48



May 10, 1948

Berator Model Magnet DC5 171-8
Total Coil Flux Linkage F-DC5-1a
1/8 Scale DWG 3L1402 5-10-48
Gap 1/4" at Center (Full Scale)
Flux Linkage on 5" Section of Model
Model Coils: 2 Coils 46 Turns Each
92 Turns Total
Each Loop has 46 Turns
See Graph F-DC5-1





8 Model Magnet DC5A Index

a. Discussion

b. Sketch

c. Photographs

BEVA 20

d. Graphs

L-DC5A-1	Efficiency and leakage coefficients
H-DC5A-1	Flux density around the magnetic path
U-DC5A-1	Radial uniformity
U-DC5A-1a	Radial uniformity - Expended
F-DC5A-1	Coil flux linkage
F-DC5A-1a	Total coil flux linkage
E-DC5A-1	Stored energy

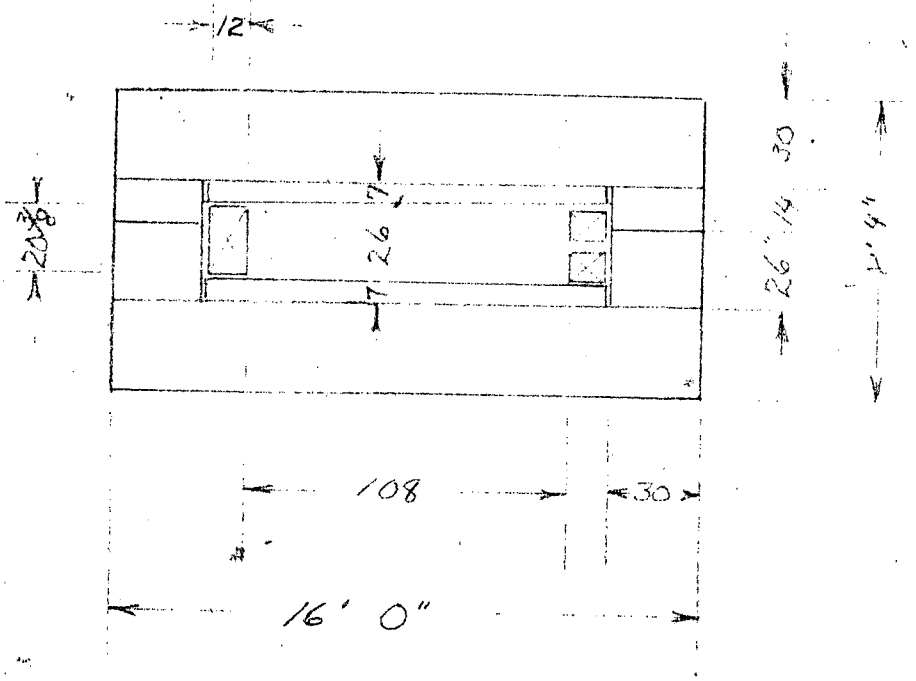
8 Model Magnet DC5A

a. Discussion

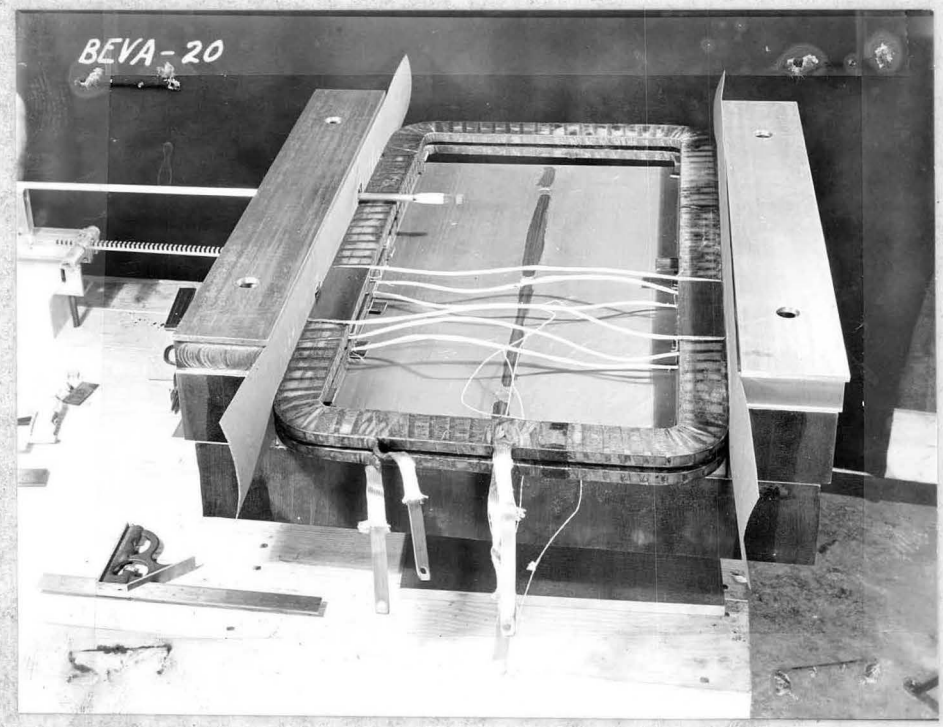
Bevatron model magnet DC5A was designed to adapt model magnet DC5 to a larger aperture. The radial width between the inner edges of the coils was increased from 54 inches to 108 inches. The gap was increased from 14 inches to 26 inches. Extensions were added to the leg slabs to increase the distance between the yoke slabs, and the legs were moved out to increase the distance between leg slabs.

The n value in the model magnet design was changed from 0.40 on DC3A to 0.75 on DC5A. The exciting coil placement was changed in an effort to increase the useful gap width. These changes increased the useful width of the magnetic field at the injection field and at the higher fields from 73 inches to 94 inches. A decision was made at this time to design a model magnet with an even larger aperture, 4' x 14', as an initial stage in the development of the bevatron. This magnet was to be designed so that it could be converted to the 1' x 4' aperture at a later time. (See model DC6 and DC6A)

BEVATRON MODEL MAGNET DC5A



GAP 26"
RADIUS 50'
$n = 0.75$
MODEL COILS: 4 COILS 26 TURNS EACH = 104 TURNS
DIMENSIONS ARE FULL SCALE
MODEL IS 1/8 SCALE
ASSEMBLY DWG. 3L 1402



BEVA 20

Bevatron Model Magnet DC5A

BEVATRON MODEL MAGNET DC5A X-DC5A-1

EFFICIENCY AND LEAKAGE COEFFICIENTS

5-4-48

1/8 SCALE DWG 3K 1402

% LEAKAGE COEFFICIENT =

$$\frac{\text{TOTAL FLUX}}{\text{FLUX DENSITY AT CENTER} \times \text{POLE AREA BASED ON 96" WIDTH}}$$

% EFFICIENCY = $\frac{2.02 \times \text{FLUX DENSITY AT CENTER} \times \text{GAP HEIGHT (INCHES)}}{\text{TOTAL AMPERE TURNS}}$

160

140

120

100

80

60

40

20

0

PERCENT

LOOP #

#1

#2

#3

#4

#5

#6

AVERAGE TURN ON COIL

AMPERE TURN EFFICIENCY

CROSS-SECTION OF MAGNET

COILS

0 2 4 6 8

MAGNETIC FIELD AT CENTER OF GAP - KILOGAUSS

171-8
H-DC5A-1
4-29-48

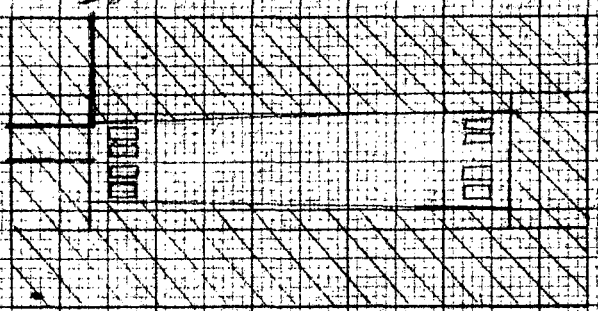
BEVATRON MODEL MAGNET DC 5"A

FLUX DENSITY AROUND MAGNETIC PATH

1/8 SCALE DWG. SL 1402

GAP 26" (FULL SCALE) AT CENTER

104 TURNS TOTAL - ONE MODEL COIL



#4
#5
#6

100% EFFICIENCY

H IN GAP

FLUX DENSITY IN KILO-GAUSS

0 2 4 6 8 10 12 14 16 18

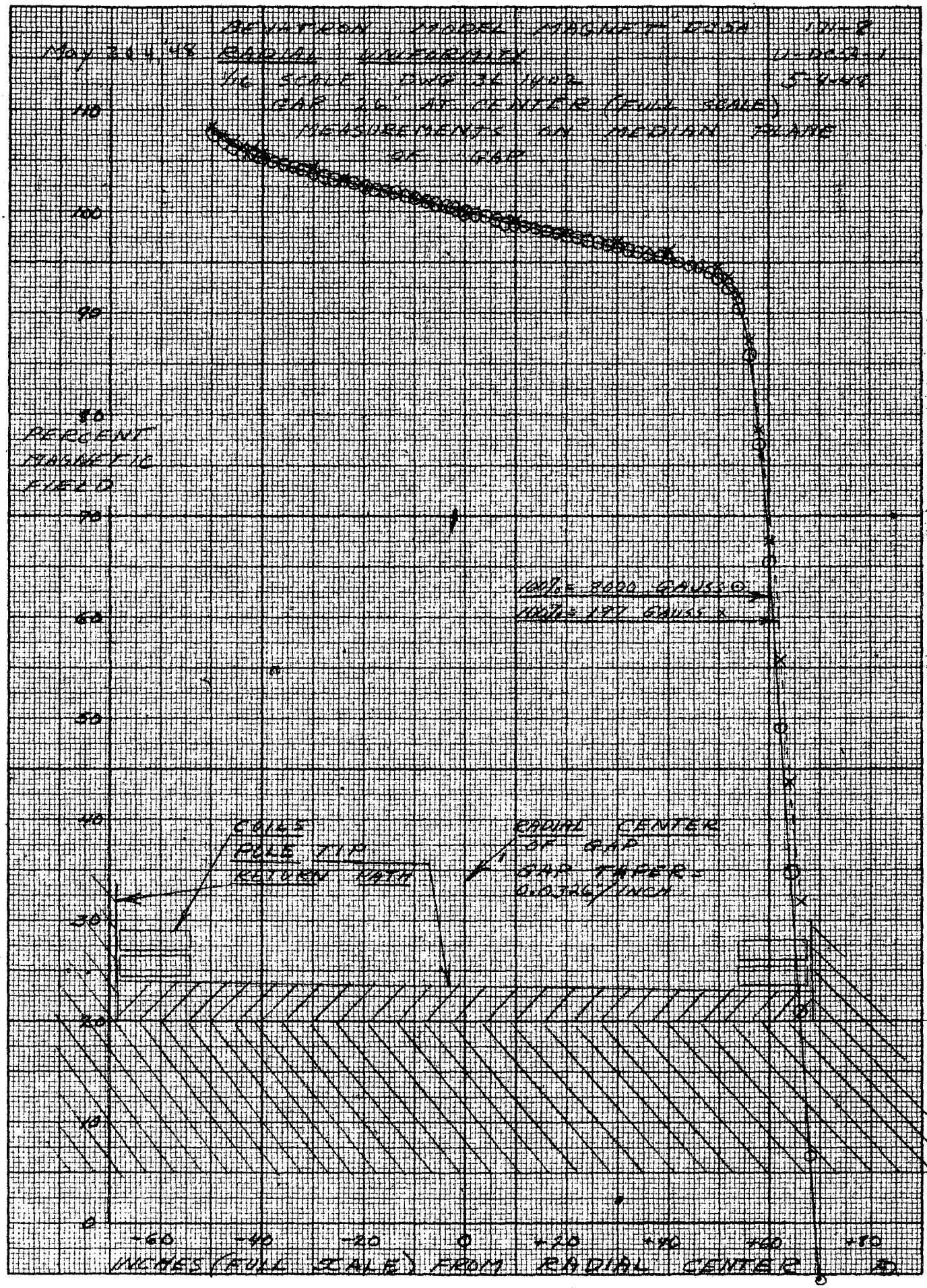
AMPERE TURNS × 10⁴ (FULL SCALE)

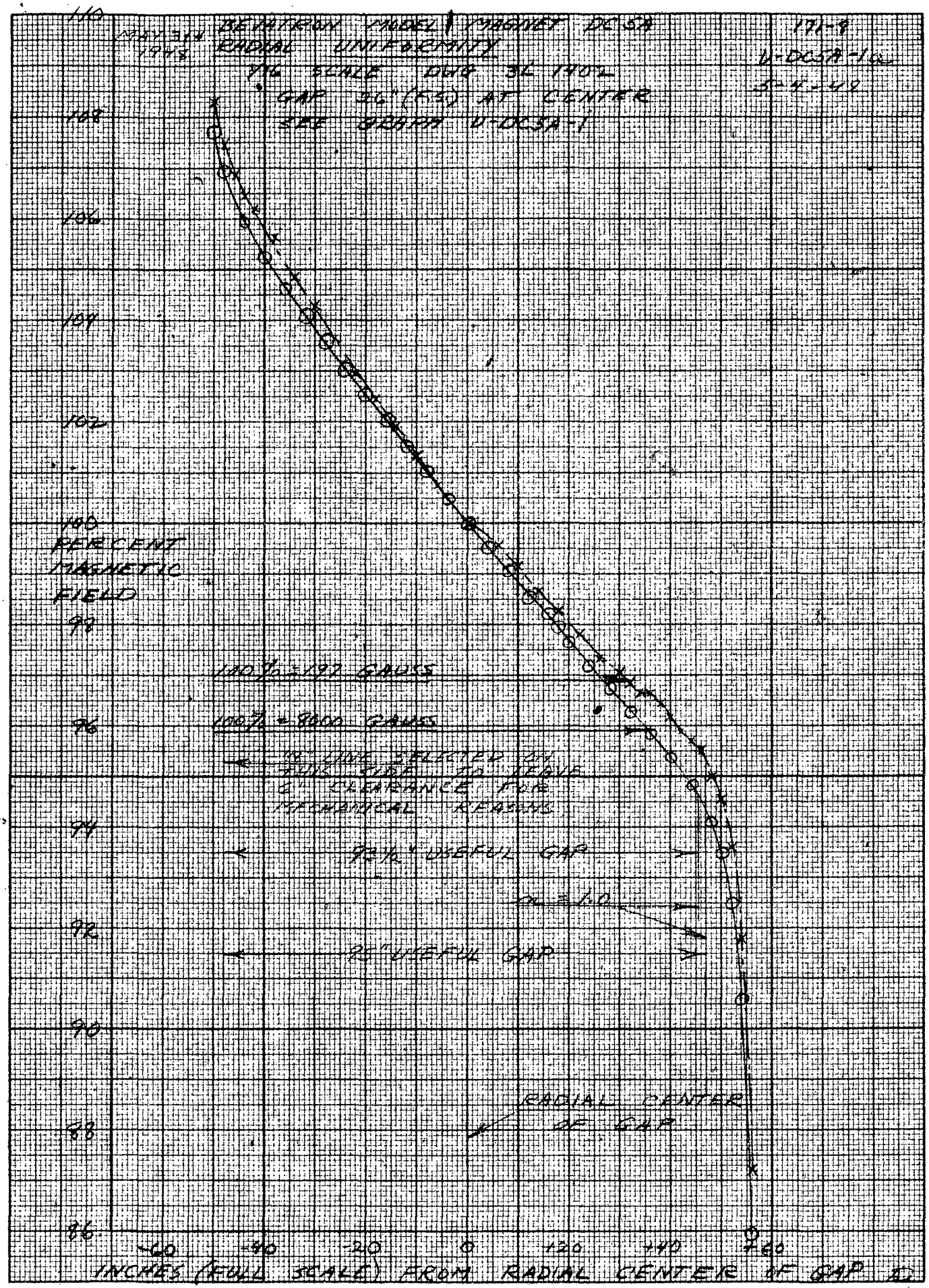
0 10 20 30 40 50

0 100 200 300 400 500 600 700

MODEL CURRENT IN AMPERES

KEUFFEL & ESSER CO., N. Y. NO. 359-143
10 X 10 to the ½ Inch. 5th lines accented.
MADE IN U. S. A.





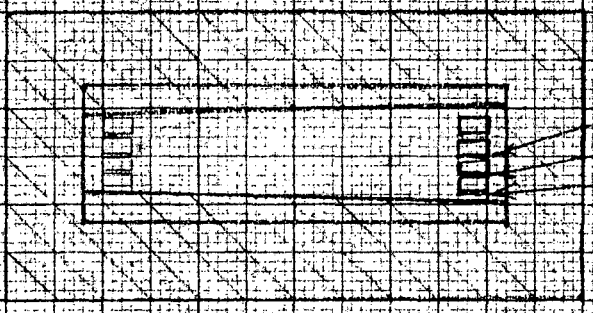
EUGENE DIETZGEN CO.
PRINTED IN U.S.A.

NO. 340 - M DIETZGEN GRAPH PAPER
MILLIMETER

Apr 29, 1948

Bevatron Model Magnet DC5A
Coil Flux Linkage
1/8 Scale DWG # 3L 1402
Gap 26" at Center (Full Scale) 4-29-48
Flux Linkage on 5" Section of Model
Model Coils: 4 Coils 26 Turns Each
104 Turns Total
Each Loop Has 26 Turns

171-B
F-DC5A-1



Flux Linkage in Maxwells
Turns x 10^6

110
100
90
80
70
60
50
40
30
20
10
0

Loop #
1 ⊙
2 △
3 □

0 100 200 300 400 500 600

Model Current in Amperes

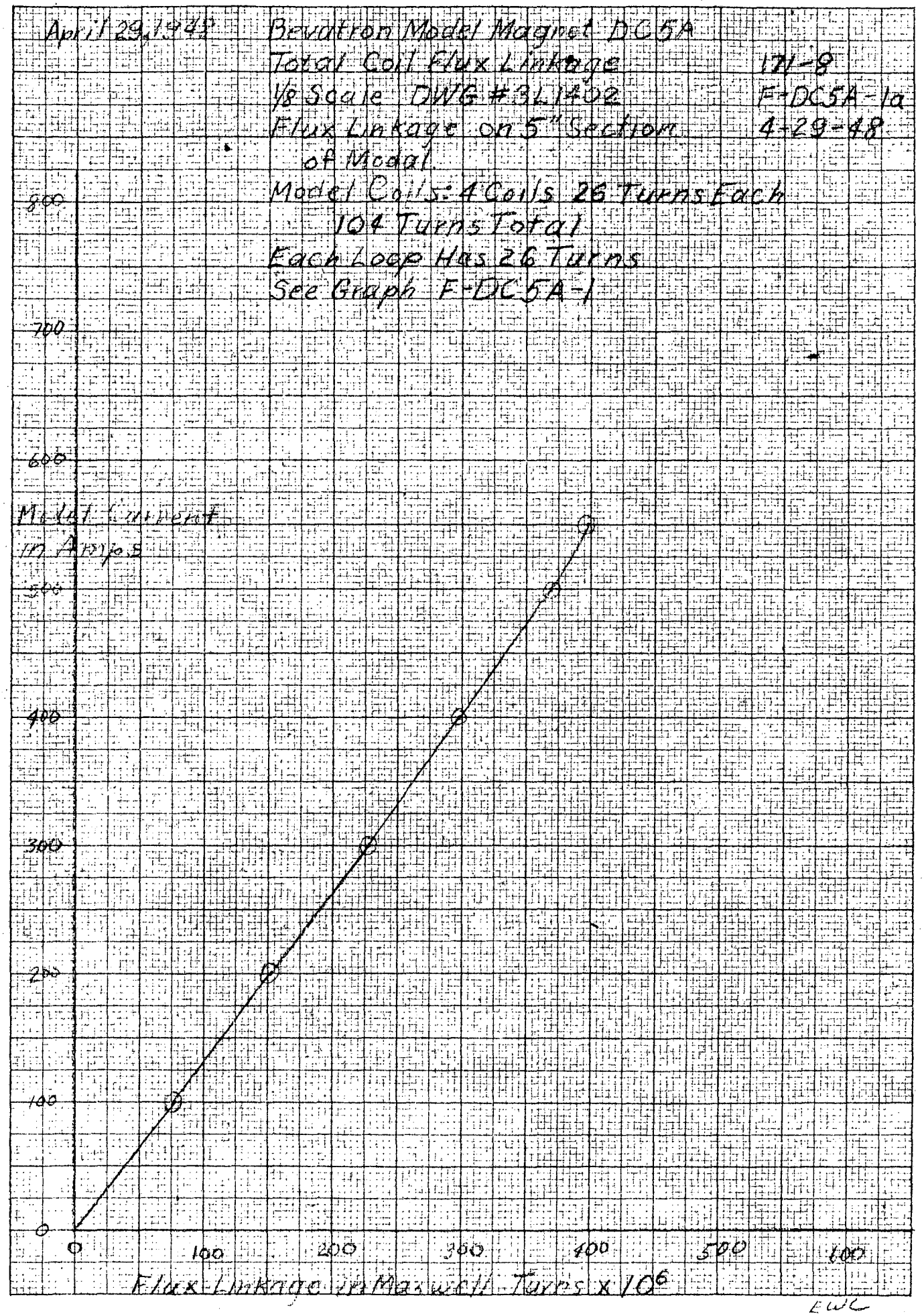
KEUFFEL & ESSER CO., N. Y. NO. 359-11G
10 × 10 to the ½ Inch, 5th lines accented.
Engraving 7 × 10 in.
MADE IN U.S.A.

April 29, 1948

Bevatron Model Magnet DC5A
Total Coil Flux Linkage
1/8 Scale DWG #31.1402
Flux Linkage on 5" Section of Model

171-8
F-DC5A-1a
4-29-48

Model Coils: 4 Coils 26 Turns Each
104 Turns Total
Each Loop Has 26 Turns
See Graph F-DC-5A-1



KEUFFEL & ESSER CO., N. Y. NO. 359-11G
10 × 10 to the ½ Inch, 5th lines accented.
Eccentric 7 × 10 In.
MADE IN U.S.A.

EWC

May 14, 1948

Boxcar Core Model Magnet DC54
1/8 Scale Dwg # 3L 1402

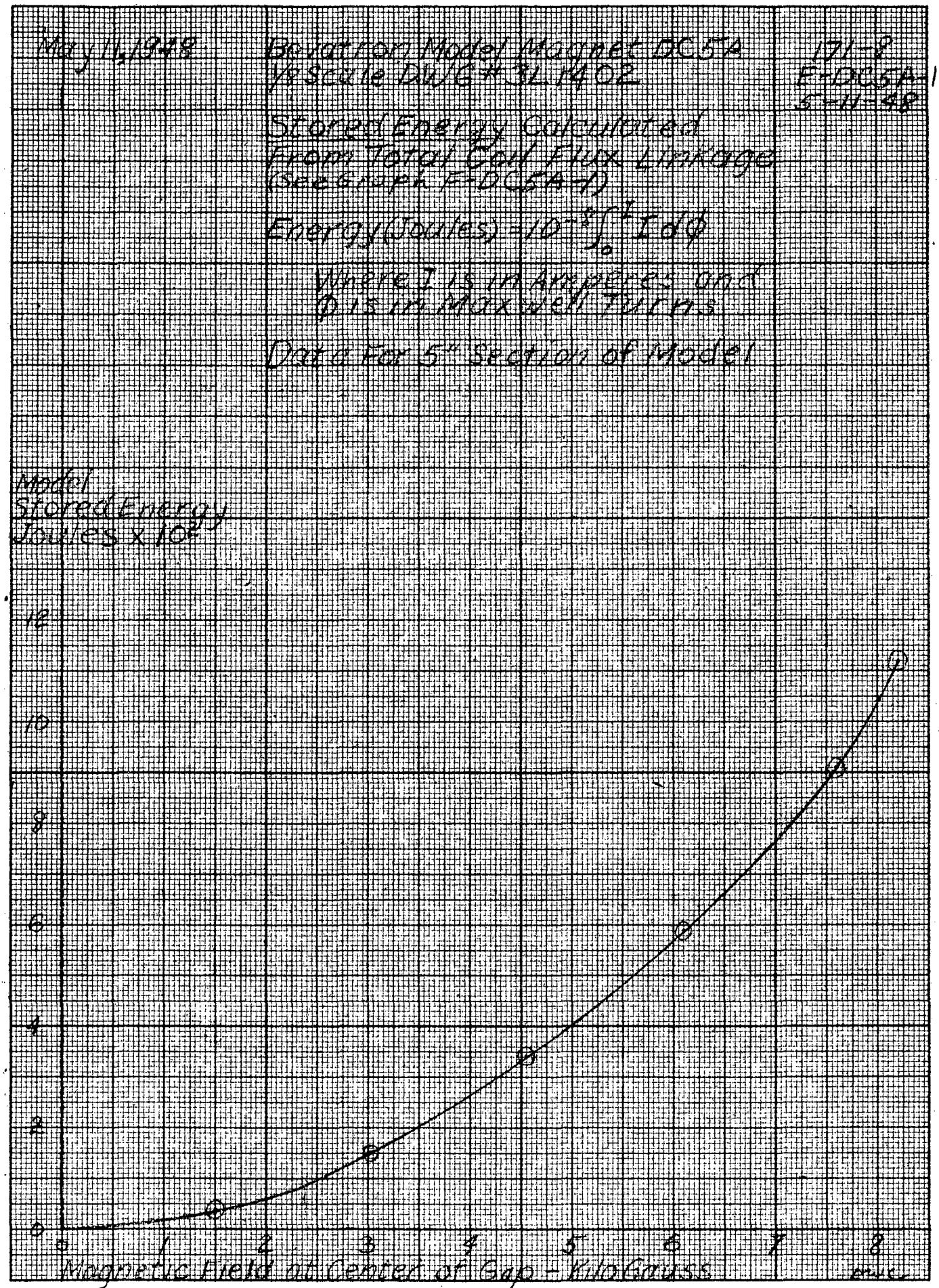
171-8
E-DC5A-1
5-14-48

Stored Energy Calculated
From Total Coil Flux Linkage
(See Graph E-DC54-D)

Energy (Joules) $= 10^{-8} \int_0^I \Phi \, dI$

Where I is in Amperes and
Φ is in Maxwell Turns.

Data For 5" Section of Model



9 Model Magnets DC6 and DC6A series Index

a. Discussion

b. Sketches

c. Photographs

BEVA 34

BEVA 35

BEVA 36

BEVA 37

d. Graphs

1) Model Magnets DC6 series

a) Model magnet DC6

H-DC6-1	Magnetization at center
H-DC6-2	Flux density around the magnetic path
H-DC6-3	Flux density around the magnetic path
H-DC6-4	Sketch showing location of flux loops
H-DC6-5	Flux density around the magnetic path
H-DC6-6	Magnetization at center - Low field
F-DC6-1	Coil flux linkage
F-DC6-1a	Total coil flux linkage
F-DC6-2	Coil flux linkage - Low field
E-DC6-1	Stored energy

b) Model magnet DC6.1

L-DC6.1-1	Efficiency and leakage coefficients
H-DC6.1-1 (cor)	Magnetization at gap center
H-DC6.1-2	Flux density around the magnetic path
H-DC6.1-3	Flux density around the magnetic path
H-DC6.1-4	Flux density around the magnetic path
H-DC6.1-5	Sketch showing location of the flux loops
F-DC6.1-1	Coil flux linkage

F-DC6.1-1a Total coil flux linkage

F-DC6.1-2 Coil flux linkage - Low field

E-DC6.1-1 (cor)Stored energy

c) Model magnet DC6.2

H-DC6.2-1 Magnetization at gap center

H-DC6.2-2 Flux density around the magnetic path

H-DC6.2-3 Flux density around the magnetic path

H-DC6.2-4 Flux density around the magnetic path

H-DC6.2-5 Sketch showing location of the flux loops

d) Model magnet DC6.3

H-DC6.3-1 Magnetization at gap center

H-DC6.3-2 Flux density around the magnetic path

H-DC6.3-3 Flux density around the magnetic path

H-DC6.3-4 Flux density around the magnetic path

H-DC6.3-5 Sketch showing the location of the flux loops

e) Model magnet DC6.4

H-DC6.4-1 Magnetization at gap center

H-DC6.4-2 Flux density around the magnetic path

H-DC6.4-3 Flux density around the magnetic path

H-DC6.4-4 Flux density around the magnetic path

H-DC6.4-5 Sketch showing the location of the flux loops

f) Model magnet DC6.5

H-DC6.5-1 Magnetization at gap center

F-DC6.5-1 Coil loop flux linkage

F-DC6.5-1a Total coil loop flux linkage

E-DC6.5-1 Stored energy

g) Model magnet DC6.6

H-DC6.6-1 Magnetization at gap center

H-DC6.6-2 Flux density around the magnetic path

H-DC6.6-3 Flux density around the magnetic path

H-DC6.6-4	Flux density around the magnetic path
H-DC6.6-5	Sketch showing location of the flux loops
H-DC6.6-6	Magnetization at gap center - Low field
U-DC6.6-1	Radial uniformity
U-DC6.6-1a	Radial uniformity - Expanded.

h) Model magnet DC6.7

H-DC6.7-1	Magnetization at gap center

i) Model magnet DC6.8

H-DC6.8-1	Magnetization at gap center

j) Model magnet DC6.9

H-DC6.9-1	Magnetization at gap center

2) Model magnet DC6A series

a) Model magnet DC6A

L-DC6A-1	Efficiency and leakage coefficients
H-DC6A-1	Flux density around the magnetic path
H-DC6A-2	Flux density around the magnetic path
H-DC6A-3	Flux density around the magnetic path
H-DC6A-4	Sketch showing location of flux loops
H-DC6A-5	Magnetization at gap center - Low field
F-DC6A-1	Coil flux linkage
F-DC6A-1a	Total coil flux linkage
E-DC6A-1 (cor)	Stored energy

b) Model magnet DC6A.1

H-DC6A.1-1	Magnetization at gap center
U-DC6A.1-1	Radial uniformity
U-DC6A.1-1a	Radial uniformity - Expanded
F-DC6A.1-1	Coil flux linkage
F-DC6A.1-1a	Total coil flux linkage
E-DC6A.1-1	Stored energy

c) Model magnet DC6A.2

H-DC6A.2-1	Magnetization at gap center
H-DC6A.2-2	Flux density around the magnetic path
H-DC6A.2-3	Flux density around the magnetic path
H-DC6A.2-4	Flux density around the magnetic path
H-DC6A.2-5	Sketch showing location of flux loops
H-DC6A.2-6	Magnetization at gap center - Low field

U-DC6A.2-1	Radial uniformity
U-DC6A.2-1a	Radial uniformity - Expanded

d) Magnet magnet DC6A.3

H-DC6A.3-1	Magnetization at gap center
H-DC6A.3-2	Magnetization at gap center - Low field
H-DC6A.3-3	Flux density around the magnetic path
H-DC6A.3-4	Flux density around the magnetic path
H-DC6A.3-5	Flux density around the magnetic path
H-DC6A.3-6	Sketch showing the location of flux loops
U-DC6A.3-1	Radial uniformity
U-DC6A.3-1a	Radial uniformity - Expanded
F-DC6A.3-1	Coil loop flux linkage
F-DC6A.3-1a	Total coil loop flux linkage
E-DC6A.3-1	Stored energy
S-DC6A.3-29	Flux density on yoke
S-DC6A.3-30	Flux density on yoke
S-DC6A.3-31	Sketch showing location of flux loops on yoke
S-DC6A.3-32 (cor)	Flux density on coils
S-DC6A.3-33	Flux density on coils
S-DC6A.3-34	Flux density on coils
S-DC6A.3-35	Flux density on coils
S-DC6A.3-36	Flux density on coils
S-DC6A.3-41	Stray field - Azimuthal uniformity - 2100 gauss
S-DC6A.3-42	Stray field - Azimuthal uniformity - 5050 gauss
S-DC6A.3-43	Stray field - Azimuthal uniformity - 200 gauss
S-DC6A.3-44	Stray field - Radial uniformity - 200 gauss
S-DC6A.3-45	Stray field - Radial uniformity - 2100 gauss
S-DC6A.3-46	Stray field - Radial uniformity - 5050 gauss
S-DC6A.3-47	Leakage flux summary

e) Model Magnet DC6A.4

H-DC6A.4-1	Magnetization at gap center
H-DC6A.4-2	Magnetization at gap center - Low field

f) Model Magnet DC6A.5

H-DC6A.5-1	Magnetization at gap center
H-DC6A.5-2	Magnetization at gap center - Low field

g) Model Magnet DC6A.6

H-DC6A.6-1	Magnetization at gap center
H-DC6A.6-2	Magnetization at gap center - Low field

9 Model Magnets DC6 and DC6A Series

a. Discussion

Bevatron model magnets DC6 and DC6A were designed to incorporate the best features observed on the previous DC model magnets of both type A and type B. A decision was made at this time to enlarge the aperture from 2' x 8' to 4' x 14' for the initial stage. These were the first models designed to accomodate both a large (4' x 14') and a small (1' x 4') aperture without leg extensions. It was decided to use pole pieces similar to those used on model DC5A for the larger aperture (model DC6A), and similar to those used on model DC4 for the smaller aperture (model DC6). It was decided that at a later date the actual shape of the wings could be determined to give the maximum width field at the injection field (see model DC4B). The radius of the initial stage (4' x 14' aperture) was set at 552 inches instead of 600 inches as on the models DC3A and DC5A. The radius on the final stage (1' x 4' aperture) remained at 600 inches. These were the first models built in $2\frac{1}{2}^{\circ}$ sectors on the arc of a circle. This series was 1/12 scale.

(1) DC6 series

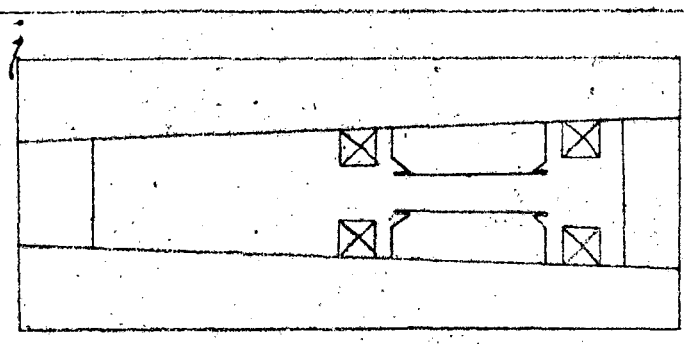
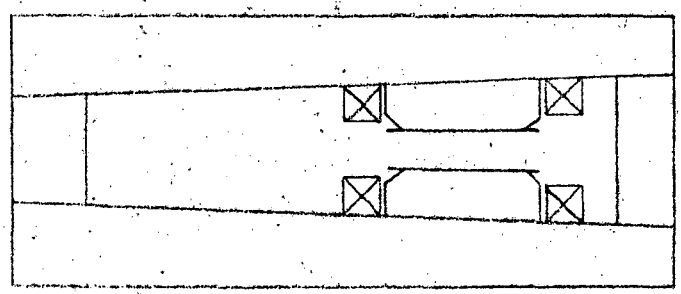
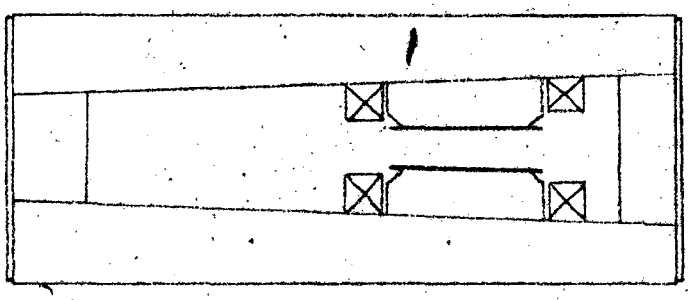
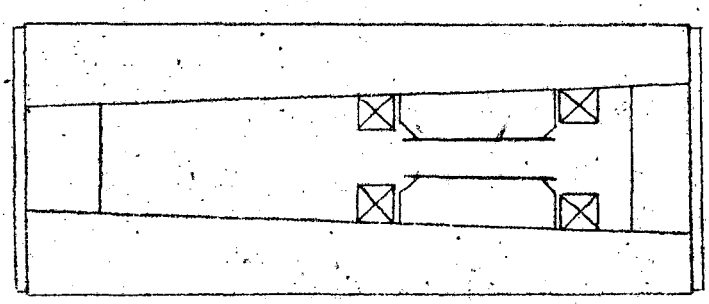
Bevatron model magnets DC6 through DC6.9 are the designs for the 1' x 4' aperture for this series. Small changes in the placement of the steel and the design of the coils were made on these models to obtain the maximum magnet efficiency for the minimum amount of steel and copper. (See sketches for the actual mechanical changes.) Model DC6.6 was chosen as the final design for this model.

(2) DC6A series

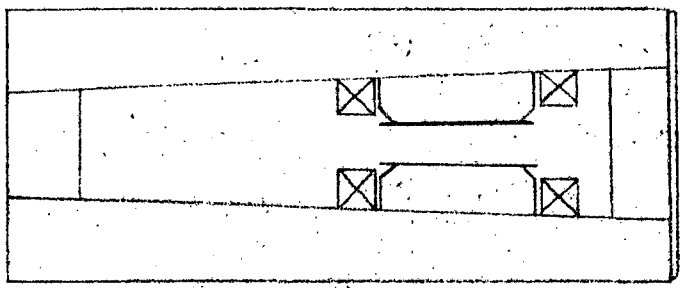
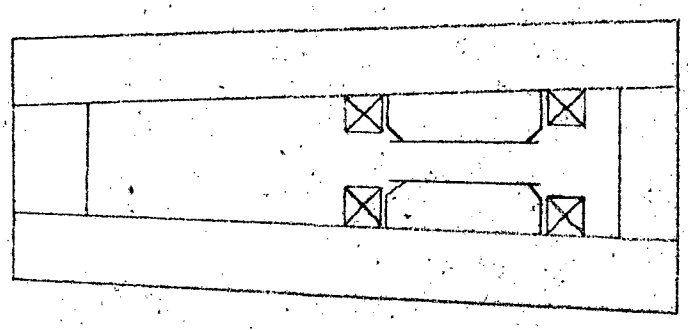
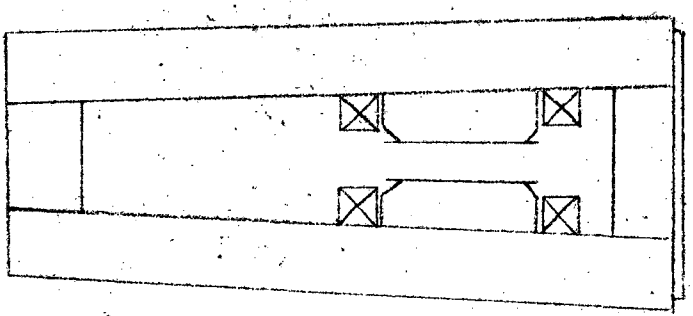
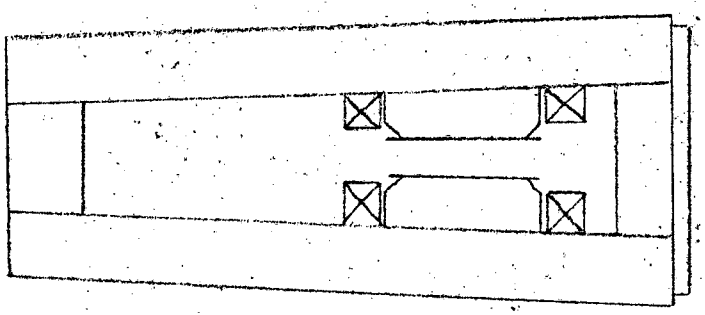
Bevatron model magnet DC6A was the original design of the larger aperture (4' x 14') in this series. On model DC6A.1, the end of the exciting coil was bent up closer to the edge of the yoke for mechanical reasons. On model magnet DC6A.2 the parallel sided yoke slabs used on

model DC6.5 were substituted for the original tapered yoke slabs. Model magnet DC6A.3 had three inches of steel added to the outer leg slabs to conform to model DC6.6. Various copper to copper spacings on the exciting coils were tested to observe the changes in magnet efficiency on models DC6A.4, DC6A.5, and DC6A.6. The vertical spacing of 19-7/8" on model DC6A.3 gave an efficiency of 83% as compared to 86% to 87.5% on models DC6A.4, DC6A.5, and DC6A.6 which had closer spacing. Model magnet DC6A.3 was chosen as the final design for this model.

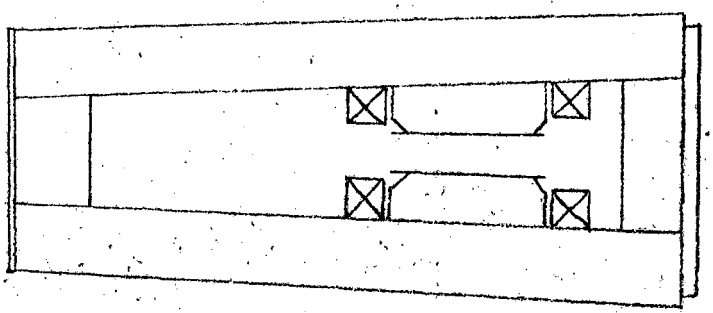
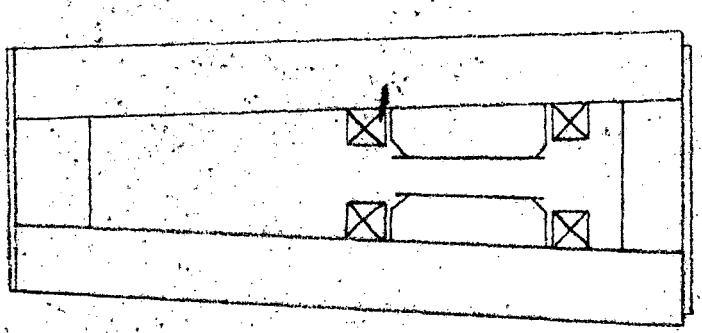
DC6 SERIES BEVATRON MAGNET

MODEL NUMBER	CROSS SECTION	REMARKS
DC6 —		AS SHOWN ON DWG 3L1635
DC6.1		SAME AS DC6 EXCEPT COILS ARE CLOSER TO POLES - COIL TO POLE CLEARANCE IS 1" (WAS 8")
DC6.2		SAME AS DC6.1 EXCEPT 3" (F.S.) STEEL PLATE ADDED TO EACH LEG SLAB
DC6.3		SAME AS DC6.1 EXCEPT 6" (F.S.) STEEL PLATE ADDED TO EACH LEG SLAB

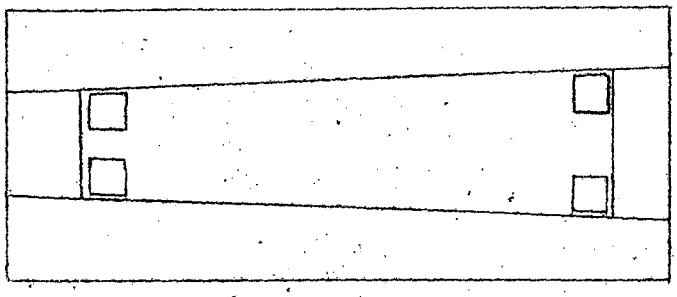
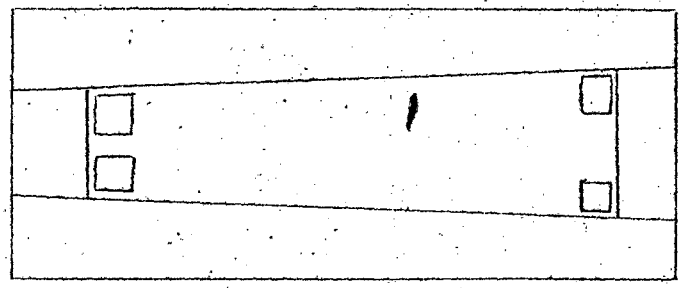
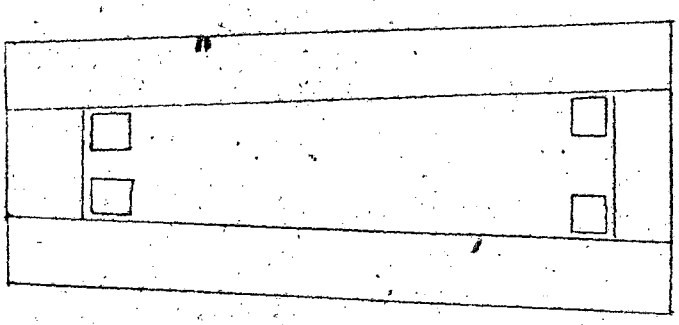
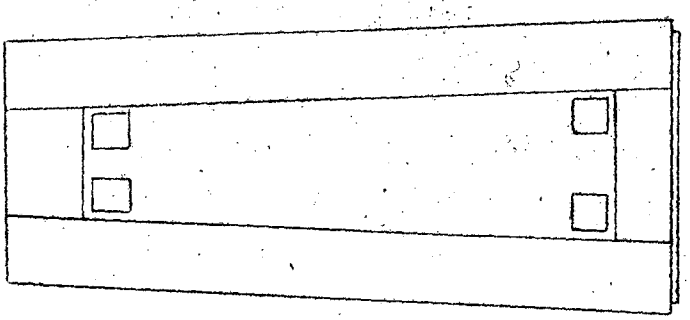
DC6 SERIES BEVATRON MAGNET

MODEL NUMBER	CROSS SECTION	REMARKS
DC6.4		SAME AS DC6.1 EXCEPT 3" (F.S.) STEEL PLATE ADDED TO OUTER LEG SLAB
DC6.5		SAME AS DC6.1 EXCEPT TOP & BOTTOM YOKE SLABS HAVE UNIFORM HEIGHT
DC6.6		SAME AS DC6.5 EXCEPT 3" (F.S.) STEEL PLATE ADDED TO OUTER LEG SLAB SEE FOLLOWING SKETCH FOR DIM. OF THIS MODEL
DC6.7		SAME AS DC6.5 EXCEPT 6" (F.S.) STEEL PLATE ADDED TO OUTER LEG SLAB.

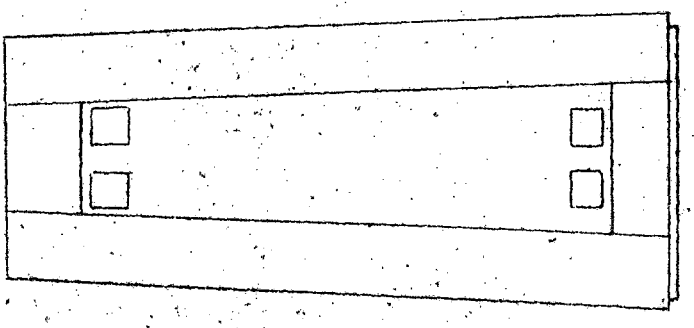
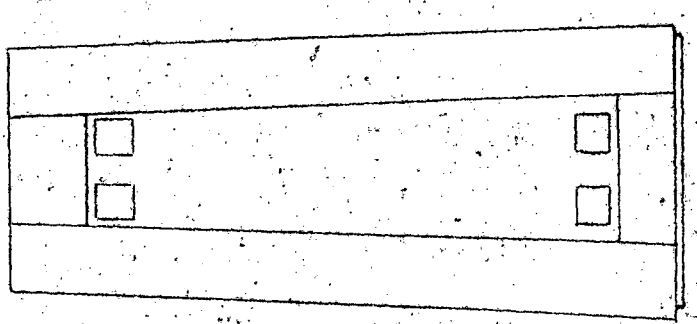
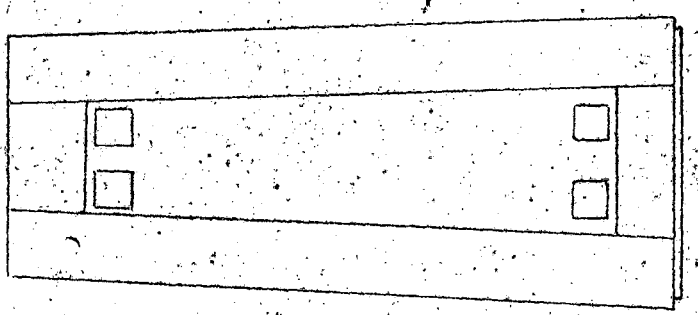
DC6 SERIES BEVATRON MAGNET

MODEL NUMBER	CROSS SECTION	REMARKS
DC6.8		SAME AS DC6.5 EXCEPT 6" (F.S.) STEEL PLATE ADDED TO OUTER LEG SLAB AND 3" (F.S.) STEEL PLATE ADDED
DC6.9		SAME AS DC6.5 EXCEPT 3" (F.S.) STEEL PLATE ADDED TO EACH LEG SLAB

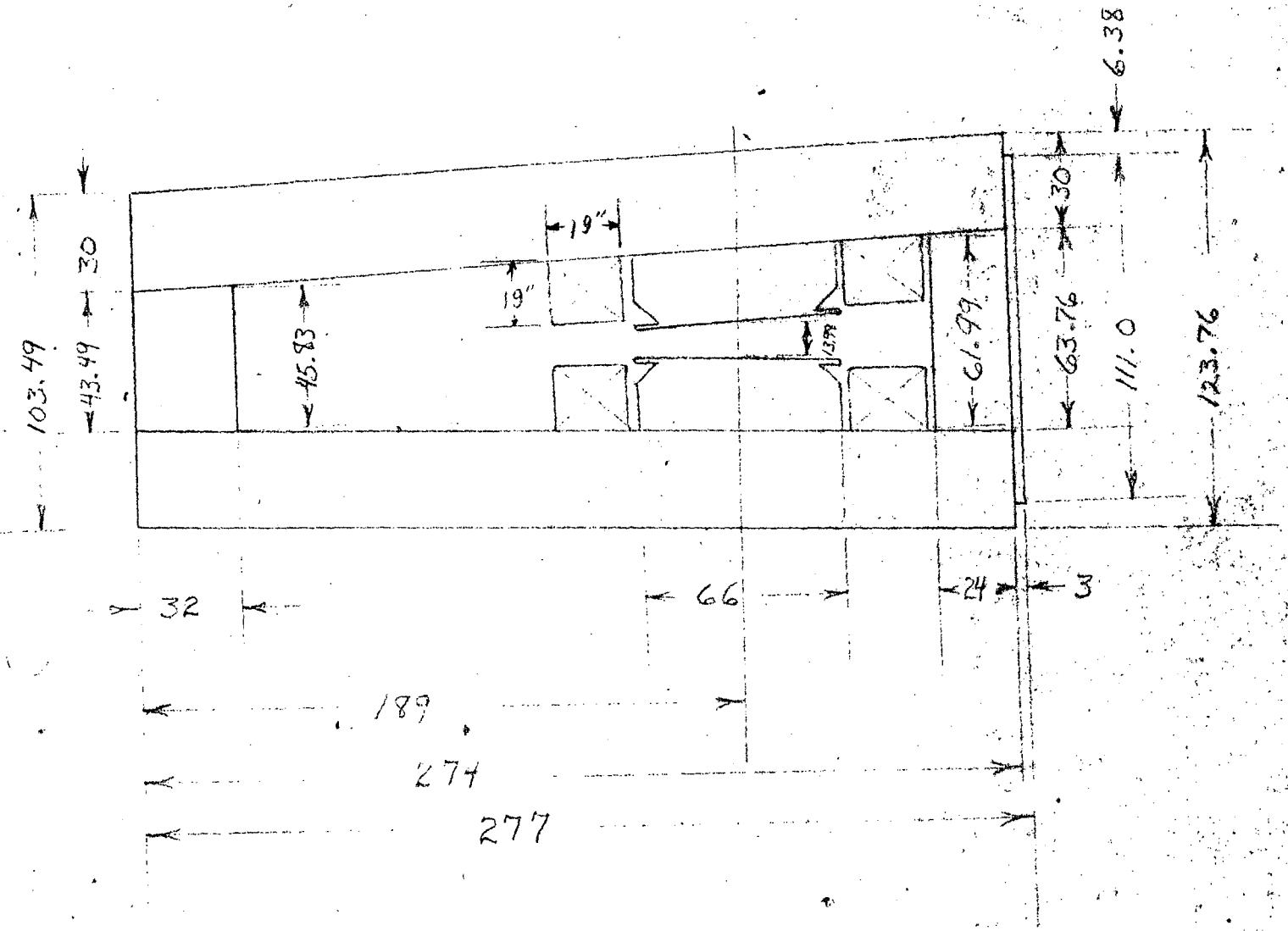
DC6A SERIES BEVATRON MAGNET

MODEL NUMBER	CROSS SECTION	REMARKS
DC6A		AS SHOWN ON DWG. 3L1635
DC6A.1		SAME AS DC6A EXCEPT COIL ENDS HAVE A LONGER BEND DWG. 3L1703C
DC6A.2		SAME AS DC6A.1 EXCEPT TOP & BOTTOM YOKE SLABS HAVE PARALLEL SIDES. DWG. 3L1962
DC6A.3		SAME AS DC6A.2 EXCEPT 3" STEEL PLATE ADDED TO OUTER LEG SLAB. OUTER SIDE OF EXCITING COIL SPACED 19 7/8" COPPER TO COPPER SEE FOLLOWING SKETCH FOR DIM. OF THIS MODEL

DC6A SERIES BEVATRON MAGNET

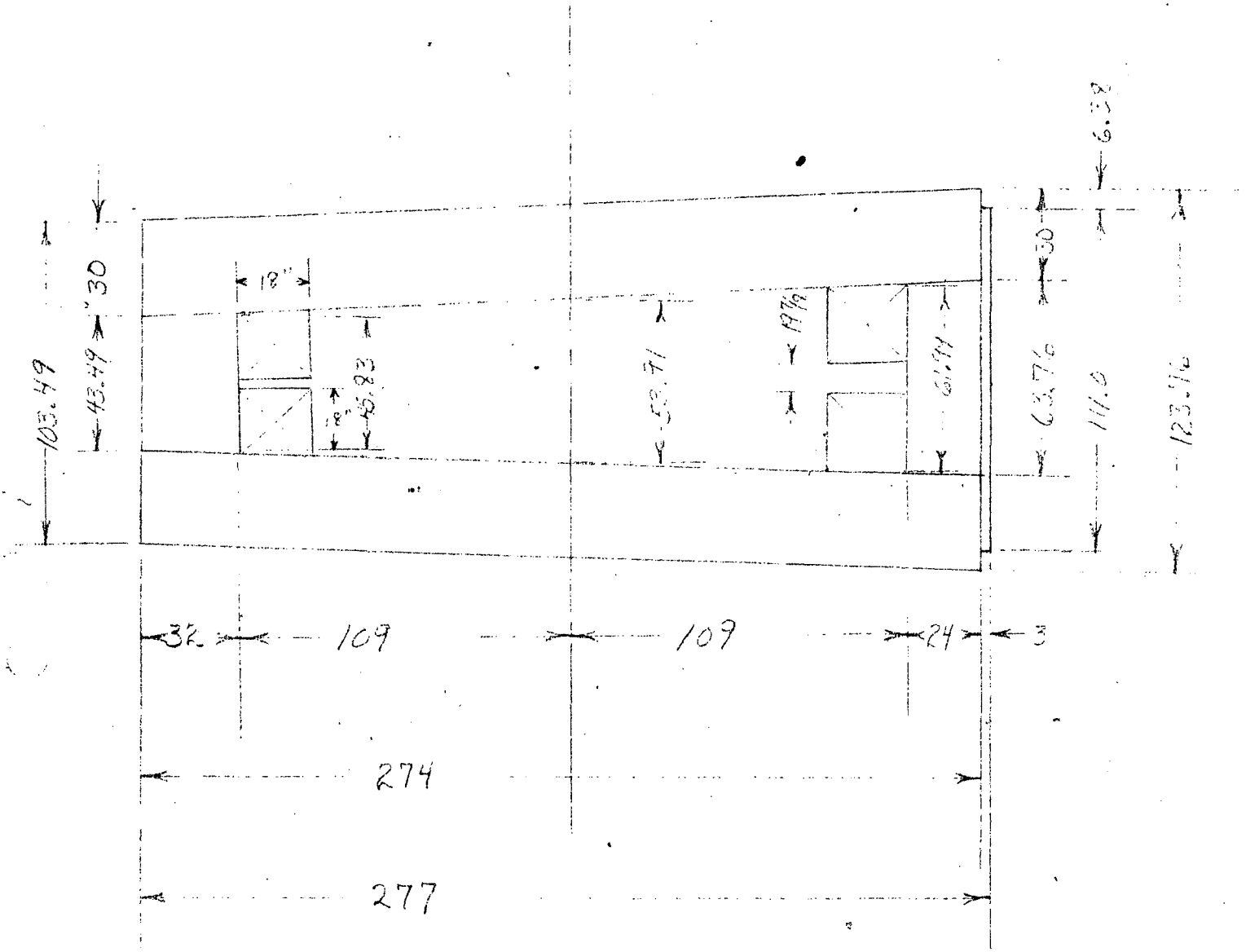
MODEL NUMBER	CROSS SECTION	REMARKS
DC6A.4		SAME AS DC6A.3 EXCEPT, OUTER SIDE OF EXCITING COIL SPACED 8 5/8" COPPER TO COPPER
DC6A.5		SAME AS DC6A.3 EXCEPT OUTER SIDE OF EXCITING COIL SPACED 13 7/8" COPPER TO COPPER
DC6A.6		SAME AS DC6A.3 EXCEPT OUTER SIDE OF EXCITING COIL SPACED 10 7/8" COPPER TO COPPER

BEVATRON MODEL MAGNET DC 6.6

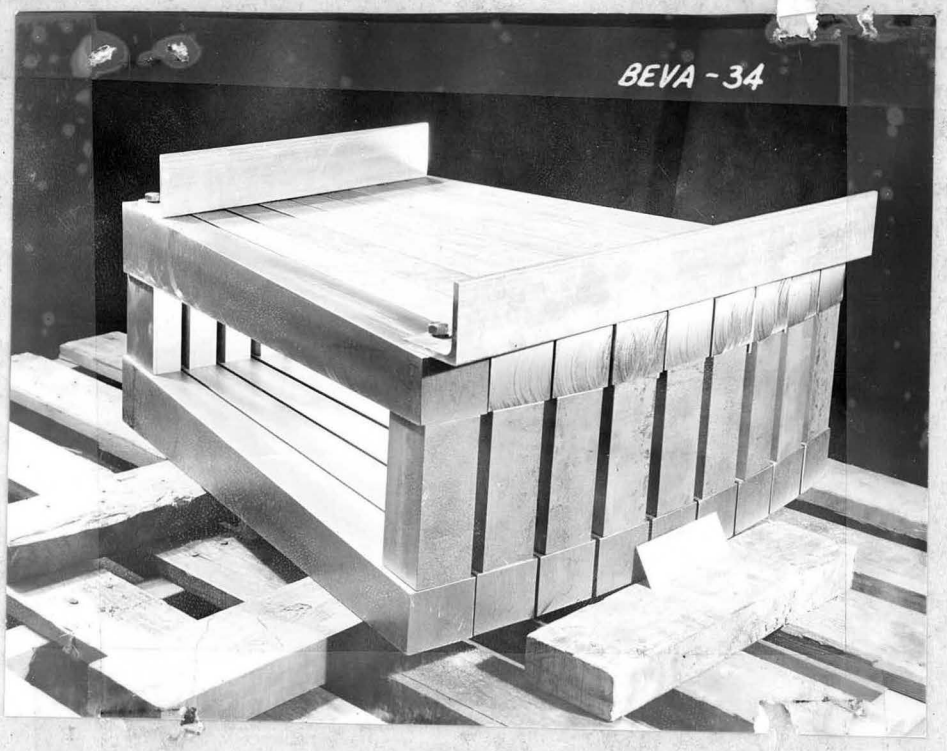


GAP 13.98"
RADIUS 608"
n = 0.77
MODEL COILS: 4 COILS 21 TURNS EACH = 84 TURNS
DIMENSIONS ARE FULL SCALE INCHES
MODEL IS 1/12 SCALE
ASSEMBLY DWG. 3L1635
COIL DWG. 3L1923
YOKE DWG. 3L1962
3" STEEL PLATE ADDED TO OUTER LEG SLAB

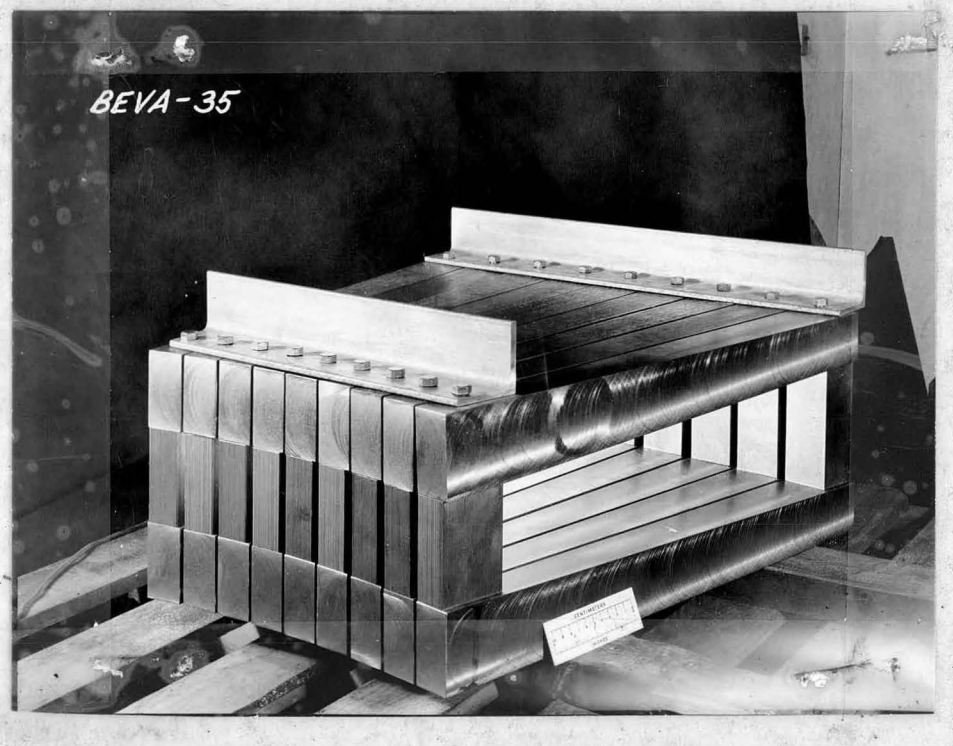
BEVATRON MODEL MAGNET DC 6A.3



GAP 53.91
RADIUS 552
ν = 0.76
MODEL COILS : 2 COILS 49 TURNS EACH = 98 TURNS
DIMENSIONS ARE FULL SCALE
MODEL IS 1/12 SCALE
ASSEMBLY DWG 3L 1635
COIL DWG. 3L 1703C *
YOKE DWG 3L 1962
3" STEEL PLATE ADDED TO OUTER LEG SLAB
OUTER COIL SPACING 19⅞" COPPER TO COPPER

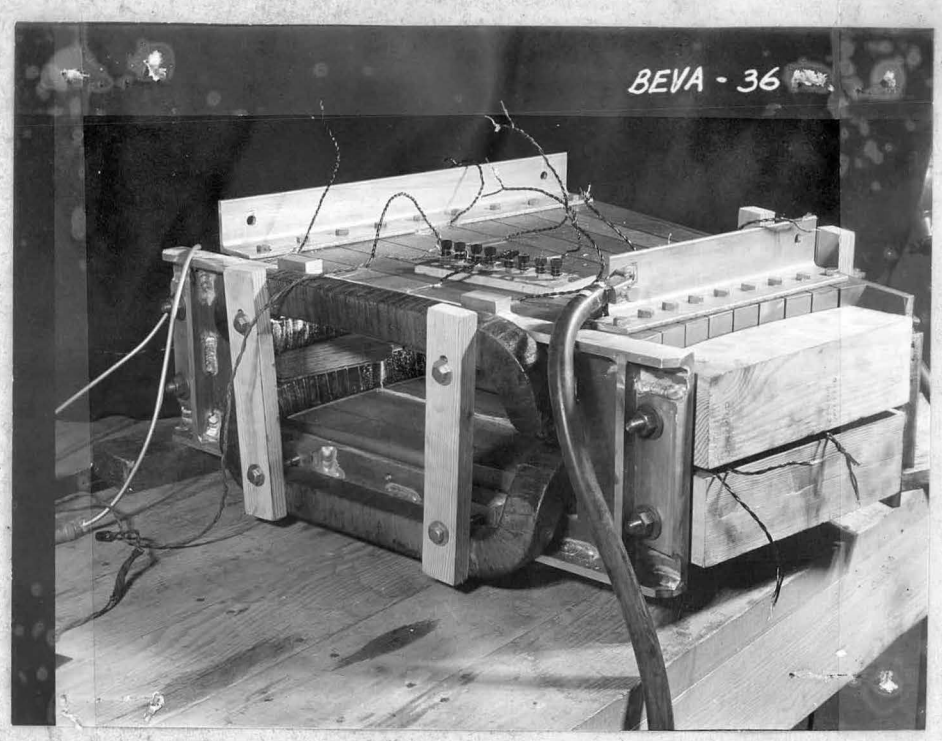


BEVA 34

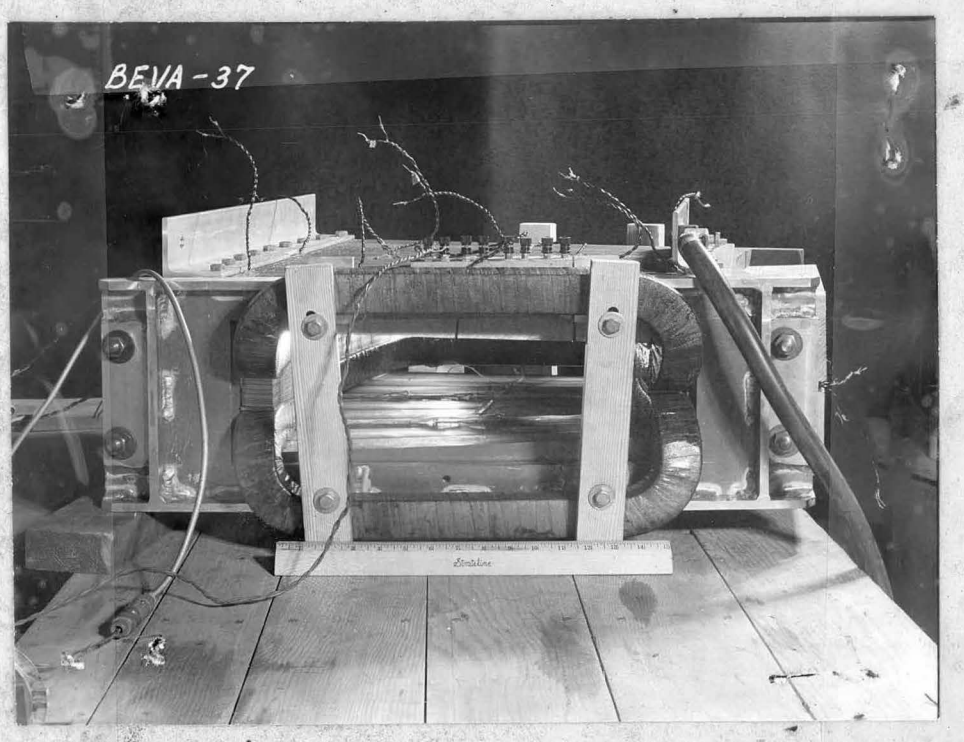


BEVA 35

Bevetron Model Magnet DC6A

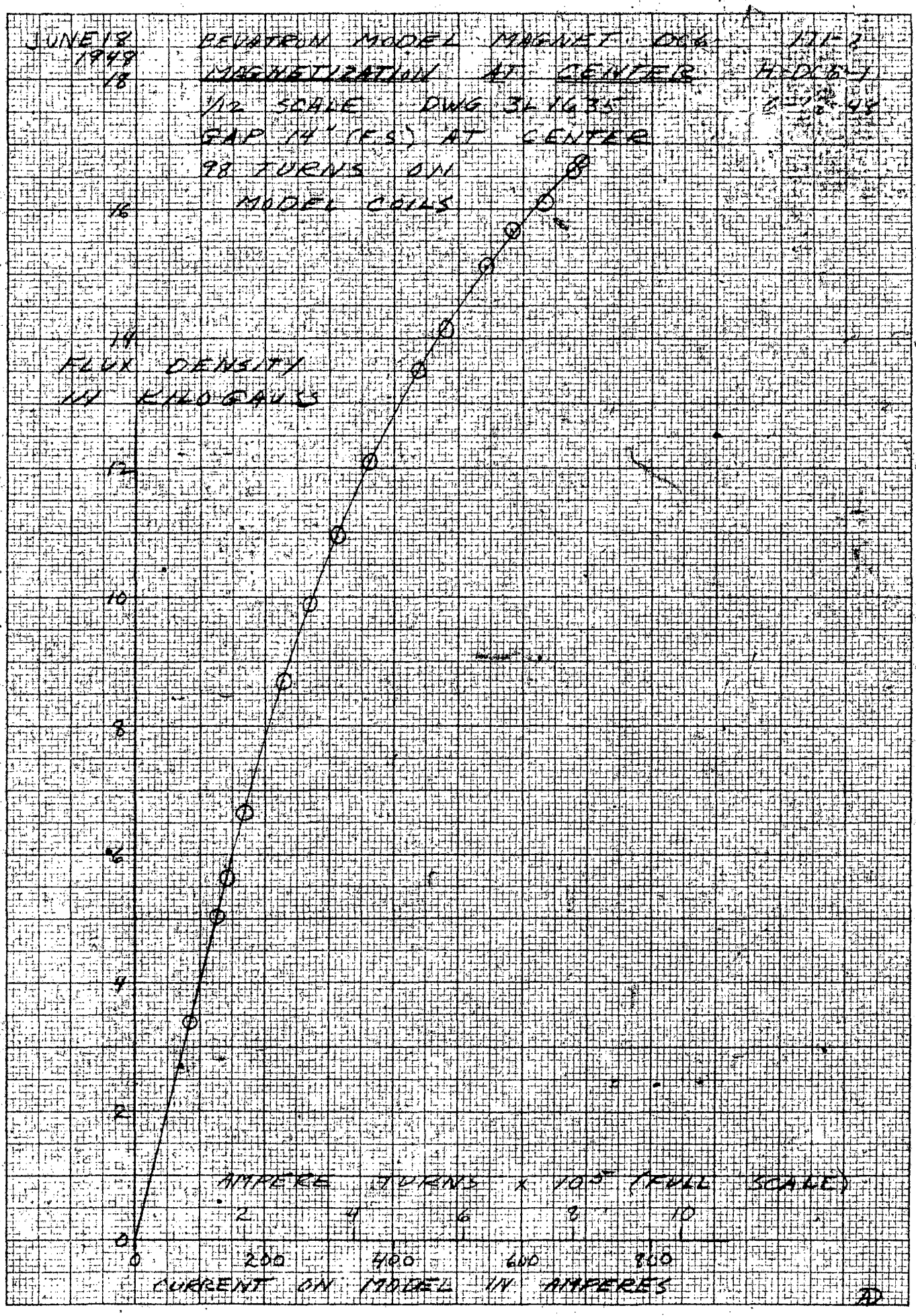


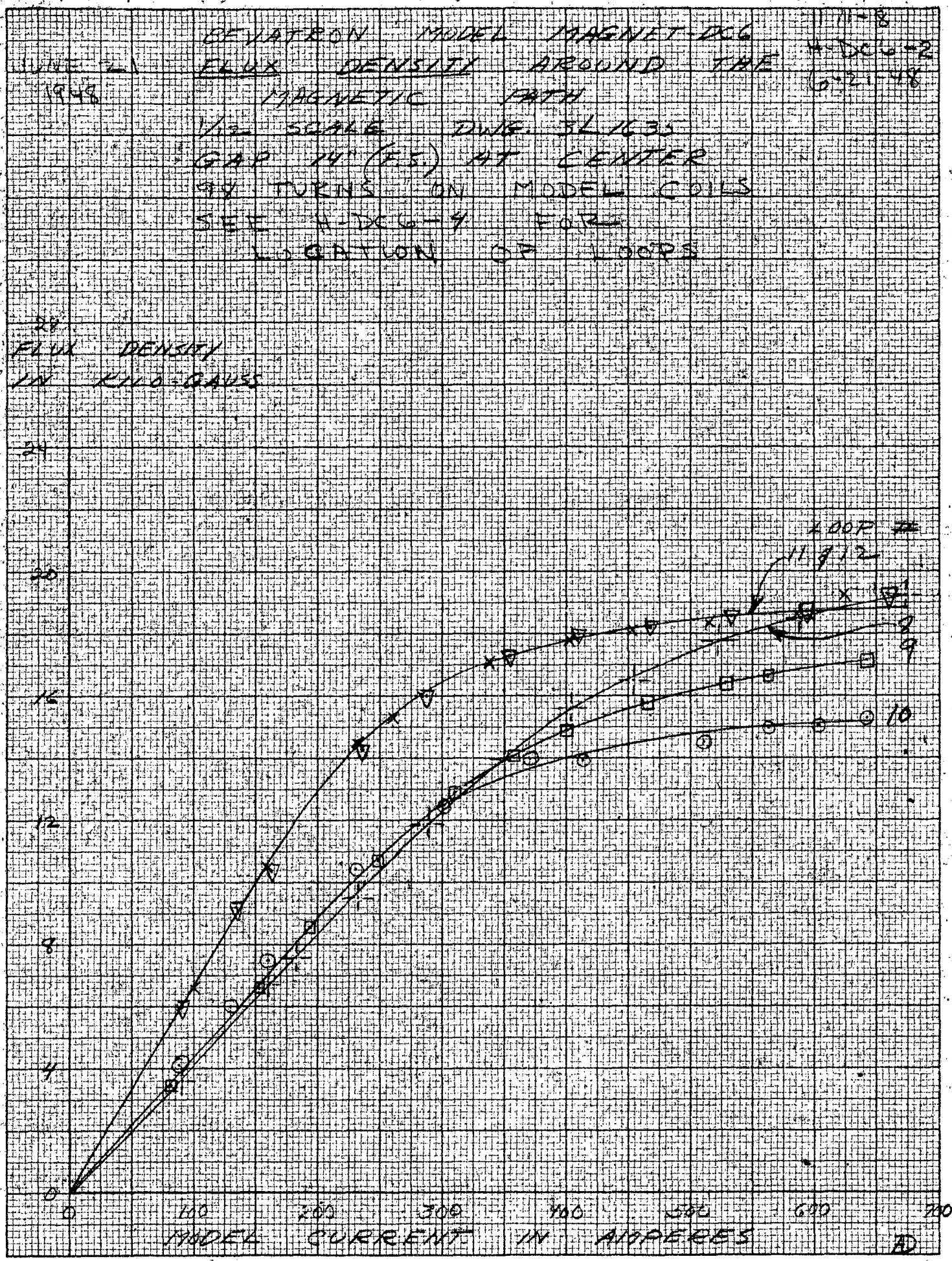
BEVA 36



BEVA 37

Bevatron Model Magnet DC6A




LINE-1
1948
BEWATRON MODEL MAGNET-DC6
FLUX DENSITY AROUND THE
MAGNETIC PATH
1/12 SCALE DWG. 3L163
GAP 14" (E5.) AT CENTER
94 TURNS ON MODEL COILS
SEE H-DC6-4 FOR
LOCATION OF LOOPS
H-DC6-2
6-21-48
FLUX DENSITY
IN KILO-GAUSS
28
24
20
16
12
8
4
0
0
100
200
300
400
500
600
700
MODEL CURRENT IN AMPERES
LOOP #
11 & 12
9
10
AD

JUNE 21 1948

ELEVATION MODEL MAGNET DCG H-DCG-F3 7-8 6-21-48

FLUX DENSITY AROUND THE MAGNETIC PATH

1/2 SCALE DWG. 32 1635

GAP 1" (EX.) AT CENTER OF GAP

98 TURNS ON EACH COIL

SEE H-DCG-4 FOR LOCATION OF LOOPS

28

FLUX DENSITY IN KILO-GAUSS

24

20

16

12

8

4

0

0 100 200 300 400 500 600 700

MODEL CURRENT IN AMPERES

LOOP #

15

13

14

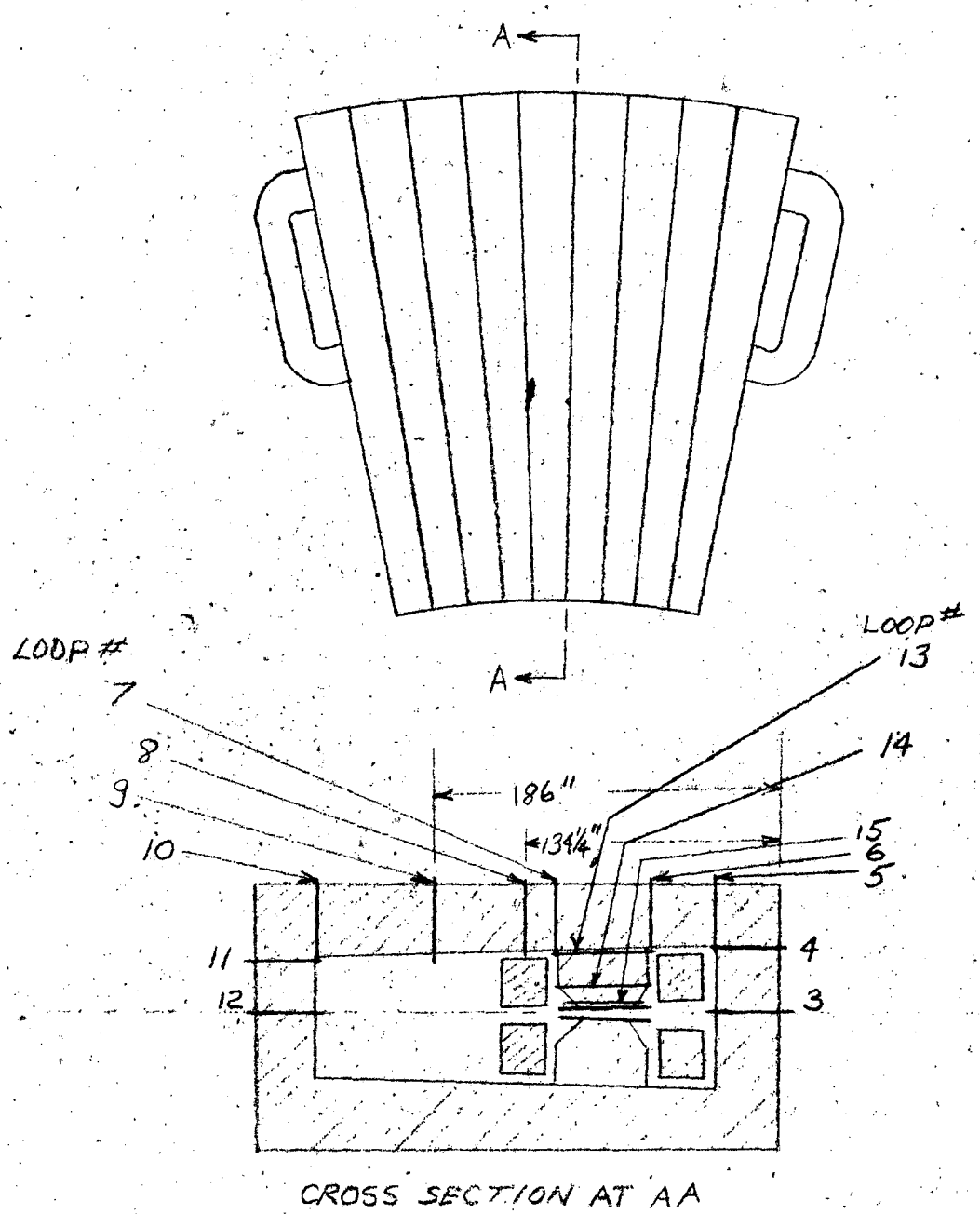
KEUFFEL & ESSER CO., N. Y. NO. 359T-120
10 X 10 to the ½ inch, 5th lines accented.
Engraving 7½ X 10 in.
MADE IN U.S.A.

JUNE 21, 1948

BEVATRON MODEL MAGNET DC6
LOCATION OF FLUX LOOPS
1/12 SCALE DWG 3L1635

GAP 14" (FS) AT CENTER
98 TURNS ON MODEL
SEE GRAPHS H-DC6-2
H-DC6-3
H-DC6-5

171-8
H-DC6-4
6-21-48



CROSS SECTION AT AA

JUNE 21 1948

REVISION MODEL MAGNET DC6

FLUX DENSITY AROUND MAGNETIC PATH

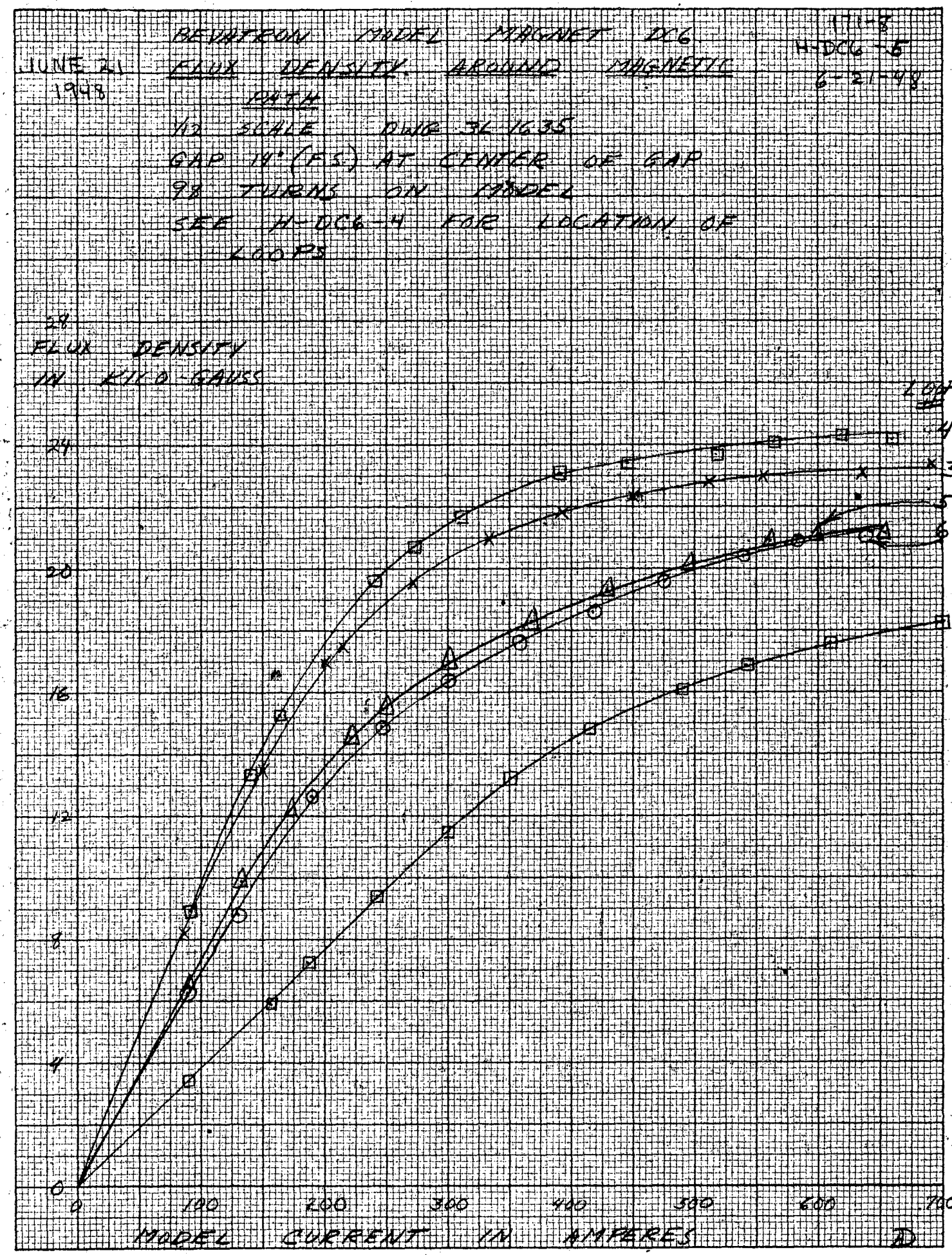
1/2 SCALE DWG 3L 16 35

GAP 1/4" (F.S.) AT CENTER OF GAP

98 TURNS ON MODEL

SEE H-DC6-4 FOR LOCATION OF COILS

11-8
H-DC6-5
6-21-48



JUNE 21 1948

DEVIATION MODEL MAGNET DC6

MAGNETIZATION

½ SCALE CURVE 3216 B5

GAP 1¼" (45) AT CENTER

MODEL COILS = 98 TURNS TOTAL

171-8

H-DC6-6

6-21-48

350

300

FLUX DENSITY

IN GAUSS

250

200

150

100

50

0

0 1 2 3 4 5 6 7

MODEL CURRENT IN AMPERES

A

KEUFFEL & ESSER CO., N. Y. NO. 8597-120
10 X 10 to the ½ inch. 5th lines accented.
Engraving 9½ X 10 in.
MADE IN U.S.A.

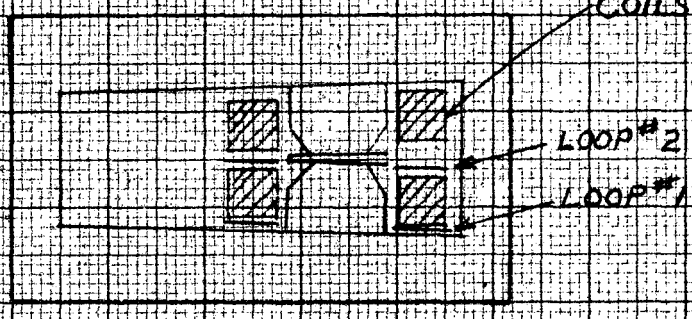
BEVATRON MODEL MAGNET DC 6 — 177-8
COIL FLUX LINKAGE — F-DC6-1
1/12 SCALE DWG 32 K 35 — 6-18-48
JUNE 9 1948
GAP 14" (F.S.) AT CENTER OF GAP
MODEL COILS: 2 COILS 49 TURNS LOOP #1
EACH: 98 TURNS TOTAL
EACH LOOP HAS 7 TURNS
FLUX LINKAGE IS ON 7.5°
SECTION ON MODEL

FLUX LINKAGE IN MAXWELL TURNS x 10^6

32
28
24
20
16
12
8
4
0

0 100 200 300 400 500 600 700

MODEL CURRENT IN AMPERES



KEUFFEL & ESSER CO., N. Y. NO. 359-139
10 X 10 to the ½ Inch. 5th lines accented.
Engraving 7 ⅝ X 10 in.
MADE IN U.S.A.

F-DC6-1a

6-18-48

JUNE 18, 1948

BEVATRON MODEL MAGNET DC6

TOTAL COIL FLUX LINKAGE

1/2 SCALE DWG 3L 1636

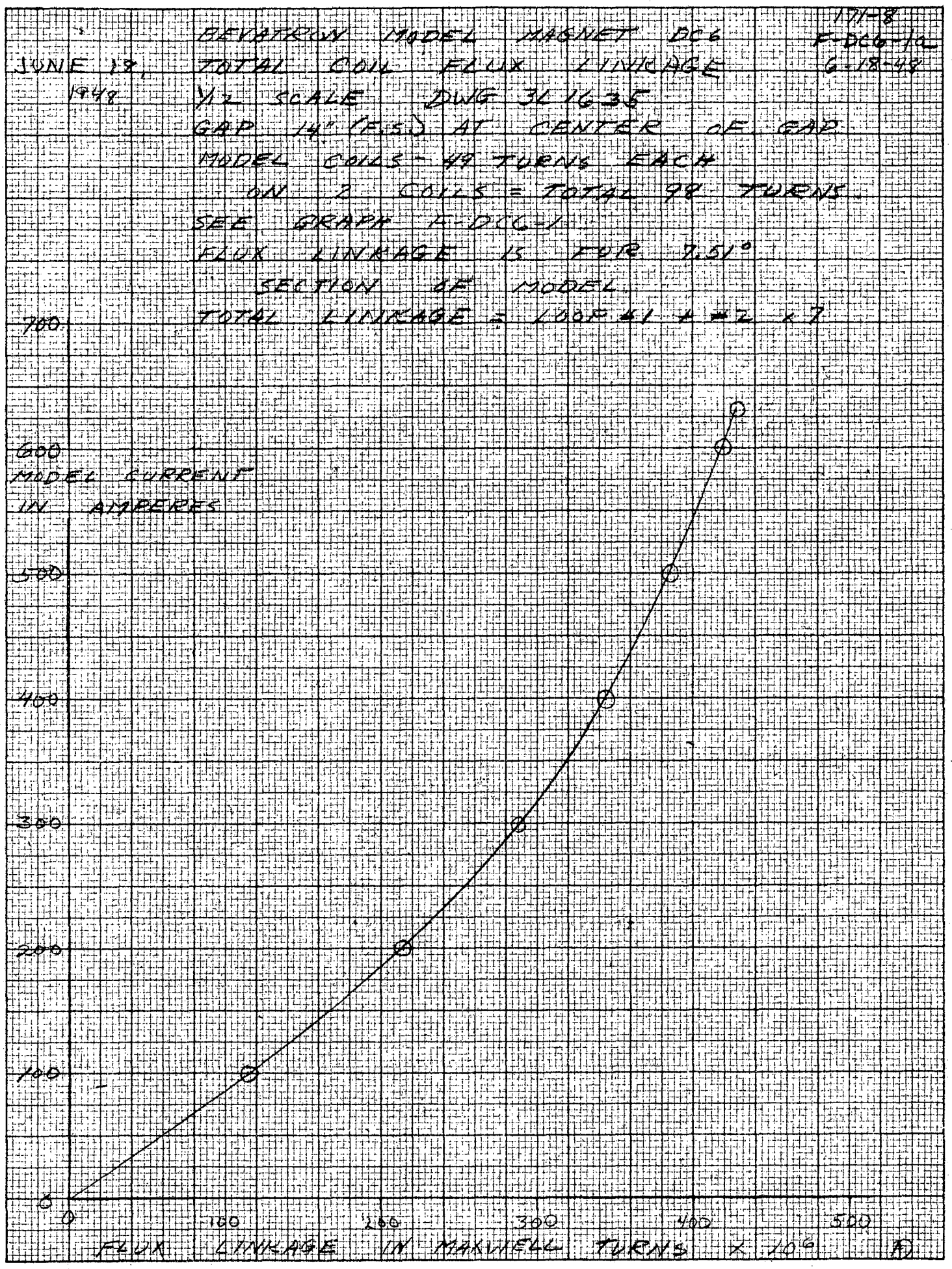
GAP 14" (F.S.) AT CENTER OF GAP

MODEL COILS - 49 TURNS EACH ON 2 COILS = TOTAL 98 TURNS

SEE GRAPH F-DC6-1

FLUX LINKAGE IS FOR 7.5° SECTION OF MODEL

TOTAL LINKAGE = LOOP #1 + #2 x 7



CYCLOTRON MODEL MAGNET DC6 - 171-8

F-DC6-2

6-24-48

JUNE 18 1948

COIL FLUX LINKAGE

1/12 SCALE DWG 3L 1635

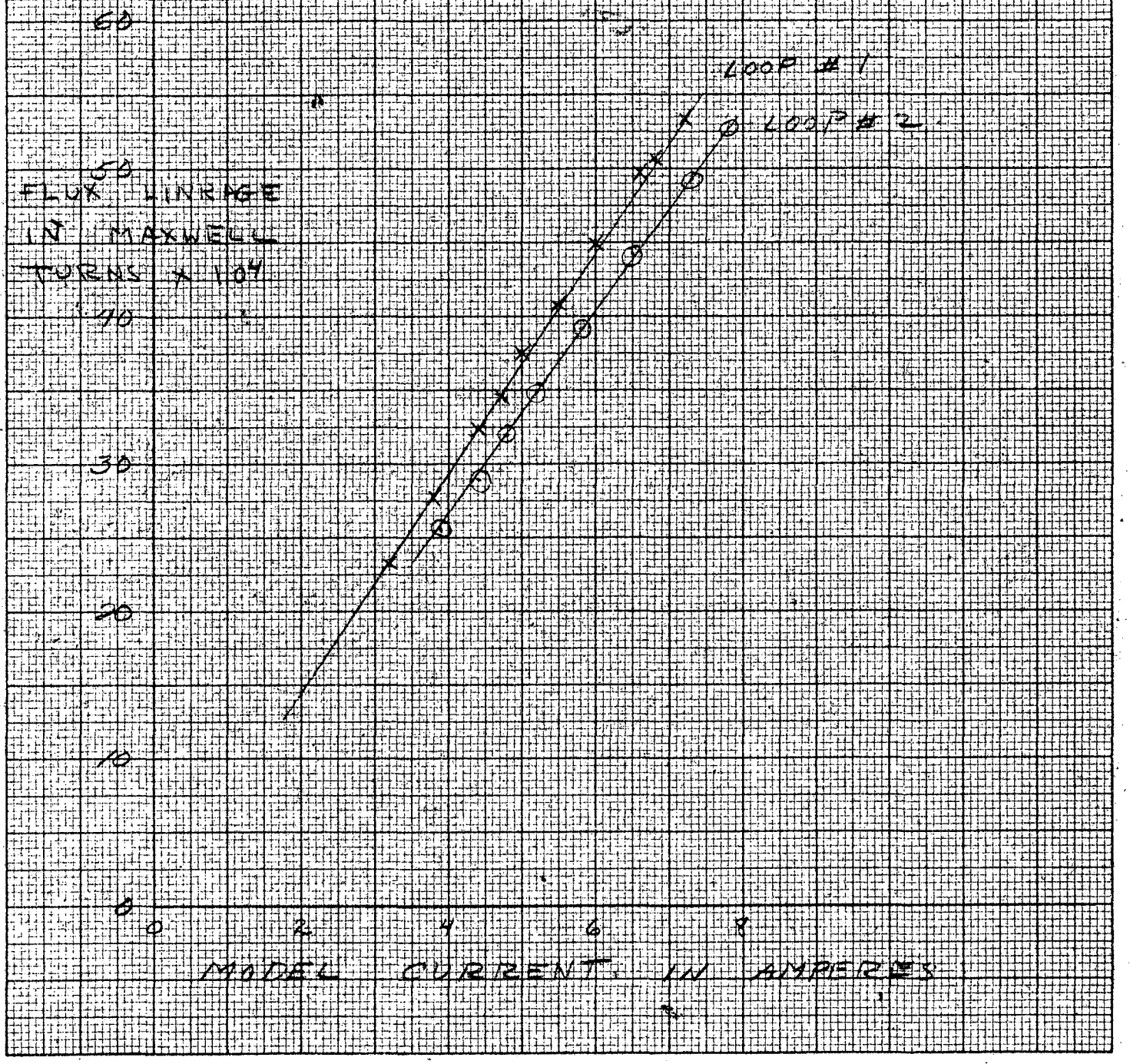
GAP 14" (EA) AT CENTER

FLUX LINKAGE ON 7.5° SECTION ON MODEL.

MODEL COILS: 2 COILS 49 TURNS EACH = 98 TURNS TOTAL

EACH LOOP HAS 7 TURNS

SEE F-DC6-1 FOR LOCATION OF LOOPS



JUNE 22, 1948 BEVATRON MODEL MAGNET DC6 17-8
1/2 SCALE DWG #L-1635 E-DC6-1
6-22-48

STORED ENERGY ON MODEL

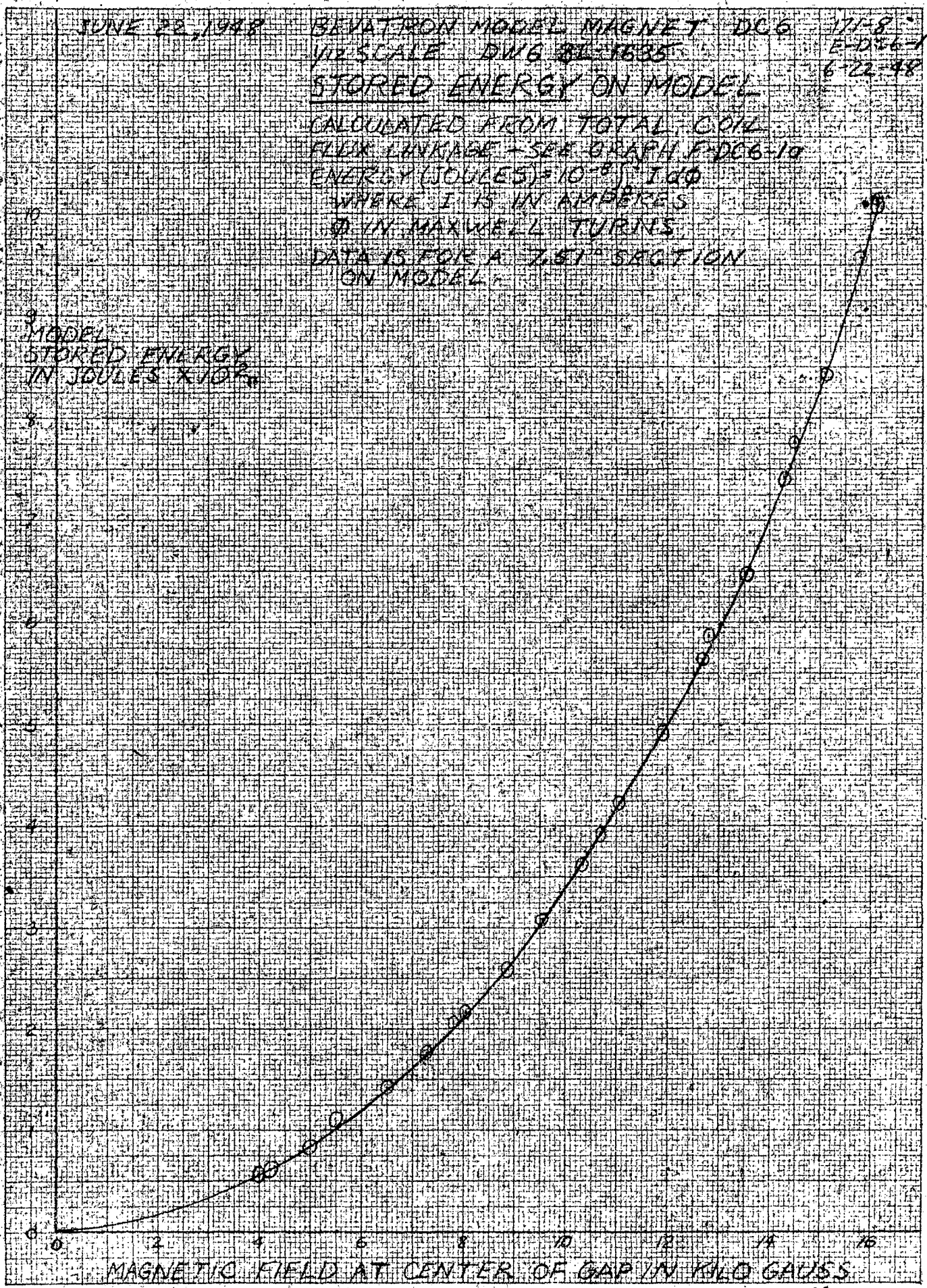
CALCULATED FROM TOTAL COIL FLUX LINKAGE - SEE GRAPH F-DC6-10

ENERGY (JOULES) = $10^{-8} \int I \, d\Phi$

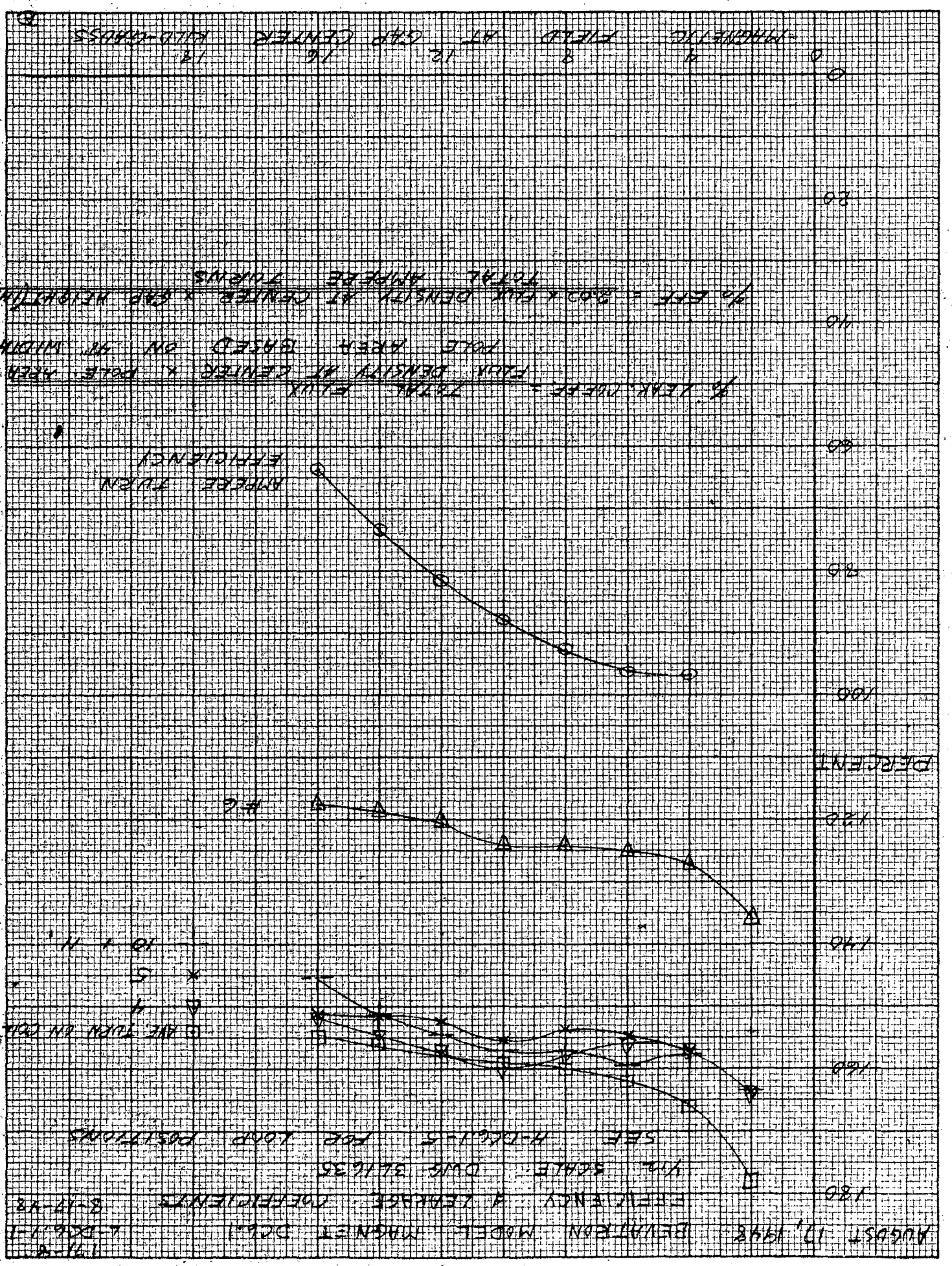
WHERE I IS IN AMPERES

Φ IN MAXWELL TURNS

DATA IS FOR A 7.5° SECTION ON MODEL.

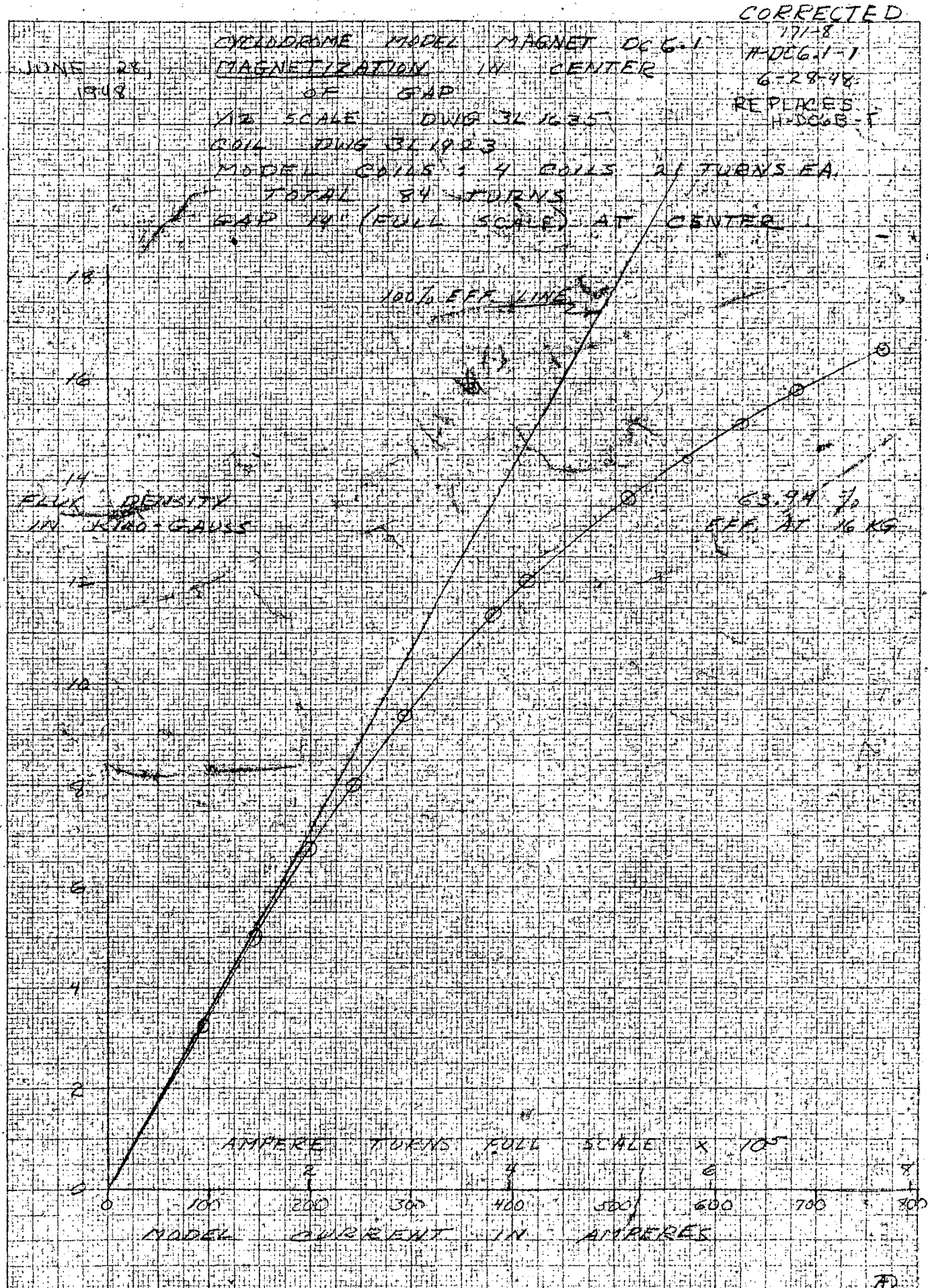


EWC



CORRECTED
191-8
H-DC6.1-1
6-28-48
REPLACES
H-DC6.B-1

CYCLOTRON MODEL MAGNET DC 6.1
MAGNETIZATION IN CENTER OF GAP
JUNE 28, 1948
1/2 SCALE DWG 32 16 35
COIL DWG 32 1923
MODEL COILS : 4 COILS 21 TURNS EA.
TOTAL 84 TURNS
GAP 14" (FULL SCALE) AT CENTER



KEUFFEL & ESSER CO., N. Y. NO. 359-11-0
Millimeters, 5 mm. lines accented, cm. lines heavy.
MADE IN U.S.A.

JUNE 28, 1946

CYCLOTRON MODEL MAGNET DC6.1 171-8

FLUX DENSITY AROUND MAGNETIC PATH H-DC6.1-2

6-29-46

1/2 SCALE DWG 3L1635

COIL DWG 3L1923

MODEL COILS: 4 COILS 21 TURNS EACH

TOTAL 84 TURNS

GAP 14" (F.S.) AT CENTER

LOCATION OF LOOPS SHOWN ON H-DC6.1-5

LOOP #
6 □
4 ○
5 ×

FLUX DENSITY IN KILOGAUSS

24
22
20
18
16
14
12
10
8
6
4
2
0

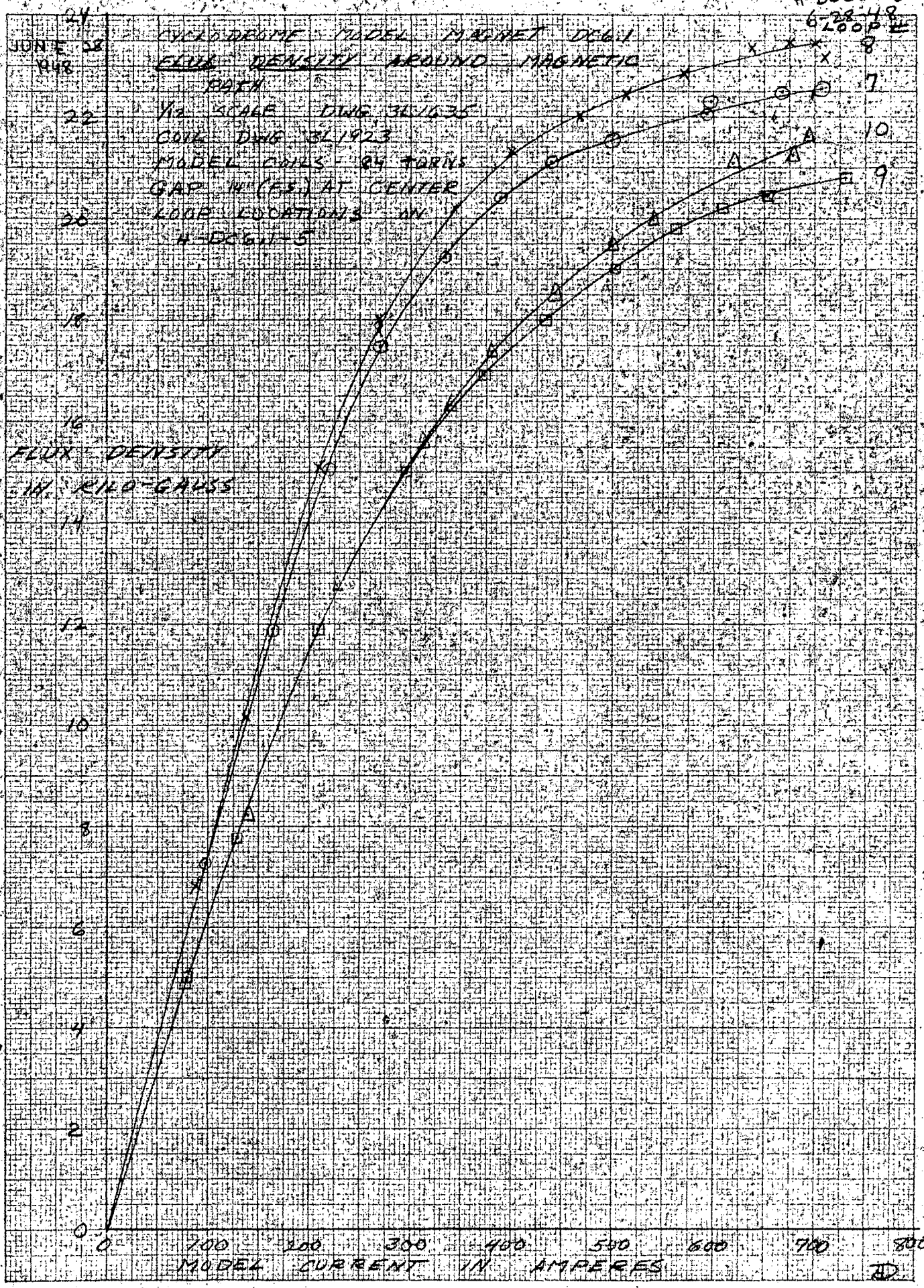
0 100 200 300 400 500 600 700 800

MODEL CURRENT IN AMPERES

D

KEUFFEL & ESSER CO., N. Y., NO. 359, 14 G
Millimeters, 5 mm. lines accented, cm. lines heavy.
MADE IN U.S.A.

171-8
H-DC6.1-3



88

JUNE 28, 1948 CYCLOTRON MODEL MAGNET DC6-1

FLUX DENSITY AROUND MAGNETIC PATH

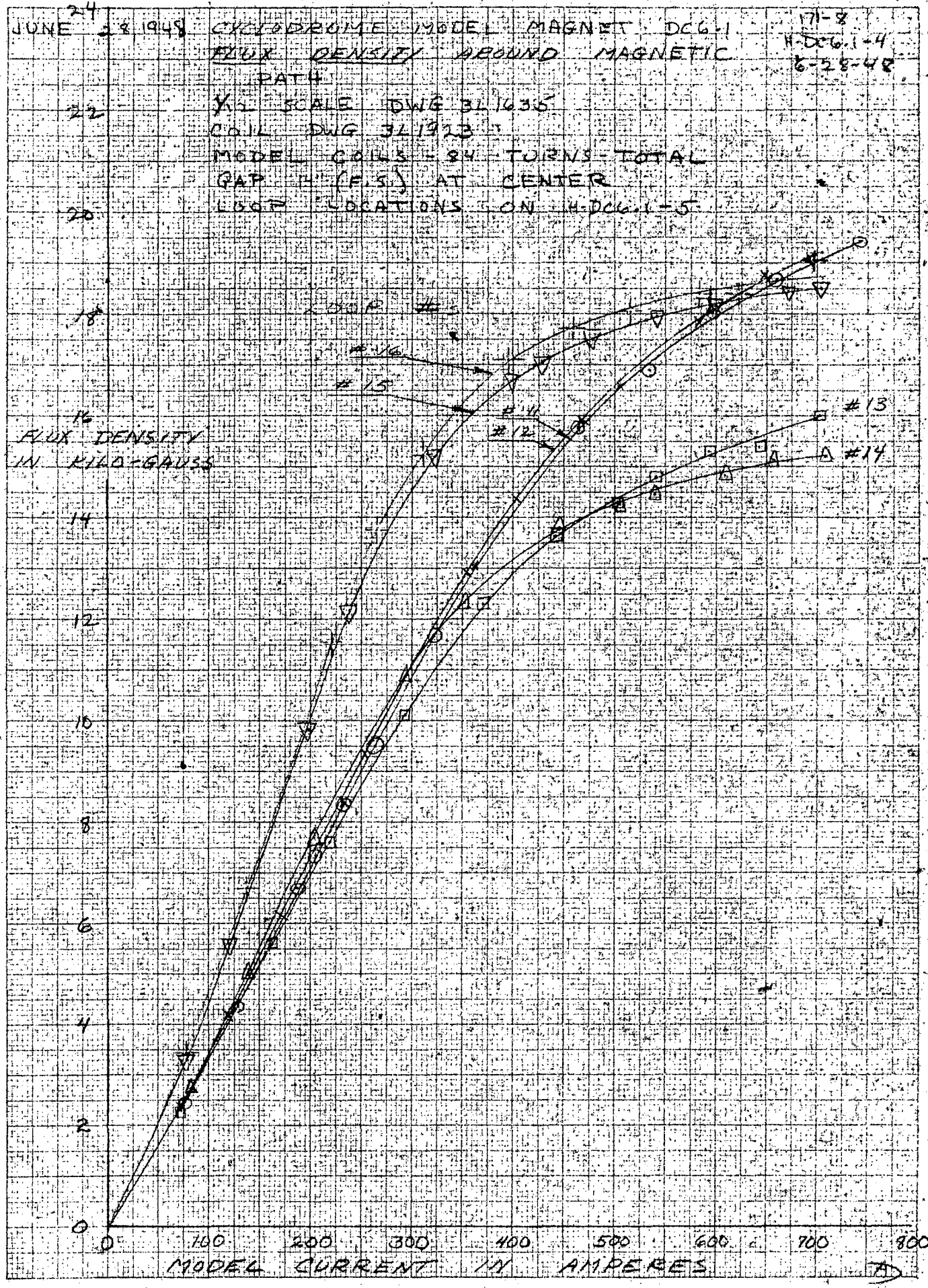
X-Y SCALE DWG 3L1635

COIL DWG 3L1923

MODEL COILS - 84 - TURNS - TOTAL

GAP 1" (F.S.) AT CENTER

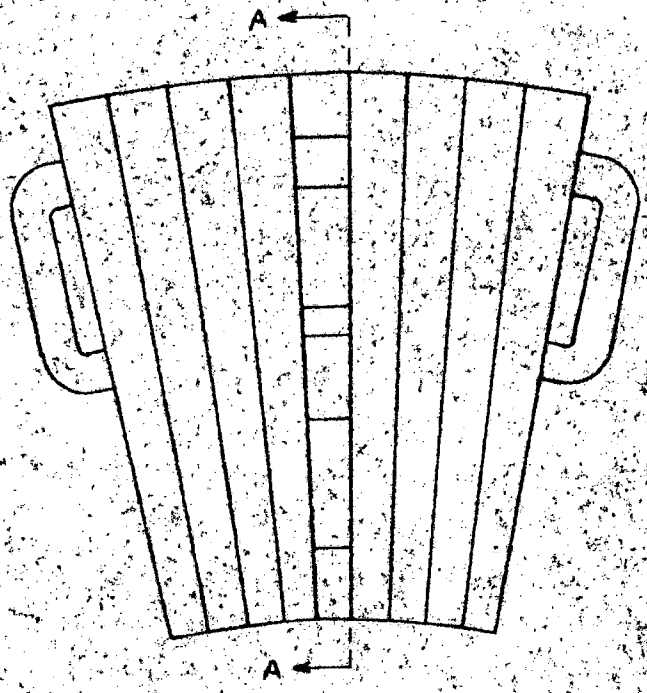
LOOP LOCATIONS ON H-DC6.1-5

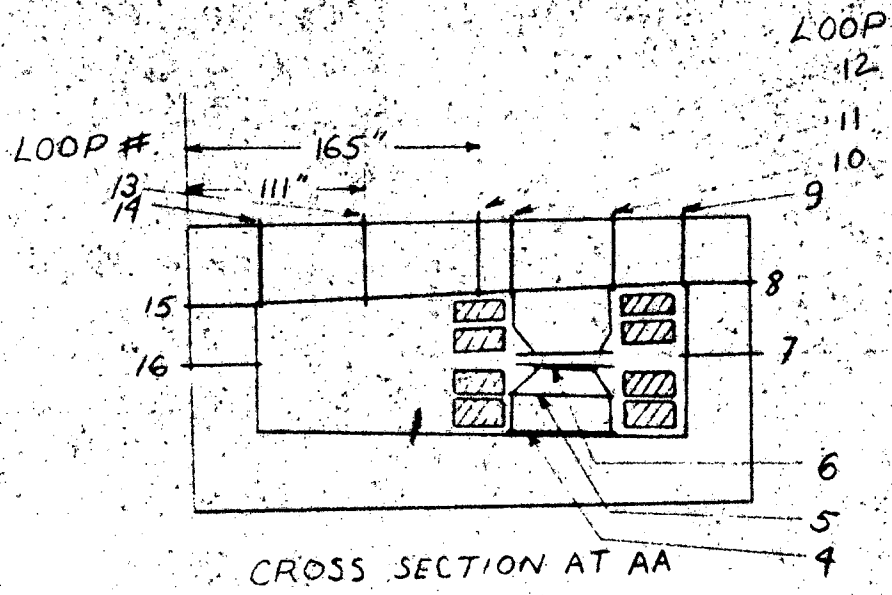


JUNE 28, 1948

CYCLODROME MODEL MAGNET DC6.1
LOCATION OF FLUX LOOPS
1/12 SCALE DWG 3L1635
GAP 14" FULL SCALE AT CENTER
COIL DWG 3L1923
84 TURNS TOTAL ON MODEL COILS
SEE GRAPHS H-DC6.1-2, H-DC6.1-3, H-DC6.1-4

171-8
H-DC6.1-5
6-28-48





CROSS SECTION AT AA

JUNE 30, 1948 CYCLODROME MODEL MAGNET DC6.1 171-8
F-DC6.1-1
6-30-48

COIL FLUX LINKAGE
½ SCALE DWG 3L1835
COIL DRAWING 3L1823
MODEL COILS: 4 COILS 21 TURNS EACH
TOTAL 84 TURNS
GAP 14" (E.S.) AT CENTER
EACH LOOP HAS 21 TURNS
FLUX LINKAGE IS ON 5.56° SECTION
ON MODEL

FLUX LINKAGE
IN MAXWELL TURNS
X 10^6

LOOP #
1 ○
2 △
3 □

LOOP #S
3
2
1

MODEL CURRENT IN AMPERES

EWC

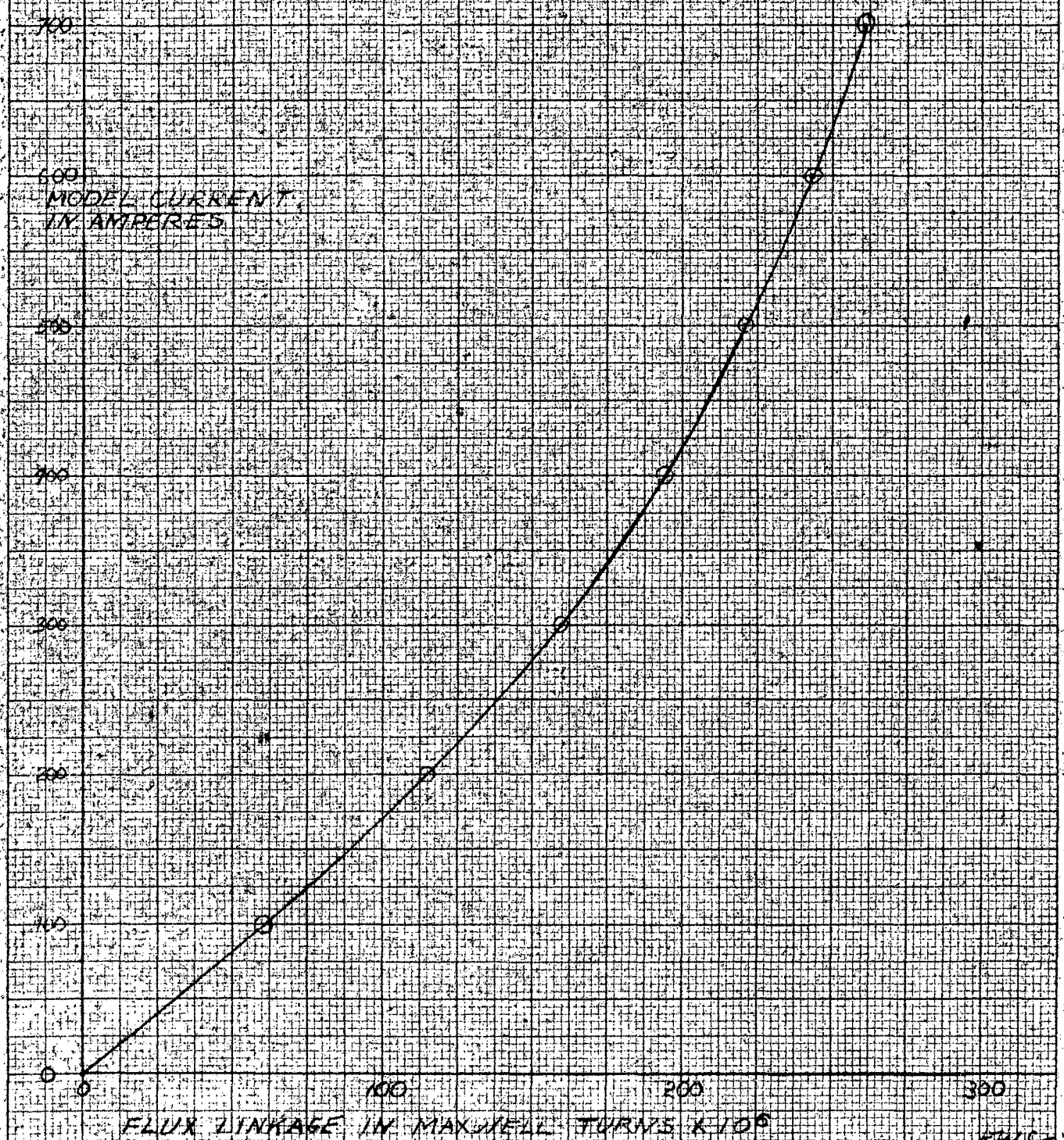
JUNE 30, 1948

CYCLODROME MODEL MAGNET DC6.1

TOTAL COIL FLUX LINKAGE

(7)-8
F-DC6.1-1a
6-30-48

½ SCALE DWG JL 1635
COIL DWG JL 1923
MODEL COILS: 4 COILS 21 TURNS EACH
TOTAL 84 TURNS
GAP ¼" (F.S.) AT CENTER
SEE GRAPH F-DC6.1-1
FLUX LINKAGE IS FOR 5.56° SECTION
ON MODEL
TOTAL LINKAGE = LOOP #1 + #2 + #C + #3



EWG

JULY 2, 1948

CYCLODEOME MODEL MAGNET DC6.1

17-8

F-DC6.1-2

7-2-48

COIL FLUX LINKAGE

½ SCALE DWG 3L1635

COIL DWG 3L1925

GAP 12 (FS) AT CENTER

MODEL COILS: 4 COILS 21 TURNS EACH
TOTAL 84 TURNS
EACH LOOP WAS 21 TURNS

FLUX LINKAGE IS ON 5.56° SECTION OF MODEL

SEE GRAPH F-DC6.1-1 FOR LOCATION OF LOOPS

LOOP #5

FLUX DENSITY IN MAXWELL TURNS X 10⁵

35
30
25
20
15
10
5
0

0 5 10 15 20 25

MODEL CURRENT IN AMPERES

EWC

JULY 19, 1948

CYCLODROME MODEL MAGNET DC6.1

½ SCALE DWG 3L1635T

STORED ENERGY ON MODEL

CALCULATED FROM TOTAL COIL FLUX LINKAGE - SEE GRAPH E-DC6.1-14

ENERGY (JOULES) = $4\pi \cdot 10^{-8} \int I \, d\phi$

WHERE I IS IN 10^3 AMPERES

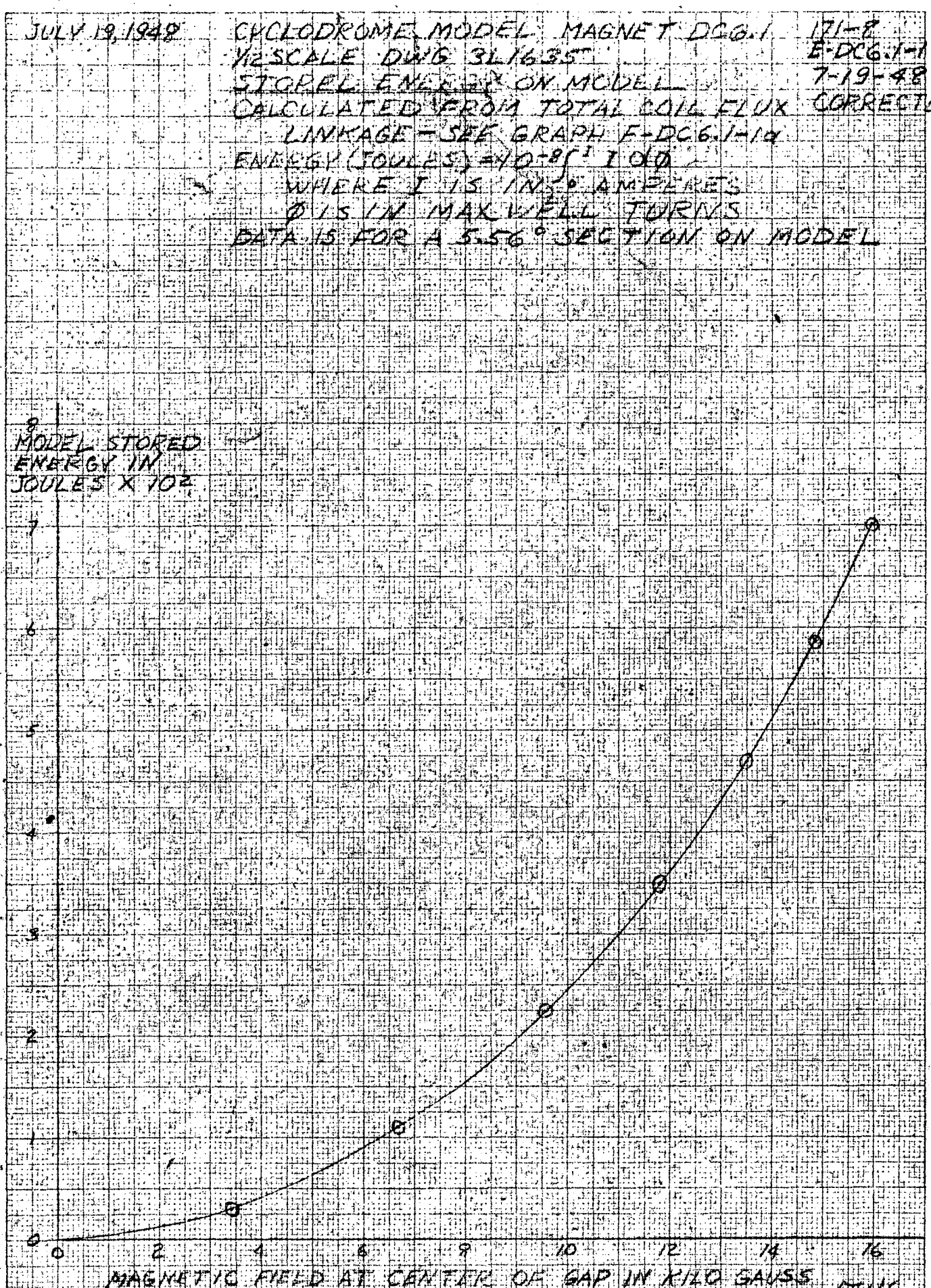
ϕ IS IN MAXWELL TURNS

DATA IS FOR A 5.56° SECTION ON MODEL

171-8

E-DC6.1-1

7-19-48 CORRECTED



KEUFFEL & ESSER CO., N. Y. NO. 358-14G
MADE IN U.S.A.

JUNE 28, 1948

CYCLODROME MODEL MAGNET DC6.2

171-8

MAGNETIZATION IN CENTER OF GAP

H-DC6.2-1

6-28-48

½ SCALE DWG 3L1635

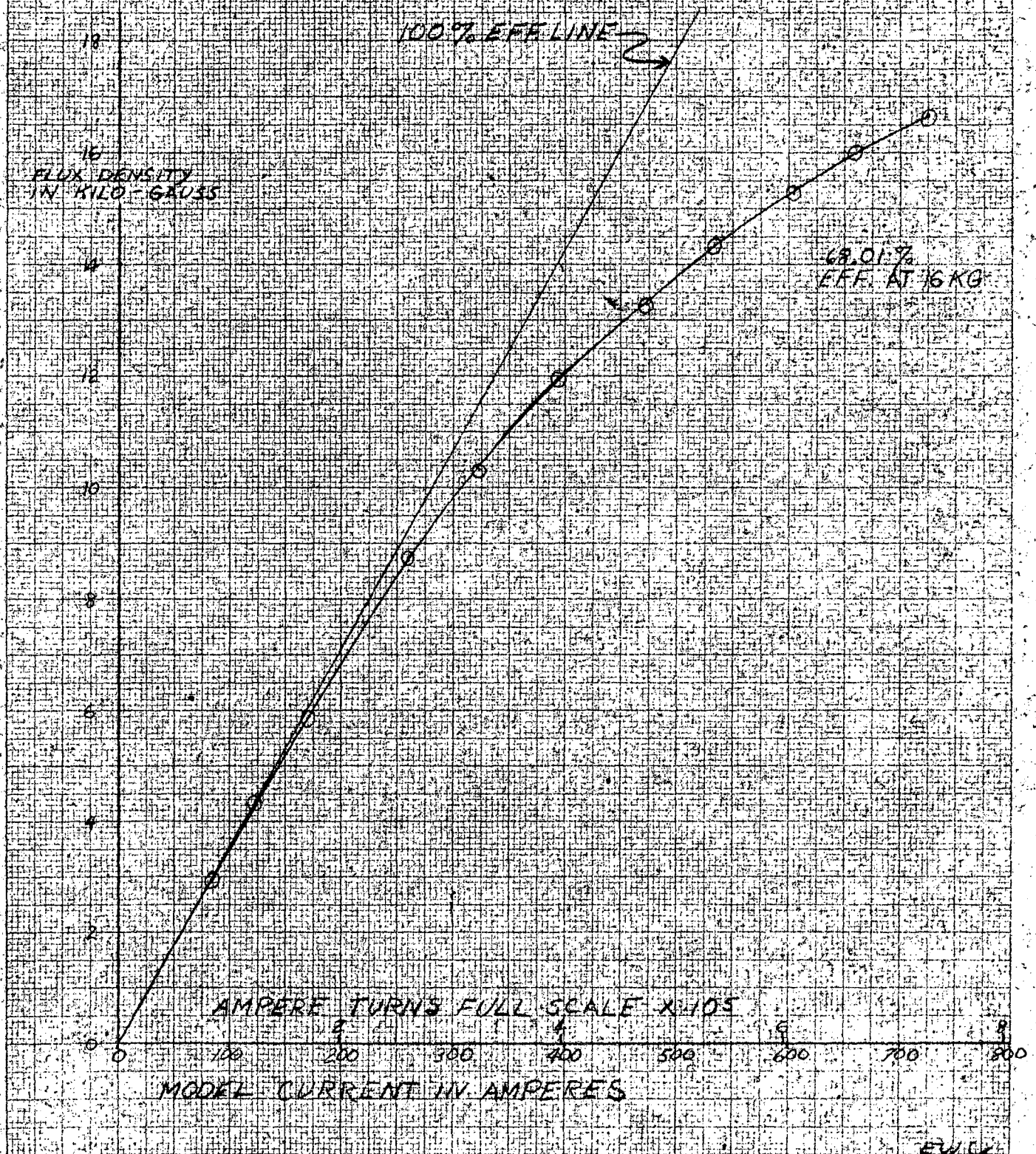
COIL DWG 3L1923

MODEL COILS: 4 COILS 21 TURNS EACH

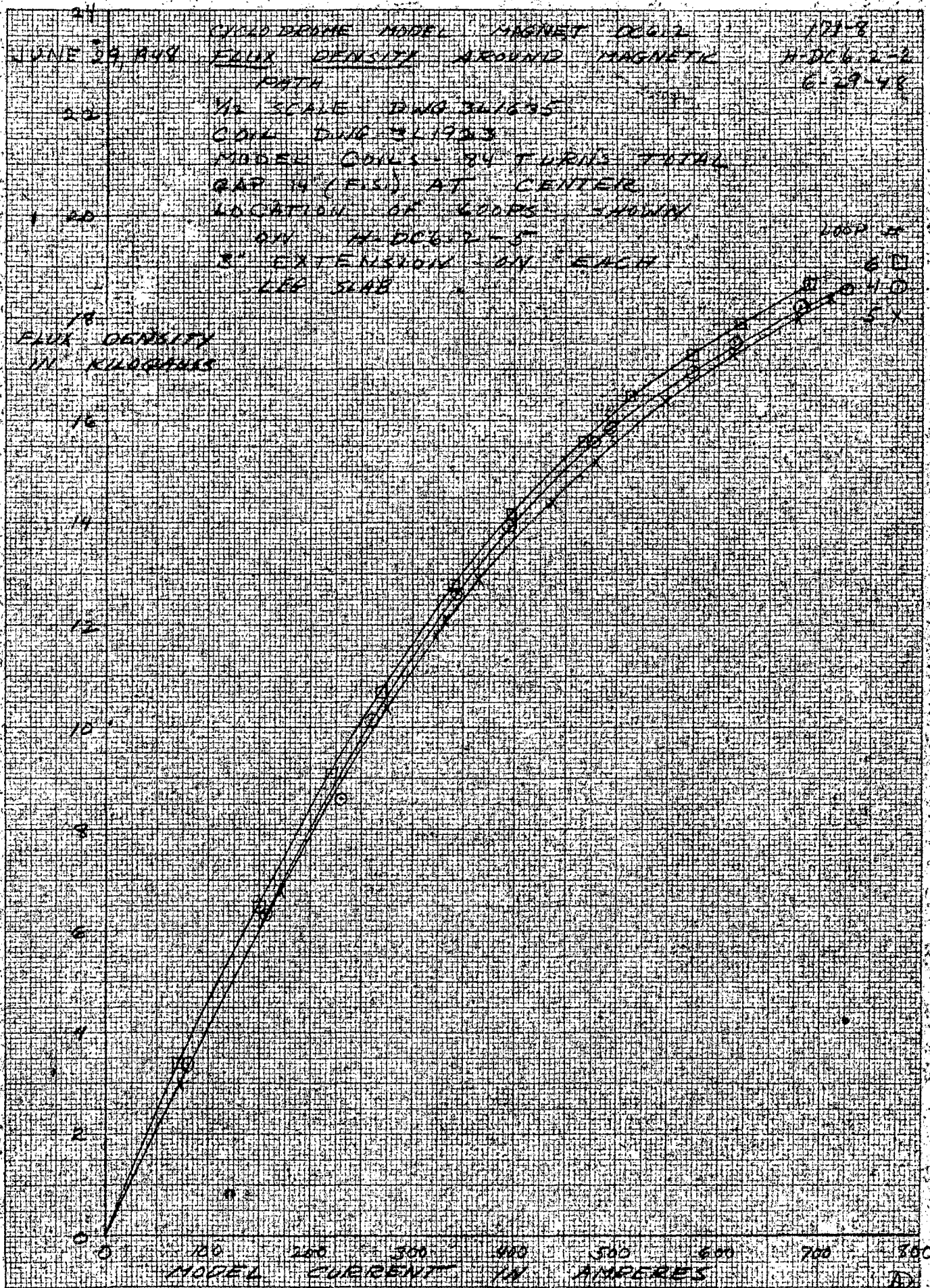
TOTAL 84 TURNS

GAP 14" (FULL SCALE) AT CENTER

3" (F.S.) ADDED TO EACH LEG-SLAB



EWC



H-DC6.2-3

JUNE 29 1948

CYCLOTRON MODEL MAGNET DC6.2

6-29-48

FLUX DENSITY AROUND MAGNET PATH

1/2 SCALE DWG 321635

COIL DWG #L19-3

MODEL COILS 84 TURNS

GAP 19 (EFF.) CENTER

LOOP LOCATIONS

SAW H-DC6.2-5

3½(F.S.) EXTENSION ADDED TO EACH LEG S-N3

LOOP #4

LOOP #

4

9

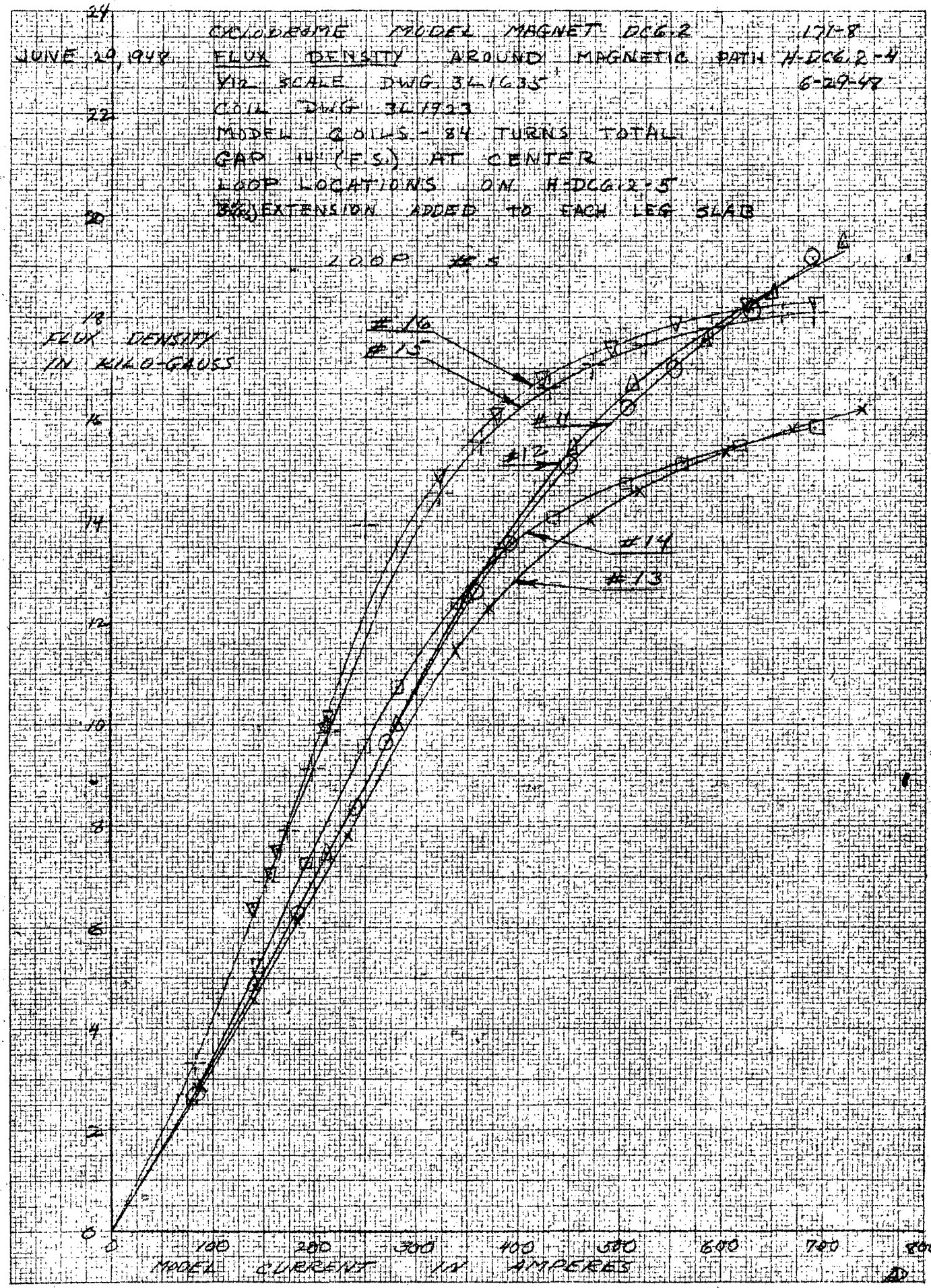
FLUX DENSITY IN KILOGAUSS

24
22
20
18
16
14
12
10
8
6
4
2
0

0 100 200 300 400 500 600 700 800

MODEL CURRENT IN AMPERES

A

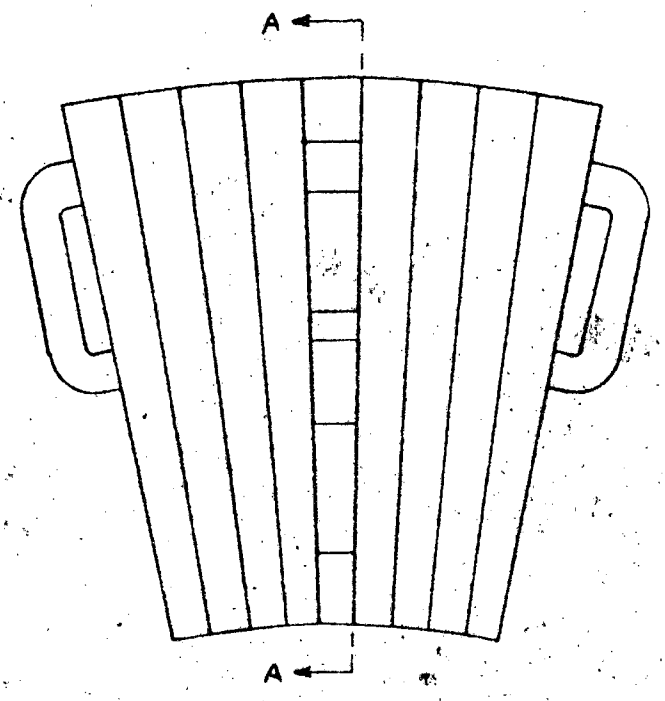


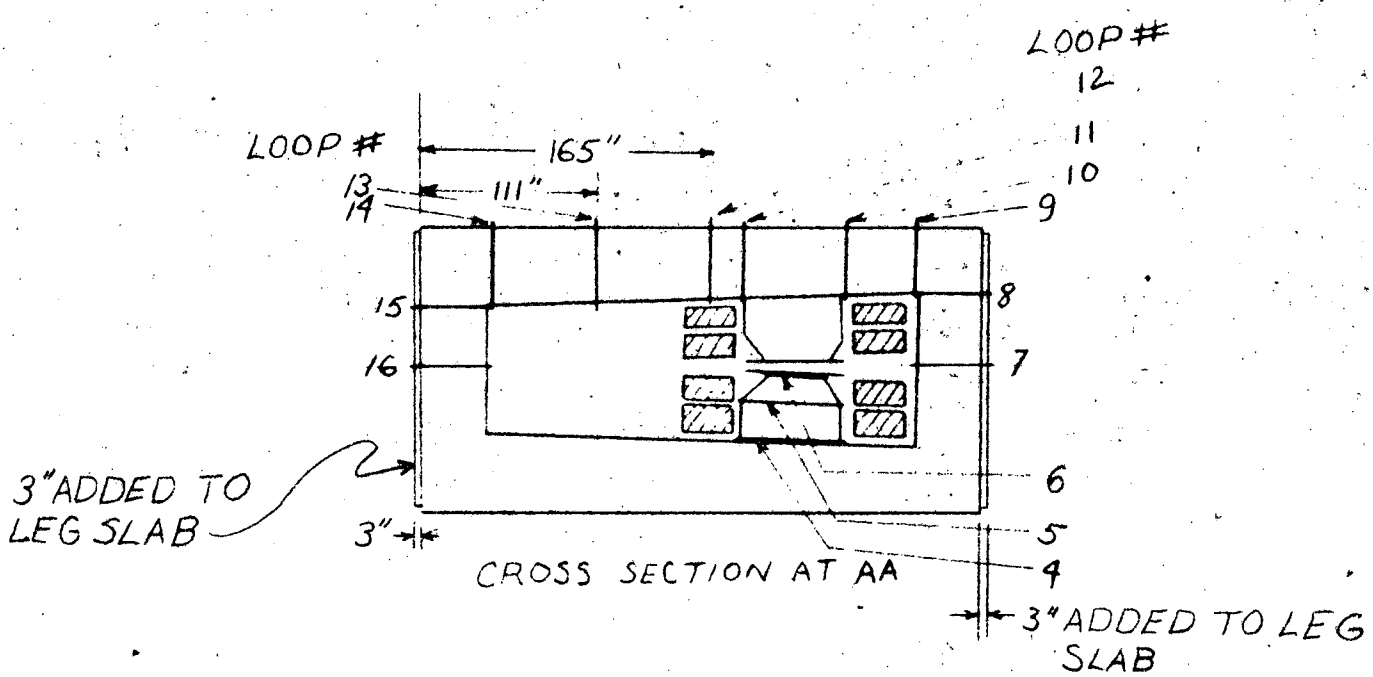
JUNE 28, 1948

CYCLODROME MODEL MAGNET DC6.2
LOCATION OF FLUX LOOPS

171-8
H-DC6.2-5
6-28-48

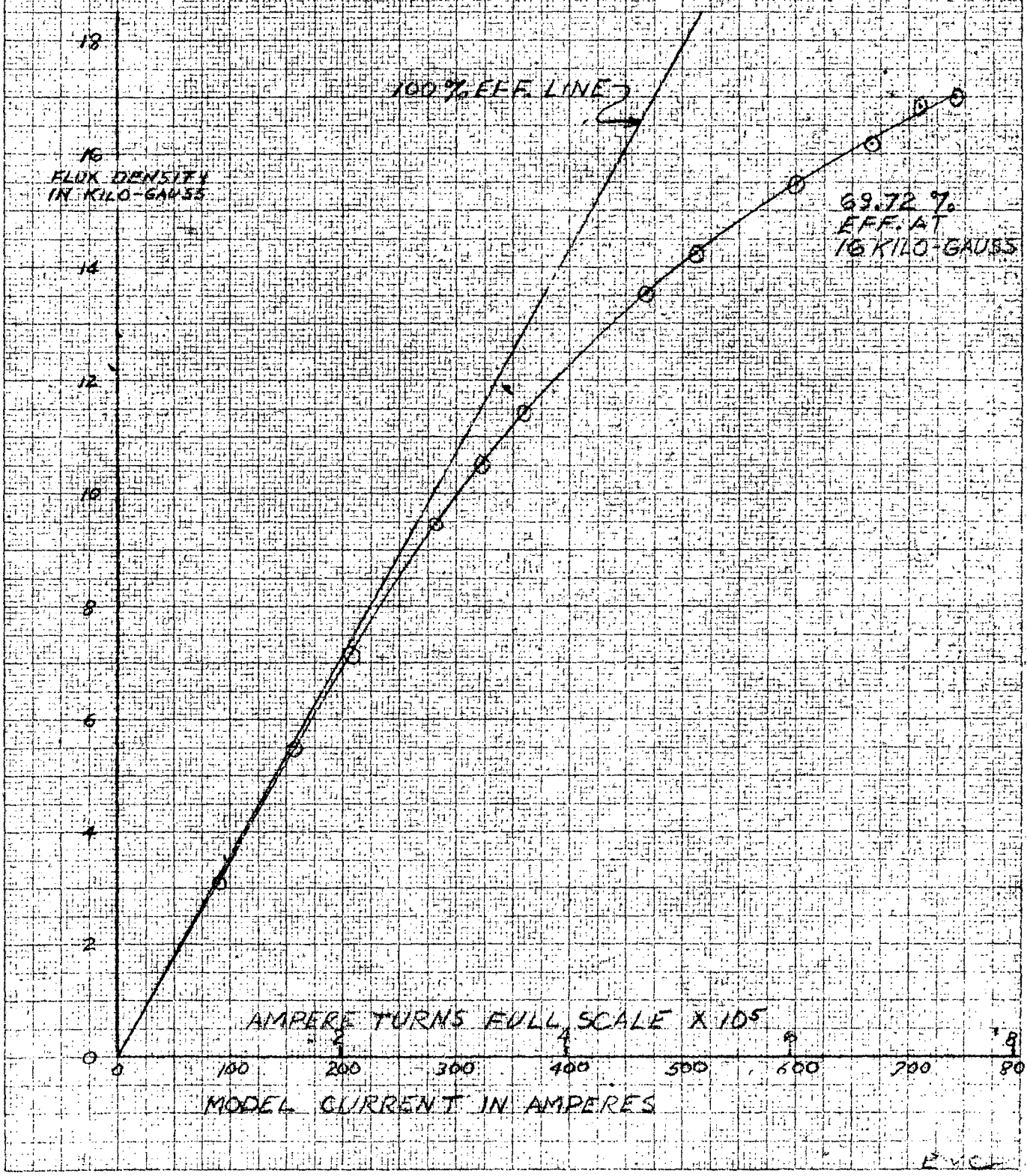
1/12 SCALE DWG 3L1635
GAP 14" FULL SCALE AT CENTER
COIL DWG 3L1923
84 TURNS TOTAL ON MODEL COILS
SEE GRAPHS H-DC6.2-2, H-DC6.2-3, H-DC6.2-4





JUNE 29, 1948

CYCLODROME MODEL MAGNET DC 6.3 — 171-8
MAGNETIZATION IN CENTER OF GAP — H-DC6.3-1
1/12 SCALE DWG 3L 1635 — 6-29-48
COIL DWG 3L 1923
MODEL COILS: 4 COILS 21 TURNS EACH
TOTAL 84 TURNS
GAP 14" (FULL SCALE) AT CENTER
6" (FULL SCALE) ADDED TO EACH LEG SLAB



E.V.C.

JUNE 30, 1948

CYCLOTRON MODEL MAGNET DC 6.3

FLUX DENSITY AROUND MAGNETIC PATH

½ SCALE DWG 3L1635

COIL DWG 3L1923

MODEL COILS - 84 TURNS TOTAL

GAP .14" (F.S.) AT CENTER

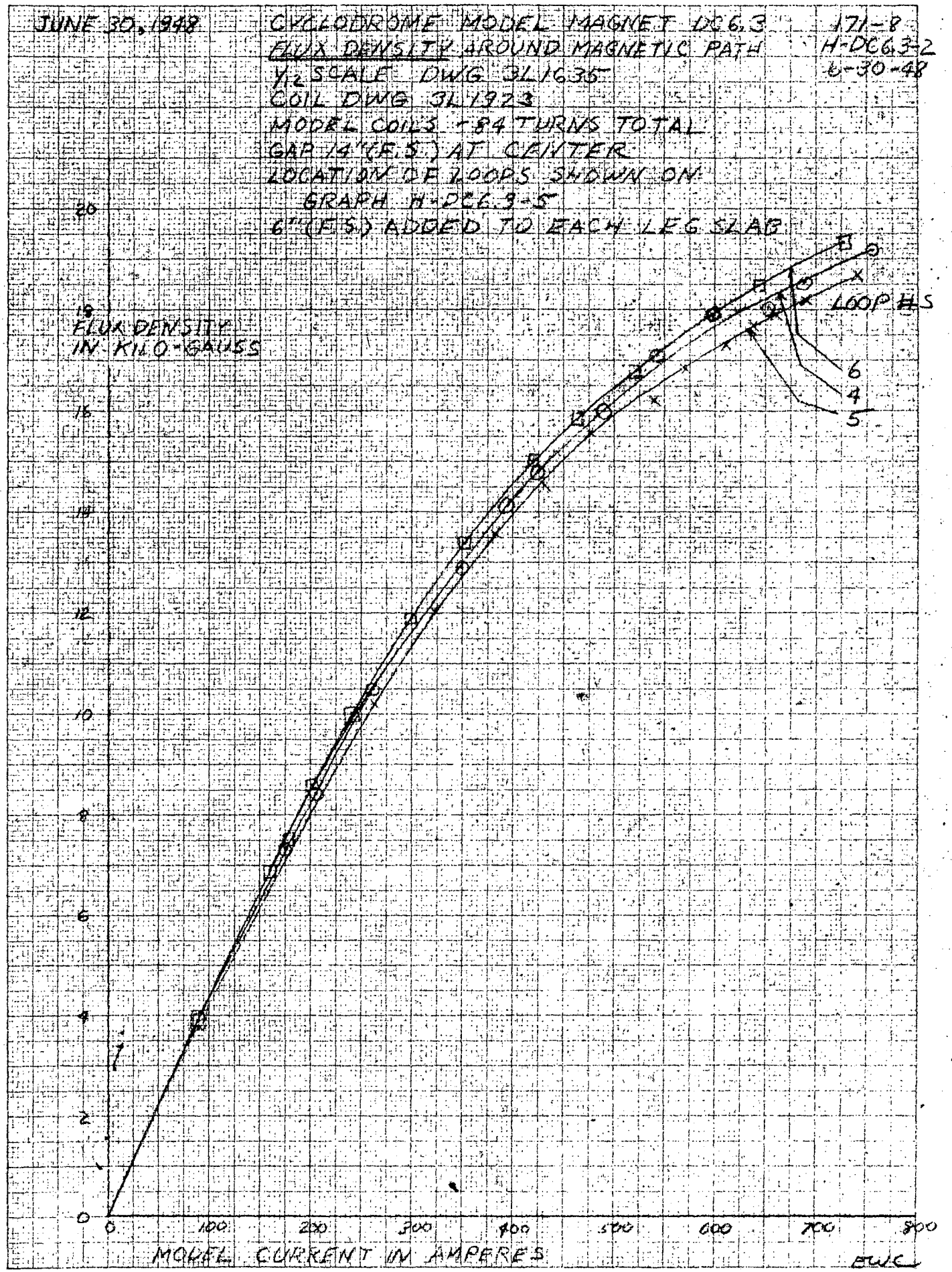
LOCATION OF LOOPS SHOWN ON GRAPH H-DC6.3-5

6" (F.S.) ADDED TO EACH LEG SLAB

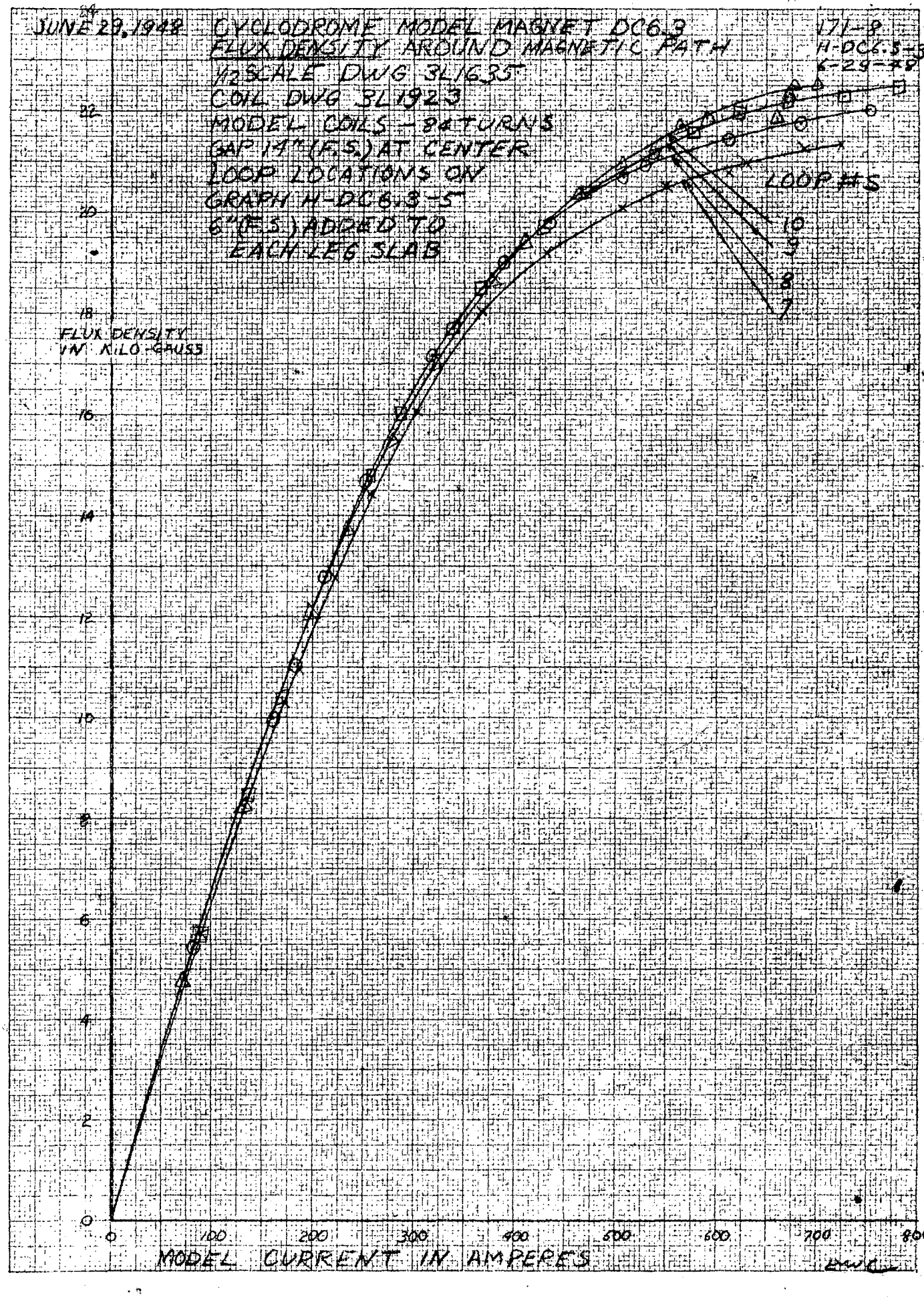
171-8

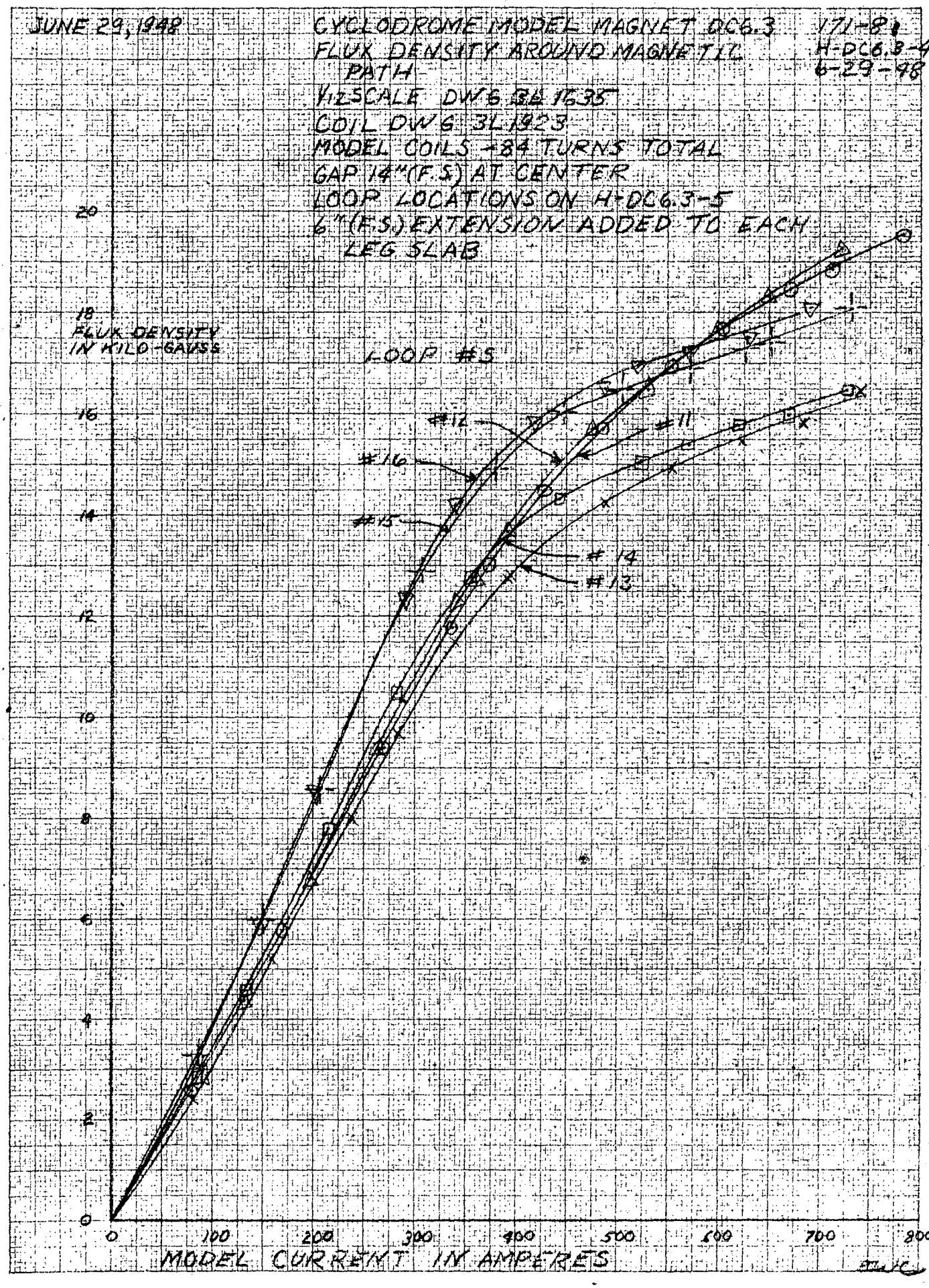
H-DC63-2

6-30-48



BWC


JUNE 29, 1948 CYCLODROME MODEL MAGNET DC6.3
FLUX DENSITY AROUND MAGNETIC PATH
1/2 SCALE DWG 3L1635
COIL DWG 3L1923
MODEL COILS - 84 TURNS
GAP 1.4" (F.S.) AT CENTER
LOOP LOCATIONS ON
GRAPH H-DC6.3-5"
6" (F.S.) ADDED TO
EACH LEG SLAB
171-8
H-DC6.5-3
6-29-48
LOOP #S
10
9
8
7
FLUX DENSITY
IN KILO-GAUSS
0
2
4
6
8
10
12
14
16
18
20
22
0
100
200
300
400
500
600
700
800
MODEL CURRENT IN AMPERES

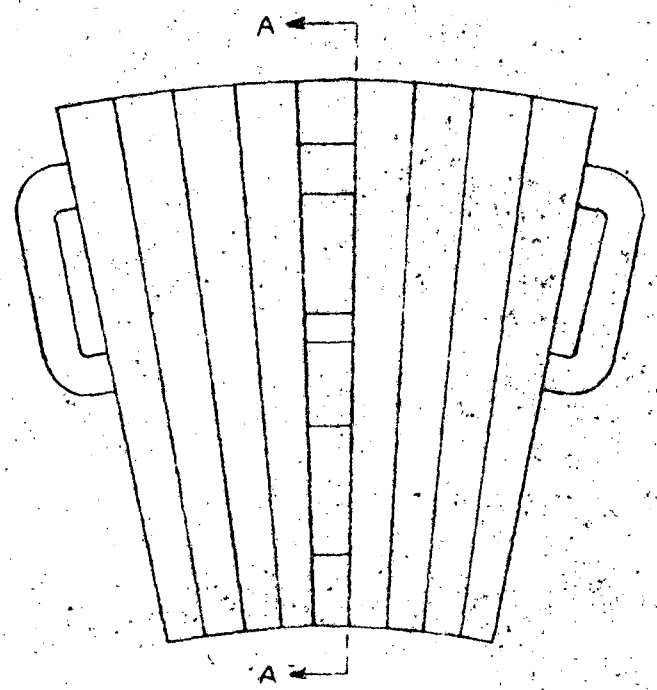

JUNE 29, 1948
CYCLODROME MODEL MAGNET DC6.3
FLUX DENSITY AROUND MAGNET I.L. PATH
VIZ SCALE DWG SL 1635
COIL DWG 3L1923
MODEL COILS -84 TURNS TOTAL
GAP 14" (F.S.) AT CENTER
LOOP LOCATIONS ON H-DC6.3-5
6" (F.S.) EXTENSION ADDED TO EACH LEG SLAB
V71-8
H-DC6.3-4
6-29-48
FLUX DENSITY IN KILO-GAUSS
LOOP #5
#12
#11
#16
#15
#14
#13
0
2
4
6
8
10
12
14
16
18
20
0
100
200
300
400
500
600
700
800
MODEL CURRENT IN AMPERES

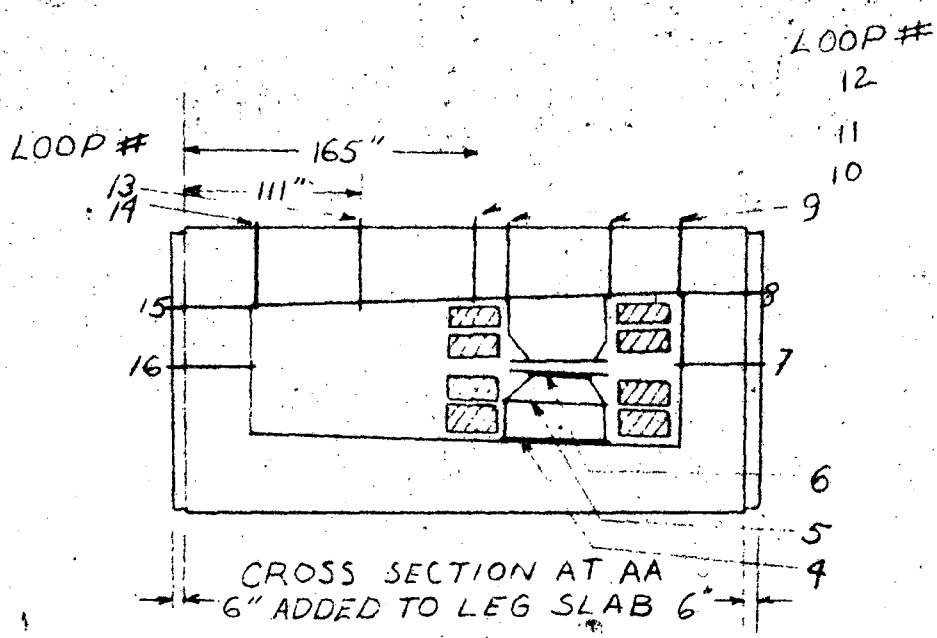
JUNE 28, 1948

CYCLODROME MODEL MAGNET DC6.3
LOCATION OF FLUX LOOPS

171-9
H-DC6.3-5
6-28-48

1/12 SCALE DWG 3L1635
GAP 14" FULL SCALE AT CENTER
COIL DWG 3L1923
84 TURNS TOTAL ON MODEL COILS
SEE GRAPHS H-DC6.3-2, H-DC6.3-3, H-DC6.3-4



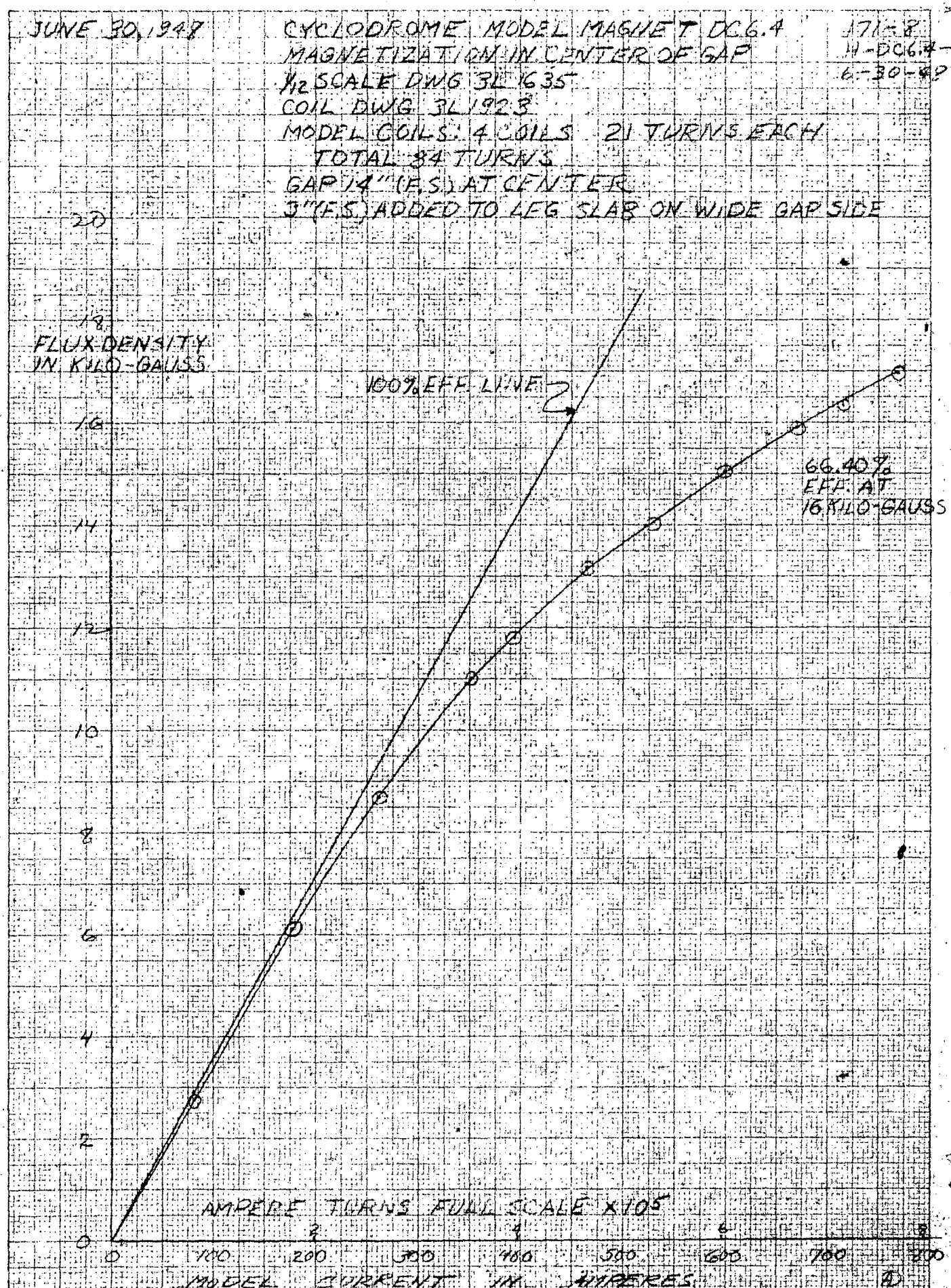


JUNE 30, 1948

CYCLODROME MODEL MAGNET DC6.4
MAGNETIZATION IN CENTER OF GAP

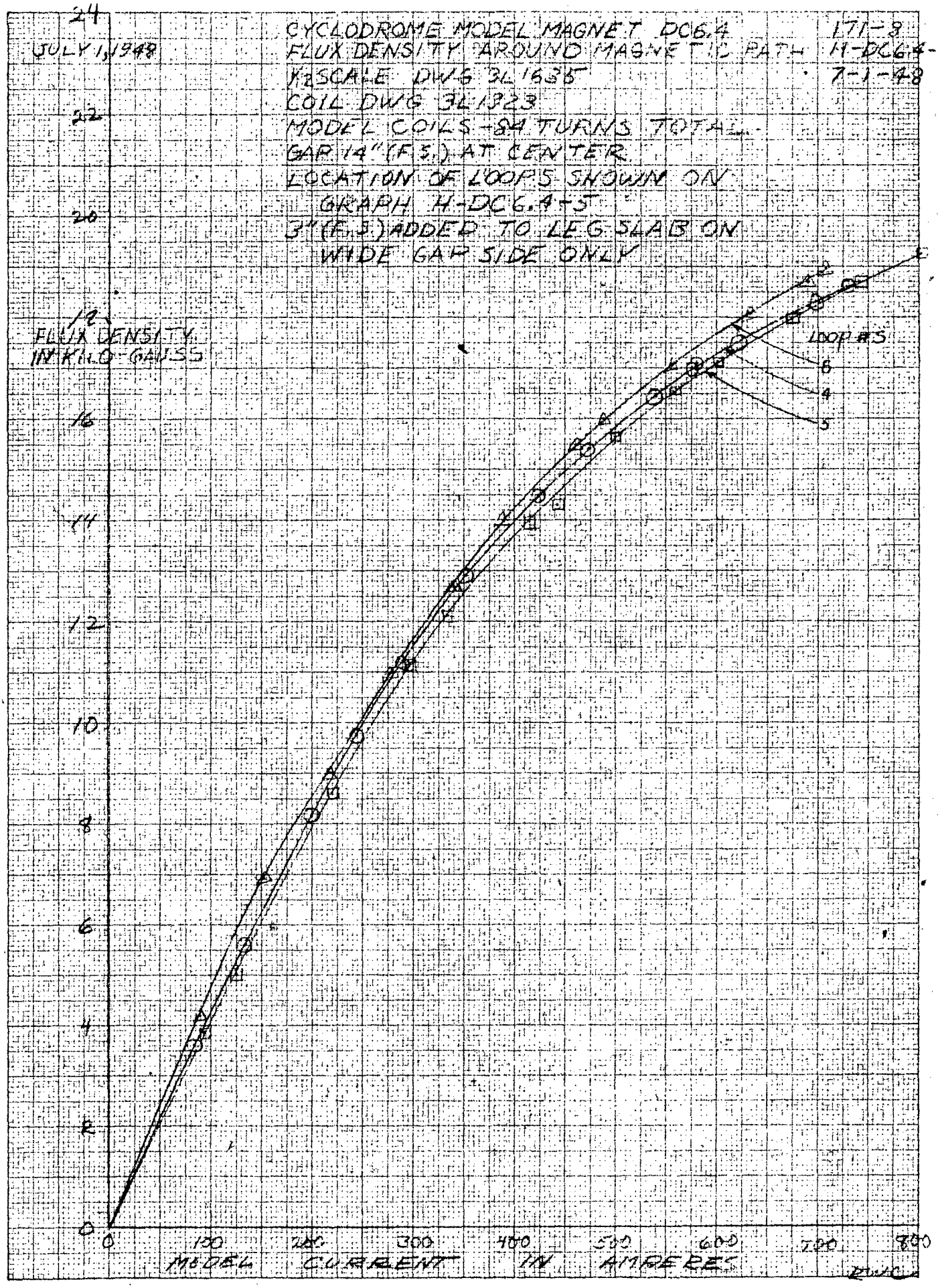
171-8
11-DC6.4-
6-30-48

1/12 SCALE DWG 3L 1635
COIL DWG 3L 1923
MODEL COILS: 4 COILS 21 TURNS EACH
TOTAL 84 TURNS
GAP 1/4" (F.S.) AT CENTER
3" (F.S.) ADDED TO LEG SLAB ON WIDE GAP SIDE



JULY 1, 1948

CYCLODROME MODEL MAGNET DC6.4 — 171-8
FLUX DENSITY AROUND MAGNETIC PATH — H-DC6.4-2
K2 SCALE DWG 3L1635 — 7-1-48
COIL DWG 3L1823
MODEL COILS - 84 TURNS TOTAL.
GAP 14" (F.S.) AT CENTER.
LOCATION OF LOOPS SHOWN ON GRAPH H-DC6.4-3
3" (F.S.) ADDED TO LEG SLAB ON WIDE GAP SIDE ONLY



171-8
H-DC6.4-3
6-30-48

JUNE 30, 1948

CYCLODRONE MODEL MAGNET DC 6.4
FLUX DENSITY AROUND THE MAGNETIC PATH
½" SCALE DWG 3L1605
COIL DWG 3L1923
MODEL COIL = 84 TURNS
GAP 14" (FS) AT CENTER
EDGE LOCATIONS
ON H-DC 6.4-5
3" EXTENSION ADDED TO OUTER LEG
SLAB ONLY

LOOPS
#8
#7
#9
#10

FLUX DENSITY
IN KILO-GAUSS

24
22
20
18
16
14
12
10
8
6
4
2
0

0 100 200 300 400 500 600 700 800

MODEL CURRENT IN AMPERES

JULY 1, 1948

CYCLODROME MODEL MAGNET DC6.4

FLUX DENSITY AROUND MAGNETIC PATH

½ SCALE DWG 3L16635

COIL DWG 3L1923

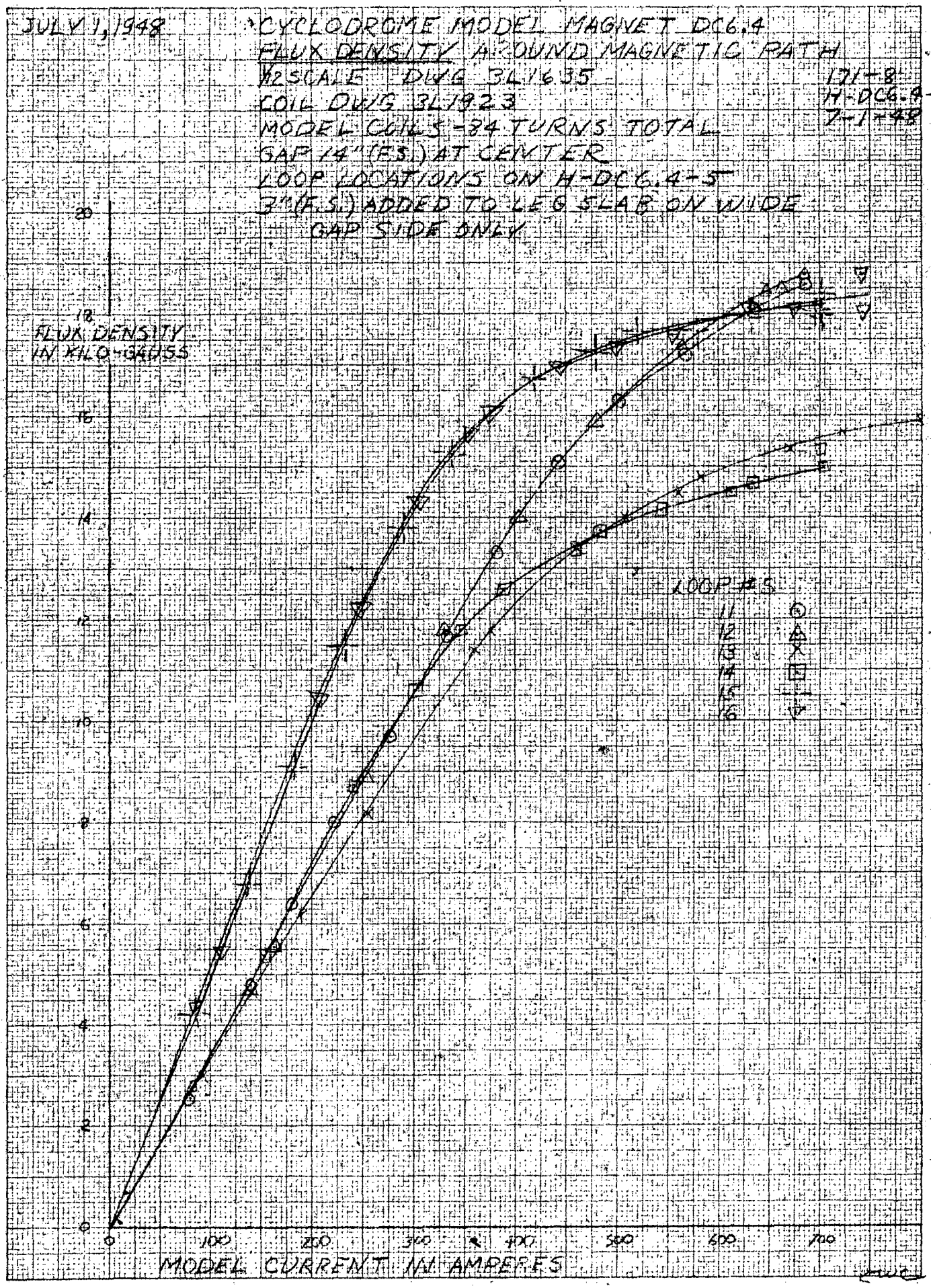
MODEL COILS - 84 TURNS TOTAL

GAP 14" (ES.) AT CENTER

LOOP LOCATIONS ON H-DC6.4-5

3" (F.S.) ADDED TO LEG SLAB ON WIDE GAP SIDE ONLY

171-8
H-DC6.4-4
7-1-48

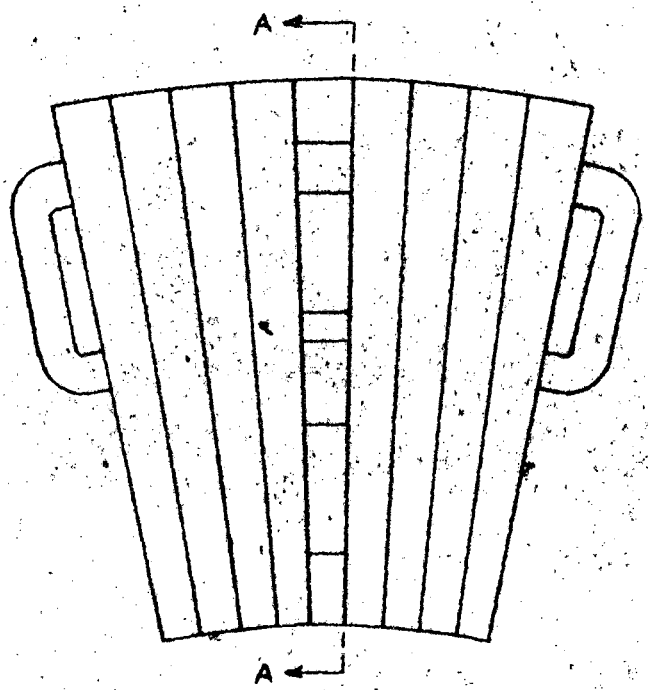


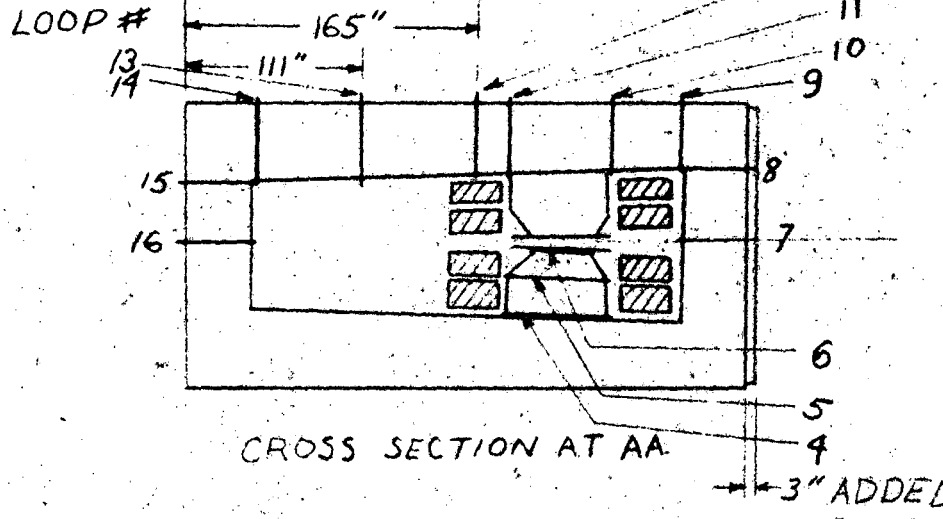
JULY 1, 1948

171-8
H-DC6.4-
7-1-48

CYCLODROME MODEL MAGNET DC6.4
LOCATION OF FLUX LOOPS

1/12 SCALE DWG 3L1635
GAP 14" FULL SCALE AT CENTER
COIL DWG 3L1923
84 TURNS TOTAL ON MODEL COILS
SEE GRAPHS H-DC6.4-2, H-DC6.4-3, H-DC6.4-4

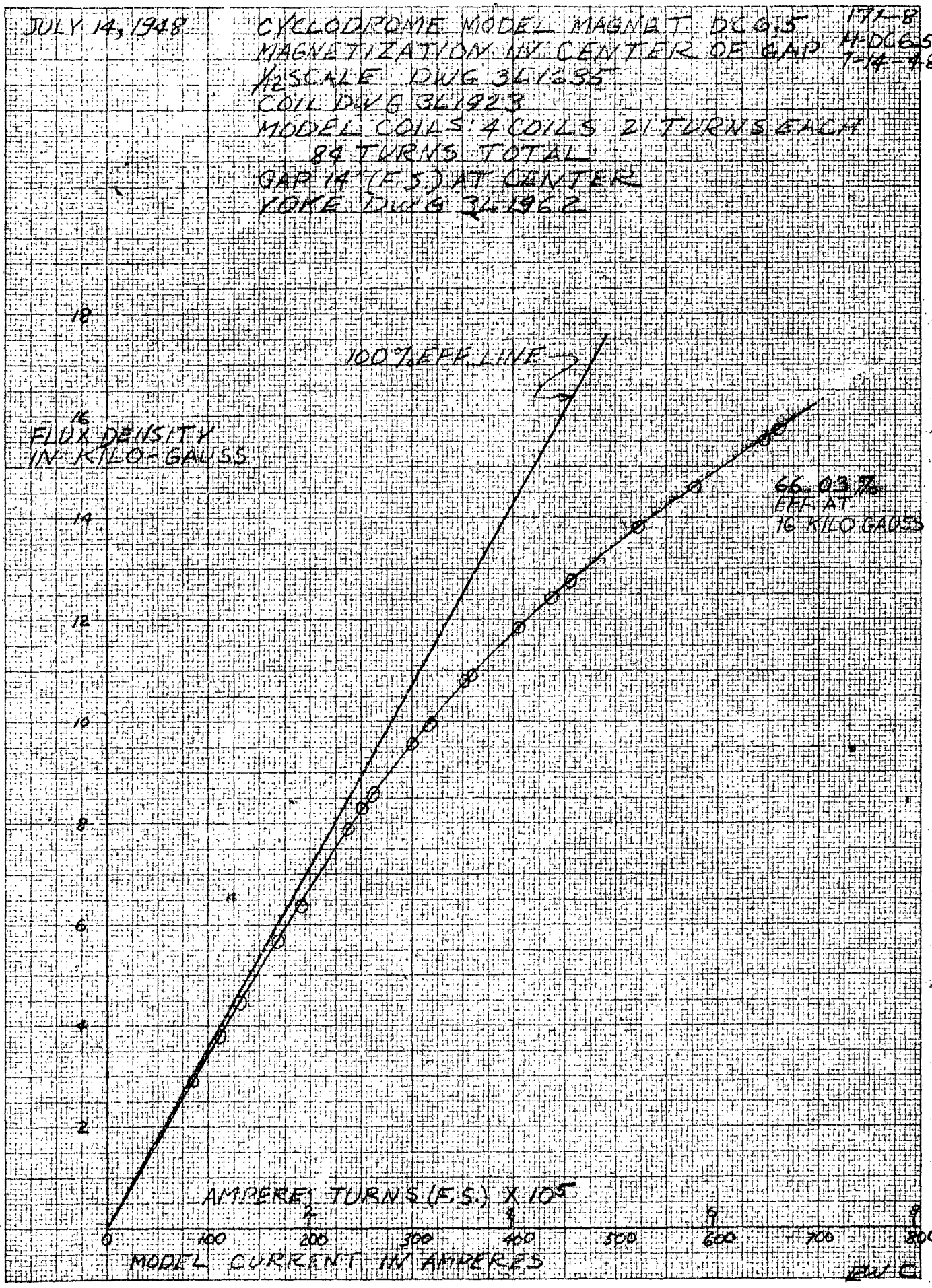




CROSS SECTION AT AA

JULY 14, 1948

CYCLOTRON MODEL MAGNET DC 0.5 171-8
MAGNETIZATION AT CENTER OF GAP M-DC65-1
7-14-48
½ SCALE DWG 3L-1935
COIL DWG 3L-1923
MODEL COILS: 4 COILS 21 TURNS EACH
84 TURNS TOTAL
GAP 14" (F.S.) AT CENTER
YOKE DWG 3L-1962



DWG C

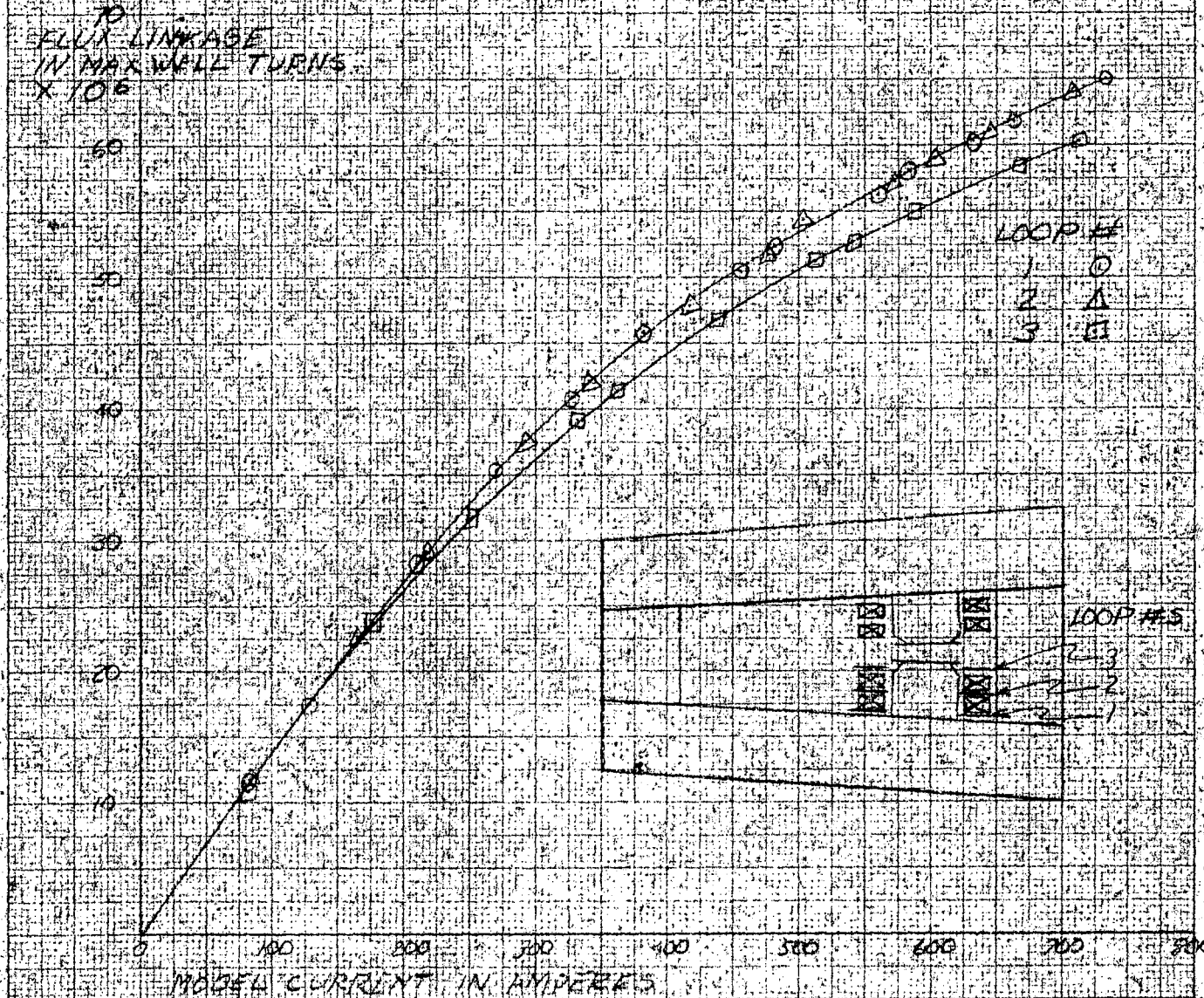
JULY 14, 1948.

CYCLODROME MODEL MAGNET DC6,5

COIL LOOP FLUX LINKAGE

171-8
F-DC6.5-1
7-19-48

VIA SCALE
COIL DRAWING 3L1923
MODEL COILS: 4 COILS 21 TURNS EACH
84 TURNS
GAP 14 (F.S.) AT CENTER
YOKE DWG 3L1962
EACH LOOP HAS 21 TURNS
FLUX LINKAGE IS ON 5.56 SECTION
OF MODEL

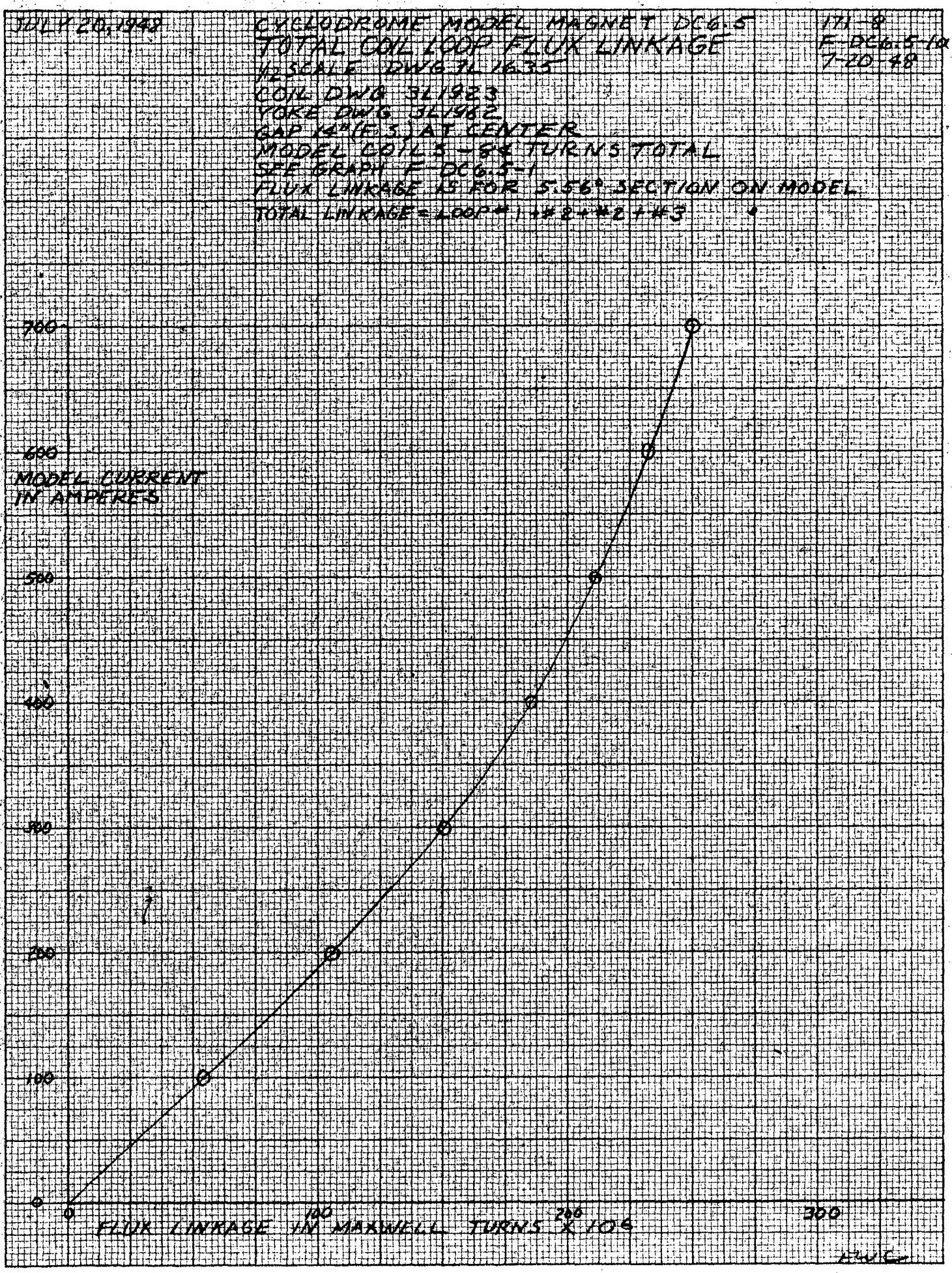


EWC

JULY 20, 1949

CYCLODROME MODEL MAGNET DC6.5
TOTAL COIL LOOP FLUX LINKAGE
½ SCALE DWG TL 16.35
COIL DWG 3L1923
YOKE DWG 3L1962
GAP .14" (C.S.) AT CENTER
MODEL COIL 3-54 TURNS TOTAL
SEE GRAPH F-DC6.5-1
FLUX LINKAGE AS FOR 5.56° SECTION ON MODEL
TOTAL LINKAGE = LOOP #1 + #2 + #2 + #3

IN-8
F-DC6.5-1A
7-20-49



KEUFFEL & ESSER CO., N. Y. NO. 3597-12G
10 × 10 to the ½ inch, 5th lines accented.
Engraving 7½ × 10 in.
MADE IN U.S.A.

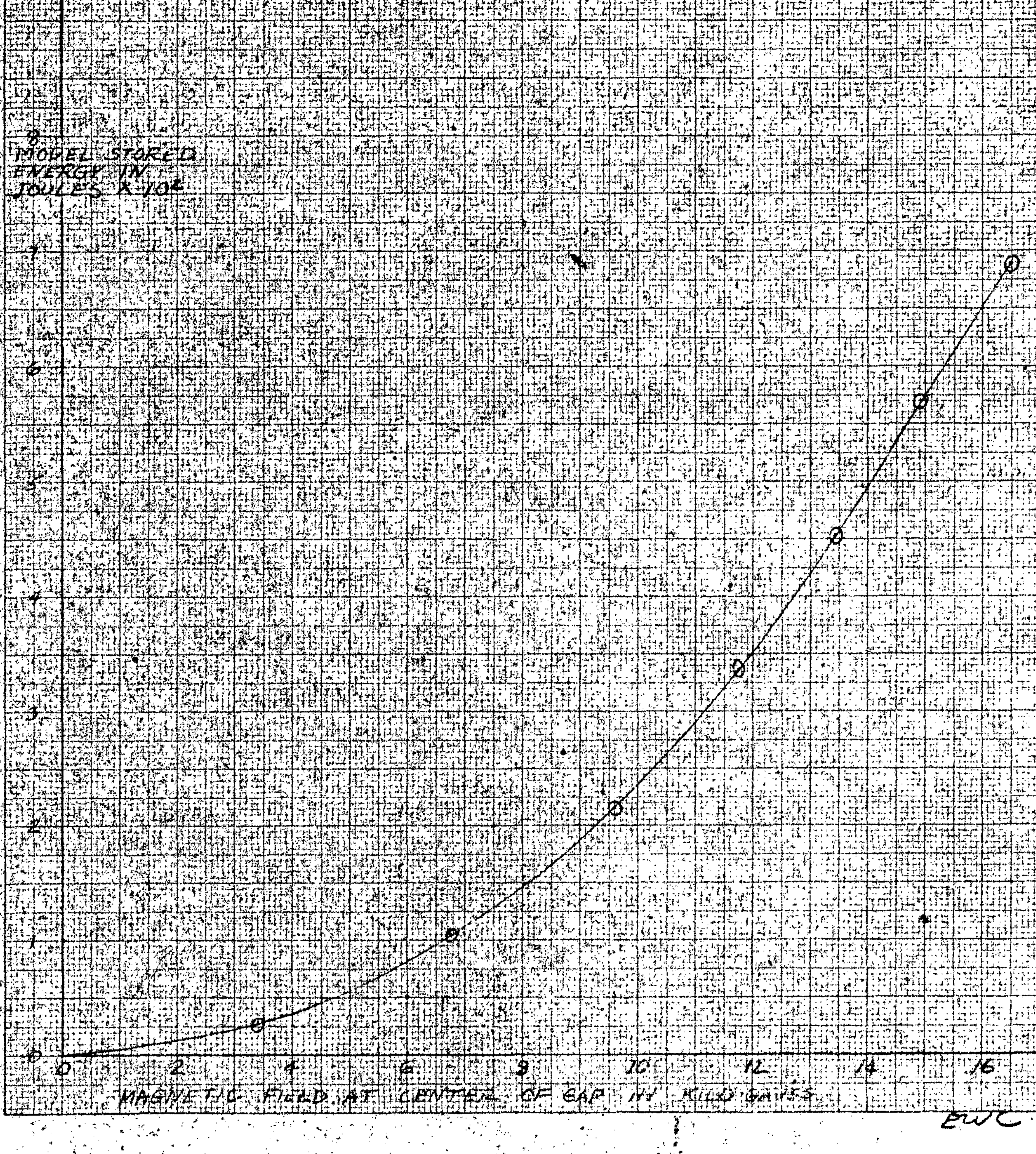
JULY 20, 1948

CYCLODROME MODEL MAGNET DC6.5
STORED ENERGY ON MODEL
1/2 SCALE DWG 3L1635
COIL DWG 5L1923
YOKE DWG 5L1962
CALCULATED FROM TOTAL COIL LOOP
FLUX LINKAGE - SEE GRAPH
F-DC6.5-1a

ENERGY (JOULES) = $10^{-8}\int^{I} I\,d\phi$
WHERE I IS IN AMPERES
ϕ IS IN MAXWELL TURNS

DATA IS FOR A 5.56° SECTION OF MODEL

171-8
E-DC6.5-1
7-20-48

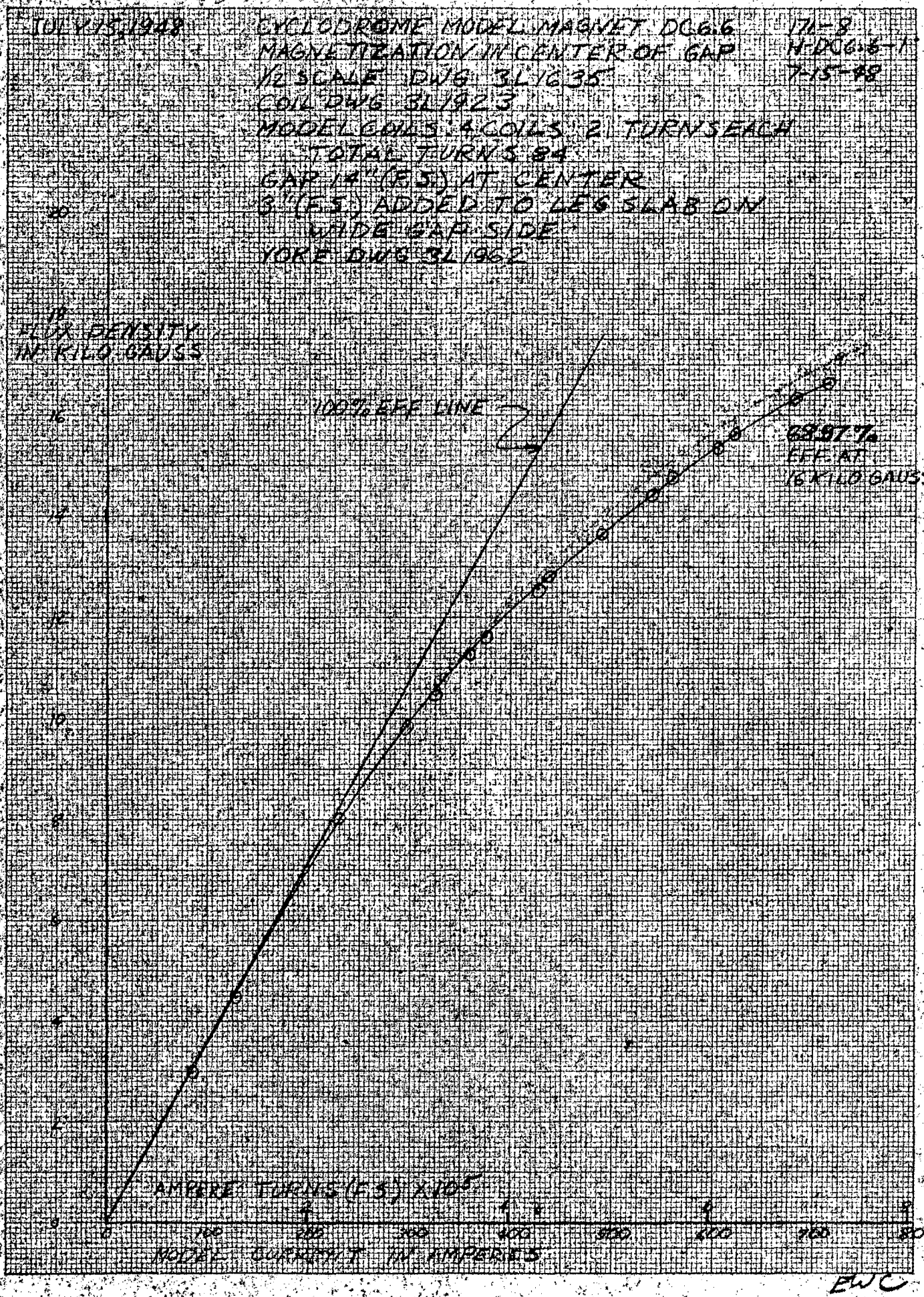


EWC

JULY 15, 1948

CYCLOTRON MODEL MAGNET DC6.6
MAGNETIZATION IN CENTER OF GAP
1/2 SCALE DWG 3L/G35
COIL DWG 3L1923
MODEL COILS: 4 COILS 2 TURNS EACH
TOTAL TURNS 84
GAP 1.4" (F.S.) AT CENTER
3" (F.S.) ADDED TO LEG SLABS ON
WIDE GAP SIDE
YOKE DWG 3L1962

17L-8
M-DC6.6-1
7-15-48



EWC

JULY 6, 1948

CYCLODROME MODEL MAGNET DC 6.6 171-8

FLUX DENSITY AROUND MAGNETIC PATH

H-DC6.6-2

7-16-48

½ SCALE DWG 3L1935

GAP 12" (F.S.) AT CENTER

COIL DWG 3L1923

YOKE DWG 3L1962

MODEL COILS - 84 TURNS TOTAL

3" (F.S.) ADDED TO OUTER LEG SLAB

LOCATION OF LOOPS SHOWN ON GRAPH H-DC6.6-5

100 PT #5

FLUX DENSITY IN KILOGAUSS

20
18
16
14
12
10
8
6
4
2
0

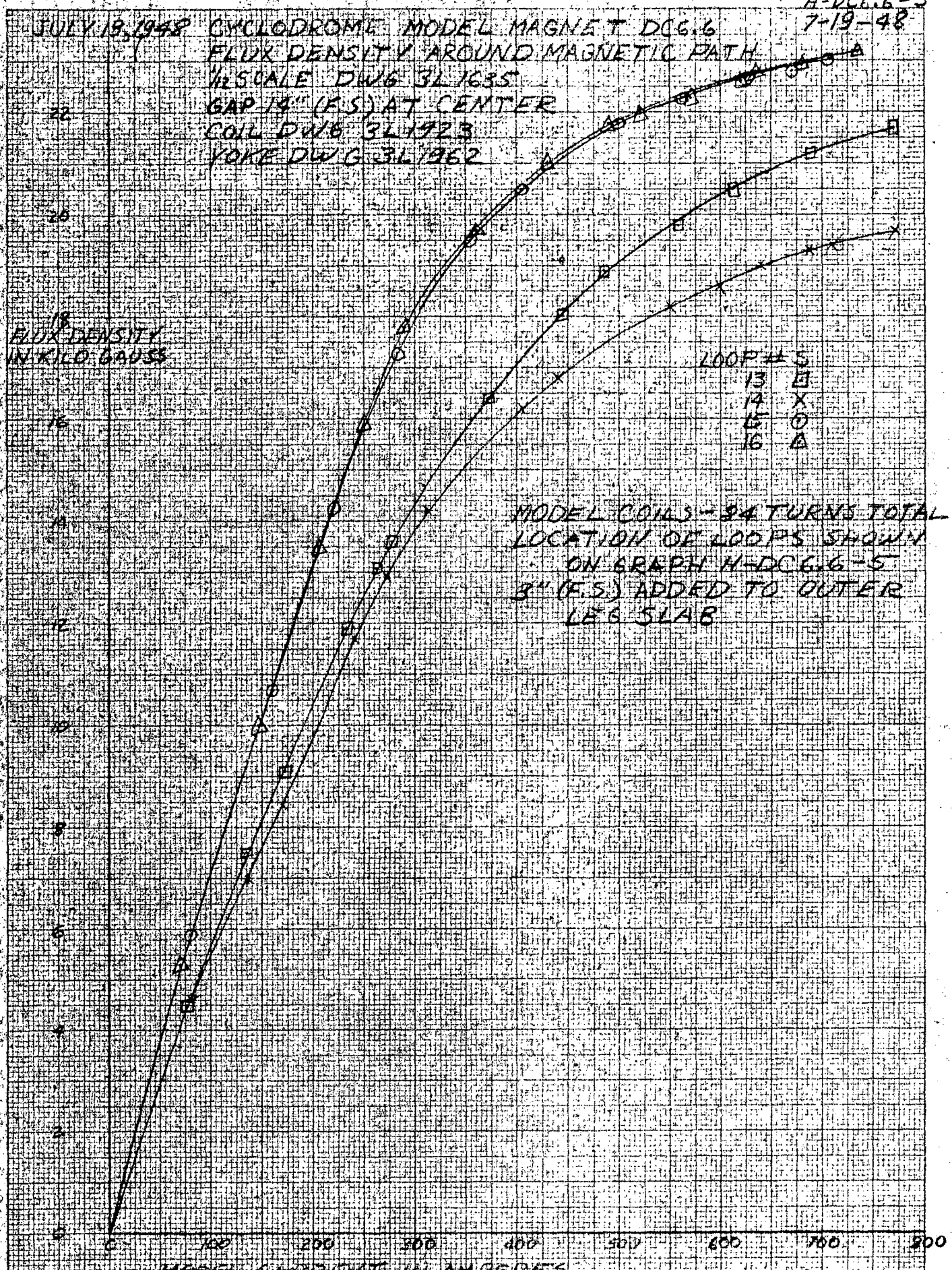
0 100 200 300 400 500 600 700 800

MODEL CURRENT IN AMPERES

UNIVERSITY OF CALIFORNIA RADIATION LABORATORY

171-8
H-DC6.6-3
7-19-48

JULY 19, 1948 CYCLODROME MODEL MAGNET DC6.6
FLUX DENSITY AROUND MAGNETIC PATH
½ SCALE DWG 3L1635
GAP 1⅛" (F.S.) AT CENTER
COIL DWG 3L1723
YOKE DWG 3L1962



DWG C

171-8

H-DC6.6-4

7-19-48

JULY 19, 1948

CYCLODROME MODEL MAGNET DC6.6

FLUX DENSITY AROUND MAGNETIC PATH

½ SCALE DWG 3L1635

GAP 14" (E.S.) AT CENTER

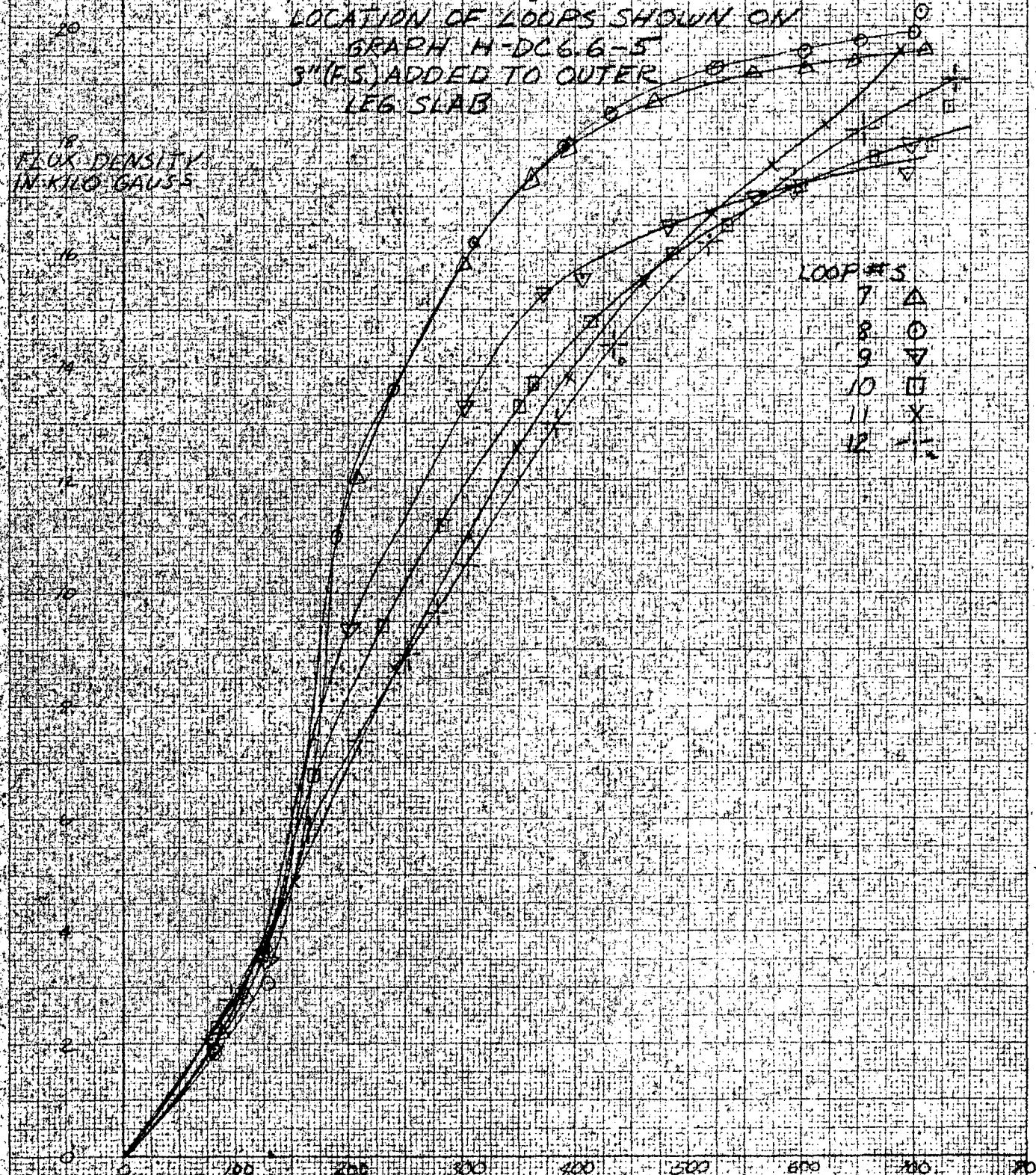
COIL DWG 3L1923

YOKE DWG 3L1962

MODEL COILS - 84 TURNS TOTAL

LOCATION OF LOOPS SHOWN ON GRAPH H-DC6.6-5

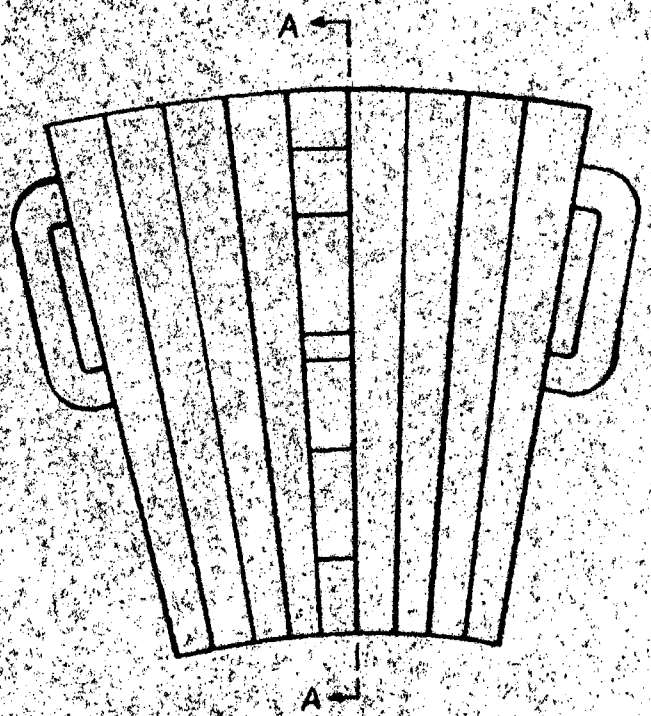
3" (E.S.) ADDED TO OUTER LEG SLAB

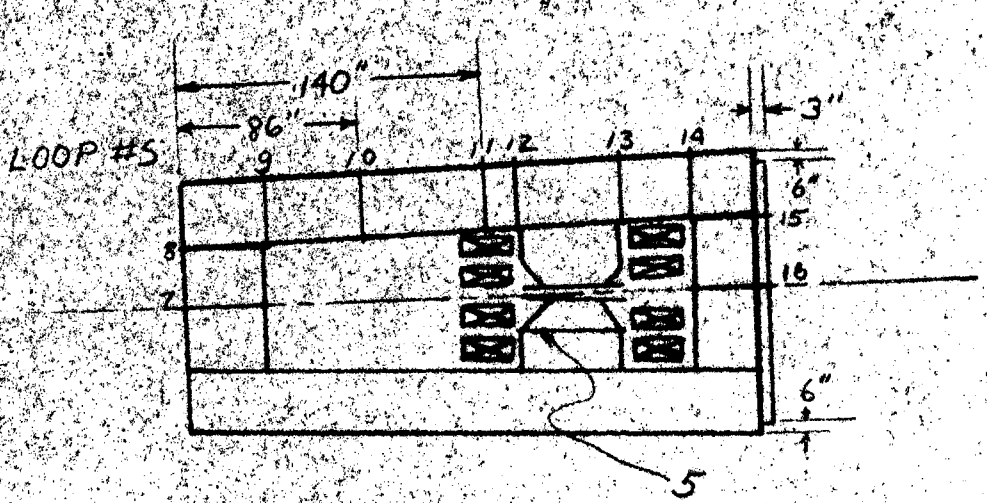


JULY 19, 1948

171-8
H-DC6.6-5
7-19-48

CYCLODROME MODEL MAGNET DC6.6
LOCATION OF FLUX LOOPS
1/12 SCALE DWG 3L 1635
COIL DWG 3L 1823
YOKE DWG. 3L 1962
84 TURNS TOTAL ON MODEL COILS
3" (F.S.) ADDED TO OUTER LEG SLAB
GAP 14" (F.S.) AT CENTER
SEE GRAPHS H-DC6.6-2 H-DC6.6-3 H-DC6.6-4





CROSS SECTION AT AA

EWC

171-8

H-DC6.6-6

7-19-48

CALIFORNIA MODEL MAGNET DC6.6

JULY 19, 1948

MAGNETIZATION

½ SCALE DWG 3L 4635

GAP 1½" (FULL SCALE) AT CENTER

MODEL COILS 84 TURNS TOTAL

COIL DWG 3L 1923

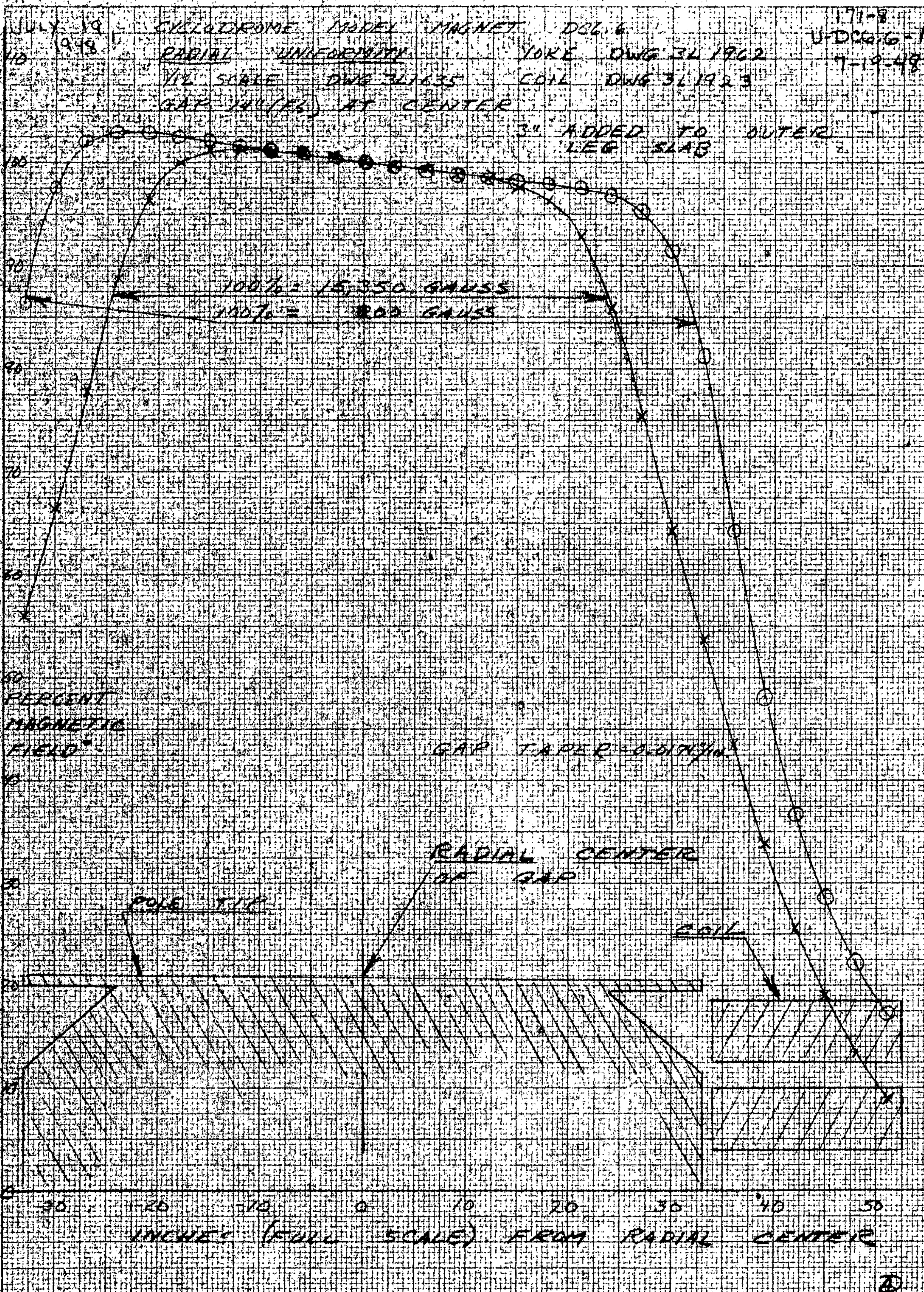
YOKE DWG 3L 1962

3" (E.S.) ADDED TO OUTER LEG SLAB

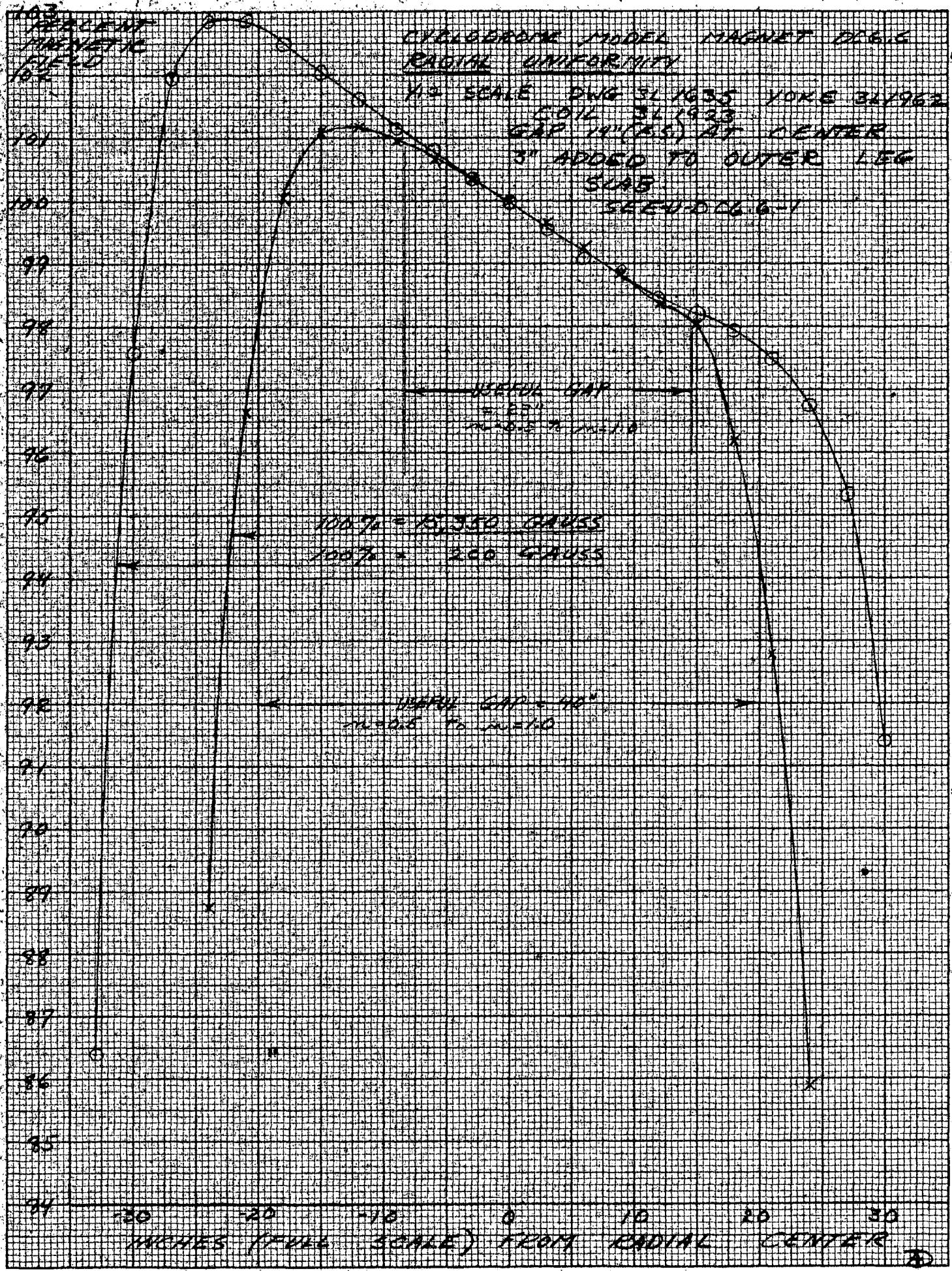
FLUX DENSITY

KILO GAUSS

MODEL CURRENT IN AMPERES

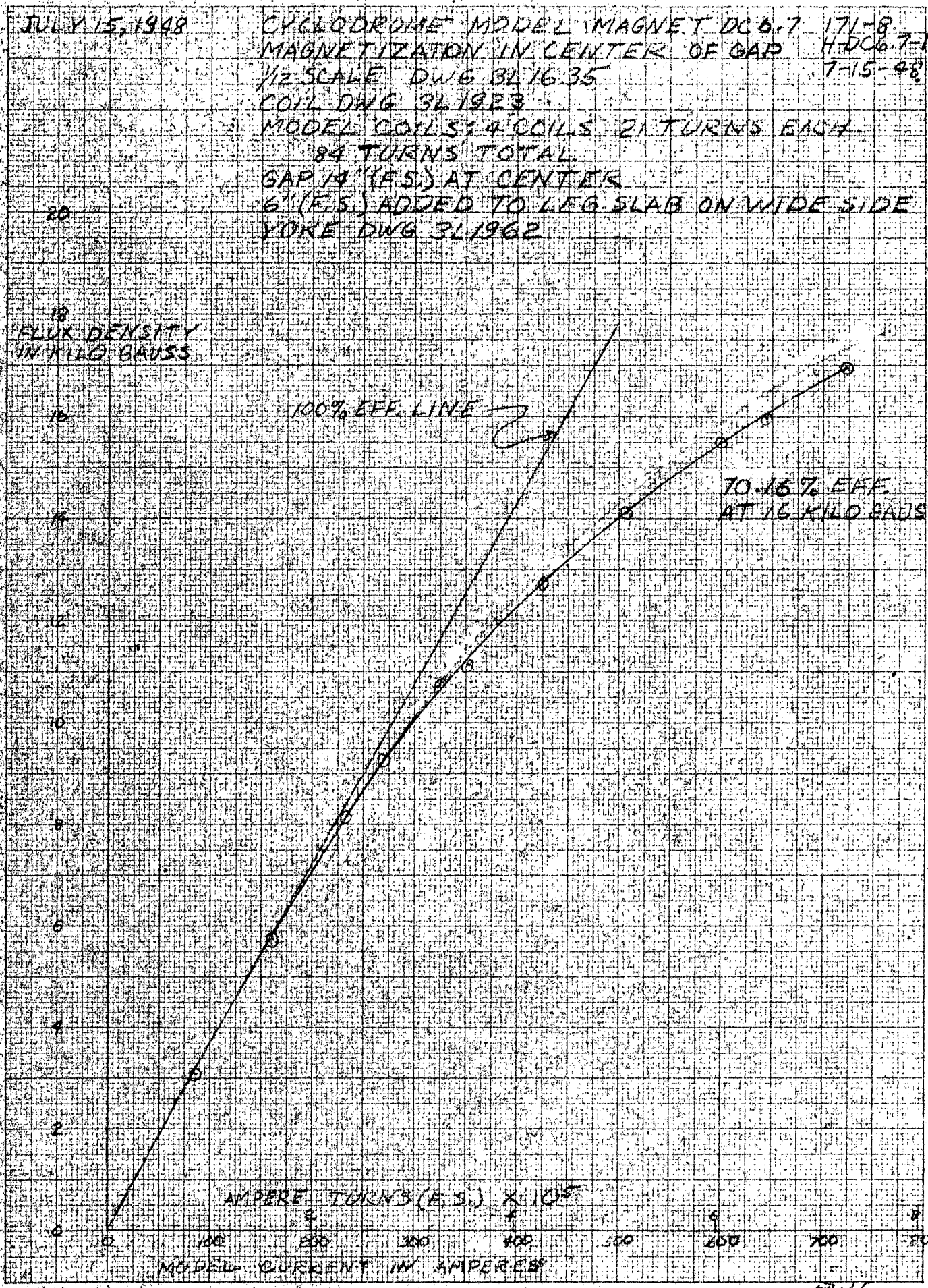

JULY 19 1948
CYCLODROME MODEL MAGNET DCL 6
RADIAL UNIFORMITY
1/12 SCALE DWG 3L1635
YOKE DWG 3L1962
COIL DWG 3L1923
171-8
U-DCL6-6-1
7-19-48
3" ADDED TO OUTER LEG SLAB
100% = 15,350 GAUSS
PERCENT MAGNETIC FIELD
GAP TAPER 0.01 IN/IN
RADIAL CENTER OF GAP
POLE TIP
COIL
INCHES (FULL SCALE) FROM RADIAL CENTER

171-8
U-DC6.6-1C
7-19-48



JULY 15, 1948

CYCLODROME MODEL MAGNET DC 6.7 171-8.
MAGNETIZATION IN CENTER OF GAP H-DC6.7-1
7-15-48.
1/2 SCALE DWG 32 1635
COIL DWG 32 1923
MODEL COILS: 4 COILS 21 TURNS EACH
84 TURNS TOTAL
GAP 1/4" (F.S.) AT CENTER
6" (F.S.) ADDED TO LEG SLAB ON WIDE SIDE
YOKE DWG 32 1962



JULY 15, 1948

CYCLODROME MODEL MAGNET DC6.8
MAGNETIZATION IN CENTER OF GAP
½ SCALE DWG 3L1635
COIL DWG 3L1823
MODEL COILS: 4 COILS 21 TURNS EACH
84 TURNS TOTAL
GAP 14 (F.S.) IN CENTER
YOKE DWG 3L1962
6" (F.S.) ADDED TO LEG SLAB ON WIDE GAP SIDE
3" (F.S.) ADDED TO LEG SLAB ON NARROW GAP SIDE

171-8
H-DC6.8-1
7-15-48

FLUX DENSITY IN KILO GAUSS

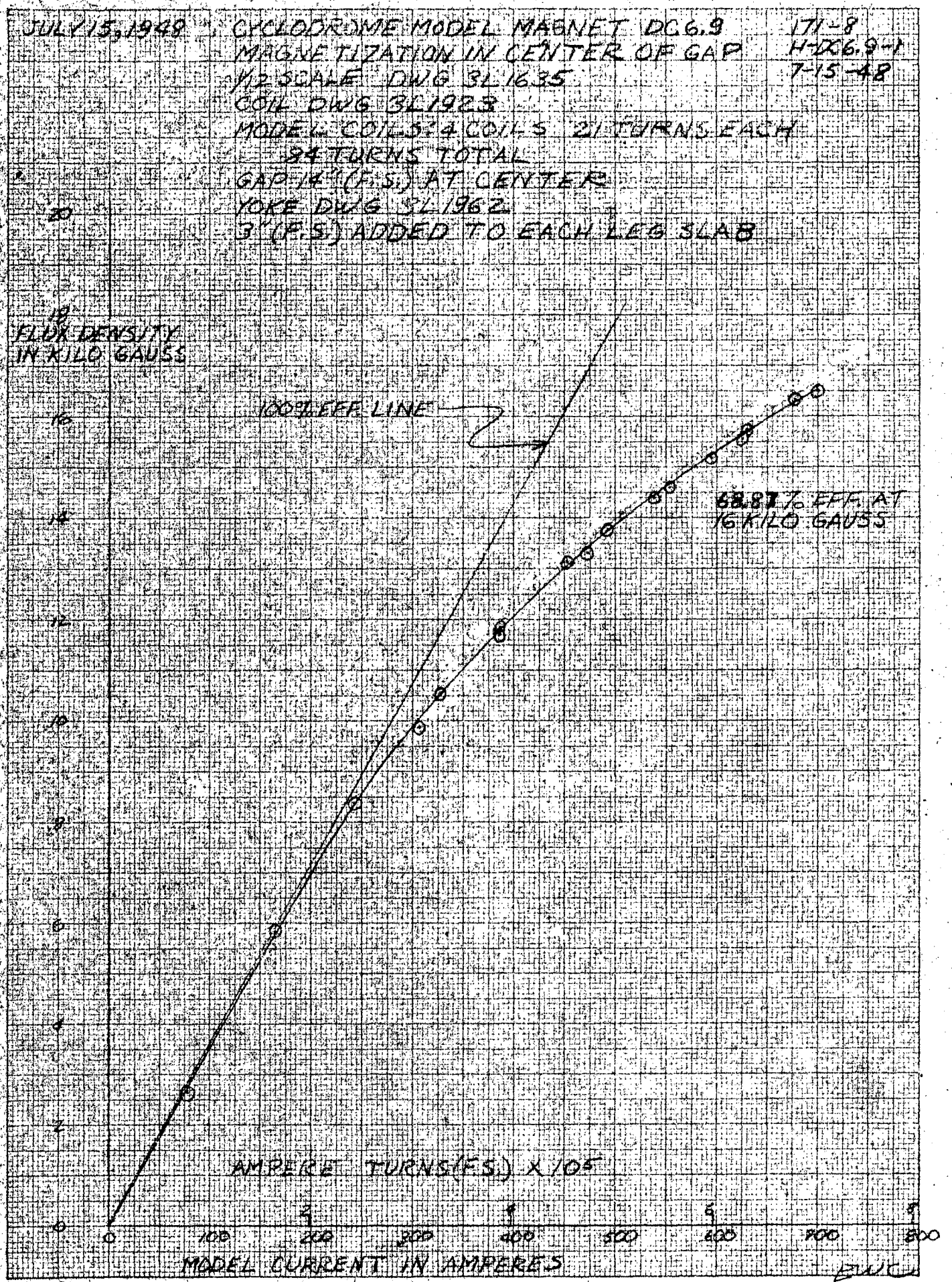
100% EFF. LINE

29.94% EFF. AT 16 KILO GAUSS

AMPERE TURNS (F.S.) X 10⁵

MODEL CURRENT IN AMPERES

JULY 15, 1948 CYCLOTRON MODEL MAGNET DC 6.9 171-8
MAGNETIZATION IN CENTER OF GAP H-DC 6.9-1
1/2 SCALE DWG 3L1685 7-15-48
COIL DWG 3L1923
MODEL COILS 4 COILS 21 TURNS EACH
84 TURNS TOTAL
GAP .14" (F.S.) AT CENTER
YOKE DWG 3L1962
3" (F.S.) ADDED TO EACH LEG SLAB



111-8
L-DCCA-1
6-21-48

BEVATRON MODEL MAGNET DCCA

JUNE 21, 1948 EFFICIENCY & LEAKAGE COEFFICIENTS

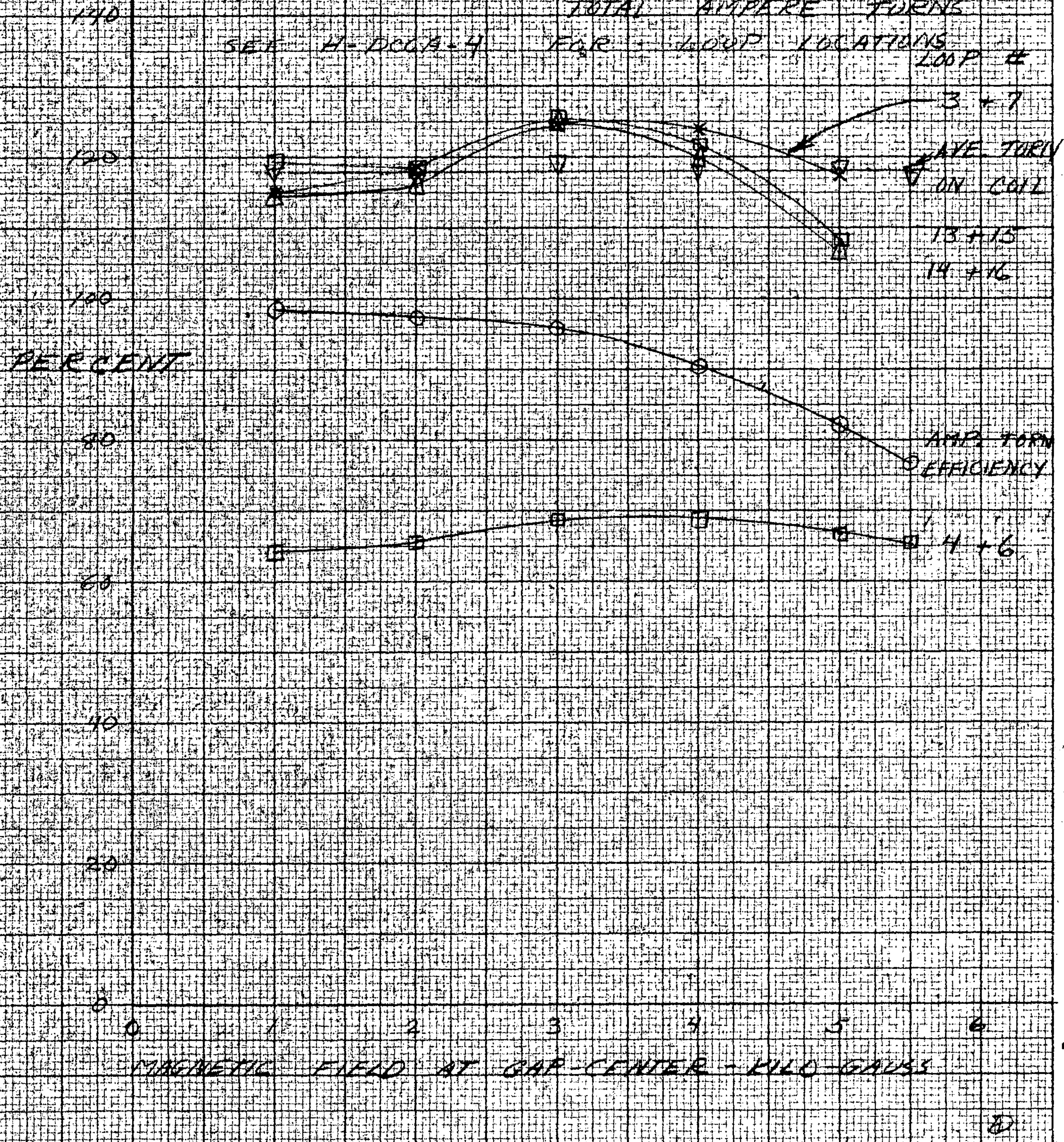
1/12 SCALE DWG 3L1635

$$\% \text{ LEAK COEFF} = \frac{\text{TOTAL FLUX} \times 100}{\text{FLUX DENSITY AT CENTER} \times \text{POLE AREA}}$$

POLE AREA BASED ON 14 FOOT WIDTH

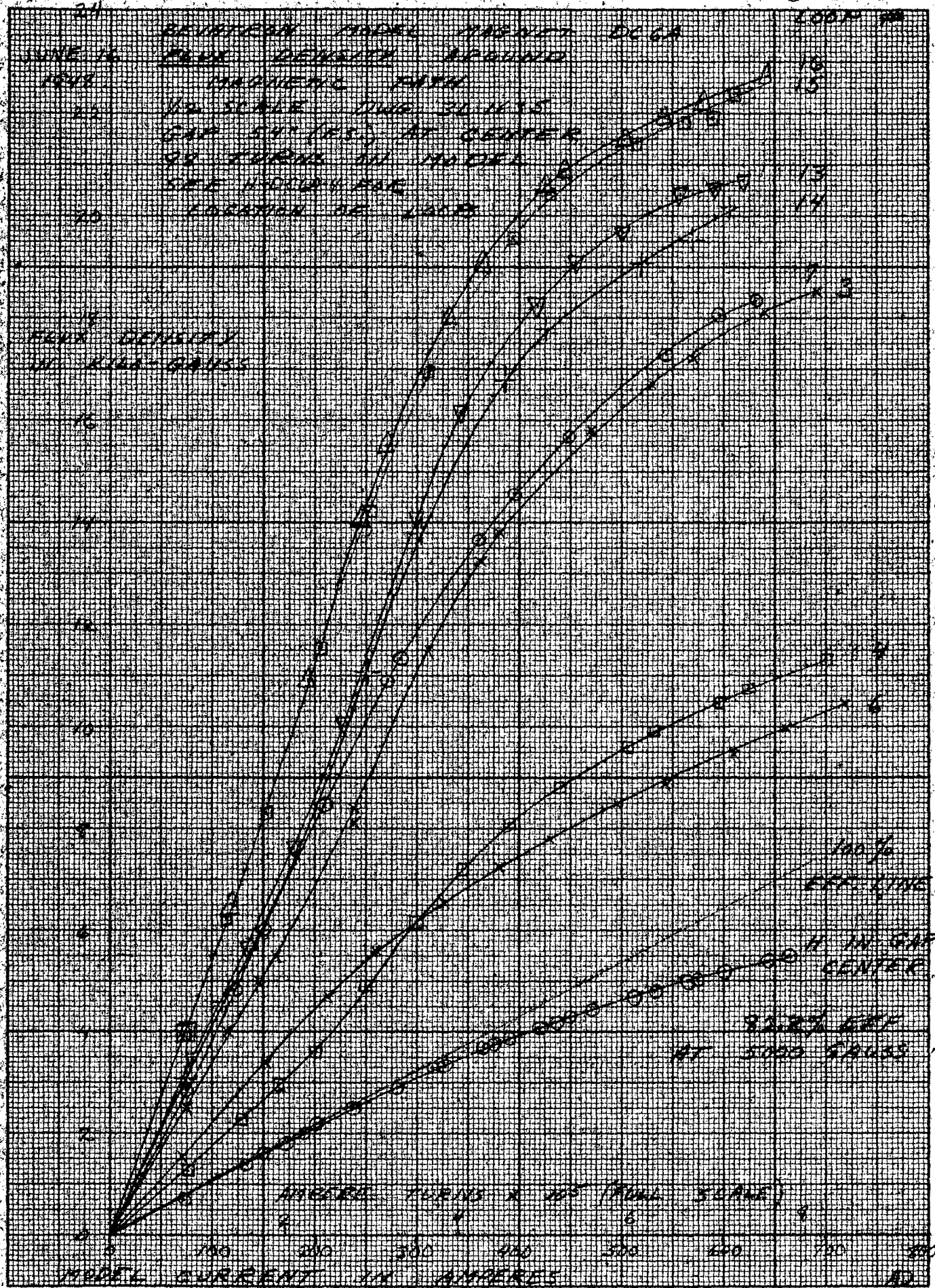
$$\% \text{ EFF} = \frac{100 \times 2.02 \times \text{FLUX DENSITY AT CENTER} \times \text{GAP HEIGHT (IN.)}}{\text{TOTAL AMPERE TURNS}}$$

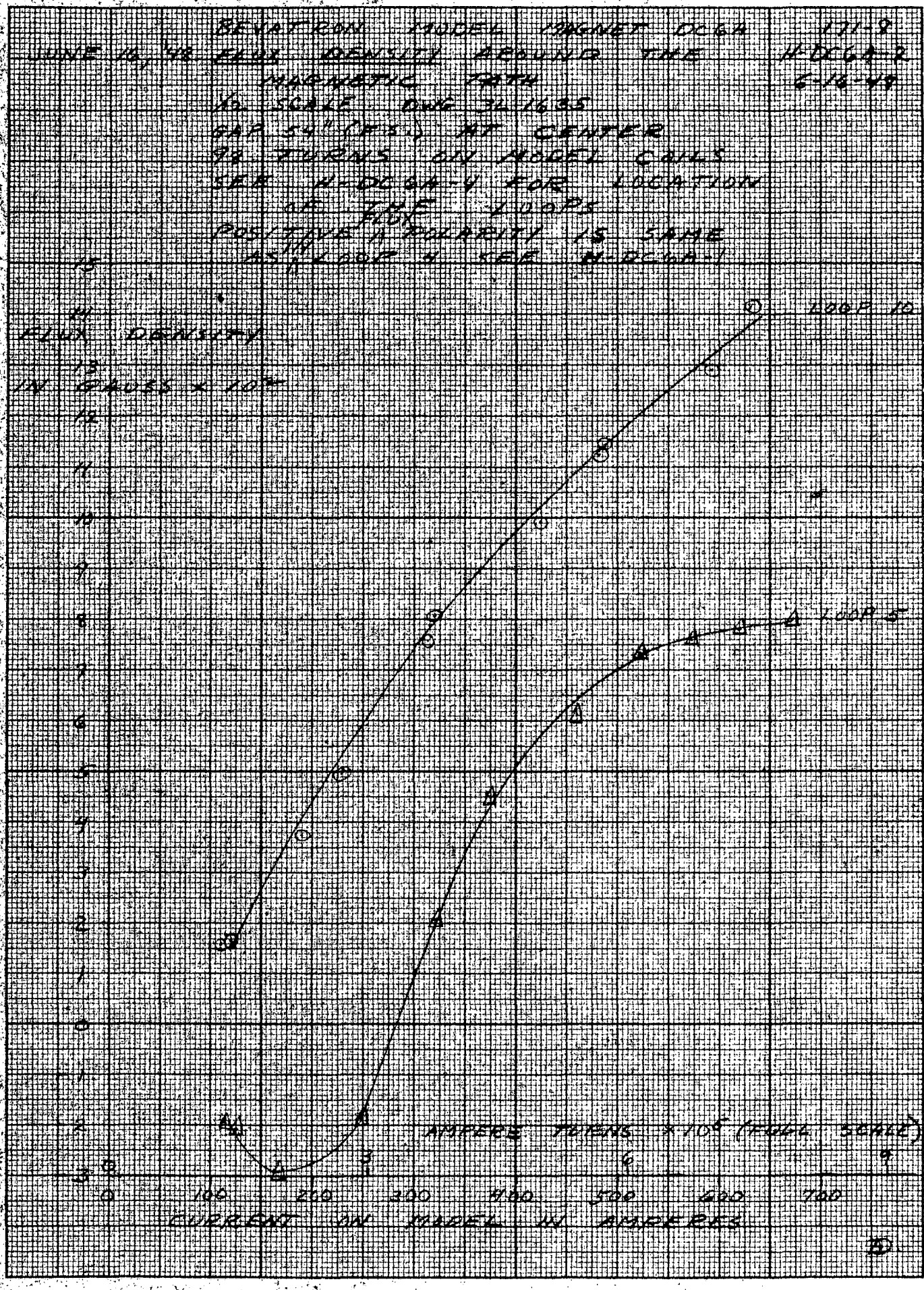
SEE H-DCCA-4 FOR LOOP LOCATIONS



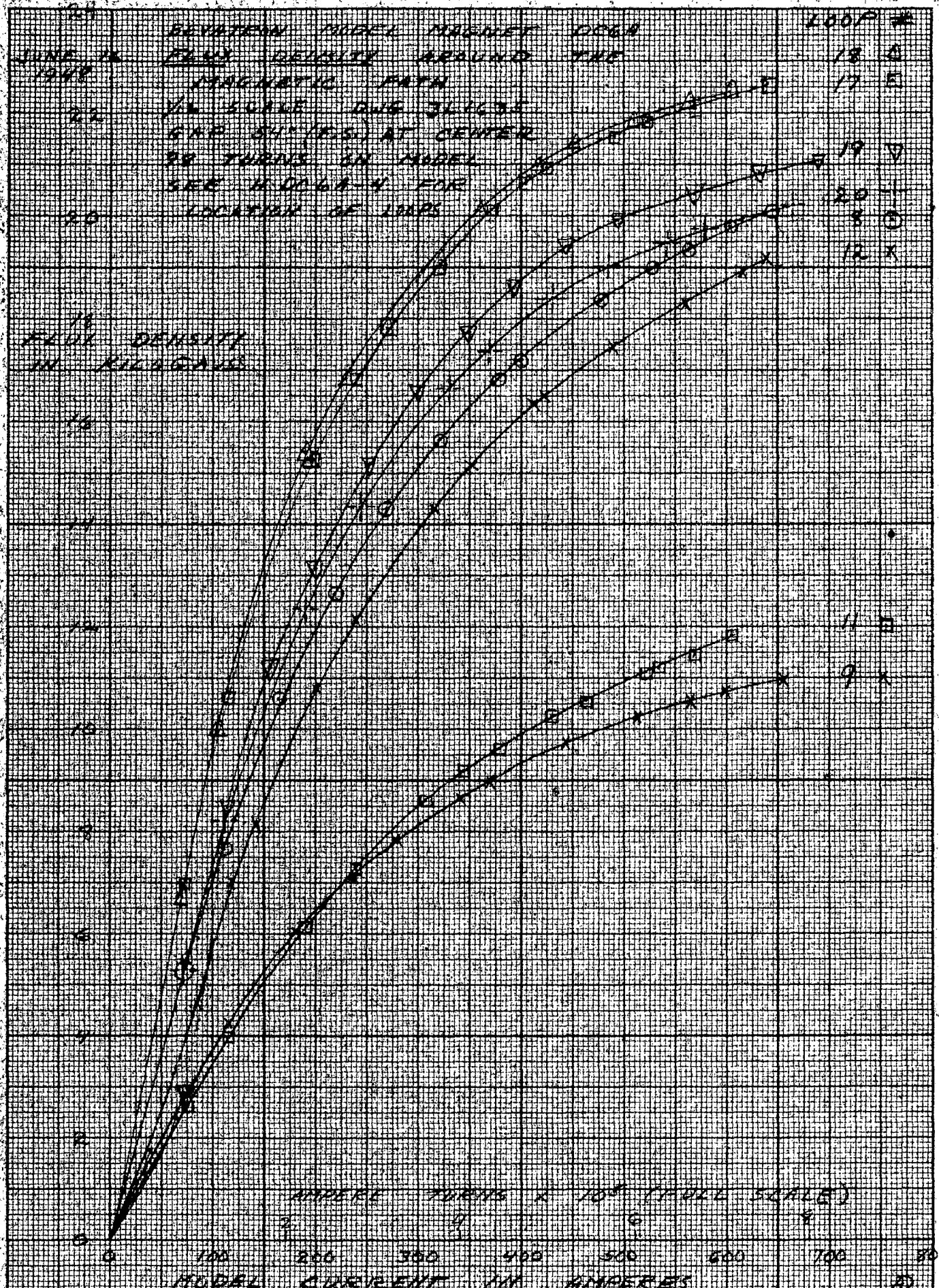
D

171-8
H-DC6A-1
6-16-48





171-8
H-DC6A-3
6-16-48



JUNE 16, 1948

BEVATRON MODEL MAGNET DC6A
FLUX DENSITY AROUND THE MAGNETIC PATH

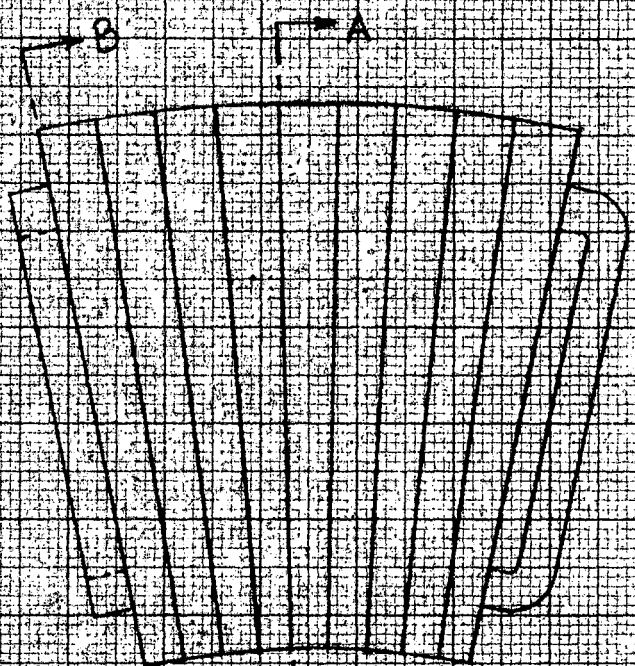
1/12 SCALE DWG 3L1635

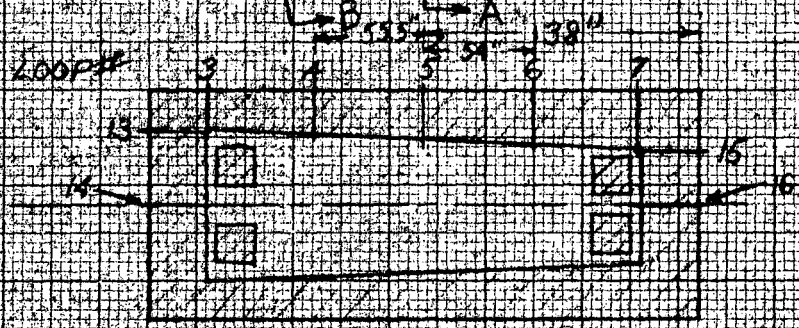
GAP 54" (F 5) AT CENTER

LOCATION OF FLUX LOOPS

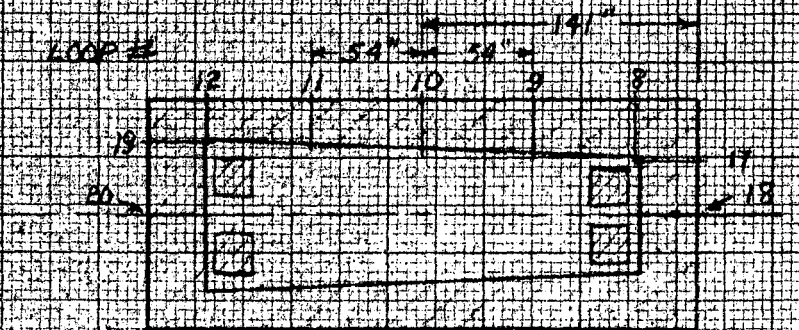
SEE GRAPHS H-DC6A-1
H-DC6A-2
H-DC6A-3

17-8
H-DC6A-4
6-16-48

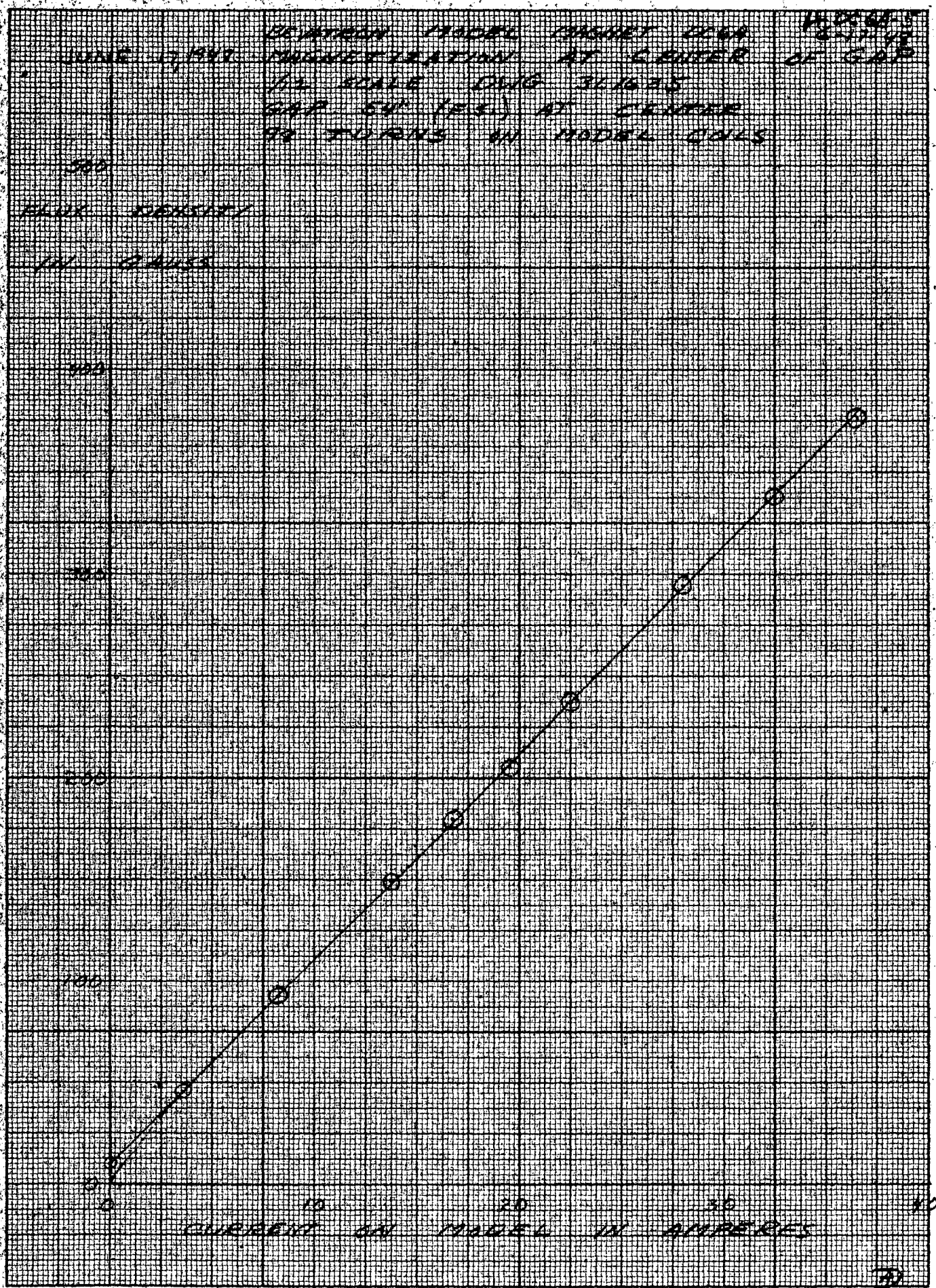




CROSS SECTION AT AA



CROSS SECTION AT BB



BEVATRON MODEL MAGNET DC64 171-8

JUNE 11, 1948 COIL FLUX LINKAGE F-DC6A-1

½" SCALE DWG 3X163F 6-14-48

GAP 54 INCHES (FULL SCALE)

MODEL COILS : 2 COILS 42 TURNS

EACH = 21 TURNS TOTAL

EACH LOOP HAS 7 TURNS

FLUX LINKAGE IS ON 7.43° SECTION OF MODEL

LOOP 1 ⊙

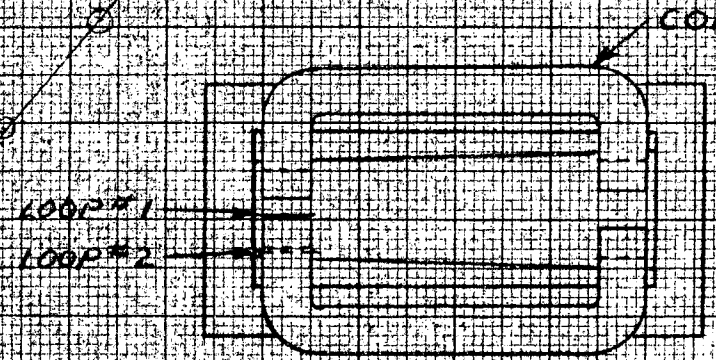
LOOP 2 ×

FLUX LINKAGE IN MAXWELL TURNS × 10^6

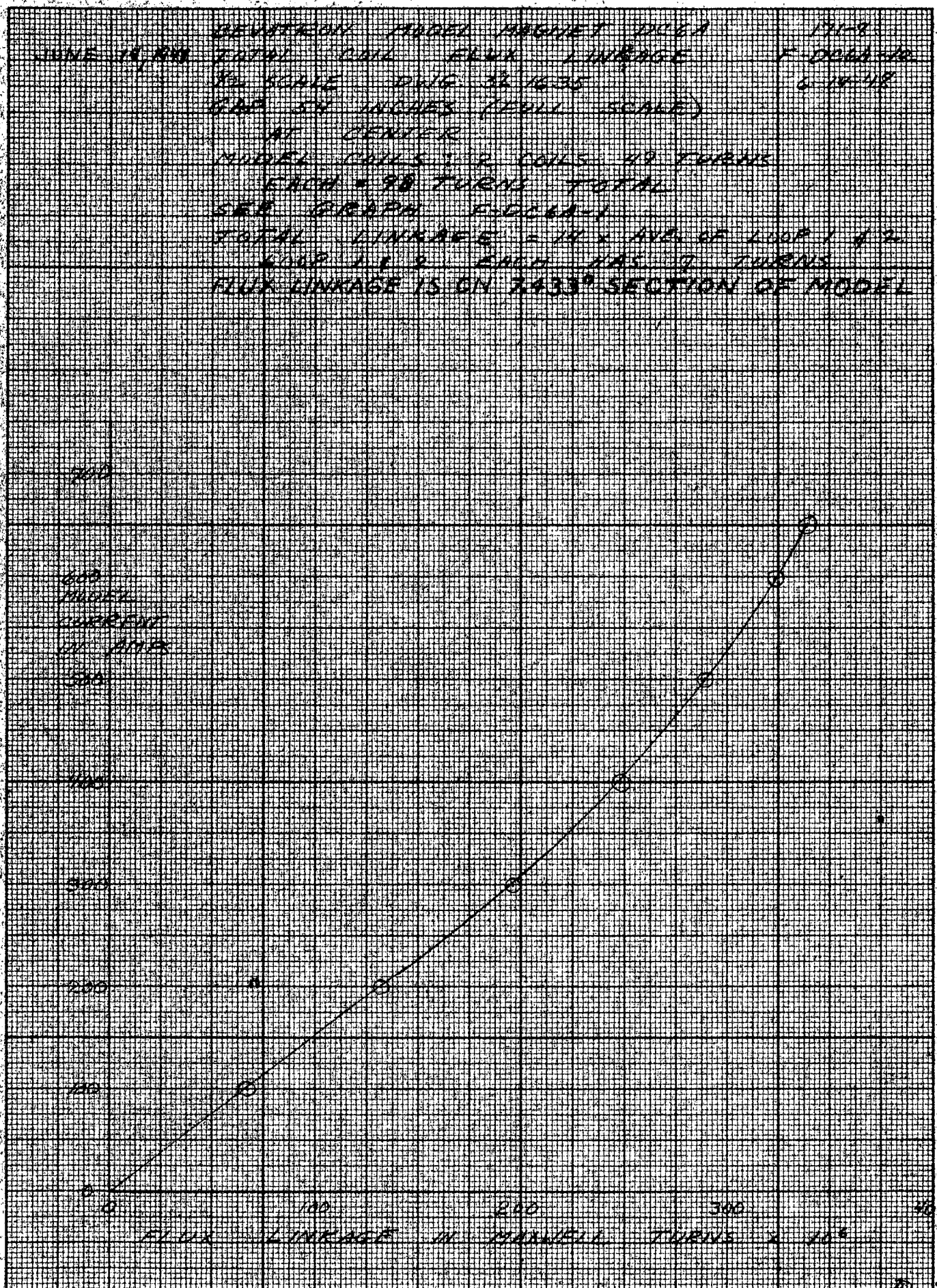
0 4 8 12 16 20 24

0 100 200 300 400 500 600

MODEL CURRENT IN AMPERES



KEUFFEL & ESSER CO., N. Y. NO. 358-110
10 X 10 to the ½ inch 5th line accented
Engraving 7 X 10 in.
MADE IN U.S.A.



JULY 14, 1948

CYCLOTRON MODEL MAGNET DC6A — 171-8

1/12 SCALE - DWG SL1635 — E-DC6A-1

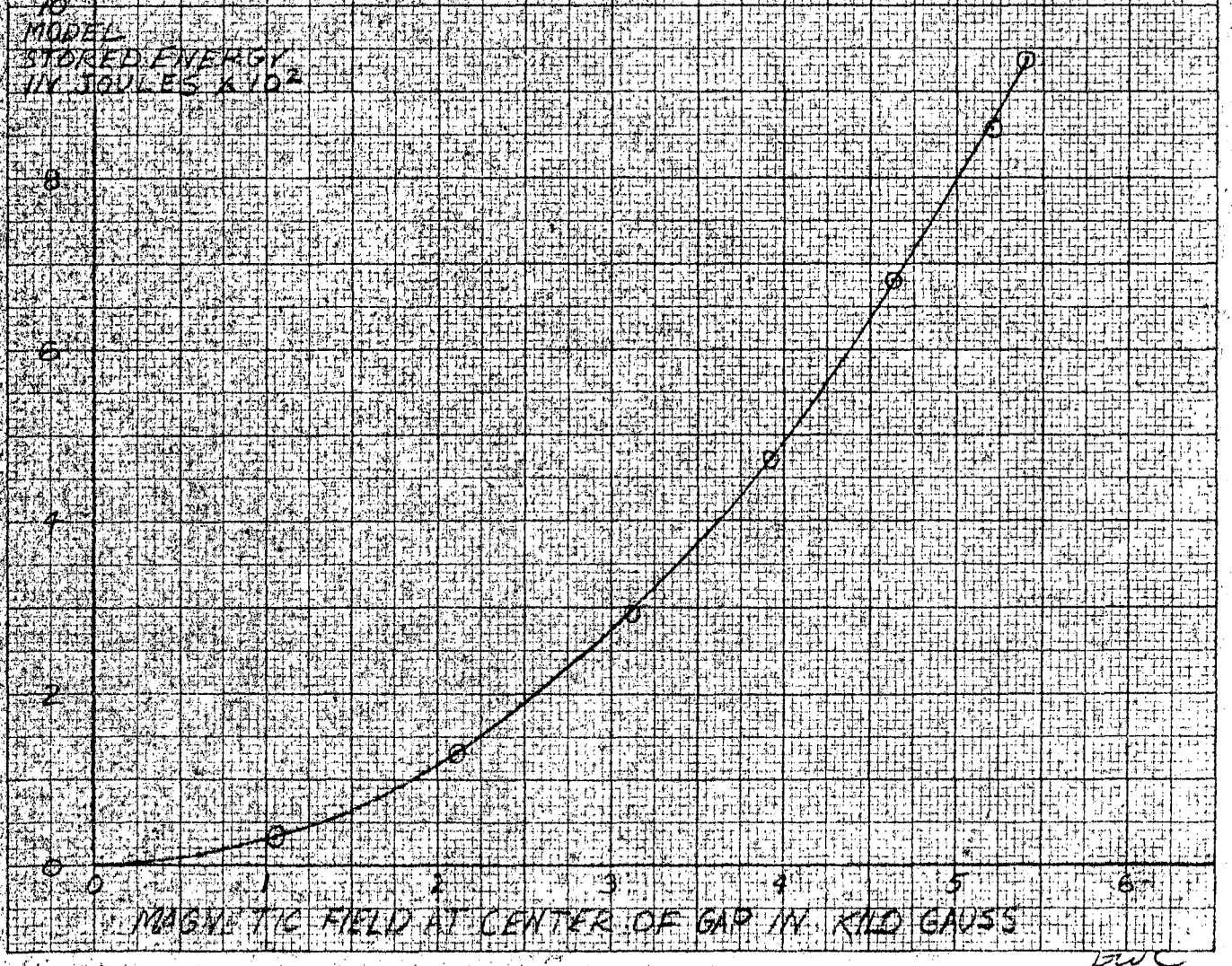
STORED ENERGY ON MODEL — 7-14-48

CALCULATED FROM TOTAL COIL FLUX LINKAGE F-DC6A-1 — CORRECTED

ENERGY (JOULES) = $10^{-8} \int^{\Phi} I \, d\Phi$

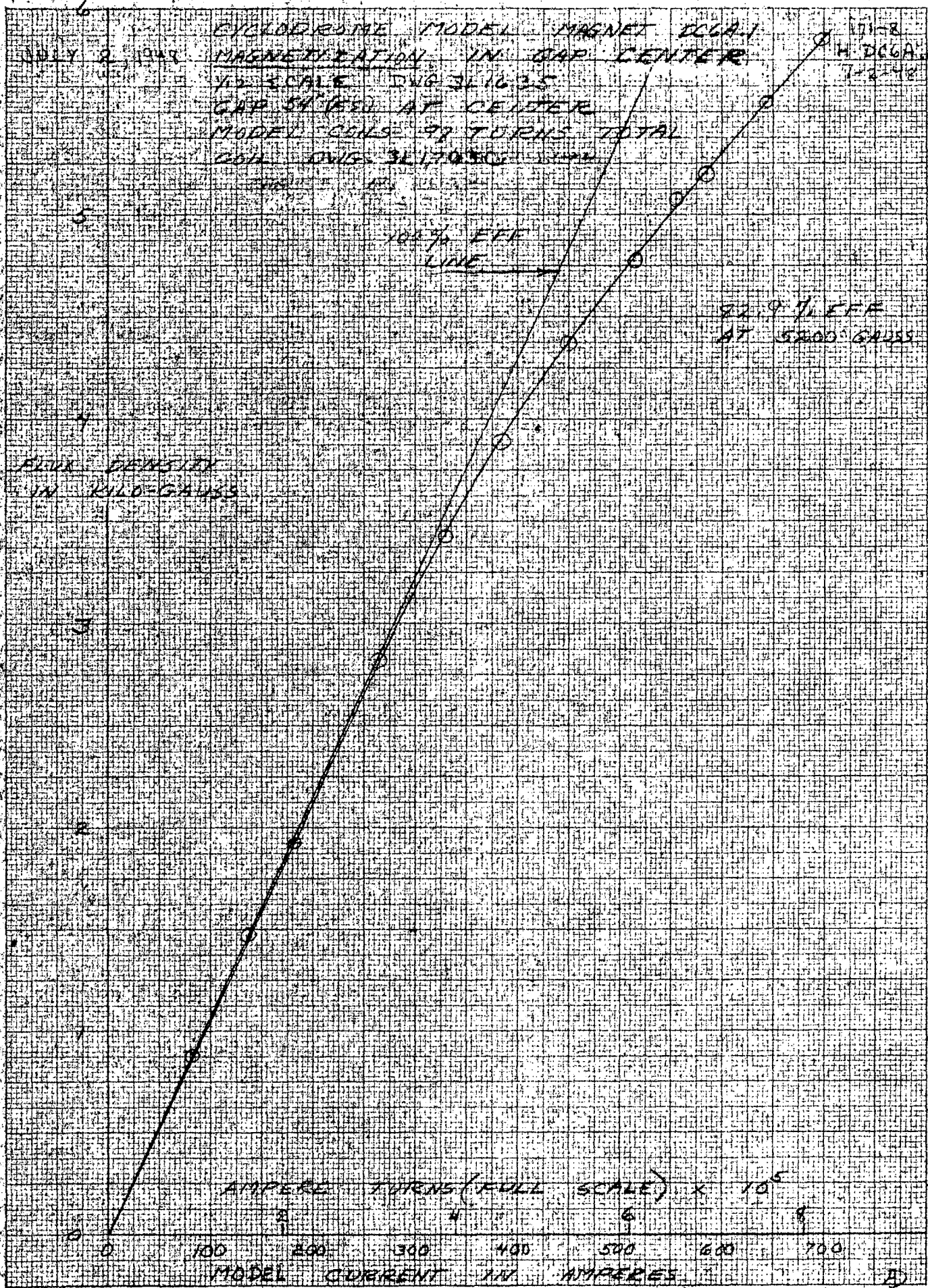
WHERE I IS IN AMPERES AND Φ IS IN MAXWELL TURNS

DATA IS FOR A 7.43° SECTION ON MODEL



KEUFFEL & ESSER CO., N. Y. No. 359-11C
10 X 10 to the inch, 5th liner accented
Engraving 7 X 10 in.
MADE IN U.S.A.

EWC


CYCLOTRON MODEL MAGNET DC6A1
MAGNETIZATION IN GAP CENTER
½ SCALE DWG 3L 1635
GAP 54" AT CENTER
MODEL COILS 78 TURNS TOTAL
COIL CWG 3L 17035
JULY 2, 1942
H DC6A1-1
7-2-42
104% EFF LINE
22.9% EFF AT 5200 GAUSS
FLUX DENSITY IN KILO-GAUSS
AMPERE TURNS (FULL SCALE) X 10⁵
MODEL CURRENT IN AMPERES
0
100
200
300
400
500
600
700
1
2
3
4
5
6
7
8

JULY 8, 1948

CYCLOTRON MODEL MAGNET DC6A1

LARGE UNIFORMITY

½ SCALE DWG 3L/635

GAP 5" AT CENTER (E.3.)

COIL DWG 3L/703C

MEASUREMENTS TAKEN ON MEDIAN PLANE OF GAP

171-8

4-DC6A1-1

7-8-48

100% = 5300 GAUSS

PERCENT MAGNETIC FIELD

110
100
90
80
70
60
50
40
30
20
10
0

GAP TAPER = 0.074 INCHES PER INCH

COIL

POLE

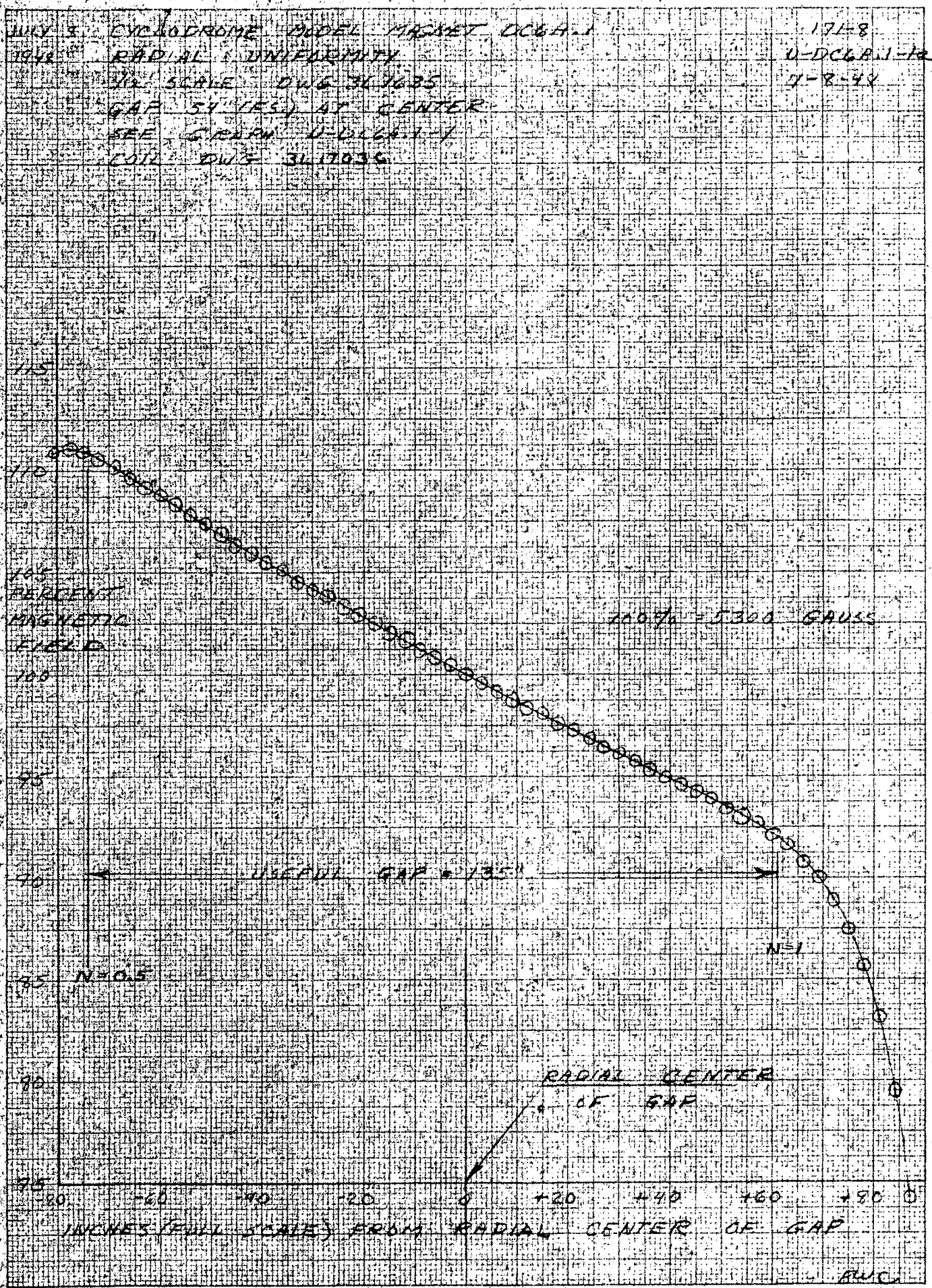
RADIAL CENTER OF GAP

COIL

-120 -90 -60 -30 0 30 60 90 120

INCHES FULL SCALE FROM RADIAL CENTER

DUC


JULY 3 CYCLOTRON MODEL MAGNET DC6A-1
1942 RADIAL UNIFORMITY
1/2" SCALE DWG 34-1625
GAP 5" (ES.) AT CENTER
SEE SHEAR U-DC6A-1-1
COIL DWG 34-17036
17-8
U-DC6A-1-12
7-8-42
PERCENT MAGNETIC FIELD
115
110
105
100
95
90
85
80
75
100% = 5300 GAUSS
USEFUL GAP = 13"
N=1
N=0.5
-80
-60
-40
-20
0
+20
+40
+60
+80
INCHES (FULL SCALE) FROM RADIAL CENTER OF GAP
RADIAL CENTER OF GAP
AWC

171-8
F-DC6A.1-1

11-7-48

CYCLOTRON MODEL MAGNET DC6A.1

COIL FLUX LINKAGE

½" SCALE DWG 32/635

GAP 54" (FULL SCALE) AT CENTER

MODEL COILS: 2 COILS 49 TURNS EACH. 98 TURNS TOTAL

EACH LOOP HAS 7 TURNS

FLUX LINKAGE IS ON 7.433" SECTION OF MODEL

COIL DWG 32/703C

LOOP # 1 ⊙

LOOP # 2 △

FLUX LINKAGE IN MAXWELL TURNS X 10⁶

24

20

16

12

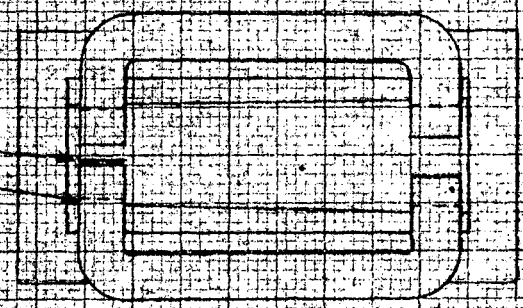
8

4

0

0 100 200 300 400 500 600

MODEL CURRENT IN AMPERES



JULY 8, 48 CYCLOTRON MODEL MAGNET DC6A.1 171-8

TOTAL COIL FLUX LINKAGE F-DC6A.1-1a

1/12 SCALE DWG 3L1635 7-8-48

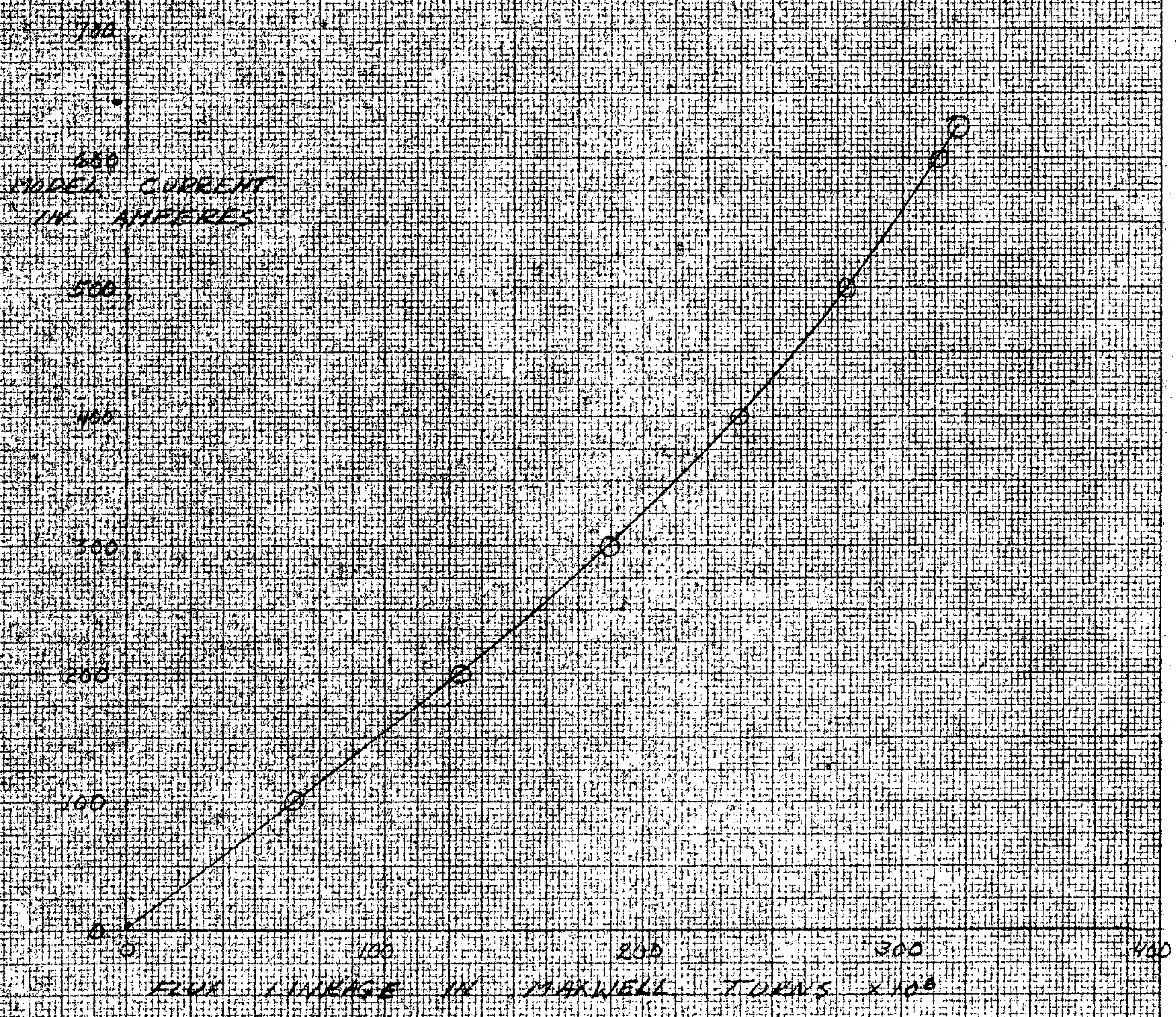
GAP 54" (FULL SCALE) AT CENTER

MODEL COILS - 2 COILS 49 TURNS EACH = 98 TURNS TOTAL

SEE GRAPH F-DC6A.1-1

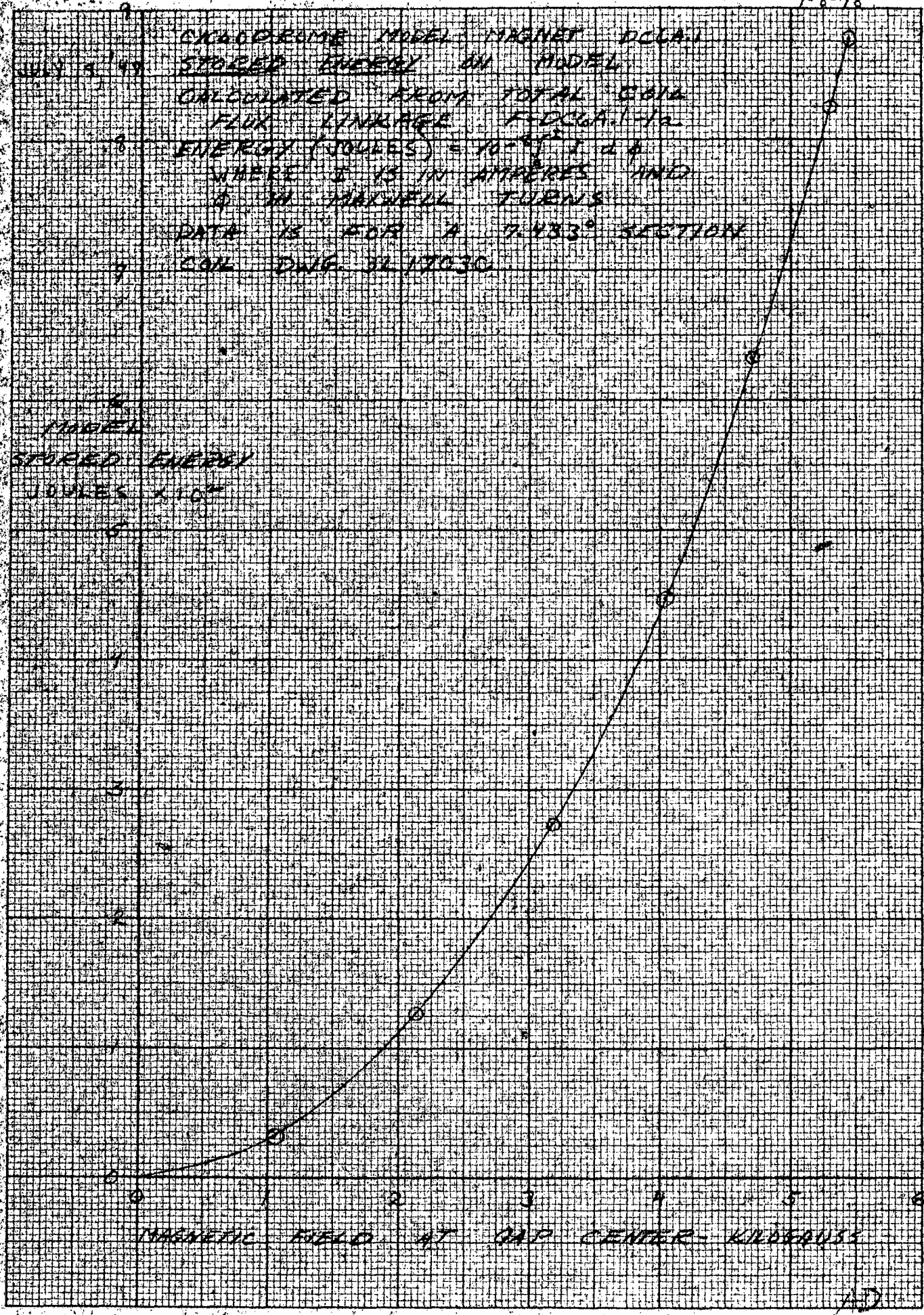
FLUX LINKAGE IS ON 7.433° SECTION OF MODEL

COIL DWG 3L1703C

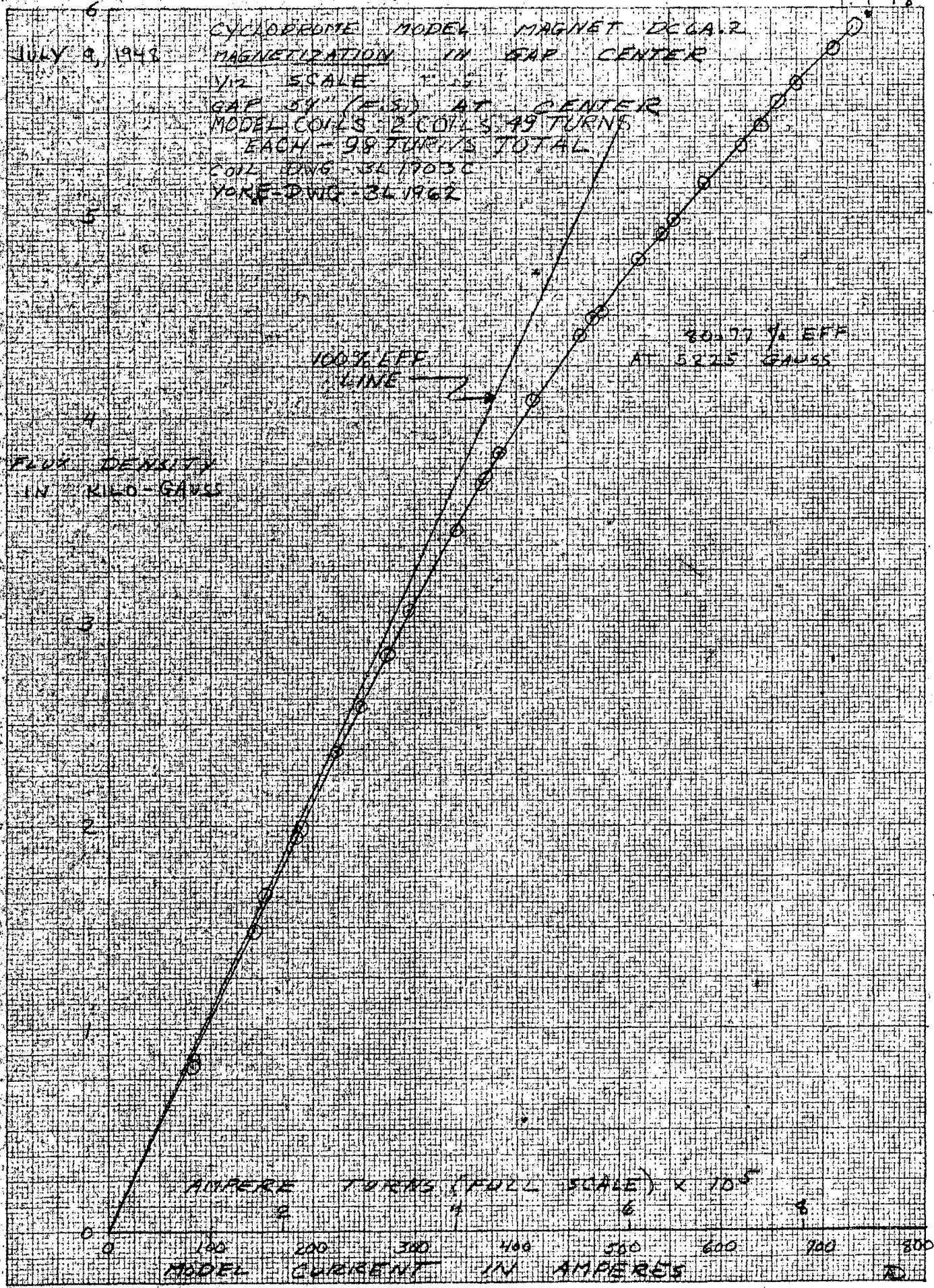


EWC

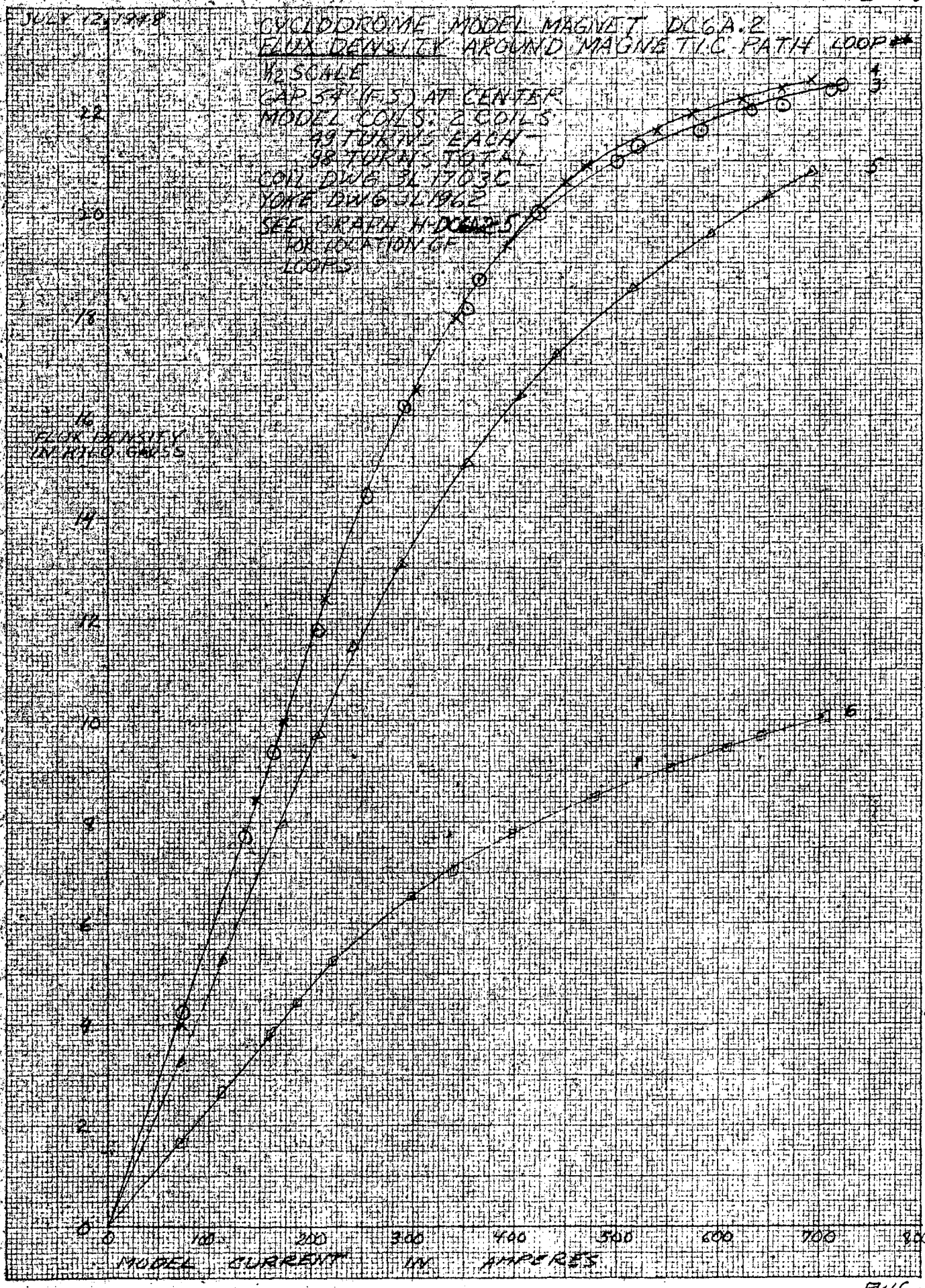
171-8
E-DC6A.1-1
7-8-48



171-8
H-DC6A.2.-1
7-9-48



171-8
H-DC6A.2-2
7-12-48



EWC

JULY 12, 1948

CYCLOTRON MODEL MAGNET DC6A.2

FLUX DENSITY AROUND MAGNETIC PATH

H-DC6A.2-3

7-12-48

1/2 SCALE

400 P #

GAP 5/8" (E-S) AT CENTER

MODEL COILS: 2 COILS 49 TURNS EACH

98 TURNS TOTAL

COIL DWG 3L17036

YOKE DWG 3L1962

SEE GRAPH H-DC6A.2-5

FOR LOCATION OF

LOOPS

10

11

9

8

FLUX DENSITY

IN KILO GAUSS

MODEL CURRENT IN AMPERES

0 100 200 300 400 500 600 700 800

0 2 4 6 8 10 12 14 16 18 20 22 24

E.O.L.

171-8

H-DC6A.2-4

7-12-48

JULY 12, 1948

CYCLODROME MODEL MAGNET DC6A.2
FLUX DENSITY AROUND MAGNETIC PATH

1/2 SCALE

GAP 58" (F.S.) AT CENTER

MODEL COILS: 2 COILS 49 TURNS

98 TURNS TOTAL

COIL DWG 3L VP03C

YOKE DWG 3L 7962

SEE GRAPH H-DC6A.2-5

FOR LOCATION OF LOOP

POSITIVE FLUX FOLLOWS IT IS IN SAME DIRECTION AS LOOP #8 - SEE GRAPH H-DC6A.2-3

LOOP #7

FLUX DENSITY IN KILO GAUSS

20

15

10

.05

0 100 200 300 400 500 600 700 800

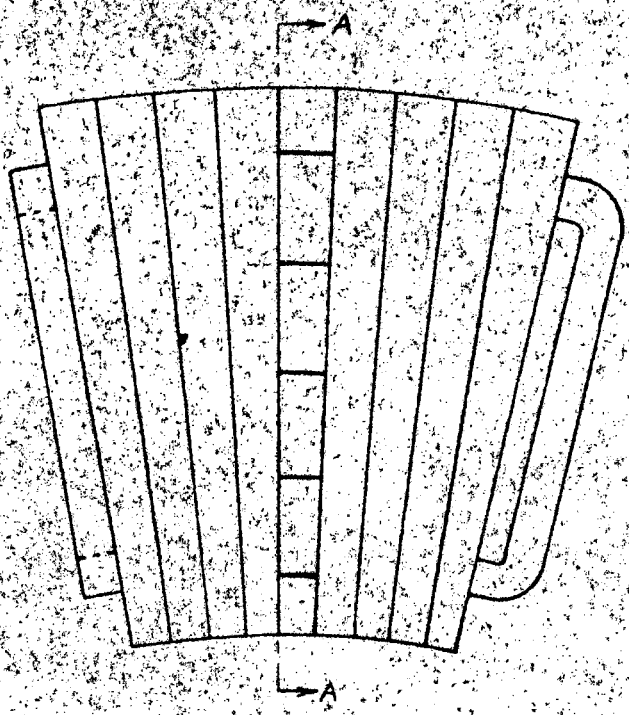
MODEL CURRENT IN AMPERES

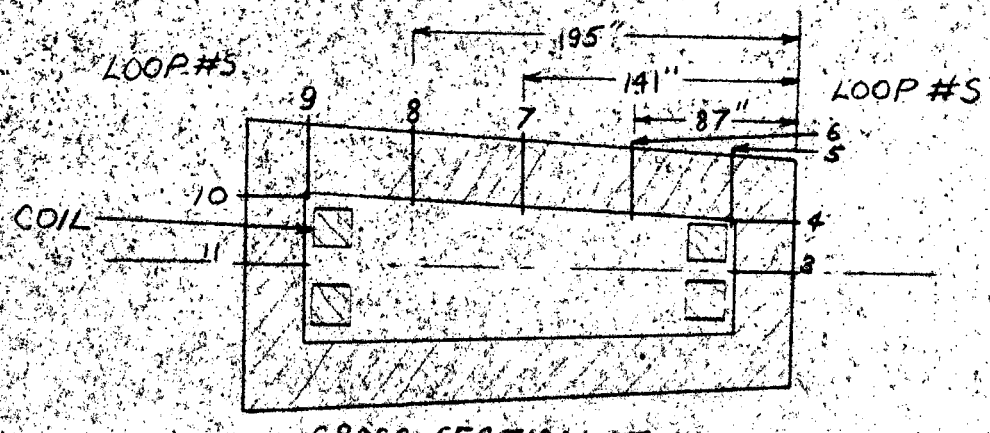
DWC

JULY 12, 1948

171-8
H-DC6A.2-5
7-12-48

CYCLODROME MODEL MAGNET DC6A:2
FLUX DENSITY AROUND MAGNETIC PATH
1/2 SCALE
GAP .54" (F.S.) AT CENTER
LOCATION OF FLUX LOOPS
SEE GRAPHS H-DC6A.2-2
H-DC6A.2-3
H-DC6A.2-4





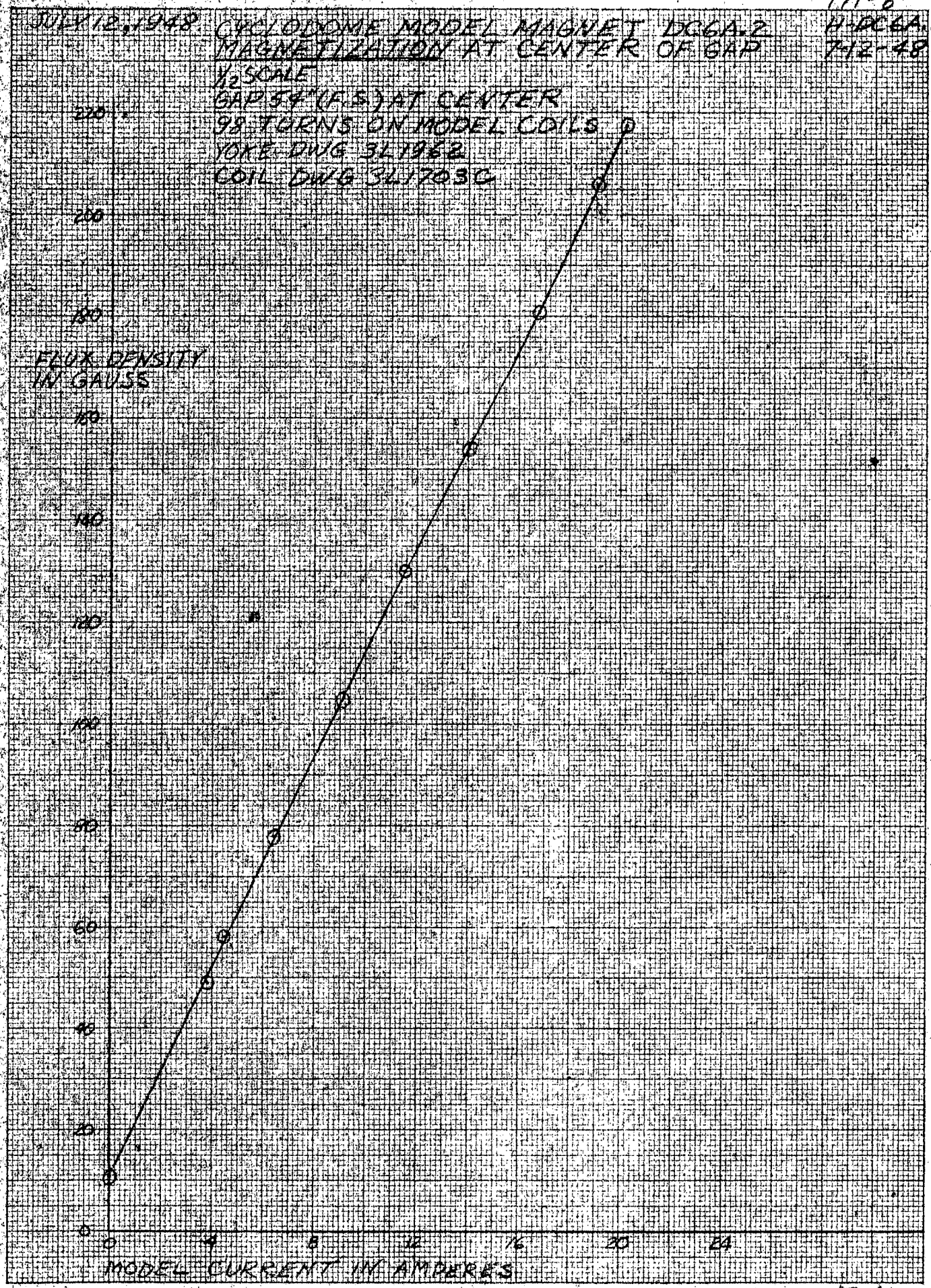
CROSS SECTION AT AA

PWC

171-8

JULY 12, 1948 CYCLOTRON MODEL MAGNET DC6A.2 W-DC6A.2-6
MAGNETIZATION AT CENTER OF GAP 7-12-48

½ SCALE
GAP 5¼" (F.S.) AT CENTER
98 TURNS ON MODEL COILS
YOKE DWG 3L1962
COIL DWG 3L1703C



EWC

JULY 13, 1948 CYCLOTRON MODEL MAGNET DC6A.2 17-8
RADIAL UNIFORMITY U-DC6A.2-
½ SCALE DWG 34 1635 7-13-48
GAP 5⅝" AT CENTER (F.S.)
MODEL COIL 5 92 TURNS TOTAL
COIL DWG 34170SC
YOKE DWG 34186Z
MEASUREMENTS
TAKEN ALONG
MEDIAN PLANE
OF GAP

○ 100% = 196 GAUSS
× 100% = 5225 GAUSS

PERCENT MAGNETIC FIELD

110
100
90
80
70
60
50
40
30
20
10
0

GAP TAPER = 0.0734 INCHES PER INCH

COIL

RADIAL CENTER OF GAP

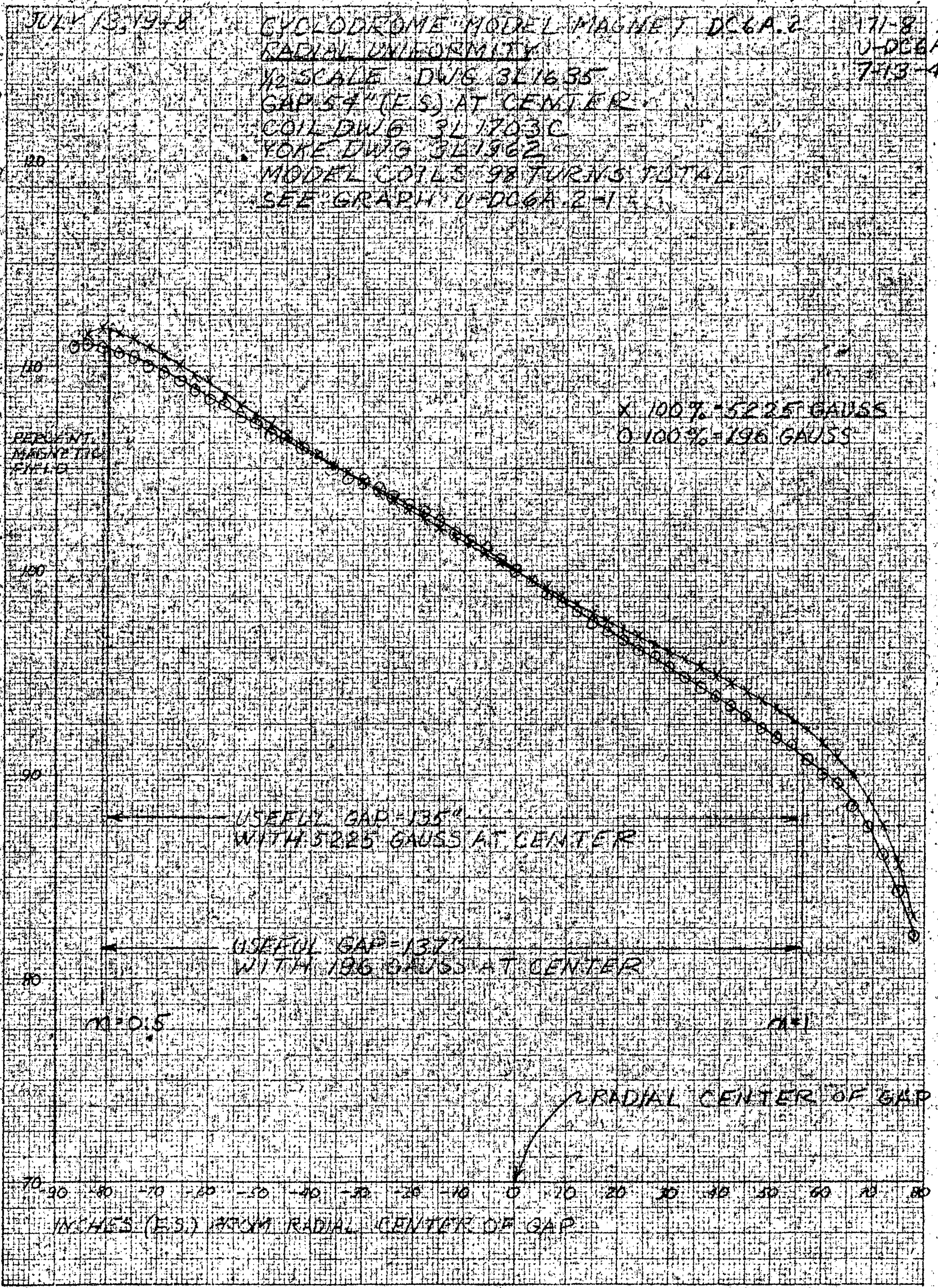
-120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120

INCHES (F.S.) FROM RADIAL CENTER OF GAP

EWC

KEUFFEL & ESSER CO., N. Y. NO. 359-146
Millimeters, 5 mm lines accented, cm figures every 5 cm
MADE IN U.S.A.

146


JULY 13, 1948
CYCLODROME MODEL MAGNET DC6A.2
RADIAL UNIFORMITY
½ SCALE DWG 3L1635
GAP 54" (F.S.) AT CENTER
COIL DWG 3L1703C
YOKE DWG 3L1962
MODEL COILS 98 TURNS TOTAL
SEE GRAPH U-DC6A.2-1
171-8
U-DC6A.2-1a
7-13-48
PERCENT MAGNETIC FIELD
X 100% = 5225 GAUSS
O 100% = 196 GAUSS
USEFUL GAP = 135"
WITH 5225 GAUSS AT CENTER
USEFUL GAP = 137"
WITH 196 GAUSS AT CENTER
n = 0.5
n = 1
RADIAL CENTER OF GAP
70
80
90
100
110
120
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80
INCHES (F.S.) FROM RADIAL CENTER OF GAP

FWC

CYCLODRONE MODEL MAGNET DCL4.3 17-8

JULY 23 H IN GAP CENTER H-DCL4.3-1

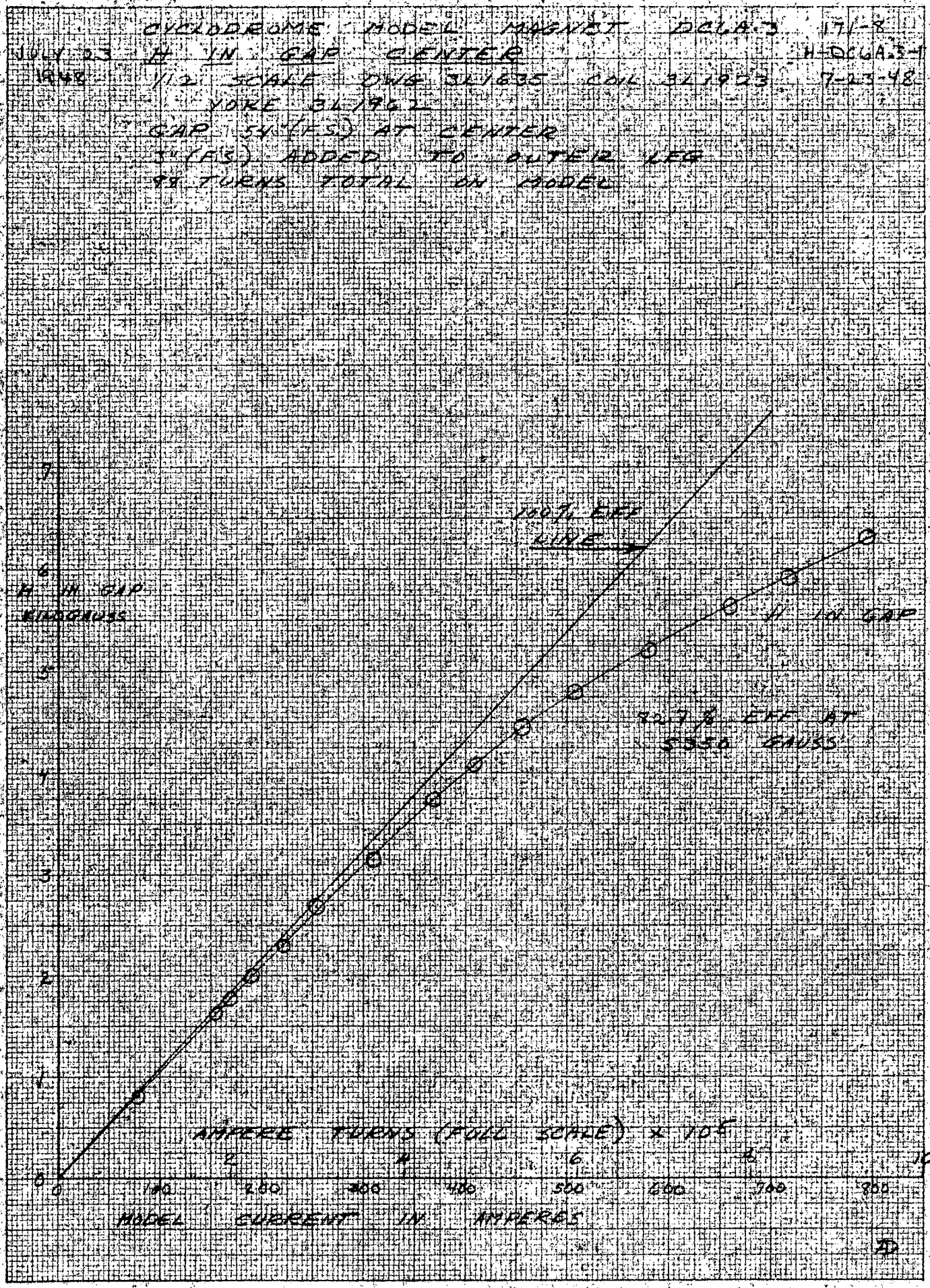
1948 1/2 SCALE DWG 34/1635 COIL 34/1923 7-23-48

YOKE 34/1962

GAP 3/4" (F.S.) AT CENTER

3/4" (F.S.) ADDED TO OUTER 12 LEG

88 TURNS TOTAL ON MODEL



JULY 23, 1998 CYCLOTRON MODEL MAGNET DC6A.3 171-8
MAGNETIZATION IN GAP CENTER M-DC6A.3-2
1/2 SCALE DWG 3L16835 F-23-98
COIL DWG 3L19213
YOKE DWG 3L19612
GAP 3" AT CENTER
MODEL COILS - 98 TURNS TOTAL
3" (F.S.) ADDED TO OUTER LEG SLAB

160
140
120
100
80
60
40
20
0

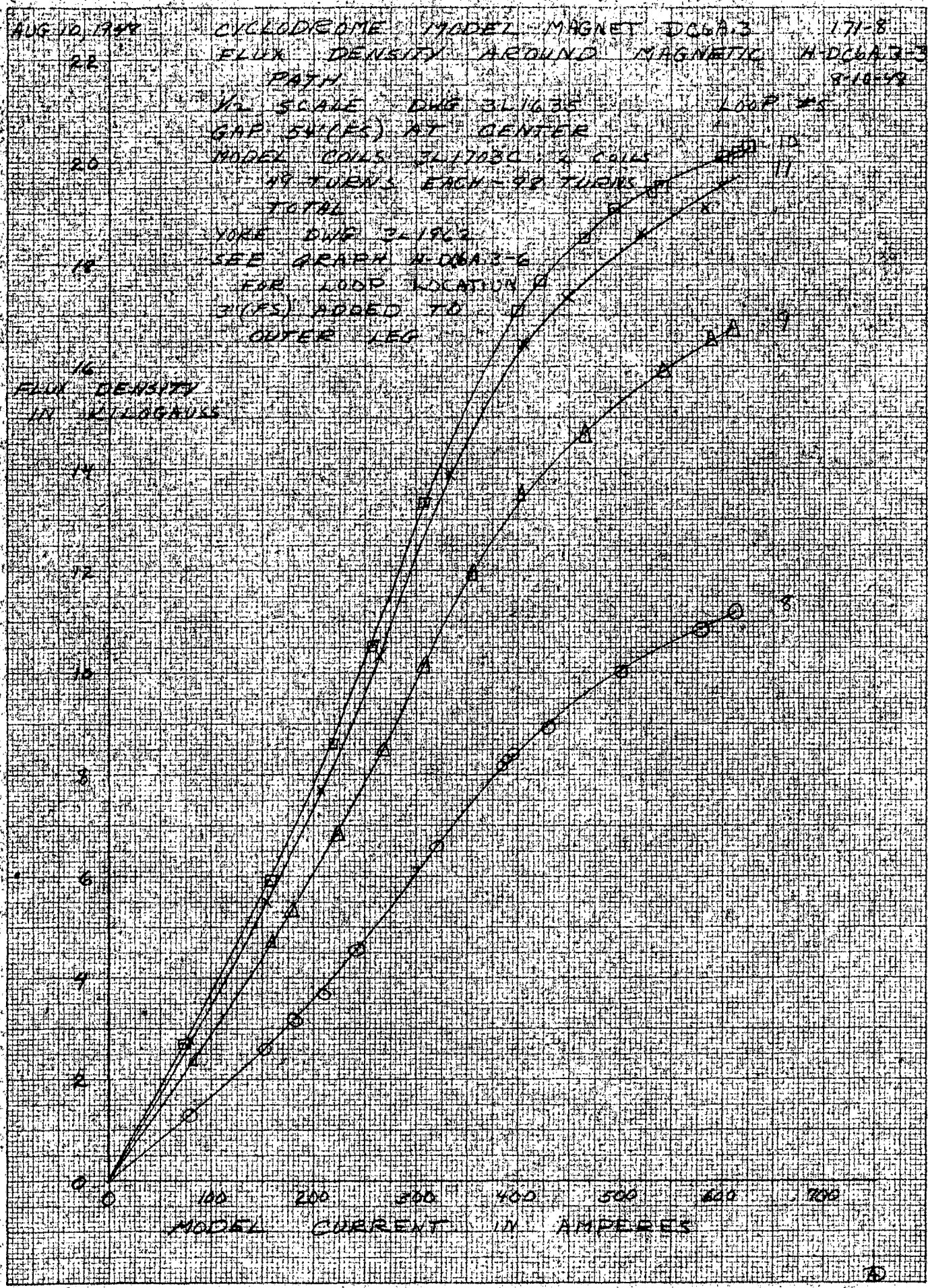
FLUX DENSITY IN GAUSS

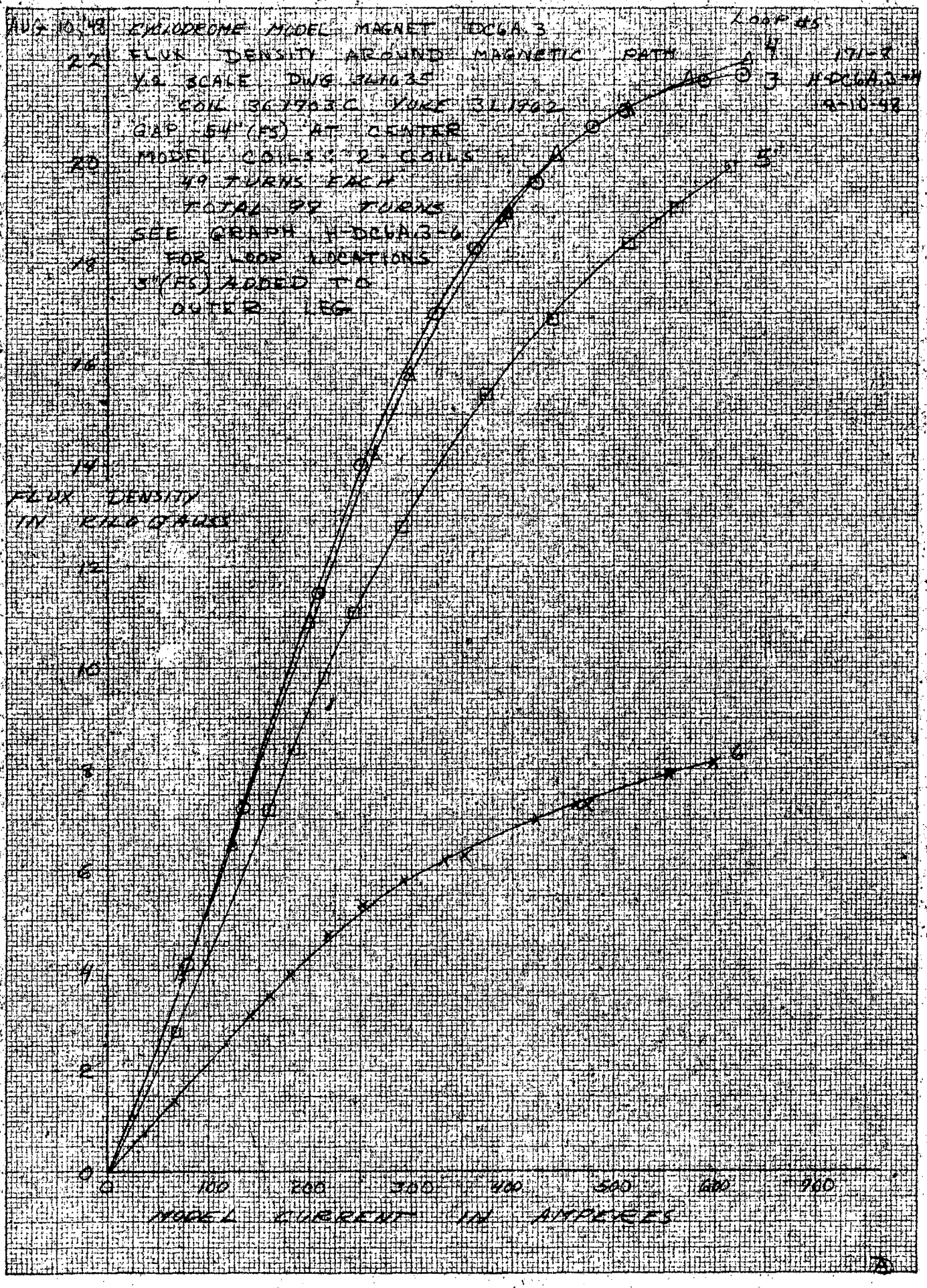
0 2 4 6 8 10 12 14

MODEL CURRENT IN AMPERES

EUCL

KEUFFEL & ESSER CO., N. Y. NO. 359T-12a
10 X 10 to the ¼ inch. 5th lines accented.
Engraving 7½ X 10 in.
MADE IN U.S.A.


AUG 10 1948
CYCLOTRON MODEL MAGNET DC6A.3
FLUX DENSITY AROUND MAGNETIC PATH
H-DC6A.3-3
8-10-48
1/2 SCALE DWG 3L1635
GAP 5" (ES) AT CENTER
LOOP #5
MODEL COILS 3L1708C - 2 COILS
48 TURNS EACH = 96 TURNS TOTAL
YOKE DWG 3L1962
SEE DRAWING H-DC6A.3-6 FOR LOOP LOCATION
3 (ES) MOVED TO OUTER LEG
FLUX DENSITY IN KILOGAUSS
MODEL CURRENT IN AMPERES
0
2
4
6
8
10
12
14
16
18
20
22
100
200
300
400
500
600
700


AUG 10, 49 EMMODROME MODEL MAGNET DC6A.3
FLUX DENSITY AROUND MAGNETIC PATH
V.S. SCALE DWG 3L1763S
COIL 3L1763C YOKE 3L1762
GAP .64" (FS) AT CENTER
MODEL COILS: 2 COILS
49 TURNS EACH
TOTAL 98 TURNS
SEE GRAPH Y-DC6A.3-6
FOR LOOP LOCATIONS
3" (FS) ADDED TO
OUTER LEG
Loop #5
#DC6A.3-4
9-10-49
FLUX DENSITY
IN KILO GAUSS
0
2
4
6
8
10
12
14
16
18
20
22
0
100
200
300
400
500
600
700
MODEL CURRENT IN AMPERES
A
B
C
D
E
F
G
H
J
K

171-8

H-DC6A3-5
8-10-45

AUG 10, '49 CYCLODROME MODEL MAGNET DC6A-3
FLUX DENSITY AROUND MAGNETIC PATH

LOOP #7

1/2 SCALE 3L635
GAP 5¼" (FS) AT CENTER
MODEL COILS DWG 3L1703C
2 COILS 49 TURNS EACH
98 TURNS TOTAL
YOKE DWG 3L1962
SEE GRAPH H-DC6A3-6 FOR LOOP LOCATION
3" (FS) ADDED TO OUTER LEG SLAB
POLARITY IS SAME AS LOOP #8

FLUX DENSITY IN GAUSS

2500
2000
1500
1000
500
0

0 100 200 300 400 500 600 700

MODEL CURRENT IN AMPERES

AD

AUGUST 10, 1948

CYCLODROME MODEL MAGNET DC6A.3

FLUX DENSITY AROUND MAGNETIC PATH

1/2 SCALE DWG 3L1635

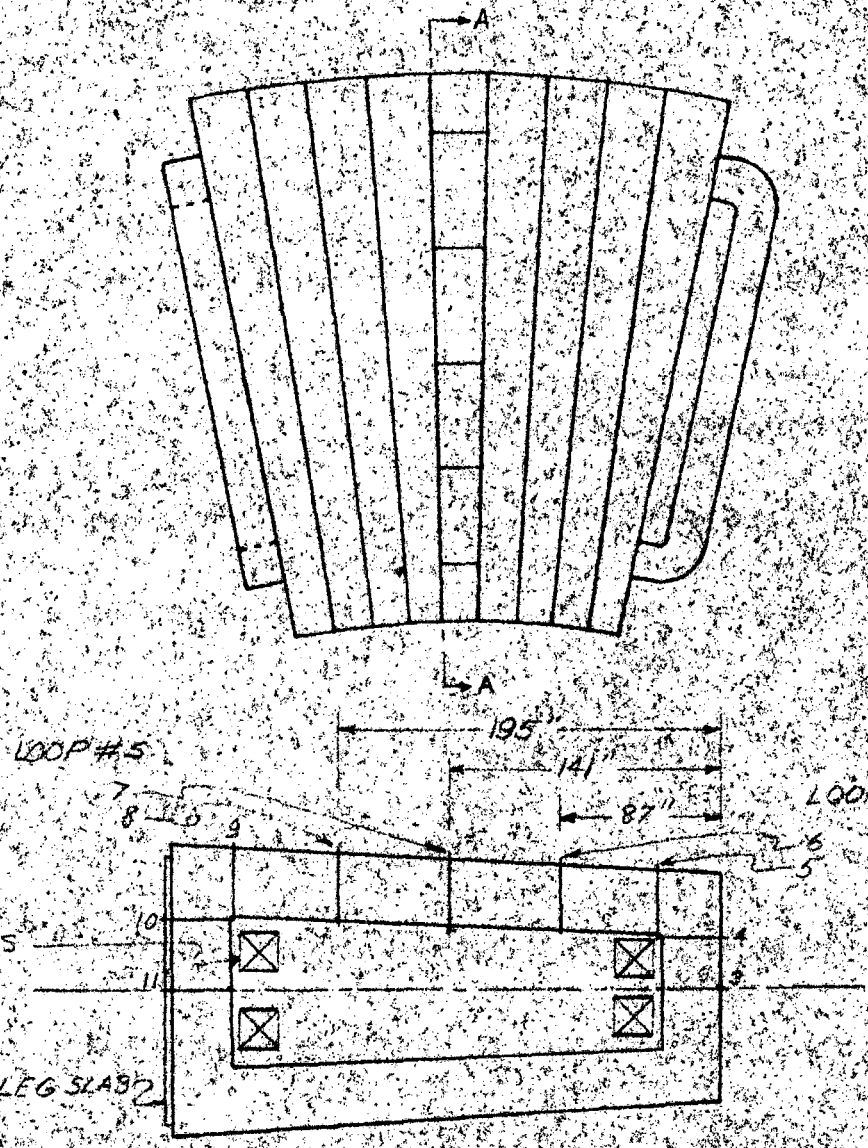
GAP 54" (F.S.) AT CENTER

YOKE DWG 3L1962

COILS DWG 3L1703C - 38 TURNS TOTAL

SEE GRAPHS H-DC6A.3-3
H-DC6A.3-4
H-DC6A.3-5

171-8
H-DC6A.3-6
8-10-48



CROSS SECTION AT AA

EWC

SEPT. 13, 1948 — BEVATRON MODEL MAGNET DC6A3 — 171-8

RADIAL UNIFORMITY — U-DC6A3-1

1/12 SCALE — DWG 34L635 — 9-13-48

COIL DWG 34L1206C — YOKE 34L1621

GAP 6" (FS) AT CENTER

MODEL COILS 98 TURNS TOTAL

MEASUREMENTS TAKEN ALONG MEDIAN PLANE OF GAP

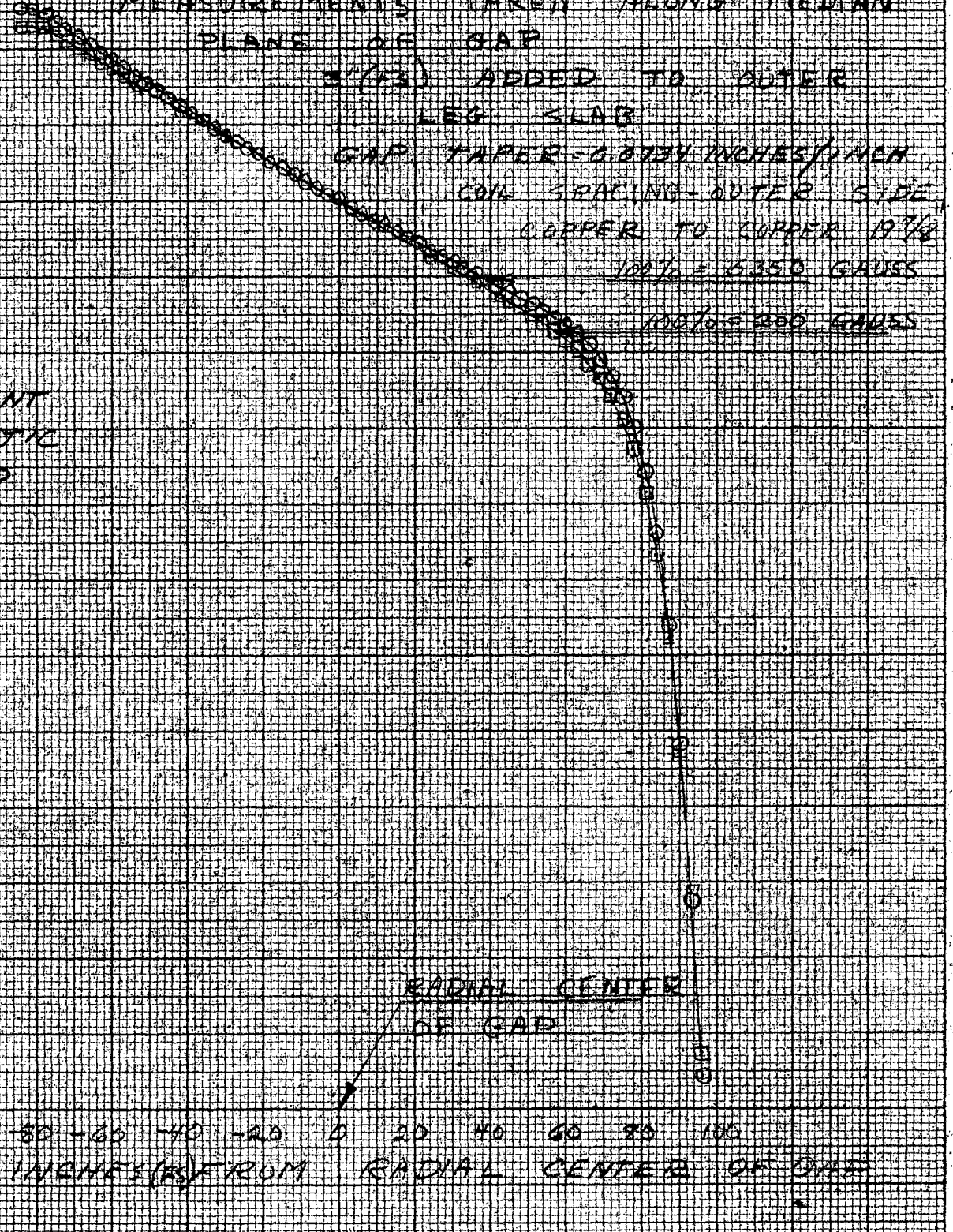
3" (FS) ADDED TO OUTER LEG SLAB

GAP TAPER = 0.0734 INCHES/INCH

COIL SPACING - OUTER SIDE COPPER TO COPPER 19 7/8"

100% = 6350 GAUSS

100% = 200 GAUSS



SEPT 13, 1943 BEVATRON MODEL MAGNET DC&A3

RADIAL UNIFORMITY

1/12 SCALE DWG 341635

COIL DWG 341703C YOKE 341962

MODEL COILS 92 TURNS TOTAL

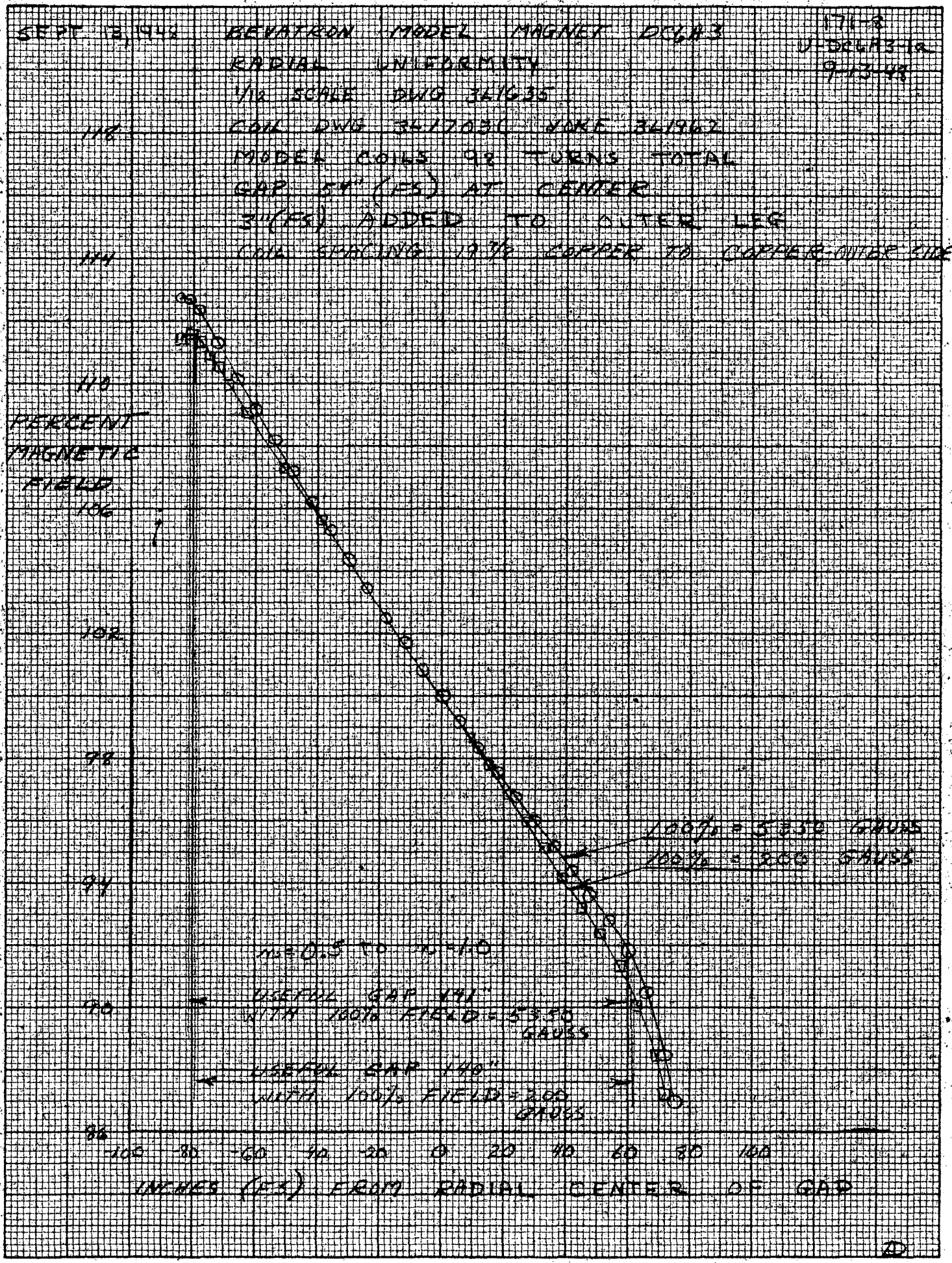
GAP .5" (FS) AT CENTER

3" (FS) ADDED TO OUTER LEG

COIL SPACING 19 1/2 COPPER TO COPPER-MIDE LINE

U-DC&A3-1a

9-13-43



KEUFFEL & ESSER CO., N. Y. NO. 3997-1SG
10 X 10 to the ⅛ inch, 6th lines accented.
Engraving 7⅞ X 10 in.
MADE IN U.S.A.

AUG 10, 48 CYCLOTRON MODEL MAGNET DC-6A.3 171-S

COIL LOOP FLUX LINKAGE F-DC-6A.3-1

1/2 SCALE DWG 3L-1625 8-10-48

GAP 54"(CS) AT CENTER

MODEL COILS: DWG 3L-1903C - 2 COILS

99 TURNS EACH - TOTAL 198 TURNS

EACH LOOP HAS 7 TURNS

FLUX LINKAGE VS AN 8423° SECTION OF MODEL

3"(FE) ADDED TO OUTER LEG SLAB

FLUX LINKAGE IN MAXWELL TURNS - $\times 10^6$

LOOP #2

LOOP #1

LOOP #1

LOOP #2

MODEL CURRENT IN AMPERES

KEUFFEL & ESSER CO., N. Y. NO. 3557-12G
10 X 10 to the ½ inch, 5th lines accented.
Forming 7¾ X 10 in.
MADE IN U.S.A.

AUGUST 10, 1948

CYCLODROME MODEL MAGNET DC6A.3

TOTAL COIL LOOP FLUX LINKAGE

1/2 SCALE DWG 3L1635

MODEL COILS DWG 3L1703C

2 COILS 49 TURNS EACH

98 TURNS TOTAL

YOKE DWG 3L1962

GAP 5" (F.S.)

FLUX LINKAGE IS ON 7.433° SECTION ON MODEL

3" (F.S.) ADDED TO OUTER LEG SLAB

SEE GRAPH FDC6A.3-1

127-9
F-DC6A.3-1a
9-10-48

MODEL CURRENT IN AMPERES

0
100
200
300
400
500
600
700

0
100
200
300

FLUX LINKAGE IN MAXWELL TURNS X 10⁶

EWC

AUGUST 10, 1948

CYCLODROME MODEL MAGNET DC6A.3

STORED ENERGY ON MODEL
CALCULATED FROM TOTAL COIL
LOOP FLUX LINKAGE
SEE GRAPH F-DC6A.3-1α

$$\text{ENERGY(JOULES)} = 10^{-1} \int_0^{\Phi} I \, d\Phi$$

WHERE I IS IN AMPERES
AND Φ IS IN MAXWELL TURNS

DATA IS FOR A 7.833° SECTION
OF MODEL

½ SCALE DWG 3L16.3-5
COIL DWG 3L17.03C
YOKE DWG 3L13K2

71-8
E-DC6A.3-1
9-10-48

MODEL STORED ENERGY IN JOULES X 10^2

MAGNETIC FIELD AT GAP CENTER IN KILOGAUSS

EWG

AUGUST 16 1948 — GENERATION MODEL MAGNET DCGA3 — 17-8

FLUX DENSITY ON YOKE — S-DCGA3-29

1/2 SCALE DWG 3L7263-1 — 8-16-48

COIL 3L7236-2 — 2 COILS 49 TURNS EACH × 98 TURNS TOTAL

GAP 3" (FS) AT CENTERS.

3 (FS) ADDED TO OUTER LEG

YOKE 3L7262

POSITIVE FLUX IS FLUX LEAVING YOKE

NEGATIVE FLUX IS FLUX ENTERING YOKE

SEE S-DCGA3-31 FOR LOOP LOCATIONS

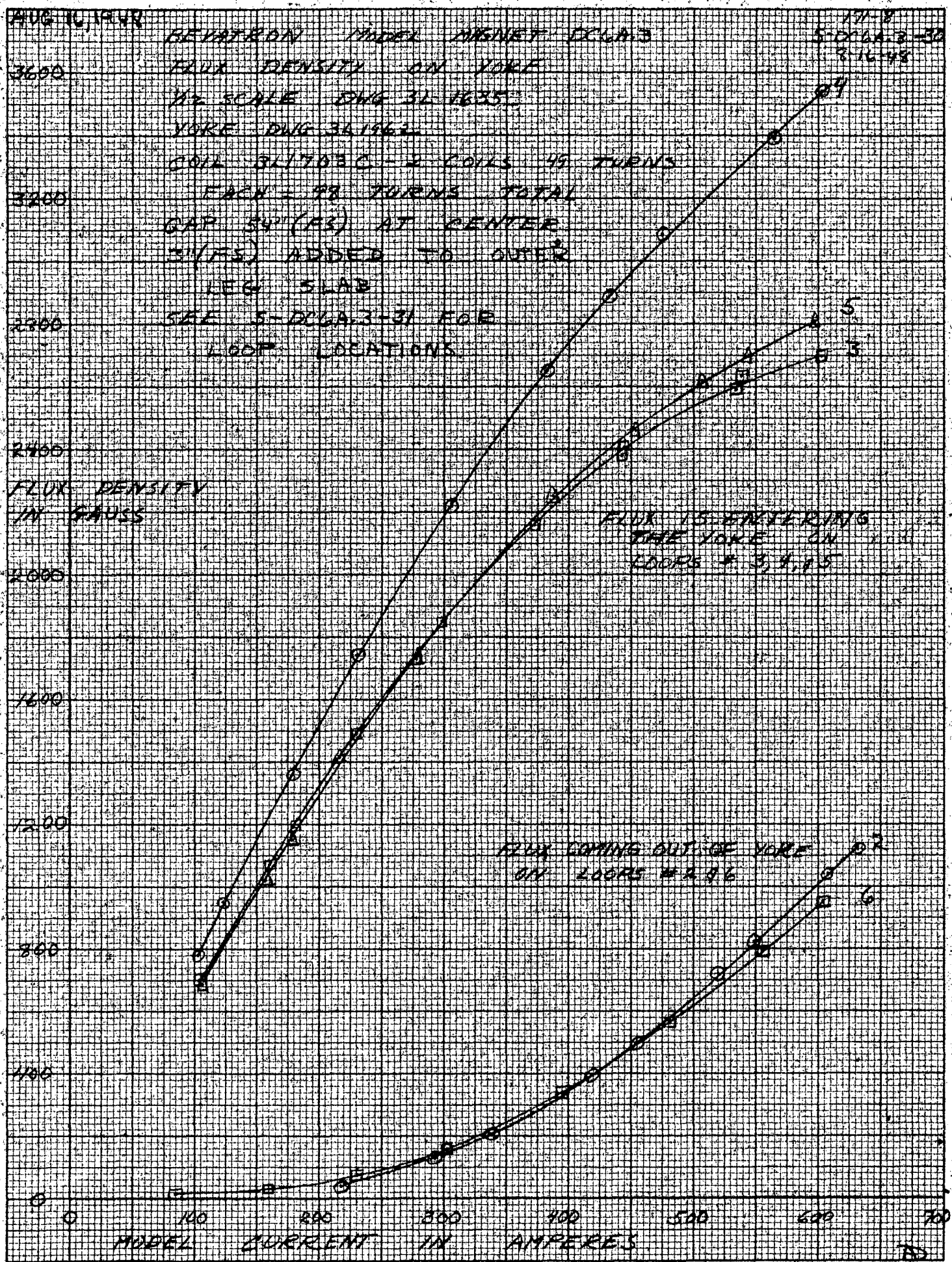
FLUX DENSITY IN GAUSS

400
300
200
100
0
-100

0 100 200 300 400 500 600 700

MODEL CURRENT IN AMPERES

KEUFFEL & ESSER CO., N. Y. No. 358-140
Millimeter, 5 inch. lines accented, cm. lines heavy
MADE IN U.S.A.



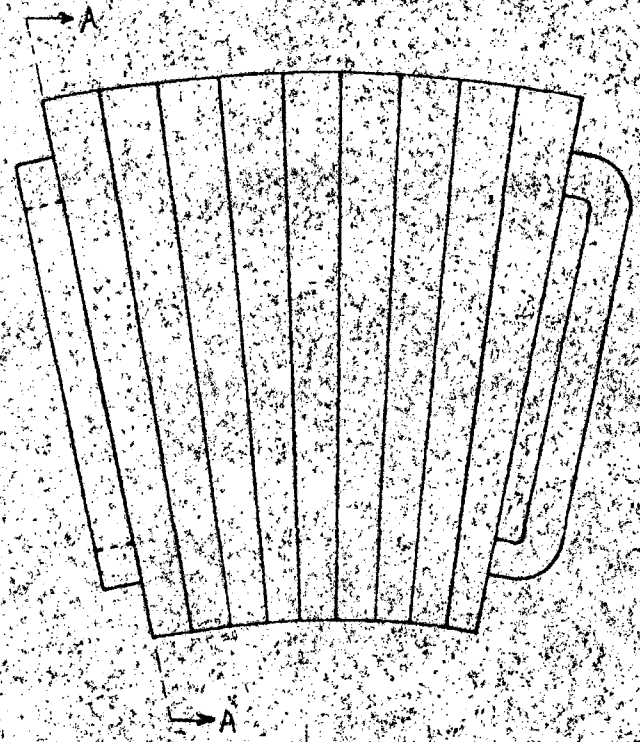
AUGUST 16, 1948

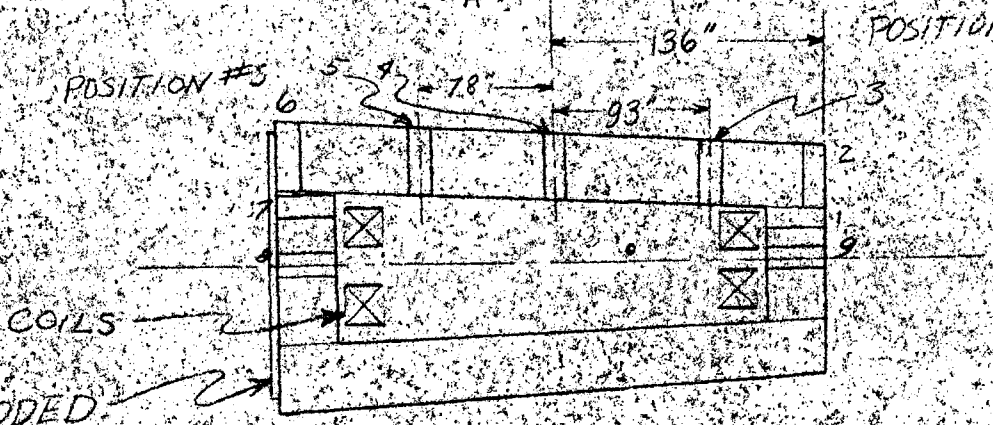
171-8

BEVATRON MODEL MAGNET DC6A.3

S-DC6A.3-31
8-16-48

FLUX DENSITY ON YOKE
1/12 SCALE DWG 3L1635
YOKE DWG 3L1962 COIL DWG 3L1703C
GAP 54" (F.S.) AT CENTER
3" (F.S.) ADDED TO OUTER LEG SLAB

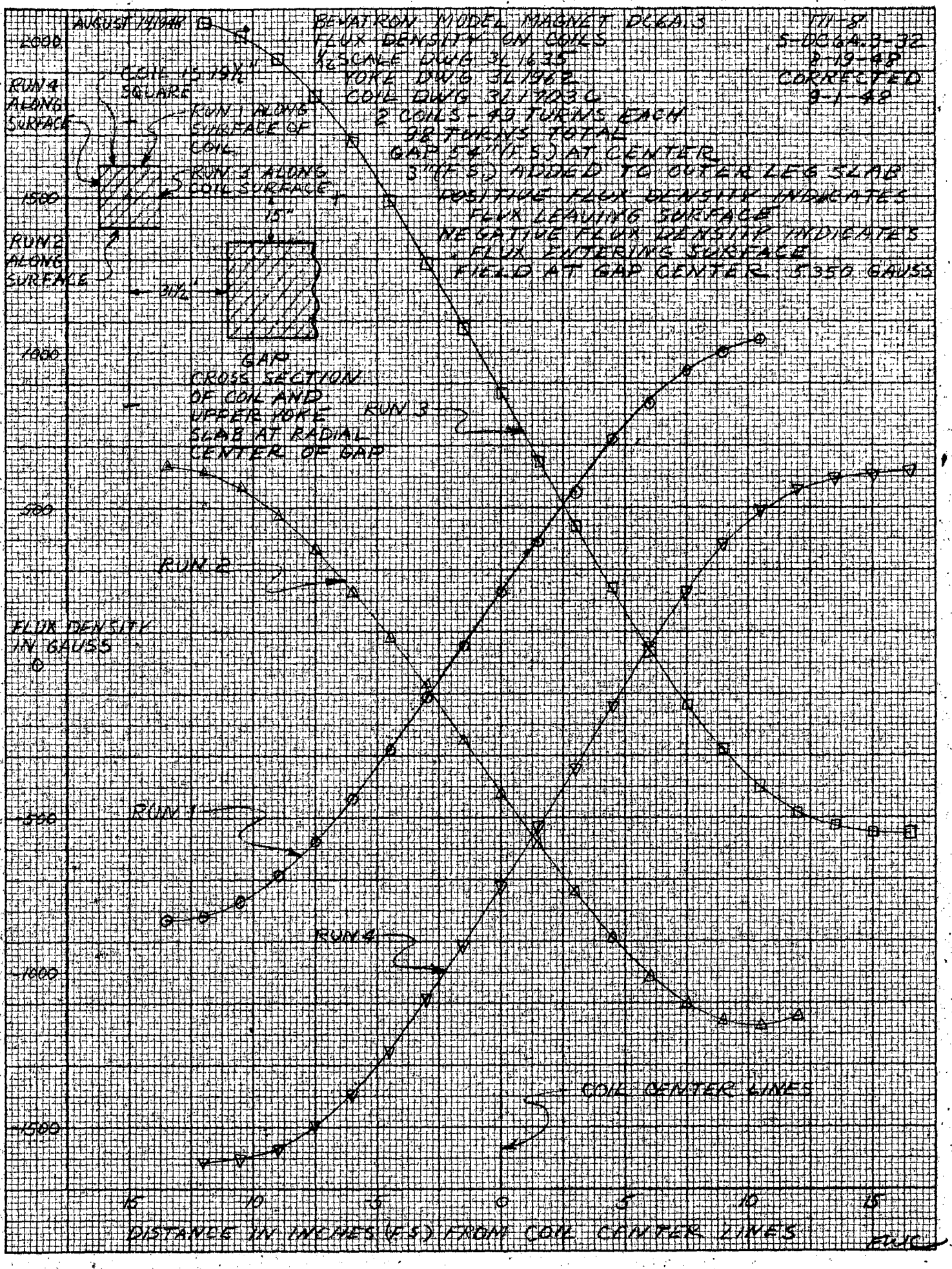




CROSS SECTION AT AA

SEE GRAPHS S-DC6A.3-29
S-DC6A.3-30

EWC



AUGUST 23, 1948

BEVATRON MODEL MAGNET DC6A-3
FLUX DENSITY ON COILS
½ SCALE DWG 3L-1635
YOKE DWG 3L1962
COIL DWG 3L1703C
2 COILS - 49 TURNS EACH
98 TURNS TOTAL
FIELD AT GAP CENTER 5350 GAUSS
GAP 5¾" (F.S.) AT CENTER
3" (F.S.) ADDED TO OUTER LEG SLAB
POSITIVE FLUX DENSITY INDICATES FLUX LEAVING SURFACE
NEGATIVE FLUX DENSITY INDICATES FLUX ENTERING SURFACE

17-9
S. DC6A. 3-33
8-23-48

+1500
+1000
+500
0
-500
-1000
-1500

FLUX DENSITY IN GAUSS

RUN 7
RUN 5
RUN 6
RUN 6 ALONG COIL SURFACE
RUN 5 ALONG COIL SURFACE
RUN 7 ALONG COIL SURFACE
3" ADDED
COIL IS 19½" SQUARE
COIL CENTER

CROSS SECTION OF COIL AND UPPER YOKE SLAB 45" ABOVE MEDIAN PLANE OF GAP ON OUTER LEG SIDE

TOWARD RADIAL CENTER OF GAP

-15 -10 -5 0 5 10 15

F.S. DISTANCE IN INCHES FROM COIL CENTER LINES

EWC

KEUFFEL & ESSER CO., N. Y. NO. 359T-12G
10 X 10 to the ½ inch, 5th lines accented.
Engraving 7½ X 10 in.
MADE IN U.S.A.

AUGUST 23, 1948

BEVATRON MODEL MAGNET DC6A.3
FLUX DENSITY ON COILS
½ SCALE DWG 3L K635

YOKE DWG 3L 19612
COIL DWG 3L 17033C
2 COILS - 49 TURNS EACH
98 TURNS TOTAL
FIELD AT GAP CENTER 3350 GAUSS
GAP 3-4" (F.S.) AT CENTER
3" (F.S.) ADDED TO OUTER LEG SLAB
POSITIVE FLUX DENSITY INDICATES FLUX LEAVING SURFACE
NEGATIVE FLUX DENSITY INDICATES FLUX ENTERING SURFACE

DWG. #
5-DC6A.3-3A
8-23-48

2000
1500
1000
500
0
-500
-1000
-1500

FLUX DENSITY IN GAUSS

RUN 10
RUN 9
RUN 8 ALONG COIL SURFACE
RUN 9 ALONG COIL SURFACE
RUN 10 ALONG COIL SURFACE

COIL CENTERS

-15 -10 -5 0 5 10 15

F.S. DISTANCE IN INCHES FROM COIL CENTERS LINE

COIL IS 19½" SQUARE

3½"

2"

TOWARD RADIAL CENTER OF GAP

CROSS SECTION OF COIL AND UPPER YOKE SLAB 39½" ABOVE MEDIAN PLANE OF GAP ON INNER LEG SIDE

KEUFFEL & ESSER CO., N. Y. NO. 358T-129
10 × 10 to the ½ inch, 5th lines accented.
Engraving 7½ × 10 in.
MADE IN U.S.A.

AUGUST 28, 1942

DEVIATION MODEL MAGNET - DC6A-3
FLUX DENSITY ON COILS
½ SCALE DWG 34L635
YOKE DWG 34L986E
COIL DWG 34L703C
2 COILS - 49 TURNS EACH
98 TURNS TOTAL
FIELD AT GAP CENTER 5350 GAUSS
GAP 5.4"(5.5) AT CENTER
3"(5.5) ADDED TO OUTER LEG SLAB
POSITIVE FLUX DENSITY
INDICATES FLUX LEAVING
SURFACE
NEGATIVE FLUX DENSITY
INDICATES FLUX ENTERING
SURFACE

171-B
5-DC6A3-35
8-24-42

1500
1000
500
-500
-1000
-1500

FLUX DENSITY IN GAUSS

RUN 12
RUN 11
RUN 13
RUN 11 ALONG SURFACE
RUN 13 ALONG SURFACE
RUN 12 ALONG SURFACE
COIL 15 19½" SQUARE
15"
31½"
GAP
CROSS SECTION OF COIL AND UPPER YOKE SLAB 6¼" FROM RADIAL CENTER OF GAP TOWARD INNER LEG SLAB

COIL CENTER

-20 -15 -10 -5 0 5 10 15 20

F.S. INCHES FROM COIL CENTER LINES

DWC

KEUFFEL & ESSER CO. N. Y. NO. 359T-120
10 X 10 to the ½ inch. 5th lines accented.
Engraving 7½ X 10 in.
MADE IN U.S.A.

AUGUST 24, 1948

BETATRON MODEL MAGNET DC 6A-3

FLUX DENSITY ON COIL 3

½ SCALE DWG 3L1632

YOKE DWG 3L1962

COIL DWG 3L1703C

2 COILS 49 TURNS EACH

98 TURNS TOTAL

FIELD AT GAP CENTER 5350 GAUSS

GAP 3.4" (E.S.) AT CENTER

3" (F.S.) ADDED TO OUTER LEG SLAB

POSITIVE FLUX DENSITY INDICATES FLUX LEAVING SURFACE

NEGATIVE FLUX DENSITY INDICATES FLUX LEAVING SURFACE

FLUX DENSITY IN GAUSS

1000

500

0

500

1000

1500

RUN 15

RUN 14

RUN 16 ALONG SURFACE

RUN 15 ALONG SURFACE

RUN 14 ALONG SURFACE

RUN 16

COIL CENTER

COIL IS 19½" SQUARE

15"

31½"

GAP

CROSS SECTION OF COIL AND UPPER YOKE SLAB 56" FROM RADIAL CENTER OF GAP TOWARD OUTER LEG SLAB.

15 10 5 0 5 10 15

F.S. DISTANCE IN INCHES FROM COIL CENTER LINES

ELEC.

KEUFFEL & ESSER CO., N. Y. NO. 359T-12G
10 X 10 to the ½ inch. 5th lines accented.
Extra wide 7½ X 10 in.
MADE IN U.S.A.

SEPT 23, 1948 BEVATRON MODEL MAGNET DC6A3

VERTICAL COMPONENT - STRAY FIELD

1/12 SCALE DWG 3L1635

COIL DWG 3U7A3C YOKE DWG 3L1962

3" (FS) ADDED TO OUTER LEG SLAB

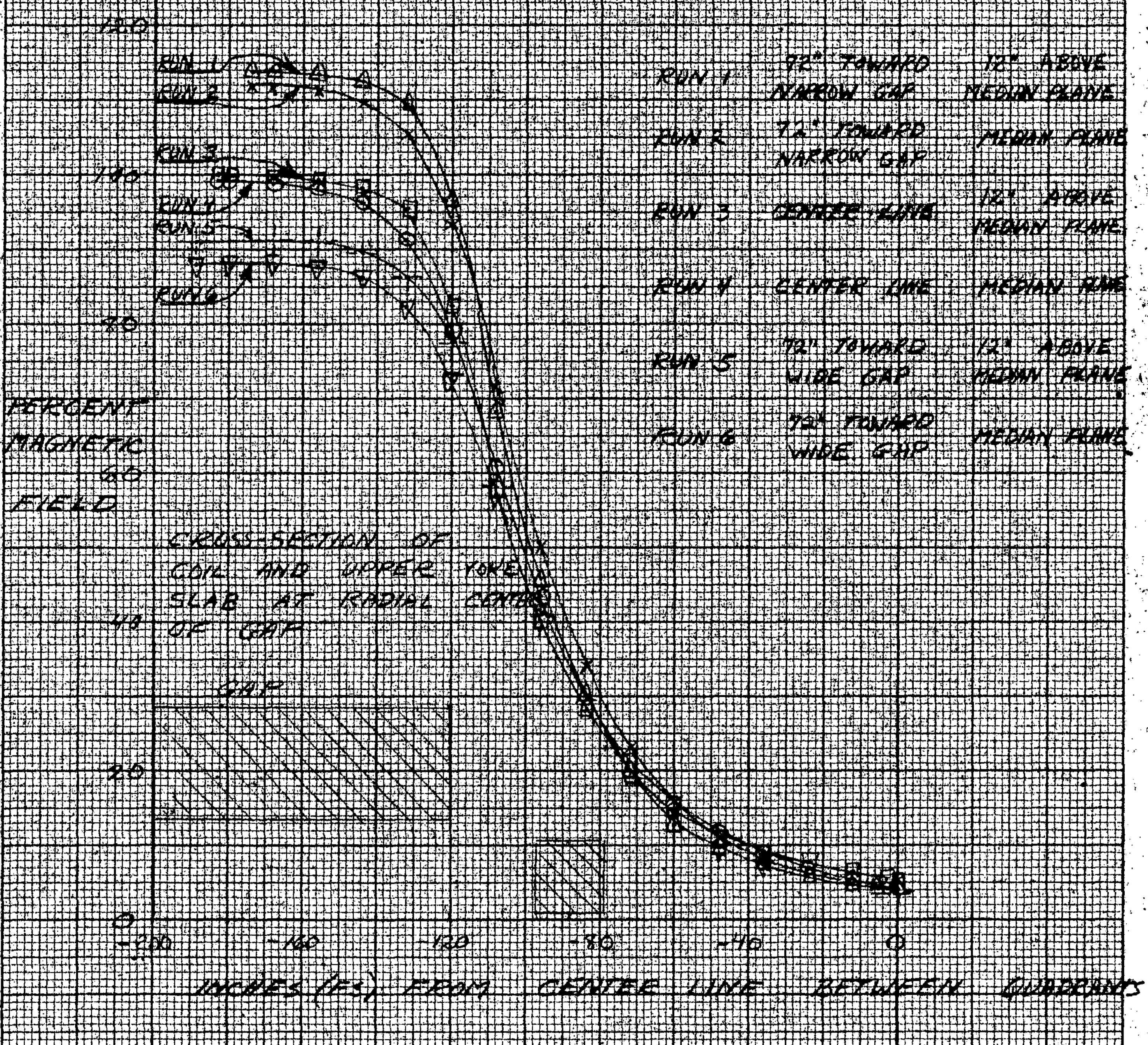
GAP 54" (FS) AT CENTER

MAGNETIC FIELD 2100 GAUSS AT GAP CENTER = 100%

SEE GRAPH 5-DC6A3-5

CURVES ARE DRAWN FOR TWO QUADRANTS

CM-8
5-DC6A3-4
9-23-48



SEPT 24 1948 BEVATRON MODEL MAGNET DCGA3 5-DCGA3-4

VERTICAL COMPONENT STRAY FIELD 9-24-48

1/12 SCALE DWG 3L1635

COIL DWG 3L1703C YOKE 3L1762

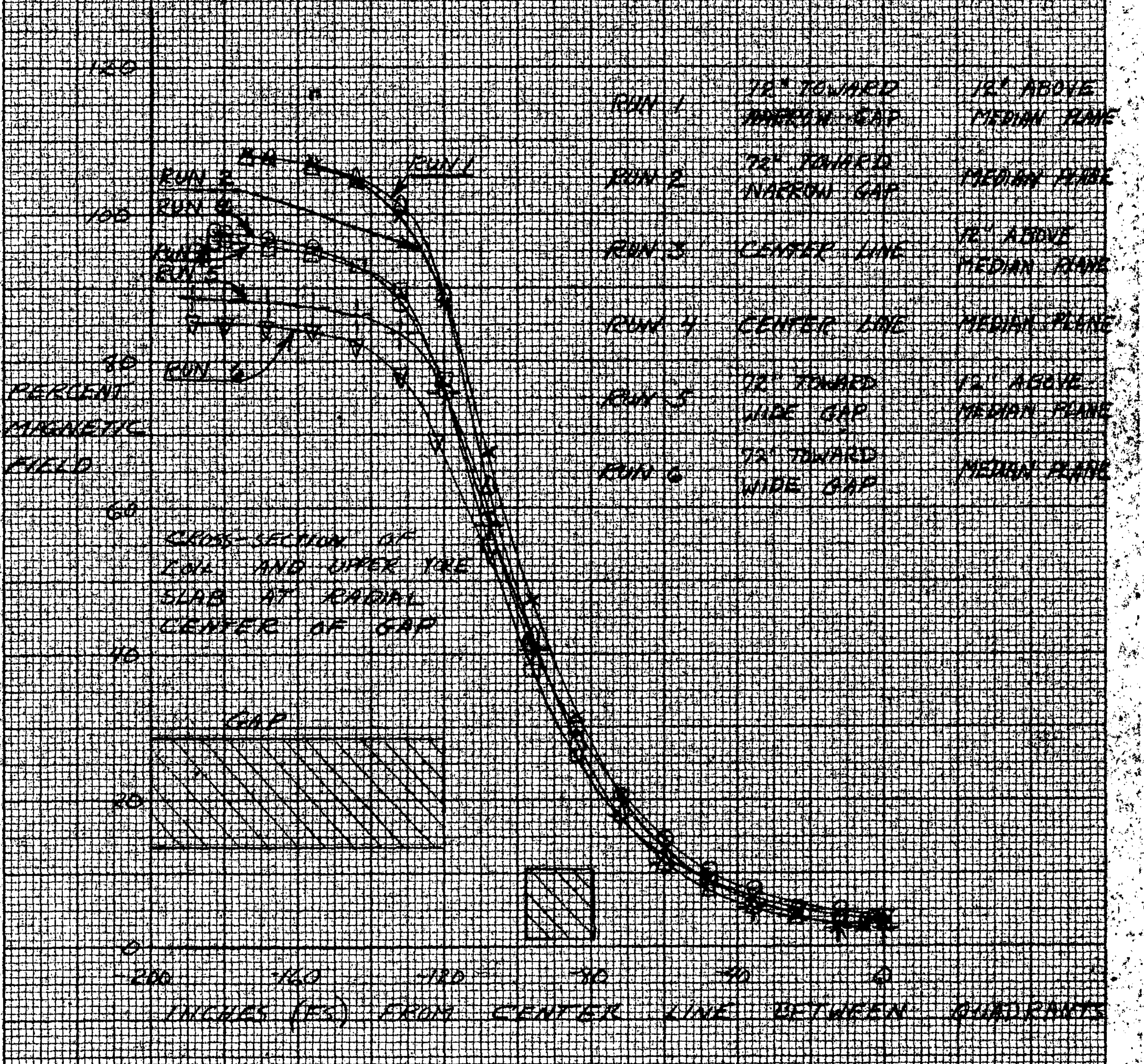
3"(FS) ADDED TO OUTER LEG SLAB

GAP 54"(FS) AT CENTER

MAGNETIC FIELD 5050 GAUSS AT GAP CENTER = 100 %

SEE GRAPH 5-DCGA3-5

CURVES ARE DRAWN FOR TWO QUADRANTS



171-8

SEPT 24, 1948 BEVATRON MODEL MAGNET DCGA3 5-DCGA3-43

VERTICAL COMPONENT - STRAY FIELD 9-24-48

1/12 SCALE DWG 3L1635

COIL DWG 3L1703C YOKE 3L1962

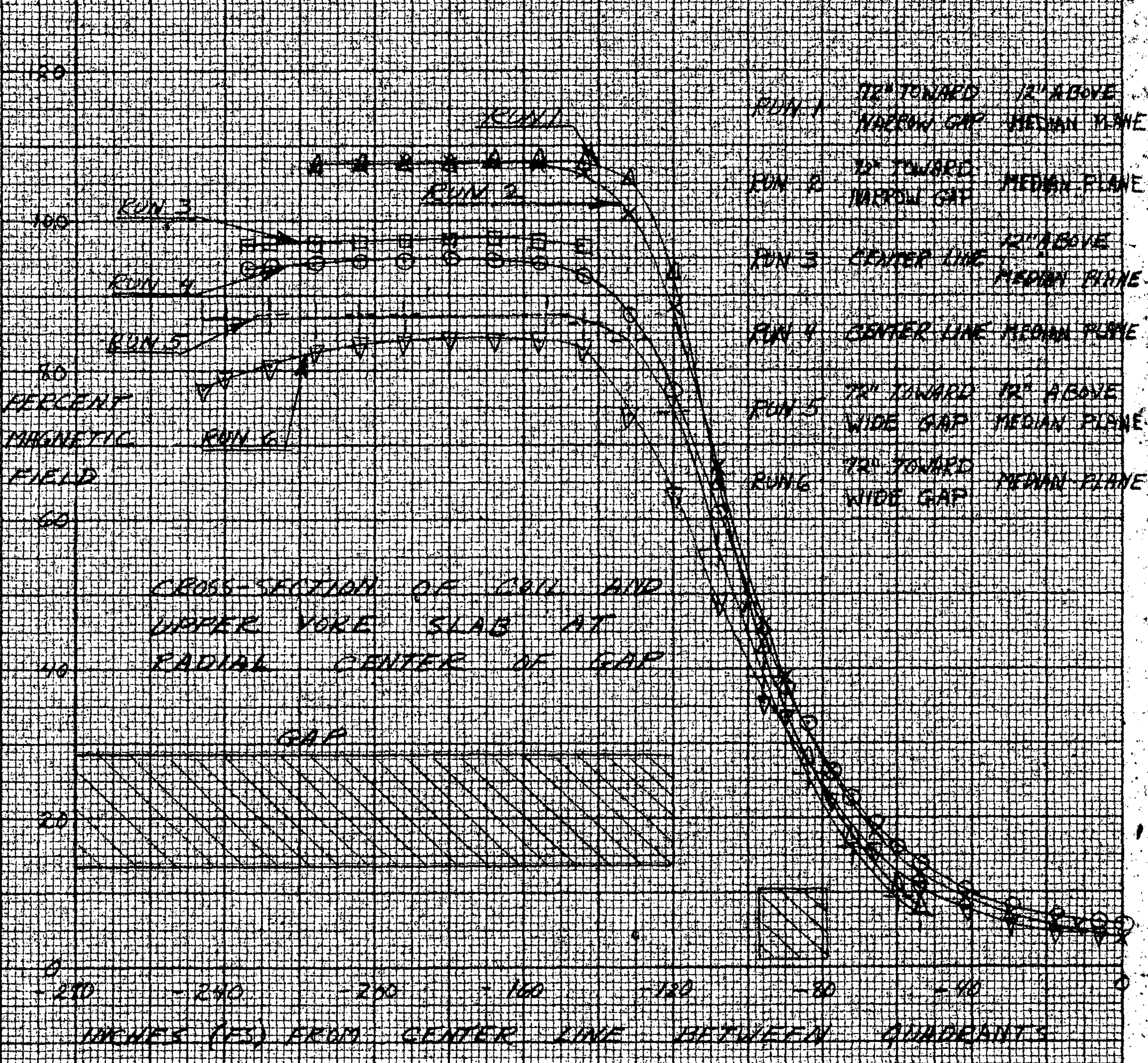
3" (FS) ADDED TO OUTER LEG SLAB

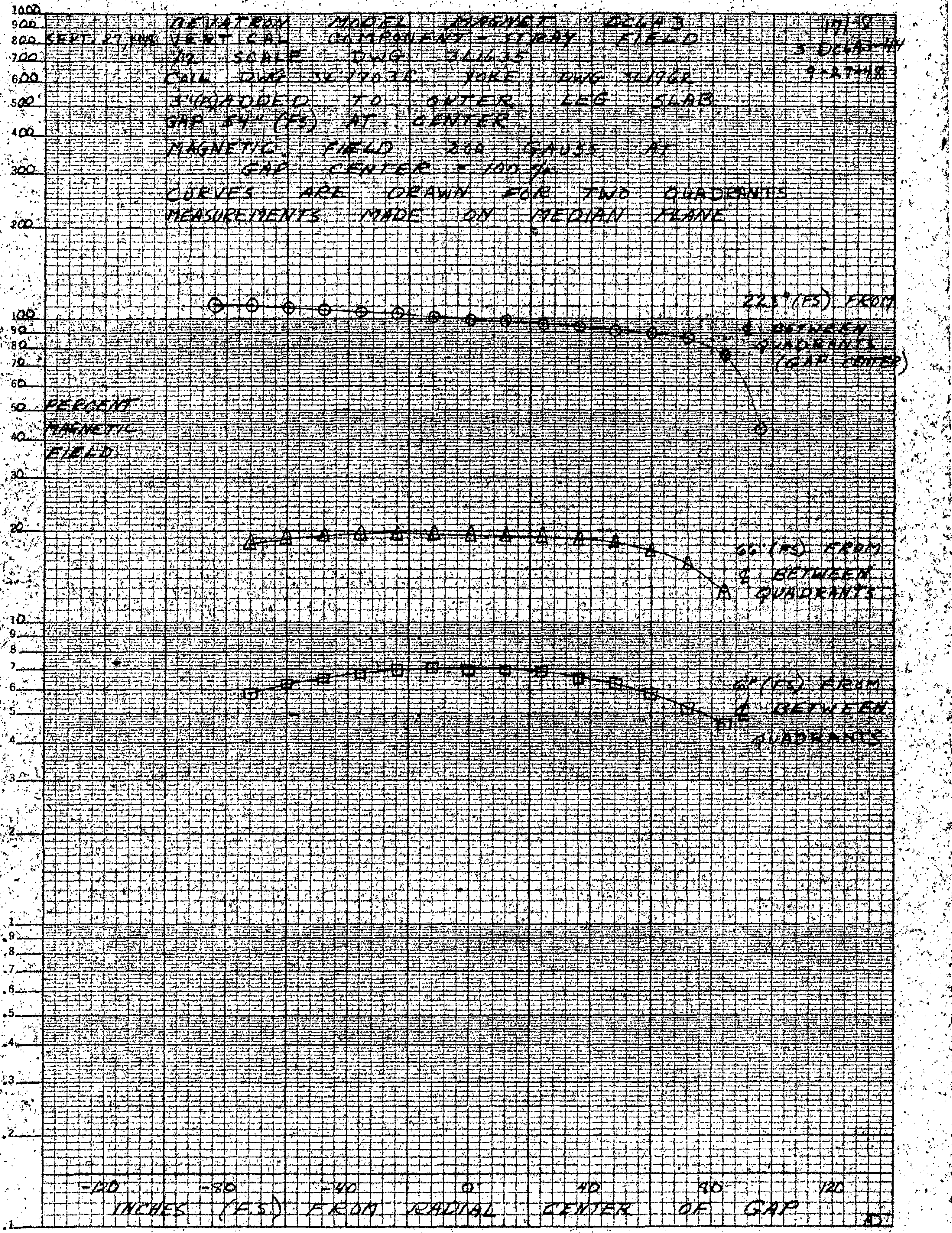
GAP 54" (FS) AT CENTER

MAGNETIC FIELD 200 GAUSS AT GAP CENTER = 100%

SEE GRAPH 5-DCGA3-5

CURVES ARE DRAWN FOR TWO QUADRANTS




BEVATRON MODEL MAGNET
VERTICAL COMPONENT - STRAY FIELD
1/12 SCALE
ADDED TO OUTER LEG SLAB
AT CENTER
MAGNETIC FIELD 200 GAUSS AT
GAP CENTER = 100 %
CURVES ARE DRAWN FOR TWO QUADRANTS
MEASUREMENTS MADE ON MEDIAN PLANE
9-27-48
22.5" (FS) FROM
℄ BETWEEN
QUADRANTS
(GAP CENTER)
66" (FS) FROM
℄ BETWEEN
QUADRANTS
PERCENT
MAGNETIC
FIELD
INCHES (F.S) FROM RADIAL CENTER OF GAP
-120
-80
-40
0
40
80
120

SEPT 27, '48 | REVATRON | MODEL MAGNET | D-44-3 | 171-8

VERTICAL COMPONENT - STRAY FIELD | 3-DC-183-48

1/2 SCALE | POLE 36 INCHES | 9-27-48

COIL POLE FACE | YOKE POLE 71-7942

3" (FS) ADDED TO OUTER VEE GAP

GAP 64" (FS) AT CENTER

MAGNETIC FIELD 2100 GAUSS AT GAP CENTER = 100%

CURVES ARE DRAWN FOR TWO QUADRANTS

PERCENT MAGNETIC FIELD

60" (FS) FROM & BETWEEN QUADRANTS MEDIAN PLANE

60" (FS) FROM & BETWEEN QUADRANTS 12" ABOVE MEDIAN PLANE

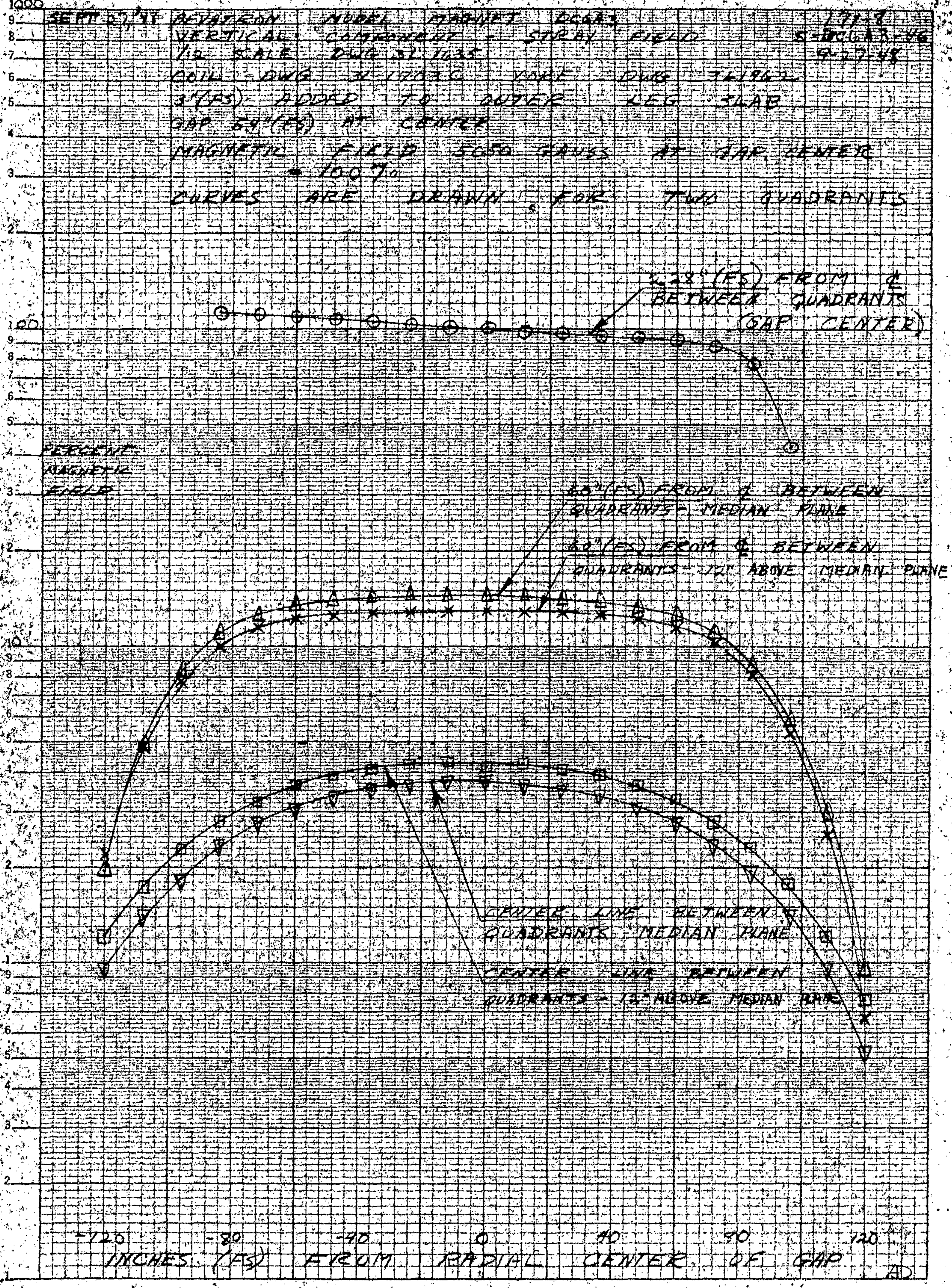
CENTER LINE BETWEEN QUADRANTS - MEDIAN PLANE

CENTER LINE BETWEEN QUADRANTS - 12" ABOVE MEDIAN PLANE

-120 -80 -40 0 40 80 120

INCHES (FS) FROM RADIAL CENTER OF GAP

J. E. STEPHENS & STEPHENS CO., N. Y. NO. 359-R10
Semi-Logarithmic, 4 Cycles X 10 to the inch
MADE IN U.S.A.



BEVATRON MODEL MAGNET
VERTICAL COMPONENT - STRAY FIELD
1/12 SCALE
COIL DWG
3"(FS) ADDED TO OUTER LEG SLAB
GAP 54"(FS) AT CENTER
MAGNETIC FIELD 5050 GAUSS AT GAP CENTER = 100%
CURVES ARE DRAWN FOR TWO QUADRANTS
BETWEEN QUADRANTS (GAP CENTER)
PERCENT MAGNETIC FIELD
60"(FS) FROM ℄ BETWEEN QUADRANTS - MEDIAN PLANE
60"(FS) FROM ℄ BETWEEN QUADRANTS - 12" ABOVE MEDIAN PLANE
CENTER LINE BETWEEN QUADRANTS MEDIAN PLANE
CENTER LINE BETWEEN QUADRANTS - 12" ABOVE MEDIAN PLANE
-120
-80
-40
0
40
120
INCHES (FS) FROM RADIAL CENTER OF GAP

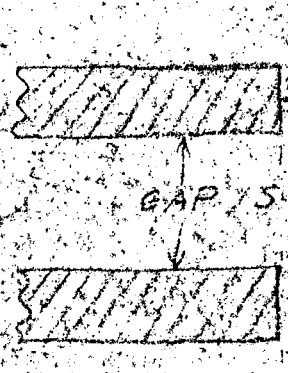
PAGE 1	RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA - BERKELEY ENGINEERING NOTES	JOB NUMBER 171-8	FILE NO. C	PAGE 1

SUBJECT: BEVATRON LEAKAGE FLUX

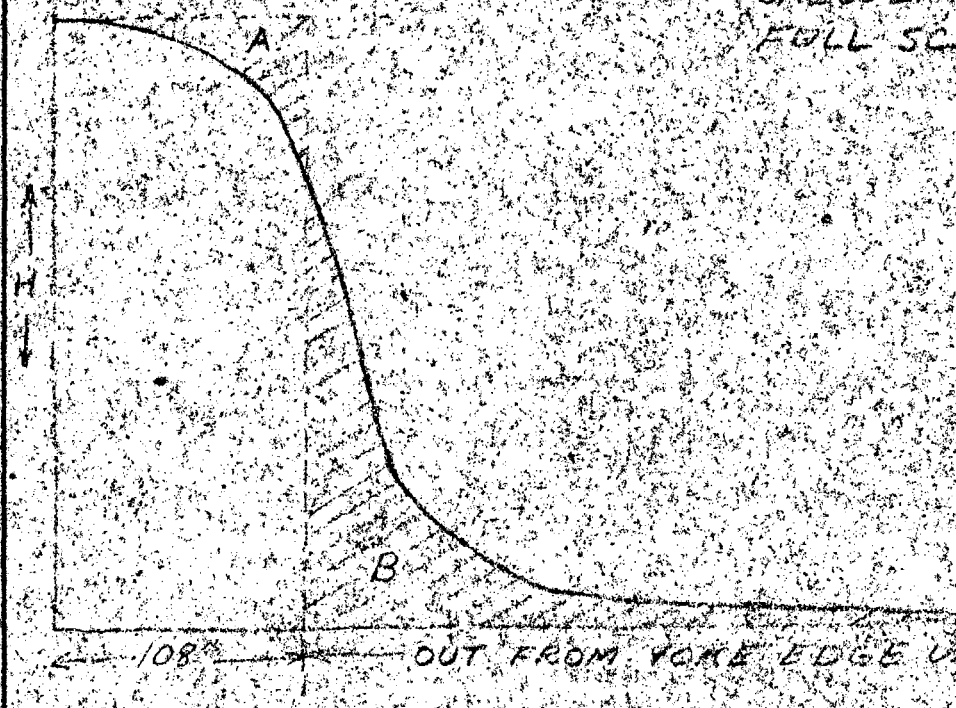
NAME: E. W. Cox

DATE: 10-6-48

5-DC6A.3-97



∴ CALCULATIONS ARE FOR FULL SCALE 360° BEVATRON



① MAXWELLS IN GAP @ 5050 GAUSS (ASSUMING FIELD UNIFORMITY IS CONSTANT TO EDGE OF YOKE — SEE GRAPH F-DC6A.3-16) = 21.4×10^9

② MAXWELLS IN AREA "A" (INTEGRATED BETWEEN MAGNET COILS) = $0.244 \times 10^9 = \frac{0.244 \times 10^9 \times 100}{21.4 \times 10^9} = 1.1\%$ OF ①

③ MAXWELLS IN AREA "B" (INTEGRATED TO H=0 OUTSIDE GAP) = $1.53 \times 10^9 = \frac{1.53 \times 10^9 \times 100}{21.4 \times 10^9} = 7.2\%$ OF ①

④ TOTAL % LEAKAGE FLUX = ③ − ② = 7.2 − 1.1 = 6.1

SEPT 3, 1948 BEVATRON MODEL MAGNET DC646 11-8

MAGNETIZATION AT GAP CENTER #DC646-1

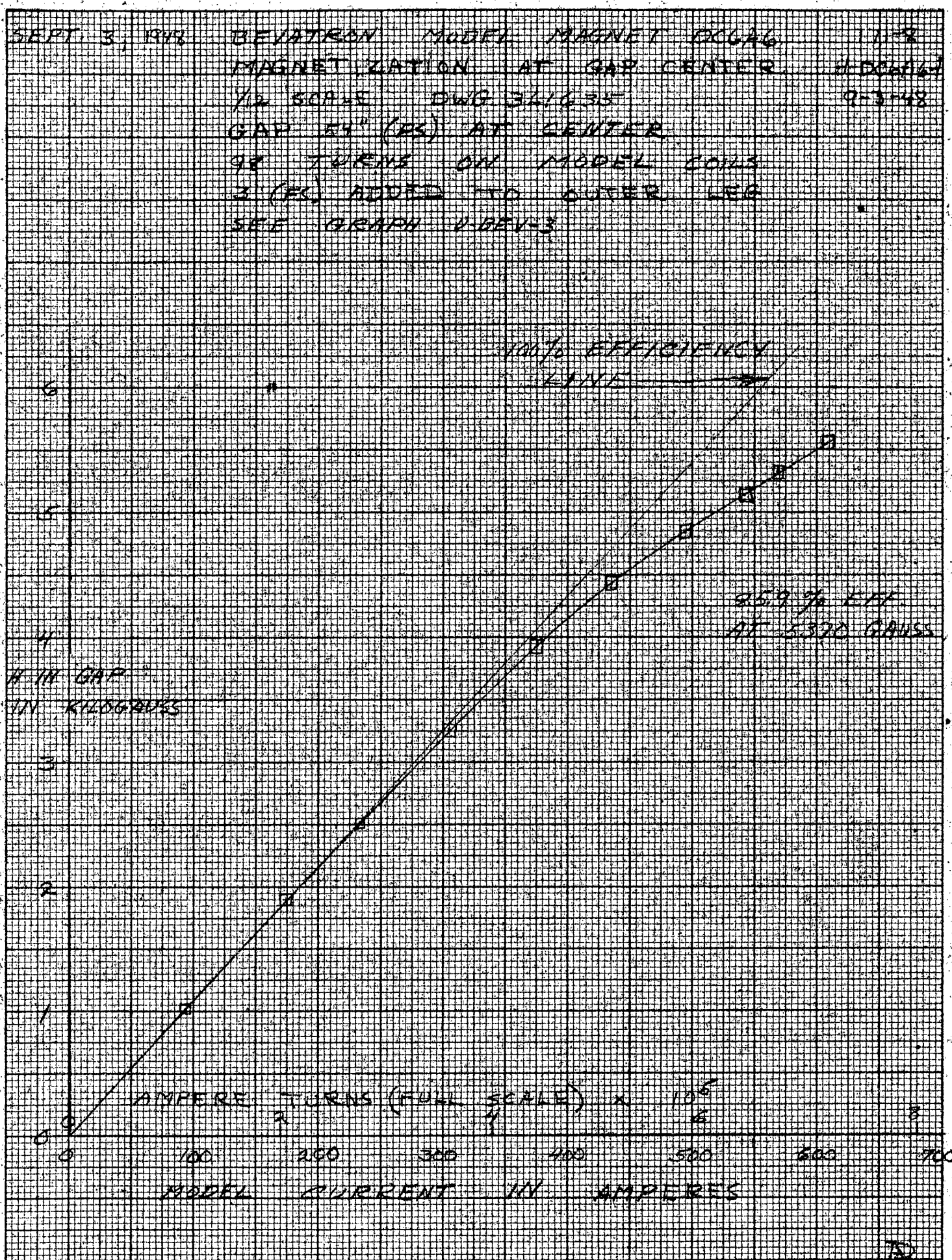
1/2 SCALE DWG 32/6 33 9-3-48

GAP 54" (FE) AT CENTER

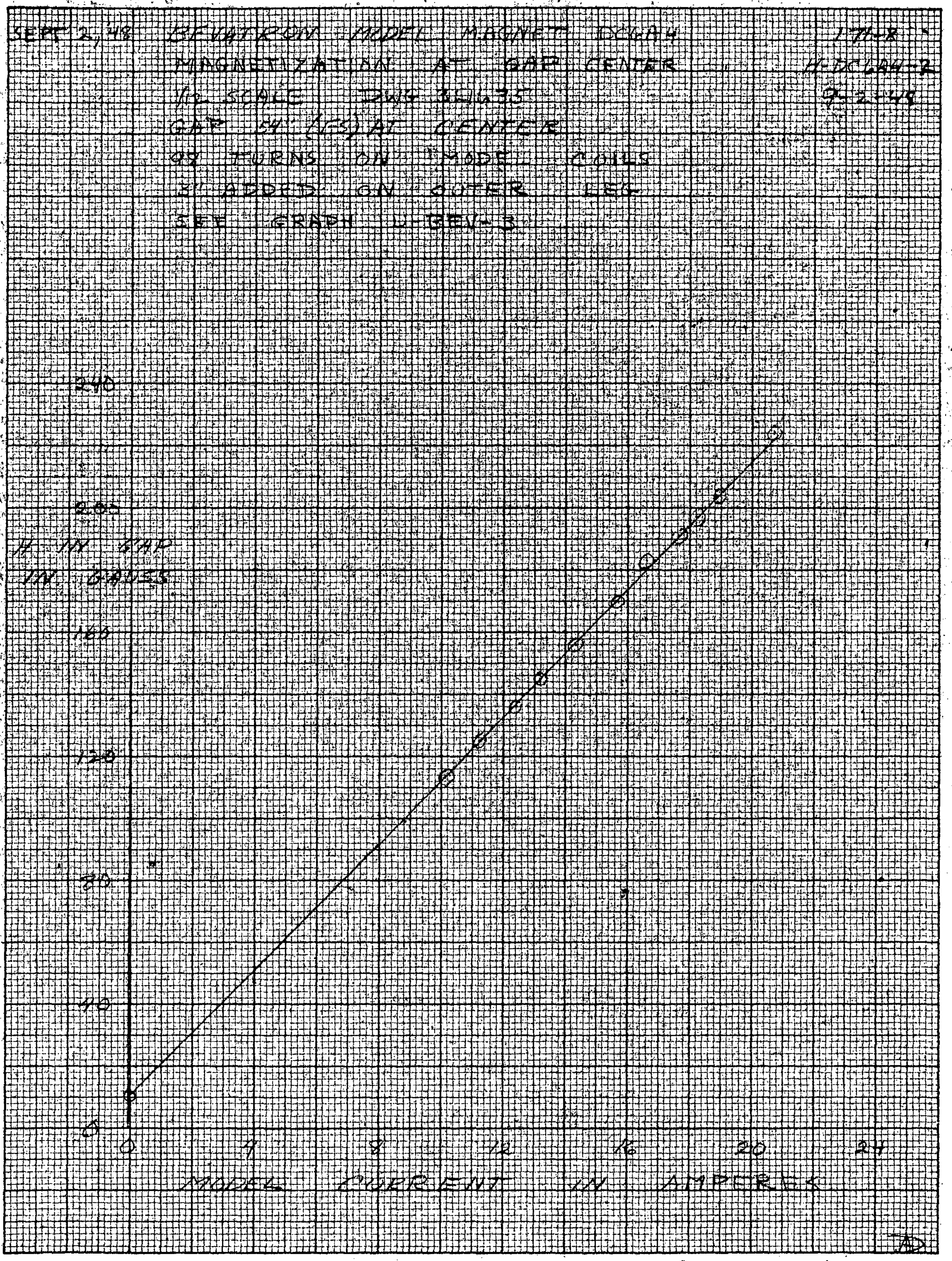
98 TURNS ON MODEL COILS

3 (FE) ADDED TO OUTER LEG

SEE GRAPH V-BEV-3



KEUFFEL & ESSER CO. N. Y. NO. 3397-120
10 X 10 to the ½ inch, 5th lines accented.
Engraving 7½ X 10½in.
MADE IN U.S.A.



CALIBRATION MODEL MAGNET DC6A5F T-8

SEPT. 1, 1948 MAGNETIZATION AT GAP CENTER H-DC6A5-1

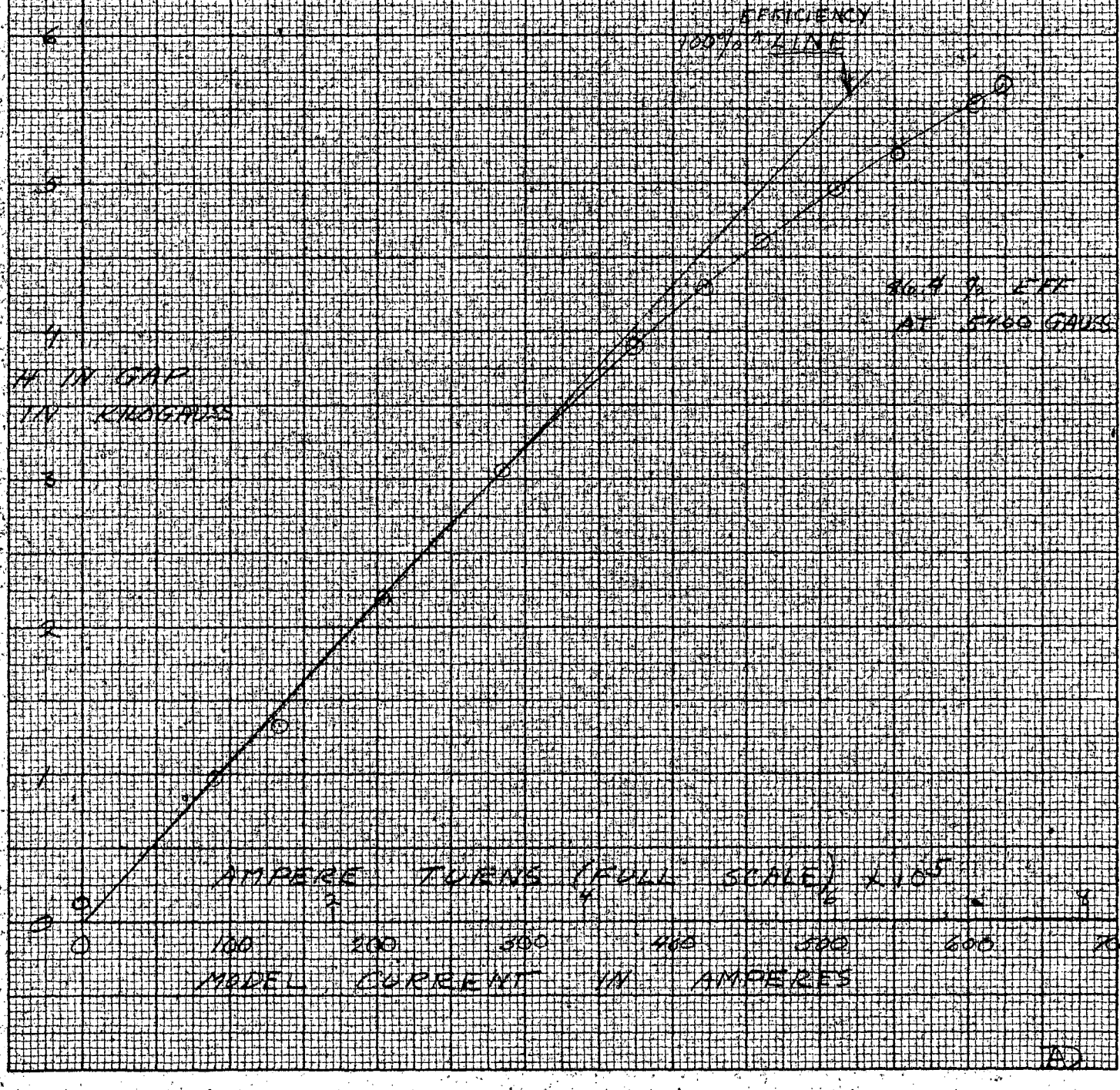
½ SCALE DWG 3L1633 9-8-48

GAP 5" (ES) AT CENTER

98 TURNS ON MODEL COILS

3" (ES) ADDED TO OUTER LEG

SEE GRAPH H-BEV-3



KEUFFEL & ESSER CO. N. Y. NO. 358-1120
10 X 10 to the ¼ inch, 5th lines accented.
Engraving 7¾ X 10 in.
MADE IN U.S.A.

SEPT 3, '48 BEVATRON MODEL MAGNET DC645 171-8

MAGNETIZATION AT GAP CENTER M-DC645-1

9-3-48

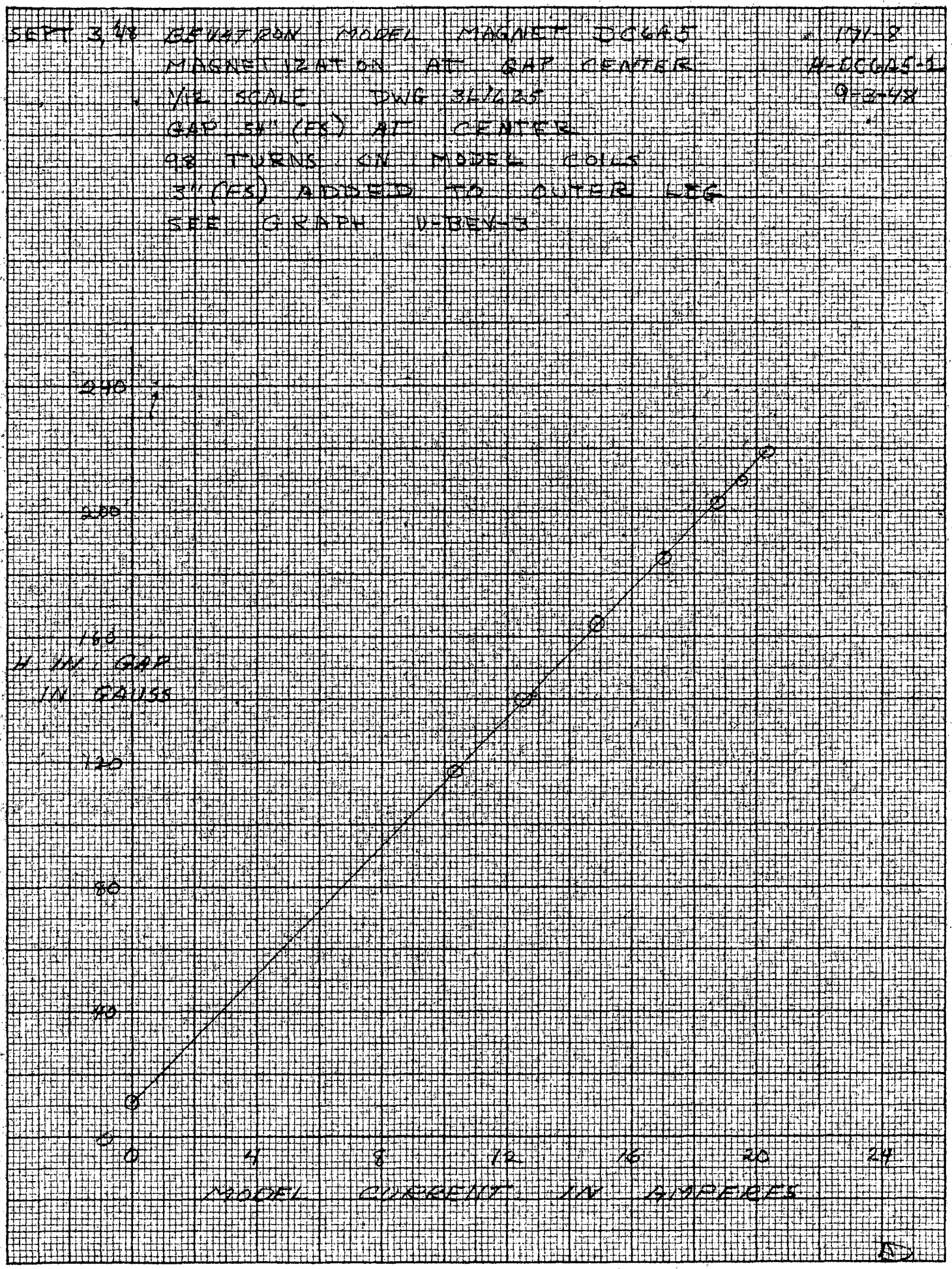
M.E. SCALE DWG 31/425

GAP 5" (FS) AT CENTER

98 TURNS ON MODEL COILS

3" (FS) ADDED TO OUTER LEG

SEE GRAPH V-BEV-3



KEUFFEL & ESSER CO., N. Y. NO. 359T-12G
10 × 10 to the ½ inch, 5th lines accented.
Engraving 7½ × 10 in.
MADE IN U.S.A.

SEPT 1, '48 BETATRON MODEL MAGNET 2CG6A4 171-8

MAGNETIZATION AT GAP CENTER 4-1-48

1/2 SCALE DWG 324635

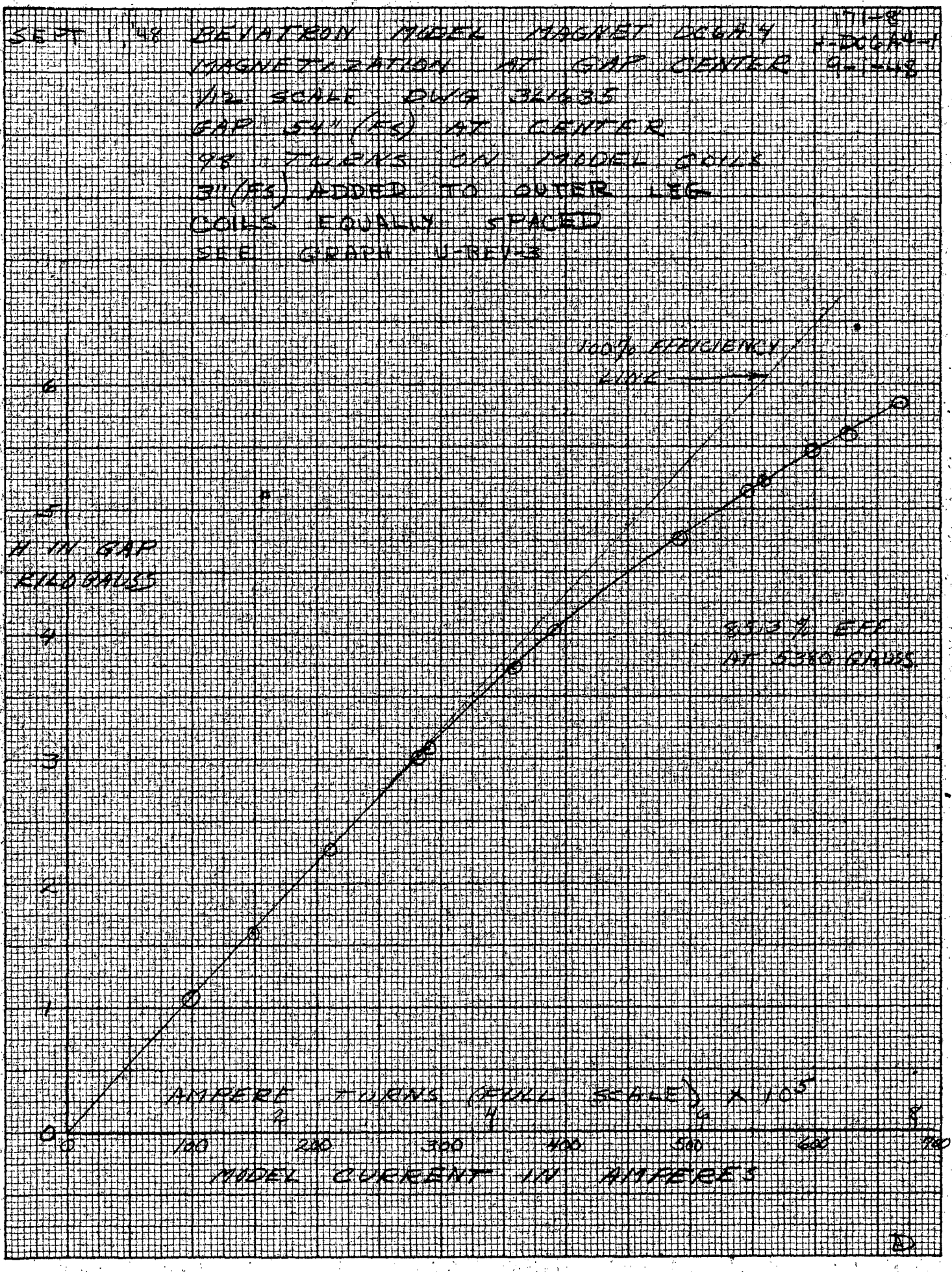
GAP .54" (FS) AT CENTER

98 TURNS ON MODEL COILS

3" (FS) ADDED TO OUTER LEG

COILS EQUALLY SPACED

SEE GRAPH U-REV-3



KEUFFEL & ESSER CO., N. Y. NO. 3387-12S
10 × 10 to the ½ Inch, 5th lines accented.
Engraving 7½ × 10 in.
MADE IN U.S.A.

SEPT 3, 1948 RETATRON MODEL MAGNET DC24C 17C-8

MAGNETIZATION AT GAP CENTER MDC646-2

1/12 SCALE DWG 3L1635 9-3-48

GAP 5½" (FS) AT GAP CENTER

9K TURNS ON MODEL COILS

3" ADDED ON OUTER LEG

SEE GRAPH V-BEV-3